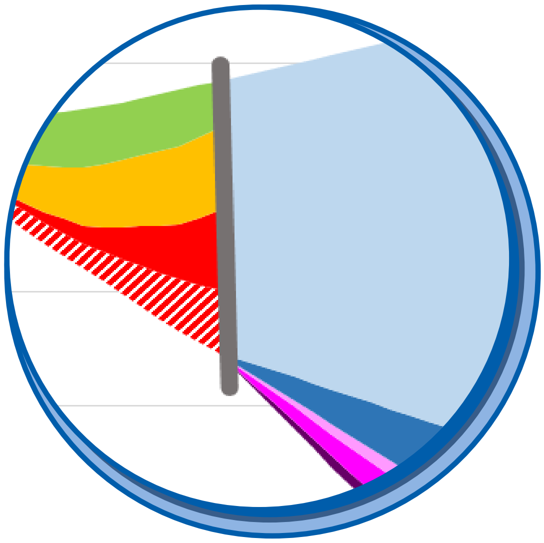
Net Zero Devon

CENTRE FOR ENERGY AND THE ENVIRONMENT

Internal Document 974

February 2020



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CENTRE FOR ENERGY AND THE ENVIRONMENT

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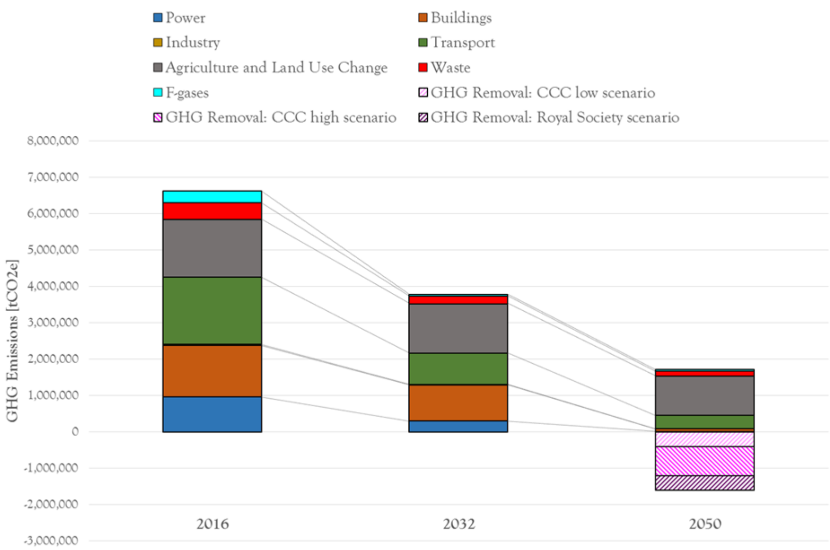
Management Summary

Devon County Council (DCC) declared a climate emergency in February 2019, pledging to facilitate the reduction of Devon's carbon emissions to net-zero by 2050 at the latest. Districts within Devon have also declared climate emergencies and aim to become carbon neutral at earlier dates (2025, 2030 and 2040).

The Centre for Energy and the Environment at the University of Exeter was commissioned by DCC to provide quantified projections of carbon emissions for DCC administered Devon (i.e. not including Plymouth and Torbay) following a "business as usual" path, and with the national policies (either in place, or required) to achieve Net Zero. These projections were based on meeting Net Zero by 2050 (the currently proposed national timeline). To assess the impact of targeting an earlier date for Net Zero further work was undertaken to assess how Devon may be able to meet the target by 2030.

Devon's greenhouse gas (GHG) emissions in 2016 were 6,628 ktCO_2e. Between 2008 and 2016 emission fell 16%. However, much of the reduction was in the power sector which benefits from national renewable electricity production. If the power sector is excluded, GHG emissions fell 5% between 2008 and 2016 but emissions and rose 5% between 2011 and 2016. The dominant sectors in 2016 (88% of emissions) were, transport (28%), agriculture (24%), buildings (21%) and power (15%). Projections from the 2016 baseline utilised two reports produced by the Committee on Climate Change (CCC) in 2018: *Progress Report to Parliament* and *Net Zero: The UK's contribution to stopping global warming*. These documents assess and project GHG emissions by sector in the UK to 2032 and 2050 respectively and these emission reduction projections were apportioned to the equivalent sectors in Devon.

The projections show that in the absence of any carbon reduction policy GHG emissions in Devon would rise 15% (to 7,645 ktCO_2e) in 2050. Low, medium and high risk policies to the end of the 5th Carbon Budget in 2032 would see emissions fall 32% (to 4,485 ktCO_2e or 3,791 ktCO_2e if policy to meet the "policy gap" was to be identified) compared to the 6,804 ktCO_2e under business as usual. Of this carbon reduction, 12% is from "low risk" policy, 38% from "medium risk" policy and 27% from "high risk" policy. The final 23% is the current policy gap. Projecting to 2050, the CCC's Core scenario would see emissions drop 58% (to 2,771 ktCO_2e), and delivering the measures in the Further Ambition scenario would see an 74% fall (to 1,720 ktCO_2e). The inclusion of GHG removal technologies or off-setting would be required to achieve carbon neutrality (see graph below).



Emissions reductions by sector are summarised as follows:

- Power
  Emissions from the power sector in Devon (1,410 ktCO_2e in 2016) are projected to fall to 67 ktCO_2e in 2050 (98%) despite the anticipated doubling electricity demand mainly due to use in heat pumps in buildings and eclectic vehicles. Nationally future generation will be from variable renewables (57%, mostly offshore wind), with nuclear and existing hydro and biomass with carbon capture and storage (CCS) making up 20%. The residual 23% will use fossil gas with all the CO_2 emissions captured and stored. CCS will also play a major role in the production of hydrogen for use in industry and transport as 84% of hydrogen production will come from reforming gas into hydrogen and CO_2. Devon currently produces 32% of the electricity it uses from renewable and waste sources. Estimates of renewable energy generation potential in Devon suggest that the county has the resources to become a net electricity exporter despite the potential doubling of electricity demand foreseen by the CCC by 2050.

- Buildings
  Non-electricity (direct) emissions from buildings are responsible for 21% of Devon's emissions (972 ktCO_2e in 2016) and are projected to fall 95% to 67 ktCO_2e by 2050. This would require progressive planning policy to bring forward zero carbon standards for new development, and numerous measures to address emissions from existing buildings. For dwellings, this means providing an appropriate insulation measure for every available loft and cavity walled building (74,000 new installations), as well as the majority of solid walled buildings (74,000 new installations). For non-domestic buildings, including many used for industrial purposes, this means identifying significant energy reduction opportunities, though this sector is more varied than the domestic sector and it is harder to identify specific high level opportunities. In addition to this, the heat supply to buildings will need to be decarbonised. For off-gas buildings this is likely to mean heat pumps, whilst for on-gas buildings this may include low carbon heat networks (61,000 in Devon) as well as heat pumps (potentially up to 233,000 installations in total).

- Industry
  Direct large industrial emissions (34 ktCO_2e in 2016 or 0.5% of the County's emissions) are projected to reduce by 88% to 4 ktCO_2e in 2050. Devon has little energy intensive industry and much of its business energy use is indirect (electricity) or from industrial buildings and associated transport with emissions falling under the respective sectors. Eight industrial emitters have been identified dispersed across the county the largest of which, BCT in Heathfield, went into administration in 2018. Measures to reduce industrial emissions include energy efficiency and the provision of zero carbon heat initially from bio-energy and electricity then from hydrogen and ammonia. Uptake by business will need to be driven by a national programme and accelerating this will require additional funding. It will also be necessary to deepen the understanding of industry across the county perhaps through a specialist unit working with larger emitters which would also develop a programme to reach smaller industrial emitters. In parallel with developing this industrial insight the unit could work with planners to develop appropriate low carbon industrial zones in Devon.

- Transport
  Low carbon transport is essential for Net Zero. The sector, excluding aviation and shipping, accounts for 28% of Devon's 2016 emissions (1,842 ktCO2e) and these are projected to fall by 80% to 368 ktCO_2e in 2050 (48% of emissions). A combination of technological and behavioural changes will be required to transition to electric cars and vans. Both the evolution of vehicle technology (to bring down costs and improve range) and the development of charging infrastructure will be needed. Larger vehicles such as HGVs will be harder to tackle and possible technological solutions may include bio-methane, hydrogen or electrification. In addition to these technological changes, it is assumed that 10% of car journeys (measured by distance rather than by trip) can be shifted to walking and cycling,

and that distance travelled by freight can be reduced by 10% through improvements to logistics (e.g. using urban consolidation centres). GHG emissions will be reduced from railways via fuel switching (electrification of main lines and potentially hydrogen for branch lines). Although shipping is not include in Devon's emissions it is worth noting changes in fuels for shipping (to hydrogen and ammonia) may suggest significant changes in Devon's dockyards.

- Agriculture and land use change
  Direct emissions from the Agriculture and Land Use Change sector are responsible for 24% of emissions (1,590 ktCO_2e) and are projected to fall by 32% to 1,084 ktCO_2e by 2050. This leaves the sector responsible for 63% of the footprint in 2050 and means that identifying new measures for agricultural carbon reduction is important to achieve net zero emissions. The CCC assumes a variety of on-farm practices to reduce non-CO_2 emissions from soils, livestock, waste and manure management and from reduced energy consumption in stationary and other farm machinery as well as extensive afforestation (up to 3,600 Ha/annum if 2030 is the target date for Zero Carbon). Mitigating methane emissions from sheep and cattle is addressed through livestock breeding programmes as well as reductions in both meat and dairy consumption and wastage.

- Waste
  Waste emissions, mostly methane from landfill, were 7% of Devon emission in 2016 (453 ktCO2e) and are projected to decline 71% by 2050 to129 ktCO_2e when they will represent 8% of Devon's emissions. The Council has stopped landfilling the domestic fraction of the county's waste and municipal waste is now either recycled or used for energy recovery. The position in the non-domestic waste is very different. Here, even obtaining reliable up to date information on the volume and composition of non-domestic waste streams to enable emissions assessment is a challenge. This needs to be rectified. Measures to reduce emissions from waste include additional methane capture from old landfill sites, segregated food waste collection (fed to new AD capacity) and reduced waste generation.

- F Gases
  Fluorinated gasses (F-gases) represent 5% of Devon's emissions (324 ktCO2e in 2016). Most emissions (94% in the UK) are from hydrofluorocarbons (HFCs) and the largest source is the refrigeration, air conditioning and heat pump (RACHP) sector. Emissions in 2050 are projected to be 45 ktCO2e, an 86% reduction which is likely to be achieved through regulation at national level. Acceleration to 2030 would require local measures to stop the use of RACHP and other equipment containing F-gases and local enforcement of 'management measures' including regular leak checks and repair, gas recovery at end-of-life, record keeping, training and certification of technicians and product labelling.

- GHG removal
  Achieving net zero emission in the UK will require some level of GHG removal to mitigate residual emissions in difficult sectors such as air transport. Without GHG removal Devon's residual emissions in 2050 are projected to be 1,720 ktCO_2e, 26% of 2016 emissions. A national programme of GHG removals is likely to be needed to tackle this level of residual emissions. Localised CCS technologies which could for example be applied to the flue of the Marsh Barton EfW plant may evolve and various technologies are currently being developed and trialled.

Using the CCC's net cost methodology, the net cost for Devon to achieve net zero emissions in 2050 is estimated at £658 million per year. This equates to 1.6% of Devon's GDP in 2050, or approximately £717 per head of population in that year. The proportion of GDP calculated for Devon is higher than the 1% national average which partly reflects the different composition of the carbon footprint, and the lower GDP of Devon compared to the UK average. Buildings and agriculture are the sectors with the highest abatement costs. GHG removal also has high costs. The

CCC scenarios assume that the country as a whole moves towards Net Zero in a coordinated way and that due to the wide take-up of measures across sectors they become cheaper over time.

Achieving the same amount of carbon reduction by 2030 would in effect require compressing the same measures into a timeframe that is only about a third as long. For some of the proposed measures where the technology is sufficiently mature (e.g. insulating all lofts and cavity walls) this might be possible, though it would require the funding mechanisms to do so, and there would also need to be local capacity for delivery. In addition, existing barriers that have already prevented such action from occurring would need to be overcome (e.g. in the case of these insulation measures, the lack of engagement from some property owners, issues associated with the high exposure of Devon properties to wind driven rain and the potential negative impact of this on some types of cavity fill solutions). In other cases, faster deployment may be possible but would face increased cost and other barriers. For example, electric vehicles are currently available but they are significantly more expensive than their conventional counterparts, and suffer from reduced ranges and lack of widespread charging infrastructure. In other cases, the technology may not yet be sufficiently developed to implement now e.g. some of the proposed GHG removal technologies.

These issues are significant when considered at a national level, but would be exacerbated if Devon were to pursue this timeline independently of the planned rate of change nationally. This would mean that many of these measures would need to be deployed without the support of national policy (e.g. regulation or financial rewards) and in many cases would rely on utilising technology that may not be sufficiently developed (or that is very expensive) to achieve the requisite amount of GHG emission reduction. These issues in general relate to the deployment of technological solutions (e.g. electricity generation, insulation, electric vehicles, GHG removal etc.), and so if any of these identified solutions do not prove to be possible at the scale required, then additional measures would be required. These may be from other sectors (i.e. "over delivery" in one sector to offset shortfalls in another), or could require voluntary actions by citizens and businesses in Devon to reduce demand. Examples of this could include reducing travel, accepting lower temperatures in buildings, decarbonising agriculture and industry etc. Clearly, these have a significant political dimension, would not be possible in many areas and would be opposed by many due to loss of GVA, jobs, comfort, amenity etc. In some cases (e.g. deindustrialisation), there is also the risk of "carbon leakage" i.e. those processes simply moving to another place and creating emissions there.

An indicative analysis of the costs to meet the target by 2030 increases the estimated annual net cost from £658 million to about £1,852 million (1.6% GDP in the target year to 7.1% GDP) equivalent to £2,181 per person. These costs are likely to be significantly understated, and in addition, the up-front capital costs involved would be significantly higher as the net costs are inclusive of benefits. As these benefits do not necessarily align with the parties responsible for bearing the cost, the actual cost excluding any benefits is arguably more representative of the scale of the financing challenge that Devon could face accelerating beyond the national trajectory.

The analysis has clearly shown that significant action is needed across every sector to achieve the deep emission reduction that would be required by 2030. Should it not be possible to achieve carbon reduction in any particular sector then this would require additional reduction to be achieved in other sectors. Whilst there are significant challenges in meeting this level of reduction, particularly within an accelerated timescale, there may also be some opportunities specific to Devon.

The next step should be to undertake further "bottom up" work to establish more specifically the amount of GHG emissions reduction that could be achieved. This analysis should include envisaged costs and savings and should be based on locally available resource assessments across each sector. It may be worthwhile separating this piece of work into an analysis of each sector.

These analyses should look to engage more widely with stakeholders in Devon to utilise the locally available expertise. Devon has made great progress in this area having already established the Devon Climate Emergency Response Group and appointing a Net-Zero Task Force to develop a Devon Carbon Plan. The process will also involve a citizen's assembly which will deliberate on the plan. Budgets have been made available to support further evidence base analysis and wider public engagement processes.

The Carbon Plan will need to contain sector specific action and delivery plans, which would identify a programme of measures, the stakeholders required to deliver those measures, and identification of budgets or alternative routes to finance the measures.

The table below provides a summary of initial priority actions identified from this work as a starting point.

Indicative list of priority areas for Net Zero

Sector	Immediate Priority
General	Undertake a policy mapping exercise of current and proposed policy to establish where it supports or hinders carbon reduction and identify key gaps.
General	Produce sector-by-sector "bottom up" projections of GHG emissions using detailed local data.
Power	Undertake an up-to-date review of potential for renewable energy development and include RE development sites in the local plan.
Power	Work with WPD and others to ensure electricity infrastructure is capable of meeting increased local energy generation and demand for electricity from the heating, industry and transport sectors.
Power	Planning policy should ensure all new buildings are connected to the electricity network via three-phase supplies.
Power	Look to trial and support smart electricity projects, including those with battery storage aspects.
Buildings	Investigate opportunities to require zero carbon from all new planned development.
Buildings	Undertake a bottom-up assessment of opportunities for insulation in existing dwellings by tenure, and seek to make use of existing ECO funding whilst lobbying for more ambitious national insulation programmes.
Buildings	Pro-actively enforce the MEES (Minimum Energy Efficiency Standards) which apply to all privately rented dwellings and non-domestic buildings.
Buildings	Seek to engage the non-domestic sector by working with landlords and institutions like the Chamber of Commerce to identify the potential for retrofitting existing non-domestic buildings.
Buildings	Create a renewable heat strategy by appraising the potential for low carbon heat networks, heat pumps, and hybrid boilers, including identifying current potential funding models and barriers to uptake.
Buildings	Work in partnership with large energy users in the non-domestic sectors including health and education sectors to share best practice in energy reduction

Sector	Immediate Priority
Industry	Support identified large emitters with carbon reduction activities.
Industry	Undertake a detailed review or business activity in the county to identify energy-intensive industrial users.
Industry	Appraise the potential for low carbon industrial zones (LCIZ)
Transport	Explore ways to promote the uptake of EVs e.g. via reduced or free parking, permissive use of bus lanes etc.
Transport	Work with partners to plan and develop charging infrastructure across the county in key public and work places and include plans to address the tourism sector
Transport	Seek to shift trips from private car to lower carbon alternatives such as walking, cycling, car clubs and public transport.
Transport	Work with bodies such as the Freight Transport Association and the Road Haulage Association as well as with major hauliers and haulage clients directly to reduce emissions from freight movement, for example by planning consolidation centres.
Transport	Work with bus providers to consider the business case for replacing the existing bus fleet with zero carbon variants e.g. by following London's example.
Agriculture land use & forestry	Use County farms to pioneer changes in on farm practises to reduce methane and nitrous oxide intensity of crops and livestock farming and work with landowners and NFU to roll out countywide. Promote the adoption of low-impact diets.
Agriculture land use & forestry	Support the development of on-farm bio-methane collection and use with a focus on supplying bio-methane for farm machinery. Deliver on County farms together with electrification and building energy efficiency measures.
Agriculture land use & forestry	Use the planning system to identify preferred areas for tree planting and peatland restoration which match the required scale, adopt planning policies which prioritise afforestation and peatland restoration and apply on county owned land.
Waste	Check status of all legacy and recent landfill sites and assess opportunities for additional methane capture and energy production.
Waste	Drive forward increased separation of food/biodegradable waste collection with waste directed to local Anaerobic Digestion facilities.
Waste	Develop local promotion campaigns with the aim of reducing waste generation (especially food waste) with a 25% reduction by 2025 and to increase household/municipal recycling rates (especially plastics) from the current 56% to 65% to reduce disposal emissions from EfW.
Waste	Increase heat offtake from EfW plants to improve efficiency and reducing net emissions.
Waste	Identify processing gaps in wider South West region waste recycling and treatment facilities and make appropriate provision for particular materials where gaps are identified.
Waste	Develop a much better understanding of commercial waste generation and treatment in the county to enable monitoring and regulation with the aim of reducing waste volumes and increasing recycling.

Sector	Immediate Priority
Waste	Liaise with South West Water to achieve a reduction in methane and N_2O emissions of least 20% by 2030.
F-gases	Pro-actively enforce Air Conditioning inspections for all systems with an effective rated output in excess of 12 kW.
GHG Removal	Identify potential sites where trial of GHG removal technologies may be viable and seek to capture central government funds in partnership with technology providers to host prototypes.

CONTENTS

1. Introduction

Devon County Council (DCC) declared a climate emergency in February 2019, pledging to facilitate the reduction of Devon's carbon emissions to net-zero by 2050 at the latest. Districts within Devon have also declared climate emergencies and aim to become carbon neutral at earlier dates (2025, 2030 and 2040). For the purpose of this study carbon neutral is interpreted as achieving net zero greenhouse gas (GHG) emissions in line with the Committee on Climate Change's Net Zero report (see below). The Centre for Energy and the Environment (CEE) at the University of Exeter was commissioned by DCC to provide quantified projections of carbon emissions for the administrative area of Devon[1] following a "business as usual" path, and with the national policies (either in place, or required) to achieve Net Zero. These projections were based on meeting Net Zero by 2050 (the currently proposed national timeline), but given the aims of districts within Devon to accelerate this timetable further work was undertaken to assess how Devon may be able to meet the target by 2030 and identify some of the challenges this will involve.

2. Projecting Emissions to 2050

Greenhouse gas (GHG) emission projections for Devon start from a baseline GHG inventory for the County. This is an inventory of emissions that arise within its geographic boundary i.e. they are accounted for on a *production* basis. For example, whilst emissions arise from the Industrial sector in producing goods that are traded beyond Devon's borders, the emissions from all of the production are allocated to Devon. Similarly, any goods that are imported into Devon will result in emissions in manufacture that occur elsewhere and that are not counted in Devon's footprint. It is estimated by the Committee on Climate Change[3] in its 2018 Progress Report to Parliament that in the UK the average GHG emissions are 8 tCO_2e/person if measured on a *production* basis or 13 tCO_2e/person if measured on a *consumption* basis.

Initial analysis (see Appendix A) provides historic GHG emissions from 2008 to the most recently published data (2016) broken down by sector and greenhouse gas, together with total emissions expressed in tonnes of carbon dioxide equivalent (tCO_2e)[2].

In order to project emissions from 2016 forward to 2050, two key documents from the Committee on Climate Change[3] (CCC) were utilised:

- 2018 Progress Report to Parliament (referred to as the Progress Report)[4]
- Net Zero: The UK's contribution to stopping global warming (referred to as the Net Zero report)[5].

Both of these documents assess and project GHG emissions by sector in the UK. The Progress Report is the latest in an annual series of reports that charts progress in each sector over recent years,

[1] In this report Devon refers to the DCC administrative area (i.e. not including Plymouth and Torbay)
[2] For methodology see "Greenhouse Gas Inventories for SWEEG: Methodology Paper", CEE, July 2019
[3] The CCC is a statutory body set up under the 2008 Climate Change Act whose purpose is to advise the UK Government and Devolved Administrations on emissions targets and report to Parliament on progress made in reducing greenhouse gas emissions and preparing for climate change
[4] The CCC's 2019 Report to Parliament was released on 10 July 2019. The format of the 2019 report does not provide the sectorial analysis included in the 2018 report so the 2018 report has been used in this analysis.
[5] The CCC's "Net Zero, The UK's contribution ot stopping global warming" was published in May 2019 together with the Net Zero Technical report which is used extensively in these projections.

and analyses the potential of existing and required policy to meet the requirements of future carbon budget periods[6]. The 2018 Progress Report runs to 2032, the end of the fifth carbon budget. The Net Zero report considers what policies and action is necessary by 2050 in order to achieve Net Zero GHG emissions.

In this work national emissions reduction projections from the two documents have been apportioned to the equivalent sectors in Devon. For example, if it were assumed nationally that by a certain year transport emissions would halve due to a series of government policies, then it was assumed transport emissions in Devon would also halve. Exceptions to this approach occurred in some areas, for example in the Industry sector much of the decarbonisation is associated with certain types of heavy industry that are not found in Devon, so the trajectory for the Industry sector in Devon discounted savings from those sectors. In other areas however, no specific considerations for Devon were made.

This is therefore a simplified approach, and differs from one where a series of known policies are individually modelled for Devon. Whilst this might be possible on a policy-by-policy basis, the approach taken has the advantage of being based on the latest assessment of government policies and calculated costs and savings. Many of the required decarbonisation measures are only really feasible when tackled at a national scale. A full "bottom-up" calculation of the impact of individual policies would require in depth detail on the uptake, impact and costs of each policy, which were not available. However, while much of the policy in the CCC reports is national, in many cases there will be a strong requirement for local actors to effectively engage at the delivery stage e.g. home insulation programmes, electric vehicle infrastructure, diet change etc.

In general, the sectors in Devon's GHG inventory, the Progress Report and the Net Zero report align well. The exceptions are the transport sector and the agriculture and land use sectors.

In the case of transport the Progress Report combines all transport modes (including aviation and shipping) into one sector, whereas for the other two, aviation and shipping are segregated. As the savings associated with each policy in the Progress Report could not be isolated it was necessary to consider transport as a single sector, inclusive of aviation and shipping. An analysis of Devon's historic aviation and shipping emissions[7] concluded that, due to the incomplete nature of the emissions data and high levels of uncertainty, aviation and shipping should not be included. The Transport sector therefore includes only inland surface transport.

The agriculture and land use change sectors are often combined, so for the calculations undertaken here they were also combined.

The Progress Report projects GHG emissions across the UK economy based on existing policies that are in place to deliver GHG reduction to 2032. For each of these policies, the CCC used three criteria to assess those policies:

- Design and implementation: Whether the policy tackles the right barriers, has the right track record of delivery, and avoids risks associated with a lack of coherence or political support.

[6] Carbon budget periods are periods of 5 years that commenced in 2008 when the UK Climate Change Act came into force.
[7] "Greenhouse Gas Inventories for SWEEG: Methodology Paper", CEE, July 2019

- Incentives: Whether there are the right monetary or regulatory incentives in place to deliver the policy.
- Funding: Whether there is sufficient funding now and in the future to deliver the policy.

If all three criteria are met, then the policy is deemed to be low risk. Where any one of the criteria is failed then the policy is deemed to be medium risk. At a national level, two-thirds of potential emission reduction in 2032 is at this risk of under-delivery. Proposals which are not specified in sufficient detail to be classified as policies are labelled as high risk intentions. At a national level, a quarter of potential emission reduction in 2032 is at this high level of risk. In addition, in order to meet the CCC's least-cost path for decarbonisation, additional potential policies have been identified to bridge any gap between policies in place or intended and the CCC's least cost pathway. Delivering this "policy gap" will be required both to provide contingency for meeting carbon budgets, and to decarbonise further than the Climate Change Act's 80% reduction requirement (i.e. to Net Zero). These policies from both CCC reports were assigned to each sector within Devon to enable GHG trajectories within each of these sectors to be developed to 2032 (with policy risks) and then 2050.

The Net Zero report is used for projections from 2032 to 2050. The Net Zero Core Scenario addresses the 80% GHG reduction required by 2050 under the Climate Change Act. The Further Ambition Scenario considers more challenging more expensive options which nationally archive 96% emission reduction by 2050. Achieving the remaining 4% to deliver Net Zero requires further Speculative Options which have high costs, technology challenges or low levels of public acceptability.

Projections from the two CCC reports are combined and apportioned to Devon. An example of the output that was produced for each sector is shown in Figure 1, together with an explanation of how the graph is intended to be interpreted.

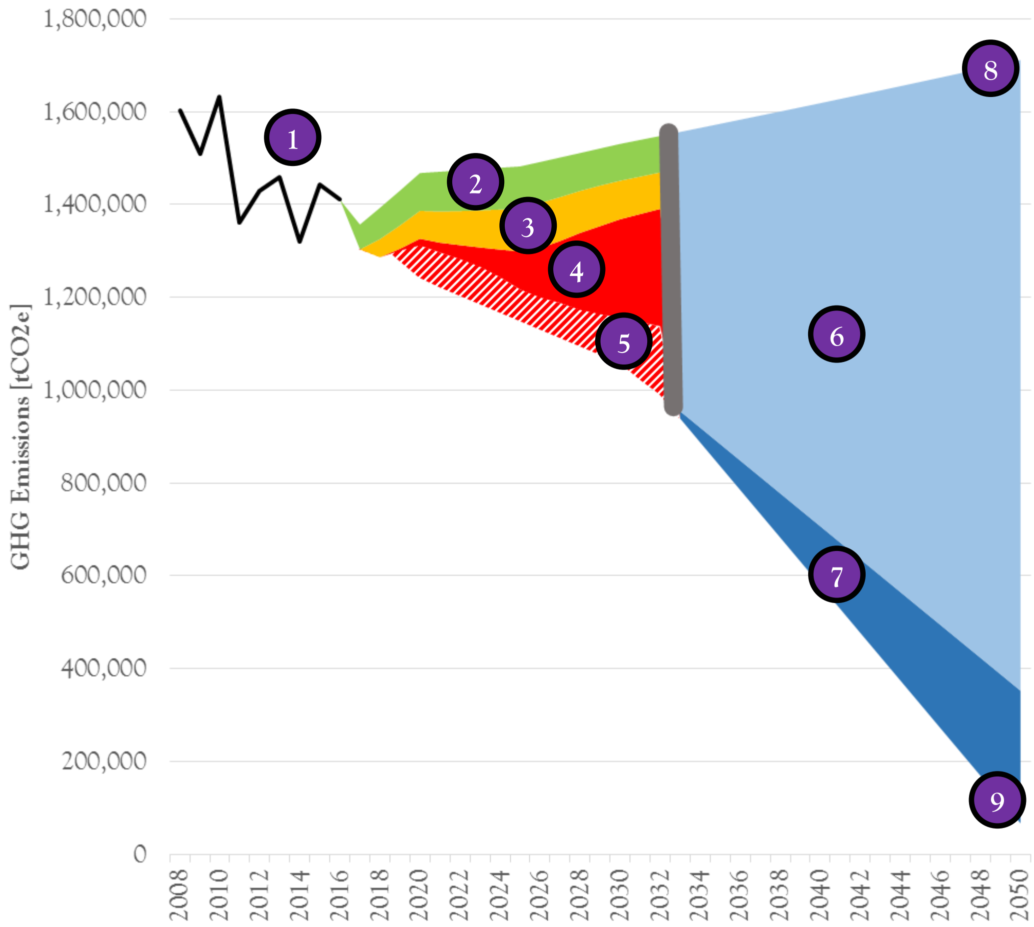


Figure 1: GHG Emission trajectory for a sector (buildings) as used within this report. Each part of the graph means the following: 1 = historic emissions; 2 = savings to 2032 from low risk policies; 3 = savings to 2032 from medium risk policies; 4 = savings to 2032 from high risk intentions; 5 = savings to 2032 that would need to be delivered to meet the CCC's least-cost decarbonisation path but where there is currently no policy; 6 = savings from 2032 to 2050 from the Net Zero report Core Scenario; 7 = savings from 2032 to 2050 from the Net Zero report Further Ambition Scenario; 8 = emissions in 2050 in the absence of any policy (business as usual); 9 = emissions in 2050 with all identified policy delivered.

3. Devon's GHG Emissions

Devon's 2016 GHG emissions (excluding aviation and shipping[8]) were 6,628 ktCO_2e. The split of emissions is shown in in

Figure 3.

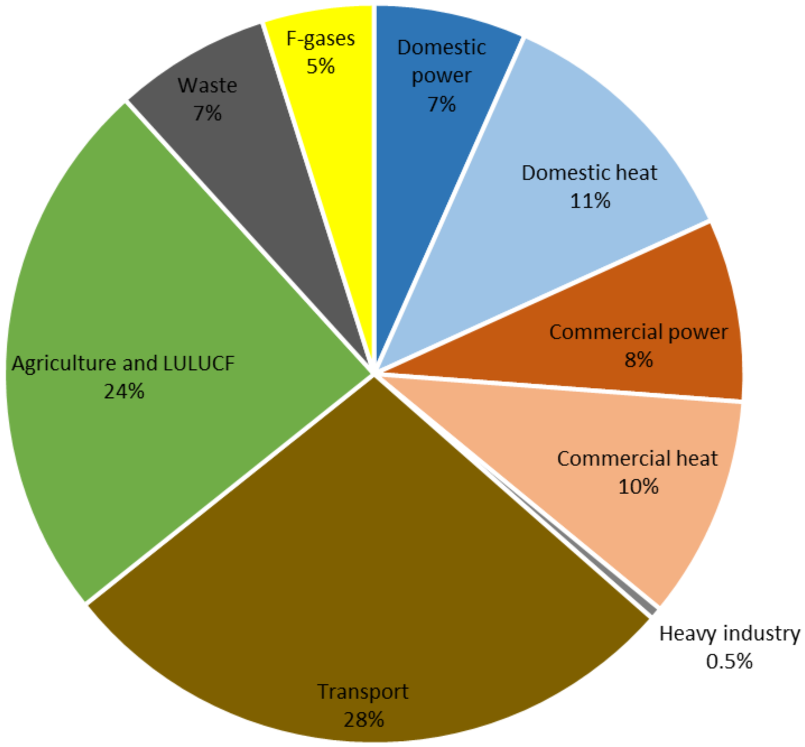


Figure 2: The make-up of Devon's 2016 GHG emissions

Current and projected GHG emissions in the administrative area of Devon are shown in

Figure 3 (values for 2016, 2032 and 2050 are provided in Appendix B). 2016 emissions (6,628 ktCO_2e), in the absence of any carbon reduction policy, would rise to 7,645 ktCO_2e in 2050 (including an allowance for population growth[9]). Low, medium and high risk policies to the end of the 5th Carbon Budget in 2032 would see emissions fall to 4,485 ktCO_2e (or 3,791 ktCO_2e if policy

8 An analysis of Devon's historic aviation and shipping emissions concluded that due to the incomplete nature of the emissions data and high levels of uncertainty aviation and shipping should not be included. Estimates of aviation emissions for flights out of Exeter Airport suggested that aviation emissions from this source were some 9% of transport emissions and 3% of total emissions. Estimated emissions from fishing vessels were 1% of transport emissions and 0.3% of total emissions.

9 The projected BAU carbon emissions are based on nationally projected changes to emissions which include the impacts of population change (growth). Analysis of population projections show that by 2030 the UK population is set to increase at a slightly faster rate than the Devon population (the ratio of the two populations in 2030 indexed to 2019 is 98%) and so the nationally projected BAU carbon emissions were taken forward as being reasonable in the context of the uncertainties within the approach adopted for this study.

to meet the "policy gap" to and achieve the CCC's least-cost decarbonisation path was to be identified) compared to the 6,804 ktCO_2e under business as usual. Of this carbon reduction, 12% is from "low risk" policy, 38% from "medium risk" policy and 27% from "high risk" policy. The final 23% is the current policy gap. Projecting to 2050, the CCC's Core scenario would see emissions drop to 2,771 ktCO_2e, and delivering the measures in the Further Ambition scenario would see a further fall to 1,720 ktCO_2e. The inclusion of GHG removal technologies and offsetting would be required to achieve net zero emissions.

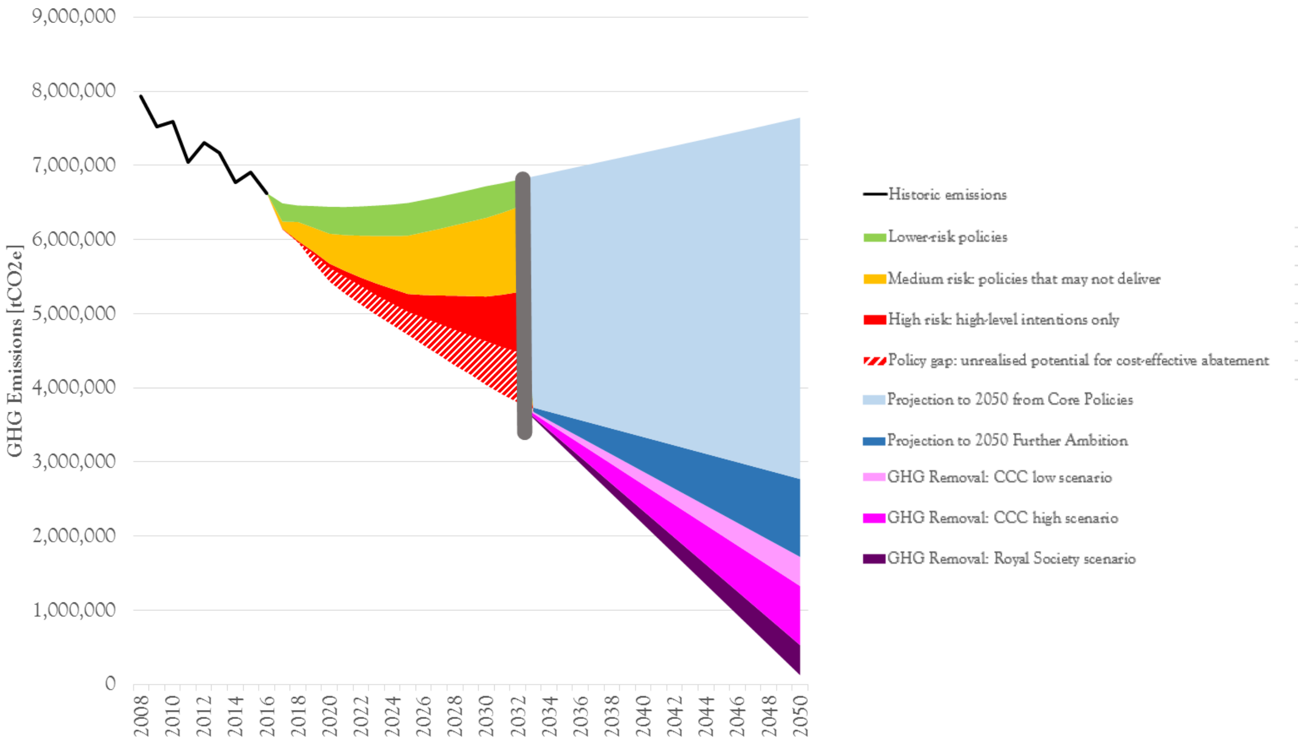


Figure 3: Projected GHG emissions in Devon including policies and their risk levels to 2032, and the CCC Net Zero scenarios to 2050, including GHG removal (purple shades)

Projected emissions broken down by sector are shown in Figure 4. This shows the scale and proportions of carbon reduction from business as usual that are associated with measures in each sector from Core scenario policies (dark shades) and the additional savings associated with the Further Ambition scenario (light shades). At a national level, the Core scenario results in 77% emission reduction, and the Further Ambition scenario a 96% reduction. The largest reductions in emissions are planned to come from the Power, Buildings and Transport sectors, with a significant amount of further abatement required from GHG removal technologies.

The underlying policies and assumptions driving these trajectories are discussed in the next sections.

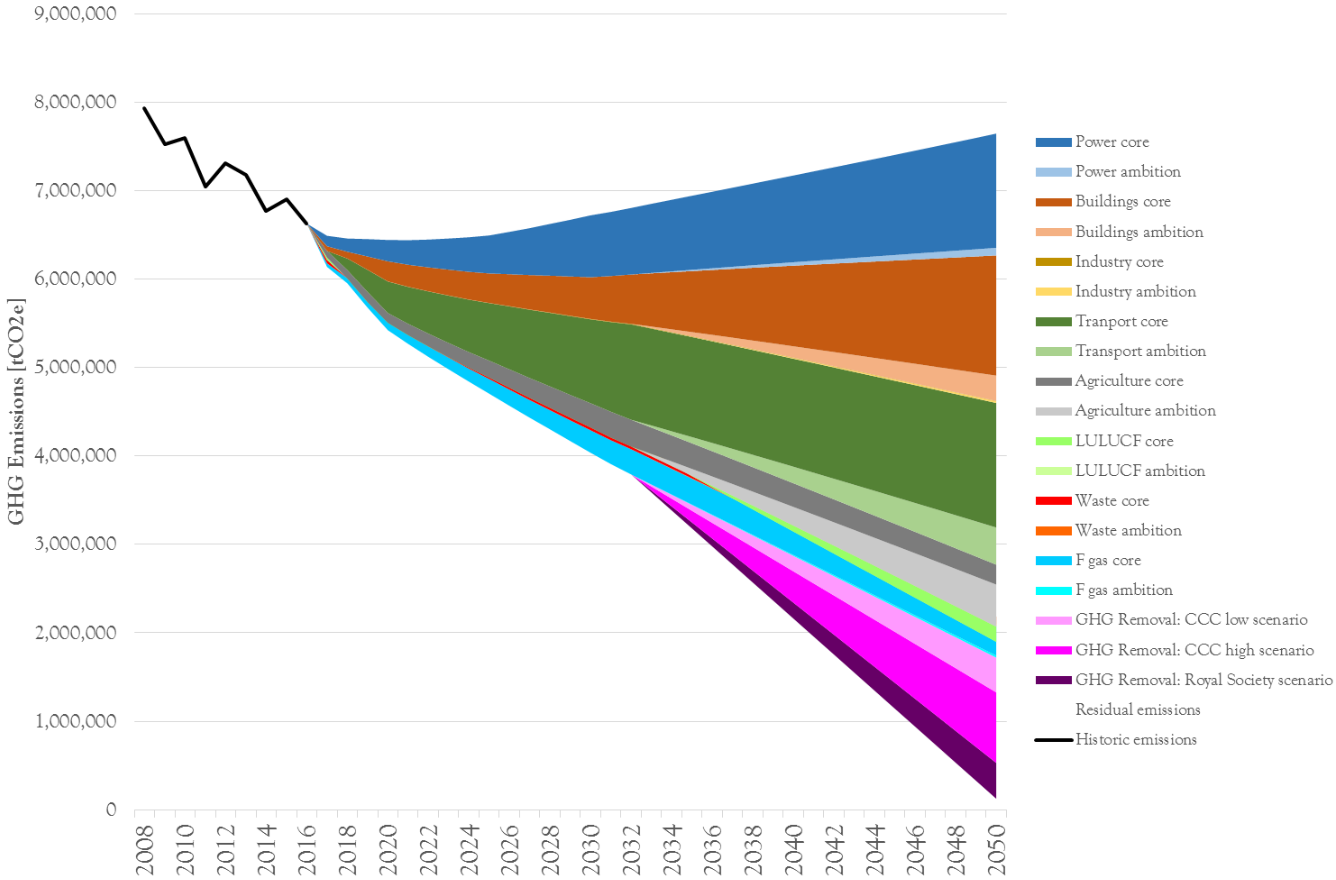


Figure 4: GHG trajectories in Devon to 2050 arranged by sector with each sector split into the Core (dark shades) and Further Ambition (light shades) scenarios..

4. POWER

Projected GHG emissions for the Power sector (i.e. electricity consumed by all sectors in Devon) are shown in Figure 5 (values for 2016, 2032 and 2050 are provided in Appendix A).

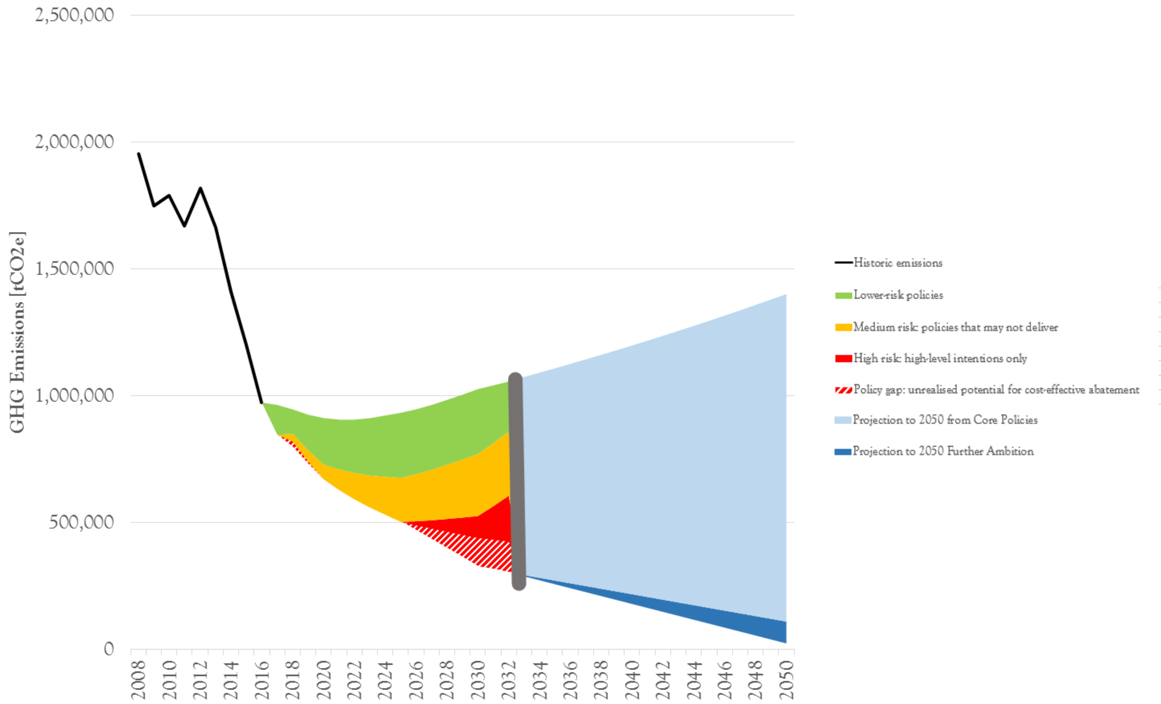


Figure 5: Projected GHG emissions in the Devon's Power sector to 2050 as a result of national policy (interpretation of graph is described in caption to Figure 1)

Power, distributed through the national and regional electricity networks is the sector of the UK economy which has decarbonised most rapidly with emissions in 2017 (72 $MtCO_2e$) falling 64% from 1990 levels (203$MtCO_2e$) and 54% from 2010 levels (157$MtCO_2e$).

The resulting national grid emission factor has fallen by 47% from 499 gCO_2/kWh in 2010 to 263 gCO_2/kWh in 2017. The use of a national emissions factor for local Scope 2 CO_2 emissions calculations precludes considering carbon emissions from power at a local level by, for example, considering renewable electricity generation in Devon as Devon's CO_2 reduction. All renewable energy generation in the UK contributes to national emissions reduction, so while Devon should do everything possible to deliver renewable electricity generation, the emission reduction benefits will be shared across the country. The national strategy for decarbonising the power sector is shown in Figure 6.

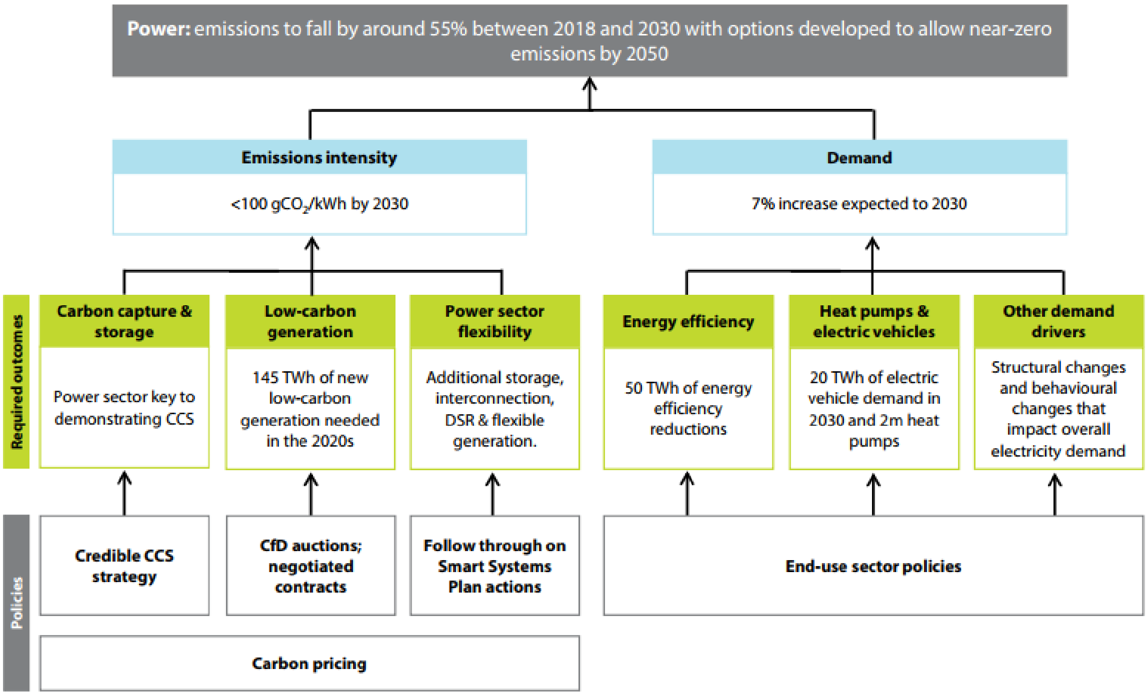


Figure 6: CCC indicators for monitoring progress in the UK power sector to 2030[10]

The CCC highlights the potential growth in national demand for electricity to 2050 (Figure 7).

New uses for electricity in vehicles and buildings (See Sections 7 and 5 respectively) and for hydrogen production double the demand for power from 300TWh in 2017 to 600TWh in 2050. Other potential for further electrification could conceivably more than quadruple current demand to over 1,300TWh.

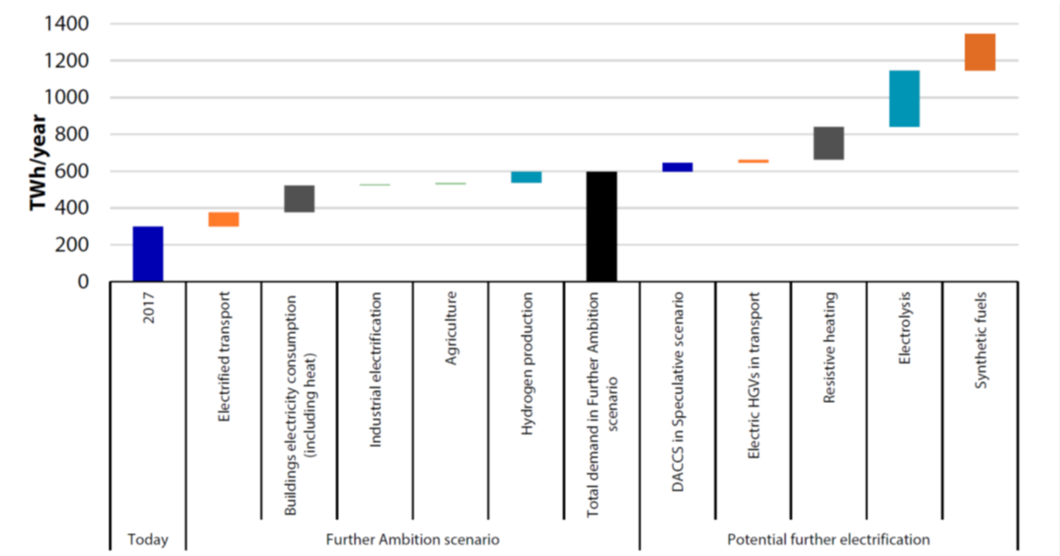


Figure 7: Potential new UK electricity demands from 2017 to 2050[11] (source CCC Net Zero technical report)

[10] Figure 2.5 of the CCC 2018 progress report. Abbreviations: CCS carbon capture and storage, DSR demand side response, CfD contract for difference.

4.1 Low Risk Policy to 2032

Low risk policies are responsible for 26% of projected carbon reduction to 2032. The CCC identifies policy on renewables incentives, in particular contracted contracts for difference (CfD) auctions (which should provide around 130 TWh of generation from renewables nationally by 2020/21), and the switching away from coal fired generation, which is to be banned by 2025, as current low risk policies.

4.2 Medium Risk Policy to 2032

Medium risk policies are responsible for 34% of projected carbon reduction to 2032. The CCC has identified these as:

- The Hinckley C nuclear power station due the scale and complexity of the project
- Further CfD auctions
- Power system flexibility

4.3 High Risk Policy to 2032

High risk policies are responsible for 24% of projected carbon reduction to 2032. The CCC has identified these risks as the potential impact of:

- Delay or cancellation of other planned nuclear plants after Hinckley C (which would reduce low carbon electricity generation)
- Reduction of low carbon electricity imports from the continent |(e.g. less nuclear electricity from France)

4.4 Policy Gap Risk Policy to 2032

Policy gaps are responsible for 16% of projected carbon reduction to 2032. The CCC has identified these as:

- Policy on carbon capture and storage (CCS), which is essential for the full decarbonisation of the power sector, is the largest gap.
- A pathway for a subsidy free route to market for renewable energy
- Contingency plans for alternative technologies to replace new nuclear or power import risk.

4.5 Core Scenario to 2050

The CCC has identified the following core options that would be required to continue the 80% GHG reduction trajectory nationally:

- Expansion of renewables, nuclear power and CCS to produce 95% of the UKs electricity requiring significant new renewable generation and a fleet of gas fired power stations to provide stability to the power generation system of which half will need to be decarbonised through CCS.
- Hydrogen in the Core scenario is restricted to niche, localised applications, requiring limited additional hydrogen transportation or storage infrastructure.

[11] Figure 2.3 of the CCC Net Zero Technical report. Abbreviations: DACCS direct air carbon capture and storage, HGV heavy goods vehicle

4.6 Further Ambition to 2050

Emissions from the power sector are reduced to close to zero in the Further Ambition scenario while meeting increased electricity demand. The CCC has identified the following further ambition options that would be required to continue the 80% GHG reduction trajectory nationally:

- Hydrogen use in the Further Ambition scenario is more widespread.
- Gas distribution networks are used to transport hydrogen to buildings, power generation and industrial facilities and refuelling stations and some new hydrogen transmission infrastructure is also built.
- Decarbonising power plant through hydrogen fuel may be more effective than building dedicated gas CCS power plants.
- New nuclear
- Biomass energy with carbon capture and storage (BECCS)In this scenario all gas generation has CCS (Figure 8)[12]

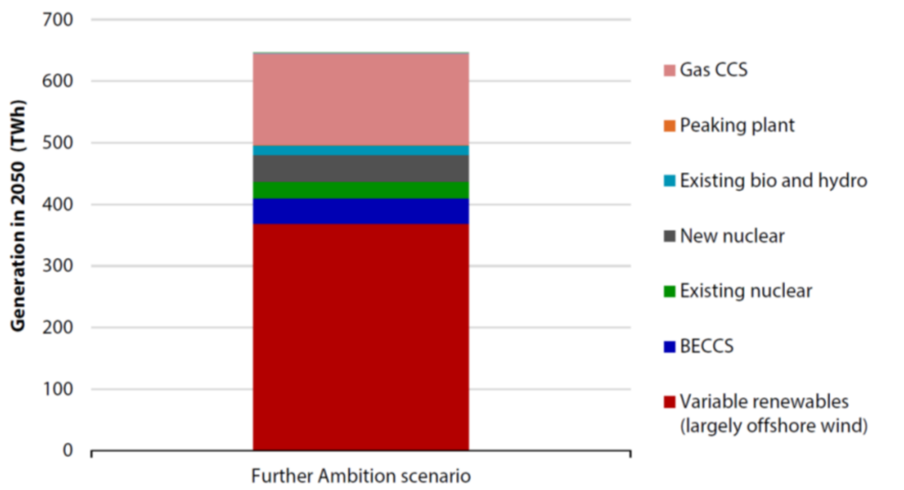


Figure 8: Illustrative generation mix for a UK low carbon power system in 2050[13]

Figure 9 shows the potential national uses and sources of hydrogen in 2050.

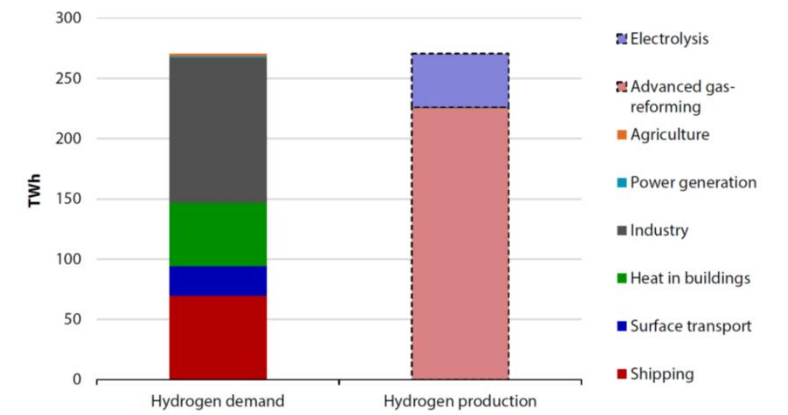


Figure 9: Use and production of hydrogen in the UK Further Ambition scenario[14] (Source Net Zero Technical report)

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[12] Peaking plant 0.6TWh (not visible on Figure 7)

[13] Figure 2.5 CCC Net Zero Technical report. Abbreviations; CCS carbon capture and storage, BECCS biomass energy with carbon capture and storage

4.7 Opportunities for Accelerated Delivery in Devon

The 905 MW Langage gas fired power station is the only large fossil fuel power generator in Devon. It is a new highly efficient combined cycle gas turbine plant and is therefore likely to operate until the end of its design life. However, capture and storage of CO_2 emissions in the vicinity the site is likely to be more expensive than elsewhere in the UK and Langage is therefore likely to be displaced by other gas CCS plant which has easier aces to long term CO_2 storage.

Exeter has two peaking power plants the aging 50MW OCGT in Marsh Barton and some smaller diesel generation facilities[15] which provide support to the electricity grid at peak times. These facilities are likely to be displaced as demand side response and battery technologies emerge.

Renewable and waste generated energy generated in Devon is summarised in Table 1. Whilst renewable electricity is only of interest in this section, heat technologies are included for interest/completeness.

Table 1: Renewable and waste generated energy in Devon in 2017/18[16]

Technology	Installations	Electricity capacity MWe	Heat capacity MWth	Total capacity MW	Electricity generation GWh	Heat generation GWh	Total generation GWh
Anaerobic digestion	35	12	7	19	76	15	91
Biomass	1,397	6	112	118	30	352	382
Energy from waste	1	13		13	36		36
Heat pumps	2,614		27	27		45	45
Hydro	65	9		9	17		17
Landfill gas	4	15		15	71		71
Onshore wind	248	145		145	329		329
Sewage gas	4	1	2	3	6	8	14
Solar PV – ground	193	418		418	403		403
Solar PV – roof	23,834	121		121	117		117
Solar thermal	1,079		4	4		3	3
Total	**29,474**	**740**	**151**	**891**	**1,085**	**422**	**1,507**

The total 1,085GWh of electricity generated represents 32% of Devon's 2017 electricity consumption (3,361GWh)[17].

Devon wide renewable energy resource potential has not been assessed since 2011[18] when earlier resource assessment work in 2005, 2006 and 2010 was summarised. PV and wind were identified as the dominant technologies. However, PV (419MW resource) was assumed to be constrained to roof

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[14] Figure 2.8 CCC Net Zero Technical report

[15] Exeter RP Limited was awarded 4.5MW and 6.4MW capacity in the 2017/18 capacity auction and Peak Gen Exeter in an entry in the NAEI inventory

[16] Source: "Renewable energy progress report for Devon 2018 to 2018" Regen, August 2019. Electricity and heat generation for AD, biomass and sewage gas disaggregated by splitting the shortfall between electricity only technologies (1,056 GWh) and total provided (1,085 GWh) using relative electrical capacity of each technology.

[17] https://www.gov.uk/government/collections/sub-national-electriCounty-consumption-data

[18] "A review of renewable energy resource assessment and targets for Devon" CEE 2011

mounted arrays. A range of "constrained"[19] wind resource was identified from 559MW to 1,993 MW.

More recent resource assessment for the Greater Exeter Strategic Plan (GESP) area, which includes East Devon, Exeter, Teignbridge and Mid Devon identified 212 MW of unconstrained wind capacity and 3,729 MW of unconstrained PV capacity[20]. Simply pro-rating theses figure to the whole of Devon[21] gives around 600 MW of wind and 10 GW of PV. Applying the same load factors as in the table above gives generation of 1,300 GWh from wind and 9,600 GWh from PV, a total of 10,900 GWh or ten times current generation. On this basis Devon has the resources to become a net electricity exporter.

The land area required for energy production from a range of renewable energy technologies in summarised in Table 2.

Table 2: Calculated factors for annual energy per hectare (source CEE[22])

Technology	Annual energy per hectare (MWh)
Solar thermal (including storage)	1,523
Solar PV	389
Woodfuel (from forestry)	2.5
Biogas (from maize)	60
Wind	519

On this basis the land required for 1,300 GWh of wind and 9,600 GWh of PV is 2,505 ha and 24,678ha respectively or 0.4% and 3.7% of Devon's land area.

[19] In the high case constraints for wind resource included adequate wind speed, buffers around buildings. The lower case adds the constraints of practical access to sites, landowner willingness for development to go ahead, political will, the time to complete planning procedures and the distance to nearest electricity grid connection.
[20] "Low Carbon and Climate Change Evidence Base for the Greater Exeter Strategic Plan" CEE, 2018
[21] From ONS Table P04UK 2011 Census: Population density, local authorities in the United Kingdom the areas of Devon and the GESP area are 656,422 ha and 244,818 ha respectively, a ratio of 2.6813.
[22] "Land Requirements for Network-based Zero Carbon Energy Solutions in East Devon", CEE, 2019

5. BUILDINGS

GHG emissions arise from buildings (of all types including domestic, commercial, public sector etc.) both from the direct combustion of fossil fuels (mainly for space heating), and from the use of electricity to power lighting and equipment. The consumption of electricity is covered in Section 4 (Power) and so this section covers only direct emissions. The projected trajectory for GHG emissions from buildings is shown in Figure 10 (values for 2016, 2032 and 2050 are provided in Appendix A).

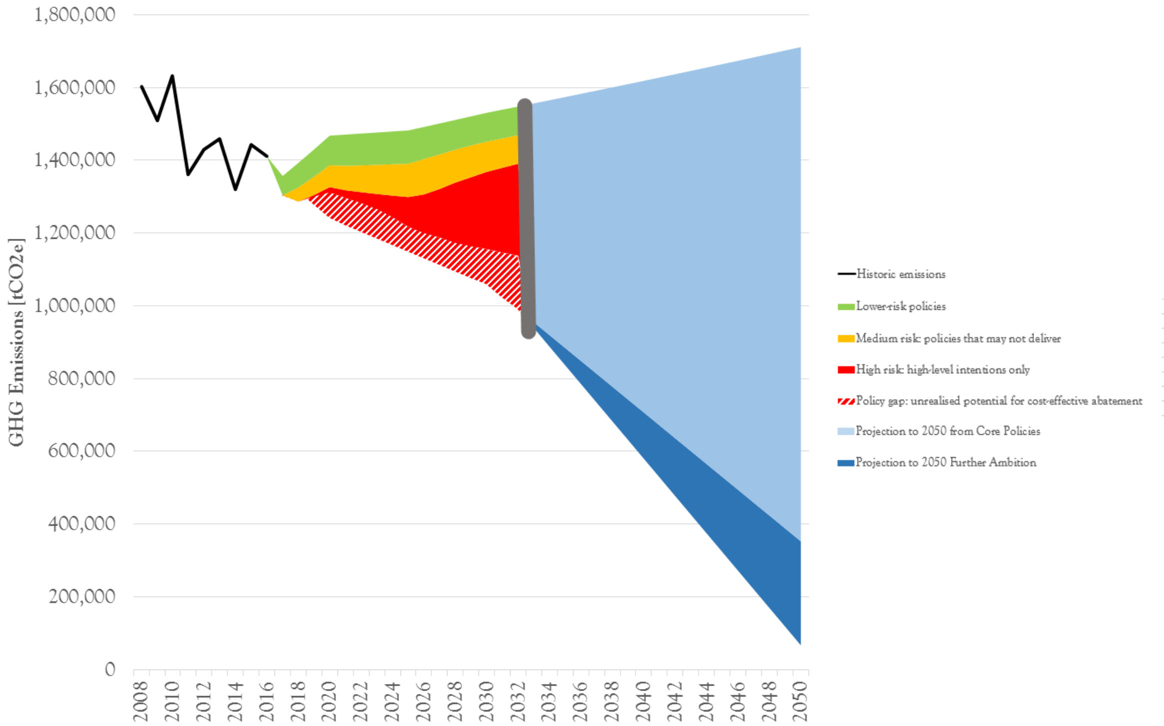

Figure 10: Projected GHG emissions in Devon's Buildings sector to 2050 as a result of national policy (interpretation of graph is described in caption to Figure 1)

The majority of emissions associated with the Buildings sector are due to the requirement for space heating (emissions associated with electricity consumption are covered in the Power sector). Reducing emissions arising from space heating relies on both reducing demand through efficiency measures, and supplying any required heat using low-carbon technologies. The approach will differ depending on whether the building is a new build or existing, and whether it is on the gas grid or not (26% of Devon's homes are off-gas compared to 16% nationally). The different approaches are highlighted in Figure 11 which identifies that for existing buildings in addition to improving the building fabric, low-regret measures for heating technology include heat pumps[23] in off-gas properties and heat networks in on-gas locations. A significant gap has been identified for on-gas properties where heat networks are not viable, with a potential technological solution being hybrid-heat pumps (potentially in conjunction with hydrogen).

In order to decarbonise emissions due to space heating in the Buildings sector, the CCC scenarios (discussed below) assume a high take-up of efficiency measures (including retrofit), and the full uptake of a low-carbon heating technology in all dwellings. This includes those that are space constrained where innovative heat pump solutions are assumed to become available, and

[23] Reference to "heat pumps" in buildings include individual air source and ground source heat pumps and communal and hybrid heat pumps of both source types

heritage buildings which would be heated by (expensive) direct electric heating. For Devon, ultimately this will mean implementing all "easy" retrofit measure (lofts and cavity walls), insulating most (over 70%) of solid walls, and ensuring all dwellings are heated using a low-carbon (including direct electric heating) technology.

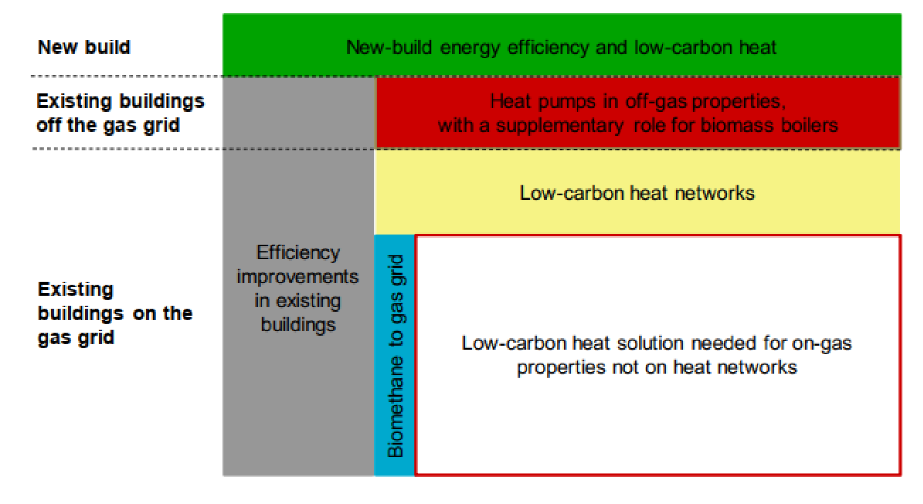

Figure 11: Low-regret measures and remaining challenges for existing buildings on the UK gas grid[24]

The CCC's least cost pathway implies a national reduction in emissions of 20% between 2016 and 2030 (Figure 12). This is envisaged to be achieved through a combination of demand reduction, and supply of low-carbon heat.

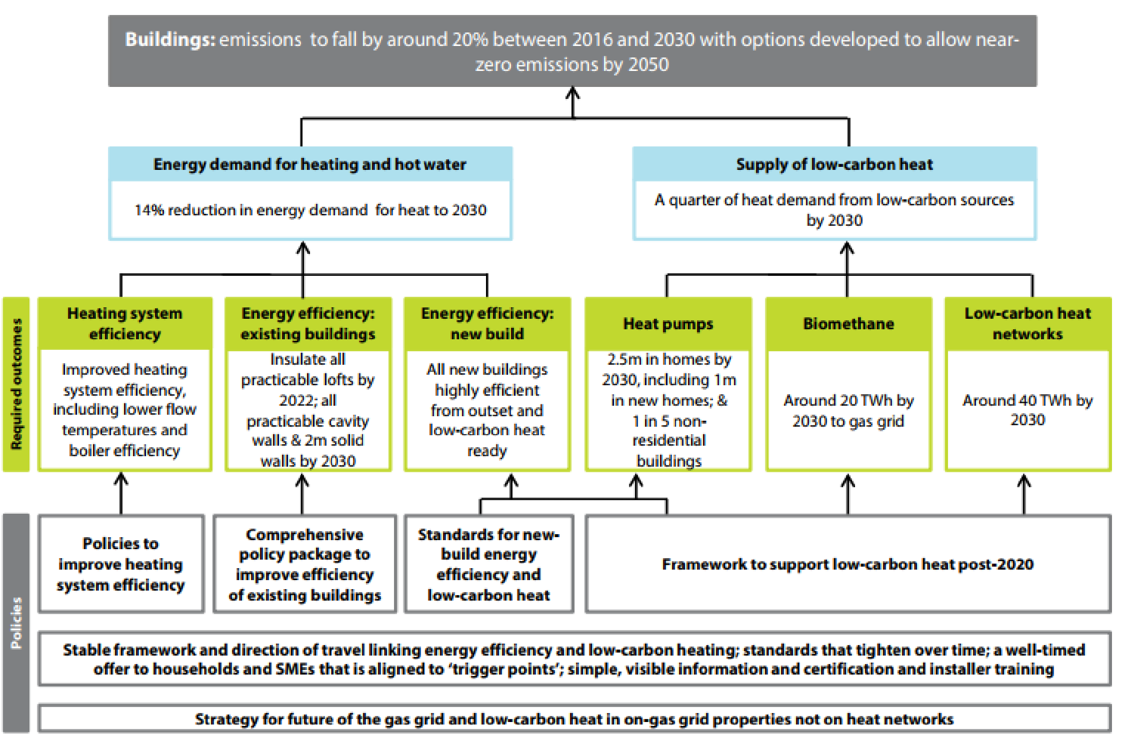

Figure 12: CCC indicators for UK buildings [25]

[24] CCC 2016, Next steps for UK Heat Policy

For Devon, this implies:

- Improvements to existing heating systems
- The insulation of all practicable lofts by 2022 (the end date for the Government's proposed third Energy Company Obligation programme) and all cavity walls by 2030
- The insulation of 24,100 solid walls by 2030.[26]
- All new buildings to be highly efficient from the offset and low-carbon heat ready
- 10,400 heat pumps (which will run off decarbonised grid electricity) in new homes by 2032[27]
- 23,100 heat pumps in existing homes by 2032[28] For context, apportioning the national deployment rate by population results in 18,100 heat pumps in existing homes by 2030.
- 8,700 heat pumps in non-residential buildings[29]
- 319 GWh bio-methane injected to the gas grid to account for Devon's share[30] of the national target by 2030[31]
- 637 GWh heat from low-carbon heat networks to account for Devon's share[32] of the national target by 2030.

5.1 Low Risk Policy to 2032

Low risk policies are responsible for 14% of projected carbon reduction to 2032. The CCC has identified these as:

- Energy efficiency:
    - Extending support for home efficiency improvements out to 2028 at the current level of Energy Company Obligation (ECO) funding.
    - A new energy and carbon reporting framework for the commercial sector.
- New Buildings:
    - Ensuring new buildings are future-proofed for low-carbon heat by 2020.
    - In May 2018 a 'Grand Challenge' mission was announced to at least halve the energy use of new buildings by 2030, including making sure every new building in Britain uses clean heating.
- Low-carbon heat:
    - Increased refinement of the Heat Networks Investment Project (HNIP).
    - Refocused regulations around the Renewable Heat Incentive (RHI)[33].

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[25] Figure 3.3 of the CCC 2018 Progress Report

[26] Based on apportioning 2 million solid wall installations on fraction of solid wall properties in Devon compared to UK total

[27] Based on analysis of uptake rates from WPD and Regen 2018, Distribution Future Energy Scenarios: A Generation and Demand Study – Technology Growth Scenarios to 2032. This establishes four pathways, of which the "Slow Progression" perhaps best aligns to the situation of the CCC Progress report. The implied installation rates in Devon in 2032 (taken as cumulative installations from 2019 to 2032) in new dwellings for the four pathways are: Steady State 1,292; Slow Progression 10,447; Consumer Power 3,473; Two degrees 15,671.

[28] Based on analysis of uptake rates from WPD and Regen 2018, Distribution Future Energy Scenarios: A Generation and Demand Study – Technology Growth Scenarios to 2032. This establishes four pathways, of which the "Slow Progression" perhaps best aligns to the situation of the CCC Progress report. The implied installation rates in Devon in 2032 in existing dwellings for the four pathways are: Steady State 9,555; Slow Progression 23,130; Consumer Power 24360; Two degrees 45,448.

[29] Estimated based on number of local business units from Nomis national statistics (43,570 total)

[30] Note: As with the power sector, the gas grid can be considered to be national infrastructure and so where bio-methane is produced is not relevant

[31] Based on pro-rating the national installation rate to Devon based on direct emissions in 2016

[32] If apportioned based on ratio of emissions from direct combustion of fuels in buildings in Devon compared to nationally.

    - New standards introduced for domestic boiler installations.

5.2 Medium Risk Policy to 2032

Medium risk policies are responsible for 14% of projected carbon reduction to 2032. The CCC has identified these as:

- Building-scale low-carbon heat options in existing buildings to 2021: The refocussed RHI still requires action to address upfront cost barriers and raising awareness.
- Heat networks to 2021: There are risks that the focus of HNIP remains around gas CHP rather than low-carbon sources such as energy from wastes, heat pumps etc..
- Hydrogen: Funding has been announced though a governance framework is required to progress the hydrogen agenda.
- Residential energy efficiency, low income: Risks around the delivery of ECO3.
- Non-residential energy efficiency: Whilst there is a commitment to improve non-residential energy efficiency by 20% there is no policy to drive this.

5.3 High Risk Policy to 2032

High risk policies are responsible for 45% of projected carbon reduction to 2032. The CCC has identified these as:

- Building-scale low-carbon heat options in existing buildings from 2021: There is an ambition to phase out high-carbon heating and to bring forward more low-carbon heat networks. However, there is no firm policy to deliver this post-2021.
- Standards for new-build to drive low-carbon heat and energy efficiency: A mission statement has been announced though policy development is required for delivery.
- Residential energy efficiency, able-to-pay: Policy is required for able-to-pay sectors and social housing sectors, and greater ambition is required for the private rented sector.

5.4 Policy Gap Risk Policy to 2032

Policy gaps are responsible for 27% of projected carbon reduction to 2032. The CCC has identified these as:

- A stable framework and direction of travel for improving energy and carbon efficiency, focused on real-world performance. Government needs to:
    - Develop policies to achieve EPC ratings of C for dwellings, including a delivery mechanism for social housing.
    - Address delivery risks in private rented sector, in particular exemptions capping contributions from landlords to improve the energy efficiency of EPC F and G rated properties.
    - Set out concrete policies to deliver the ambition on non-residential buildings.
    - Introduce voluntary public sector targets.
    - Introduce a second wave phase of standards for boiler efficiencies.
    - Strengthen standards for new buildings (residential and non-domestic buildings).
    - Reform monitoring metrics and certification and strengthening compliance and enforcement frameworks to ensure that compliance calculations are representative of the real-world performance of buildings.
    - Developing a long-term heat networks policy framework.

[33] In 2018 the RHI was updated to include the assignment of rights which allows a third party investor to help fund the purchase, installation and maintenance of renewable heating system in return for RHI payments.

    - Inclusion of details of a national governance framework to drive decisions on heat infrastructure (e,g, heat networks and/or electrification and/or decarbonisation of the gas grid) in the early 2020s.
- Consistent price signals that clearly encourage affordable, low-carbon choices for consumers relies on Government:
    - Publishing detailed plans to phase out the installation of high-carbon fossil fuel heating in the 2020s including large heat pumps displacing resistive electric heating in non-residential buildings.
    - Establishing support framework for heat pumps and bio-methane post-2021, as well as support for low-carbon technologies in heat networks.
    - Reviewing the balance of tax and regulatory costs across fuels in order to improve alignment with implicit carbon prices and reflect the decarbonisation of electricity.
- An attractive and well-timed offer to households and SMEs that is aligned to 'trigger points' along with simple, highly visible information, certification and installer training. To achieve this Government needs to:
    - Set out policy package for able-to-pay and address delivery risks around ECO.
    - Implement measures around green mortgages and fiscal incentives to encourage uptake and support financing of upfront costs.
    - Develop new policy to support SMEs.
    - Improving consumer access to data and advice such as Green Building Passports and improving EPCs and access to data underpinning EPCs and SAP.
    - Drive wider use of operational data for benchmarking in the public and commercial sectors by strengthening and extending mandatory public reporting of operational energy ratings.
    - Review professional standards and skills across the building and heat supply trades.

5.5 Core Scenario to 2050

The CCC has identified the following core options that would be required to continue the 80% GHG reduction trajectory nationally.

- Energy efficiency:
    - A mix of insulation measures providing 21% reduction in energy demand in homes.
    - A 25% reduction in non-domestic heat demand due to energy efficiency savings.
- Low-carbon heating:
    - Low-carbon heat networks being deployed in heat dense areas with the connection of 5 million homes nationally by 2050 (61,000 in Devon[34]) and 46% of heat demand from non-domestic buildings being met via these networks.
    - Heat pumps serving 17 million homes nationally by 2050 (209,000 in Devon[35]) using heat pumps of various type, and meeting 54% of heat demand from non-domestic buildings by 2045 for all buildings currently not heated using biomass (with those biomass systems being replaced by heat pumps in 2050).
    - A small number of homes nationally (1,000) using direct electric heating.
- Lighting and Appliances: Whilst electricity consumption is quantified in the Power section, it has been assumed that there are significant improvements to the efficiency of lighting (e.g. LED) and appliances for both dwellings and non-domestic buildings. In addition, it is assumed that from 2030 all cooker replacements are electric.
- Delivering current Government commitments on:

[34] Based on pro-rating the national installation rate to Devon based establishing % of national homes on a heat network in 2050 and applying this to projected homes in Devon in 2050.

[35] Based on pro-rating the national installation rate to Devon based establishing % of national homes with heat pumps in 2050 and applying this to projected homes in Devon in 2050.

- Retrofitting homes to EPC rating C by 2035.
- The Future Home Standard for new homes by 2025.
- Phasing out high-carbon fossil fuel heating in homes off the gas grid in the 2020s.
- Build and extend heat networks across the country.
- Funding of low-carbon heating beyond 2020/21.

5.6 Further Ambition to 2050

The CCC has identified the following further ambition options that would be required to continue the 80% GHG reduction trajectory nationally.

- Energy efficiency: A mix of insulation measures providing 25% reduction in energy demand in homes.
    - 6 million cavity wall insulations by 2050 (74,000 in Devon[36])
    - 6 million solid wall insulations by 2050 (74,000 in Devon[37])
- Heat pumps:
    - 19 million homes (i.e. 2 million more than under the Core Scenario) nationally (233,000 in Devon[35]) using heat pumps.
    - There is uncertainty as to which technology will prevail as hybrid heat pumps, full electrification and hydrogen boilers are currently projected to have similar costs.
- Low-carbon heat networks: It is assumed that rather than using gas to meet peak demand on heat networks it is replaced with either larger heat pumps and large water stores, or hydrogen if available through the gas grid.
- The scope of delivering carbon reduction in dwellings is extended to:
    - Homes on the gas grid with space constraints (about 20% of dwellings, which were excluded in the Core Scenario)
    - Dwellings with heritage value (either being listed or in a conservation area).
    - Addressing these dwellings is likely to be technically feasible but costly or difficult zero emissions may not occur until 2060.
- Hydrogen: The conversion of residual gas demand to hydrogen which has been produced with CCS, requiring a significant national infrastructure delivery programme and dwellings being fitted with hydrogen-ready boilers.
- Nitrous oxide used as an anaesthetic would become more significant once buildings are decarbonised. The CCC estimate that in 2050 emissions from this source could be 0.6 $MtCO_2e$ nationally, which if apportioned to Devon would be over 7,300 tCO_2e and represent 13% of emissions from the Buildings sector (although only 0.4% of Devon's residual emissions as the Buildings sector will become relatively less significant due to its projected deep decarbonisation). It is stated that nitrous oxide could potentially be replaced with xenon gas though this is currently 1,000 times more expensive than nitrous oxide.

5.7 Opportunities for Accelerated Delivery in Devon

Based on projected and proposed action that would be required to achieve net zero emissions by 2050, the following would need to be adopted or considered in Devon if a target of 2030 is required:

5.7.1 New buildings

The Government's Future Homes Standard is set to ensure all new homes are built without fossil fuel heating and to a "world-leading" energy efficiency standard by 2025. Meeting challenging

[36] Based on pro-rating the national installation rate to Devon based on fraction of solid wall properties in Devon to national

[37] Based on pro-rating the national installation rate to Devon based on fraction of cavity wall properties in Devon to national

carbon reduction targets for the buildings sector requires that new buildings do not result in any additional emissions in-use. It has been shown[38] that for a large volume housebuilder the average cost of a new dwelling is £215,000 of which 30% is profit (£65,000). The CCC has estimated that the additional cost of delivering a zero-carbon dwelling to be £4,800 with industry estimates varying from £8,000 to £12,000 with the potential to meet the CCC estimate at volume. It would therefore appear to be economically viable to require all new dwellings to achieve "zero-carbon" now. This should be mandated through planning policy. Accelerating the requirement for net zero homes ahead of the national timetable (including any development in the pipeline that has permission under earlier versions of Part L of the Building Regulations) will reduce Devon's emissions. A similar requirement would need to be made of non-domestic buildings.

5.7.2 Energy efficiency in existing buildings

Meeting the implied trajectory of energy efficiency to dwellings by 2030 would imply an installation rate of 6,600 cavity wall and 6,500 solid wall installations per annum in Devon. The current national rate of installation of wall insulation was 18,000 in 2018 and 16,000 in 2017 for solid wall insulation and 269,000 in 2018 and 258,000 in 2017 for cavity wall insulation respectively[39]. The data does not separate installed measures by local authority, but these rates if apportioned by population would result in installed rates of 220 and 3,250 for SWI and CWI in Devon in 2018 respectively. This equates to a shortfall of almost 6,300 SWI and 3,400 CWI installations per annum, which at installation costs of £13,000 and £475 per property for SWI and CWI respectively[40] would require an additional £82 million and £1.6 million annually, so almost £84 million annually total. This is a significantly higher rate than is currently being achieved. For example, in 2017 the CCC reported there were only 70,000 cavity wall and 16,000 solid wall installations in the entire country, indicating the low level of activity being delivered with current ECO funding. As the 'low hanging fruit' has been harvested, install rates for standard cavities are falling as they are harder to find and less attractive to installers due to their dispersed nature, whilst the costs and complexity in addressing future nonstandard cavities/solid wall measures remain high and in many cases unacceptable to homeowners. For Devon to accelerate ahead of the national trajectory would require means of funding these measures directly, as well as having the available supply chains and workforce in place to deliver the measures.

For non-domestic buildings, a 25% reduction in heat demand has been assumed by the CCC, though clarity has not been given as to how this might occur. In practical terms, it would require organisations (or in many cases, their landlords), to invest in efficiency measures such as insulation and/or building services.

The Minimum Energy Efficiency Standard (MEES) requires privately rented properties– both residential and non-domestic – to improve the efficiency of any building that has an EPC rating of F or G, however there is a spending cap which limits the impact of the policy. Any significant

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[38] Business, Energy and Industrial Strategy Committee Oral evidence: Energy Efficiency, HC 1730, Tuesday 12 March 2019

[39] Gov.uk Detailed report HEEE tables (accessed (19/8/19) https://www.gov.uk/government/statistics/household-energy-efficiency-statistics-detailed-report-2018

[40] https://www.energysavingtrust.org.uk/home-insulation based on typical installation costs for a semi-detached property

shift in addressing the private landlord sector will need to be balanced with effective policies which balance the interests of both the landlord and tenant if there is not to be an adverse impact in the rise of evictions as landlords seek to either recoup the costs of investment or divest properties to avoid costs. As there is no sufficiently effective policy or funding mechanism, additional funding would be needed achieve the 25% target.

5.7.3 Low-carbon heating and bio-methane

The 2050 scenarios assume that heat sources have effectively been decarbonised. The broad strategy is to connect buildings in areas of high heat demand to low carbon heat networks fed by large heat pumps, and to fit heat pumps to buildings where this is less suitable. To achieve Net Zero will require adopting this approach even for dwellings that are space constrained, or that have heritage value. These technological approaches rely on the electricity grid being decarbonised (so that heat produced from heat pumps is Net Zero), and that technology and infrastructure has developed sufficiently that hybrid heat pumps and hydrogen are a credible contributory option to the strategy. It is not considered feasible for Devon to unilaterally bring forward low carbon hydrogen, and so Net Zero heat options for Devon by 2030 rely on a switch to heat pumps, either building-scale or as part of low carbon heat networks. This assumes an annual installation rate of around 24,000 heat pumps per annum and that the electricity grid will have broadly decarbonised by 2030. For context, the CCC reported that 18,000 heat pumps were sold nationally in 2016. Monthly data from the RHI scheme[41] supresses the number of installations in Devon though it is clear that the number is very small. If the 2016 national number is apportioned based on population then this would imply an annual installation rate for Devon of 220 heat pumps which is 1% of the required rate. Assuming an ASHP costs £7,000[42] (note: GSHP are stated to be double the cost) this would imply an additional spend of £169 million annually to install standalone in residential properties heat pumps at this rate. These installations should occur alongside the proposed energy efficiency improvements, and there may be an advantage in combining the two.

The CCC includes the potential for bio-methane's role in decarbonising heat, through injection into the gas grid, under Buildings. Bio-methane's relatively small role is illustrated by the blue rectangle in Figure 11. The CCC report that 2TWh of bio-methane are currently injected into the gas grid annually with use in buildings rising to 20TWh by 2032. Industrial use of bio methane increases total use to 25TWh. Were this bio-methane to be provided from energy crops (maize at 60MWh/ha see Table 2) the UK land requirements would be some 417,000ha or 1.7% of the UK's land area.

5.7.4 Lighting and appliances

Although emissions from electricity are considered in the power sector, the projections for buildings include demand reduction associated with efficiency savings of lighting and appliances, including a switch to electric heating for cooking (e.g. using induction hobs). These advances are being achieved through research and commercialisation at a global scale. Whilst national/European policy such as energy labelling provides consumers with the information to include energy efficiency within their decision making process, ultimately this is an area that is

[41] https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-may-2019

[42] https://www.energysavingtrust.org.uk/renewable-energy/heat Average cost ASHP of £6,000 to £8,000 whilst GSHP are stated to cost £10,000 to £18,000

being led by actions above local authority area. Whilst Devon County Council or agencies within Devon could develop campaigns to promote the benefits of more efficient lighting and equipment, this does not appear to be an area where it would be possible for Devon to significantly accelerate carbon reduction relative to the national projections.

6. Industry

It should be noted that the CCC's Industry sector represents primarily heavy industry. GHG emissions arise from heavy industry both from the direct combustion of fossil fuels (mainly for process use and heating[43]), other process emissions and from the use of electricity to power processes, equipment and lighting. The consumption of electricity is covered in Section 4 (Power) and so this section covers only direct emissions. Emissions from buildings which may be part of industrial businesses fall under Section 5 (Buildings). The projected trajectory for GHG emissions from heavy industry in Devon is shown in Figure 13 (values for 2016, 2032 and 2050 are provided in Appendix A).

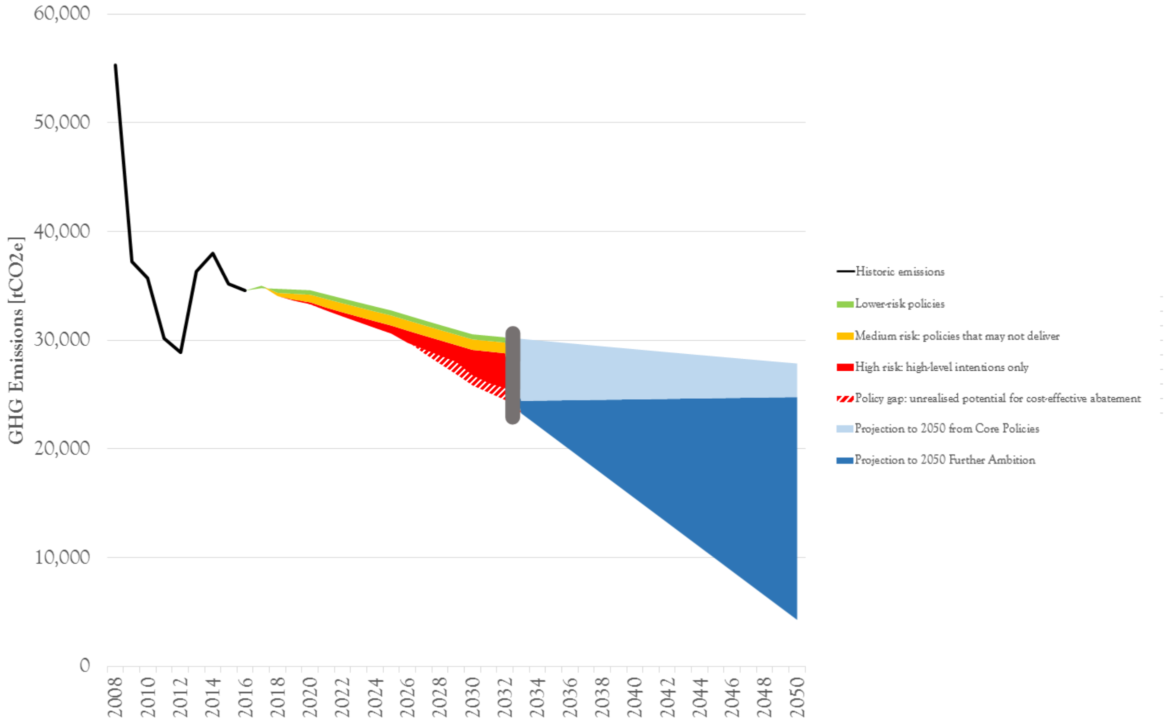

Figure 13: Projected GHG emissions in Devon's Heavy Industry sector to 2050 as a result of national policy (interpretation of graph is described in caption to Figure 1)

It should be noted that Devon's heavy industry emission are largely comprised of the "Large Industrial Installations" category in the BEIS Local Authority CO_2 emission statistics. The lack of heavy industry in Devon means that these represent a very small portion of Devon's emissions. However, significant emissions from intermediate size commercial and industrial sites are recorded in the "Industry and Commercial Gas" category which is included the Buildings section of this analysis.

The CCC's least cost pathway for Industry anticipates emissions falling by 23% between 2017 and 2030 through carbon capture and storage (CCS), bio-energy, electrification and energy efficiency as shown in Figure 14.

[43] Categorised as "Large Industrial Installations" in BEIS statistics see https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-2016

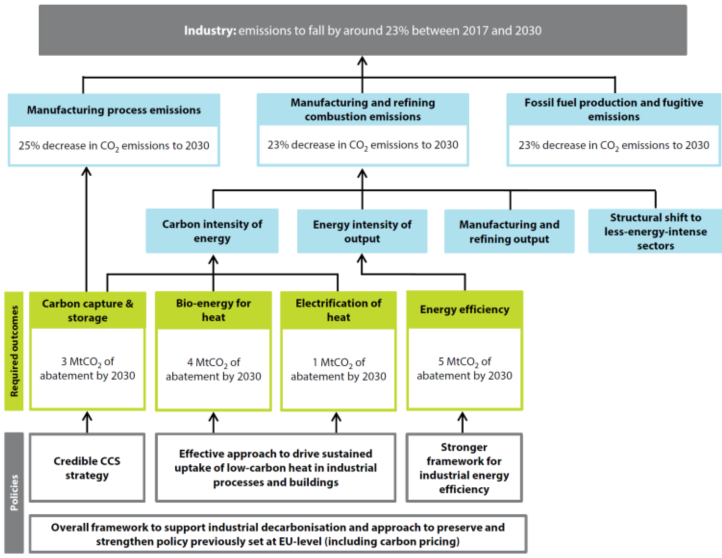

Figure 14: CCC indicators for UK industry to 2030[44]

The Net Zero report forecasts emissions for five specific high emission industrial sectors:

- Cement
- Petrochemicals and ammonia
- Iron and steel
- Refining
- Fossil fuel production - combustion

Devon has no material petrochemicals and ammonia, iron and steel, cement, refining or fossil fuel production.

Of the remaining categories the bulk of Devon's emission are assumed to fall under stationary combustion from other manufacturing and other process emissions. These sectors comprised 33% of UK industrial emissions in 2016[45]. For Devon's industry this implies opportunities for carbon emission reductions result from:

- Energy efficiency
- Bio-energy for heat
- Electrification of heat

6.1 Low Risk Policy to 2032

Low risk policies are responsible for 8% of Devon's projected carbon reduction to 2032. The CCC has identified these as:

- Energy efficiency improvements where the abatement levels achieved to date are modest.
- Low-carbon bioenergy and heat through the Renewable Heat Incentive (RHI) which supports low-carbon heat uptake in industry and is the largest single implemented policy for industry. Nationally the RHI is expected to encourage around 2 $MtCO_2e$/year of abatement between 2020 and 2030.

[44] Figure 4.4 of the CCC 2018 Progress Report

[45] Net Zero Technical Report Fig 4.5; stationary combustion 31.6 $MtCO_2e$, other 2.5 $MtCO_2e$, total 104.2$MtCO_2e$

6.2 Medium Risk Policy to 2032

Medium risk policies include emission reductions from existing Government policies that the CCC views to have significant delivery risks (e.g. insufficient funding). Medium risk policies are responsible for 17% of projected carbon reduction to 2032. The CCC has identified these as:

- Further energy efficiency
- The funding of the RHI beyond 2020/21
- Continued participation in the EU Emissions Trading Scheme (ETS)

The EU ETS, while nationally very important, currently only affects one of Devon's industrial businesses; Devonport Royal Dockyard Ltd.

6.3 High Risk Policy to 2032

High risk policies are responsible for 55% of projected carbon reduction to 2032.

The CCC considers emissions reductions from the proposals and intentions included in the Government's 2018 Clean Growth Strategy to be 'high risk' due to the lack of clear policy required to deliver them. These include:

- A 20% improvement in industrial energy efficiency
- Phasing out high-carbon fossil fuel heating in industrial buildings off the gas grid
- Industrial carbon capture and storage (CCS)

Industrial scale CCS is likely to be focussed on energy intensive industrial clusters on the eastern seaboard of the UK.

6.4 Policy Gap Risk Policy to 2032

Policy gaps are responsible for 20% of projected carbon reduction to 2032. The CCC has highlighted that the Government has no clear proposals to support a switch to low-carbon fuels for industrial process heat after 2021.

Low carbon fuels include electrification, biomass, bio-methane, hydrogen and ammonia. Electrification takes advantage of the declining emission factor in the power sector as the grid decarbonises (see Section 4). Electrification is preferred to biomass which will be directed towards locations where CCS is available (BECCS) thereby enabling CO_2 to be removed from the atmosphere. Bio-methane from anaerobic digestion is likely to be injected into the gas grid. However, the limited quantities of bio-methane available will only marginally reduce the gas grid emission factor nationally. Hydrogen is anticipated to be generated primarily through the reforming of methane with the by-product CO_2 being sequestered through CCS. The bulk of hydrogen production is therefore likely to take place in industrial clusters on the eastern seaboard of the UK. Hydrogen will either be used locally or made available nationally through the gas grid. Local zero carbon hydrogen generation is possible using electrolysis with renewable electricity. However, there are significant technical, safety and cost barriers to the deployment of hydrogen (see Section 4) making it difficult to foresee the national roll-out and therefore to make predictions about the penetration of hydrogen in Devon. Ammonia has a higher energy density than hydrogen and the advantage of being more easily transportable in a liquid state. As with hydrogen, the large scale generation, distribution and use of ammonia as a fuel and consequently it impact on emissions in Devon is currently difficult to foresee.

6.5 Core Scenario to 2050

Figure 15 shows the CCC's national emissions reduction scenarios which are dominated by sectors not present in Devon. The industrial mix in Devon means that the Devon's priority will need to be energy and resource efficiency and the transition to low carbon electricity and fuels.

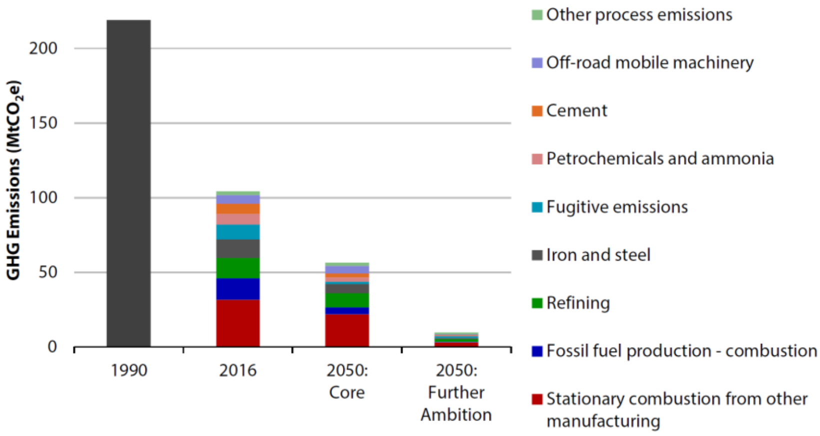

Figure 15: CCC national scenarios for very deep emission reduction in UK industry[46]

6.6 Further Ambition to 2050

The further Ambition Scenario continues emissions reduction beyond 80% by 2050 through a range of options including:

- Further use of hydrogen
- Further electrification
- CCS (including biomass energy with CCS)
- Low-carbon off-road mobile machinery (e.g. hydrogen or electrification)
- Reductions in methane venting and leakage
- Energy and resource efficiency.

Further Ambition in Devon will mean going further with energy and resource efficiency and the transition to low carbon electricity and fuels.

Speculative Options in the industrial sector identified by the CCC include:

- Further CCS including from smaller more challenging sites
- Faster deployment of low carbon fuelled technologies partially through earlier scrapping of assets

Given the earlier push towards the conversion to low carbon fuels in Devon it is difficult to assess the extent to which Devon's industry would require localised CCS or the earlier scrapping of industrial assets.

6.7 Opportunities for Accelerated Delivery in Devon

Understanding Devon's the industrial emissions in Figure 12 requires a knowledge of the types of industrial activity in the county. An indication of the types of businesses and employment prevalent in Devon is shown in Figure 16 and 17.

[46] Figure 4.5 CCC Net Zero Technical report

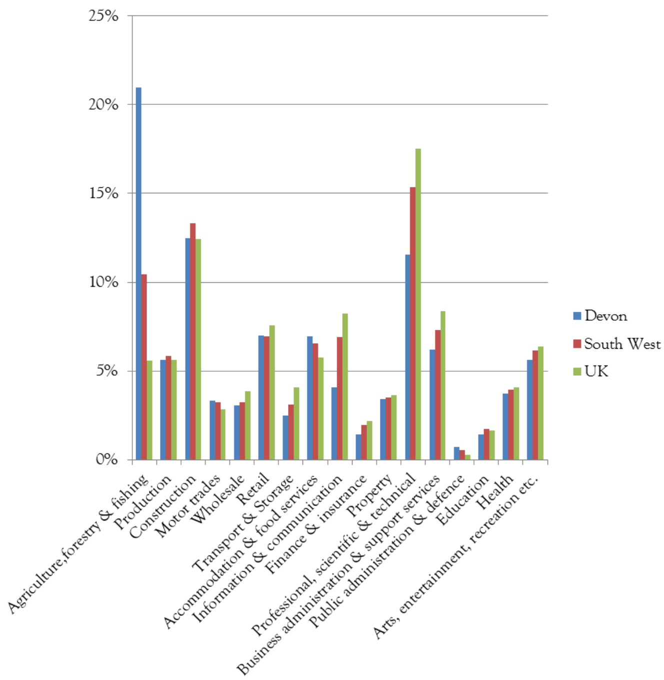

Figure 16: The number of businesses by industry sector in Devon compared to the South West and the UK[47]

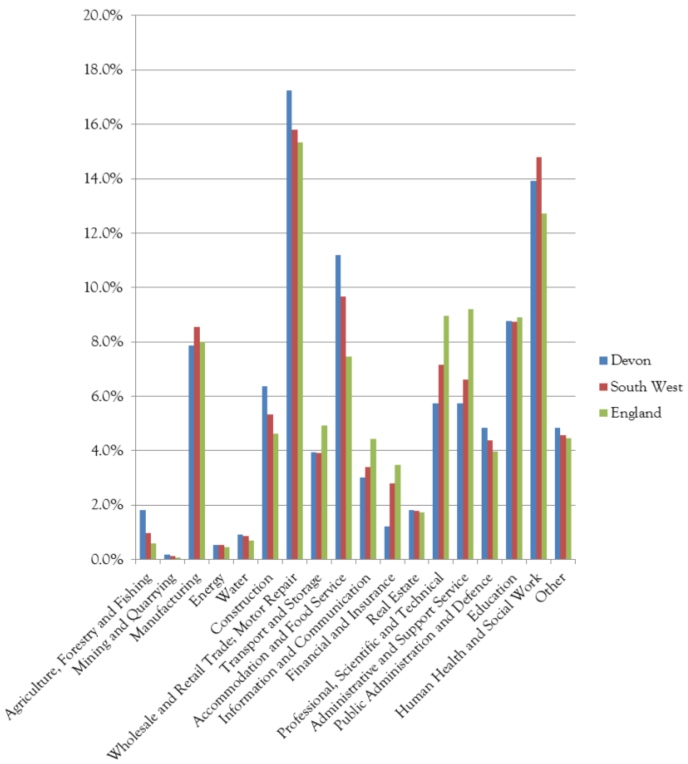

Figure 17: The number of employees by industry sector in Devon compared to the South West and the UK[48]

[47] Source data for 2018 https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/datasets/ukbusinessactivitysizeandlocation

[48] Source data for 2018 https://www.nomisweb.co.uk/query/construct/submit.asp?menuopt=201&subcomp=

When sectors where emissions will be primarily from buildings (Section 5), transport (Section 7) and agriculture (Section 8) are excluded, the residual sectors are construction and production. In both these sectors businesses numbers and employment percentages are near the regional and national averages. These observations provide little additional clarity on industrial emission sources.

Larger industrial production sites are identified in the EU Emissions Trading National Allocation Plan[49] (EU ETS NAP) and the National Atmospheric Emissions Inventory (NAEI) point source emission inventory[50].

The NAP includes both Scope 1 and 2 (indirect) emissions form company sites country wide sites. The following industrial sector companies which have sites in Devon are listed; Arconic (Exeter), BCT (Heathfield in administration), Dairy Crest (Crediton), Devon Valley (Hele), Higher Kings Mill (Collompton), Norbord (South Molton), Premier Foods (Lifton). Direct emission for all these companies, excluding Arconic, are recorded on the NAEI inventory and summarised in Table 3. Arconic is not included because its main energy use is served by electricity.

Table 3: NAEI industrial sites in Devon 2017

District	Company	Site	Industry sector	GHG emissions tCO_2e
Teignbridge	British Ceramic Tile Ltd	Heathfield	Other mineral	40,562
West Devon	Premier Foods Group Ltd	Ambrosia Creamery	Food, drink & tobacco	16,813
Mid Devon	Higher Kings Mill Ltd	Cullompton	Paper, printing & publishing	9,287
South Hams	Imerys Minerals Ltd	Lee Moor Site	Other mineral	8,603
Mid Devon	Devon Valley Ltd	Devon Valley Mill	Paper, printing & publishing	5,962
Mid Devon	Aggregate Industries UK Ltd	Westleigh Asphalt	Other mineral	5,102
North Devon	Norbord Europe Ltd	South Molton	Other	2,908
Torridge	Dartington	Torrington	Other mineral	96

NAEI industrial emission in Devon total 89,332 tCO_2e, significantly more than the 34,573 tCO_2e recorded in the 2016 inventory. This discrepancy is due to the allocation of emission between Industry and Buildings in the inventory described above.

The Carbon Reduction Commitment (CRC) Energy Efficiency Scheme league table[51] records emissions from numerous companies which have operations in Devon. However, these emissions include both Scope 1 and 2 and are further complicated by many of the companies having other sites outside Devon. This means that the league table of little use in determining the proportion of direct emissions that arise from industrial sites in the county.

The CCC's scenarios for the decarbonisation of industry involve two key national measures which are relevant in Devon; the provision of low and Net Zero electricity (covered in Section 4) and the supply of low and Net Zero fuels (including hydrogen and ammonia). Equally, the significant

[49] See https://www.gov.uk/guidance/participating-in-the-eu-ets#free-allocation
[50] See http://naei.beis.gov.uk/data/map-large-source
[51] See https://data.gov.uk/dataset/4b709a17-6e98-4021-a207-137ac931bfc3/information-for-each-carbon-reduction-commitment-crc-participant

improvement in industrial energy efficiency foreseen will rely on strong national policy which delivers the required incentives and regulations.

Materially accelerating the national programme will require additional funding. However, the design of any Devon's specific measures will need to ensure that they do not incur "carbon leakage" i.e. significantly raise costs for Devon's industry reducing profitability or increasing output prices both of which potentially risk driving industry out of Devon. Measures are therefore likely to need to be taxpayer funded either through local taxation in Devon or from external Government sources. The case for acceleration will therefore need to be made either to Devon's taxpayers or the Government. Assuming that the national programme is pursuing the least cost pathway making the case for additional costs for acceleration in Devon will be challenging.

A Climate Emergency gives the Council a mandate to convey the concern of citizens to Devon's industry. This will require getting closer to and deepening the understanding of industry across the County. This might take the form of a specialist unit which would develop relationships with the larger emitters in the County and run a programme to reach smaller industrial emitters based on a detailed understanding of Devon's industry.

In parallel with developing this industrial insight the unit could work with planners to develop appropriate low carbon industrial zones (LCIZ) in Devon's districts. LCIZ's would provide low carbon energy and emission mitigation measures to the industries locating in them and would be places were both new and existing Devon's industries would be encouraged to locate / relocate to. LCIZs would offer long term carbon cost benefits by mitigating national carbon taxes. In the short term, to accelerate the take up, the districts could also incentivise industrial businesses locating in the LCIZs through business rate reductions and other financial and regulatory incentives. The sites for such zones will be specific and may be based on the resources and a particular industry sector(s) requires e.g. raw materials, renewable energy etc. or a geographical feature .e.g. remoteness, transport links, etc. LCIZs could also have a key part in providing places where Devon can take advantage of the opportunities presented by the transition to new large scale technologies such as hydrogen, ammonia and synthetic fuels as these and the other technologies involved in Net Zero become apparent.

7. Transport

Transport GHG emissions generally arise from the direct combustion of fossil fuels across the different modes. The projected trajectory for GHG emissions from transport (excluding aviation and shipping) is shown in Figure 18 (values for 2016, 2032 and 2050 are provided in Appendix A)[52].

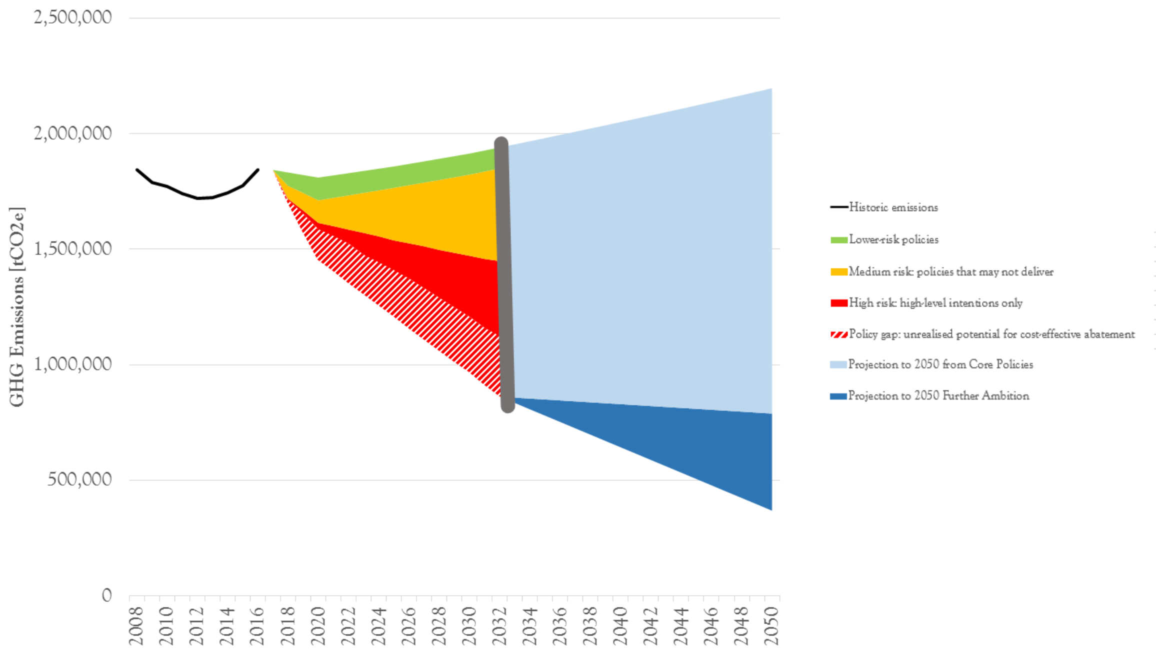

Figure 18: Projected GHG emissions in Devon's Transport sector to 2050 as a result of national policy (interpretation of graph is described in caption to Figure 1)

The CCC's least cost pathway implies a reduction in emissions of 46% between 2017 and 2030. This reduction is envisaged through a combination of reducing the carbon intensity of transport modes, and demand reduction as shown in Figure 19:

- Increased uptake of electric vehicles, with 60% of new cars to be electric in 2030.
- Continual improvement in carbon intensity of non-electric vehicles.
- Increasing the fraction of sustainable biofuels in road fuel to 11% (by energy) in 2030 (from 2.3% in 2017).
- Improving the efficiency of freighting.
- Shifting travel to more sustainable modes.

[52] An analysis of Devon's historic aviation and shipping emissions concluded that due to the incomplete nature of the emissions data and high levels of uncertainty aviation and shipping should not be included. Estimates of aviation emissions for flights out of Exeter Airport suggested that aviation emissions from this source were some 9% of transport emissions and 3% of total emissions. Estimated emissions from fishing vessels were 1% of transport emissions and 0.3% of total emissions.

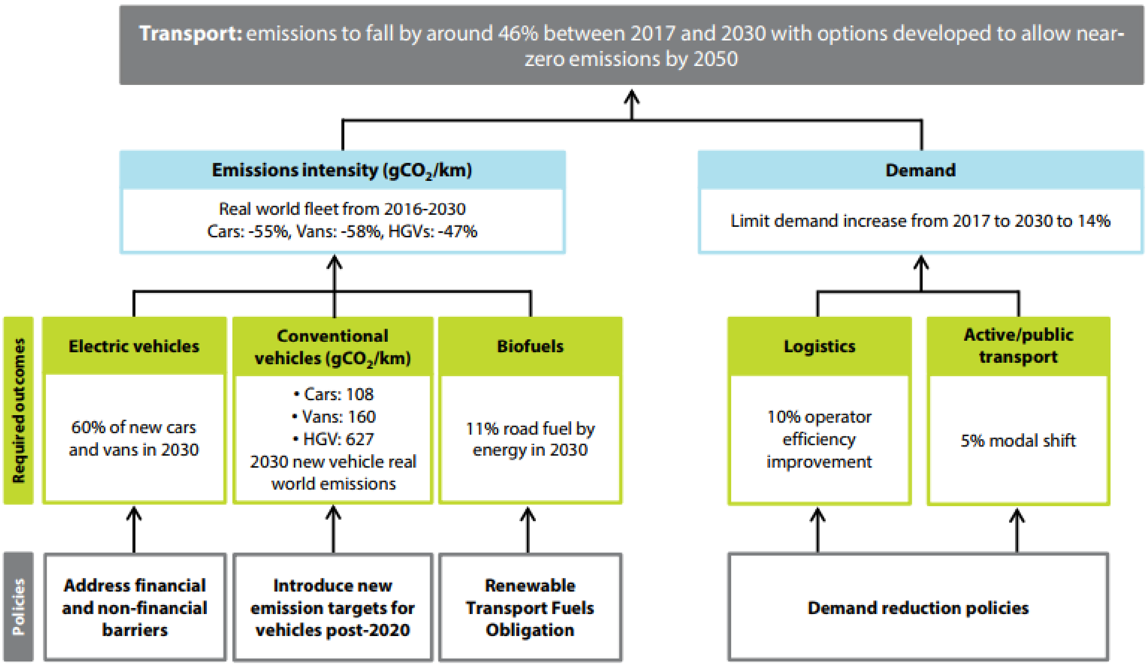

Figure 19: CCC indicators for the UK transport sector[53]

7.1 Low Risk Policy to 2032

Low risk policies are responsible for 8% of projected carbon reduction to 2032. The CCC has identified these as:

- Biofuels: The new Renewable Transport Fuel Obligation (RTFO) target has been legislated.
- Sustainable travel: The Transforming Cities fund which aims to improve productivity and spread prosperity through investment in public and sustainable transport in some of the largest English County regions has been launched.

7.2 Medium Risk Policy to 2032

Medium risk policies are responsible for 37% of projected carbon reduction to 2032. The CCC has identified these as:

- New car and van efficiency to 2020: There is uncertainty as to the extent emissions savings will be realised in the real world.
- Electric vehicles: There is uncertainty regarding commitments to grants in the longer term for EVs, and the limited progress in developing on-street charging infrastructure.
- HGV and freight efficiency: New efficiencies have been proposed but there has been no clarity over the UK regulatory approach.

7.3 High Risk Policy to 2032

High risk policies are responsible for 30% of projected carbon reduction to 2032. The CCC has identified these as:

- New car and van efficiency after 2020: The EU has proposed targets post-2020 which in themselves are not deemed to be sufficiently ambitious, though regardless of this the UK's intention to proceed post-Brexit is uncertain.

[53] Figure 5.10 of the CCC 2018 Progress Report

7.4 Policy Gap Risk Policy to 2032

Policy gaps are responsible for 24% of projected carbon reduction to 2032. The CCC has identified these as:

- New car and van efficiency:
    - Setting out a regulatory approach post-Brexit including punitive penalties for manufacturer non-compliance.
    - More stretching targets for new car and van emissions for 2025 and 2030, based on real-world performance.
- Electric vehicles:
    - Set more stretching targets for new EV sales i.e. 60% of all cars and vans in 2030 as opposed to 40—60% cars and 40% vans as targeted by the Clean Growth Strategy.
    - Ensure adequate charging infrastructure by mandating charging provision for all new development (homes and non-domestic).
    - Improve access to the electricity grid for charge point providers.
    - Ensure plug-in hybrid vehicles achieve near-zero emission by 2035 by increasing the range of the electric component of the journey.
- Fiscal incentives: Implement stronger incentives e.g. via vehicle excise duty and company car tax to encourage purchase of ultra-low emission vehicles.
- Modal shift: Increase levels of walking, cycling and public transport use—especially in cities—by planning new development with sustainable transport as a priority as well as investing in new infrastructure and promotional campaigns.
- HGVs and freight:
    - Setting out a regulatory approach post-Brexit including more stretching targets for new car and van emissions for 2025 and 2030 (15% and 30% reductions respectively from a 2019 baseline), based on real-world performance.
    - Shifting more freight from road to rail by improving logistics efficiency.
    - Investigating barriers that have currently prevented manufacturers from making lower carbon HGVs available through the government's OLEV funding route.

7.5 Core Scenario to 2050

The CCC has identified the following core options that would be required to continue the 80% GHG reduction trajectory nationally.

- Electric vehicles: The Core Scenario assumes sales of conventional cars and vans ends in 2040 resulting in 80% of the national fleet being zero-emissions by 2050 given expected vehicle lifetimes and turnover rates. The scenario also includes increased uptake of ultra-low emissions small HGVs and ongoing subsidy of zero emission motorbikes. Based on apportioning[54] costs and uptake of charging infrastructure from the Net Zero report this implies a spend in Devon of £3.6 million per annum from now to 2050 to result in a total of approximately 700 x 22 kW chargers, 600 x 43 kW chargers, 1300 x 150 kW chargers and 26 x 350 kW chargers. Nationally, 20% of target 22 kW chargers have been installed, and 9% of 42 kW chargers, with 0% for the larger capacity chargers. Western Power Distribution (WPD) has produced a strategy[55] which outlines the work it is doing locally to prepare for the shift to electric vehicles. It is stated that the existing network is likely to have the capacity to support charging of EVs at expected rates. Domestic chargers with 3 kW or 3.7 kW capacities can be simply connected and it is not envisaged there will be a charge by WPD . At a national level, 60% of cars are parked off-road and would therefore be suitable for this type

[54] Apportioned based on population.
[55] WPD 2019, Western Power Distribution: Electric Vehicle Strategy

of charger (around 239,000 households in Devon in 2050 with a “slow” charger). Chargers of 7 kW or greater are likely to require some network upgrading and will incur a cost (e.g. £1,000 to £3,000 for a 7 kW charger). Chargers in the range 3.7 kW to 22 kW may be installed street side to meet the needs of those households that do not have off street parking, whilst chargers of 22 kW and above will be installed in public places.

- Walking and cycling: It is assumed that 5% by distance of car journeys can be shifted to walking, cycling and public transport.
- Freight: The industry has a target of 15% reduction in emissions from HGVs by 2025 from 2015 levels to be achieved via logistics measures (6 – 8% reduction in distance travelled), improved fuel efficiency and ultra-low emission vehicles.
- Buses: Low emission buses to make up 80% of sales in 2050.

7.6 Further Ambition to 2050

The CCC has identified the following further ambition options that would be required to continue the 80% GHG reduction trajectory nationally.

- Electric vehicles: The Further Ambition Scenario assumes the planned ending of sales of conventional cars and vans is brought forward to 2035 including for hybrid vehicles, with limited regulatory approval of fossil fuel cars from 2050. The introduction of Connected Autonomous Vehicles (CAVs) could enable a faster transition to electric vehicles, if operated by businesses as fleets of taxis. Shared 'on demand' fleets of electric vehicles with increased occupancy could reduce global energy demand for transport, as well as reducing the number of electric vehicles on the road.
- HGVs: It is assumed that all HGV sales will be of low-emission varieties from 2040. For small rigid HGVs electrification is likely to be the appropriate technology, though for larger rigid and articulated HGVs choices include either hydrogen or electrification. The cost of bringing forward hydrogen refuelling infrastructure is in the same order of magnitude as the capital cost of developing electric charging infrastructure (i.e. £9.3 billion total spend nationally for electric chargers in public spaces compared to an estimated range of £3 ~ £16 billion to 2050 for hydrogen refuelling infrastructure.
- Walking and cycling: It is assumed that 10% by distance (i.e. double the uptake compared to the Core Scenario) of car journeys can be shifted to walking, cycling and public transport. If increased modal shift could be achieved (e.g. due to the benefits of electric bikes and scooters) then this may mean that the uptake of EVs could be less aggressive than modelled.
- Freight: Distance travelled reduced 10% by logistics measures including the expanded use of urban consolidation centres and expanded delivery windows. It is stated that societal changes to consumption (e.g. increased longevity of goods, or manufacturing close to point of use via 3D printing) represents an alternative potential means of reducing demand from freight.
- Railways: It is assumed that 54% of track is electrified by 2040 (generally the most busy lines) with hydrogen trains deployed on trains operated under 75 mph on lines that are not electrified.
- Synthetic Fuels: It is stated that there is a possibility that any remaining fossil fuels used in the surface transport sector could be replaced with synthetic fuels, made from electrolytic hydrogen and CO_2 captured from the air via Direct Air Capture (DAC), though this is thought to be unlikely given high costs and competing demands for DAC with CCS as a means of carbon abatement.

7.7 Opportunities for Accelerated Delivery in Devon

Based on projected and proposed action that would be required to achieve net zero emissions by 2050, the following would need to be adopted or considered in Devon if a target of 2030 is required:

- Conventional cars and vans: The CCC state that the average lifespan of a car is 14 years, however some can remain on roads for over 20 years. Given the longer-term strategy for decarbonisation of vehicles involves electrification, this would imply that to meet a Net Zero target implies an immediate ban on the sale of conventional vehicles. Local authorities do not have the powers to mandate such a change. In addition, the most advanced country internationally on bringing forward EVs (Norway), is targeting 2025 as the point at which fossil-fuel powered cars and vans will be banned. If conventional vehicles persist in Devon into the 2020s and 2030s, then achieving Net Zero would necessitate making deeper cuts elsewhere, including potentially offsetting.
- Electric vehicles: Alongside a move away from internal combustion engines, EVs will need to effectively address a range of barriers if they are to be widely taken up in Devon ahead of national timetables:
    - Technology: EVs must meet the requirements of users. At present, the greatest barrier is battery capacity which limits the range of electric cars and vans. Whilst this will improve both with vehicle and charging technology, it is not an area Devon can unilaterally develop.
    - Costs: The CCC estimate that by 2030 a new medium sized battery car will be marginally lower to purchase (£160) than an equivalent conventional car and will save almost £2,000 over a 14 year lifetime. This would result in electric cars becoming cost-effective during the 2020s (or 2030 in the case of electric vans). In the meantime, to bridge any gap additional funding would be required. In the absence of national grants specifically available for Devon to meet a carbon target, these funds would need to be met locally.
    - Infrastructure: Based on the estimated extents of the charging infrastructure stated in Section 7.5 this would imply an annual spend of £10.2 million per annum between now and 2030 in Devon on charging infrastructure in public spaces. As much of this will be on very rapid chargers (150 and 350 kW) costs associated with being a first-mover may therefore be higher.
- Modal shift: The CCC scenarios assume up to 10% modal shift (by distance travelled), which would need to be achieved at almost three times faster if Net Zero by 2030 is required.
- Freight: The CCC scenarios are based on improvements to HGVs (both in vehicle design and in terms of switching to fuels such as hydrogen), both of which are cannot be directly influenced locally. Some of the reductions in emissions are associated with improvements in logistics, and so to that end Devon could proactively seek to work with bodies such as the Freight Transport Association and the Road Haulage Association as well as with major Devon's hauliers and haulage clients directly.
- Buses: The 2050 Core scenario assumes that low emission buses and coaches reach 80% of sales by 2050, although the CCC also states that accelerated roll-out of electric and hydrogen buses and coaches could reach 100% market share by 2040. Development of bus (and fuelling) technology is not an area Devon can achieve unilaterally, however there is evidence that these technologies are already being taken up and becoming cost-effective. The CCC states that for buses and urban distribution applications, electric vehicles in Sweden have already reached cost parity, and the Mayor of London[56] has stated that in central London, all double-deck buses will be hybrid by 2019, all single-deck buses will emit zero exhaust emissions by 2020, and by 2037 at the latest, all 9,200 buses across London will be zero emission. So whilst there are technical solutions to address emissions from buses in Devon, the greatest barrier is how to fund a programme of replacement buses, especially given utilisation of buses will be significantly lower than in London, and the co-benefit drivers (i.e. improved air quality) are not as immediately pressing (although still important).

[56] https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/cleaner-buses

- Railways: Savings from railways are projected to arise from electrification of the mainline and use of hydrogen trains on branch lines. The former will be achieved as a roll-out of national infrastructure whilst the latter is on the verge of being deployed in the UK (2022[57]).

[57] https://www.telegraph.co.uk/cars/news/hydrogen-fuel-cell-trains-run-british-railways-2022/

8. Agriculture and Land Use Change

GHG emissions from the Agriculture, Land Use Change and Forestry sectors are considered together in the both the CCC reports, and so they are aggregated here. The projected trajectory for GHG emissions from these sectors is shown in Figure 20 (values for 2016, 2032 and 2050 are provided in Appendix A).

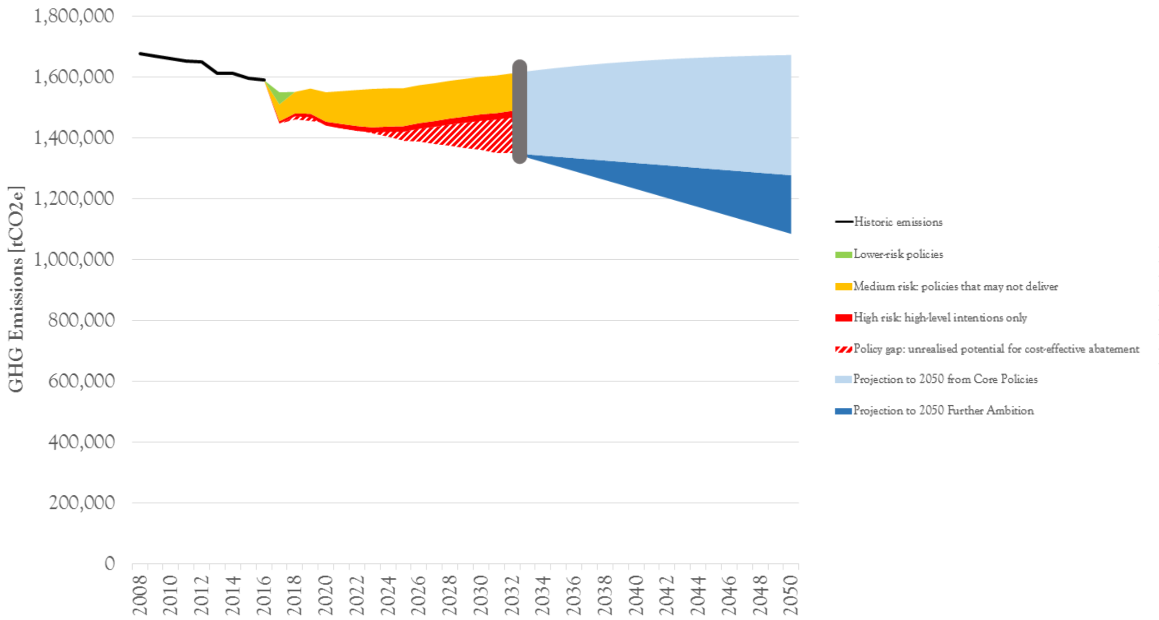

Figure 20: Projected GHG emissions in Devon's Agriculture and Land Use Change sector to 2050 as a result of national policy (interpretation of graph is described in caption to Figure 1)

The CCC's least cost pathway implies a reduction in emissions of 20% between 2016 and 2030. This is envisaged to be achieved through the following combination of reducing the carbon intensity of crops and livestock, and from changing the output of crops and livestock products as shown in Figure 21.

Over the period to 2050, emissions from this sector are projected to fall from 1,590 ktCO_2e in 2016 to 1,080 ktCO_2e in 2050. In 2016 it was responsible for 24% of the overall GHG footprint, whilst in 2050 this would represent 63% of the residual emissions; a factor of almost three times greater than the next largest sector (Transport, 21%). This would mean that even assuming decarbonisation can be achieved via interventions at the rate implied by the national programme, significant carbon offsetting will be required to achieve net-zero.

Key to understanding the nature of agricultural emissions and the potential impact of emissions reductions from the sector are facts that:

- A significant proportion of agricultural emissions occur in the form of methane which is a short lived greenhouse gas. The effect of these short-lived GHGs on global average temperature is much more closely controlled by their emissions rate as opposed to the cumulative total of emissions over time. As such in respect to Devon achieving carbon neutrality, methane emissions from agriculture do not necessarily need to be rapidly brought to net-zero, but rather stabilised and then slowly decreased to prevent continually increasing global average temperature. An alternative approach to measuring and reporting emissions from biological sources has been proposed by the New Zealand Parliamentary Commissioner for the Environment, this approaches' relevance to Devon is considered in the Discussion section.

- The agricultural sector and other land managers could play a major role in facilitating the sequestration of carbon to offset residual emissions. The scale and nature of this opportunity is explored further in Section 11: Greenhouse Gas Removals.

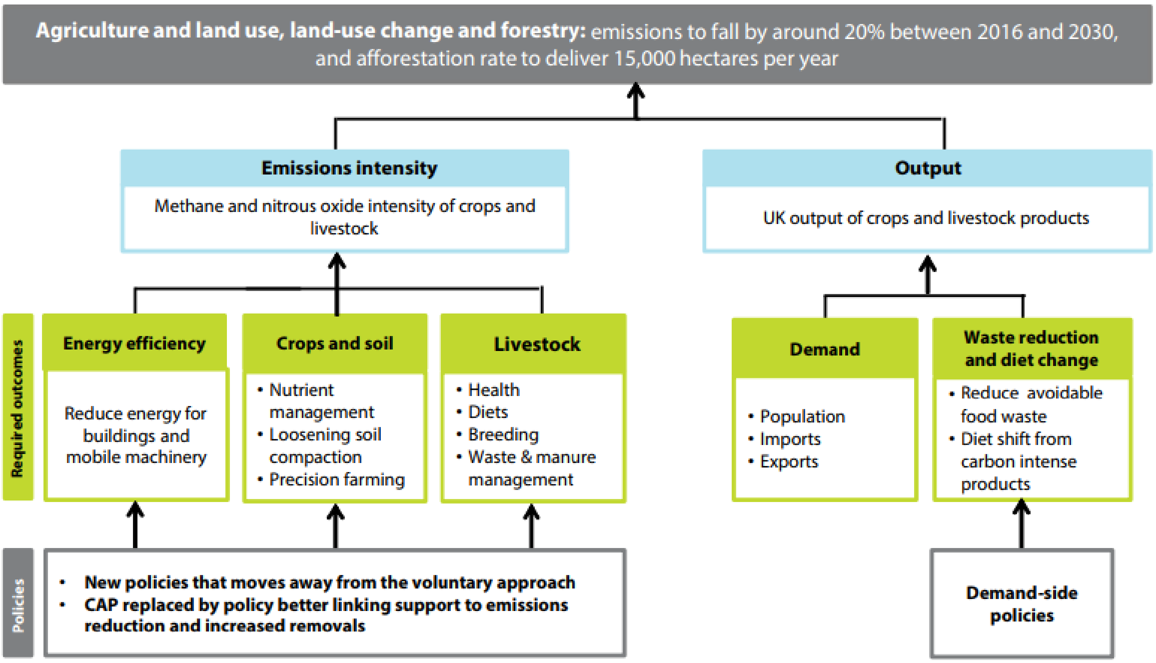

Figure 21: CCC indicator national framework for the UK agriculture sector[58]

8.1 Low Risk Policy to 2032

The CCC has not identified any low risk policies. All carbon reduction identified is either medium or high risk, or currently constitutes a gap in policy.

8.2 Medium Risk Policy to 2032

Medium risk policies are responsible for 47% of projected carbon reduction to 2032. The CCC has identified these as:

- The Clean Growth Strategy set out an intention to develop low-emissions fertiliser and tackle endemic diseases in cattle. This should be turned into firm policies.

8.3 High Risk Policy to 2032

High risk policies are responsible for 8% of projected carbon reduction to 2032. The CCC has identified these as:

- Agricultural policies are required to reduce emissions through crop and soil management, livestock diet health and breeding, waste and manure management, and energy efficiency.
- The main projected savings from the land use change sector involves afforestation which will require the replacement scheme for CAP linking the payment of public money to a range of public goods that tree planting can deliver, and the creation of Forestry Investment Zones to incentivise afforestation. England's target for woodland cover implies an annual afforestation

[58] Figure 6.9 of the CCC 2018 Progress Report. Abbreviations: CAP Common Agricultural Policy

rate of 6,000 Ha/annum to 2060, whilst the CCC's scenario to 2030 relies on 15,000 Ha/annum in the UK, increasing to 27,000 Ha/annum to unlock further savings. If these rates were allocated to Devon[59] this results in annual rates of 299 to 736 Ha/annum. Devon's current woodland area is approximately 79,000 Ha (12% of land area). The current annual tree planting rate in the UK is 7,000 Ha/annum.

- The UK Peatland Strategy[60] targets two million hectares of peatland in good condition, under restoration or being sustainably managed by 2040. If this is apportioned to Devon purely on an area basis then this is approximately 55,000 Ha, or 8% of land area in Devon.

8.4 Policy Gap Risk Policy to 2032

Policy gaps are responsible for 45% of projected carbon reduction to 2032. The CCC has identified these as:

- A stronger policy framework should be developed that goes beyond the current industry-led voluntary approach as this is showing that emissions have remained static.
- New policies should be covered to cover other measures e.g. for crops and soils, sheep health, livestock diets and breeding, waste and manure management and energy efficiency. This should be addressed in developing the post-CAP policy framework that better links support more closely with emissions reductions.
- Developing a strategy to accelerate afforestation rates including ensuring the post-CAP policy framework better links support more closely with tree planting, and other land use measures such as peatland restoration.

8.5 Core Scenario to 2050

The CCC has identified the following core options that would be required to continue the 80% GHG reduction trajectory nationally.

- A variety of on-farm practices to reduce non-CO_2 emissions from soils, livestock, waste and manure management and from reduced energy consumption in stationary machinery. In some cases, they represent low regret options required to meet an 80% target by 2050, where costs and barriers to implementation are relatively low (e.g. practices to improve efficient use of nitrogen).
- Continuing the rate of afforestation from the 2030 more ambitious rate of 27,000 Ha/annum nationally (736 Ha/annum in Devon) and planting trees on 1% of additional agricultural land by 2030.

8.6 Further Ambition to 2050

The CCC has identified the following further ambition options that would be required to continue the 80% GHG reduction trajectory nationally.

- Replacing natural gas with electricity (some of which can be met with on-site renewables like wind or solar) and almost completely decarbonising on-farm machinery by switching away from diesel and biofuels by 2050 and replacing with hydrogen, electricity, bio-methane or robotics.
- A higher level of deployment for low-carbon on-farm practices.
- Moving to healthier diets away from beef, lamb and dairy (a 20% reduction by 2050, which results in an 8% reduction in cattle and sheep numbers in the UK and a 23% decrease in grassland area) and reducing avoidable food waste (20% reduction by 2025).

[59] Based on the ratio of land area of Cornwall to England or UK respectively.
[60] The UK Peatland Strategy 2018 – 2040, IUCN National Committee United Kingdom Peatland Programme.

- Speculative options in the agriculture sector have also been considered, and it is stated that some of these options would be required to achieve net-zero.
    - Further livestock breeding measures.
    - A more aggressive reduction in beef, lamb and dairy options of 50% by 2050.
    - A 50% reduction in food waste.
    - Replacing any remaining fossil fuels used in agricultural vehicles with synthetic fuels (expensive option).
- Increasing the national tree planting rate to 30,000 Ha/annum (818 Ha/annum Devon) whilst improving the productivity of new stock by 10%.
- Planting trees on 10% of farm land and extending hedges by 40%.
- Planting energy crops (quantity unspecified).
- Restoring 55% of peatland area.
- Harvested biomass from trees (76% for fuel, the remainder for long-lived products e.g. construction).
- The demands on land use implied by the Further Ambition option would rely on a 20% shift away from beef, lamb and dairy, a medium level of improvement in crop productivity and increase in livestock stocking density, a 20% reduction in food waste by 2025 and moving 10% of horticulture crop to indoor systems.
- Speculative options in the land use sector have also been considered, and it is stated that some of these options would be required to achieve net-zero.
    - Reaching annual tree planting rates of 47,000 Ha/annum (1,282 Ha/annum in Devon).
    - Further restoration of peatlands (75% uplands and 50% lowlands) and seasonal management of the water table on 25% of lowland peat.
    - Switching some crop production on lowland peat to paludiculture or 'wet-farming' (e.g. crops that can be grown in water) would allow the water table to be raised permanently and for emissions to fall compared to conventional crop production.

8.7 Opportunities for Accelerated Delivery in Devon

Based on projected and proposed action that would be required to achieve net zero emissions by 2050, the following would need to be adopted or considered in Devon if a target of 2030 is required:

- Agricultural practices: The CCC scenarios assume a variety of on-farm practices to reduce non-CO_2 emissions from soils, livestock, waste and manure management. It is argued that as a whole, these measures will actually be cost-saving for the sector. However, the scenarios are based on an estimate of the rate at which the industry as a whole would be able to develop and implement these measures, and so early adoption by Devon would imply that the local agriculture sector is capable and motivated to accelerate on the national timetable. The CCC also assume that this will in part be driven by the post-CAP funding mechanism which will reward farmers for socially positive land management practices. The development of this funding mechanism is outside of Devon's control.
- Farm machinery: The zero-carbon scenarios assume shifting from natural gas to electricity, and that all mobile machinery is replaced with electric, bio-methane, or hydrogen alternatives, alongside the increasing use of robotics. This is unlikely to be an area where Devon can accelerate on the national timetable alone. The agriculture sector can support the decarbonisation of the electricity grid, for example by increasing the uptake of farm-scale anaerobic digestion (or other renewable energy technologies such as wind or solar), some of which could be directly utilised to meet the energy demand on farms. In accounting terms, the saving would be attributed to the Power sector rather than the Agriculture sector.
- Diets: The diets assumed in the scenarios are used to assess demand from the agriculture sector. As emissions are measured in terms of supply rather than demand (i.e. the emissions associated with food production in Devon as opposed to the emissions associated with the

food eaten by Devon's residents) increasing the uptake of low-impact diets in Devon will not in itself be sufficient to drive down emissions in Devon's agriculture sector, as produce is traded beyond Devon's border. Nonetheless, differing livestock practices result in different levels of environmental impact (for example meat produced on Dartmoor versus that produced in a feedlot). They may be opportunities to change methods of farming practices that could accompany shifts in diet (e.g. eating more expensive lower impact meat as the meat component in flexitarian diets).

- Afforestation: Meeting the most aggressive of the afforestation CCC rates implies almost 3,600 Ha/annum in Devon in 2030. This is equivalent to half the current afforestation rate for the whole of England, and would constitute over 0.5% of total Devon's land area per year at that rate.
- Peat: Devon would need to meet the national timeline for peatland restoration three times faster which would require identifying additional funding. This is based on an initial first order estimate, and a more detailed review of peatland in Devon would be needed. An analysis of land use indicates that the area of peatland in Devon is low, which mean emissions due to peat are also would lower (as would potential savings from peat management).
- Blue Carbon: Blue carbon is the carbon stored in coastal and marine ecosystems[61]. It is not currently included in the reporting of Devon's GHG footprint, nor is it considered in the CCC reports. Nevertheless, the consideration of the potential to use coastal habitats through the management of marine ecosystems within Devon's borders may offer some potential for GHG removal, and is an area that could be explored further.

[61] https://www.iucn.org/resources/issues-briefs/blue-carbon

9. Waste

92% of emissions from waste in the UK arise from methane the majority of which are emitted from the decomposition of biodegradable waste in landfill sites. As biodegradable waste is segregated in waste collection and landfill is ended emissions are forecast to decline. Devon County Council, which is responsible for Local Authority Collected Waste (LACW) (household and some commercial waste) in the County, stopped landfilling all but a very small fraction of LACW in Feb 2019 (although methane emissions from old landfill sites will continue for many years). LACW is now either recycled or used for energy recovery. However there is still a significant volume of commercial and industrial waste including biodegradable waste that is currently sent to landfill. The projected trajectory for GHG emissions from all waste in Devon is shown in Figure 22 (values for 2016, 2032 and 2050 are provided in Appendix A).

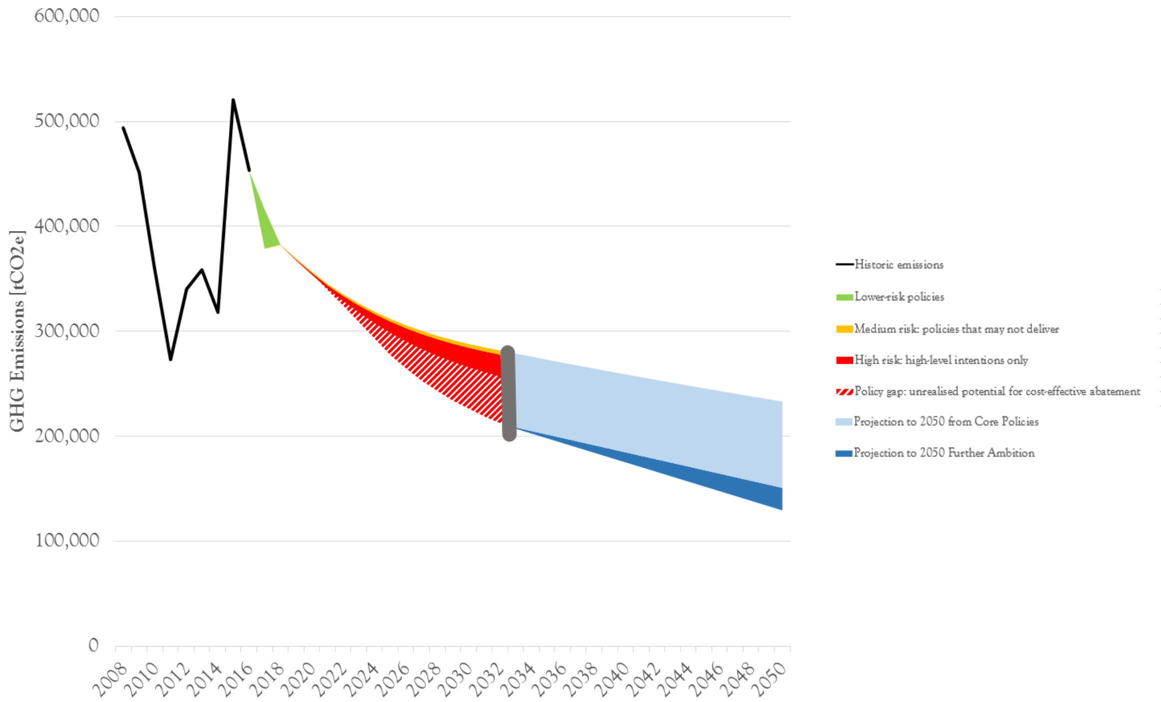

Figure 22: Projected GHG emissions in Devon's Waste sector to 2050 as a result of national policy (interpretation of graph is described in caption to Figure 1)

The large variation in historic emissions stems from landfill sources in the NAEI base data.

The CCC's least cost national pathway anticipates emissions falling by 56% between 2016 and 2030 through measures to reduce methane emission from landfill as shown in Figure 23.

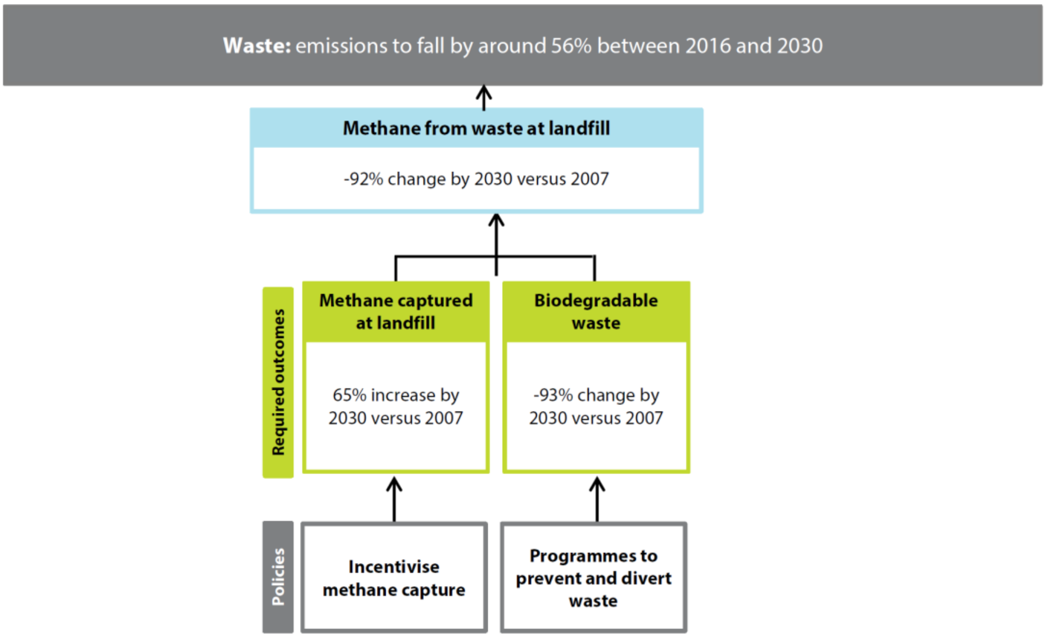

Figure 23: CCCs indicators for the UK waste sector[62]

9.1 Low Risk Policy to 2032

The CCC has not identified any low risk policies. All GHG reduction identified is either medium or high risk, or currently constitutes a gap in policy.

9.2 Medium Risk Policy to 2032

Medium risk policies are responsible for 6% of projected GHG reduction to 2032. The CCC has identified these as:

- Waste prevention.
- Elimination of biodegradable waste streams to landfill by 2030 in England.
- Recycling rates in England rise to 65%.

9.3 High Risk Policy to 2032

High risk policies are responsible for 30% of projected GHG reduction to 2032. The CCC has identified the following proposals for England in the Clean Growth Strategy as high risk:

- The ambition for the UK to be a zero avoidable waste economy by 2050.
- The intention to work towards no food waste entering landfill by 2030.
- The desire to explore innovative ways to manage emissions from landfill, including legacy sites.

9.4 Policy Gap Risk Policy to 2032

Policy gaps are responsible for 65% of projected GHG reduction to 2032. The CCC has identified these as:

- Banning biodegradable waste to landfill no later than 2025.
- Managing emissions from legacy landfill sites.

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[62] Taken from Figure 7.4 of the CCC 2018 progress report

9.5 Core Scenario to 2050

The CCC has identified the following core options that would be required to continue the 80% GHG reduction trajectory nationally:

- Elimination of biodegradable waste streams to landfill in England by 2030 (achieved in Devon for Local Authority Collected Waste).
- Household/municipal recycling rates in England rise to 65%.

9.6 Further Ambition to 2050

The CCC has identified the following further ambition options that would be required to continue the 80% GHG reduction trajectory nationally.

- A 20% reduction in avoidable food waste by 2025.
- Bio-degradable waste streams sent to landfill is eliminated by 2025 at the latest through a mandatory separate collection of bio-degradable waste by 2023.
- Waste water treatment plant to achieve a reduction in methane and N_2O emissions of least 20% by 2050 through incentive mechanisms for water companies.

Alternative approaches identified by the CCC include:

- A 20% reduction in avoidable food waste by 2025 rising to 50% reduction by 2050.

9.7 Opportunities for Accelerated Delivery in Devon

Based on projected and proposed action required to achieve net zero emissions by 2050, the following would need to be adopted or considered in Devon if a target of 2030 is required:

- Check status of all legacy and recent landfill sites and assess opportunities for additional methane capture and energy production. Maps of historic landfill sites are available[63].
- Instigate separate food / biodegradable waste collection in all districts in Devon with waste directed to AD to include households and businesses generating food/biodegradable waste.
- Ensure sufficient capacity for anaerobic digestion of Devon's food waste[64].
- Obtain reliable and up to date information on volume and composition of non-domestic waste streams to enable emissions assessment.
- Work with businesses , communities and individuals to share good practice and provide support to encourage behavioural change
- Reduced waste generation especially food waste with a 25% reduction from 2017 by 2025 to reduce waste collection and disposal emissions.
- Increase Devon's household/municipal recycling rates from the current 56% (Household waste) (South West 49.7%) to 70% by 2025 (from 2017) to reduce disposal emissions from energy from waste (EfW) facilities.
- Increase heat offtake from EfW plants to improve efficiency and reducing net emissions.
- Improve recycling of the materials that have been identified as having a higher carbon footprint – metal, textiles and plastics
- Identify processing gaps in wider South West region waste recycling and treatment facilities and make appropriate provision for particular materials where gaps are identified.
- Liaise with South West Water to achieve a reduction in methane and N_2O emissions of least 20% by 2030.

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[63] See https://environment.data.gov.uk/DefraDataDownload/?mapService=EA/HistoricLandfill&Mode=spatial

[64] Biodegradable waste comprises 60% of Devon's domestic residual waste

10. F-GASES

Fluorinated gasses (F-gases) account for a small percentage of UK GHG emissions (3% in 2017) and although released in small volumes they can have a global warming potential (GWP) up to 23,000 times greater than CO_2. The four F-gases included in the UK emissions inventory are hydrofluorocarbons (HFCs) 94%, sulphur hexafluoride (SF_6) 4%, perfluorocarbons (PFCs) 2% and nitrogen trifluoride (NF_3) less than 1%, of which HFCs were 94% in 2017. The largest source of emissions of HFCs is the refrigeration, air conditioning and heat pump sector (RACHP).

The projected trajectory for GHG emissions from F-gases is shown in Figure 24 (values for 2016, 2032 and 2050 are provided in Appendix A).

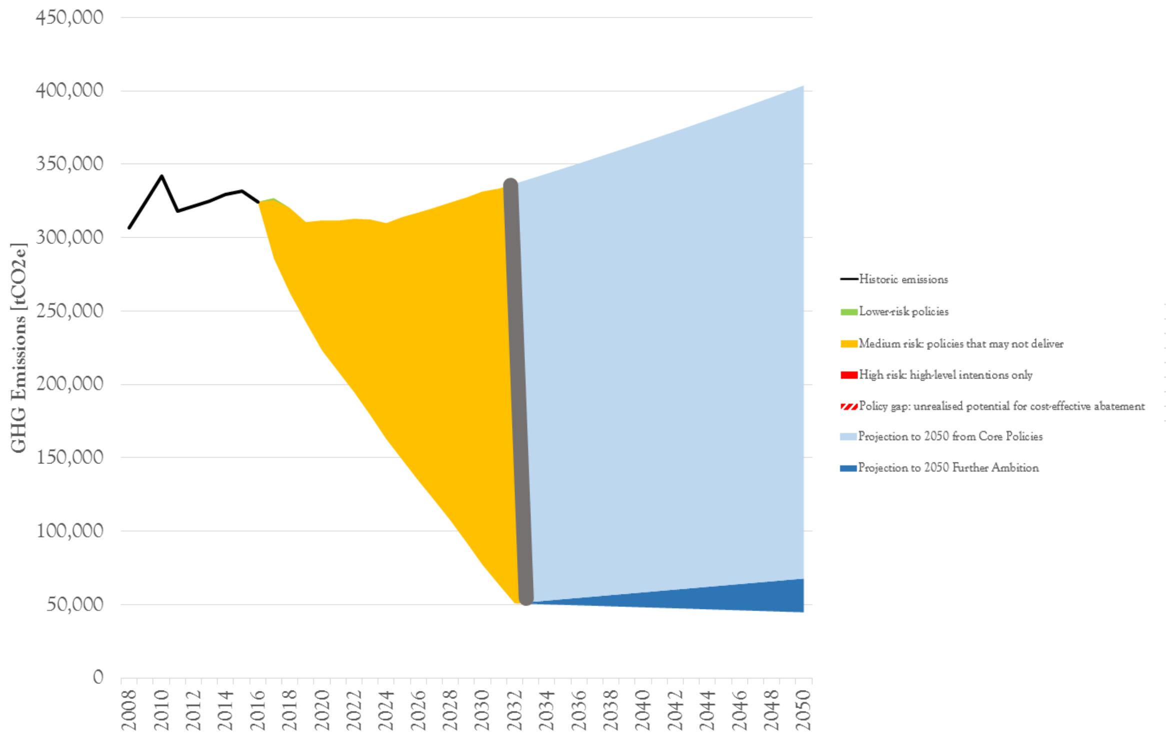

Figure 24: Projected GHG emissions in Devon's F-gases sector to 2050 as a result of national policy (interpretation of graph is described in caption to Figure 1)

Emissions from F-gases have been estimated in Devon by apportioning national emissions on the basis if the proportional sizes of non-domestic electricity emissions (as refrigeration, air conditioning and heat pumps are responsible for a high proportion[65] of these emissions). In addition, emissions from industrial and transport refrigeration are also significant. A bottom-up calculation of F-gas emissions in Devon would enable a better understanding of the particular issues associated with these emissions locally. The national strategy for reducing emissions from F-gases is summarised in Figure 25.

[65] https://www.theccc.org.uk/wp-content/uploads/2019/05/Assessment-of-potential-to-reduce-UK-F-gas-emissions-Ricardo-and-Gluckman-Consulting.pdf

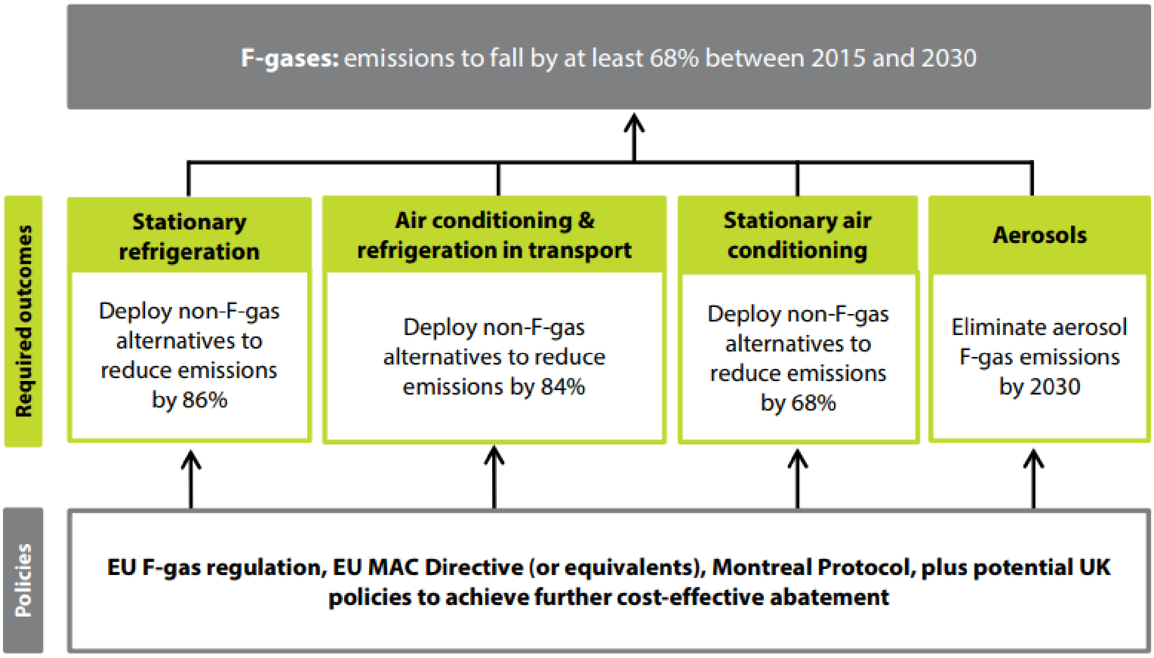

Figure 25: CCC indicators for the UK F-Gas sector[66]

10.1 Low Risk Policy to 2032

The CCC has not identified any low risk policies. All GHG reduction identified is medium risk.

10.2 Medium Risk Policy to 2032

Medium risk policies are responsible for all projected GHG reduction to 2032. The CCC has identified these as:

- Continue the UK's inclusion in the EU F-gas Regulation, or develop equivalent or stronger legislation in the UK.
- Deliver a plan to restrict the use of F-gases to the very limited uses where there are currently no viable alternatives.

10.3 High Risk Policy to 2032

The CCC has not identified any high risk policies. All GHG reduction identified is medium risk.

10.4 Policy Gap Risk Policy to 2032

The CCC has not identified any policy gaps. All GHG reduction identified is medium risk.

10.5 Core Scenario to 2050

The CCC has identified the following core options that would be required to continue the 80% GHG reduction trajectory nationally.

- A market cap on HFCs that is 79% below 2015 levels by 2030.
- Bans on the use of F-gases in many new types of equipment where less harmful alternatives are widely available.

[66] Figure 8.3 of the CCC 2018 Progress Report. Abbreviations: MAC mobile air conditioning

- Mandatory 'management measures' including regular leak checks and repair, gas recovery at end-of-life, record keeping, training and certification of technicians and product labelling.

10.6 Further Ambition to 2050

The CCC has identified the following further ambition options that would be required to continue the 80% GHG reduction trajectory nationally.

- In 2016 it was estimated[67] that UK F-Gas emissions from Metered Dose Inhalers (MDIs) were 1.0 million tonnes CO2 equivalent, based on a usage of 54 million MDIs11. This was approximately 6% of total UK F-Gas emissions in 2016. Around 40 million MDIs were prescribed in the UK in 2006, rising by 35% to reach the level of 54 million in 2016. This increase is at a considerably higher rate than the growth in population, which rose by 8% during the same period. Current EU F-Gas Regulation12 exempts MDIs from the EU HFC phase-down, hence there are no direct regulatory pressures on this application of HFCs. Without any change to the current prescribing practices usage and emissions will continue to rise slowly. The UK population is forecast to have risen a further 8% by 2030. A conservative estimate is a further 10% rise of MDI use by 2030, leading to a projected emission of 1.1 MT CO_2e. It is forecast that MDIs will represent over 25% of UK F-Gas emissions during the 5th carbon budget period. The Further Ambition scenario sees a transition from MDIs to dry-powder inhalers (DPIs) and low-GWP alternatives before 2027, which would reduce emissions by around 90%. In this scenario it is assumed that salbutamol MDIs are replaced with low-GWP alternatives due to their lower costs compared to DPIs.
- Additional regulations to deliver further reductions in the refrigeration, air-conditioning and heat pumps (RACHP) sector, including:
  - Reduced use of R-410A (GWP of 2,088) in medium sized air-conditioning, replaced with variable refrigerant flow (VRF) systems using lower-GWP HFC-32 (GWP 675).
  - Wider use of propane split air-conditioning.
  - Reduced use of Hydrofluoroolefin/HFC blends in small commercial, industrial and marine refrigeration.
  - Retrofitting of existing equipment that uses HFCs (R-134a systems and small R-404A systems).
  - Leak reductions through improved design, maintenance and end-of-life recovery.

10.7 Opportunities for Accelerated Delivery in Devon

Based on projected and proposed action that would be required to achieve net zero emissions by 2050, the following would need to be adopted or considered in Devon if a target of 2030 is required:

- Local measure to stop the use of F-gases in RACHP and other equipment
- Local enforcement of 'management measures' including regular leak checks and repair, gas recovery at end-of-life, record keeping, training and certification of technicians and product labelling

[67] Ricardo Energy and Environment 2019, 'Assessment of the potential to reduce UK F-gas emissions beyond the ambition of the F-gas Regulation and Kigali Amendment'

11. GHG Removal

GHG removal is not part of the CCC's annual Report to Parliament as the 80% emissions reduction required by the Climate Change Act does not necessitate GHG removal. There are therefore no current policies that apply directly to GHG removal and no current policy gaps per se.

Achieving net zero emission in the UK will require some level of GHG removal to mitigate residual emissions in difficult sectors such as agriculture and air transport. Given Devon's rural character there is significant potential for the County to mitigate its GHG emissions in the agriculture and land use sectors. Nationally the main projected savings from these sectors involves afforestation. This will require any replacement scheme for the Common Agricultural Policy to include payment of public money for the range of public goods that tree planting can deliver, and the creation of Forestry Investment Zones to incentivise afforestation. England's target for woodland cover implies an annual afforestation rate of 6,000 Ha/annum to 2060, whilst the CCC's scenario to 2030 in the Report to Parliament relies on 15,000 Ha/annum in the UK, increasing in the Net Zero core scenario to 27,000 Ha/annum to unlock further savings. The current annual tree planting rate in the UK is 7,000 Ha/annum. The area of Devon is 662,000ha which, if all forested, would sequester approximately 3,400 ktCO2e/annum[68] or 65% of the County's current emissions.

Peatland also has a role to play. The UK Peatland Strategy[69] targets two million hectares of peatland in good condition, under restoration or being sustainably managed by 2040.

For GHG removal involving use of timber and biomass the CCC emphasise that for removal to occur it will be critical to assure the sustainability of timber and biomass fuel and stress that this will require strong comprehensive standards. There is scope, the CCC asserts, that the domestic supply of timber and biomass fuel can promote biodiversity and resilience to climate change in UK landscapes without conflicting with food production.

11.1 Core Scenario to 2050

The Core Scenario includes:

- Continuing the rate of afforestation from the 2030 more ambitious rate of 27,000 Ha/annum nationally and planting trees on 1% of additional agricultural land by 2030.
- Using biomass with CCS (BECCS) for energy production removing 20 $MtCO_2e$ by 2050.
- Timber frame house and engineered wood system penetration remains at today's levels (15-28%).

11.2 Further Ambition to 2050

The Further Ambition scenario includes:

- Increasing the national tree planting rate to 30,000 Ha/annum Planting trees on 10% of farm land, extending hedges by 40% and restoring 55% of peatland area.

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[68] Based on Forestry Commission statistics. Combining 2017 estimate of the sequestration of UK forestry (interpolated between 19.8 $MtCO_2$ in 2015 and 21.1 $MtCO_2$ in 2020) and total woodland area in 2017 (3,166,000ha) gives a sequestration rate of 6.4tCO_2/ha/annum. Source https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2017 .

[69] The UK Peatland Strategy 2018 – 2040, IUCN National Committee United Kingdom Peatland Programme.

- Expanding BECCS in various applications to remove 51 $MtCO_2e$ using 173 TWh of resource.
- In 2050 timber framed new build houses rise to over 40%. Engineering wood systems reach 5% by 2050.
- Demonstrating direct air capture with carbon dioxide storage (DACCS). DACCS separates CO_2 from the air using chemical reagents. The separated carbon dioxide is then stored in geological formations (for example in depleted oil and gas fields). DACCS has large energy requirements and needs access to CCS infrastructure.

Speculative Options include:

- In the land use sector:
  - Reaching annual tree planting rates of 47,000 Ha/annum.
  - Further restoration of peatlands (75% uplands and 50% lowlands) and seasonal management of the water table on 25% of lowland peat.
  - Switching some crop production on lowland peat to paludiculture or 'wet-farming' (e.g. crops that can be grown in water) would allow the water table to be raised permanently and for emissions to fall compared to conventional crop production.
- Timber frame houses rising to 80% of new homes in 2050.
- Technologies such as biochar and enhanced weathering:
  - Biochar is formed by heating organic matter in low oxygen conditions, as in pyrolysis and gasification technologies. Biochar can be added to soils as a stable long term store of carbon which can also improve soil fertility.
  - Enhanced weathering is achieved by spreading ground up silicate rock over the land surface which naturally fixes carbon from the air. Crushing rock is energy intensive and there would be significant environmental concerns to be overcome before deploying this practise on any scale.
- DACCS deployment

11.3 Opportunities for Accelerated Delivery in Devon

Figure 2 and Appendix 2 illustrate that even with the most ambitious GHG removal scenario Devon is left with 124 $ktCO_2e$ of residual emissions.

Options for achieving GHG removal in Devon include:

- Localised CCS technologies which may evolve. Various technologies are currently being developed and trialled. Examples include:
  - Accelerated carbonation technology for the treatment of thermal residues[70]
  - Solvent based carbon dioxide extraction from flue gasses[71]
  - Carbon dioxide injection into fertiliser production[72]

  Techniques like these could potentially be applied to flue gases emitted from combustion plant in Devon e.g. the Marsh Barton EfW plant. The 2016 NAEI inventory reports 29 $kTCO_2e$ per annum CO_2 emissions from the Marsh Barton EfW. Capturing these emissions would for example sequester 23% of the 124$ktCO_2e$ of residual emissions in Devon.

[70] https://c8a.co.uk/about-us/ accessed 26/06/19
[71] https://www.drax.com/press_release/world-first-co2-beccs-ccus/ accesses 26/06/19
[72] https://ccmtechnologies.co.uk/technology accessed 26/06/19

- Increased use of timber in construction. As timber framed homes are currently a viable technology there would appear to be few barriers to pursuing this aside from the supply of sustainable timber required. Tree planting should therefore be encouraged in Devon.

12. Costs

12.1 Costs to Achieve Net Zero by 2050

As part of its analysis for the UK to achieve Net Zero by 2050, the CCC undertook a high level assessment of the costs and benefits of meeting the target. At a national scale, it was found that action was preferable to inaction, and that achieving Net Zero by 2050 would cost 1 to 2% of GDP in 2050, a similar to the cost to that estimated in earlier studies to achieve an 80% reduction by 2050. The CCC also found that there may be additional co-benefits (for example improved air quality or reduced thermal discomfort in buildings), as well as economic opportunities for the UK to exploit a growing global market. These additional benefits were not quantified.

The approach taken was to establish net carbon abatement costs in each sector and combine these with the projected sectorial carbon reduction to estimate the net cost of meeting the targets. These net costs are expressed as an annual cost in 2050 both in absolute terms and as a proportion of annual GDP in 2050. The CCC analysis does not present annual (net) cost profiles, only saying that any such profile would vary across sectors with costs likely to be lower in earlier years of the transition. The only quantitative indication of the cost trajectory is an estimate of 2030 annual cost of under 1% of GDP which compares to the 2050 the cost of Net Zero estimated at 1.3% of GDP. As the economy is projected to grow by 46% between 2030 and 2050, the implied annual cost in 2030 is approximately £27 billion, compared to £51 billion in 2050 (i.e. an almost doubling in spend is forecast over the period).

The CCC has calculated abatement costs in terms of resource costs. These have been established by adding up costs and cost savings from carbon abatement measures, and comparing them to costs in an alternative scenario (generally of a hypothetical world with no climate action or climate damages). The example given is that for a loft insulation project, the net cost would comprise the annualised cost of the installation and the annual cost savings. Therefore, if the measure pays back within its lifetime it would have a negative cost (a saving). Other co-benefits e.g. reduced cold related illness and downstream impacts on the health service, are not included in the assessment. This approach does not fully capture the structural shifts required when transitioning from one mode of operation to another, with the example given being switching from gas-fired power stations (whose costs are dominated by annual running costs) to wind power (whose costs are dominated by upfront costs which would require up-front financing). The CCC admits that its approach to costs is simplified and that economic models should be used to assess the impact of decarbonisation on GDP.

While this approach to calculating costs and benefits results in the establishment of high level overall costs (or benefits) for each sector, it masks the underlying costs and benefits, which in many cases do not fall to the same party. For example, insulating dwellings would result in savings to those occupiers who live in the homes which benefit from the insulation, but if publicly funded the cost would be spread across society as a whole e.g. via general taxation or through higher energy bills.

The approach taken to estimate the net cost to Devon has been to use the nationally calculated net costs and scale them to Devon based on the relative magnitude of emissions from each sector. For example, emissions from the Power sector in Devon are 0.3% of those nationally, so that factor was applied to the net cost of achieving Net Zero nationally (£4 billion under the Further Ambition scenario) to estimate the local net cost (£48million). The underlying assumption is that the costs and benefits assumed in the national calculations apply at a local level. In the example of the Power sector, whilst almost all of the decarbonisation occurs outside Devon (e.g. offshore wind farms), it is assumed that the financing of those projects (and resultant benefits) are proportionate to power use in Devon relative to the country as a whole. This is a simplified approach intended to provide a first order estimate of the economic impact on Devon.

For context, the 2017 the GVA of Devon's businesses totalled £16.3bn. Figures 26 and 27 show the GVA split by business sector[73]

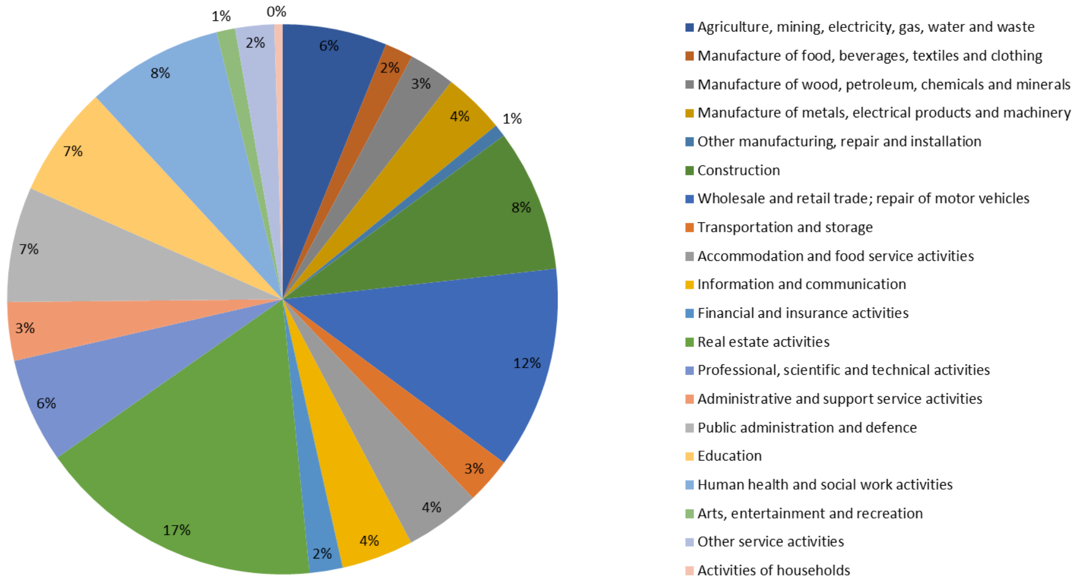

Figure 26: GVA of businesses in Devon in 2017 by sector in %

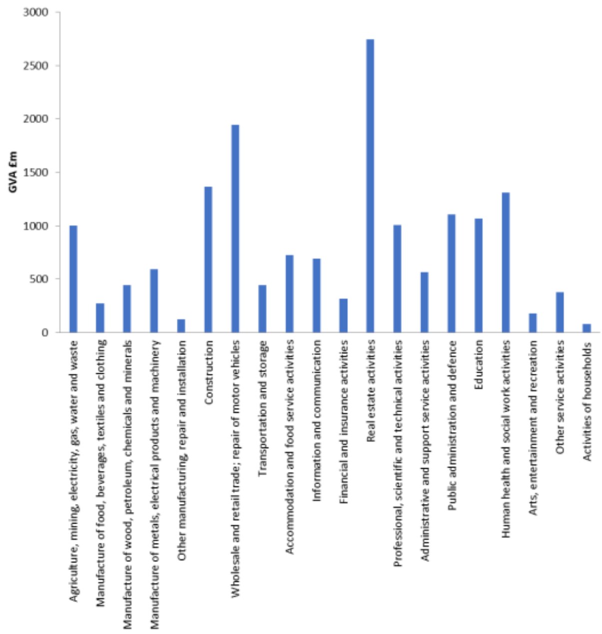

Figure 27: GVA of businesses in Devon in 2017 by sector in £m

[73] See https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/regionalgrossvalueaddedbalancedlocalauthoritiesbynuts1region

The apportioned 2050 costs for Devon meeting net zero are shown in Table 4. Achieving the Further Ambition scenario would hypothetically result in a net cost of £492 million with a further £166 million to achieve Net Zero using GHG removal technologies; a total of £658 million. This equates to 1.6% of Devon's GDP in 2050, or approximately £717 per head of population in that year. The proportion of GDP calculated for Devon is higher than the 1% national average which partly reflects the different composition of the carbon footprint, and the lower GDP of Devon compared to the UK average. Net costs vary between sectors both in magnitude and direction (some are net costs and some a net benefit).The cost of the Further Ambition scenario is always more expensive than the Core scenario as the magnitude of carbon reduction is greater, and the measures required for the further quantum of carbon reduction are harder and therefore more costly to achieve.

The following underlying cost factors have been identified by the CCC for each of the sectors, and separated into those sectors where net cost is expected to be marginal or negative, and those that it is projected to be expensive.

Sectors with low or negative abatement costs:

- Power: Net costs are low as although significant capital investment will be required for reinforcement of the transmission grid and, for the deepest emissions reduction, expensive CCS and hydrogen infrastructure will be required, these are almost offset by fuel cost savings from renewable energy (compared to conventional fossil fuel power generation). The cost of decarbonising electricity is borne via levies in the energy bills of householders and businesses. The CCC indicate that decarbonisation will add between £85 – £120 per year to energy bills between 2016 and 2030. Householders could offset this by £150 through efficiency savings from replacing lighting, appliances and boilers at replacement periods. While demand reduction is a separate issue from decarbonising supply (i.e. bills would be even lower without the decarbonisation) the argument is that maintaining energy bills at current levels would be broadly tolerable. Projecting to 2050 the CCC's view is that on balance switching to electric heating and vehicles whilst decarbonising the electricity supply by developing more renewable energy capacity will be broadly cost neutral. However, how these costs are allocated at an individual level may mean that not everyone would experience cost neutrality going forward.
- Transport: Electric cars are expected to be cheaper to purchase than conventional cars by 2030, and in addition will be cheaper to run. Low-carbon HGVs could also offset their higher purchase costs through lower running costs. Buses are the only identified mode of transport within the sector with high net costs.
- Agriculture and Land Use: On balance, many of the proposed abatement measures result in enhanced productivity thereby resulting in a net-cost saving.
- Waste: The assumptions assume a reasonable cost in banning waste from landfill, though this is almost offset by the assumed benefit associated with reduced household waste.
- F-gases: It is assumed that the proposed measures have a small cost benefit.

Sectors with high abatement costs:

- Buildings: The costs associated in switching to heat pumps and additional insulation which in many cases will be on harder to treat properties are high even once savings are taken into account. Current national spend on rolling-out low carbon heating is £100 million, whereas the Net Zero scenario implies a national spend annual of £15 billion with deployment beginning before 2030. If apportioned to Devon this is approximately £181 million per annum (0.7% of Devon's GDP in 2030).

- Industry: Measures in industry are mainly focussed around heavy industrial processes and consist of switching to low-carbon fuels and CCS, both of which are expensive. There may be some savings associated with improved efficiency, though these are not identified in any detail. The competitiveness of UK industry would need to be considered in the context of these costs. If they are levied directly on industry then those industries may lose trade to competitors which do not meet the same level of carbon performance i.e. "carbon leakage" would occur. Handling emissions from this sector may therefore require emissions trading schemes.
- GHG Removal: Both BECCS and DACCS are expected to be expensive solutions. The cost of DACCS is almost trebled if imported biomass is used as opposed to domestically produced bioenergy. It has been assumed that the cost of this would be largely borne by industries that have not reduced their own emissions to zero, for example Aviation.

Table 4: Apportioned net costs for Devon in the year of 2050 (i.e. the aggregate cost will be much higher as there will need to be spending in every year to 2050) by sector expressed in absolute terms, as a proportion of GDP and per head of population in that year.

	Cost of Core (77% reduction)			Cost of Further Ambition (96% reduction)			Additional cost to Net Zero		
Sector	**Net cost (£million)**	**Net cost as % GDP**	**Net Cost £/capita**	**Net cost (£million)**	**Net cost as % GDP**	**Net Cost £/capita**	**Net cost (£million)**	**Net cost as % GDP**	**Net Cost £/capita**
Power	-28.6	-0.1%	-£31	47.7	0.1%	£52	0.0	0.0%	£0
Buildings	167.3	0.4%	£182	233.7	0.6%	£255	0.0	0.0%	£0
Industry	0.1	0.0%	£0	2.6	0.0%	£3	0.0	0.0%	£0
Transport	29.0	0.1%	£32	3.5	0.0%	£4	0.0	0.0%	£0
Agriculture & Land Use Change	23.8	0.1%	£26	96.6	0.2%	£105	0.0	0.0%	£0
Waste and F-gases	0.0	0.0%	£0	2.4	0.0%	£3	0.0	0.0%	£0
GHG Removal	31.9	0.1%	£35	105.2	0.2%	£115	165.7	0.4%	£181
Total	**223.6**	**0.5%**	**£244**	**491.7**	**1.2%**	**£536**	**165.7**	**0.4%**	**£181**

12.2 Costs to Achieve Net Zero by 2030

The work of the CCC is predicated around decarbonising the UK's economy by 2050. The proposed delivery programme is based on the current technology available, and forecasts of advances both in technology, and the cost of that technology. It has been shown in the previous sections that while there may be some areas identified in the CCC reports that Devon could choose to accelerate delivery to reach the proposed 2050 levels by 2030, there are likely to be other areas where Devon does not have that ability. This could be for a variety of reasons for example political (e.g. low carbon power generation is a national infrastructure programme and short of becoming an "energy island" Devon does not have control over the carbon intensity of the electricity grid) or technological (e.g. the mass roll-out of electric vehicles will depend on the global development of cost-competitive cars with ranges that meet the needs of most users which is outside of Devon's direct control, or the proposed technologies for GHG removal have not yet been commercially deployed).

The CCC scenarios assume that the country as a whole moves towards Net Zero in a coordinated way and that due to the wide take-up of measures across sectors, the associated technological fixes become cheaper over time. For example, between 2025 and 2050 nuclear energy is forecast to fall in price by 28%, air source heat pumps by 11%, batteries for electric vehicles by 32%, and fuel cells for HGVs by 40%. Even if it were technically feasible for Devon to accelerate the CCC programme from 2050 to 2030, the associated (net) costs reported by the CCC would be significantly higher for Devon.

In the absence of any other data, for indicative purposes the CCC cost data for decarbonisation to 2050 was apportioned to Devon as if the rate of delivery was significantly accelerated to meet the target by 2030. The inherent assumptions in this approach are:

- All the measures identified to meet Net Zero in 2050 are available for deployment in the run up to 2030. In practice this is not the case.
- The costs of deploying those solutions would be the same in trying to hit a 2030 target. This would not be the case, costs would be higher as Devon would not benefit from the learning associated with economies of scale that a coordinated national programme would deliver.
- There is the capacity both nationally and in Devon to develop and deploy the required decarbonisation measures.
- The cost profile is the same shape as for a programme that extends to 2050 (i.e. spend is higher towards the end of the period).
- As with Section 12.1 it is assumed that the cost (and benefit) of measures that would need to occur nationally fall proportionately in Devon.

The CCC's approach was taken to establish the net cost in 2030 that is to report the costs as an annual cost in the target year of decarbonisation. To achieve this, the programme was compressed into a much shorter period i.e. rather than from 2019 to 2050 (31 years), the programme would run from 2019 to 2030 (11 years), and so the rate was increased by a factor of 2.8. This factor was applied to the net costs from the 2050 Devon scenario and compared relative to the projected populations and GDP of Devon in 2030 (both of which were lower than the 2050 equivalents). The results are shown in Table 5.

Compared to meeting the target in 2050, the annual net cost increased from £658 million to £1,852 million and from 1.6% GDP in the target year to 7.1% GDP, equivalent to £2,181 per person. These costs are likely to be significantly understated, and in practice not all of the projected emissions reduction would be technically feasible in this timeframe. In addition, the up-front capital costs involved would be significantly higher as the CCC's net costs are inclusive of benefits. As these benefits do not necessarily align with the parties responsible for bearing the cost, the actual cost excluding any benefits (which could not be inferred from the CCC reports) is arguably more representative of the scale of the financing challenge that Devon could face accelerating beyond the national trajectory.

Table 5: Apportioned net costs for Devon in 2030 by sector expressed in absolute terms, as a proportion of GDP and per head of population in that year.

	Cost of Core (77% reduction)			Cost of Further Ambition (96% reduction)			Additional cost to Net Zero		
Sector	**Net cost (£million)**	**Net cost as % GDP**	**Net Cost £/capita**	**Net cost (£million)**	**Net cost as % GDP**	**Net Cost £/capita**	**Net cost (£million)**	**Net cost as % GDP**	**Net Cost £/capita**
Power	-80.5	-0.3%	-£95	134.6	0.5%	£158	0.0	0.0%	£0
Buildings	471.6	1.8%	£555	658.6	2.5%	£775	0.0	0.0%	£0
Industry	0.3	0.0%	£0	7.2	0.0%	£9	0.0	0.0%	£0
Transport	81.7	0.3%	£96	10.0	0.0%	£12	0.0	0.0%	£0
Agriculture & Land Use Change	67.2	0.3%	£79	272.2	1.0%	£320	0.0	0.0%	£0
Waste and F-gases	0.0	0.0%	£0	6.7	0.0%	£8	0.0	0.0%	£0
GHG Removal	89.9	0.3%	£106	296.3	1.1%	£349	467.0	1.8%	£550
Total	**630.1**	**2.4%**	**£742**	**1385.7**	**5.3%**	**£1,631**	**467.0**	**1.8%**	**£550**

13. Discussion

13.1 General

The estimates of projected GHG emissions across Devon have demonstrated the scale of action that would need to occur in order to reach net-zero emissions. The projections were, in the first instance, based upon a suggested national timeline of decarbonisation by 2050. This highlighted that there is still much uncertainty regarding measures and policies in place to achieve interim targets in 2032 based upon a trajectory of an 80% national reduction in emission by 2050, and that significant additional measures (the Further Ambition scenario) and GHG removal technology will be required to get to net-zero. GHG emissions projected to 2032 and 2050 that would arise assuming all measures assessed in the analysis were taken up are shown in Figure 28 and (on a proportional basis) Figure 29. It can be seen that currently emissions are approximately 6.5 $MtCO_2e$ from a range of sectors, though by 2050 almost every sector has been decarbonised with total residual emissions of around 1.7 $MtCO_2e$ which would need to be offset by GHG removal technologies.

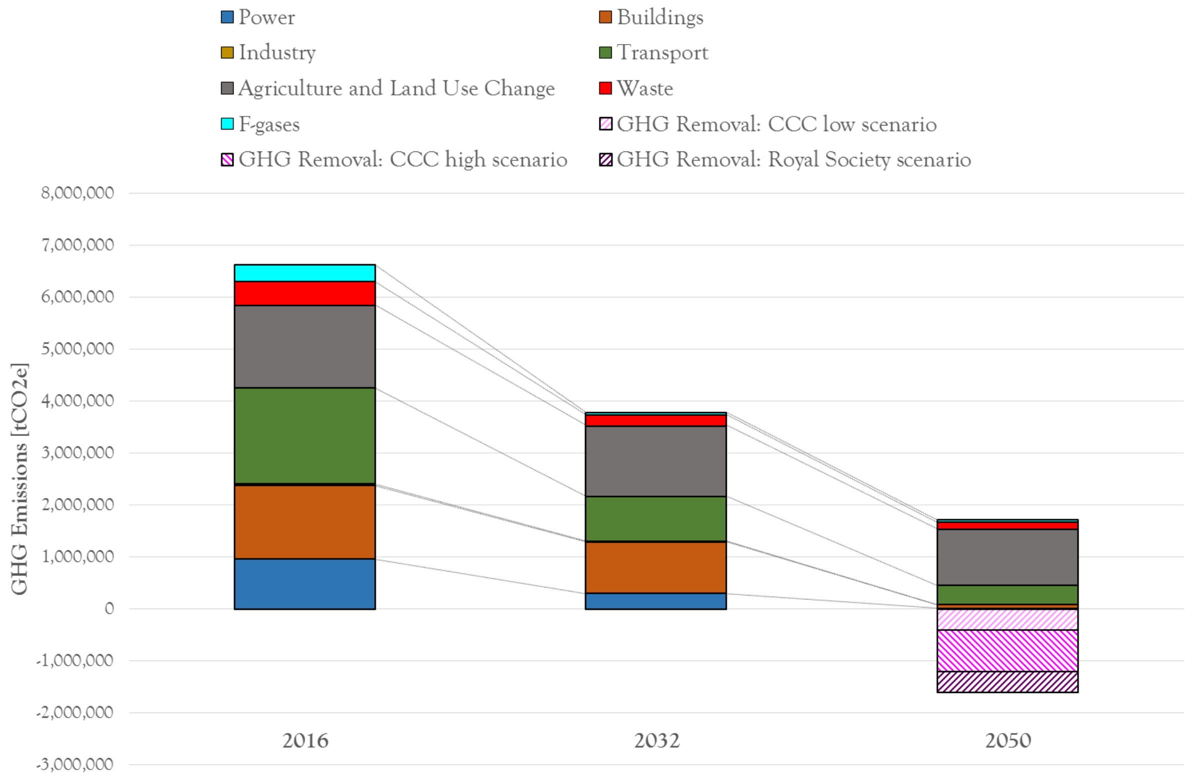

Figure 28: Current and projected residual emissions (tCO_2e) in Devon by sector in 2032 and 2050 based on the national timetable

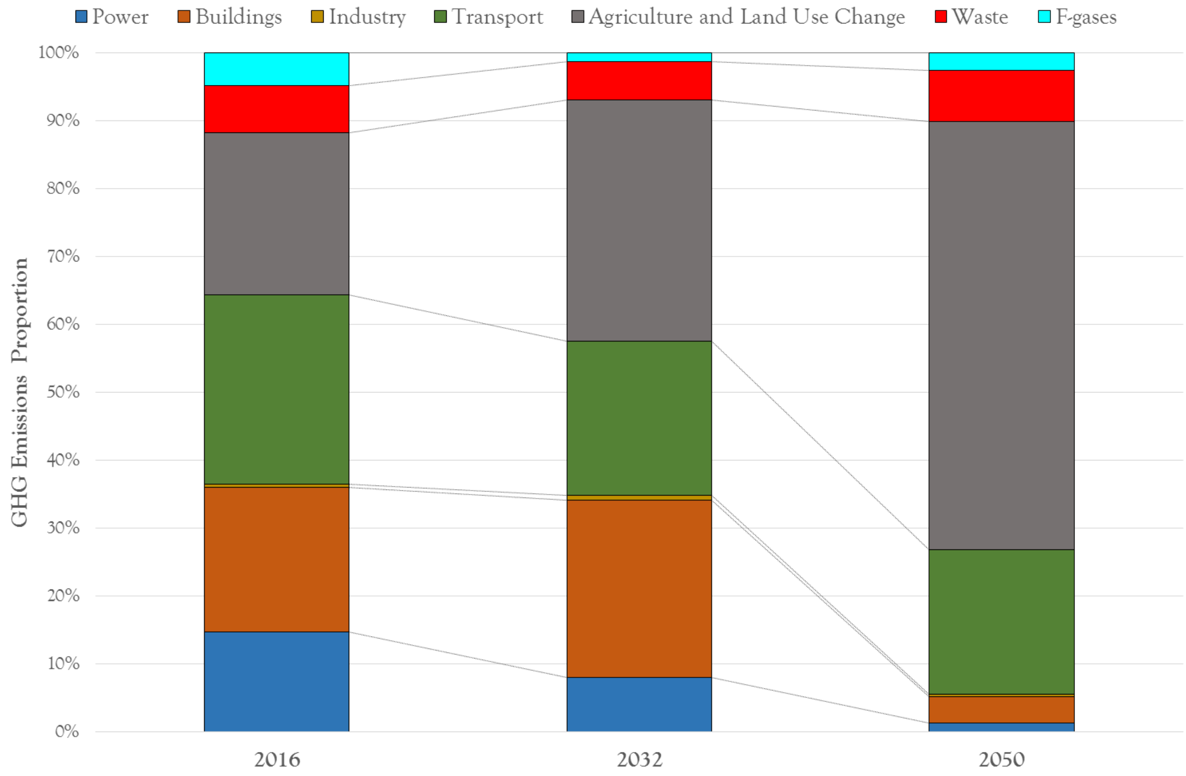

Figure 29: Current and projected residual emissions as a proportion of the total (excluding GHG removals) in Devon by sector in 2032 and 2050 based on the national timetable

Achieving the same amount of carbon reduction by 2030 would in effect require compressing the same measures into a timeframe that is only about a third as long. For some of the proposed measures where the technology is sufficiently mature (e.g. insulating all lofts and cavity walls) this might be possible, though it would require the funding mechanisms to do so, and there would also need to be local capacity for delivery. In addition, existing barriers that have already prevented such action from occurring would need to be overcome (e.g. in the case of these insulation measures, the lack of engagement from some property owners). In other cases, faster deployment may be possible but would face increased cost and other barriers. For example, electric vehicles are currently available but they are significantly more expensive than their conventional counterparts, and suffer from reduced ranges and lack of widespread charging infrastructure. In other cases, the technology may not yet be sufficiently developed to implement now e.g. some of the proposed GHG removal technologies.

These issues are significant when considered at a national level, but would be exacerbated if Devon were to pursue this timeline independently of the planned rate of change nationally. This would mean that many of these measures would need to be deployed without the support of national policy (e.g. regulation or financial rewards) and in many cases would rely on utilising technology that may not be sufficiently developed (or that is very expensive) to achieve the requisite amount of GHG emission reduction. These issues in general relate to the deployment of technological solutions (e.g. electricity generation, insulation, electric vehicles, GHG removal etc.), and so if any of these identified solutions do not prove to be possible at the scale required, then additional measures would be required. These may be from other sectors (i.e. "over delivery" in one sector to offset shortfalls in another), or could require voluntary actions by citizens and businesses in Devon to reduce demand. Examples of this could include reducing travel, accepting lower temperatures in buildings, decarbonising industry etc. Clearly, these have a significant political dimension, would not be possible in many areas and would be fiercely opposed by many due to loss of GVA, jobs, comfort, amenity etc. In some cases (e.g. deindustrialisation), there is also the risk of "carbon leakage" i.e. those processes simply moving to another geographical place and creating emissions there.

The analysis has not been able to separate technological from behavioural measures due to the way the CCC has aggregated emissions reduction. It is also important to note that in many cases, behavioural and technological changes need to occur together (e.g. people need to both switch and adapt to electric vehicles), and that even it is not always possible to assign savings to one of the two when they act together. For example, if travel distances by private car are reduced by 10%, and 30% of cars switch to electric versions, then the cumulative impact can be calculated, but the relative reduction from each will depend on which has been presumed to occur first (i.e. emissions from the behaviour action will be greater if it is assumed to have occurred before the switch to electric vehicles has occurred).

The analysis has been based on emissions in Devon on a "production" rather than a "consumption" basis. It has been shown that at a national level the latter results in emissions that are over 1.6 times higher. Care needs to be taken to understand and communicate what net-zero emissions means in the context of Devon. In the case of emissions on a "production" basis this refers to all emissions arising due to activity within Devon. For example, any energy consumed in buildings or industry, any transport in the territory, etc. In the case of emissions on a "consumption" basis this would include emission from imports and exclude emissions from exports of goods and services. As Devon is a net importer of goods and services, emissions would be higher on this basis. Both accounting measures have advantages, and arguably measuring on a consumption basis is a better reflection of Devon's impact, though it is harder to measure and potentially less easy to influence (e.g. if goods are being produced globally). Accounting for emissions on a production basis (as is undertaken at a national level in terms of reporting progress against the Climate Change Act) means that emissions from sectors like Power and Agriculture are heavily influenced by action outside the territory. In the case of power, the carbon intensity of any electricity consumed in Devon is reliant on the mix of generating technologies that occurs across the national electricity grid. Whilst Devon can set additional targets (e.g. Devon should be 100% fed from renewable electricity) installing more renewable generation capacity in the territory would not in itself reduce emissions materially locally.

The analysis has clearly shown that significant action is needed across every sector in Devon to achieve the deep emission reduction that would be required by 2030. Should it not be possible to achieve carbon reduction in any particular sector then this would require additional reduction to be achieved in other sectors. Whilst there are significant challenges in meeting this level of reduction, particularly within an accelerated timescale, there may also be some opportunities specific to Devon. Some of the key drivers and messages from the sectors considered are discussed below.

13.2 Power

The power sector is the sector that has seen the greatest emissions reduction over the past decade. This has been driven almost entirely by the reduced carbon intensity of the national grid, due to a significant switch away from coal fired powered stations, and increased amounts of renewably generated electricity. Whilst Devon continues to be connected to national electricity infrastructure (and it is not proposed that Devon should become an "energy island"), decarbonisation of the sector will be reliant on further uptake of renewable power generation, principally from large offshore wind, CCS and nuclear energy at a national scale.

13.3 Buildings

Buildings is a significant sector representing 21% of Devon emissions. Decarbonising the Buildings sector in Devon will require minimising emissions from new buildings, as well as practically insulating all existing buildings and switching their heating systems to low-carbon alternatives. Regarding new buildings Devon faces similar challenges to elsewhere in the UK, namely that standards for new development broadly sit within the requirements of national planning policy and building regulations. Currently local authorities are not able to require new dwellings to achieve standards in advance of approximately Code 4 of the now defunct Code for Sustainable Homes. It has recently been shown that the cost of requiring "zero carbon" for new developments is relatively small compared to the average profit per dwelling achievable by volume house builders. Devon could look to test this by requiring all new development to meet a "zero carbon" standard. It is especially important that this is enacted as soon as possible, given the lag between the granting of planning permission and the building out of pipeline developments that persists in the construction sector.

Existing buildings will need to be insulated. This will involve identifying and insulating all uninsulated cavity walls and lofts (including further top-ups to lofts), and insulating most solid wall properties. This is likely to be an expensive task; the cost of external solid wall insulation alone costs[74] £6,500 to £13,000 per dwelling whilst addressing a property in a more holistic way e.g. using the Dutch *Energisprong* method currently costs £65,000 per property with a target of £40,000 through prefabrication, smart technology and economies of scale[75]. This is in-line with provisional cost estimates emerging from Devon's *ZEBCat* project[76] of £35,000 to £70,000 per property. To address approximately 72,000 solid wall dwellings in Devon at £40,000 a property would cost £2.9 billon (15% of Devon's current GVA). Although the intention would be for installations to be funded by repayments to be made on an energy plan over a long period (payback periods of 30 years proposed), this still represents a significant investment. Time will tell if the lessons from *ZEBCat*[77] can rolled out across Devon. As well as financing insulation programmes, there will also need to be sufficient local skills and capacity to install the measures.

These levels of efficiency improvements will be required in order to reduce both energy demand and peak heat loss, the latter being important for heat pumps. The efficiency of heat pumps is severely compromised if they have to operate at higher temperatures to overcome high heat loss, which would in turn increase the amount of electricity required. This would both increase energy bills (and worsen payback periods), and require an increased amount of low carbon electricity upstream. Alternative pathways to decarbonising heating systems include heat networks or an increased use of hydrogen to replace gas fired heating systems, though the development of hydrogen systems will need to be coordinated at a national scale.

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[74] http://www.nef.org.uk/knowledge-hub/energy-in-the-home/solid-wall-insulation
[75]https://www.cibsejournal.com/case-studies/a-forward-leap-how-dutch-housing-process-energiesprong-guarantees-performance/
[76] https://www.green-alliance.org.uk/resources/reinventing_retrofit.pdf
[77] https://www.devon.gov.uk/energyandclimatechange/saving-energy/zero-energy-building-catalyst

Whilst the arguments put forward have been predominantly in the context of residential buildings, it is also presumed that emissions from non-domestic buildings are also all but eliminated, predominantly through efficiency measures where possible, and switching to similar low-carbon heat sources as for dwellings.

In addition, further carbon reduction is projected to be achieved due to the improving efficiencies of lighting and equipment that is used within buildings, though this development is part of global technological development and not an area Devon can realistically accelerate. If decarbonisation from buildings cannot be achieved entirely using efficiency and low carbon heating systems, then the only other available option available would be to reduce demand for energy, with heat being the most significant end use. Examples of this include accepting lower internal temperatures, washing less etc. and are likely to be unpopular and difficult to implement at scale.

13.4 Industry

Direct industrial emissions arise predominantly from industrial activity in the production sector of Devon's economy (although emission associated with this sector are higher as emissions from electricity are aggregated with other non-domestic buildings in the Buildings sector as this is how the data is reported by BEIS). Initial analysis has suggests that one large emitter may be responsible for over half the County's direct industrial emissions. Opportunities for emission reduction are identified as CCS for large industrial emitters as well as electrification and bioenergy for heat, and general unspecified energy efficiency improvements elsewhere. It is especially important for this sector that the cost of any carbon abatement over business-as-usual can be funded, otherwise this would place Devon's businesses at a competitive disadvantage which would both harm Devon's economy, and ultimately would result in business moving elsewhere and continuing with producing goods without reducing emissions (i.e. carbon leakage). Once any low regret/"low hanging fruit" measures have been implemented, this would require the identification of funding (e.g. from local, central or European budgets) to fun decarbonisation measures.

A Climate Emergency gives the Council a mandate to convey the concern of citizens to Devon's industry. This will require getting closer to and deepening the understanding of industry across the County. An opportunity for Devon to proactively target emission reduction from this sector could involve funding a specialist unit which would develop relationships with the larger emitters in the County and run a programme to reach smaller industrial emitters based on a detailed understanding of Devon's industry. Prioritising sectors by energy intensity is recommended.

13.5 Transport

Transport is a significant source of emissions in Devon (28%) and under the net-zero scenario is still projected to be responsible for 21% of the residual emissions. This assumes that emissions from transport are reduced by around 80%. The main driver of this change is the shifting from conventional to electric vehicles (which also assumes a decarbonised electricity supply). This transition will require that conventional vehicles are no longer sold. Given that the average lifespan of cars is 14 years, with a 2030 target, this would require that halting the sale of conventional vehicles commences now (unless it were possible to scrap these cars by 2030, though this would be a waste of the embedded emissions). Nationally, the target for banning such cars is 2040. Even if this could be achieved now in Devon (the local authority does not have this power and so it would require behaviour change), the higher cost (which is expected to become neutral by 2030) and poor range are significant barriers. The area where local action could be proactively taken is in the provision of charging infrastructure where an annual spend of at least £10.2 million per annum between now and 2030 would be required.

The scenario assumes a 10% modal shift (by distance travelled) from private car use by 2030. This would require extensive investment in public transport including zero carbon buses which at present not cost-competitive. Freight emissions from HGVs are a significant source of emissions (around 15% of transport emissions nationally) and aside from switching to hydrogen vehicles (not currently cost competitive) and/or bio-methane, Devon could proactively seek to work with bodies such as the Freight Transport Association and the Road Haulage Association, as well as local hauliers directly, to make improvements to logistics. This may also result in co-benefits with regard to congestion and local air quality.

Failure to deliver these actions would necessitate either deeper emission reductions in other sectors, or reductions within the sector through reducing the demand for travel. As it is not possible to obligate reductions in travel, this would need to be a voluntary course of action delivered at scale by Devon's citizens and businesses. Doing so, if it were possible, would have significant economic and social impacts.

13.6 Agriculture and land use change

Agriculture is Devon's largest emitter (27.9%) and only when combined with land use change (24.0%) does the combined sector fall marginally below transport (27.8%). By 2050 the combined sector is far more important as because as other sectors decarbonise agriculture and land use change become responsible for 63% of residual emissions. This highlights the specific challenges associated with carbon abatement within the sector as the majority of emissions from this sector arise from farming of ruminant livestock.

Importantly a significant proportion of agricultural emissions from livestock farming occur in the form of methane which is a short lived greenhouse gas. As such in respect to Devon achieving carbon neutrality, methane emissions from agriculture do not need to be rapidly brought to net-zero, but rather stabilised and then slowly decreased to prevent continually increasing global average temperature.

Some emission reduction would be possible through improved farming and land management practices. These need to be explored in greater detail, but there is a wealth of experience in Devon's farming community. Otherwise, changes to diets resulting in reduced farming of livestock could also significantly reduce emissions from agriculture in Devon. These changes in diet would need to occur more widely than in Devon, given that meat and dairy produce is exported beyond Devon's borders. Though if the amount of meat and dairy consumed by Devon's citizens did considerably decrease then this would likely reduce the amount of livestock farmed in Devon to some extent, though it has not been possible to quantify this here. Significantly changing diets in this way would have economic impacts on the sector and impact on amenity for citizens, and it may not be possible for this sort of social change to be significantly accelerated on locally compared to the underlying national change. Although not accounted for within this sector specifically, the use of agricultural land to generate low carbon electricity (e.g. wind, PV or on-farm anaerobic digestion) represents a further opportunity where Devon can proactively seek to reduce emissions.

Regarding land use change, currently the land mix results in a net sink (under 4% of the total footprint). To meet the decarbonisation scenarios within Devon's boundaries would require planting forest on 0.6% of total Devon land area every year to 2030 (i.e. 3,600 Ha/annum in Devon in 2030). There may also be specific local opportunities regarding management of peatland, and using coastal and marine ecosystems to sequester carbon, though this would require further analysis.

13.7 Waste

Even with the measures anticipated by 2050 the waste sector is projected to be responsible for 8% of Devon's emissions (currently 7%).

Waste generation (especially food) should be reduced by 25% by 2025. This will require a strong element of behaviour change which could be supported by local campaigns. Further reductions should be targeted in an effort to reduce 2050 emissions projections.

Devon's recycling rates should be increased from the current 56% which, although above the South West rate of 49.7%, fall short of the 65% national target needed to reduce emissions from waste collection and treatment. Increasing plastic recycling will reduce fossil content in black bag (residual) waste (e.g. plastics) and consequently reduce fossil emissions EfW facilities, Increasing heat offtake from EfW plants improves their efficiency also reducing net emissions.

A county wide collection regime that separates food waste should be established and the food waste collected should be processed using anaerobic digestion with the methane produced optimally utilised.

In addition, it should be ensured that all legacy and recent landfill sites are capped, and that the methane is utilised.

13.8 F-gases

Emissions from F-gases (currently 5%) are a relatively small part of Devon's footprint. However, under the net-zero scenario, the decarbonisation of other sectors means that the F-gas contribution continues to play a role (3% by 2050). The sector is driven by national and international legislation, that outlaws refrigerants of various types and mandates inspection regimes and testing. There is therefore relatively limited scope for Devon to accelerate emission reduction from F-gases. It is noted however that air conditioning inspections (which are required for any system with a rated output of over 12 kW) are enforced by the local trading standards bodies (Devon's district councils). More proactive enforcement of these air conditioning inspections may be a route to lower emissions.

13.9 GHG Removal

The projected pathway for decarbonisation results in residual emissions in Devon of approximately 1,720 MtCO_2e. These emissions would need to be offset with GHG removal measures to achieve net-zero emissions. The CCC scenarios investigated are dominated by biomass CCS and in the case of the Royal Society scenario, direct air CCS. These are likely to be approaches that are taken up at a national level, and that being the case it would be reasonable for Devon to claim a proportionate share of those savings. However the nature of Devon's emission, especially the dominance of agricultural emissions in 2050 leads to none of the CCC's removal scenarios achieving net zero. In Even with the most extreme scenario some 124kt of residual CO_2e remain to be removed in 2050.

If Devon were to pursue a 2030 deadline, then it would need to develop GHG removal measures within the territory. Extensive tree planting and technology based solutions are likely to be required. There are some emerging localised CCS techniques that are being developed and these could potentially be applied to flue gases emitted from combustion plant in Devon e.g. the Marsh Barton EfW plant.

13.10 Next Steps

The costs presented in the analysis are based on the values ascribed nationally by the CCC. These costs are net of any financial benefits (though do not consider further co-benefits e.g. improvements to air quality). These costs and benefits are also stated to not fall equally across society. For example, a domestic insulation programme that is funded for through energy bills (or subsidised by a local authority) would result in the cost being borne by society whilst the financial benefits would accrue only to those dwellings that receive insulation. For these reasons, it has not been possible here to obtain a gross cost of carbon reduction within each sector or for each measure. The analysis undertaken is “top down”, in that it allocates carbon reduction and costs from a national to a local level. This presumes a number of issues that may not be specifically true in the case of Devon, but the approach is nonetheless useful in providing an initial indication of the extent of the action required to achieve net-zero, given the source information available.

In order to estimate the gross cost of each measure then a “bottom up” measure-by-measure analysis would be needed. This would need to establish specific costs for all aspects of each measure. In the case of some measures these may not be available e.g. if the measure is not yet commercially developed and Devon is seeking to deploy earlier than nationally. Whilst measurement of costs on a gross basis would be more useful in terms of practically gathering budgets carbon reduction programmes, the presentation of the findings in net terms better demonstrates the strategic value within Devon of decarbonisation.

The next step should be to undertake further “bottom up” work to establish more specifically the amount of GHG emissions reduction that could be achieved. This analysis should include envisaged costs and savings and should be based on locally available resource assessments across each sector. It may be worthwhile separating this piece of work into an analysis of each sector.

These analyses should look to engage more widely with stakeholders in Devon to utilise the locally available expertise. Devon has made great progress in this having already established the Devon Climate Emergency Response Group and appointing a Net-Zero Task Force to develop a Devon Carbon Plan. The process will also involve a citizen’s assembly which will deliberate on the plan.

Budgets have been made available to support further evidence base analysis and wider public engagement processes.

The Carbon Plan will need to contain sector specific action and delivery plans, which would identify a programme of measures, the stakeholders required to deliver those measures, and identification of budgets or alternative routes to finance the measures.

The table below provides a summary of initial priority actions identified from this work as a starting point.

Indicative list of priority areas for Net Zero

Sector	Immediate Priority
General	Undertake a policy mapping exercise of current and proposed policy to establish where it supports or hinders carbon reduction and identify key gaps.
General	Produce sector-by-sector "bottom up" projections of GHG emissions using detailed local data.
Power	Undertake an up-to-date review of potential for renewable energy development and include RE development sites in the local plan.
Power	Work with WPD and others to ensure electricity infrastructure is capable of meeting increased local energy generation and demand for electricity from the heating, industry and transport sectors.
Power	Planning policy should ensure all new buildings are connected to the electricity network via three-phase supplies.
Power	Look to trial and support smart electricity projects, including those with battery storage aspects.
Buildings	Investigate opportunities to require zero carbon from all new planned development.
Buildings	Undertake a bottom-up assessment of opportunities for insulation in existing dwellings by tenure, and seek to make use of existing ECO funding whilst lobbying for more ambitious national insulation programmes.
Buildings	Pro-actively enforce the MEES (Minimum Energy Efficiency Standards) which apply to all privately rented dwellings and non-domestic buildings.
Buildings	Seek to engage the non-domestic sector by working with landlords and institutions like the Chamber of Commerce to identify the potential for retrofitting existing non-domestic buildings.
Buildings	Create a renewable heat strategy by appraising the potential for low carbon heat networks, heat pumps, and hybrid boilers, including identifying current potential funding models and barriers to uptake.
Buildings	Work in partnership with large energy users in the non-domestic sectors including health and education sectors to share best practice in energy reduction
Industry	Support identified large emitters with carbon reduction activities.
Industry	Undertake a detailed review or business activity in the county to identify energy-intensive industrial users.
Industry	Appraise the potential for low carbon industrial zones (LCIZ)
Transport	Explore ways to promote the uptake of EVs e.g. via reduced or free parking, permissive use of bus lanes etc.
Transport	Work with partners to plan and develop charging infrastructure across the county in key public and work places and include plans to address the tourism sector

Sector	Immediate Priority
Transport	Seek to shift trips from private car to lower carbon alternatives such as walking, cycling, car clubs and public transport.
Transport	Work with bodies such as the Freight Transport Association and the Road Haulage Association as well as with major hauliers and haulage clients directly to reduce emissions from freight movement, for example by planning consolidation centres.
Transport	Work with bus providers to consider the business case for replacing the existing bus fleet with zero carbon variants e.g. by following London's example.
Agriculture land use & forestry	Use County farms to pioneer changes in on farm practises to reduce methane and nitrous oxide intensity of crops and livestock farming and work with landowners and NFU to roll out countywide. Promote the adoption of low-impact diets.
Agriculture land use & forestry	Support the development of on-farm bio-methane collection and use with a focus on supplying bio-methane for farm machinery. Deliver on County farms together with electrification and building energy efficiency measures.
Agriculture land use & forestry	Use the planning system to identify preferred areas for tree planting and peatland restoration which match the required scale, adopt planning policies which prioritise afforestation and peatland restoration and apply on county owned land.
Waste	Check status of all legacy and recent landfill sites and assess opportunities for additional methane capture and energy production.
Waste	Drive forward increased separation of food/biodegradable waste collection with waste directed to local Anaerobic Digestion facilities.
Waste	Develop local promotion campaigns with the aim of reducing waste generation (especially food waste) with a 25% reduction by 2025 and to increase household recycling rates (especially plastics) from the current 56% to 65% to reduce disposal emissions from EfW.
Waste	Increase heat offtake from EfW plants to improve efficiency and reducing net emissions.
Waste	Identify processing gaps in wider South West region waste recycling and treatment facilities and make appropriate provision for particular materials where gaps are identified.
Waste	Develop a much better understanding of commercial waste generation and treatment in the county to enable monitoring and regulation with the aim of reducing waste volumes and increasing recycling.
Waste	Liaise with South West Water to achieve a reduction in methane and N_2O emissions of least 20% by 2030.
F-gases	Pro-actively enforce Air Conditioning inspections for all systems with an effective rated output in excess of 12 kW.
GHG Removal	Identify potential sites where trial of GHG removal technologies may be viable and seek to capture central government funds in partnership with technology providers to host prototypes.

APPENDIX A: DEVON'S HISTORIC GHG EMISSIONS

Devon's GHG historic GHG emission trends are shown by GHG on Figures A1 and by sector in Figure A2.

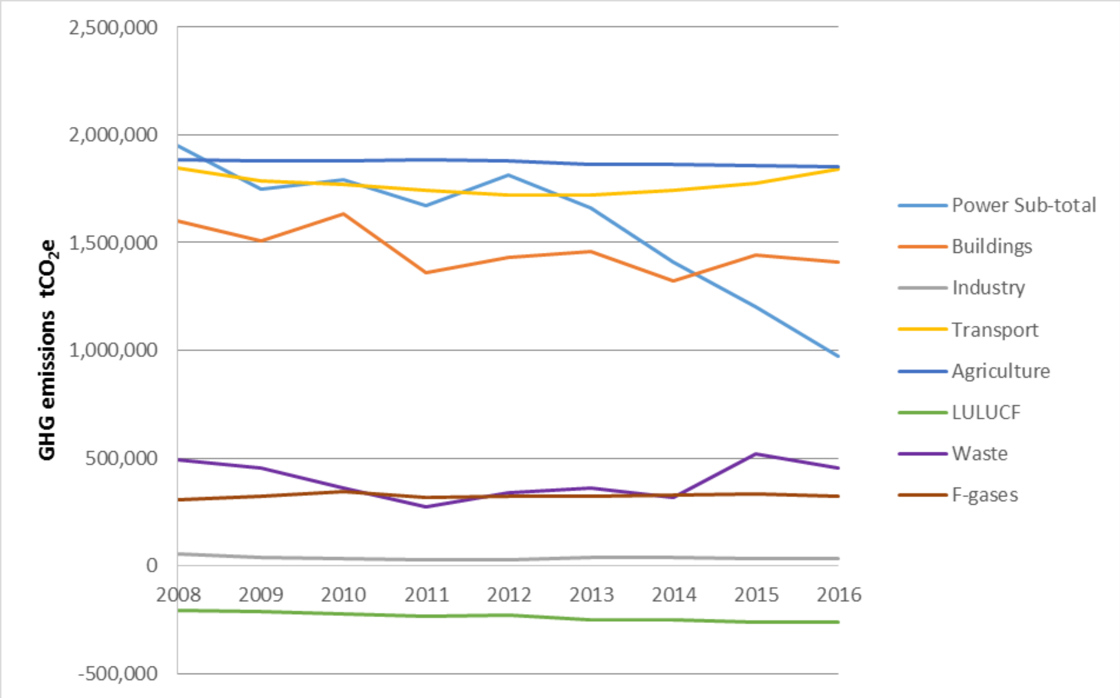

Figure A1: Devon's emissions by GHG

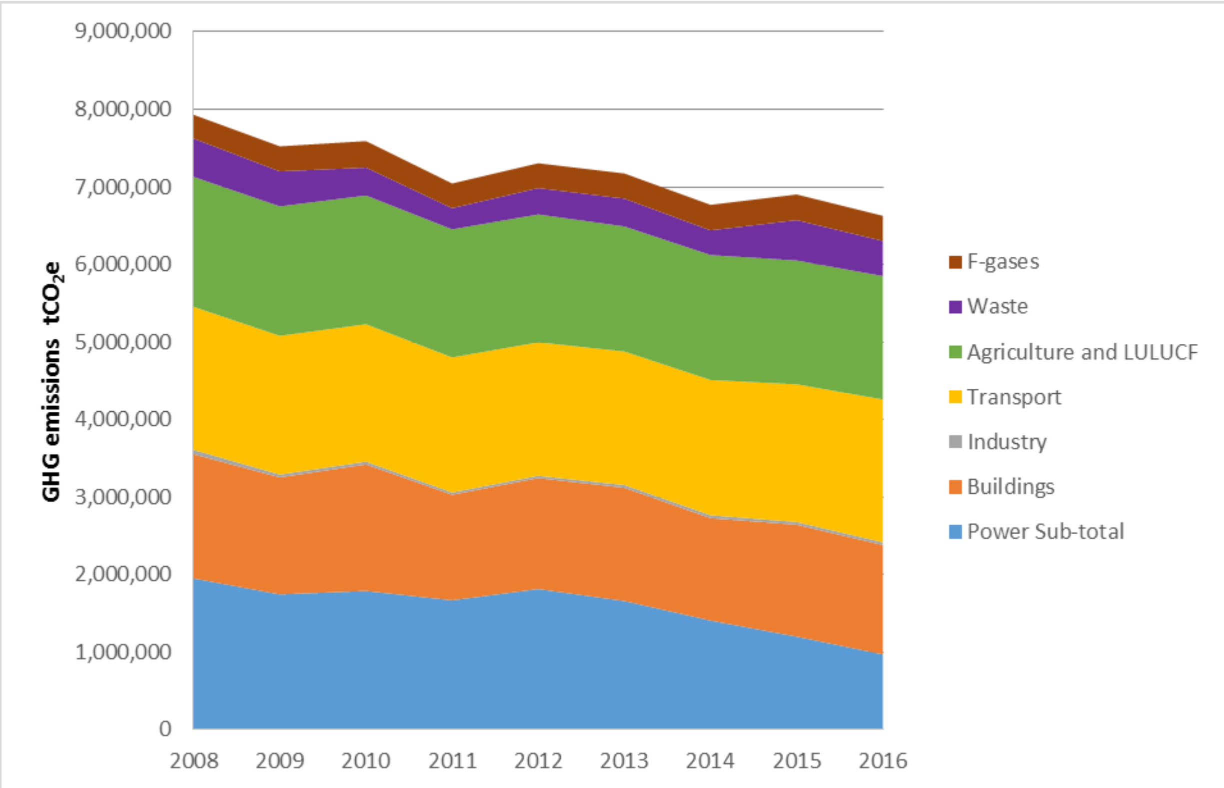

Figure A2: Devon's GHG emissions by sector

Total GHG emissions fell 16% between 2008 and 2016. However, much of the reduction is in the power sector which benefits from national renewable electricity production. If the power sector is excluded, GHG emissions fell 5% between 2008 and 2016 but emissions rose 5% between 2011 and 2016. The dominant sectors in 2016 (88% of emissions) were transport (28%), agriculture and land use change (24%), buildings (21%) and power (15%).

APPENDIX B: DATA TABLES

This appendix contains the underlying data (tCO_2e) in years 2016, 2032 and 2050 for the trajectory graphs (e.g. Figure 1) that are used for each sector within the report.

Power

	2016	2032	2050
BAU pathway	972,399	1,055,070	1,400,336
Savings from lower-risk policies	0	*197,525*	0
Savings from medium-risk policies	0	*252,649*	0
Savings from high risk high-level intentions	0	*180,647*	0
Savings from current policy gaps	0	*121,540*	0
Savings to 2050 from Core Policies	0	0	*1,291,413*
Savings to 2050 from Further Ambition Policies	0	0	*86,191*
Adopt all measures pathway	972,399	302,707	22,732

Buildings

	2016	2032	2050
BAU pathway	1,410,365	1,547,788	1,711,276
Savings from lower-risk policies	0	*78,747*	0
Savings from medium-risk policies	0	*78,563*	0
Savings from high risk high-level intentions	0	*252,422*	0
Savings from current policy gaps	0	*147,940*	0
Savings to 2050 from Core Policies	0	0	*1,358,556*
Savings to 2050 from Further Ambition Policies	0	0	*285,912*
Adopt all measures pathway	1,410,365	990,116	66,807

Industry

	2016	2032	2050
BAU pathway	34,572	30,271	27,863
Savings from lower-risk policies	0	*478*	0
Savings from medium-risk policies	0	*984*	0
Savings from high risk high-level intentions	0	*3,211*	0
Savings from current policy gaps	0	*1,192*	0
Savings to 2050 from Core Policies	0	0	*3,084*
Savings to 2050 from Further Ambition Policies	0	0	*20,499*
Adopt all measures pathway	34,572	24,406	4,281

Transport

	2016	2032	2050
BAU pathway	1,842,807	1,940,252	2,196,428
Savings from lower-risk policies	*0*	*91,018*	*0*
Savings from medium-risk policies	*0*	*401,033*	*0*
Savings from high risk high-level intentions	*0*	*324,774*	*0*
Savings from current policy gaps	*0*	*262,020*	*0*
Savings to 2050 from Core Policies	*0*	*0*	*1,407,877*
Savings to 2050 from Further Ambition Policies	*0*	*0*	*420,495*
Adopt all measures pathway	1,842,807	861,407	368,056

Agriculture and Land Use Change

	2016	2032	2050
BAU pathway	1,589,615	1,611,832	1,672,174
Savings from lower-risk policies	*0*	*0*	*0*
Savings from medium-risk policies	*0*	*123,412*	*0*
Savings from high risk high-level intentions	*0*	*22,205*	*0*
Savings from current policy gaps	*0*	*117,065*	*0*
Savings to 2050 from Core Policies	*0*	*0*	*395,314*
Savings to 2050 from Further Ambition Policies	*0*	*0*	*192,977*
Adopt all measures pathway	1,589,615	1,349,150	1,083,882

Waste

	2016	2032	2050
BAU pathway	453,367	281,803	233,190
Savings from lower-risk policies	*0*	*0*	*0*
Savings from medium-risk policies	*0*	*3,861*	*0*
Savings from high risk high-level intentions	*0*	*20,915*	*0*
Savings from current policy gaps	*0*	*45,183*	*0*
Savings to 2050 from Core Policies	*0*	*0*	*82,289*
Savings to 2050 from Further Ambition Policies	*0*	*0*	*21,464*
Adopt all measures pathway	453,367	211,844	129,437

F-gases

	2016	2032	2050
BAU pathway	324,376	336,738	403,684
Savings from lower-risk policies	0	0	0
Savings from medium-risk policies	0	285,831	0
Savings from high risk high-level intentions	0	0	0
Savings from current policy gaps	0	0	0
Savings to 2050 from Core Policies	0	0	335,881
Savings to 2050 from Further Ambition Policies	0	0	23,011
Adopt all measures pathway	324,376	50,907	44,792

Devon Total

	2016	2032	2050
BAU pathway	6,627,501	6,803,755	7,644,951
Savings from lower-risk policies	0	367,769	0
Savings from medium-risk policies	0	1,146,333	0
Savings from high risk high-level intentions	0	804,175	0
Savings from current policy gaps	0	694,941	0
Savings to 2050 from Core Policies	0	0	4,874,415
Savings to 2050 from Further Ambition Policies	0	0	1,050,548
Savings from GHG Removal: CCC low scenario	0	0	392,781
Additional savings from GHG Removal: CCC high scenario	0	0	797,837
Additional savings from GHG Removal: Royal Society scenario	0	0	405,056
Adopt all measures pathway	6,627,501	3,790,537	124,314

Devon by Sector

	2016	2032	2050
BAU pathway	6,627,501	6,803,755	7,644,951
Savings from Power Core Policies	*0*	*752,363*	*1,291,413*
Savings from Power Further Ambition Policies	*0*	*0*	*86,191*
Savings from Buildings Core Policies	*0*	*557,673*	*1,358,556*
Savings from Buildings Further Ambition Policies	*0*	*0*	*285,912*
Savings from Industry Core Policies	*0*	*5,865*	*3,084*
Savings from Industry Further Ambition Policies	*0*	*0*	*20,499*
Savings from Transport Core Policies	*0*	*1,078,845*	*1,407,877*
Savings from Transport Further Ambition Policies	*0*	*0*	*420,495*
Savings from Agriculture Core Policies	*0*	*302,414*	*224,719*
Savings from Agriculture Further Ambition Policies	*0*	*0*	*476,687*
Savings from LULUCF Core Policies	*0*	*-39,732*	*170,596*
Savings from LULUCF Further Ambition Policies	*0*	*0*	*-283,710*
Savings from Waste Core Policies	*0*	*69,959*	*82,289*
Savings from Waste Further Ambition Policies	*0*	*0*	*21,464*
Savings from F-gases Core Policies	*0*	*285,831*	*335,881*
Savings from F-gases Further Ambition Policies	*0*	*0*	*23,011*
Savings from GHG Removal: CCC low scenario	*0*	*0*	*392,781*
Additional savings from GHG Removal: CCC high scenario	*0*	*0*	*797,837*
Additional savings from GHG Removal: Royal Society scenario	*0*	*0*	*405,056*
Adopt all measures pathway	6,627,501	3,790,537	124,314