DecarboniseNow

Securing a low carbon Britain

Filling the Policy Gap – Prioritising the UK's Climate Policies

Chris Friedler, with contributions by Polly Green and George Harding Rolls

DECARBONISENOW

FILLING THE POLICY GAP – PRIORITISING THE UK'S CLIMATE POLICIES

(Chris Friedler, with contributions by Polly Green and George Harding Rolls)

Prepared by Chris Friedler, with contributions from Polly Green and George Harding Rolls

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Foreword

'Filling the Policy Gap – Prioritising the UK's Climate Policies' is the foundation stone of DecarboniseNow. DecarboniseNow is not an established organisation, but a new venture to constructively engage the public and potential climate stakeholders into adopting new technologies and strategies to cut the UK's greenhouse gas emissions. This report outlines much of our approach that differs from traditional environmental NGOs, as well from academic or policy organisations within the climate change field.

This report comes at an unusual time. The UK's decision to leave the European Union appears to have left some functions of government delayed, with climate policy since the 2015 government largely resting on the Emissions Reductions Plan, now renamed to the Clean Growth Plan. Meanwhile, deadlines for many climate policies are for the end of the decade, and with many policies taking years of planning to complete and implement, the UK is fast approaching a potential stall in its climate policies. This is against an excellent history of emissions reduction, with a drop in power sector emissions resulting in 2016 UK greenhouse gas emissions being 42% lower than 1990 levels.

The UK's future climate change policy is deeply uncertain. Not only will a withdrawal from the European Union be likely to affect existing legislation, but the details of this withdrawal itself are still uncertain at the time of writing. The Committee on Climate Change (CCC) has consistently warned that current policy is not on track to deliver emissions cuts in line with the fourth and fifth carbon budgets. Clearly, a rapid shift in current policies is needed to meet these targets. While the power sector is likely to continue reducing emissions, other sectors will now need new policies to rapidly turn around mostly little emissions reduction in their sectors so far, especially the transport sector.

DecarboniseNow's future likewise has just begun. I'm very excited to lead this evidence based campaigning organisation with a very different outlook on the challenge of climate change. We fiercely believe in engaging and not working against environmental stakeholders and decision makers, whilst engaging and empowering members of the public who support us –the Friends of DecarboniseNow. Alongside the Friends of DecarboniseNow, I hope this report will act as a roadmap and inspiring summary of the UK's climate policies, which will highlight the action not just DecarboniseNow needs to take to reduce the UK's emissions, but the whole nation.

Chris Friedler

Lead director and head of publications at DecarboniseNow

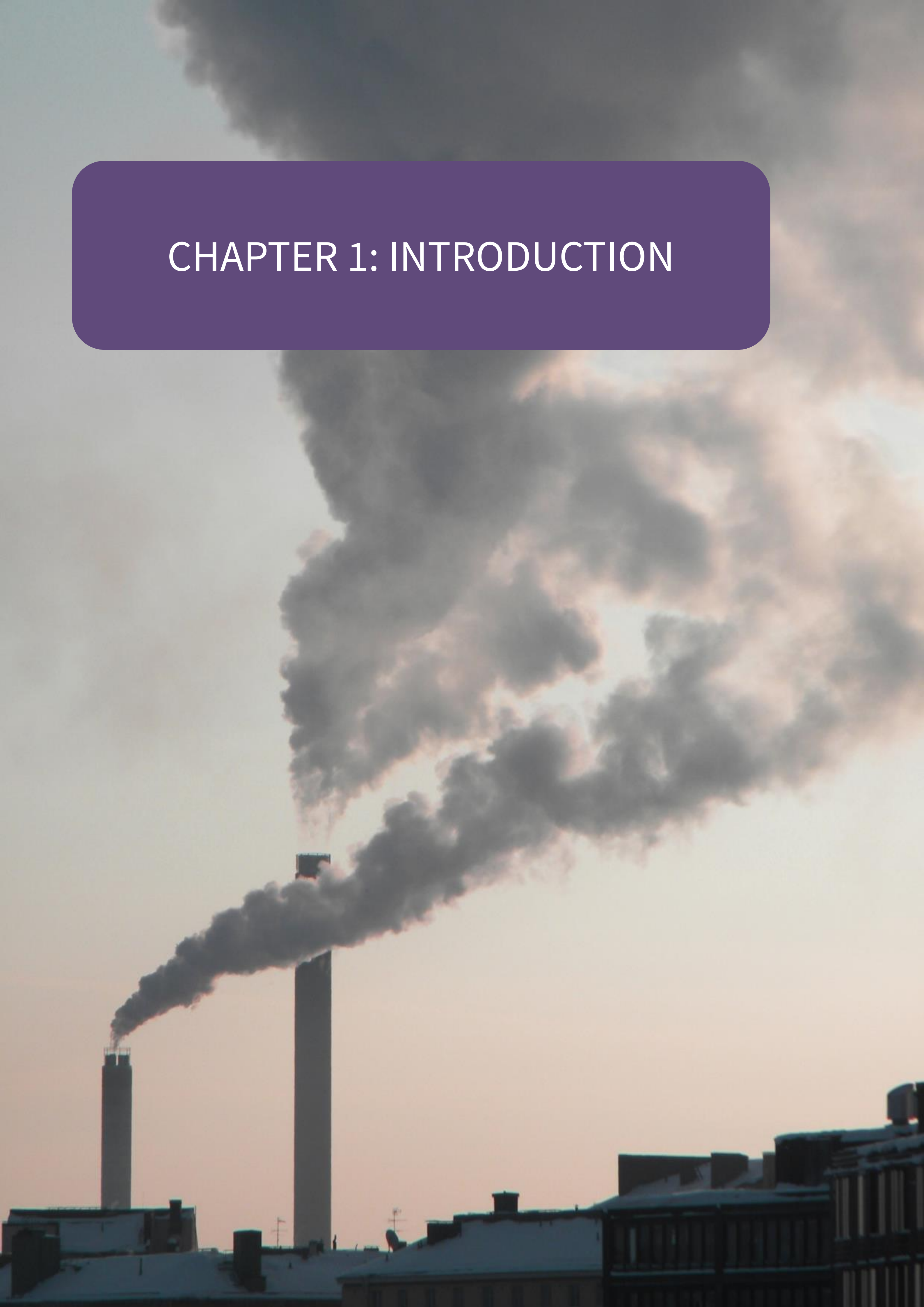
Summary

The Committee on Climate Change provides advice to the UK government on how to reduce emissions in the UK, and produces yearly reports assessing the progress being made. The latest 2016 progress report includes a detailed analysis of the policies the UK should take to cut emissions and meet its legally binding climate targets. However, the CCC notes that current policies are not sufficient to do this, with a lack of policies in place or at risk to reduce emissions by a sufficient amount. This has created a 'policy gap', leaving some emissions reductions without sufficient policies to reduce them.

This report examines each of the 33 policies or policy areas across the seven different economic sectors that the 2016 Progress Report examines, drawing from data from the report, other Committee reports and wider related and relevant policy literature. Each of these policies is assessed against our criteria, which reflect our values as an organisation. As with the CCC's report, we assess seven different economic sectors: power, buildings, industry, transport, agriculture and land use, land use change and forestry (LULUCF), waste and F-gases. A prioritisation score is assigned to each policy based on our criteria, allowing a ranking system to be put in place. Policies that score equal numbers are assessed by the importance of individual criteria or wider context specific to their sector.

We conclude in our prioritisation ranking that Ultra Low Emissions Vehicles (ULEVs), offshore wind and other pot 2 technologies and new legislation for F-gas legislation are the highest ranked policies. These are ranked in descending order respectively, with ULEVs being our highest prioritised policy. Our next steps will be to develop further publications on and start cooperatively campaigning for the uptake of ULEVs, with offshore wind and other policies further down the prioritisation list gaining further publications and campaigns in relation to how highly they are prioritised.

CHAPTER 1: INTRODUCTION



1. What DecarboniseNow is and its goals

DecarboniseNow is a new not for profit company and network, which aims to research and enact the best policies to eliminate greenhouse gas emissions in the UK as quickly as possible. It does this through a network of volunteers, the Friends of DecarboniseNow, which are linked via the internet based network that DecarboniseNow provides. Publications written by the organisation are completed remotely by these volunteers and overseen by its lead author and editor. Campaigns by the organisation focus on advising and working with decision makers and the public, based on the content and findings of the publications team. A non-combative and negotiation based stance is essential in these campaigns, and its role is to advise action based on these findings.

The premise for DecarboniseNow is to link the large volunteer bases of famous environmental NGOs such as the World Wildlife Fund and Greenpeace with a less intensive campaign based approach, with more emphasis on a think tank NGOs approach, such as Green Alliance and E3G. This allows potentially large numbers of members of the public from across the UK to assist in conducting policy writing under guidance from the board of directors. It also requires a more evidence and holistic based approach to campaigning, negotiating and providing advice as well as working with different partners as much as possible. DecarboniseNow also allows a narrower area of specifically climate change mitigation in the UK rather than wider and more international environmentalism.

DecarboniseNow focuses on decarbonising the UK in particular due to the power of example given by decarbonising a small country with a large economy and medium level population. The UK as a historic climate leader and with close political, financial and economic to both the USA and countries of Europe is also well placed to spread information about how to decarbonise and the technologies and policies available and needed to do so. There is also the moral role of one of the earliest large greenhouse gas polluters taking action as early as possible.

Apart from bringing members of the public together to write and campaign, DecarboniseNow exists to provide an independent, non-affiliated organisation to monitor and advise on climate policy in the UK. While there are other organisations with the same goal, the unique structure and potentially large volunteer base of DecarboniseNow as well as its unusual management of publication led 'soft' campaigning makes it a unique organisation.

The ultimate goal of DecarboniseNow is to outline how to decarbonise the UK as much as possible, as quickly as possible, and in a way which is economically efficient, environmentally friendly, socially just and politically unifying. While in UK law there is a requirement for greenhouse gas emissions to fall 80% by 1990 levels by 2050, DecarboniseNow aims to assess speeding up this process as much as possible, and make potentially deeper cuts. A deep reduction in anthropogenic emissions would ensure that the UK would be making its biggest possible commitment to reducing emissions internally. It would also involve making emissions reductions across all the economic sectors responsible for emissions, therefore allowing research and practice on how to decarbonise each of these sectors to be shared with other countries. Ultimately, if it is possible for emissions to reach below net zero, the absorption of greenhouse gas emissions in the UK's biosphere would then also have a negative effect on emissions, lowering emissions from the globe.

A rapid reduction in emissions with the capacity to decarbonise faster should be implemented if reasonably possible in line with the precautionary principle. There is scientific and political uncertainty if a 1.5°Cdegree temperature rise should be the global limit, which would therefore make the current UK climate target stricter. DecarboniseNow also believes that political uncertainty between now and 2050 should mean that the UK should try and overshoot its current climate targets, for should another developed country fail its own climate targets then global targets may be missed.

The economic efficiency of UK decarbonisation is a key aim and concern of DecarboniseNow. A core belief of DecarboniseNow is that decarbonisation efforts should enhance and enrich the UK and global economy, not disrupt it. Finding the lowest cost solution that sustains the deepest emissions reductions in the fastest time while remaining socially just, environmentally friendly and politically popular is a well highlighted challenge, and DecarboniseNow aims to look objectively at all the economic impacts of new technologies and practices to decarbonise the UK, including upfront costs.

While decarbonising the UK is strongly positive for the UK environment in terms of emissions reductions, it is an important aim for DecarboniseNow to ensure solutions do not cause additional environmental problems in the process. We recognise very few technologies or practices cause no environmental problems whatsoever, but minimising environmental impact other than emissions reduction is an important goal in our organisation.

Social justice is an aim of DecarboniseNow, as decarbonisation must not be unethical to society. Policies that alienate groups in society or provoke hostility are to be avoided. Publications and campaigns by DecarboniseNow must involve fairness to all sections of society, working with the public to produce favourable outcomes for society as whole.

Political unity and consensus are a strong component in securing low carbon policies, in political parties and society as a whole. While it is outside DecarboniseNow's scope to influence political parties, it does aim to build connections between different political groups in society to advance understand and negotiation on climate policy.

2. The Committee on Climate Change and its 2016 progress report

The Committee on Climate Change is an independent body which advises the UK government and devolved administrations on carbon targets and progress made in reducing greenhouse gas emissions. Its creation was an integral part of the 2008 Climate Change Act, the role of the CCC being to provide targets and advice on how to meet the 80% below 1990 emissions levels target by 2050. The CCC consists of 9 scientific and policy experts, with a staff team preparing the CCC's reports.

The CCC is responsible for setting Carbon Budgets, a set of targets that aim to deliver the eventual 80% target in 2050. Currently there are five, listed in Table 1.1.

Table 1.1: UK Carbon Budgets

Years	Emission reduction (based on 1990 levels)
2008-12	23%
2013-17	29%
2018-22	35% by 2020
2023-27	50% by 2025
2028-32	57% by 2030

[1]

These budgets allow a rise in ambition as technologies become more developed. The UK is set to achieve the first three; however there is a current gap in policy on how to reach the fourth and fifth carbon budgets.

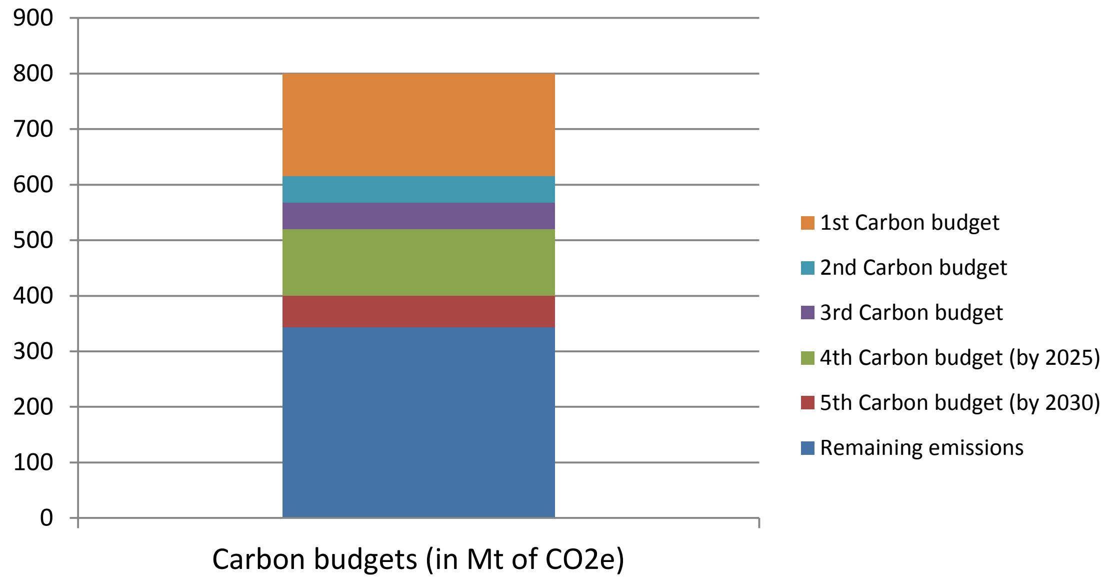


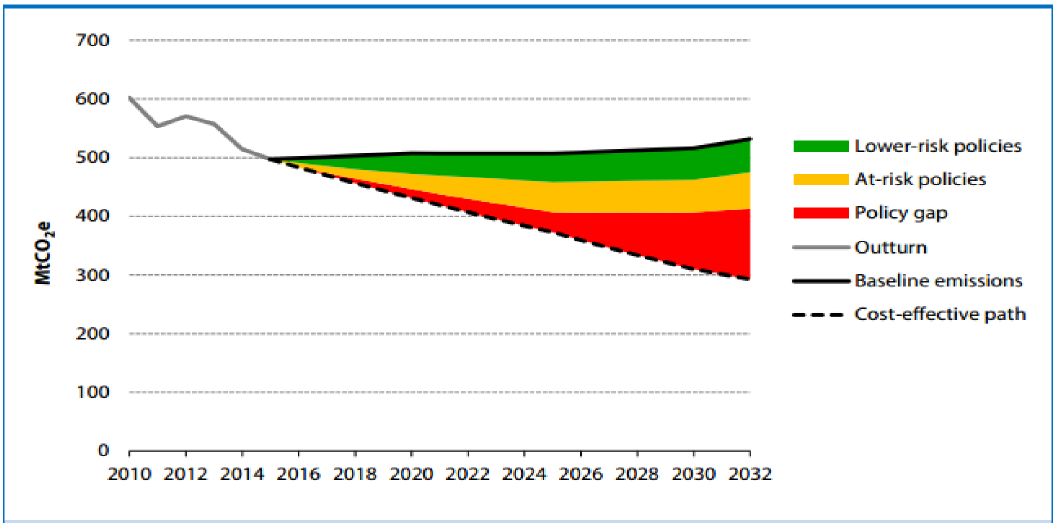
Figure 1.1: UK Carbon budgets imposed on 1990 UK greenhouse gas emissions[2]

The Committee on Climate Change produces annual progress reports to Parliament. These analyse what needs to be done to keep UK policy in line with the climate targets it sets out. They outline what policies the UK is doing well on to keep to these targets, and highlighting where policies are failing or new ones are needed to produce the emissions reductions needed. The latest 2016 report was written against the backdrop of the December 2015 international Paris agreement, the UK's referendum on exiting the European Union, and the agreement to put the fifth carbon budget into law. Effectively, their report acts as a comprehensive checklist for government policy on climate change, setting out policies on the power, buildings, industry, transport, agriculture and land use, land use change and forestry, waste and F-gases sectors of the economy.

3. Government 'policy gap' on climate change

The 2016 report shows and repeatedly emphasises that current UK government policies are not enough to meet the fourth and fifth carbon budgets. While some policies do result in a certain reduction in emissions, many policies are at risk or non-existent, therefore leading to what is termed in the report as a 'policy gap'. Further government will to fill this gap is needed to meet emissions targets.

Current government response to this has been that a new policy on climate change and how to meet these budgets will be made available by the end of 2016 in an emissions reduction plan. However, more recently it has been indicated that due to the referendum result for Britain to leave the European Union this policy is likely to be delayed until 2017 at an unspecified date.[3] The recent call for a UK general election in 2017 is also likely to further delay this plan. Much current government policy established in the last government focuses on the years until 2020/21, with longer term policy less substantial. Much of the reductions in greenhouse gas emissions in recent years have been from reduced emissions in the power sector, and with a ban on new coal fired power generation by 2025 and restricted by 2023 as well as renewable deployment this trend will continue.[4] Other sectors have less policy surrounding them, such as the buildings sector and low carbon heat. The below graph summarises the policy gap in UK greenhouse gas emissions from all sectors, with the gap increasing towards the end of the fifth carbon budget.



Source: DECC (2015) *Updated energy and emissions projections*; CCC analysis.

Figure 1.2: Policy Gap summary[4]

4. Prioritising the CCC's policies

It is the intention of this report to rank the policies recommended in the CCC 2016 report by criteria, selecting the most urgently needed and sorting in order the most important policies to follow. This report gathers the policies from the power, buildings, industry, transport, agriculture and land use, land use change and forestry, waste and F-gases chapters of the CCC 2016 report, combining the policies in the UK wide chapter (Chapter 1) into their respective sectors. This is done for ease and convenience, to avoid repetition and overlap. Chapter 9 of the CCC 2016 report (devolved administrations) is not covered, as the DecarboniseNow report aims to look at the range of policies from a UK wide perspective.

The power sector chapter includes the policies and policy areas which are: pre-2020 rollout of renewables, the phase out of coal fired power plants, post 2021 pot 1 (onshore wind, solar and biomass power) rollout, offshore wind, marine and other pot 2 technologies, new nuclear power, grid flexibility (through grid storage, interconnection and demand responses) and power sector Carbon Capture and Storage (CCS) development.

The buildings sector chapter includes the policies and policy areas such as: low carbon heating systems in existing buildings, low carbon heating systems in new buildings, heat networks, hydrogen heating, residential energy efficiency and non-residential energy efficiency.

The industry sector chapter includes the policies and policy areas such as: industrial energy efficiency improvement and roadmaps to achieve this, biomass for space and process heat, other forms of low carbon space and process heat and industrial CCS.

The transport sector chapter includes the policies and policy areas such as: increasing efficiency of conventional vehicles, increasing the uptake of Ultra Low Emission Vehicles (ULEVs), greater uptake of biofuels, 'smarter' travel choices, changes to freight transport and aviation and shipping improvements.

The agriculture, land use, land use change and forestry sector chapter includes the policies and policy areas such as: stronger implementation of the Smarter Inventory for Agriculture, strengthening of the current Greenhouse Gas Action Plan (GHGAP), measures post 2022 to deliver emissions reduction within agriculture to 2030 and beyond, afforestation and agroforestry.

The waste sector chapter includes the policies and the policy areas such as: approaches through the food waste chain, increase methane capture rates, and reduce biodegradable waste to landfill.

The F-gases sector chapter includes the policies and the policy areas such as: stronger implementation of monitoring and updating progress on F-gases regulation and new UK policy on going beyond the regulatory minimum.

The above policy areas are general groupings of policies found in the CCC 2016 report, some sectors evidentially having more overlapping policies and more policies to be found than others. These different sectors will each have separate chapters (Chapters 3-9) in this report analysing each policy and comparing them against the criteria. Chapter 10 merges prioritising policies across all sectors to give the final results on which policies DecarboniseNow prioritises based on criteria such as urgency and emissions reductions involved.

Power (21% of 2015 UK emissions)	Buildings (18% of 2015 UK emissions)	Industry (23% of 2015 UK emissions)
Pre 2021 renewables	Low carbon heat (existing buildings)	Industrial energy efficiency
Coal plants phase out	Low carbon heat (new buildings)	Biomass space and process heat
Post 2021 renewables	Heat networks	Low carbon space and process heat
Offshore wind and pot 2 technologies	Hydrogen	Industrial CCS
New nuclear	Residential energy efficiency	
Flexibility	Non-residential energy efficiency	
Power sector CCS		

Transport (24% of 2015 UK emissions)	Agriculture / LULUCF (8% of 2015 UK emissions)	Waste (4% of 2015 UK emissions)
Conventional vehicle efficiency	Smart Inventory	Waste Prevention
Ultra Low Emission Vehicles	Pre 2022 agriculture policy	Waste diversion
Biofuels	Post 2022 agriculture policy	Methane capture
Smarter travel choices	Afforestation	**F gases (3% of 2015 UK emissions)**
Freight	Agro Forestry	Stronger implementation of existing legislation
Aviation and shipping		New legislation

Figure 1.3: Summary of policies for each sector, with percentage that sector contributes to UK greenhouse gas emissions in 2015 (in $MtCO_2e$)

5. DecarboniseNow's capability to investigate the prioritised policies

As a new, relatively small internet based organisation, DecarboniseNow's influence (at least in the short term) will have to come mostly from the arguments and ideas it projects, rather than from its reputation or funding. Therefore, it is important for the organisation to make a clear case for certain policies based on strong, persuasive arguments based on the evidence, rather than political clout. Highly politicised areas like renewable energy are more likely to cause problems for DecarboniseNow in this field, as the dialogue by the organisation will have to compete with not only others in the environmental NGO movement but also energy companies and political campaigners. However, this may mean that DecarboniseNow may have an advantage on areas of policy less highlighted in the media and covered by such powerful interests – industrial energy efficiency has not been granted nearly so much attention by similar political actors, thus DecarboniseNow may have a potentially clear avenue to make the case for such policies to encourage greater industrial energy efficiency.

Credibility is a key initial challenge for DecarboniseNow. With no track record, and with an unusually open approach to gathering information, DecarboniseNow may be viewed negatively. Therefore, to improve credibility the organisation must cover new ground, proposing new ideas which generate discussion, and secondly that this and subsequent reports are also open to discussion from outside organisations and experts. Regarding the former, a heavily research focused look at many often overlooked policies will stand out, but also demonstrate that more preparation has gone into looking at climate policies as a whole due to researching the evidence for *all* potential climate policies recommended by the CCC. As this and subsequent reports are based heavily on Committee on Climate Change policies and findings, a highly credible organisation in the climate change policy field, this also generates credibility for the organisation. External experts and organisations working with DecarboniseNow and critiquing the publications produced extends greater credibility as well as transparency.

DecarboniseNow is a low funded, low cost organisation, hence its internet based network. However, this does not mean that DecarboniseNow cannot provide some funding for certain projects. While as a new organisation income is starting from a low base, appeals and funding initiative may be able to contribute to some policies in the longer term. While funding for large scale infrastructure appears unrealistic, funding from DecarboniseNow, possibly pooled with other groups, may contribute very directly to smaller scale policies.

DecarboniseNow's ability to influence policy will not affect the outcome of the prioritisation of policies within this report, due to large uncertainties involved (see Chapter 10). The implications of the influence of DecarboniseNow must still be considered however, so that consequences of future campaigns on future decisions can be understood.

6. Criteria used

The above section showcases some of the means of deciding within this report how capable DecarboniseNow is of assisting on the prioritised list of the Committee on Climate Change's policies. However, firstly those policies are to be ranked in Chapters 3-9 by sector and then ranked as a whole in Chapter 10. The criteria to do this are outlined in Chapter 2, and in brief here. There are multiple considerations of what to attach to the criteria used to assess the policies in the CCC 2016 report.

The existing level of policy, political will and policy attention is one such factor, for if a strong policy already exists, for example in the case of strong F-gas regulation, that will lower its priority compared to an area which has no current policy in place to protect the action that needs to be taken, for example, the uptake of low carbon heat in the 2020s. The urgency needed to enact new or strengthen existing low carbon policies is another important factor, as agricultural emissions policies may not be as urgent as CCS policy, which has a long and uncertain timeframe. The actual emissions reductions involved is the most basic criteria, as policies outlined in the CCC's progress report will vary in the amount of CO_2e they reduce, and therefore policies that keep the UK on track towards its carbon budgets. Economic credibility must also be a factor in assessing policies, less economically competitive options causing more drawbacks in the short term. The long term sustainability of any policy is important, for if a sudden reversal of policy is likely then effort may be better concentrated elsewhere, the recent U-turn on CCS being one example. Additional impacts and effects are also factors, for progress enacting one policy may help another policy succeed, or the reverse. Industrial emissions may be reducing by removing less need for the oil and gas sector for example.

The factors above are not of equal ranking in terms of importance for prioritising the policies outlined in the CCC's progress report. Therefore, a ranking system will be put in place to rank the criteria, which will then be used to rank the policies (see chapter 2).

7. Goals of this report

Key goals of this report include to provide information about low carbon policies in the UK, revisit the content from the Committee on Climate Change, promote discussion and debate around the results of what policies have been prioritised in this report, take a holistic, wide reaching view of all the major low carbon policies necessary to decarbonising the UK, and most significantly, outline the direction and priorities of a new organisation committed to reducing the UK's greenhouse gas emissions.

Given that DecarboniseNow publishes policy documents, then runs campaigns to translate that into the wider world, this report is a vital foundation stone for the organisation. It starts the organisation's research from the top down, looking at the problem of climate change in the UK as a whole, rationally thinking through what the most important policies are, and through that determining where the organisation goes next with its activities. If this report highly recommends new CCS policy, or stronger electric vehicles (EVs) policy, then that is where the organisation goes next, providing a transparent process, where the organisation is seen to consider what the problem of emissions in the UK entails, consider the solutions (provided by the Committee on Climate Change), and decide which solutions are the most important or urgent to follow. While this does not mean DecarboniseNow is going to discard looking into all the policies outlined in by the CCC, the size of the organisation in its current state as well as the resources involved in publications and campaigns make it necessary for a prioritisation to be made.

CHAPTER 2: CRITERIA USED

1. Overview

The criteria used to identify and rank the policies outlined in the CCC’s 2016 report is a critical element in showcasing the methodology and transparency of why this report has chosen to prioritise some of the CCC’s recommended policies over others. This is vital for DecarboniseNow as an organisation, as it guides where the area of research and campaigning will be headed in the months to come. This chapter outlines what the criteria for prioritising policies are, and how they shall be used with and against each other.

2. Existing level of policy attention

The CCC’s 2016 progress report already notes the level of attention a certain policy has received by the UK government, ranking these into a colour coordinated system. Green indicates that current policy is broadly consistent with the CCC’s carbon budget scenarios, amber indicates there is uncertainty, and red indicates that the policy is not consistent with carbon targets. Within this, some policies may have a more settled policy framework than others, or be more certain or consistent with climate targets within each of these three categories. Therefore, it is still necessary to rank the CCC’s policies using these criteria, but the colour coordinated system eases the process by grouping policies together.

Prioritising based on current level of attention is important because researching an area that already has strong, stable policies in place to enact is likely to make less of an overall impact in reducing the UK’s emissions. It also allows DecarboniseNow to provide insight into reducing emissions in ‘at risk’ or less well known areas, without clashing with as many other organisations of a similar nature. In short, prioritising policies based on the existing level of attention given means DecarboniseNow can act where help on meeting emissions targets is most needed, due to lack of attention by government or other political actors.

These criteria will be applied in the following chapters by the following method. Firstly, the colour coordinated scheme will be assessed policy by policy. As such, policies given a green rating will be receiving greater government attention than those with amber or red lights.

Secondly, policies with a history of low level attention receive a higher priority, as policies that have recently received a U-turn in policy attention (such as CCS) will still have a history of research and funding and therefore further foundations than areas which have always received low levels of attention. It is also possible that policies recently changed may be changed back, as the policy may be volatile or a ‘political football’.

Thirdly, the level of attention given by other organisations such as businesses, NGOs or the public should also be taken into account through wider research. If a business led initiative is providing funding to a government neglected policy, or an NGO is campaigning for a particular policy, even though government attention may be low there may be other organisations that generate a big impact. Likewise, if a policy is receiving little attention by any non-governmental or business organisation, that should receive a higher priority.

Fourth and finally, policies that are seen as politically difficult or unfeasible, and have been avoided in the past should receive greater priority. This is due to the fact there may be great political barriers that will take time to resolve, and it is necessary to start that process earlier rather than later.

3. Urgency

Many of the policies outlined in the 2016 progress report are to set in motion a new technology or infrastructure system, which may take years or decades to achieve. For example, both low carbon transport and heating are both dependent on new technologies becoming the dominant ones for their respective sectors. With this in mind, taking a holistic view towards policies is vital, for many are on a strict time frame to reduce emissions. Therefore, due to the pressing needs to reduce emissions, all policies are urgent, but some more so than others. A policy to mainstream a new technology may well be more urgent than a policy to change the policy framework on an existing one. With delay to certain policies, it becomes impossible to reach the climate targets put forward at later dates, as these targets are partially based on scenarios assuming these technologies are available. Urgency is clearly a vital area to prioritise emissions in.

This will be done in this report be assessing the following. Firstly, through analysis of the CCC 2016 report and wider research, it should be analysed where government policies should already be at to be consistent with our scenarios for reaching emissions targets. CCS for example has been conceived in many models to be far further along in development than it currently is.[4] The policies furthest behind relative to their own targets in the majority of literature covered should be prioritised the most.

Secondly, time scales involved for policies to be largely self-sufficient should be examined. Offshore wind for example requires far more policy incentive and longer term than solar, which with the right policy framework could become a self-sufficient technology largely determined by non-government actors. If a new technology requires 15 years to become self-sufficient rather than 5, prioritising the former will result in fewer policies left to chance and unforeseen problems in the future.

4. Emissions reductions involved

The sheer volume of emissions reduced is of course the main focus of decarbonising the UK. Equally, there will be a diverse amount of different policies outlined in the CCC's 2016 report that will reduce emissions by varying amounts. It is then important to identify and rank which policies reduce the most emissions and bring the UK closer to its emissions targets. It is also important to realise that some policies, particularly in the power sector, are already reducing emissions, whereas other areas are yet to make a big impact. Some policies can then be said to be snapshots of reducing emissions, as already active policies the amount of emissions they reduce are slowly getting lower as they do so, whereas other less active policies are more static in the number of tonnes of CO_2e they are reducing.

Prioritising this criterion seems relatively straightforward: simply comparing the number of tonnes of emissions reduced per policy, based on the latest available data (ideally 2015/6). In reality, this may be considerably more difficult to do, as this may be reliant on data which estimates the reductions involved, and there may also be overlap between policies on emissions reducing, as well as the fact that some policies will have more data available than others, for example agricultural emissions have a lack of data. Nevertheless, reasonably comparing the number of tonnes reduced by each policy is the easiest way to see the direct impact of each policy on meeting climate targets, and makes them easier to prioritise.

The majority of policies in this report have an estimated emissions reduction potential under 16Mt CO_2e – 2% of 1990 level UK greenhouse gas emissions. We therefore consider emissions reduction potential of over 16Mt a high priority, 8-16Mt medium priority, and below 8Mt (1% of 1990 emissions) a low priority. However, many policies are estimated or projected only until 2030, and some policies have a great deal more emissions reductions potential after this date, so the physical number provided for each policy may be backed up with further emissions abatement potential at a future date.

5. Economic credibility

If a strong economic argument can be made for low carbon technologies, then their uptake is more likely than not to increase, potentially rapidly. While it is beyond DecarboniseNow's capacity to majorly influence markets, it *is* within DecarboniseNow's capacity to bring costs of experimental or new technologies down to a very small degree or showcase them to potential investors. With this in mind, throughout this report when assessing the economic credibility criteria, we examine 3 factors, outlined below:

1) Up front capital costs of low carbon policies and technologies as they currently stand. Offshore wind currently has lower strike price than wave energy[4], and as both fulfil the function of reducing emissions, as well as having similar social and other environmental advantages and disadvantages, unless wave energy can demonstrate significant advantages over offshore wind by the logic of this criteria, offshore wind should be prioritised over wave power. The upfront costs of policies as they stand in the present day should not be underestimated, as they will significantly affect the short term reductions that can be made in emissions reduction.

2) Pence per CO_2 avoided, which ties in with section 4 in this chapter (emissions reductions involved) and seeks to assess how economically efficient investment can be in reducing emissions. Some policies may be difficult to assess this way due to lack of information, particularly new or untested policies, but it is still an essential component of the economic credibility criteria, as maximum investor efficiency would result in the highest reduction in emissions.

3) Projections of future cost. If a policy is currently expensive but has rapidly declining costs, then DecarboniseNow should seek to promote it more immediately than a policy that has much longer term and smaller reductions. Investing or advising others to invest in the former policies could also be ahead of more cautious businesses or the UK government, and by doing so DecarboniseNow could bring costs down a little to make it more attractive to these political actors.

6. Long term sustainability of policy

It is not enough to create a policy to reduce emissions; it must also be robust enough to be maintained across different governments, different political climates and future geopolitical events. Resilience to policies against these potential future shocks is therefore critical. In this report, this criterion will examine all three elements. Regarding different governments and decision makers, priority must be given to policies which take some action to bind themselves to future governments through time – the Climate Change Act 2008 is an example of a policy that is difficult to repeal. Policies that are spread across a number of political actors and organisations are safer from a sudden change in political climate – if they are centrally bound in national government, then policies are more at risk from a swing away from ambitious climate policy in the event of a suddenly changing geopolitical climate.

7. Externalities of policy impacts

These policies do not exist in isolation, but are part of a complex system. While it would be impossible to catalogue every impact and knock on effect a potential policy would make, some awareness should be given to the potential outcomes of these policies. Success in implementing a policy to continue building onshore wind and solar into the 2020s may have a positive impact in greater uptake of renewables, a cleaner electricity grid for electric heating and transport, and reducing reliance on other power sources such as nuclear and offshore wind. However, political and public resistance to climate policy in general and clean electricity resulting from this could be a negative impact, as well as agricultural workers resisting further engagement in emissions reduction due to conflict over these power sources on their land.

While impossible to predict with certainty or to catalogue in full detail the impact of every policy proposed by the Committee on Climate Change in its progress report, this report does prioritise policies that have clear, obvious and likely positive impacts on other policies and emissions sectors in the same report. Those with more negative impacts should be categorised further down in priority ranking.

8. Points based system of the criteria

While there are six criteria above, not all are to be ranked in equal measure. This is related to their ability and importance to prioritise the policies outlined in the 2016 progress report. Each criterion shall be given a relative weighting out of three, to be contrasted with the priority score based on the above criteria. If one of the criteria is determined to have a medium priority it would be given a score of 2, and then have this multiplied by the weighting of the criteria. Hence urgency would be given a weighting of 2 if it was of medium urgency within the context of a specific policy, then multiplied by 3 to give a score of 6 for that criterion for that policy. Scoring a policy appears thus:

Table 2.1: Example of criteria weighting and scoring system

Policy X		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	9
Urgency	3	6
Emissions reduction involved	3	3
Economic credibility	2	6
Long term sustainability	2	2
Externality of impacts	2	2
TOTAL		**28 (of 45 maximum)**

The decision to weight criteria differently is due to not all criteria being as critical in prioritising policy, but also not wishing to leave out important such criteria including the long term sustainability of policy. The selection and weighting of the above criteria is in part subjective, but is based on our values and founding principles as an organisation. This report to an extent, as explained in the introduction, is partly a 'roadmap' for our organisation to prioritise and shape what areas our policy shall focus on, and as such the prioritisation criteria and their interpretation will be partly subjective. However, these criteria put in place a traceable system to refer back to the decisions made in this report.

9. Applying these criteria

The correct application of these criteria to prioritising the policies outlined in the 2016 progress report is critical to fulfilling the purpose of this report. The process of applying the criteria will be as follows. Description and information of a policy suggested by the CCC will be assessed, with every criteria being used to assess the policy and how closely it fits with the criteria, including sub criteria. If sufficient information is not available about the policy, additional research will be carried out to see how closely the policy fits with the criteria. Once all the policies in a chapter have been assessed and analysis written, all the policies are compared together, allowing cross linkage and synthesis to take place. Then each policy is given a score by the above scoring system, and ranked accordingly. If policies have the same prioritisation score they may have subtle differences which rank one higher than the other – this will be accounted for Chapter 10's analysis. The process repeats for Chapter 10, in which all the policies from all the sectors are assessed against each other. With this structure in place, there is a clear, methodological and transparent system in place to show how the prioritisation of policies is used in this report.

CHAPTER 3: POWER

1. Introduction

By far the most active sector in reducing emissions, as well as being the forefront of the public and political consciousness, the power sector also has some of the largest emissions reductions to make, with a 75% reduction in emissions from 2015 to 2030 advocated by the CCC, comparable only to the relatively small F-gases sector (with the same percentage target). UK power sector emissions were 102Mt CO_2e in 2015, and the only sector for emissions to fall significantly between then and 2016, falling to 77Mt in 2016[5]. Whilst pre-2020 policy seems set to achieve targets and coal phase out is happening more quickly than anticipated, the ambition to reduce gas use, increase grid flexibility and longer term policies are more uncertain. Policies that are considered in this chapter based on the CCC's report are: the renewables pipeline until 2020, the phase out of coal fired power plants, the future of low cost renewables such as onshore wind and solar PV post 2021, the development of offshore wind and other pot 2 technologies (such as marine power), new nuclear power (and contingency plans should the new plants not be secured), grid flexibility (covering grid storage to compensate for renewables, interconnection of electricity grids nationally and internationally, and shaping the demand for electricity), and the development of Carbon Capture and Storage (CCS). The power sector policies are particularly urgent and important for the electrification of heating of buildings, industry, and transport and rely on a fast transition to a low carbon power mix.

2. Pre-2020 renewables

Given the years needed to plan out and invest in a large low carbon power infrastructure, the need to develop renewables early to decarbonise power further into the future is essential to climate mitigation. The renewable power pipeline includes the rollout of onshore and offshore wind, solar PV and biomass technologies to reach this. There is a comfortable capacity in these projects to achieve this target by 2020, and the CCC gives it a green rating in its 'traffic light' system towards the end of its power sector chapter, one of only three policies in the 2016 progress report to have one.[4] There has been an extensive history of the UK government rolling out these technologies, going back to the 1990s and accelerated after the 2008 Climate Change Act[6]. While the UK has already surpassed its climate targets for 2020, it would be extremely difficult to reverse the construction pipeline of these renewables in the timeframe available, given the funding and planning permissions secured and in some cases the construction work undertaken. Third party interest is also very high in this policy; with changes to renewable subsidies subject to much media attention, NGO interest, business interests as well as local governments and other political actors[7]. Tied to this are political difficulties that the construction of solar PV and especially onshore wind has experienced in the past, changes to the subsidy structure of these technologies resulting from vocal opposition despite high public approval ratings.[8] In spite of this, it is unlikely that the pre-2020 renewable targets will not be met, and given the positive signs of implementation and development, it seems that this policy has had a very high level of policy attention, making this a non-priority policy.

Given the few years needed to implement this policy, it would seem that this policy could be urgent – however, given the difficulty of reversing construction of those renewable in the pipeline, the high policy attention and the on track indicators, urgency for this policy should be treated as very low, as this policy would be difficult to overturn in the few years remaining.[4] Opposition to onshore wind and solar PV is more likely to be focused on post 2020; therefore concern over the stability of these technologies should be focused on section 4, low cost renewable policy post 2021. These technologies are not yet but very close to financial self-sufficiency (see Figure 3.1), hence the need for subsidies before 2020 to increase their rollout. Post 2020, these technologies are likely to be self-sufficient, as subsidies drop to very low and eventually null levels, however they still would require a new policy to get them to the current energy market (see section 4 below).

Emissions abated by this policy are dependent on the power source they are replacing. The CCC estimates this policy will result in an additional 30TWh of electricity being provided by renewables by 2020 from 2015. The emissions of CO_2 from coal from our calculations would be 9Mt for 30TWh (see annexes), so if these renewables were directly abating coal they would have an emissions abatement potential of 9Mt by 2020 – it is likely they would abate gas more often than coal, so this abatement potential is likely to be lower, but nonetheless emissions abatement potential is middle range in comparison to other policies within this report.

Given publicity surrounding the subsidies regarding this policy, it may well be perceived that this policy is highly uneconomical. This varies for the technologies covered under the pre-2020 policy. The costs are calculated in price per MWh of electricity produced, and can be seen here in the reproduced table in the CCC's report:

Table 2.2. Deployment of renewables in 2015

Technology (% of UK Generation in 2015)	Installed Capacity in 2015 (GW)	Of which, capacity added in 2015 (GW)	Further capacity in Pipeline to 2020[1] (GW)	Expected capacity and generation in 2020	CCC indicator generation in 2020	Current cost estimates (£/MWh)[2]
Onshore wind (8%)	9.1	0.6	3.4	12.5 GW, 29 TWh	30 TWh	≤£80
Offshore wind (6%)	5.1	0.6	5.8	10.9 GW, 43 TWh	36 TWh	≤£115
Biomass (9%)	3.2	0.6 (0.9 retired)	1.5	4.6 GW 32 TWh	24 TWh	£87
Solar PV (2%)	8.9	3.5	1	9.9 GW, 8 TWh	-	≤£80
Wave (<1%)	<0.1	0	<1	<0.1 GW, <1 TWh	-	£200-300
Tidal stream (<1%)	<0.1	0	<1	<0.1 GW, <1 TWh	-	£100-200
Tidal lagoons (0%)	0	0	0	0	-	£115

Source: DECC (March 2016) *Energy Trends*, Low Carbon Contracts Company (2016) *CfD Register*, CCC Analysis.
Notes: 1. Awarded a CfD, or expected to deploy under the Renewables Obligation. Note this includes the Neart Na Goithe offshore wind farm (0.45 GW), which is currently contesting a cancelled CfD.
2. Onshore wind, offshore wind and solar costs represent recent CfD auction prices; other values are levelised costs drawn from our 2015 *Power Sector Scenarios* report.
3. For reference, in our 2015 *Power Sector Scenarios* report we estimated levelised costs for current new build CCGT costs to be £65-75/MWh (the lower end of the range reflects a market carbon price forecast, the upper end of the range reflects a 'target-consistent' carbon price forecast). For more information see: CCC (2015) *Power Sector Scenarios for the Fifth Carbon Budget*.
4. Load factors for renewable technologies range from around 10% for solar PV, to 80% for biomass. Wind load factors are around 30% (onshore wind) and 40% (offshore wind).

Figure 3.1: The CCC's Deployment of Renewables in 2015 figures

With new build Combined Cycle Gas Turbines (CCGT) cost competitive at £65-75 per MWh, it can be seen that onshore wind and solar at under £80 MWh are either cost competitive or very close to being cost competitive, as can be seen from Figure 3.1. As costs are falling for both technologies, it seems likely they will be cost competitive shortly after or by 2020.

Other technologies, particularly wave and tidal power schemes, are likely to not be cost competitive for some time. The cost competiveness is important to capital costs, not only as cost competiveness of these technologies is achieved capital costs will fall, but also the technology will become more self-sufficient and less reliant on government subsidies and eventually totally independent. Given that the capital costs are currently supported to 2020 and that there will be energy companies' support and investment in seeing these projects through, government subsidies are sufficient to meet the CCC's projections and deliver the finance required for energy providers to install a sufficient amount of renewable power. Much of the Contracts for Difference funding went to pot 2 technologies (such as offshore wind)[4] rather than pot 1 technologies (such as onshore wind and solar), the CCC noting that the first auction round of CfD in 2015 secured £300 million in funding for 2TWh of pot 1 technologies and 6TWh of pot 2 technologies. The more expensive pot 2 technologies take the bulk of the funding, implying a relatively small amount of subsidy for pot 1 technologies. Pence per CO_2 avoided is likely to be mid-range, as low cost investment into these technologies will equal a medium level of emissions reduction.

The long term sustainability and future of this policy is short, given the 2020 cut off for these renewables and uncertainty about many of the technologies post 2020. Regarding the latter, much of this will be covered in section 4 of this chapter. As for the pre-2020 targets, it seems unlikely to not hit relevant targets at this stage, as much infrastructure has already been built and investment decisions made, thereby rating a low priority.

Externalities vary according to technology type, with onshore wind being publicised for its external impacts of visual pollution.[9] Solar PV too is criticised for its visual pollution[10], with biomass being heavily criticised for its sustainability impacts due to the deforestation involved as well as the embedded emissions of importing biomass resources, primarily from the United States of America.[11] Public subsidies leading to higher energy bills for consumers has also been highlighted as a concern over renewable power, as well as the variability that renewable power can cause in the power grid. Addressing each of these, visual pollution from these sources can be reduced by placing wind and solar farms in strategic places, and ensuring fully that local communities are engaged in the planning stages of these projects. Given the pressure surrounding central government on this issue, there has been a visual pollution backlash against onshore wind and solar PV, leading to greater powers for local governments and communities that largely addresses this. Many rejected projects, while unlikely to be a concern before 2020, after 2020 may lead to a slower uptake of these technologies. Biomass resources, as the CCC emphasises, must be ensured to be from sustainable sources, and a limit on the amount of use of biomass may go some way to limiting environmental damage from this resource. Consumer bill impacts are likely to be more than offset by changes in efficiency[12], and as renewable power costs come down so too will energy bills rise, implying this is a temporary problem that if managed correctly with energy efficiency, can be avoided. As for variability, greater rollout and public awareness over flexibility options (see section 7 of this chapter) can go some way to avoiding concern over this issue as well as providing a practical solution. Positive externalities from this policy is an uptake in British jobs in this new sector, as renewable resources typically employ more people per unit of energy generated than non-renewable technologies[13]. The innovative nature of some of these technologies is also giving Britain a potential advantage and bringing industry back to some areas, such as offshore wind knowledge and skills being exportable to other countries as well as potentially rejuvenating coastal areas in eastern England. Overall, externalities are diffuse for this policy both up to 2020 and further forward and are dependent on technology. Pot 1 technologies clearly have more negative externalities than pot 2 technologies, so other than cost it would seem that, going forward, pot 2 technologies are more publically acceptable in many aspects such as visual pollution, capacity factor, sustainability and so on.

3. Coal plants phase out

The UK government has a policy to no longer use unabated coal fired power plants by 2025 at latest, with the distinct possibility of withdrawal before then, with the EU power plants directive requiring plants to close by 2023, and the age of many of these power stations and a high carbon price potentially making many of them uneconomic before 2025.[4] The CCC gives this policy a green rating, the second of just three policies in its report to receive one. The policy may have been a relatively recent announcement, in late 2015 in preparation for the Paris summit, but the policy history behind it was relatively extensive, as many of the UK's coal fired power plants were required to close anyway to comply with carbon budgets, tightening EU power plants regulations, a high carbon price and the age of many of them which are due for decommissioning. The level of attention by third party actors has also been high, as environmental NGOs and sustainability concerned businesses expressed favour towards this policy. Politically, given the old age of many of these coal plants and the longer term decline of the coal industry within the United Kingdom, this is not a controversial area, especially with the greater persuasive power of the competing gas industry. Despite this, the Coal Authority and similar organisations still hold persuasive power within the UK, and given the 2023 EU deadline (now subject to uncertainty given the recent EU referendum) as well as a worsening global situation for coal, the 2025 date may if anything be optimistic in its projection for when coal will be phased out. Policy attention is therefore high for this policy, and priority given should accordingly be low.

The urgency for this policy is immediate due to the short time frame, and the fast emissions reductions that can be made to meet the fourth and ultimately fifth carbon budgets. While the 2025 date exists, it is provided as a 'latest case' date and closing coal fired power plants before then may be perfectly possible and desirable for emissions reductions. Given recent declines in coal's share in the electricity mix to 9% (see Figure 3.2) in 2016[14], it seems that a fast reduction in coal is rapidly happening, and with strong government policy already in place, while there is a short timescale involved in phasing out coal, it is being given greater urgency than many other polices within this report, and is of lesser concern comparatively.

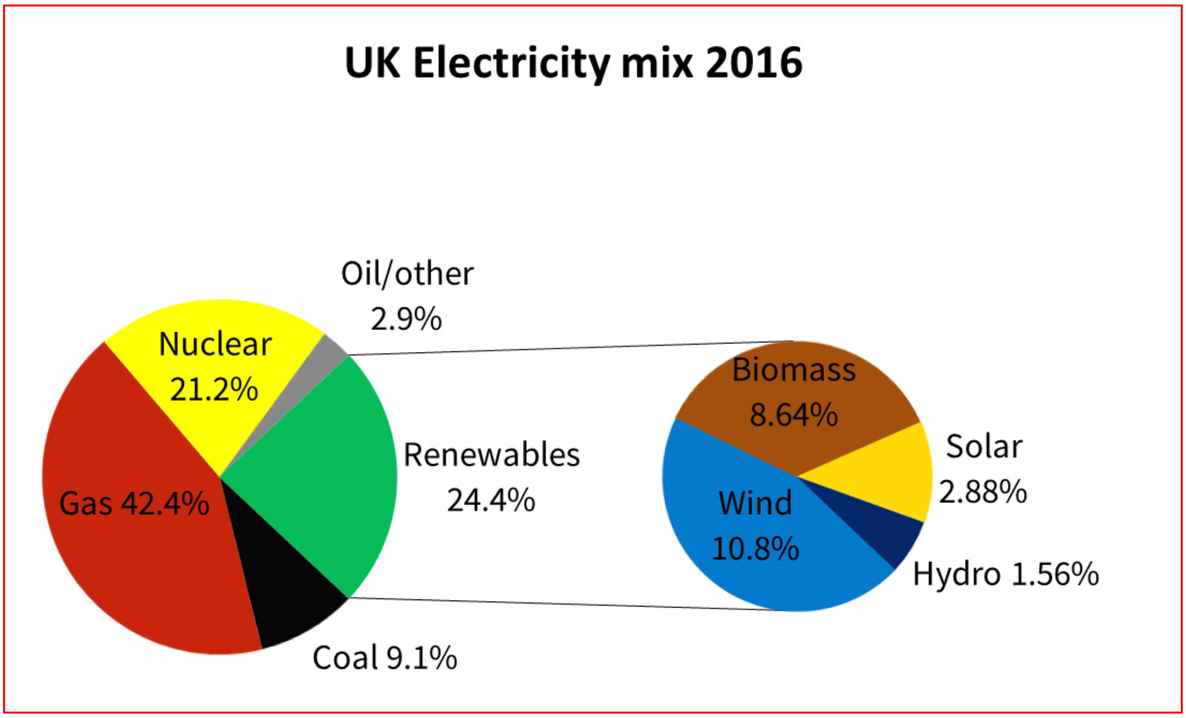


Figure 3.2: UK electricity mix 2016[14]

The emissions abatement potential of phasing out coal power is partly dependent on what replaces it in the power mix. The provisional emissions statistics by the government for 2016 shows coal is responsible for 33.4Mt of emissions.[5] With a majority of this coming from coal fired power stations, this is a significant chunk of emissions, and would reduce emissions 4% further below 1990 levels if cut out of the power mix. However, the replacement of coal in the power mix is likely to deliver a less significant chunk of emissions reductions, as it is likely to be replaced by a mix of-gas and renewables, and the higher the CCGT content the less emissions will be saved. However, this is still a major amount of emissions that can be reduced, and in a short space of time.

The economic case for coal power has worsened globally and in the UK in a shorter time than anticipated in many policy scenarios, in part due to the Paris Agreement, decline in global demand, a high carbon price in the UK, declining gas prices, and the success of renewable power.[15] With this in mind, the cost for running coal power and making a profit longer term are increasingly difficult for suppliers, with the cost of decommissioning largely the responsibility of the energy suppliers. Given this, the capital costs of decommissioning these plants, as well as the economical capability of running these, seems to be against coal fired power plants remaining open, especially as longer term costs look set to increase with higher carbon prices and international pressure. Pence per CO_2 in decommissioning coal fired power plants is very high, as the cost of decommissioning is low and the CO_2 abatement potential high.

Given the 2025 or sooner deadline for coal fired power to decline, long term sustainability of this policy looks set, as a reversal of decommissioning coal fired power plants seems unlikely – if anything, the 2025 date for a phase out may be generous considering other factors affecting the industry. Politically this is very strong environmental policy for the government, and a reversal would likely face much opposition, as well as a significant withdrawal of environmental policy generally. It seems that this policy is relatively safe from withdrawal, and longer term unabated coal fired power is unlikely to remain in the UK after 2025 if not considerably sooner.

Externalities likely to emerge from this policy are most fundamentally, considerably cleaner air in addition to emissions reductions, loss of jobs from remaining coal fired power plants, increased demand on other power sources and potentially new capacity, particularly backup capacity being required. The decline of coal power may also reduce anti-climate mitigation lobbying power against climate policies. CCGT backup power is still cost competitive and relatively quick to build, and with an increased renewable pipeline until 2025, as well as cost competitive offshore wind and other renewables post 2023, this is likely to ease strain on the power sector without requiring coal fired power plants to remain open. Loss of jobs from coal cannot be avoided if emissions are to be reduced, however given that renewables create more jobs per unit of energy as a general rule[13], a switchover scheme within the energy industry with coal workers having their jobs diverted into new forms of power may act as a compensation measure, as well as ensuring additional new jobs would be created.

4. Low cost renewables post 2021

Post 2021, previous policy and funding for onshore wind and solar PV disappear, the predominant 'pot 1' technologies. Offshore wind, biomass, marine and other technologies shall still be eligible for government funding past this date (and are hence considered separately below in section 5). The CCC gives a red rating for pot 1 technologies post 2021, as there is currently no new policy for ensuring their route to market after this date. The CCC also notes there are no planned auctions for pot 1 technologies after 2021, and that they could provide cheaper electricity going forward than CCGT plants. Policy history is inseparable from pre-2020 onshore wind and solar PV history, but it seems that visual pollution and cost of subsidies is a main barrier to uptake of these technologies going forward. There is also the practical matter of how much land is available, or should be available, for these technologies, and how much of a contribution both these technologies can ultimately make to the electricity grid given these restrictions. Support for these technologies is still high from many third party actors, although opposition is also high from other third party actors. Onshore wind and solar PV still enjoy high public support despite this[8], but politically, these technologies are likely to split and divide many parts of the country, with higher opposition in rural areas. Making these technologies subsidy free removes one of the main barriers, but the other question of land space required and the accompanying potential visual pollution remains a problem. Doing nothing, as the lack of policy so far is supporting, it arguably not satisfactory for either proponent of the argument for these technologies, as it does not give certainty about their future. Policy attention is very low and possibly quite negative for these technologies, so a shift towards thinking about alternative policies for bringing these technologies to market post 2021 should be considered and built upon.

As with pre-2020 renewables being non-urgent due to being difficult to take out of the construction pipeline due to inertia in the system, equally post 2021 renewables urgently need planning now for the same reasons. Planning new onshore wind and solar PV in 2017 (the year of writing) could lead to years of planning, consent, construction and operation. Self-sufficiency is a key issue in this policy, and as years of government subsidies have gone into making these two technologies self-sufficient, now they are self-sufficient or imminently self-sufficient in cost it is potentially wasteful not to allow the energy industry to develop them further. Urgency is high for this policy, particularly given that offshore wind funding is low ambition, and nuclear and CCS plans are facing increasing delays. Strategy should therefore in the immediate term be developed in anticipation of potential further deployment of these technologies.

Emissions abatement potential from these technologies would be dependent on their uptake - it is also likely that, given their more limited potential, offshore wind, nuclear, CCS and flexibility options are likely to deliver large abatement potential in the longer term. Despite this, the CCC identifies 25GW of potential for onshore wind in total by 2030[4] and 60GW of solar potential according to industry reports and the DECC's renewable energy pathways.[16] Given their respective capacity factors of 30% and 10%,[4] this could amount to them providing 19.3% and 15.5% of power based on the electricity mix of 2015 (with 65.7TWh and 52.56TWh respectively).[17] As the electricity mix is due to expand in future and CCGT is likely to be the predominant power source being replaced rather than coal, the role of these technologies is likely to be considerably smaller than this indicated factor, as well as the emissions they reduce being considerably smaller due to early phase out of coal, it is unlikely they will make the emissions reductions this amount of electricity might imply. With this in mind, had these technologies been at full deployment in 2015, renewable generation would have jumped from 26% to 50.8% of the power mix.[17] Had this been equally distributed in replacing coal and gas, this could have reduced emissions in the power sector by half, with an abatement potential in this scenario of 50Mt.[17] This figure is however hypothetical, and with coal fired generation phased out long before these technologies could reach this capacity, as well as the high potential for these technologies not to be deployed on this scale, and an increasing electrical demand, it is unlikely that these technologies would have such a high abatement potential. Despite this, 16Mt and beyond is considered a high emissions abatement potential in this report, and as such, the emissions abated from this policy, while difficult to quantify based on uncertainties in policy and deployment options, are likely to be high regardless.

This policy would largely exist to take advantage of the lack of subsidies required by these technologies, unlike pot 2 technologies (listed below in section 5), thus being relatively self-sufficient economically. The CCC anticipates pot 1 technologies will no longer require subsidies by 2020.[4] In previous years, the Levy Control Framework has been primarily responsible for covering these subsidies of renewable power technologies.[18] A new economically viable route to market should not be as challenging as in previous years due to a low cost. Onshore wind and solar will start at £80 per MWh in 2020, with the potential to fall further in future (see Figure 3.1). This puts then in a favourable position to compete with CCGT (£65-£75 per MWh) meaning capital costs can now be favourable to private investors without subsidy, and with the history of the Levy Control Framework major suppliers will have experience with the new technology. In short, capital costs are going forward past 2021 are very compatible with private investment – however, policy must be made for the contacts necessary for investors to build on public land. Without this, this policy is likely to stall. Unlike other policies in this report, here is not a case of financial barriers restricting policy; it is policy barriers restricting finance. The economic case here is strong, what is ultimately required is new and stable policy. Pence per CO_2 from this policy is likely to be high return, as there are medium upfront costs but which are privately financed and have a high emissions abatement potential.

Longer term, these technologies are simply limited due to land space and visual impact. There is also the potential for competition with other technologies more efficient but currently more expensive. When offshore wind becomes cost competitive, there may be less incentive to invest in onshore wind, a technology with a smaller load factor, smaller chances of planning permission and less popularity. This also illustrates the problem that onshore wind is limited in its deployment due to land space requirements, and there are multiple uses for the remote, rural landscape it is likely to reside in, compared to offshore wind which can be built in great number in areas required for services far less and with a much large recoverable resource of wind. Equally, solar fields if on a large enough scale could disrupt farming land. As capacity grows and reaches more areas of the country, it is also likely that this will increase opposition to these technologies. It is therefore possible for these technologies to reach their highest targets of 25GW and 60GW, but it may be unlikely due to these factors. Politically, the lack of policy thus far on these technologies may be a political move to appease vocal opponents of these technologies, so it may be the case that this policy is not enacted and route to market for onshore wind and solar PV is not created.

Due to the decreasing space for these technologies, negative external impacts are likely to increase. Claims of visual pollution are likely to increase as these technologies increment onto more landscape. Visual pollution is the main and strongest impact. Multiple other claimed impacts are less prevalent than given media credence – noise from wind turbines has dramatically reduced to very low levels since the earliest turbine models in the UK, and avian deaths from wind farms has been proven to be significantly smaller than other urban or man-made structures.[9] Positive externalities from increasing this policy are large, as further investment in these technologies will create a large amount of jobs per unit of energy compared to non-renewable resources.[13] If energy companies invest in these technologies, it may also protect them and their staff from financial issues should fossil fuel prices become volatile and as the UK closes gas and coal fired power plants to meet the fifth carbon budget. Dependent on area, it also has the potential to bring jobs and investment to rural or sparsely populated parts of the country that otherwise have a narrower and less diversified economy.

5. Offshore wind and pot 2 technologies

Pot 2 technologies refer chiefly to offshore wind, with other technologies such tidal lagoons, tidal turbines and wave power and others being included. Given that these technologies are still not cost competitive with existing technologies, the government allocates Contracts for Difference, which delivers an amount of money to bidders for that technology in the energy industry – the most efficient competitors receive government funding on top of their investment to make the infrastructural development of offshore wind farms possible.[19] Offshore wind is anticipated to become cost competitive around 2023,[20] and it is therefore important to continue rolling out the technology to a sufficient scale where it is possible for this to happen, through Contracts for Difference up until that date. The CCC gives this policy an amber rating, for the government recently announced that £730 million per year would be given to new auctions for pot 2 technologies.[21] The CCC estimate this will result in 3-6GW, on the lowest end of their indicators for the necessary rollout of this technology. Any funding given to the other technologies in this category such as tidal lagoons will 'crowd out' sufficient funding for offshore wind, pushing back the date where it can become cost competitive. Both these factors are why the CCC gives this policy an amber rating. The policy history of pot 2 technologies has been extensive, with trials of wave and tidal energy occurring since 2003[22] and the first offshore wind farm in the UK constructed in 2000, with regular rollout of the technology since 2008.[23] The UK has frequently been dubbed a world leader in all these technologies, and contracts for difference for pot 2 technologies have occurred since the 2010-2015 government.[4] Third party interest in these technologies is high, with environmental NGOs advocating strong take up of these technologies, energy businesses such as Dong Energy investing heavily in these, and construction, shipping and many coastal industries having great interest in these technologies. Politically, offshore wind has had fewer opponents than onshore alternatives,[8] although the proposed Severn Tidal Barrage attracted great criticism from environmentalists and investors alike.[24] These technologies are not controversial in the same way that pot 1 technologies are, however the general conflict between renewables and fossil fuel interest remains. In summary, policy attention has been high but potentially insufficient to reach targets, and likely to continue to be so going forward.

Given that offshore wind is likely to deliver the main bulk of emissions reductions from renewables, urgency should be given to offshore wind based on this alone (see below). Coupled with the technology likely to be cost competitive by 2023, and ongoing problems with nuclear and CCS deployment, and a lack of policy for pot 1 technologies, the UK may be increasingly reliant on offshore wind, so urgency should be given to developing this technology quickly. However, given the long history of policy attention and existing policy that, while not sufficient, is also grounded and in progress, this implies two paths about the nature of low carbon power sources. One, to focus on other sources which are having greater problems to deployment, or two, to increase investment and ambition in offshore wind to compensate for these technologies. If the latter is the path that the government is considering, and the CCC does outline this as a contingency plan, then much greater urgency must be placed on offshore wind. Otherwise, urgency should still be relatively high due to the overall importance of this technology. Other technologies in pot 2 are considerably less urgent due to high cost, longer development pathways, and many of their benefits already being gained by the cheaper and easier to deploy offshore wind. Self-sufficiency for the technology has not yet been reached, but given the relatively quick time scale of 2023, as well as increasingly optimistic price drops in the technology's cost, self-sufficiency is much faster than many other technologies in this report.

Emissions abatement potential is likely to be higher than other renewables, simply due to the higher capacity offshore based technologies could have. As with other policies in this chapter, such potential will be highly dependent on non-predictable factors such as the deployment of power sector options. Offshore wind could have a capacity of 40GW by 2030 in Committee scenarios,[4] with more rapid deployment after the mid-2020s. Imposed upon the 2015 power demand, with offshore wind at 40GW with the 40% load factor used by the CCC, this amounts to 41.2% of power that could have come from offshore wind in 2015 (140.2TWh)[25] had it been deployed to full potential – more than both solar and onshore wind in section 5 above. Given more recent nature of the technology, it is also possible that further technological gains could be made to expand capacity, such as higher load factors, and floating wind turbines to be utilised in deeper waters. Given that there are fewer planning objections and complaints about visual pollution regarding offshore wind than onshore and solar,[8] the capacity of this 40GW to be reached may be significantly higher than the pot 1 alternatives, meaning this emissions reduction potential may be more achievable at a higher level. Either way, as with the above section, the abatement potential is clearly high for this technology, as a 34% increase in the electricity mix in 2015 in offshore wind would result in a 68% decrease in power sector emissions, bringing the 102Mt in 2015 (brought about by that 40GW of capacity) to 31Mt if applied unilaterally to coal and gas. While this a hypothetical scenario, as with the above section of this chapter, it demonstrates the large abatement potential of this policy. Longer term, offshore wind may have a larger role to play, with the CCC noting that offshore wind has more energy potential than the current electrical demand of the UK.[4] Regardless, the emissions reduced by this policy are high. Regarding other pot 2 technologies, they are unlikely to dominate the pot 2 rounds in the same way as offshore wind, but they also have significant abatement potential should they be fully deployed.

Capital costs are still high for offshore wind, but not stubbornly so and cost reductions have been rapidly and consistently outperforming most indicators.[4] Given lack of investment and development, wave and tidal technologies remain over double the cost of offshore wind. This fall is noticeable in its speed – the CCC note the cost of offshore wind as £115 per MWh in 2015, whereas in early 2017 some offshore wind farms are costing £97 per MWh, four years ahead of the 2020 target of £100 per MWh.[26] The government anticipates the technology becoming cost competitive by 2026, and has warned the industry is will not receive subsidies if it fails to do so.[27] Given the fast cost reductions, it seems likely that this will occur, and economically offshore wind may soon provide a realistic cheaper alternative to nuclear and other power options. Pence per CO_2 is likely to be similar to pot 1 technologies, as offshore wind likely has a higher abatement potential and higher capital costs. Despite currently high costs, economic factors are only a medium priority given the good outlook for the cost effectiveness of this technology.

Longer term, marine power has further potential to grow, but with many of the same benefits, offshore wind is still likely to be the main technology in this category. Given the positive development of offshore wind, there is potential for the technology to exceed industry indicators and become cost competitive earlier than the 2026 deadline. Given the finance already pledged, it seems unlikely that cost will be a large political issue and barrier to this technology, and this argument will get less persuasive the closer to 2026 this technology gets, or indeed the estimated 2023 deadline for cost competitiveness from the industry. Past 2023 or 2026, offshore wind has enormous potential to become a large part of the electricity mix, with policies needed in place to encourage subsidy free offshore wind farms to become a fast and large part of the electricity mix. With an increasing demand for power with the electrification of transport, buildings and industry further into the future, cheap offshore wind may become an important part of the power mix, with battery storage increasingly its load factor as with other renewables. A failure to bring in new nuclear or CCS technologies could result in a large increase in offshore wind technology.

Externalities of these technologies are mostly likely to be felt along the coast. An additional reason for offshore wind's development history was concerns about the externalities of the related technology of onshore wind. As modern offshore wind farms are predominantly built out of sight from the shoreline, this removes the main negative externality of onshore wind and solar PV. Similar positive externalities also apply, with the creation of large numbers of jobs, especially in coastal regions previously reliant on other industries.

6. New nuclear power (and contingency plans)

Nuclear power until very recently has been the largest low carbon power source in the UK, and even currently, if renewables are broken into their constituent technologies rather than grouped together it is still the predominant low carbon power source.[14] This will not last at current rates, as with the exception of the Sizewell B reactor, most nuclear power plants are reaching the end of their productive lives, and are expected to shut down during the 2020s.[4] This poses a problem for emissions reductions, as it will effectively stall or even slightly reverse reductions gained from renewables. One alternative however is to build new nuclear power. The first station, which may become part of a proposed new fleet of nuclear power stations, is known as Hinkley Point C. Hinkley Point C still had not reached a final investment decision by early 2016, and the CCC gave it an amber rating as such, as there are ongoing delays.[4] Since then approval has been given and construction started, although this is facing further delays.[28] Given the long history of nuclear power in the UK, and previous attempted revivals of the power source,[29] the concept of new nuclear in the UK has had a lot of policy attention. Third party attention has been high, partly because of the long policy history and partly because of divided attitudes to nuclear power. Environment NGOs remain divided on the issue, and public support for nuclear power is low compared to renewable power.[8] Politically, nuclear power has had a divisive history and continuing delays to Hinkley Point C risk political embarrassment on the government's behalf. Equally, sceptics of the transition to renewable power are likely to be assuaged by a return to a well-established power source.

While the nuclear industry remains optimistic for new nuclear power in the UK during the 2020s, given past inaccurate nuclear power build rates[30] and the very long development time for Hinkley Point C, time scales for new nuclear plants should be assumed to be more pessimistic than those advocated by the nuclear industry. With this in mind, the 2023 target given for first power generated, especially considering the delays so far may be seen as optimistic. Given that this is meant to be first in a fleet of new nuclear reactors, urgency could be high, as this project will need to swiftly enter the power grid soon enough to make nuclear power a viable option. Urgency is also less high when considering that this technology is financially relatively self-sufficient and the main factor in time limitation will be fewer controllable factors such as construction issues. Given the more pressing need to develop pot 2 renewables and CCS, the urgency for this policy is rated at medium, especially given its long term nature.

Emissions abatement potential depends on how much capacity can be deployed by nuclear and how quickly, coupled with how much is desirable with regards to renewables capacity. The UK could in theory build enough nuclear power plants to provide all power and therefore have an abatement potential of close to 102Mt, reducing most emissions in the power sector. In reality this is virtually impossible, due to a wide range of practical factors like the inflexibility of nuclear power to demand, increasing costs and a timeframe for construction that is not compatible with the fifth carbon budget. Despite this, nuclear could still have a high emissions abatement potential, but this is dependent on the speed and cost of construction. As Hinkley Point C has been hit with multiple delays and increasing costs (see below), the emissions abatement potential of new nuclear is totally reliant on its ability to come to market and enter the electricity sector, which currently looks unlikely to happen on a large scale in the short term future.

This is largely because of uncertainty over the pricing of new nuclear power. Capital costs, as well as construction speeds, have been overly optimistic in previous years regarding nuclear power. Currently, Hinkley Point C has a strike price of £92 per MWh.[31] Offshore wind recently reached £97 per MWh and pot 1 technology will soon be under £80 per MWh, so capital costs are comparatively high for new nuclear. Future nuclear stations are likely to be more unfavourable in comparison to other technologies, as it uncertain if there will be a reduction in nuclear power costs, whereas renewable technologies are all likely to have fewer capital costs than nuclear by the time the next power plant is built. Given the usually higher than expected costs of nuclear power, it also seems possible that Hinkley Point C is likely to be more expensive than pot 1 technology and offshore wind. Pence per CO_2 is unpredictable, as it will depend on the abatement potential of nuclear power, which could vary enormously depending on government policy, investor interest and construction speed. Economically new nuclear is likely to be unfavourable in comparison to other low carbon technologies, and the need for them to replace baseload power may be reduced if flexibility options for renewables are developed further.

Longer term, given the large amount of time need to prepare and construct nuclear power with the fast emissions reductions that need to be made in the power sector by 2030, it seems unlikely that unless the reliability and speed of nuclear power station construction can be improved that they will represent a significant share of the electricity mix to 2030, especially as 8 of the 9GW currently in capacity is to close,[4] showing 8GW of nuclear power would have to be constructed between now and then just to remain at current levels. If Hinkley Point C continues to face delays during construction and increasing costs, as well as renewable power rapidly decreasing now and into the 2020s, the economic case for new nuclear power is likely to be the main barrier. It seems possible but perhaps unlikely that a new nuclear renaissance will occur going further forward.

The most publicised externality of nuclear power is the possibility of radioactivity and a nuclear accident. Given the recent Fukushima disaster and the determination of countries such as Germany and Japan to abolish nuclear power,[32] global attitudes among policy makers and the public are still cautious. While nuclear accidents occurring are severe externalities, their likelihood is low, especially given higher safety and operation standards and reactor designs in the UK than the Chernobyl, as well as the absence of extreme weather and natural disasters such as tsunamis. Despite this, politically nuclear power is divisive, and may draw intense criticism or support from local residents and planners. Nuclear power can also deliver confidence among sceptics of renewable power that a low carbon transition is possible, but given rising costs and delays in other countries such as Finland and France over new nuclear power, [30] this confidence could also be eroded if Hinkley Point C runs into further problems.

7. Flexibility (grid storage, interconnection, demand response)

There are many options for electricity grid decarbonisation, but a renewables heavy grid would rely heavily on CCGT for backup in response to variability, with a nuclear heavy grid being struggling to adapt to sudden changes in demand without CCGT. An alternative to this is to make the electricity grid more flexible to cope with changes in demand. Such options include electricity grid storage, such as battery storage plants, pumped water storage, greater interconnection of electricity grids nationally and internationally, so that electricity can be transported more easily from one area to another, and demand response, such as the rollout of smart meters and encouraging businesses, industry and consumers to reduce demand at certain times. The CCC gives this policy an amber rating, noting that the Department of Energy and Climate Change and Ofgem were conducting a joint review into electricity flexibility.[4] Smart meters continue to roll out, pilot battery storage plants are in operation, and more electricity interconnection is currently under construction. Policy attention has been split within this policy, with smart meters and electricity interconnection having a policy history and receiving attention. Demand response too has had policy attention, with potential to go further. Policy attention on energy storage seems to have accelerated in recent years, with treasury funding worth £50million going into research and pilot projects.[27] Given the rapidly decreasing costs of batteries for other purposes (such as electric vehicles) this is likely to increase in future. Third party engagement on this policy is relatively low, with environmental NGOs not prioritising this policy particularly and business interest mostly within the construction and infrastructure industry. Battery storage has created a variety of interest from electronics companies and technical researches, but is still relatively small, thus not making a large political impact. Politically this policy is likely to be relatively popular, as grid flexibility is a useful policy regardless of what the electricity mix is likely to contain. Despite this, many of these projects involve significant public funds. Policy attention is therefore medium, as history exists and it could be politically popular, but more work is necessary to ensure this policy is compatible with climate targets. Battery storage seems especially far behind as a policy option.

Given the deep reductions in the power sector by 2030 and the high uptake of intermittent renewables needed between now and then, this technology may be more urgent than it initially appears. Indeed, given the uncertainties involved, as well as a contingency plan for slower uptake in nuclear or CCS, flexibility in the electricity grid, and especially grid storage, may stabilise a large amount of renewables on the electricity system, replacing remaining gas plants with low capacity factors. Battery storage will take a significant amount of time to develop, and grid interconnection may take many years to plan and develop, therefore urgency is moderately high to develop these options now. Other options such as smart meters are completing their rollout on schedule, reducing the urgency. Overall urgency is medium, although that belies the differences within the options available in this policy.

The emissions abatement potential for these measures expands the range of renewables, making it possible for them to become closer to delivering 100% of electrical power if required. Assessing its potential emissions reduction is extremely difficult, as it will depend on the electricity mix of the future, which could be a large variety of options. If unabated CCGT is to be removed from the electricity grid, flexibility options would become critically important. We give this policy a medium rating for emissions abatement, as it is unlikely that this policy is likely to reduce demand by a high level as nuclear and renewables have the potential to, it also likely to bring higher benefits than other options in this report. This assessment is highly speculative however, due to the difficulty in assessing this policy.

Capital costs are potentially high. £50 million was recently awarded by the Chancellor for research into flexibility technologies,[27] and the smart meter rollout will cost £11 billion.[33] Pence per CO_2 avoided is difficult to calculate regarding this policy due to unclear abatement potential and uncertain future costs. The future costs for battery storage in particular is an uncertain area.

There are many uncertainties about how this wide range of options will operate longer term – smart meters for example, have been met with mixed responses in other European countries.[34] Battery storage, while currently a considerable option, will have to rely on a very large reduction in cost to become a cost effective technology, which is uncertain whether it will achieve at this stage in its development. Many of these options must be implemented into the electricity market first to see their long term sustainability.

Externalities of these solutions vary by technology. With the recent notification by the United Kingdom to leave the European Union, international interconnection of electricity grids may be less politically popular than previously, and more legally complicated. Smart meters and demand side response may receive a backlash from consumers and businesses, who may object to being persuaded on their electricity use, or may suffer from lack of utilisation or lack of use, or may be a success depending on how they are received.

8. Develop CCS

The process of trapping and burying stored carbon from coal and gas fired power is known as Carbon Capture and Storage or CCS. The CCC recommends that this be developed as an option to save costs in the future, for use in the power and industrial sectors. The CCC also gives this policy a red rating, noting there have been backwards steps from the government on CCS. This is due to the government withdrawing the main policy for development of CCS, a competition of £1 billion towards pilot projects.[4] Policy attention has been high in the past, not only due to energy companies researching potential pilot projects for the former government policy but also expertise with the kind of technology from the oil and gas industry. Third party actors are mostly those within the research divisions of fossil fuel industries, with environmental NGOs showing relatively little interest in CCS,[35] and many in the fossil fuel industry intent on existing technologies. The political nature of the withdrawal of this policy as a cost saving measure is likely to remain an issue for CCS, due to the high initial capital cost of funding such projects. Justifying the expense needed for CCS will remain a key barrier to furthering political will on this issue. This policy therefore has a medium level of policy attention, due to past history on this policy but politically motivated uncertainty over its future.

CCS is a longer term policy than many in this chapter, but given the recent backwards steps delaying progress on this technology, as well as the long development cycle and time need to make this technology market compatible and cost competitive, this could drive up urgency. Indeed, it is also difficult to assess when CCS will become commercially available, with greater certainty only becoming available with more pilot projects. This could mean CCS becoming a self-sufficient technology could take some time. There is also additional urgency to keep progress so far on CCS research and demonstration readily available for a new policy rather than abandoned as policy moves on. Urgency for CCS in the power sector is higher than in the industrial one due to the swifter and deeper cuts that are required in the former sector rather than the latter. Therefore, a new policy is high urgency, and one that protects the industry from further large swings in policy.

Emissions abated from the technology would depend as ever on the mix of other technologies in the electricity sector. Given its sluggish development compared to other technologies, it is unlikely that CCS shall expand to fill 100% of the power mix, although its abatement potential is still 108Mt, due to possibility that this could occur. In reality, due to fugitive emissions, it is unlikely to be quite 108Mt, but still a significant share. Actual emissions abated will depend on the electricity mix, but CCS still has the *potential* to reduce a high amount of emissions, therefore CCS has a high abatement potential.

Despite much of the technology being well known and understood by the oil and gas sector, the development of CCS could prove most costly, at least regarding capital costs. Yet the CCC states that development of CCS is still the most cost effective path to reduce emissions. Therefore the £1 billion demonstration that would have been deployed is still a necessary cost, but the large upfront costs of CCS are still a significant challenge. These may be more forthcoming and acceptable once offshore wind and other renewables becoming cost competitive in the mid-2020s, potentially 'freeing up' public finances for low carbon power. Looking through the costs of CCS in the power sector it would appear that while CCS is initially expensive at around £150 per MWh,[36] towards and beyond 2030 costs will continue to fall to a self-sufficient level, with even potential for cost competitive systems in the 2020s at a £86 per MWh by 2028.[37] It is also likely to be unpredictable in price due to many research and development costs as well as further market costs that are yet unknown. Pence per CO_2 avoided is middle ground, as the high expense of CCS in its current form plays off against the large potential saving in greenhouse gas emissions.

CCS is by its nature a long term policy, especially regarding its use in industry (see chapter 5). This makes it extremely vulnerable to policy change and political volatility, particularly through the research and development phases and entry into commercial markets throughout the 2020s. Demonstrating strong political will to CCS in its early stages shall be the main barrier to developing the policy further, and keeping a sufficient amount of funding forthcoming over the time needed to commercialise CCS could result in some major long term challenges.

Externalities from CCS are more difficult to quantify than other options in this chapter due to few pilot plants around the world and none in the UK to take examples from. Public perception of CCS, while low, is negative compared to renewable power.[8] The potential for carbon leakage from reservoirs is still a potential issue, and the possibility of stations not capturing a sufficient amount of CO_2 may also threaten targets.[38] There is a range of potential externalities which are not currently understood, adding additional priority for developing pilot plants to determine the extent and nature of these externalities.

9. Findings

Comparing their rankings, the seven policies outlined by the Committee based against our criteria appear thus:

Table 3.1: Pre-2020 renewables		
Criteria	**Weighting**	**Score**
Existing level of policy	3	3

attention		
Urgency	3	3
Emissions reduction involved	3	6
Economic credibility	2	4
Long term sustainability	2	6
Externality of impacts	2	4
TOTAL		**26**

Table 3.2: Coal plants phase out		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	3
Urgency	3	3
Emissions reduction involved	3	9
Economic credibility	2	6
Long term sustainability	2	6
Externality of impacts	2	6
TOTAL		**33**

Table 3.3: Low cost renewables post 2021		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	9
Urgency	3	9
Emissions reduction involved	3	9
Economic credibility	2	6
Long term sustainability	2	2
Externality of impacts	2	4
TOTAL		**39**

Table 3.4: Offshore wind and pot 2 technologies		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	9
Emissions reduction involved	3	9
Economic credibility	2	4
Long term sustainability	2	6

Externality of impacts	2	6
TOTAL		**40**

Table 3.5: New nuclear		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	3
Urgency	3	6
Emissions reduction involved	3	9
Economic credibility	2	4
Long term sustainability	2	2
Externality of impacts	2	4
TOTAL		**28**

Table 3.6: Flexibility (grid storage, interconnection, demand response)		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	6
Emissions reduction involved	3	6
Economic credibility	2	4
Long term sustainability	2	4
Externality of impacts	2	4
TOTAL		**30**

Table 3.7: Develop CCS		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	9
Emissions reduction involved	3	6
Economic credibility	2	2
Long term sustainability	2	2
Externality of impacts	2	4
TOTAL		**29**

Within this chapter, it can be seen that most policies have high emissions abatement potential, with the remainder having medium emissions abatement potential. Offshore wind and pot 2 technologies are the most prioritised policy, due to the low external impacts involved, emissions reduction potential, increasingly favourable economics and long term sustainability. Offshore wind can radically transform the power mix in a way that can only be matched on a large enough scale by nuclear and CCS, both of which are ranked lower due to a less favourable economic outlook, longer timescales and less popularity. Pre-2020 renewable and coal plants phase out are ranked lower, not due to lack of importance but mostly due to the speed and relative policy safety in which they are occurring. Low cost renewables post 2021 is ranked second due to quick and cheap emissions reductions that can be made in the shorter term. Grid flexibility is harder to anticipate than other policies in this chapter due to the wide ranging scale of options and less information on many of them, but is still an important area of policy attention and can transform the effectiveness of many of the other solutions within this chapter.

CHAPTER 4: BUILDINGS

1. Introduction

Emissions from buildings made up 18% of emissions in the UK in 2015 at 85Mt CO_2e.[4] In order to meet the UK's climate targets, this will have to fall to nearly zero by 2050. 64Mt of these are from residential emissions, with 21Mt from non-residential emissions.[4] The predominant areas of policy to reduce emissions from this sector are energy efficiency gains and the installation of low carbon heating technology. Within energy efficiency gains are policies to increase energy efficiency from the residential sector, and to increase efficiency from non-residential building such as those used in the commercial and public sectors. Low carbon heating technologies include the installation of air source heat pumps, ground source heat pumps, biomass heating and solar thermal heating, both in retrofitting old buildings and developing stringent low carbon heating standards for new ones. It also includes developing heat networks for policies such as district heating and biomethane, as well as exploring adding hydrogen as a heating source to the existing network. Therefore the policies or group of policies we examine here are low carbon heat uptake in existing buildings, implementing low carbon heating standards in new buildings, developing heat networks, exploring the possibility of hydrogen heating, improving residential energy efficiency and non-residential energy efficiency. With the exception of hydrogen, all these policies are demonstrated below, specifically with regards to their contributions to 2030 targets set out by the CCC.

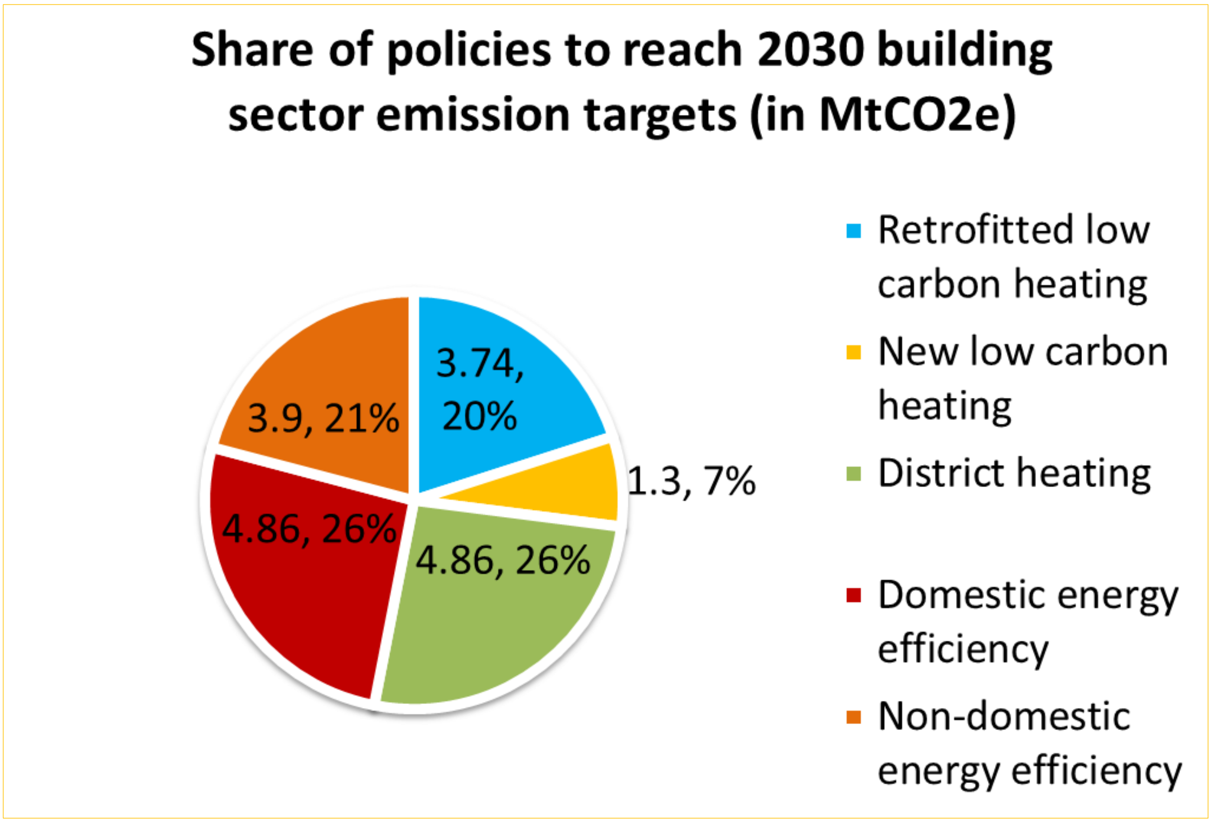


Figure 4.1: Heat policies required to meet the CCC's targets by 2030[4]

2. Low carbon heat uptake in existing buildings

This policy includes a large number of low carbon technologies, which are ground source heat pumps, air source heat pumps, biomass heating and solar thermal heating. The predominant policy that covers roll out of these technologies is the Renewable Heat Incentive (RHI). However, the CCC gives an amber rating to the RHI until 2021, and a red rating after this date.[4] This is due to the fact that the RHI has been extended to 2021, but has less consultation involved in the installation of the technologies and is underfunded, even more so than in previous years. The RHI has also not kept pace with the projections the CCC has set to roll out these technologies in line with climate targets. After 2021, there is no policy to continue the uptake of these technologies, meaning investors and policy makers alike have no guarantee there will be a market for these technologies beyond this date. The fact that these technologies have been covered by this policy for a number of years is indicative that there has been policy attention in this area, but given that this is insufficient to meet pathways required for this sector to meet its climate targets, is underfunded and there is no certainty is will continue after 2021, policy attention does exist here, but in a small and insufficient and unsustainable capacity. Given that the installation of these technologies occurs in multiple kinds of buildings, there could be a potentially wide range of political actors here in that direct sense, but it seems likely that the predominant actors will largely be broadly categorised into the government, businesses and individual households, as well as local councils and the businesses responsible for the development and deployment of these technologies. Therefore there is potentially a huge and unpredictable range of political actors, however in the initial phases of deployment this may be more driven by government policy and enthusiasm for uptake among building owners. Politically, the cost of these low carbon heating alternatives is likely to come under the most scrutiny, especially as the RHI has already had cut funding.[4] An alternative to this could be to pour government finance from other sectors as they become cost competitive such as renewable power towards renewable heating, or encouraging private investment in the technologies to reduce the financial burden on policy makers. Overall, policy attention towards low carbon heat uptake has existed but is insufficient for the immediate present and lacking entirely further into the future.

Urgency is affected by the potentially long timescales for these technologies to follow the CCC's cost effective pathways, to keep the cost of installing heat pumps as low as possible. As policies currently stand, this policy shall fail to achieve the emissions reductions required, but post 2021 there shall be no policy at all when more drastic cuts will be needed.[4] Urgency is therefore high, as this policy requires immediate changes to stay on target pre-2021, and meeting those targets as fully as possible will ensure ease after 2021, for which new policy must be put in place to ensure the continuation of these technologies. The self-sufficiency of these technologies is likely to evolve over a long timescale, as not only are there financial barriers for these technologies to overcome, but incentives to retrofit large number of buildings will require a lasting policy commitment and policies designed to ensure uptake at an appropriate rate. This will require a long lasting commitment to educating building owners about the new technology and its benefits, as well as lessening the financial burden, particularly in the present while costs of new technologies such as air source heat pumps are still high.

The CCC forecasts in its central scenarios (for the fifth carbon budget) that low carbon heat technologies will deliver an emissions reduction of 3Mt from the residential sector and 1.5Mt from the non-residential sector, totalling 4.5Mt in emissions reductions by 2030.[39] The 2016 Progress Report foresees of the 18.7Mt cut between 2015 and 2030 13% of this coming from low carbon heating retrofitted in homes and a further 7% from non-residential buildings, totalling 3.7Mt in 2030 (see Figure 4.1).[4] Longer term, heat pumps are likely to play an increasingly large role in reducing emissions from buildings as energy efficiency measures are exhausted in the shorter term. As there are currently 81Mt of emissions in the building sector and this is a key policy for emissions reduction, it seems that both in the near and longer term that low carbon heating technologies such as heat pumps and biomass heating will have a large role for potential emissions reductions within this sector. The CCC's Paris Agreement response sees 19Mt of emissions remaining for the buildings sector in 2050 in its central scenario and 4Mt for its maximum scenario.[40] Table 4.1 shows the uptake of heat pumps in the heating mix from each (note that the CCC states this could include heat pumps or hydrogen heating):

Table 4.1: Uptake of heat pumps and hydrogen under Central and Maximum scenarios

Scenario	Sector	Percentage of heat pumps or hydrogen
Central	Domestic	70%
	Non-domestic	35%
Maximum	Domestic	60%
	Non-domestic	50%

Whatever scenario, it is clear that heat pumps and other low carbon heating technologies are likely to be a significant emissions reducer by 2050 if targets are to be met, possibly by 10s of Mt, and therefore savings made by this policy could be very large.

The capital costs of these technologies vary, but the CCC estimates in their sectoral report notes that while low carbon heating in total (including heat networks and other policies listed below) will cost £0.6 billion towards 2030,[39] this will be more than offset by energy efficiency measures within the same timeframe. The average cost is £34 per tonne of CO_2 saved; also answering that cost per CO_2 is likely to be low, due to the potentially large emissions reduction potential. At the level projected within the CCC's requirements, retrofitting low carbon heating in residential areas will require funding throughout the

2020s, meaning low carbon heating is likely to cost a significant amount over an extended period, and will require large amount of investment from government, communities, businesses and other involved actors, meaning the economic viability of this policy requires a high priority.

This policy will be critical both in the short and longer term, as the reliance of the building sector on either this policy or potentially hydrogen to reduce heating in buildings is critical to meeting the 2050 emissions reductions target, largely because of the amount of emissions reduced by this policy. This policy will require a strong policy and financial commitment through the 2020s – this may even supersede renewable power and electric transport as the most politically and economically visible climate policy, as EVs and offshore wind become cost competitive by the middle of the decade. If these technologies are installed in enough buildings, there will also be considerable public interest, which could threaten the long term survival of this policy if this is negative. Therefore, it is crucial that the government develops and safeguards a long term strategy on low carbon heating and funding for it.

The externalities of this policy are extremely large and diffuse in scale, due to the large number of individuals that will benefit from low carbon heating. However, intrusiveness and cost may cause negative effects, depending on how policy is handled. While it inadvisable to say with any certainty all the external impacts that this policy is likely to have, it is probable that the impacts will be wide reaching and very unpredictable.

3. Low carbon heating standards in new buildings

The government has taken backward steps on this policy, as the CCC notes that the Zero Carbon Homes policy (specifically designed for new homes to be as low emission as possible) was cancelled in 2015.[4] Unsurprisingly, the CCC gives this policy a red rating, as the sudden repeal of the policy leaves this area without any policy framework. Clearly, as there has been an actual policy already, there is a history of policy attention here, however the sudden withdrawal is likely to cause problems in convincing the relevant industries that a new policy on this will stay firm through time. Despite that, there is a strong argument for creating a new policy for zero carbon new homes sooner rather than later, due to the relevant businesses and skills only recently having their policy cut off, and being able to recuperate their relevant skills now rather than in the future. This is one of several climate related policies that was repealed after the election of the new government in 2015, and while the Zero Carbon Homes caused opposition from NGOs and other groups, it was overshadowed by more publicised policy repeals such as premature ending of subsidies for onshore wind and solar. While it may concern third party actors, even repeal of the Zero Carbon Homes policy might not strike as much concern from third party political actors than other climate policies. Concerns over competitiveness and a more general rollback of industry related environmental policies may have influenced the decision to repeal this policy, and therefore emphasises the political nature of this decision. Clearly creating a new zero carbon homes policy would be highly political and potentially not popular with decision makers after the recentness of the repeal. The policy attention can therefore be said to be insufficient despite pre-existing policy.

There is an anticipated 8 million more homes to be built within the UK by 2030, according to the Next Steps for UK heat policy report by the CCC.[41] Therefore delay seems highly illogical, as the emissions saving from this policy will therefore be slowly annulled the longer this policy is left. Urgency is high for this policy, as it needs to be implemented quickly to achieve emissions reduction savings for the policy to cost effective and of full use. As with low carbon heating in retrofitted properties, this is likely to come with high funding and policy requirements into the next decade, so this policy could take some time to become self-sufficient. Therefore urgency for this policy is high, as it requires policy guidance and fast implementation to be of full effect.

New build low carbon heating accounts for 7% of the emissions cuts in the buildings by 2030 in the 2016 Progress Report, totalling 1.3Mt (see Figure 4.1).[4] The sectoral scenarios outline 2Mt of potential emissions reduction from new build heat pumps by 2030.[39] Assuming every household in the UK has the potential to retrofit low carbon heating however, the 23 million homes currently connected to the gas grid are likely to outmatch potential emissions reductions gains compared to the 5 million homes to be built by 2030 and the potential 8 million to be built by 2050.[41] However this is still an important if small potential emissions reduction, especially closer to 2050.

The economic cost for energy efficiency in new homes is clear, as this is an immediate cost savings measure – however as low carbon heating is expenditure with a positive rather than negative cost, it will require strong policy to require builders to have an incentive to include it in new construction. Pence per CO_2 avoided is likely to be slightly higher than retrofitting low carbon heat, as emissions savings are likely to be smaller. While heat pumps are cost competitive in mid-2020s in new homes according to the CCC's Next Steps for UK Heating policy report, they will still require funding for at least the 2020s, in much the same as retrofitting low carbon heating, indicating this policy too will take a significant time to become self-sufficient.

As with retrofitting low carbon heating, this policy will require long term sustained policy and funding, and as this policy has already been repealed it serves as an example as to how policies such as this one can be dramatically retracted – precisely the problem that would effect this policy if it was to be reintroduced. Decoupling this policy from government further or implementing this policy more strongly through statute could potentially safeguard it further from future repeal were a new Zero Carbon Homes policy to be introduced.

External impacts are likely to be significantly lessened compared to retrofitting low carbon heating, for if low carbon heating is integrated into the construction process, many of the impacts that directly affect individuals such as the cost of upgrading or construction process of installing a heat pump would be eradicated. However, this is likely to be replaced by building and construction opposition, who may see this technology as an unnecessary and overburdening additional expense. Strong policy or a cohesive working dialogue with these industries on the financial and other benefits of these technologies could be a key way to avoid such externalities and opposition.

4. Heat networks

Heat networks for the building sector are community and district heating schemes, linking up properties for heat distribution within communities to avoid waste heat. The CCC gives this policy an amber rating, stating that while £320 million has been established by government to develop heat networks, this is below the funding levels recommended to meet its 2020 target. It envisages 250,000 homes linked up by heat networks by 2020.[4] Clearly this policy is receiving some policy attention, and the £320 million funding is an improvement on the previous year, as there was previously no funding. However, this is likely to deliver heat networks to 400,000 rather than the 600,000 required by the end of the decade, making this policy insufficient to meet the needs of the CCC's targets.[4] The CCC does note that this number may change based on the design or implementation of this policy. This policy is unlikely to involve a large amount of businesses or NGOs; however local councils and political actors within the area where this policy is tested and first implemented may have considerable influence over this new policy. Politically, the time constraint of implementing this policy by 2020, may take attention away from this policy, but as funding has already been set aside, it seems the ambition politically to develop heat networks is certainly present – there are however no policies beyond 2021, when funding expires. In brief, this policy may not have sufficient policy implementation, but with funding set aside and the possibility that the policy may be successfully implemented as per the CCC's recommended levels, this policy has received a borderline sufficient level of policy attention.

Given the date of 2021 to implement this policy, just five years from the CCC's report and four years from this one, urgency is high, as this is a policy that does not have a great deal of time to be delayed. While the policy deals with a relatively small number of homes, this does not change the short timeframe available to implement this policy and test the technology behind it. The technology may take time to become cost competitive depending on the type of heat networks are used (see the economics section below) and this will only be ascertained for the longer term if this policy is rapidly rolled out and the technology showed on a larger scale, before 2021 to demonstrate its potential or otherwise.

The sectoral scenarios for the fifth carbon budget outline 2Mt of emissions abatement potential from heat networks in residential areas, with an additional 3.5Mt from non-residential areas, reaching 5.5Mt of abatement potential by 2030.[39] The 2016 Progress Report outlines 26% of the emissions cut between now and 2030 as being met through heat networks, at 4.8Mt.[4] Beyond this, there is difficulty in prediction – if all barriers to heat networks are overcome, due to technical reasons, they are still only likely to the provide 20% of heating of buildings within the UK, and their uptake to that level will be dependent on how they compete with other low carbon heating solutions.[4] Looking further ahead to the Paris Agreement response, it can be seen in all scenarios that heat pumps account for a much higher percentage of heat demand than heat networks, and therefore it would seem especially under the maximum scenario that heat pumps have potential to reduce emissions by much further than heat networks.[40] The CCC in its Next Steps for UK Heat Policy report states that neither technology should be ruled out at the current stage, but one may prove more successful than the other.[41] Either way, there does not seem to be quite the large potential for heat networks that exists for low carbon heating reductions.

The direct cost of heat networks over time will be difficult to calculate, as there are various different technologies and sources of heat within the blanket term of heat networks. Certainty, the £320 million funding is no small capital cost, especially for such a small number of homes (under 1%) that will be covered by this policy by 2021.[41] However, the more expensive types of technologies, such as water source heat pumps at £200 per tonne of CO_2 are likely to fall in cost through time, although that figure is for costs of abatement in 2030 rather than the present.[39] Many options within heat networks are technologies that have negative costs, such as waste heat and energy from waste, so this policy may determine individual 'winners' and 'losers' based on capital costs or future availability. The cost for pence per CO_2 is likely to be high, as not only is there a high cost of the technology, but the emissions reduction for this policy are likely to be smaller than for other policies used here such as low carbon heating. It too seems that this policy will take time to become self-sufficient, as the high costs of some of the options remain by 2030. As with low carbon heating, there are sustained and long terms costs invoked by this policy.

Key barriers which affect this policy over the longer term are financial barriers, low enthusiasm and mistrust about the policy, as well as lack of strong government intervention. The funding put forward for heat networks will certainly help break down these barriers, but it worth noting it will take enthusiasm from local authorities and clear policy alignment to overcome this in the immediate future. Post 2021 there is no current policy, and given the funding required and uncertainties in how this policy will perform given the variety of technologies involved, the long term future of this policy is highly uncertain.

External actors by this extension are potentially fewer than other policies, as small urban areas will be trialled for extended use of heating networks. Despite this, the reaction of these local areas connected by heat networks may shape future policy – if residents in the area feel the policy is invasive, or local councils feel it is still too expensive, this may deter interest in the policy and create less ambition in it for the future.

5. Hydrogen

Hydrogen has large potential as a heating fuel, as it can replace gas whilst still utilising natural gas infrastructure. This is more experimental than other policies in this chapter, and the CCC recommends further strategy to develop this as an option, along with more detailed technical studies. This is brought further in their Next Steps for UK Heat Policy report, which states:

'Hydrogen pilots can also begin and must be of sufficient scale and diversity to allow us to understand whether this can be a genuine option at large scale. As large-scale hydrogen deployment would require use of carbon capture and storage (CCS), a strategy for CCS deployment remains an urgent priority'.[41]

The 2016 progress report gives this policy an amber rating, as while there was no policy previously, small scale feasibility studies have been created. These are not, as the CCC notes, strategies however, and the need for further policy remains. Clearly this policy does not have a long history of attention, given that it has gone from no policy to small scale feasibility studies. The need for CCS deployment in the longer term also adds the lack of policy attention that CCS has been receiving onto this. External actors interested in this option may include the gas industry, as this changes the heating system less than low carbon heating, as well as those involved in CCS deployment.[42] As with other buildings sector options, the number of third party actors is lower than other sectors, with government having to intervene as the main creator and implementer of this policy. Therefore politically this is potentially a difficult option, as this policy is likely to require high government intervention, completely overhauling an existing system with long term, high costs. Opposition to change from gas and heating companies may also act as a deterrent.

This is a long term policy, with rollout of hydrogen heating not expected at scale until the 2030s and 2040s.[41] As the current policy is to create a strategy to develop and discover more about hydrogen rather than implement it on a large scale such as heat networks and low carbon heating, it is fair to say that policy urgency around this is relatively low. Despite that, it appears it will take a considerable length of time before this policy becomes self-sufficient. A switch from natural gas to hydrogen has been compared in the CCC's report to be akin to switching from town gas to natural gas, which required widespread government investment and funding, and while gas heating systems are currently cost competitive, the infrastructure required to make them so needed strong government intervention, otherwise it is unlikely the same system would have been created.[43] Therefore hydrogen must go through a similar phase, and will not be a self-sufficient policy until this is done. Despite this, the urgency for this policy is still low, not least because of the greater urgency of developing CCS further first.

Emissions reduced by this policy are harder to find an exact number for, as the CCC includes the emissions reduced by hydrogen in boilers and heat networks. The sectoral scenarios for the fifth carbon budget give 15% of services heating demand met by hydrogen by 2030, but under heat networks and boilers, with no specific figures given.[39] It also states that hydrogen is unlikely to enter into the sector until about 2023. Despite this it is clear that hydrogen heating in the near term is likely to reduce emissions less than other buildings policies, but further to 2050 there could be further potential as the technology develops. As seen above, the Paris Agreement response by the CCC sees 70% of domestic heating demand being met by heat pumps OR hydrogen networks, leaving the strong possibility that there are large potential emissions reductions available from this technology, but longer term than heat pumps and other forms of low carbon heating.[40] It is also considerably more uncertainty due to the immature nature of the technology. Despite this, hydrogen heating should be treated as having a high potential emissions reduction potential.

Capital costs for hydrogen are currently extremely uncertain, and this is reflected in the CCC's reporting on the policy. The need for projects to demonstrate hydrogen's costs in the field is needed to get a more accurate idea of how hydrogen heating will cost longer term. It is likely as low carbon heating such as heat pumps will be the primary competitor; it will need to become cost competitive at the same rate as this alternative solution. Given the rollout of hydrogen is predicted to be slower than heat pumps, it could well be at a disadvantage here, for if considerable public finance has gone into upgrading the heat infrastructure to heat pumps and getting that technology cost competitive, it is questionable whether the same willpower shall exist for a policy with a similar purpose. Hydrogen also has to be considered in the added cost and time factor alongside with the development of CCS, which itself has high capital costs and a potentially long path to self-sufficiency.[41 43] In short, it is probable that hydrogen costs will be high and long term, but without further tests and research in the field we cannot ascertain the economic viability of this technology, reinforcing the need to test this technology further.

Hydrogen policy is by its nature long term, and the risks to it are no fewer because of this. The CCC notes in its Next Steps for UK Heat Policy that hydrogen would take strong government leadership, as there are major barriers to overcome.[41] It also states that it may take 20 years for the gas grid to have full exposure to the technology, and with major rol out starting in 2030 and research and development policy starting before then; it would require strong government initiative and funding for over 30 years. Therefore this policy seems extremely fragile against future watering down or withdrawal, especially against the backdrop of other intensive climate policies such as CCS development, other low carbon heating, transport electrification and so on.

External impacts are unknown with any specific certainty, but it is likely that if a switch to hydrogen mirrors that of switching to gas, external impacts will be largely the same. This could benefit individuals, as this would be less disruptive than heat pump uptake.[42] However it is still likely that individuals may view disruption negatively, and the CCC notes in Next Steps for UK Heat Policy that hydrogen must be developed in a way that to 'reassure the public and businesses that fuel switching to hydrogen networks can be done safely, affordably, and with minimal disruption'.[41] Failure to do this may lead to hydrogen uptake being slowed or abandoned, but this policy must be tested first before any reasonable statements can be made on its future.

6. Residential energy efficiency

The CCC gives residential energy efficiency standards an amber rating, as while it has a long policy history and record of attention, current policies are insufficient to meet targets, and funding is decreased for after 2017. It notes that energy efficiency policy has been weakened in 2015. Policies surrounding energy efficiency in homes were wide ranging, with the Community Emissions Reduction Target, Community Energy Saving Programme, Green Deal and Green Deal Home Improvement Fund all now cancelled, leaving the ECO (Energy Company Obligation) until the end of this year.[4] So whilst there is an extensive policy history in this area, this reversal on many policies and the lack of energy efficiency policy past this year is a source of concern. The ECO is to be extended to and beyond 2018, but only towards households in fuel poverty, thus largely restricting the number of homes that can be treated by this policy. This policy has had further attention by third party political actors, as households, building and construction companies, environmental NGOs and others have been critical of both withdrawal and implementation of many energy efficiency policies in the past. Politically, energy efficiency is a cost saving option, but this is balanced against lack of political will, as it may not be seen as a strong enough policy for emissions reduction and market interference to many free market economists. This is not the case in either argument, as the emissions reductions abatement involved shows, and energy efficiency can create and revitalise home improvement industries, creating jobs and economic opportunities that save consumers money.[44] Therefore, there is a mixed picture for policy attention regarding energy efficiency, as while it has received great policy attention in the past and there is interest from third parties in sustaining it, the future for this policy is uncertain and current ambition is insufficient.

Given the 2017 cut-off date for the majority of the sole remaining energy efficiency policy for the residential sector, urgency for this policy is very high, as new policy will be required for next year and beyond. Given that there is no new policy at the time of writing, it seems that should a new energy efficiency policy arise it is likely to do so in the Government's delayed Clean Growth Plan, due for publication in 2017. Given that many other policies within the buildings sector will require long term funding, strong policies and long timescales to implement, an ambitious energy efficiency policy in line with the CCC's targets is a necessity to reducing emissions from the buildings sector, and 'buys time' to allow for the slower development of other policies. High urgency is recommended, and a new and effective energy efficiency plan must be designed and implemented quickly.

In the sectoral scenarios for the fifth carbon budget, 6Mt of emissions reductions potential originates from domestic energy efficiency by 2030, rising to 7Mt in the maximum scenario.[39] Within the 2016 progress report, it represents 26% of the emissions abatement potential, for 2030, totalling 4.86Mt of emissions.[4] Longer term, the CCC notes in its Next Steps for UK Heat Policy that energy efficiency standards in domestic (and non-domestic) buildings is needed throughout the 2020s to prepare for increased heat pumps and hydrogen heating beyond 2030.[41] This suggests that energy efficiency is shorter term in its savings than these other policies, and there is less scope past 2030 to reduce emissions, with the Sectoral Scenarios stating much of the economically viable energy efficiency measures will be exhausted by the mid-2020s under its scenarios. Despite that, there are modest but important gains that can be made from energy efficiency in the domestic sector.

The CCC notes in the 2016 progress report that to meet standards in line with their indicators that the ECO policy, in order to meet its own targets specifically to meet the needs of the fuel poor by 2030, will require £1.2 billion per year to reach its goal, far more than the £320 million per year pledged.[4] The amount needed to bring all homes up to energy efficiency standards is therefore still higher. While in total the expenditure will reach cost savings high enough for this policy to actually save £0.6 billion ultimately, the initial capital cost is indeed high. However, the large cost savings are essential to develop alongside more expensive low carbon heating options, heating networks and hydrogen deployment. Compared to the cost savings gained by increasing energy efficiency, while politically encouraging the initial investment may be difficult, the economic case for energy efficiency is clear due to the large cost savings. Pence per CO_2 avoided is likely to be low, as the emissions reduction potential is medium, but the costs are essentially low when taking into account the large cost savings available. Self-sufficiency though reductions in future cost is unlikely to be achieved with this policy, as it will require government incentives to get energy efficiency technologies into homes and finance businesses that are willing to perform this. However, given that the policy is predicted to be exhausted of energy efficiency potential around 2030, this policy can be viewed as a roughly 10 year investment, with benefits exceeding this investment timeframe considerably.[41] This could be more appealing than other buildings policies, which will require investment of higher cost over a longer period.

Therefore, longer term energy efficiency policies have a limited natural lifespan, and speeding up energy efficiency gains may make it easier for decision makers to invest in alternative buildings policies, due to lack of cheaper or easier alternatives. However, the predominant barrier longer term is lack of government ambition and funding, which must be increased and rapidly to not only implement this policy, but to ease the transition to alternative buildings policy, such as heat pumps and hydrogen.[40] Implementing a stronger policy at a national level is crucial to ensuring this and other buildings policies can lower emissions from this sector.

External impacts are likely to be mostly positive, as switching to a more energy efficient housing stock, either by retrofitting or new build can bring a multitude of non-climate benefits, largely being lower fuel bills.[43] Despite this, many residents may object to the intrusion of implementing some of these measures, particularly measures such as solid wall insulation due to its nature.[45] However, as shown by the large cost savings of this policy, it is likely to predominantly bring positive benefits in many other areas, and communicating the multiple benefits of this policy can reduce negative views or impacts in relation to it.

7. Non-residential energy efficiency

As with residential energy efficiency, the CCC gives this policy an amber rating, and there are a variety of similarities and overlap between this policy and the points raised in the domestic energy efficiency policy. The CRC Energy Efficiency Scheme covers non-residential energy efficiency, but has recently undergone changes that make some bodies such as schools exempt.[4] This is due to be removed in 2019, but later merged, with the Climate Change Levy (the UK's carbon tax), which the CCC recommends. As with residential energy efficiency, there is a history of policy attention, but this is not matched by the current policy reaching sufficient targets. It differs in that as far fewer changes have been made to this policy than those in the residential sector, there is less involvement of third party NGOs, and the political actors are still predominantly the public and private companies alongside government that will take on the costs of energy efficiency. Also politically this policy is likely to be uncontroversial, as it is soon to be merged with a large policy which is more fundamental to climate policy and therefore less likely to be removed. In short, policy attention for this policy is not sufficient to meet targets, but has a longer term future than alternatives, with few backwards steps.

Given the longer term nature of this policy as it shall be merged with the Climate Change Levy, the urgency for this policy is low, as its future is largely determined. When compared to domestic energy efficiency, the case for higher ambition is less urgent, but it faces the same problems in the sense that the current policy is not meeting short term targets. Additional funding in the short term may reduce the urgency, but it is inadvisable to leave energy efficiency gains for a later date, to the interconnected time dependent nature of policies within the buildings sector. Self-sufficiency will not be explicitly gained through this policy, as it shall rely on government support throughout its life, however by the end of the 2020s the majority of gains are likely to already have been made, so this policy can be thought of as a shorter investment period than low carbon heating.[41]

Emissions reductions involved are 3.9Mt by 2030 according to the 21% that they will represent according to the CCC's 2016 report, of the 22% cut on buildings emissions from 2015 to 2030 in accordance with the fifth carbon budget.[4] [39] The sectoral scenarios for the fifth carbon budget show 5Mt of potential emissions. In either case, there is a lower potential for emissions reduction under this policy, with few savings likely to be available after the mid-2020s.

Economically, the case for this policy is much the same as energy efficiency from residential buildings, as there will be government led capital costs for a period of around a decade to provide overall emissions savings. Current funding for energy efficient companies are funded under the Green Investment Bank (£7 million), Salix Finance (for the public sector only, £87 million in 2015/16) and through the Revolving Green Fund (over £90 million across its lifetime, also public sector).[4] It will require further public spending in order to meet respective committee targets. Pence CO_2 avoided and projections of future costs are largely the same as residential energy efficiency.

Longer term protection of this policy is also along similar lines to residential energy efficiency.

External impacts for non-residential areas are likely to be similar, however short term cost impacts and lack of interest in savings may be more of relevance to businesses, and stronger financial incentives may be required – equally, many businesses may recognise the cost savings that energy efficiency can bring more quickly than households. There is also the potential for fast emissions reductions if large companies and public entities switch altogether throughout all their properties.[46]

8. Findings

Comparing their rankings, the six policies outlined by the CCC based against our criteria appear thus:

Table 4.2: Low carbon heat uptake in existing buildings		
Criteria	**Weighting**	**Score**
Existing level of policy	3	9

attention		
Urgency	3	9
Emissions reduction involved	3	9
Economic credibility	2	2
Long term sustainability	2	4
Externality of impacts	2	4
TOTAL		**37**

Table 4.3: Low carbon heating standards in new buildings		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	9
Emissions reduction involved	3	3
Economic credibility	2	4
Long term sustainability	2	4
Externality of impacts	2	6
TOTAL		**32**

Table 4.4: Heat networks		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	3
Urgency	3	9
Emissions reduction involved	3	3
Economic credibility	2	4
Long term sustainability	2	4
Externality of impacts	2	6
TOTAL		**29**

Table 4.5: Hydrogen		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	3
Emissions reduction involved	3	9
Economic credibility	2	2
Long term sustainability	2	2

Externality of impacts	2	6
TOTAL		**28**

Table 4.6: Residential energy efficiency		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	9
Emissions reduction involved	3	3
Economic credibility	2	6
Long term sustainability	2	6
Externality of impacts	2	4
TOTAL		**34**

Table 4.7: Non-residential energy efficiency		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	9
Emissions reduction involved	3	3
Economic credibility	2	6
Long term sustainability	2	6
Externality of impacts	2	4
TOTAL		**34**

Low carbon heating in existing buildings is the most prioritised policy in this chapter, with low carbon heating in new homes following. Alternative methods of heating such as heat networks and hydrogen heating are ranked at the bottom of priorities, with both energy efficiency policies scoring equally and in the middle range of the six policies involved. The urgency of developing all of these options should be treated with consideration, but hydrogen networks have long timescales, and alternative low carbon heating is likely to be able to be installed more quickly and economically. Heat networks meanwhile should be rated lower due to relatively high levels of existing policy attention and a relatively small emissions reduction potential. For this reason energy efficiency measures are smaller compared to low carbon heating systems in existing and new buildings, and the scale of emissions reduction they represent coupled with severe policy deficiencies are present make them the highest priorities within the buildings sector.

CHAPTER 5: INDUSTRY

1. Introduction

Emissions from the UK industrial sector stood at 113Mt in 2015, or 23% of the UK's total emissions during that year.[4] It is also the first sector in this report that the CCC defines as a 'hard to treat' sector, as even under the maximum scenarios envisaged by the CCC by 2050 in their response to the Paris Agreement, 32Mt of emissions (just over a quarter of current amounts) remain.[40] This is in part due to the fact that many of the industrial emissions come from processes which are essential to the production of certain goods, and there are currently no technologically viable solutions to reduce emissions further. The sources of emissions within the industry sector are also incredibly varied, with many different industries contributing to emissions in different ways. The CCC identifies policies for emissions reductions to be made across the sector, which include energy efficiency improvements in the current system, with roadmaps developed across industry about how to reduce emissions further.[4] One of the principle sources of emissions within industry is heat, to provide for the industrial space used and heat used in industrial processes themselves. There are two viable policies to reduce emissions from these sources, bioenergy such as biomass, and other forms of low carbon heat, principally electricity from renewable sources. Finally, as some processes are not currently known to have emissions low alternatives, Carbon Capture and Storage possesses large potential to reduce emissions from these processes by sequestering CO_2 underground.

2. Energy Efficiency improvements and roadmaps

As with other sectors, energy efficiency can achieve fast emissions reductions at a net cost benefit. The CCC splits energy efficiency into two categories in its coloured priority system, giving action plans for industry to achieve higher energy efficiency a red rating, with existing policies on energy efficiency receiving an amber rating.[4] Much of this policy can be split into two in this way, but as both strategies concern industrial energy efficiency we feel it is best to keep them in the same policy category. The CCC notes that the government needs to outline larger energy efficiency projects, and that roadmap discussions have started, but are not finished. It would therefore seem that policy attention so far has not been absent, but short of what is required. Historically, there has been slow discussions and engagement with industry into arranging new action plans and new efficiency gains. The eight largest industrial sectors have roadmap plans to some degree in the government's 2050 Roadmaps report – however this does not cover all industrial emissions efficiency savings that could be made, and the government response thus far has been that the eight sectors alone are sufficient.[4] This does imply a backdrop of policy attention, but perhaps at insufficient level. The main political actors likely to be involved in this are the companies and industries responsible for the equipment used which could be used more efficiently – it seems less likely that NGOs and third party businesses would have a high level of interest, so this policy could benefit from third party environmentally minded concern. Politically, the main barrier should be the impact of interfering in industry, and the fear that this will affect competiveness or the economy.[47] Realistically, unlike industrial CCS, there are predominantly low expenditure and high return changes to be made in energy efficiency, which could save money and increase industrial productivity, so showing decision makers and those in industry the positive changes that could benefit could lead to greater political acceptability of this policy.[48] Additionally, the sooner roadmaps and plans are established, the sooner industries can be advised on what action plans they can take to save emissions and cost. The attention this policy is receiving is not sufficient, as while there has been some policy history here, it is clearly not sufficiently advanced for the relatively easy gains that could be made and quickly to a hard to treat sector of the economy, plus the need for environmental advice from an external third party organisation adds to this case.

The CCC includes the below graph in their report, showcasing the policies that will required to reduce industrial emissions by 2032 to meet its targets.

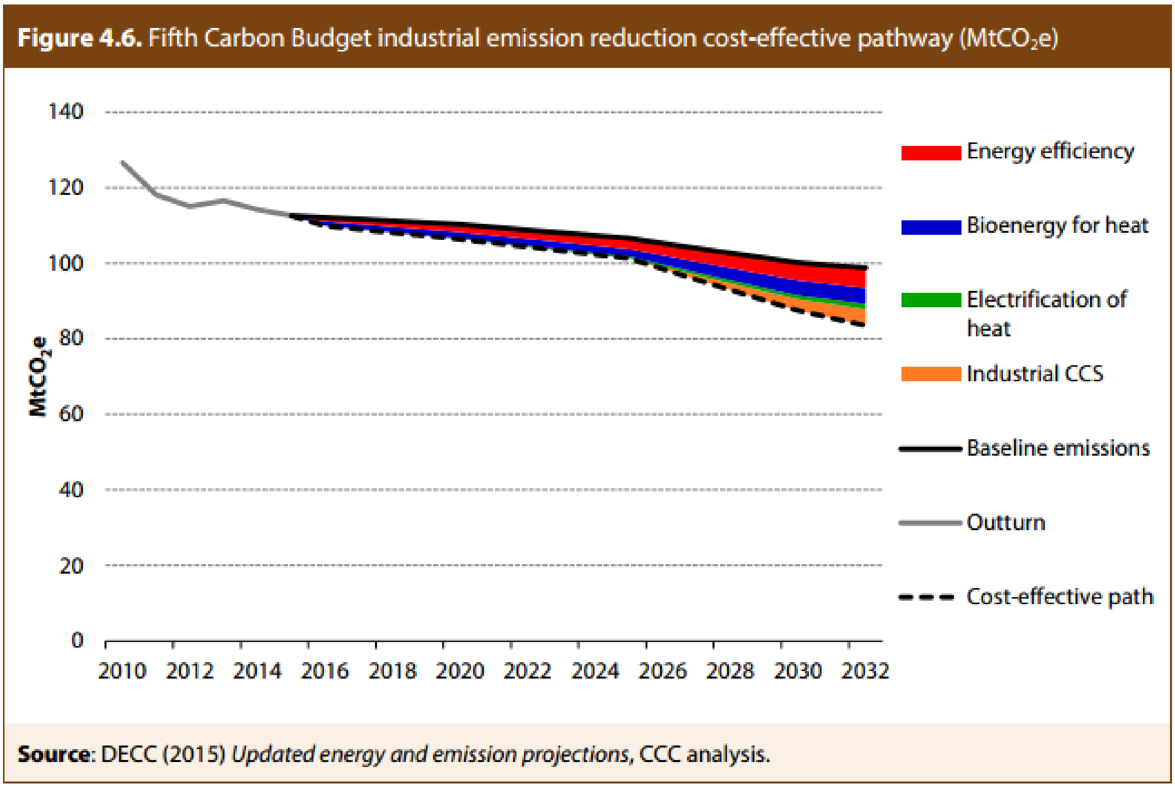


Figure 5.1: Graph from the 2016 Progress Report outlining the mitigation measures used for the industrial sector across the Fifth Carbon Budget in order to keep to the cost effective path[4]

Not only is this policy one of the first policies of the four advised, but it represents the largest chunk of emissions savings by the end of the fifth carbon budget. Given the slower pace of bioenergy, decarbonisation of the electricity system and especially CCS, energy efficiency in industry is the most urgent of the four policies outlined for industries, particularly as it can be said that energy efficiency saving can be made now to allow time for the other slower technological solutions to catch up. Many of the other policies will take time to develop and become self-sufficient, whereas energy efficiency savings, if plans are prepared to assess where and how they can be made, are likely to be lower cost and quicker to implement in the short term. Given that other sectors of the economy need to reduce emissions to balance out lower gains that can be made as the power sector decarbonises, as well as providing greater security, we recommend this policy be given a high urgency rating, as other policies in industry while not strictly dependent will need time to develop.

Emissions saved from energy efficiency in industry are uncertain due to the fact that action plans have not been developed in all areas, hence an additional need for further action plans.[4] Hence, estimates about the amount of emissions saved vary across scenarios. The CCC identifies 5Mt of emissions savings that can be made by 2030, and the Government's 2050 Pathways report identifies 8Mt of emissions that can be saved from this method by 2050 under its max tech scenario, and with other industrial sectors not covered in this report, it is possible that there are still greater energy efficiency savings to be made.[4] [49]It should be noted in the 2050 Roadmaps that the majority of emissions saving in most scenarios does not come from energy efficiency gains.

Economically, of the four policy options for reducing emissions from industry, energy efficiency requires by far the lowest up front cost, the CCC finding in its sectoral scenarios for the Fifth Carbon Budget that cost per tonne of CO_2 abated was -114, saving money without including the economic benefits of avoiding emissions, compared to the +67 for industrial CCS.[39] The 2050 roadmaps reports anticipates a total spending of £6 billion for all industrial policies to reach climate targets, rising to £16 billion in maximum technical deployment scenarios.[49] However as energy efficiency is the smallest of these it is likely that these costs will be considerably smaller. In terms of future costs, the 'easier' and less expensive efficiency improvements are likely to be made first, with more expensive or technically difficult options worked upon later. However, if further roadmaps and plans are made, not only will more efficiency measures become apparent, but further cost reduction mechanisms may also be discovered, so future costs can be a combination of more difficult technical solutions balanced against further cost reduction technologies. Again, the full extent of this may need to be examined in further roadmaps and emissions reductions plans, but it seems from the 2050 Roadmaps report that overall energy efficiency will remain a low capital cost option.

Longer term, the chief threat to this policy would be appear to be lack of political will and fear of economic interference with industry.[47] [48] It is important to set up governmental policy incentives to encourage immediate and sustained gains in industrial efficiency. Current government policies do this, but not to the speed and standard required to stay in line with the CCC's targets.[4] Increasing political will by showcasing the benefits of energy efficiency to both governments and industry alike, whilst highlighting the very low immediate costs compared to the high immediate gains, could go far in addressing this. The economic interference argument can be countered by showing the economic and productivity benefits of increasing efficiency standards, therefore increasing not decreasing economic competitiveness of industry. Policies that encourage industry to engage in efficiency standards in a 'hands off' competitive manner rather than a heavy regulatory sense could also allay fears of industry being overburdened with government interference.

External impacts are likely to be fairly low, as energy efficiency will improve the efficiency of industrial businesses, however many industrial actors may object to any government interference, or may not be willing to adopt new equipment. Again, a campaign of co-operation and development rather than authoritarianism and infringement is important at giving industry a role in shaping its own future for its own benefit.

3. Bioenergy for space and process heat

Heating industrial spaces such as factories or refineries as well as the heat needed in industrial processes is the predominant cause of most industrial emissions, but this same heat can be provided by bioenergy or low carbon electrification.[4] Looking at bioenergy, it is the only other policy in this chapter that the CCC recommends to implement immediately, with low carbon heat and CCS not making emissions reductions until the late 2020s. Bioenergy for industry is established under the current policy of the renewable heat incentive, which has funding allocated until 2021.[4] However, the RHI expires in 2021, and while it may be extended at a later date, there is currently no policy for bioenergy in industry after this date. Hence the CCC gives bioenergy until 2021 amber rating, with bioenergy after 2021 a red rating. Bioenergy until 2021 has received an amber rating largely because the current policy has kept uptake of bioenergy for heat in line with the CCC's indicators, however within the next few years there requires a greater uptake in bioenergy heat, and the current policy does not do more to more to tackle uptake factors, meaning the projections for the next few years could be at risk. New policy will be required to bring this in line with indicators for the sector. While this policy has received attention under the RHI, this is a general renewable heat mechanism, and a specific policy towards bioenergy in industry could resolve the issues until and after 2021. So while attention does exist in this area, it isn't specifically towards bioenergy in industry. It is unlikely that external actors outside of government or industry will be attentive on this policy except for producers of bioenergy, who are likely to take a positive view in the increase of the policy; it is unlikely to receive widespread attention outside of these small areas.

Politically, this policy is likely to receive similar barriers to bioenergy in other regards, such as hostility due to cost, potential environmental degradation, political will to invest in a new technology on a larger scale, and further into the future, competition from electrical low carbon space and process heating. Therefore, bioenergy has a history of policy attention which has sufficiently met targets, but this level is soon to be insufficient.

This brings in urgency, which is acute for this policy, as not only are the pre-2021 uptake rates for bioenergy likely to be off course over the period from now to then, but it will take time to develop a new policy past 2021,[4] and as this is a new use of the technology, it will be needed to ensure investors of continuing government support. Bioenergy will also take time to be an independent technology in this use, meaning government support is also needed, extending the priority for this policy still higher, as the lack of independence means it requires further aid into the future to meet climate commitments.

The CCC identifies 4Mt of emissions that can be avoided via bioenergy by 2030, and the 2050 Roadmaps report stating it could reduce emissions by 10Mt by 2050, with further possible gains in sectors not covered by the report.[4] [49] All emissions reductions in industry within approximately the next 10 years are anticipated to be via this policy or energy efficiency.[4]

Bioenergy in industry will require financial assistance from the government throughout the 2020s, and in pence per tonne CO_2 avoided is second only to CCS in expense in 2030 at an average cost of +32 per tonne abated within the industrial sector.[39] As CCS deployment only reaches into mitigation scenarios towards the end of the 2020s, bioenergy is likely to be the most consistently expensive policy between now and the fifth carbon budget, with CCS taking more of a role towards 2050. Given this, and the £6 billion DECC estimates needs to be spent between now and 2030 to achieve these emissions reductions, it seems that a large portion of that £6 billion is likely to go to bioenergy, with CCS not arriving until around 2025 and low carbon heat and energy efficiency having negative cost.[4] Therefore the capital costs are high for bioenergy, especially given the medium amount of emissions abatement potential the technology has. It should also be highly prioritised, for if it is to continue receiving financial support until 2030, it clearly will take a long time for this policy to be financially independent and a self-sufficient technology.

Bioenergy in industry will require financial assistance from the government throughout the 2020s, which may cause resistance from government. This may increase or decrease based on the basis that many other technologies such as offshore wind will not require subsidies as the 2020s progress, either causing a 'bonfire' of subsidies or a reshuffling in low carbon technology spending. This policy therefore may have a high chance of risk, especially as there is likely to be less political and environmental will to preserve it, potentially as other policies in power and transport will be more visible. It will require a commitment to the benefits of reducing emissions in the industrial sector to keep this policy afloat across the 2020s, with strong emphasis on the government reducing emissions from *all* sectors of the economy to keep a policy which is likely to be politically sensitive and expensive.

As with other biomass policies, key externalities will depend on how the bioenergy is harnessed and collected (see Chapter 3). Bioenergy in industry differs mostly in increased expense for the government and industry, and as with all industry emissions policies, may cause some issues around government interference, but largely the externalities are still predominantly in the sourcing of the biomass (discussed in Chapter 3).

4. Low carbon space and process heat

Examining other low carbon heating, this is chiefly likely to be through electricity from a largely decarbonised electricity grid. Given that much of power use is already for industrial use, this can be thought of as further diversion of electricity into the industrial sector, and as electricity is already likely to increase to heat buildings into the future, this is a natural progression of the sociotechnical system change lower emissions are bringing. The CCC has merged low carbon heat and bioenergy into the same category in its colour coded assessment system, largely as they are currently governed by the same policies. Therefore low carbon heat also comes under the RHI, which shall be insufficient from now to 2021, so the CCC has given an amber rating to this policy pre-2021, and post 2021 there is currently no policy.[4] Our recommendations are much the same as bioenergy for policy attention – it exists, but at an insufficient level.

Unlike bioenergy, electrification of space and process heat in industry is not expected to create major opportunities in emissions reductions in the CCC's projections until the mid-2020s.[4] This immediately makes it a less urgent policy priority than bioenergy and energy efficiency. It will also take funding throughout the 2020s to implement, meaning it is unlikely to be a self-sufficient policy in the short term and will require policy and financial aid throughout the immediate future.[49] However because of this it will take time to develop this policy and the technology required for it, so while this policy is less urgent it still requires attention to develop, especially post 2021.

The emissions reductions involved in this policy are the smallest of the policies in industry, with the CCC foreseeing 1Mt of savings by 2030, and the 2050 Roadmaps report anticipating 3Mt by 2050.[4, 49] The report also states 16Mt of emissions will be avoided by grid decarbonisation, however these reductions by the CCC's accounting would be included in power sector reductions, and not as a direct result of this policy.

Electrification of space and process heating that is identified by the CCC is in capital cost negative when business savings are taken into account, making it a preferable option to bioenergy. Whereas bioenergy has a +32 cost per tonne of CO_2, low carbon electric space heat has -26 costs, almost cancelling the same relative amount of bioenergy in terms of cost.[39] However, this includes abatement options that the CCC has highlighted – there are further options to reduce industrial emissions through electrification as with bioenergy, but some of these with current technology are highly uneconomical. So despite requiring government subsidy throughout the 2020s, the build in supply chains in technology such as heat pumps is still likely to save money on alternative resources throughout the fourth and fifth carbon budgets. Further into the future electrification becomes more difficult to financially achieve, as the technical ability to decarbonise some area of industry increase in expense as new technical solutions are needed.[40] Low carbon heating in this area like bioenergy is likely to require financial assistance from government over a long period of time, despite cost savings that can be made.

Regarding future uncertainty, due to later arrival of electrification and the lower capital cost, despite government subsidy, many of the objections and barriers of electrification are removed if it can be shown that effectively industry is gaining by the financial and efficiency benefits of switching to electrification of low carbon power. This should be emphasized when maintaining government subsidies or schemes to encourage investment in this technology, showcasing this policy as an industry aid rather than burden. However, as with other industrial policies, it may be attacked as being government interference in the free market or an expensive taxpayer burden.

Compared to the wide range of external impacts that bioenergy and biomass has, electrification has relatively few. The main issues involved are likely to be greater industry demand for power on top of increasing demand in homes and transport, putting strain on the power grid. Its effect on the utilities market and electricity bills should be monitored, however due to the relatively low power demand compared to domestic and commercial heating and electric transport, this is likely to be considerably smaller. Industry must work with government to bring about this policy, as it requires industry uptake and enthusiasm coupled with government incentives and cooperation to integrate the new technology.

5. Industrial Carbon Capture and Storage

Policy attention on CCS has been high in past years, as the UK has often considered itself a world leader in developing the technology, and has considerable technical experience within the oil and gas sector which is transferable to CCS. However, despite government finance and policy for research, CCS has lagged behind its technical advancement rate predicted.[4] The CCC gives a red rating towards industrial CCS, noting that the predominant policy on developing CCS, a demonstration competition, has been cancelled under government policy. So while government attention has historically been high towards this policy, recent backwards steps have taken it away from the implementation agenda, and emphasis has also been historically more focused towards the power sector rather than the industrial. Third party actors wishing to push this agenda are predominantly likely to be research and development teams within CCS, as industry has had a variable enthusiasm to CCS, some seeing it as an additional cost.[36] Environmentalist groups appear to have a low level of interest in CCS,[35] and many businesses are unlikely to invest in the technology if it has no policy to safeguard its future and the upfront cost is prohibitive. Politically, CCS appears to have taken backward steps largely because of a general cost cutting measure, with the cancellation of the demonstration competition worth £1 billion.[4] Therefore it seems that politically, finance for CCS will be dependent on what other public finance is being spent on within the low carbon sector, and how well generally the economy is performing, as well as the size of the public spending budget per government. Overall, this policy is given a medium priority for policy attention, as while it has definitely benefited from a programme of research and development in many years previously, its current policy attention has dropped dramatically, and will be required to rapidly increase to become a major policy in low carbon development.

When examining urgency, CCS has a potentially difficult timeframe to examine, as it is hard to assess when exactly the technology will move from research and development to market phases.[36] However, this only adds urgency to this policy, as if it is slower than anticipated it may slow emission reduction gains that can be made from the industrial sector. It is clear that this technology will take a considerable amount of time to become self-sufficient, requiring heavy assistance for some time.[36 37] As the U-turn on CCS will threaten the knowledge acquired in previous phases over time, it is also important to reinstate a CCS policy to keep research and development incoming, rather than moving on to other projects and sectors. Whilst the infrastructure exists to continue research and development it should be protected to ensure continuation of the policy. There is high urgency to protect both power sector and industrial CCS. Despite CCS not reducing emissions until the late 2020s,[4] the amount of time committed to research and development that could be needed make industrial CCS policy a priority in the present.

Emissions reduction involved from CCS are around 3Mt by the end of fifth carbon budget in the CCC's projections.[4] The maximum scenario reductions in the 2050 Roadmaps report are in the range of 23Mt, and one of the highest emissions savings.[49] It seems that closer to 2050 there are large potential emissions reductions from CCS, but there is variability in many scenarios, and this variability reflects that this is an uncertain technology, with unclear development trajectories as it is still in the research and development stage. The potential emissions saving however are still large, and within the industrial sector the largest emissions reductions gains that could be made.

Capital costs for CCS are potentially very high and over a sustained period of time. While for industrial CCS specifically total spending has totalled £1 million on a feasibility study for the technology's use within industry, the total spending on demonstration competition funding alone has been £1 billion, or was allocated as such before government withdrawal of the competition. The primary use in mind for CCS during this completion was for the power rather industrial sector.[4] The CCC find that it is double the cost of the next most expensive policy within the industrial sector (bioenergy), at +67 per tonne of CO_2 abated.[39] This implies a significant chunk of the £6 billion envisaged for industry emissions reductions policies until 2030.[49] However due to the linked up nature of power sector and industry CCS, with the emphasis in development of CCS being focused on the power sector, research and development costs that may be accounted for instead within the power sector may mask the cost of CCS in industry. Looking through the costs of CCS in the power sector above (see Chapter 3) it would appear that while CCS is initially expensive, towards and beyond 2030 costs will continue to fall to a self-sufficient level.[36 37] It is also likely to be unpredictable in price due to many research and development costs as well as further market costs that are yet unknown. Pence per CO_2 avoided is middle ground, as the high expense of CCS in its current form plays off against the large potential saving in greenhouse gas emissions.

Longer term, given the slow nature and high expense of this policy, it seems extremely vulnerable to policy change and political volatility, particularly through the research and development phases and entry into commercial markets throughout the 2020s. If industry is uncertain about new technologies and potential costs in the above three policies, it is likely to be far more worried by them regarding this policy. It will require strong political and industry will to develop CCS, and given the finance involved, it will be extremely difficult to devolve funding or policy to a third party actor. Therefore industrial CCS has a high risk of not being sustainable politically longer term.

External impacts could be volatile, with potential impacts of CCS such as carbon leakage not yet known in full detail.[38]Industry may well object to this technology as it is likely to be expensive in the short term and potentially disruptive, politically it may receive criticism because of this, and environmental and technical issues are still to be resolved.[38] In short, there may be a large quantity of external impacts, but not many of them are fully understood as yet due to the experimental and new nature of the technology.

6. Findings

Comparing their rankings, the four policies outlined by the CCC produce scores based against our criteria thus:

Table 5.1: Energy Efficiency improvements and roadmaps

Criteria	Weighting	Score
Existing level of policy attention	3	6
Urgency	3	9
Emissions reduction involved	3	6

Economic credibility	2	6
Long term sustainability	2	6
Externality of impacts	2	6
TOTAL		**39**

Table 5.2: Bioenergy for space and process heat		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	9
Emissions reduction involved	3	3
Economic credibility	2	2
Long term sustainability	2	4
Externality of impacts	2	2
TOTAL		**26**

Table 5.3: Low carbon space and process heat		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	3
Emissions reduction involved	3	3
Economic credibility	2	4
Long term sustainability	2	6
Externality of impacts	2	6
TOTAL		**26**

Table 5.4: Industrial Carbon Capture and Storage		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	9
Emissions reduction involved	3	9
Economic credibility	2	2
Long term sustainability	2	2
Externality of impacts	2	4
TOTAL		**32**

One key theme between all four policies is that they have received some but not a sufficient level of policy attention throughout. Energy efficiency comes out with the highest score largely due to the urgency of developing such options now, due to the longer timescales of low carbon space and process heat and industrial CCS. The latter is second highest predominantly because of having the highest abatement potential of all the options within this chapter. Space and process heat options are both rated equally, although both for different reasons – bioenergy scores lower on external impacts and sustainability, whereas low carbon space and process heat has less urgency and small emissions abatement potential.

CHAPTER 6: TRANSPORT

1. Introduction

The transport sector overtook the power sector as the largest economic sector for emissions as coal use continued to fall and renewable power rose in 2015. The transport sector was responsible for 24% of the UK's emissions in 2015, at 118Mt CO_2e.[4] However, international shipping and aviation emissions are not included in this, as there is great legal difficulty in ascertain how the divide up emissions on or over international waters. With these included, this adds an additional 34.2Mt from aviation and 7.5Mt from shipping.[4] The CCC includes its own policies for both internal and external aviation and shipping. The majority of transport emissions are however still from surface transport, 98% of these coming from road transport, the 2% of rail transport providing a diminutive figure.[4] Rail transport is not included in the CCC's assessment of reducing emissions, potentially due to the increasing electrification of Britain's rail network that is happening in its own right relatively independently of climate targets, reducing emissions from diesel locomotives.[50] With transport emissions originating predominantly from road vehicles, the largest emissions savings can be made with ultra-low emission vehicles – we differ in our assessment slightly from the CCC as we include hydrogen vehicles here, but also accept that such technologies are far from commercial development. We also feel that given the mentions of hydrogen in our chapters of this report it is appropriate to include it in passing in this section also. The switch to electric vehicles is still the predominant emissions saver in the transport sector longer term. Reducing emissions from conventional vehicles, encouraging the uptake of biofuels, creating smarter travel options by encouraging less use of road vehicles, and operating freight operations more smoothly also all have an important role to play in reducing emissions, and can relive the pressure of a sudden switch to electric vehicles. Each of these policies has a wide range of emissions reduction potential, demonstrated in Figure 6.1 below.

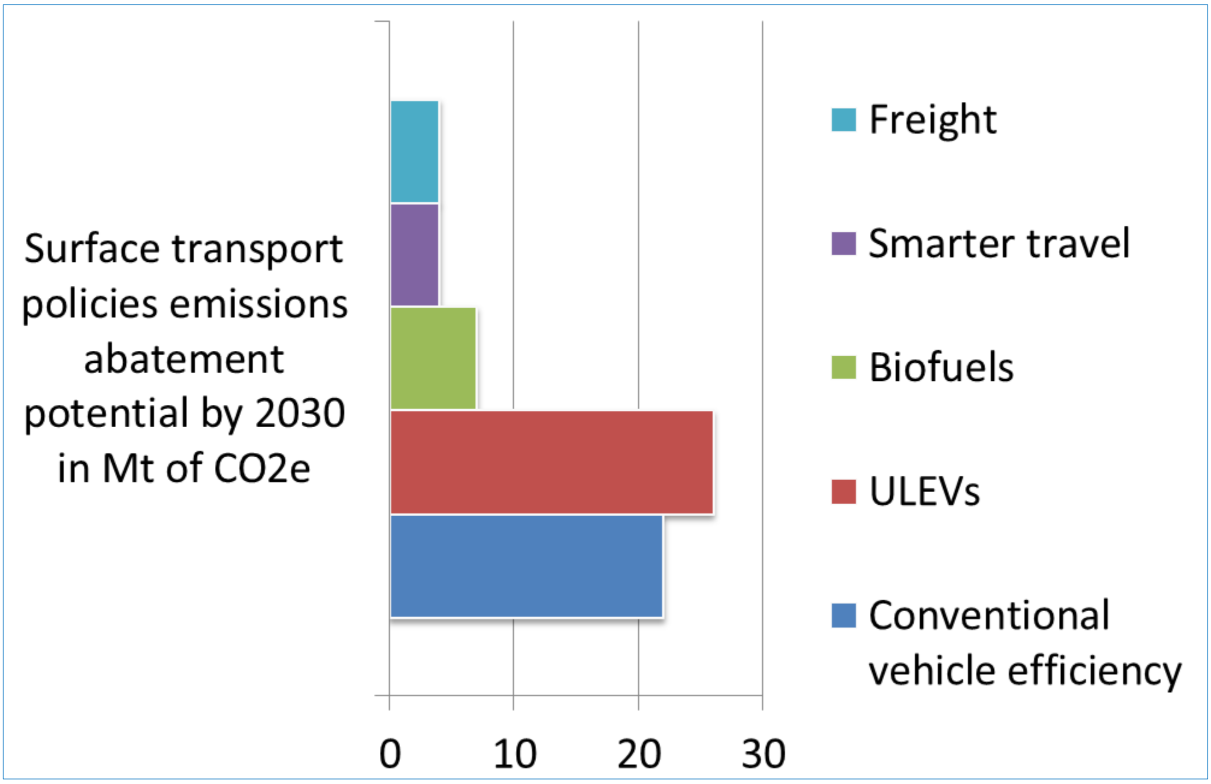


Figure 6.1: Emissions reduction potential of surface transport policies[39]

2. Increasing conventional vehicle efficiency

Transport emissions have not fallen substantially since 1990 and as electric vehicles were not available on a large scale during this period, much of policy has attempted to reduce emissions focused and continues to focus on increasing the efficiency of existing vehicles via regulation.[4] An increased demand for travel has outpaced the increasing efficiency of new vehicles, leading to a very small emissions reduction since 1990 and rise in the last few years.[4] Policy attention is largely European Union driven, as the standards of CO_2 per km is set by the EU and shall be for post 2020 policy also, meaning that if the UK is to exit the EU then it will have to develop its own strong framework for increasing efficiency alongside its existing finance policies for increasing efficiency.[51] These include the Vehicle Excise Duty, the Company Car Tax, and the Enhanced Capital Allowance, the first two effectively acting as tax disincentives for highly polluting cars, and the latter an allowance for low emitting vehicles.[4] The CCC gives this policy amber rating for pre-2020 policy, noting current policy is not a sufficient incentive for more efficient vehicles, giving a red rating to post 2020 policy, as there are currently no EU targets in place.[4] Given the vote for the UK to leave the EU, this may be increasingly fragile. Given the recent Volkswagen emissions scandal of cheated emissions testing, as well as from other car manufacturers, many environmental NGOs are likely to sceptical about the reliability of data provided on emissions quantity by car manufacturers, and the CCC notes there is a gap between test cycle and real world emissions. The automotive industry, including lobby groups such as the Society of Motor Manufacturers and Traders is likely to be resistant to any government involvement in their industry, as are automotive enthusiast groups.[52] Given vehicles are imported into the UK from other countries, there may also be concerns about the barriers to trade and economic disincentive this may place on the UK, especially in light of uncertainty given the vote to leave the EU. This policy is likely to attract attention from outsider third parties, leading to a large amount of political debate – 'restricting' the automotive industry may be less politically popular than furthering economic opportunity for them with electric vehicles, as decision makers are unlikely to want to be seen restricting the automotive industry, especially if increasing efficiency policies are unpopular or neutral with environmentalist groups who are sceptical about the transparency of the automotive industry. In brief, this policy has a mixed reception in terms of policy attention – while it has a long history of implementation and this has been the dominant form of emissions reduction in the transport sector thus far, post 2020 is lacking and uncertain, pre-2020 policy is not sufficient, and politically it may suffer from a lack of support from both climate change mitigation advocates and those opposed to mitigation measures.

Given that post 2020 policy is still non-existent, it would seem that urgency for this policy is high. Despite that, implementing new measures to increase efficiency may be relatively fast paced, reducing pressure, but this fails to give the automotive industry much clarity. There is also still the question of reaching pre-2020 targets, which still do not give consumers sufficient incentive to increase efficiency. Given the large percentage drop that is required in the fifth carbon budget and the slower rate of deployment of the other main mitigation option of ULEVs, the urgency for this policy is indeed high.[4] Self-sufficiency of this policy is a complex topic, as it can already be said to be a relatively self-sufficient policy, as it is government regulations and laws requiring vehicle manufactures to change their technologies at their own expense.[39] But the current UK government taxes on vehicles to do this, as well as the Enhanced Capital Allowance, is clearly an income and expenditure of government finance. It is a self-sufficient policy in the sense that it does not require a large amount of capital funding and waiting for new technologies to develop, in contrast to many other policies in this report. Urgency is high in terms of timescale, but there is less need to speed up the development of this policy to further the economic and technical aspects of development.

Emissions reduced by 2030 are to be in the vicinity of 22Mt by 2030, according to the sectoral scenarios report.[39] This is large amount, and a significant amount of the emissions reduction in the transport sector, coming second in emissions abatement only to ULEVs. In a similar way to other sectors, this policy represents a short term improvement in efficiency before the new technologies to replace the original polluting technology becomes available in the mid-2020s. This policy represents much quicker short term gains in emissions reductions than ULEVs.

As with other energy efficiency policies, this policy gives a cost saving in the sector due to the benefits for performing the same service with less energy input. The sectoral scenarios find that improvements to car efficiency by 2030 save £1 per tonne of CO_2, £15 for HGVs and £30 for vans.[39] The pence per CO_2 avoided is very efficient, as an investment in this policy which is in fact a cost saving results in a large amount of CO_2e avoided. Future cost is also likely to be low risk, as the efficiency technology will develop alongside increasing standards. It therefore seems that this policy is a low regrets option economically, due to cost saving, low capital costs and even direct gains through taxation, and larger amounts of cost savings into the future.[39] It is also worth noting for this and other policies in this chapter that the CCC envisages £1.3 billion being spent to achieve the transport emissions reductions target by 2030.[39]

Longer term, this policy may decrease in use as ULEVs begin to become more widespread – there is also likely to be a point where efficiency standards become so high the only way to overcome them is for automotive manufacturers to produce ULEVS and nothing else. While this policy is likely to achieve high emissions reductions before 2030, its use after this date is likely to diminish as ULEVs become an increasingly large share of emissions reductions in the transport sector. There may also be much scope not for reducing the *emissions* of ULEVs but the *electricity demand* further into the future. A 100% ULEV car, van and HGV fleet would have a large electrical demand, (see section 3) in addition to buildings and industry becoming increasingly electrified – therefore, efficiency standards in a similar manner to the emissions standards here may help reduce this drain on the power sector, which will have to expand rapidly and with low carbon systems to accommodate these new policies and remain low carbon. This policy is unlikely to be particularly controversial or withdrawn in future – similar standards exist across many countries across the world,[53] and the low cost of implementing it coupled with large cost savings makes it economically a rational option.

Externalities of this policy are likely to be small, as they have been small in the past. There may be objections within the automotive industry to this policy as they may see it as a restriction; however they will still be making cost savings in their own technology through greater efficiency.

3. Ultra-low emission vehicles

Ultra-low emissions vehicles, predominantly electric and hybrid vehicles but also potentially hydrogen vehicles further into the future represent not only a key technology within the transport sector but also for the entirety of emissions reduction within the UK. The CCC gives current policy efforts an amber rating, stating that there is not a government strategy on improving infrastructure changes for electric vehicles, and that there is no long term policy on electric vehicles.[4] It is of note that electric vehicles have received further funding under the Chancellor's budget revisions (see below paragraphs), as well as being a key component in the government's industrial strategy since the CCC's report was published, implying that the government sees future potential in this technology and policy is fast changing.[54] [55]This therefore seems a little more positive now than at the time of publication for the CCC's report. Policy attention on electric vehicles has been high in the past, as government funding of over £600 million has been allocated to emission free vehicles particularly recently,[54] as well as a history of uptake of hybrid vehicles. The CCC notes that the uptake of electric vehicles has outperformed their indicators to date.[4] There is also considerable third party interest in electric vehicles, from strong support from environmentalist groups, increasing economic and business interest from the automotive and manufacturing industries, and with multiple other societal groups and political actors. This is helped in part not only by the UK's commitment to ULEVs but also a rapidly growing global outlook for these vehicles, with technological gains being made in China and the USA, and stringent targets imposed within India, China and other European countries, increasing political acceptability and national policy attention.[56] Politically, the main barrier to electric vehicles is likely to be cost and electricity demand. The former of these has received perhaps more media and political attention, but forecasts for the cost competiveness of ULEVs is looking increasingly positive, with some studies anticipating electric cars becoming cost competitive globally by 2022,[57] so this may become a temporary problem. Electricity demand is likely to become a more politically sensitive issue as demand increases, although this may not be negative, as demand from the transport sector may fuel an increase in low carbon power and storage just as they are becoming cost competitive. Politically there are so many political actors involved in the process it is difficult to say with certainty what obstacles ULEVs may encounter, but they are likely to decrease as costs come down and the technology becomes more independent. Overall, policy attention has been good but not sufficiently long term in the past, with a high degree of third party interest and mid-level risk of political unacceptability making policy attention for ULEVs medium overall. Considering how much emissions reduction potential they also have, it is important to increase policy attention to high levels based on this factor alone.

Urgency for this policy may seem less high for increasing conventional vehicles standards, as it will take further time for ULEVs to make significant emissions reductions. However it is important not to disregard bringing a sufficient pipeline of ULEVs onto UK roads to reduce ease the transition to electric vehicles and reduce emissions, as well as developing the EV infrastructure required for a higher rollout of ULEVs at a later date. This policy will also require more support than efficiency standards for it to reach a level of self-sufficiency in the middle to the end of the 2020s. It is also important to consider the fast and deep reductions this policy can make, 'buying time' for other policies in the sector and other sectors like the buildings sector, which may be slower to develop.

In the CCC's 2050 surface transport scenarios in its response to the Paris Agreement, electric vehicles have almost entirely replaced the conventional road transport technologies.[40] Given that over 90% of the 118Mt emitted from the transport sector in 2015 (not including international aviation and shipping) comes from road transport, the potential for emissions cuts from zero emission or close to zero emission transport technologies is huge, and a significant portion of the UK's overall emissions.[4] The CCC's sectoral scenarios see a 26Mt cut in transport emissions coming from ULEVs by 2030, as with improvements in efficiency standards, the equivalent of a 3% reduction on 1990 levels of overall UK emissions.[39] This is one of the largest single policies for emissions reduction in this report, with potential to develop alternative technologies such as hydrogen at a later point to deal with harder to treat HGVs. Given the increasingly positive status of ULEVs worldwide, as well as their potential to go further longer term in emissions reduction, this policy should be treated with high regard with not only the large amount of emissions it can reduce, but also potentially the speed at which it can do it. With the technology likely cost competitive in less than a decade[57] and the CCC anticipating 60% of new sales being from ULEVs by 2030,[4] there could be rapid reductions in emissions from the transport sector in the 2030s if the government imposed sharp rules on emissions emitted by vehicles, essentially outlawing traditional vehicles without any cost to the consumer and low risk to automotive manufactures who have a stake in the new ULEV market.[58] As consumers switch vehicles as old ones are replaced, this would ensure a sudden drop in transport emissions. Overall, the sheer scale of emissions reduction possible under this policy makes it extremely persuasive as a priority for UK climate change mitigation.

As mentioned above, electric cars are likely to become cost competitive with conventional vehicles by 2025, largely negating public money being spent on these vehicles after this date.[57] There is also a large amount of finance to be deployed between now and 2030, such as EV charging infrastructure and subsidies to EVs and hybrids to get the market off the ground. The Chancellor's spring budget of 2017 allocated £270 million to EVs alongside a variety of other technologies, and the previous autumn statement allocated £390 million for driverless and EV vehicles, implying large amounts of short term funding are quite possible.[54] [59] With the CCC's £1.3 billion to transform the transport sector by 2030, it seems likely that a majority of this will go towards ULEVs and their respective infrastructure.[3] The sectoral scenarios also have mixed results on the different types of electric vehicles by 2030, with electric cars costing £90 per tonne of CO_2e, vans - £33, HGVs -£39, and buses at £103.[39] While EV cars and buses may be of positive expense in this projection, they are still cost competitive by 2030, and could be largely free of government intervention. Therefore, costs of pence per CO_2 is likely to be very efficient given the large emissions reductions involved, and the rapidly declining costs of EVs, even if many of these costs do not involve cost saving in the same way efficiency savings do. The speed of declining costs is also an economic positive, though this will require government spending and infrastructure until the technology becomes cost competitive. There is a favourable economic case for EVs, although not as much as increasing efficiency in conventional vehicles.

The longer term potential for electric vehicles is excellent, as their ability to transform the transport system is strong. However big changes have the potential to cause big challenges, and in a similar way to renewable power, there may be resistance due to the difference of technology. Keeping ULEVs as similar to the technology to they are replacing seems to have been a key design feature in EVs so far, and this approach may ensure less opposition among consumers than radically large differences. Given this approach, there is likely to be less of a public backlash against ULEVs than more radically different technologies such as onshore wind, and while this is impossible to predict with any real certainty, it seems likely that ULEVs will meet less opposition that those kinds of new, radically different technologies. The persistent issue of market interference and cost are likely to be a major influence on negative perceptions of ULEVs, as well as fears over grid instability.[60] These can be addressed by showcasing the economic opportunities these new technologies can bring, including bringing new jobs to the UK if government policies act quickly enough,[54] and observation and understanding that government subsidies are only temporary until EVs become cost competitive, which is happening extremely quickly. In terms of grid instability, this can be overcome by simultaneously developing grid storage and other low carbon options in the power sector, proving the system can remain resilient and stable (see Chapter 3).

Externalities from electric vehicles will be difficult to anticipate due to the vast array of potential political actors involved in the process. With protection from petrol price shocks, further economic opportunity within the UK, cleaner air and so on there are many positive external impacts. On a deeper psychological level however, the conventional car is very deeply ingrained in the public psyche, with oil dependent systems suffering from 'lock in' to the existing system, so there may be many uncertain and emotional impacts on turning away and replacing the conventional car.

4. Biofuels

Uptake of biofuels to reduce emissions from conventional petrol has had a long policy history in the UK. Biofuels represent a fast drop in emissions within the conventional system, but concerns about the sustainability and true emissions reductions of the technology have caused recent controversy – hence the CCC advocates sustainable biofuels that does not compete with food crops for land use.[4] With a historical uptake in the percentage of biofuels available at fuel pumps, biofuel currently accounts for 4.75% of transport energy. The 2020 target mandated by the EU requires this to rise to 8%.[4] Despite this history of introducing biofuels, there is a slowing uptake in biofuel gains, and no policy for how to achieve the 2020 target or beyond that date.[4] Therefore the CCC gives this policy a red rating, as there is no policy to achieve this goal despite the strong uptake of biofuels in previous years. Perhaps a reason for this decline is the opposition to biofuels from many NGOs including environmentally based ones, public opposition and resistance to the subsidies needed to increase production.[61] Politically biofuels are therefore without many proponents, as many climate mitigation advocates are opposed or sceptical of the technology, and automotive and industry as well as agriculture industries having less strong desires to increase the will for policy. Without strong advocates this may not be a policy priority for the government when it comes to climate mitigation, and given the current implications of the vote to leave the European Union, the reaction to this EU led policy on top of other factors may make this policy viewed negatively in a political sense.

Given the lack of policy and the urgency required to almost double the biofuel content of vehicles in the UK by 2020, this policy is highly urgent, as including the time it would take to develop a strategy as well as implement a change that large that quickly raises serious doubts about the commitment of the government to this policy. The lifetime of this policy is likely to be limited to the rest of this decade and the early 2020s as opportunities for biofuel deployment decrease. Given the land use needed and the incentives required, it is unlikely this policy will be able to take itself off subsidies and become self-sufficient in the way that electric vehicles could, politically making it unattractive. If this policy is to be taken as a serious option, it must be developed now, otherwise there may be the alternative route of developing other transport options, but the government must make a decision urgently.

The CCC envisages 7Mt of emissions abatement potential by 2030 from biofuels.[4] This is no small amount, although the abatement potential is still considerably smaller than that from increased efficiency and ULEVs. There may also be limited potential to reduce emissions beyond the fifth carbon budgets, in part because ULEVs will become more cost effective and they will force more conventional cars off the road networks. Relating to the above paragraph on urgency, if the government was to abandon biofuels while it would not be impossible to compensate for this 7Mt from other areas, it would require sped up progress in ULEVs and efficiency, which may be a less preferable option.

Economically, the sectoral scenarios report puts the cost of biofuels at £107 per tonne of CO_2 avoided, with only hydrogen fuel celled vehicles being more expensive.[39] Pence per CO_2 avoided is therefore far less good value than for efficiency and ULEVs, and the large cost of biofuels next to the much greater savings for less cost from other measures may perplex policy makers. The long term cost may not decrease either, with the possibility of an increase as more biofuel crop resources will be needed. While the economic case for biofuels does not seem promising, it is still considerably smaller than other policies in other sectors, and needs to be balanced against the sudden and short term emissions reductions it can make until other policies can be implemented closer to 2030.

Longer term biofuels face an uncertain policy future at present. Should an ambitious new policy regime be proposed on biofuels, it will still have a limited lifespan before other options enter the transport mix as the primary mitigation options. Given its unpopularity with many different groups and the lack of current policy, the case does not currently look optimistic, however the need for quick emissions reductions in the transport sector, which is the sector with the largest number of emissions cuts at risk for the fifth carbon budget, could be made to increase uptake.

External impacts of biofuels are still high whatever the uptake of them is, with concerns about the actual amount of emissions reductions being smaller than thought, soil degradation, additional emissions in transporting biofuels across areas, competing with land for crops, changes made to the look of the landscape, opposition from many public groups, the size of the land area needed for the amount of biofuels required, environmental degradation from creation of biofuel crops, and so on.[62] There is also the serious consideration that given that biofuels cause all of these externalities, they may be better deployed in sectors which have fewer or further off mitigation options available, such as bioenergy heating in the industrial sector (see Chapter 5). Positive externalities of biofuels include them being a valuable cash crop for agricultural workers, despite others within the agricultural sector who object to the crop being so widespread.[61]

5. 'Smarter' travel choices

Simply changing the way people travel to less emissions intensive systems and reversing the trend of increasing travel demand is an attractive policy proposal, not least due the initial simplicity of the idea. In practice, it requires much interdisciplinary work on different proposals and policies to implement. The CCC gives this policy an amber rating, as there while there is government funding to 2020, it is unclear if this will be as yet sufficient to achieve the necessary emissions reductions.[4] This policy has a history of investment and policy attention, but the results of this policy are dependent on unpredictable social factors, thus making it a difficult policy to react to and predict for policy makers. Third party actors have an interest in this policy in varying ways, as reducing travel demand is popular with environmental NGOs and public transport, but is likely to be opposed by road lobbyists and the motoring industry. Public perception of the need to travel less is also higher than many policies in this report. Politically, this policy could suffer from not being seen as a 'hard' policy solution, as it may be difficult to assess the positive impact it has on environmental and social services. However, the diffuse advantages it has alongside climate change mitigation such as public health and reducing traffic congestion could shield it from political attack.

Urgency for this policy is not particularly high, for as long as the transport sector remains carbon intensive many of these changes can provide benefit. Funding has also been provided until 2020, with some goals extending to 2025 (such as cycling targets).[4] Despite that, the sooner this policy is implemented, the larger emissions cuts can be made, as the transport emissions saved are likely to be larger. The policy is unlikely to be self-sufficient in the sense used throughout this report, as it will be dependent on government funding and policies further into the future.

The emissions avoided by this policy, like many other details, is rather speculative due to the nature of the policy, but 4Mt of abatement potential by 2030 is the figure given in the CCC's sectoral scenarios report.[39] Given the prevalence of ULEVs and efficiency, this policy is clearly the smaller option in the transport sector, but as with reducing demand in the power sector, this policy could allow slower growth of ULEVs, creating 'catch up' time if the technology were to stall. Likewise, if the growth in ULEVs is faster than expected, then some of the abatement potential from this saving could be reduced – indeed, ULEV's could save this 4Mt on their own, but the multiple benefits from a less intensive transport system still stand, and this 4MT abatement potential is a useful addition to other policies. This may have scope to go beyond 4Mt post 2030, but it seems likely most of the main benefits will emerge before then, mostly in the early 2020s while ULEVs are still non-cost competitive.

The funding secured for this policy from 2011 to 2015 was £600 million, and the latest round of funding from 2017/18 worth £580 million.[4] While these are large capital costs, especially given the short period, it is also an important factor to bear in mind that this capital has multiple benefits besides climate mitigation. These may make overall costs more favourable on the whole, and cost savings from multiple other benefits count. The sectoral scenarios for the fifth carbon budget repeats this sentiment, stating the policy is 'Likely to be cost-effective when wider benefits are considered'.[39] This rather general statement compared to more concrete cost estimates for other policies showcases the highly generalised and unpredictable nature of this policy, with a potentially difficult case to prove the link between spending and CO_2 abatement. The CCC also notes it is unclear whether the funding provided is actually enough to reach targets, the uncertainty further highlighting the difficult to measure nature of the policy. Pence per CO_2 avoided is middle value, as the cost invested is low given the offsetting of benefits, but also emissions reductions are small. This policy may have a limited lifespan over future cost, as it is likely as easier and cheaper solutions are used up costs will increase.

Therefore in the longer term this policy is likely to fade in prominence in the transport sector as an abatement policy, but its sudden, short term impact could protect it politically from withdrawal at a later date. Indeed, as funding for this policy has already been given to 2020, this policy is largely safe for the immediate future.

Externalities are diffuse, but positive externalities that could occur include many of the benefits listed by the CCC: reduced congestion, road safety, noise reduction and improved air quality being among those listed.[4] Negative externalities are likely to be small by comparison, and one of this policy's main appeals is the numerous positive benefits besides climate mitigation.[4]

6. Freight operations

With more efficient driving of freight vehicles not being the largest emissions reduction policy, it could lead to a respective reduction in emissions nonetheless, with minimal effort and a large range of other benefits. While the government is carrying out a review strategy, this is still to become policy, hence the CCC giving it a red rating in the 2016 progress report.[4] Policy attention prior to now have focused on voluntary schemes within the industry to encourage more efficient driving and other ideas, but this is still a small amount of policy history compared to full blown government policy.[4] Third party interest is unlikely to be high, as this is chiefly a policy between the freight transportation industry and government. Politically, this may be seen as a burden on the industry, with an additional argument of there being a small emissions reduction potential anyway. However, the deference of this policy to the industry rather than government to a large degree, and the potential ease of this emissions reductions strategy could equally make it an appealing policy. Policy attention has been generally low, and there is need to go further, but positive arguments can be made for the swift adoption of this policy.

As there is currently no policy for this strategy, urgency should be given to developing these ideas into tangible policy that can be used by the industry. This policy is further behind and receiving less attention than other policies in this chapter, and as it may take some time to develop it going forward, starting progress now can speed up the response later. Self-sufficiency may be relatively quick to achieve if this policy is government regulated but industry led, especially as this policy is anticipated to balance out financially in efficiency gains.

4Mt of abatement potential exists from now to 2030, a much smaller segment of the transport sector emissions reduction than efficiency or ULEVs.[4] The sectoral scenarios report estimates 6Mt of potential by 2035, implying further gains could be made longer term.[39] This emissions reduction could successfully keep emissions reduced in the freight sector until alternative technologies and vehicles come onto market to replace them, allowing further time to develop them whilst still reducing emissions within the sector.

As with Smarter Travel Choices, this policy balances out capital costs with savings made in efficiency later.[39] Pence per tonne of CO_2 avoided are also the same due to similar costs and abatement potential. Self-sufficiency is the opposite in that self-sufficiency is likely to be gained far earlier and be dominant from the start, as behaviour changes such as differing driving will be some of the main policies, and these are likely to originate from the industry.

As with Smarter Travel, this policy is likely to become outdated once alternative freight vehicle technology replaces it, although this will take time as HGVs, which the freight industry relies on, are more challenging to replace than cars and vans. Politically it shifts emissions reductions from government to the freight industry in many ways, though government intervention and funding is still required. This could make it popular among decision makers, as it reduces emissions without having to expand too heavily on government resources.

Externalities are likely to be felt exclusively by the freight industry, and positive engagement and awareness of the financial benefits to them are essential to this policy's success. Potentially negative effects could be industry fightback against government interference, which can be countermanded by benefits of the cost savings.

7. Aviation and shipping

Aviation and shipping are complicated emissions to quantify, and whilst domestic flights and crossings are included in UK carbon budgets, international emissions are not, due to the difficult nature of who is responsible for emissions over international waters.[63] With this in mind, the recommendations of the CCC for this policy are twofold: one, for the UK to organise and negotiate an international system to cap emissions from these sources, and two, develop implementation plans to reduce emissions from these sources.[4] The CCC does not provide a 'traffic light' like rating at the end of their transport chapter for this policy, however given the slow pace of international talks on this subject and the lack of implementation plans so far, it is fair to say that historical and current policy attention is low.[64] Third party interest in aviation and shipping is high and likely to grow in future, as these sectors, especially aviation, have a history of both opposition and support groups.[65] Business interest is also high due to exports and imports, as well as public interest in travel. Politically, both sectors are of strong importance to the economy, and aviation is signalled to be a massive growth area.[4] Policy attention is therefore not only lacking, but also politically contentious, not least because of a large number of third party groups.

Technically, due to the long term difficulty of finding emissions reductions technologies for aviation and shipping, one response could be to leave this policy as non-urgent, as it will take a great deal of time before research and development has proposed real alternatives to the current technologies involved.[40] However, given the lack of policy so far, as well as the long timescales it will take to develop the technology, implying research needs to begin sooner in order to ascertain how long technical alternatives will take, it should be said that urgency for this policy is high. We propose that this policy is juxtaposed between these two standpoints, with large emissions reductions before 2030 not as likely as many other policies, but as with many policies in the buildings, industry, and agriculture sectors, it will take time to develop these solutions, so policy and research must begin in earnest now. Medium priority is thereby rated to this policy. Self-sufficiency for this policy is likely to be an extremely long time away as are the technological alternatives, and in the CCC's response to the Paris Agreement, even in 2050 there are still forecast to be significant aviation and shipping emissions, suggesting in even the most stringent scenarios emissions from these sources stubbornly persist and will require large research and innovation investment for some time.[40]

Emissions targets by the CCC for all aviation emissions are to keep emissions at 37.5Mt (2005 levels).[4] This reduces emissions 14.4Mt from the 51.9Mt that would otherwise occur, due to an anticipated 60% growth rate in aviation across the early part of the 21st century.[4] In a similar way, shipping in 2050 domestically is 1.3Mt and internationally 5.1Mt - a reduction of 3.5Mt, but from current levels (emissions were 9.9Mt in 2013).[4] Under the CCC's maximum scenarios for 2050 (in its response to the Paris Agreement) it still sees aviation and shipping at 40Mt, implying there is a strong limit on how far technological improvements and emissions reductions can go in the time available.[40] If technical solutions could be found to reduce this to near zero, it would make the UK much more likely to be able to reduce emissions to net zero.

Data about the economics of many of the technical solutions to this emissions source is scarce, largely due to the lack of data and research available. Biofuels, reduced demand, Liquefied Natural Gas and greater efficiency are all potential avenues for emissions reductions in these fields, but they are only partial solutions, and the development of truly low carbon shipping and aviation is likely to be significantly more expensive, and over a long timescale.[66] It is likely a true low carbon alternative is likely to have middling CO_2 per pence cost, due to high cost and high abatement potential. Future cost is likely to increase as the need for low carbon shipping and aviation increases, but could after a long enough time decrease as technological alternatives are implemented.

This policy by its nature is long term, and variables for this policy are more uncertain than shorter term policies accordingly. There is also a wealth of ideas and policies within aviation and shipping that may not yet have been considered or analysed, hence the need for an implementation policy and strategy from the government. This policy is also politically sensitive, and this may only increase as other climate mitigation policies are exhausted, so political fighting over reducing emissions from this sector could be expected as it becomes a bigger share of emissions. While there is a multitude of longer term factors affecting this policy, they are so long term and uncertain it is difficult to put any more than pure speculation on them at this point in time.

Externalities could be large, and as the large number of third party actors for this policy shows, this policy affects large numbers of different stakeholders. The impact of business versus government politics, international trade and commerce, the economy, and travel generally could be wide reaching. The aviation industry in particular is likely to resist many changes to the technology used in its airlines, and reductions in travel demand is unlikely to be popular with the public and business past a certain point. In short, a solution similar to ULEVs for this transport technology would be ideal, as the existing sociotechnical system carries on in as similar a way to normal as possible – however such a technology does not yet exist for aviation and shipping, and uncertainty about when or if this technology will be available only fuels the wide range of potential people affected, either by emissions from aviation and shipping or changes to it.

8. Findings

Comparing their rankings, the six policies outlined by the CCC based against our criteria appear thus:

Table 6.1: Increasing conventional vehicle efficiency		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	6
Emissions reduction involved	3	9
Economic credibility	2	6
Long term sustainability	2	4
Externality of impacts	2	6
TOTAL		**37**

Table 6.2: Ultra-low emission vehicles		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	9
Emissions reduction involved	3	9
Economic credibility	2	4
Long term sustainability	2	6
Externality of impacts	2	6
TOTAL		**40**

Table 6.3: Biofuels		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	9

Urgency	3	9
Emissions reduction involved	3	3
Economic credibility	2	4
Long term sustainability	2	2
Externality of impacts	2	2
TOTAL		**29**

Table 6.4: 'Smarter' travel choices		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	3
Urgency	3	3
Emissions reduction involved	3	3
Economic credibility	2	6
Long term sustainability	2	4
Externality of impacts	2	6
TOTAL		**25**

Table 6.5: Freight operations		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	9
Urgency	3	6
Emissions reduction involved	3	3
Economic credibility	2	4
Long term sustainability	2	4
Externality of impacts	2	6
TOTAL		**32**

Table 6.6: Aviation and shipping		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	9
Urgency	3	6
Emissions reduction involved	3	9
Economic credibility	2	2
Long term sustainability	2	2
Externality of impacts	2	4

TOTAL	**32**

Clear winners from this chapter are the larger road transport policies, increasing conventional vehicle efficiency and Ultra Low Emission Vehicles. The slightly lower level of urgency reduces upgrading conventional vehicles to slightly lower than ULEVs, while it is worth noting that ULEVs are a more permanent long term solution to road vehicle decarbonisation. Freight operation and aviation and shipping policies are ranked mid-range on equal scores, with the low emissions abatement potential lowering it down rankings and the long term nature of aviation and shipping policy lowering that policy further down prioritisation. Biofuels and then smarter travel choices are ranked lowest, the long term sustainability and externalities a consistent problem for biofuels, with low emissions abatement potential, existing policy attention and lack of urgency taking smarter travel choices down to the lowest prioritised policy within the transport sector.

CHAPTER 7: AGRICULTURE AND LAND USE, LAND USE CHANGE AND FORESTRY

1. Introduction

Agriculture and LULUCF represent the largest portion of non-CO_2 emissions in the UK, with agriculture at 9% of UK emissions and 49Mt, with LULUCF acting as a carbon sink and reducing emissions by 9Mt (the equivalent of 2% of 2015).[4] Agriculture and LULUCF can be thought of as separate but related fields of policy, hence their inclusion in the same chapter but separation in the CCC and our report. Agriculture policy predominantly revolves around stronger action plans with higher ambition; with LULUCF policies acting to extend the carbon sink to absorb further emissions within the UK. Within agriculture, 23.8Mt (48.5% of agriculture emissions) originate from enteric fermentation, the digestive process within ruminant animals such as cattle.[4] 14.4Mt was from greenhouse gases released from the tilling of soils, 5Mt from waste and manure management, and 4.5Mt from machinery and 1.4Mt from other sources.[4] Within LULUCF, forestry remains the highest reducer of emissions, with grasslands as a smaller secondary source and a much smaller amount reduced from wetlands.[4] The predominant policies that the CCC calls on to meet future carbon budgets in agriculture is stronger implementation of the Smart Inventory for agriculture to ascertain emissions data more clearly, strengthening the current voluntary approach from the current policy outlined in the agricultural sector's greenhouse gas reduction plan, and creating new policies for measures post 2020 aimed at reducing emissions through crops and soil management, livestock diet, health and breeding, waste and manure management, and energy efficiency. Within LULUCF, the CCC calls for further ambition and safeguarding of reforestation policy, as well as creating an agroforestry policy for further emissions savings.

2. Stronger implementation of the Smart Inventory for agriculture

Given the uncertain nature of emissions from non-CO_2 sources and the time lag involved, as non-CO_2 emissions are focused upon further it becomes more important to be able to reliably track them. The Smart Inventory is due to be published in 2017, despite past delays, which is expected to give further clarity over emissions data.[4] Policy attention to this Inventory may appear low if delays are taken into account, but as an internal government emissions inventory, it can be argued that the inventory has a high government priority, unlike other policies in this report which have so far remained external to the government with no policy. While delays to this inventory must be taken into account, the integrated nature of it gives it a low priority, despite the probability of low level interest from environmental NGOs and businesses. It is also unlikely this could be considered to be politically difficult or infeasible, due to the low level nature of the policy. Indeed, it could be said that the Smart Inventory system is more along the lines of a policy tool rather than a policy in itself – for simplicity's sake within this report, it shall be considered in the same category as other recommendations in this report. Prioritisation for policy attention is therefore low.

Action can still be taken to reduce emissions from agriculture if this policy is not implemented soon, or indeed not at all. However, the sooner the Smart Inventory is rolled out the sooner more accurate figures and data can be ascertained. Self-sufficiency in the context outlined in the criteria is largely irrelevant to this specific example, as the Inventory will be relatively self-sufficient as an accounting system. However, this policy can be thought of as a foundation stone for future policies in the agricultural sector, as it will improve the accuracy for their planning and implementation, therefore this policy is less urgent but more useful for the improvement of other policies.

Emissions reductions involved are technically zero, as this policy will not lead to any direct reductions in emissions.

The economic cost of implementing a Smarter Inventory is low, due to it being a policy research project rather than infrastructural changes. Pence per CO_2 avoided is also low due to no direct emissions reduced, as well as future cost likely to be mildly higher as monitoring costs of non-CO_2 emissions increase.

The Inventory is likely to be sustainable in the long term due to the increasing need to monitor non-CO_2 emissions accurately as well as the low political volatility involved. There is the possibility it will be superseded by a superior inventory in the longer term future.

Externalities are likely to be extremely low due to few direct knock on effects due to no direct influences on policy change. Many of the indirect effects by this policy will be caused by the policies below that will be covered in their own sections, should they be implemented. Ultimately, this policy tool is so low in its direct impacts its priority is likely to be low overall.

3. Strengthen the current GHG action plan, and across all nations

The current government policy surrounding agricultural emissions is covered by the Greenhouse Gas Action Plan (GHG), a voluntary policy that encourages farmers and agricultural workers to change practices to livestock feed, health and soil management, with a view to reduce emissions by 3Mt within England by 2022.[4] The CCC gives this current policy a red warning for policy attention, down from amber the year previously, as they are currently awaiting government review of the GHG action plan.[4] This was due to be published in late 2016, after the date of the CCC report, and in March 2017, the review was published. It outlines no new policy post the end of the third carbon budget, 2022 (see section 4), and concludes that: 'It however remains Defra's preferred option, for the foreseeable future i.e. the remainder of carbon budget 3, that industry continues to take the lead through the GHGAP'.[67] This indicates that no new policy is incoming to increase ambition through to 2022, although the report does state: 'The Agriculture sector has to be informed, engaged and motivated; to that end Defra is, and will continue to, work in collaboration with industry to identify how we can most effectively support them'. This does imply that while government recognises the role of the GHGAP, it considers the emissions reductions therein to also be the responsibility of the agricultural sector, and does not wish to increase policy until 2022 as the sector needs to go further with the current level of government support. This appears to contrast with the CCC's advice, which states: 'The current framework therefore needs to be strengthened, and Government should set out plans to achieve this in its 2016 review of the Action Plan to be published later this year'.[4] Therefore, as more policy attention has been given to this policy it may move up the CCC's expectations, but it is still not in line with their current advice. Historically despite delays even within the time since the CCC report was published, the longstanding nature of the GHGAP indicates that there is a longstanding level of attention for a low ambition policy. Main external actors are likely to be those within the agricultural sector, who may vary from objecting to government intervention to seeing potential development opportunities in this policy, who are likely to give it a high level of attention. This policy politically shifts policy drive from government to the agricultural sector; however this may create tensions as more ambitions mitigation options are being explored. However, these may well be offset from agri-tech and other government funded schemes for the sector. In short, this policy has received a high but perhaps insufficient share of government attention.

Given that this is the sole existing government policy to reduce emissions between now and 2022, it is the most urgent policy within the 3 agricultural policies listed within this chapter. As of 2016, an estimated 1Mt of the 3Mt needed has been reduced within the agricultural sector, meaning faster emissions reductions will rapidly be required.[4] Given the speed needed, this raises issues about the more hands off approach of the 2017 GHGAP review, as this policy is clearly in need or strengthening to meet the 3Mt, whether that is by the government of the agricultural sector. The urgency required for the very short timeframe required make this policy most urgent, either within or outside government or a combination of the two.

2Mt of the 3Mt target remain to be reduced.[4] In absolute terms, this is a small reduction compared to other policies; however there is also the consideration of a successful short term emissions reduction could lead to further ambition in policy in the future (see below).

The upfront capital costs of this policy can be surprisingly high in the context of other mitigation options, the £160 million figure for agri-tech compared to the £730 million for Contracts for Difference support throughout 2021-2025.[67 21] However, the former has multiple other technical benefits, such as increased productivity, and is less focused specifically on climate mitigation. Despite this, costs can be high for innovation in emissions reductions technologies, and are likely to increase with time. Pence per CO_2

avoided is also likely to be high, as funding for agri-tech is only to reduce emissions by 2Mt on this policy, though it is unclear how much current government spending will impact emissions reduction within the period up to 2022.[67] There are also many lower costs and potentially faster policies within the GHGAP that could lower emissions, such as increased attention and education over livestock disease. Economically, this policy is likely to require more government funding if it is to be raised in line with the CCC's advice, however post 2022 policy may require even higher costs (see section 4).

This policy longer term could have the positive impact of contributing to policies post 2022, showing which lessons could be learnt in how to reduce agricultural emissions quickly. A strong policy now could also provide security if emissions reductions are slower than expected in the future, as it would give the agricultural industry more 'breathing space' to try emissions reductions policies. It would also build links between government and the agricultural industry in this field, laying a foundation for what policies and ideas would be well received and helpful and which policies weren't.

This policy would largely impact those within the agricultural industry, and as noted above, could create positive or negative feedback within the community, however due to the range of that community as well as the variety of policies proposed under the GHGAP until 2022; it is difficult to ascertain where this will fall. If the GHGAP is to be more reliant on the agricultural sector, it is essential that they embrace the agenda of policies for this policy to be successful, otherwise this policy and further policy in the sector will face opposition and difficulty in implementation.

4. Measures post 2022 to deliver emissions reductions by 2030 and beyond

The CCC advises that new policy post 2022, when the GHGAP and the third carbon budget expires, will be needed, and that it will need to focus on crops and soil management, livestock diet, health and breeding, waste and manure management and energy efficiency. The CCC advises a reduction of 8Mt from 49Mt currently to 41Mt by the end of the fifth carbon budget.[4] Measures before 2022 will not deliver these targets, so new policies covering the intervening 10 years must be developed to reach this goal. Currently, there is no policy on this, and the CCC notes this in its report by giving the policy a red rating. The GHGAP notes future changes and plans that will have to be made post 2022, however it does not commit to any itself nor does it state when such policies shall be forthcoming. Despite this, agri-tech schemes are likely to continue to contribute reducing emissions in the sector past 2022 to some degree.[67] This policy has a history of low level attention, as no progress has been made since the fourth and fifth carbon budgets were passed into law, as well as the GHGAP reviews for more recent policies being consistently delayed.[4] This policy is more likely to receive attention for being part of a wider package to reduce emissions, as many political actors outside government and the agricultural industries are unlikely to focus on agricultural emissions, as with pre-2022 policies.

Politically, the difficulty of implementing this policy will depend on the relationship between the government and the agricultural sector. The success of this policy will depend at least in part on the progress made pre-2022, as a good relationship with agricultural workers will make implementing this later and more ambitious policy smoother in its implementation.

The urgency of creating this new policy is less severe than pre-2022 policy, however there is more technical and practice based ambition in the policy that will be needed after 2022, and these will take time to research and implement. Policies are at risk according to the CCC between now and 2022, so current policies are certainly behind the policies required to reach the targets by the end of the fifth carbon budget.[4] Momentum could be built on the back of a successful pre-2022 policy, allowing more ambition and technical ability to be developed between now and new policy being implemented. Urgency is therefore low, due to 5 years to design and implement new policy, however it does add to the urgency for pre-2022 policy to assist with post-2022 policy also.

However, compared to pre-2022 policies, the emissions reductions involved could be much greater. In the CCC's response to the Paris Agreement, approximately 38Mt of emissions from agriculture remain by 2050 under a maximum ambition scenario.[40] Assuming steady levels of agricultural production, this leaves 9Mt in emissions saving from the current 49Mt, and 2Mt more if the pre-2022 savings are made at a later date. The CCC envisages 8.4Mt of emissions saving in agriculture between now and 2027, implying of these emissions savings the majority would be in the 2020s and not closer to 2050.[4] It is also noted in the CCC's findings that there could be potential for further reductions in emissions through feed changes, and it is also important to note that agricultural production could go up or down depending on changes to the UK economy between now and 2050, as noted in the GHGAP report.[67] Therefore this 9/11Mt savings figure is highly speculative, however it does seem clear that greater emissions saving stand to be made by post 2022 policy across the 2020s.

Research and development costs for new agricultural technologies and practices as well as farmers requiring grants to cope with the costs of installing new technologies such as anaerobic digestion (AD) plants to reduce agricultural slurry are the primary economic barriers to this policy going forward.[4] Upfront costs are not as severe as some policies - however the sheer variety of different policies underneath this one makes the costs more diverse. The CCC in its Sectoral Scenarios for the Fifth Carbon budget states that 80% of the emissions reductions will have a negative cost due to efficiency savings, and are often the more practice based measures, with some of the more technical measures which would save the remaining 20% costing £78 per tonne of CO_2e.[39] That estimate is based on their emissions saving of 8.5Mt by 2030, resulting in £132 million spent to avoid 1.7Mt of emissions. While this might seem a high cost for 1.7Mt of emissions rather than a higher amount, this will be offset at least in part by the saving made from the remaining 80%, and with the right timescales, i.e., finance invested incrementally over the 2020s, the financial burden of this could much more easily managed than the initial figure would suggest. As with most technological investments, finance levels require high investment now for research and development and eventually deployment into the market, and there is a risk of these technologies becoming more expensive as emissions progress into the future. If the more expensive technical solutions are implemented alongside cost saving policies in post 2022 policy, this will ease the financial burden for what is likely to be predominantly public money from central government.

As this policy is longer term than the pre-2022 policy, its longer term security is all the more critical. If this policy extends further out, potentially all the way to 2050, then this security becomes more important. This will require slow changes to farming practices over time, active engagement with the agricultural community and long term public funding. A large risk to this policy is potential conflict between the government and the agricultural sector, alongside the possibility of research and development money or public grants being withdrawn. The first of these can be mitigated by persuading the agricultural sector of the positive benefits of emissions cutting technology and practices, many of which go beyond emissions reductions in terms of benefits. The second of these could be safeguarded by melding these policies with other targets and goals, therefore making renegading on this policy even less popular with future decision makers – for example, there are great biodiversity benefits in these policies.[67] Additionally, due to the financial benefits for the agricultural community, removal of these polices could also cause unpopularity for a decision maker among those of that community.

As with short term policies, the political actors affected are likely to be those in the agricultural sector, although research and development plays an increasing role further into the future with this policy also. Therefore, the impacts on those within the agricultural sector will be the key determent of the impact of these policies. If the impact on the agricultural sector is positive and viewed as positive, the policy will be taken up far more enthusiastically and efficiently.

5. Afforestation policy

The predominant policy outlined in the LULUCF sector is afforestation, and is unique in being the only policy in this report removing rather than preventing more than 1Mt of CO_2e.[4] Replanting trees and creating new woodlands can act as a carbon sink to remove greenhouse gases, and due to emissions accounting inaccuracy in previous years, forestry provides a larger role at emissions reduction than previously thought. The CCC gives this policy an amber rating, as public funding as has been made available for tree planting, but more needs to be done to increase spending to meet afforestation rates outlined.[4] Forestry rates have been on the increase in the UK for some decades, so this has received significant policy attention in the past.[68] However, the CCC's projections differ in the rate of reforestation, which will have to increase sharply in order to reach the respective targets. Despite afforestation receiving this attention, many targets have not been met in previous years, leading to potentially questionability of new targets.[69] Afforestation is likely to receive wide interest from businesses which manage land use, local governments, communities and individuals, as well as environmental and wildlife groups. Afforestation is likely to be politically divisive if on a large enough scale, simply due to competition for land and resources.[69] However, in terms of political processes, it is likely to be relatively simple, as funding is low for tree planting. Therefore, afforestation has significant policy attention, even though it is potentially politically divisive due to land competition.

Given that trees absorb more greenhouse gas emissions as they grow, in terms of urgency the more trees planted now and into the future the more greenhouse gases will be absorbed over time.[39] The quicker trees are planted now, the quicker they will grow and absorb more greenhouse gases as they do so. Given that this policy is at risk, as well as the large savings that afforestation can bring, the urgency for this policy should be regarded as high. There is also the issue to consider that many emissions while be extremely difficult to reduce by 2050, especially those from agriculture and aviation. The further that the UK goes in emissions removal now and 2050 from afforestation, the less the risk from emissions targets not being met or higher than anticipated emissions remaining by 2050. Therefore, with this view, urgency becomes marginally higher. However, trees are also not new technologies with uncertain innovation and market pathways, which makes them less urgent compared to many other policies in this report. We therefore recommended a medium rating for urgency from this policy.

There is potential for 1.8Mt in savings by 2030 according to the CCC's 2016 report, although due to the increased potential for carbon removal as trees grow, this will reach 3.6Mt by 2035.[4] According to the Sectoral Scenarios report, a 3.7Mt savings could be made by the same date, and applying the same doubling of emissions reduction could lead to a 7.4Mt reduction by 2035.[39] Ultimately the emissions saving involved are chiefly limited by land space and funding available. The Response of the Paris Agreement states that under their maximum scenario, afforestation together with agroforestry could remove 16Mt of CO_2 from the atmosphere.[40] The rollout of the Smart Inventory for non-CO_2 emissions (see section 1 of this chapter) will also clarify more clearly the amount of emissions reduced. It seems that while there is a small emissions abatement potential in the shorter term, going forwards to 2050 there is medium level emissions abatement potential.

The Forestry Commission estimates the establishment costs for UK afforestation to be £1250-£5400 per hectare depending on the factors taken into account.[70] Meeting the 15,000 hectares a year target the CCC recommends,[4] the capital cost (not including land purchase) would therefore be in the region of £18.7 million to £81 million per year. Most estimates from the report are closer to the lower estimate however. While this is still considerably lower than many technologies, lack of public finance has been one of the main barriers to date in afforestation. Costs may be reduced if afforestation on a larger scale is introduced, but is unlikely to be reduced on anywhere near the same scale as renewable power technologies and other examples. Pence per CO_2 avoided would be mid-range, due to the low cost but lower emissions reductive power of forests.

This policy will encourage public and potentially private investment in forests for a considerable period of time. Policy and funding therefore covering it must remain stable throughout. One of the key barriers so far in afforestation has been inconsistent funding, and as the CCC suggests, additional funding from the private sector could go towards meeting yearly targets.[4] The long term sustainability of this policy should be given a high priority; largely as lacklustre interest in this policy in previous years has been the main reason for its neglect.

External impacts could be wide ranging due to competition and values over land that could be afforested.[69] It is vital for this policy's success that consultation and wide ranging engagement about afforestation occurs, for this policy's success depends in part on forest being viewed by the public and landowners as a positive benefit.

6. Agroforestry policy

Agroforestry seeks to introduce trees more into agricultural fields and pastures, allowing the benefits of greenhouse gas reduction without large changes to agricultural areas. Currently there is no policy on agroforestry, and as such the CCC give it a red rating.[4] This policy has not received great attention in past years, nor is it likely to be pushed for by many external actors. Given the lack of progress on this policy, this deserves a high priority as little seems able to change without more political will. This is unlikely to be a particularly controversial policy, although it could potentially be moved into the area of more general agricultural emissions reductions policies (see above), therefore inheriting the potential political difficulties of these policies such as relationships between the agricultural sector and government.

Regarding urgency, the CCC recommends that policy on agroforestry be implemented, with 0.6% of agricultural land to contain trees or hedgerows in addition to the current 1% by 2030.[4] While there are financial and informational barriers, the main lack of urgency has arisen from no government policy in this field. However, given the relatively small role of agro-forestry and the faster rate that it could be implemented than many policies in this report, the urgency is not high, but that does not mean this policy should be delayed. The policy could become self-sufficient very quickly if farmers were incentivised to plant further trees, and as with afforestation generally private investment could reduce urgency.

Compared to afforestation policy, agro-forestry has a smaller emissions reduction potential, however like afforestation this is quite speculative depending on land space available and enthusiasm of uptake. The CCC sees 0.6Mt of emissions reduced by 2030 in its central scenario, with this rising to 1.1Mt in higher scenarios by the same date.[39] Longer term, there are still further reductions possible, but projections still see agroforestry reductions being considerably smaller than afforestation generally.[40] 0.6Mt as a central estimate is a relatively small amount of emissions, and is therefore given a relatively low priority.

One of the most significant barriers to agroforestry thus far has been financial barriers which fall on those in the agricultural sector. The Scottish government's current provision of funding is £3600 per hectare for sheep grazing land.[71] How applicable this is to the rest of the UK is debatable, as land with livestock is likely to require less direct sunlight than crop farming, and with England having a proportionally higher percentage of cropland this may alter price incentives. This is also a slightly higher cost than many estimate for afforestation, as this includes further incentives for farmers who may not be able to profit from agroforestry for several years and whose practices may have to change with the introduction of trees. As with afforestation, this finance will be reliant of government and private sector investment year upon year to encourage growth, which will in turn require long term and consistent policy. Pence per CO_2 is likely to be high, as this is a more expensive policy than afforestation for significantly fewer emissions savings. Future cost is likely to come down, as agro-forestry becomes a more acceptable and common practice and knowledge is gained about how best to economically implement it.

Longer term policy on agroforestry will be dependent on this policy existing to begin with. There has been interest in this policy from the regional Scottish government as well as from the European Union, but it will require adoption from the UK as well as positive uptake from the agricultural sector to continue the policy further into the future.[4] As with afforestation policy, it will require set targets and firm policy to keep gains from this policy continuing. There is also potential for agro-forestry to go further, as much agricultural land for livestock could see an increase in tree cover, in additional to gains from cropland.

Externalities will fall largely upon the agricultural sector, as this policy may create opportunities or tensions between farmers and decision makers. There are a great many other environmental and crop yield benefits that can be gained from this policy if implemented correctly, but there are also costs that may fall heavily on famers if not implemented in a way which makes the government or private investors shoulder some of the burden.[72] Therefore, a policy which works alongside the business needs of the agricultural sector in a cohesive rather than heavy handed way will be a necessity to make the externalities of this policy (which are large and wide ranging) positive rather than negative.

7. Findings

Comparing their rankings, the five policies outlined by the CCC based against our criteria appear thus:

Figure 7.1: Stronger implementation of the Smart Inventory for agriculture		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	3
Urgency	3	3
Emissions reduction involved	3	3
Economic credibility	2	4
Long term sustainability	2	6
Externality of impacts	2	6
TOTAL		**25**

Figure 7.2: Strengthen the current GHG action plan, and across all nations		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	9
Emissions reduction involved	3	3
Economic credibility	2	6
Long term sustainability	2	6
Externality of impacts	2	4
TOTAL		**34**

Figure 7.3: Measures post 2022 to deliver emissions reductions by 2030 and beyond		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	9
Urgency	3	3
Emissions reduction involved	3	6
Economic credibility	2	6
Long term sustainability	2	4
Externality of impacts	2	6
TOTAL		**34**

Figure 7.4: Afforestation policy

Criteria	Weighting	Score
Existing level of policy attention	3	3
Urgency	3	6
Emissions reduction involved	3	9
Economic credibility	2	6
Long term sustainability	2	6
Externality of impacts	2	4
TOTAL		**34**

Figure 7.5: Agroforestry policy		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	9
Urgency	3	3
Emissions reduction involved	3	3
Economic credibility	2	6
Long term sustainability	2	4
Externality of impacts	2	4
TOTAL		**29**

Of the five policies outlined here, the Smart Inventory has clearly ranked lowest, largely due to not reducing emissions by a great deal or having many barriers on its own. The Smart Inventory can also be thought of as more of a policy tool rather than a policy in its own right. Of the other policies, apart from a low ranking for agroforestry, both agricultural policies and afforestation policies all receive equal scores. Agroforestry policy is rated lower largely due to the small emissions abatement potential it holds, as well a low level of urgency. Regarding the other policies, the score disguises a difference in rankings, with emissions abatement potential being high for afforestation, post 2022 agricultural policy receiving high prioritisation for policy attention and current the GHG action plan receiving high prioritisation for urgency due to the short timeframe. This results in no overall winner, but a three way tie due to different criteria receiving high attention for each policy.

CHAPTER 8: WASTE

1. Introduction

The waste sector comprises 4% of the greenhouse gas emissions in the UK at 19MtCO_2e in 2014.[4] Waste policy is a devolved matter in the UK, meaning that each policy here must be considered through each country individually rather than a whole. If policies are deficient in England more than other countries, given the higher emissions of England, a higher priority will be given to policy deficiency in England within this report. 71% of waste emissions originate from methane decomposition from landfill, 20% wastewater treatment emissions, 7% from biological treatment (composting and anaerobic digestion) and 2% from waste combustion and burning.[4] Given that methane and nitrous oxide have higher global warming potential than CO_2, emissions from waste are amplified by these gases. Key policies that the CCC recommends for reducing emissions from waste are waste prevention through the waste chain, reducing sending biodegradable waste to landfill, and increasing the rate of capturing methane from landfill.

2. Waste prevention through the waste chain

Nationally, the UK has a charity known as Waste and Resources Action Plan (WRAP) which encourages and campaigns with a degree of success to reduce waste accumulating in households. In England, the government funded Waste Prevention Programme educates and advises businesses and households on how to reduce waste further up the waste hierarchy.[4] In Scotland, the country's Circular Economy Strategy encourages similar waste prevention, emphasising recycling and reuse. Wales uses its Towards Zero Waste (2010) strategy and its Industrial and Commercial Waste Sector Plan (2013) strategy in those sectors. The CCC notes that more action is needed in the industrial and commercial sectors. In Northern Ireland, the Northern Ireland Waste Management Strategy outlines waste prevention policies, although the CCC notes that Northern Ireland needs specific actions such as separate waste collection to reinforce this policy.[4] Clearly there is existing policy attention throughout all four countries, as each has its own national policy regarding waste prevention through the waste chain. However, the 'colour ranking' system is not implemented in this Chapter alone of the CCC's report, so this element of the criteria must be discounted for this policy and the other two policies highlighted in this chapter. However, it is readily apparent that as policies exist across all four nations, that the policy ambition is relatively high in absolute terms. The predominant theme that the CCC finds in its recommendations is that there are clearer milestones to waste prevention along the waste chain.[4] This greater clarity rather than new specific goals or new policy implies a high level of policy attention that needs updating rather than re-writing. Historically, there has been a high level of policy regarding waste emissions and waste disposal generally, hence the 73% drop in emissions from waste since 1990.[4] While waste emissions specifically are may not be high on the agenda from external actors compared to other sectors, the move to a circular economy is often a high issue from environmental

NGOs.[73] The localised level of waste prevention policies may also garner many political actors key to reducing emissions further, a feature in many of the policies. Waste prevention policies are likely to offer significant cost savings for public services, and are relatively non-controversial issues, not least because they encourage non-governmental innovation and action. These policies, while diverse and diffuse, should be considered to be a low priority in terms of existing policy attention.

The CCC forecasts waste emissions to fall in line with baseline emissions until about 2020, after which time there are 4Mt which need to be reduced by climate policies by the end of the fifth carbon budget.[4] These policies are at risk, and as such policies need to be created to deal with this 4Mt policy gap (the extent of waste prevention policies' proportion of this is examined below). However, given that these emissions will not need new policies until 2020, and then relatively small emissions reductions will be made, and that waste prevention policy is unlikely to require long term technological or policy processes, this policy could be relatively minor in the urgency required. Relating to this, policy self-sufficiency could be made quickly and easily be deferred to local authorities, and potentially on much faster timescales than other emissions reductions policies such as CCS implementation. Therefore, without downplaying the role of waste emissions reductions through waste prevention policies, the urgency for this policy is likely to be low. Rapid changes in policy should be encouraged by respective authorities however.

The emissions reductions involved from this policy are deeply uncertain due to the nature of the policy – waste prevention would have to be ascertained next to the other policies in the waste category. However, the Waste Prevention Policy for England cites an evaluation by Defra from 2009, which states a 1.1Mt savings from waste prevention is possible across the UK.[74] Given the age of the analysis, as well as further progress in the Waste Prevention Policy and other policies since, it is possible this figure is outdated. This figure is also based on a waste savings of 800,000 tonnes, which has the potential to be higher or lower than the Defra estimate. However, if this 1.1Mt figure is taken at face value, this is a relatively small emissions saving, compared to other policies in this report and in relation to the other two policies concerning waste.

This policy has strong potential economically, as the upfront capital costs of waste prevention have many net financial benefits.[75] Businesses can benefit substantially by cutting down on packaging, and reuse of resources thrown away as waste can save collecting new resources. The upfront costs in many cases for waste prevention can actually be negative, and even small costs can have strong and early returns. Small repairs in electrical equipment thrown away could yield £200 million in return products to the economy every year. With this in mind, the upfront capital costs of this policy are extremely low. In terms of pence per CO_2 avoided, this policy has low costs for low emissions reductions, acting as a cheap but perhaps less meaningful policy. However, given the financial gains to be gained from this policy, the incentive for reducing this approximately 1.1Mt reduction appears stronger than other policies. Regarding future costs, these are unlikely to change drastically, as the value of reuse of discarded services will remain high, and the incentives to do so shall remain. This policy does not rely on new technologies or innovations occurring in the future, making this more stable over time.

Longer term this policy is likely to remain stable, as the incentive for quick environmental and economic benefits will remain. Unlike larger infrastructure investments in the power and transport sectors, this policy is likely to be seen as low risk politically due to the quick benefits. Therefore, it is unlikely this policy will be repealed unless there is a wider repeal of Defra policies, especially as the budget for the Waste Prevention Policy is small, at £16 million in 2015/16.[75] The broken up nature of the policy around 4 different countries as well as involvement of local authorities in waste collection makes it less centralised and more resilient to changes in policy.

This policy is interlinked with the external impacts of creating a more circular economy, reducing environmental destruction by reducing resource use, creating greater efficiency, behavioural change about valuing resources, financial savings and many other external factors. Generally these impacts are likely to be positive and generate little opposition. However, persuading communities and companies to reuse and reduce might create some issues. Many consumers may find the idea of reusing to be unacceptable socially, and business may be inflexible about changing their packaging models.[75] Working with and building understanding of the benefits of this policy may do much to reduce this however. While the externality of this policy is large, it is likely to be generally positive.

3. Reduce biodegradable waste to landfill

Waste being prevented and waste being diverted from landfill has a certain amount of overlap between the two policies. Nationally, the Landfill Tax penalises landfill operators financially for each tonne of waste generated, with Scotland and Wales soon to create their own additional landfill taxes[4]. This is in addition to policies organised by WRAP that incentivises waste to be sent to recycling. Recycling is also incentivised alongside prevention in the Waste Prevention Policy of England, as well as the 'Anaerobic Digester Strategy and Action Plan for England' encouraging food waste to go to AD rather than landfill. Scotland's Waste Regulations of 2012, its own landfill tax, as well as the Circular Economy Strategy all deal with diverting waste and sending it to recycling, flaring, AD or other methods, and these policies make the country on track to a 2025 target for a maximum of 5% of waste to go to landfill. Wales also has targets to reduce waste going to landfill in its Towards Zero Waste policy; however, it is not currently on track to meet these. The Northern Ireland Waste Management Strategy also covers reducing waste going to landfill, particularly food waste.[4] Likewise to waste prevention, policies to reduce waste going to landfill are receiving clear and consistent policy attention at a variety of levels. While the CCC recommends greater clarity from these policies, their wide ranging and comprehensive nature compared to the lack of policy with other areas in this report still indicates that landfill diversion is receiving significant policy attention. England and Northern Ireland are behind Wales and Scotland in terms of bringing forward landfill diversion targets further. Policies diverting waste from being sent to landfill have a long history and clear precedent, as well as clear support from NGOs, businesses and local authorities, in a similar way to waste prevention.[73] Policy attention is high for diverting waste from landfill, so prioritisation should be rated low accordingly.

Urgency for increasing the policy and amount of waste diverted from landfill is likely to increase post 2020, when a policy gap between emissions needed to be reduced and emissions reduced by existing policy will start to emerge. While policies to reduce emissions going to landfill can be introduced at a later stage, given the infrastructure changes to accommodate more AD, recycling and so on, unlike waste prevention these policies should be considered more urgent and made for the longer term. Some technological improvements such as for hard to treat recyclable and AD must start to be made earlier to they are available at a large scale at a later stage. While these are happening under current policy, it is not expected that these are radical enough to meet the waste emissions targets for the fifth carbon budget.[4] Therefore the urgency for this policy is more severe than for waste prevention, although policies can be made on a shorter term timescale than other areas of the economy.

Of the 19MtCO_2e in the UK waste sector in 2014, the majority of these reductions will be made from diverting waste away from landfill.[4] As 71% of that 19MtCO_2e is from landfill, an incorrect assumption could be made that 13.5MtCO_2e could be reduced by a landfill ban. However, inevitably a landfill ban would involve some food waste going to composting or AD, or waste generally going to incineration, both of which having relatively smaller emissions of their own.[38] The level of emissions would vary depending on how much or little incineration was part of the mix of waste disposal, which will be up to future policy decisions. AD, composting and incineration option all come with relatively lower greenhouse emissions per tonne of waste disposed, and the future emissions reduction from this sector will be speculative based on the mix of these. However, of the 13.5MtCO_2e potential, much is likely to remain, and it is still the largest emissions reduction of the waste policies in this chapter.

Economically, the main cost restrictions will be in bringing down the cost of AD plants, which are still reliant on government grants in some cases, and greater recycling facilities (to recycle items such as plastics).[76] Up front capital costs here are likely to be highest, however given the increasingly high landfill tax at £82.60 per tonne in 2015/16, abatement options are looking increasingly cost competitive.[39] Pence per CO_2 avoided is also likely to be good value, as the emissions reduced are much higher from landfill diversion than waste prevention for not a great deal more investment. Future cost is slightly more uncertain, as it will depend on certain abatement technologies such as AD and advanced recycling facilities falling, however these are likely to be a small investment for the public sector and not on the same level as renewable power or similar technologies. These technologies and the industries and infrastructure around them are also well established, reducing financial and investor risk. In short, the economic risk of this policy is low, and more attractive when compared the scale of emissions reductions involved.

Into the future, this policy is relatively secure due to the decentralised and low risk nature of landfill diversion policies, as with waste prevention. However, unlike waste prevention there will have to be more ambitious policies implemented more quickly, which could generate criticism. However, the low expenditure and obvious external benefits of this policy still apply, and it likely that, as with waste prevention, its main concern would be a greater repeal of Defra policy. The biggest issue with the long term security of this policy is simply implementing it quickly enough for it to take effect before the policy gap post 2020 starts to widen, and it may not be given priority quickly enough.

Relating to externalities, many of these are the same general societal benefits of less waste. Reductions in waste to landfill would result in greater landscape use as landfill sites were slowly closed, fewer issues regarding the pollution that landfill sites bring, and other circular economy benefits. The opposition to landfill reduction is likely to be low, although opposition to alternative methods of waste disposal may rise, particularly incineration, which is seen as wasteful and backward by some.[77]

4. Increase methane capture rates

While waste prevention and waste diversion have interconnected general waste policies in the four countries, methane capture at landfill sites has distinct policies of its own. Renewable energy power and heat policies overlap here, including the Renewable Heat Incentive, Renewables Obligation and Feed in Tariffs.[4] Capturing methane has potential to go much further, according to the recent ACUMEN study, and the CCC encourages further progress in capturing methane at landfill sites. However, it is important to note, that with relation to longer term policies, if landfill bans are successful, as planned for in policy in many devolved areas, this policy may have a limited lifespan longer term, as sources for methane collection disappear. While covered in renewable heat and power policies, there are no specific policies for methane capture in any of the devolved regions. Despite that, methane capture rates have increased significantly and look set to continue to rise, although not in line with the CCC's recommendations. This policy has not gathered a large amount of outside attention from external actors, but this policy has not had a visible history of controversy. The policy attention for methane capture is lower for the above waste policies; however it is still adequately covered. The main point the CCC makes regarding it is that policy need to be upgraded to reflect how bigger capture rates could be utilised.

The urgency of increasing methane capture rates is highlighted by the CCC, stating that all four countries need to make clear actions and milestones to increase methane capture rates.[4] Given the post 2020 policy gap for waste, actions realistically needs to be taken before 2020, although it be may be easier to extend existing policies to include new methane capture rates quickly, meaning that the urgency for this policy may be less than waste diversion, as no radically new technologies or policies are required.

In relation to the potential 13.5MtCO_2e potential reduction from landfill emissions, methane capture can reduce this further, but not as radically as landfill diversion.[4] Current methane capture rates are 60-65%, with a theoretical maximum of 90%. However, the CCC has doubts as to how far this can be achieved, especially regarding the downscaling of landfill sites as landfill is diverted. It is unclear from a review of the policy literature thus far how much of a reduction increased methane capture will make, however it is likely to be less than waste diversion due to the scale and practicalities involved.

The economic potential of additional methane capture is high, as captured methane can be sold on as fuel for heat or power, hence its inclusion in such policies. However it still requires governmental incentives and further exploitation of methane capture may lead to higher prices. Changes to government incentives such as the renewable heat incentive may therefore alter the economic viability of increasing methane capture rates, and if the technical challenge of increasing rates demands greater expenditure, then government incentives would have to rise. In terms of pence per CO_2, this is quite uncertain due to the potential CO_2e avoided, but is likely to be smaller than waste diversion. Future costs for methane capture may increase if fewer sites are capturing methane due to landfill sites closing down and being decommissioned, as well as slowly decreasing the yield of methane as the waste material biodegrades.

The long term sustainability of this policy could well be in doubt, given policies to reduce or ban landfill sites, and the associated reactions from political actors may contribute to an apathy about increasing methane capture rates. It is likely the longer this policy is left, the less incentive there will be to enact it, as waste diversion policies slowly decrease the number of active landfill sites. This may be a key reason why increasing methane capture is lacking in the national waste policies of England, Wales, Scotland and Northern Ireland.

Additional impacts are likely to be low, as this policy is centred around landfill sites and their operators quite exclusively, to increase an existing process and effect. Increasing methane capture for use in heating may allow the heating sector further time for policy to catch up with the emissions reductions involved, however this likely to be a relatively small contributor.

5. Findings

Comparing their rankings, the three groups of policies outlined by the CCC based against our criteria appear thus:

Table 8.1: Waste prevention through the waste chain		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	3
Urgency	3	3
Emissions reduction involved	3	3
Economic credibility	2	6
Long term sustainability	2	6
External impacts	2	4
TOTAL		**25**

Table 8.2: Reduce biodegradable waste to landfill		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	3
Urgency	3	6
Emissions reduction involved	3	6
Economic credibility	2	6
Long term sustainability	2	6
External impacts	2	6
TOTAL		**33**

Table 8.3: Increase methane capture rates		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	6
Urgency	3	6
Emissions reduction involved	3	3
Economic credibility	2	6
Long term sustainability	2	2
External impacts	2	6
TOTAL		**29**

The higher urgency, as well as the much higher potential to reduce emissions clearly prioritises reducing waste sent to landfill over waste prevention across the supply chain, despite the relative ease of doing so. Increasing methane capture rate is also slightly prioritised over this, although still considerably less than waste diversion. We feel this is an appropriate scale due to the clear incentive and potentially wide reaching range of reducing emissions from landfill, given the large potential to reduce emissions for a relatively minor cost compared to many other sectors. The main issue with waste sector policies is that they are likely to yield low reductions in emissions compared to larger sectors, which we feel is reduced by prioritising this policy.

CHAPTER 9: F-GASES

1. Introduction

Fluorinated gases or F-gases made up 3% of the UK's emissions in 2015.[4] These gases are a group of multiple artificially created greenhouse gases with a high global warming potential (GWP), thus small leakages of them have a disproportionally large impact on the UK's emissions. While there are many sources of F-gases, predominantly emissions originate from refrigeration and heating systems through leakage.[78] Currently the UK government is on track to meet its 2030 targets for F-gases with existing legislation, however much of this is EU regulation and there should be concern at whether this will be repealed at a later date given the result of the EU referendum.[51] Of most significance is the EU 2015 F-gas regulation, which has a target for a 79% cut by 2030. The Committee on Climate Change considers all policies for this sector as 'Lower risk policies' regarding the need to avoid a policy gap, the only sector in the report to do so. As this sector as largely covered by the 2015 regulation, the CCC's report focuses on two main policies – stronger implementation of monitoring and updating progress on the F-gases regulation, and a new policy designed to go further than the regulatory minimum.

2. Stronger implementation of monitoring and updating progress on F-gases regulation

The EU 2015 F-gas regulation provides a legal requirement to reduce F-gases; however the CCC recommends stronger monitoring and updating progress on this regulation. Given the recent nature of the legislation, it is possible for the government to update this going forward, and the CCC report notes that 'We will review the impacts and effectiveness of the regulation in future Progress Reports'.[4] Regarding the existing level of policy attention, the CCC gives a green rating for this policy, and given the recent nature of the legislation it seems that this policy is a low priority from this regard. While the legislation is recent, the government has added certain provisions to it already strengthening it further, and given experience of phasing out the similar Chlorofluorocarbons (CFCs) in the 1990s and the provision of alternatives to current refrigerants and other sources, it seems likely that the UK government has a good policy history for this policy. Equally, while it is not a predominant theme with many environmental NGOs, there is a precedent for similar emissions reduction due to the Montreal Protocol, and businesses providing alternatives such as the refrigeration industry also have an interest in seeing this policy enacted.[78] Political infeasibility is likely to be low, as due to the recent nature of this legislation as well as the recent UK additions to it, there may still be political ambition to amend the legislation to implement stronger monitoring and more regular updates. Due to the relatively small size of the F-gases sector in terms of emissions, it may also be politically easier for decision makers to implement smaller policies to encourage greater monitoring and updating, rather than compared to a larger sector's emissions.

In terms of urgency, while the legislation is recent, monitoring and updating this legislation will require more immediate action than the policy below of going beyond the regulatory minimum, largely because a drive to scrutinise this legislation midway between now and 2030 rather than immediately may miss important omissions of F-gas monitoring, or faults in the legislation. Given the cost effectiveness of many F-gas abatement technologies, if sufficient monitoring and reporting of F-gases are in place, this policy is largely self-sufficient, and is therefore likely to keep reducing emissions without great external support.

Absolute emissions reduced by the 2015 F-gases legislation will result in a 79% cut from 2015 to 2030 in HFCs within the EU single market, and the CCC's Sectoral Scenarios report for the fifth carbon budget states that the UK does not have a disproportionate amount of F-gases.[39] As HFCs account for 96% of F-gases and F-gases emissions totalled 17MtCO_2e in 2014, a 79% cut would equal 12.9MtCO_2e being cut by 2030 under this policy, not factoring in emissions rises caused by other sources not covered by the legislation, and assuming no rise of F-gases in 2016. There are also multiple smaller policies on new equipment emissions, such as bans on gases with higher global warming emissions potentials (GWPS).

Up front capital costs of following greater monitoring and progress updates are likely to be low, given that most abatement options are already cost competitive.[39] These could be low given that there is already enforcement enshrined in the legislation, and increasing this will add to existing spending. However, there are also a large number of different devices that emit F-gases, which may add to costs further. Given it is beyond the scope of this report to look into this further, an accurate figure cannot be held here, but pence per tonne of CO_2e avoided is dependent on how much investment is required in checking the legislation is being enforced. Given the relatively high emissions abatement potential from this policy compared to others, costs of pence per tonne is likely to be high – however, it should be noted this judgement is based on uncertainty about what kind of monitoring and progress update this policy will require.

The longer term sustainability of this policy is entirely reliant on whether or not this legislation is repealed as part of the current government's drive to exit the European Union, or whether it will be still effective if the UK does not repeal it, but exits the single market.[51] Given the volatile and unpredictable nature of current progress on the UK's exit from the European Union, it is currently difficult to say if this legislation will remain as part of UK climate policy over the longer term. However, given its potentially unstable position, the UK will have to develop its own F-gas regulation covering similar targets in order to comply with the UN Montreal Protocol, in addition to reaching greenhouse gas emission targets.[79] Given the policy below for going beyond the regulatory minimum, in order to offset the risk of this policy being repealed, the UK should develop its own separate policy regarding F-gases (see section 3 of this chapter).

External impacts of this policy are largely likely to affect the heating sector, as heat pumps also emit F-gases, and stricter standards on heat pumps are desirable to avoid emissions rising if heat pumps are to be rolled out on a large scale, which will be necessary if the UK is to meet later climate targets.[39] Given that cost effective alternatives are available, there are no major economic impacts readily visible from enforcing this policy. External impacts in short are likely to be low.

3. New policy on going beyond the regulatory minimum

While the UK is currently on track to meet targets from the F-gases sector, the CCC urges stronger domestic action to increase ambition. The CCC outlines multiple ways of achieving this, including taxes, additional bans on equipment not covered by the legislation, and funding for further research into low emissions alternatives. It also notes that the UK could use F-gases policy to make a cost effective emissions reduction, and the Sectoral Scenarios for the Fifth Carbon Budget report goes further in saying that F-gases will represent a 'share of increasingly challenging carbon budgets', suggesting F-gases will be a cost effective way to meet shorter term carbon budgets.[4] [39] This in addition to the potentially uncertain 2015 F-gases regulation could result in more ambitious UK led policy. No visible interest has been garnered by the UK government in going beyond the regulatory minimum by the EU, the CCC giving the need for new policy doing so a red rating. The UK government has led no review on how to do this, and so existing attention to this policy is low. There is a policy strong history of reducing emission from F-gases, so it may be possible to add political momentum to the recent 2015 legislation, also perhaps highlighting its potentially unstable position. Given the small amount that F-gases are responsible for greenhouse gas emissions in the UK, as well as wider issues concerning UK exit from the European Union, many NGOs and green groups may not feel the immediate need to prioritise F-gas regulation specifically, despite precedents for CFCs. Politically, there is likely to be much uncertainty about a new policy in F-gases, due to whether or not the original 2015 legislation will remain, with decision makers not being able to commit themselves. An emphasis on cheap, quick low carbon reductions with minimal government interference may gain political traction however. The biggest political barrier may be convincing decision makers a second law on F-gases is necessary in so short a time.

F-gases are not a major part of carbon budgets, however by bringing in fast reduction targets in the UK it could allow contingency plans for larger sectors which are experiencing difficulty reducing emissions such as heating and transport. Given that many F-gas abatement options are already cost effective, it could give abatement options in similar areas time to develop. This also shows that F-gas policies would be relatively self-sufficient in the short term, unlike many from the industrial sector, which would rely heavily in investment on new technologies and efficiency gains (see chapter 5). Therefore, while F-gases emissions reductions via a new policy may not be urgent compared to other sectors, it could buy some valuable 'bargaining time' for the government to meet its targets.

Emissions reductions involved could be greater from new policy compared to the 2015 regulation, hence recommendations for the UK to go further on its own. The CCC's projections see F-gas emissions dropping to just over 4MtCO_2e by the end of the fifth carbon budget (2032).[4] New UK policies could potentially speed up this process, as well as going further in emissions reductions. Much of the limit on further reductions on F-gases comes from the 2015 legislation exempting metered dose inhalers and electrical insulation. Metered dose inhalers are predominantly used for health purposes to help inhale medication designed for the lungs, and can be replaced in many case by cost effective powder equivalents. Reducing the GWP of F-gases in electrical insulation and MDIs could reduce F-gases by another 2Mt, and with research funding policies on how to phases out F-gases entirely between now and the 2030s, this new policy could secure the majority of emissions reductions involved, as well as potentially reducing another 4Mt of CO_2e of emissions, essentially bringing the F-gases sector to nearly zero.[39]

The initial costs of new and stricter UK F-gases policies would add to the costs of additional spending on new financial incentives and research to reduce emissions from all F-gas emitting technologies. Most but not all of the available technologies are cost competitive, as well as research costs for technologies to replace harder to reduce devices, so the combination of this and enacting, implementing this policy would be the main initial costs.[39] Compared to other climate policies, this would be relatively small in upfront costs, although this may rise if there is a demand for fast emissions reduction from this sector. Pence per CO_2 avoided is likely to be low, given the cost competiveness of most technologies and the relatively small amount of emissions involved. Future spending is uncertain due to some more research having to do be done on essential technologies, but given how few these are in the context of the overall policy this is a low risk factor.

Over a longer time frame, UK based F-gas policy would be less vulnerable to withdrawal from the European Union than the current 2015 F-gases law, so new policy that goes beyond that legislation might be safer from repeal. Writing this new F-gases policy into law may make it more secure, or generate debate on its necessity. If new F-gases policy is to be introduced, it might be best done as part of a legally binding package of climate policies, protecting it from repeal and also allowing for linkages with other sectors.

Given the range of technologies involved in F-gas reduction, ascertaining all the external impacts is a broad reaching area, but the cost competitiveness of most alternatives to high emitting F-gases avoids many economic impacts. Research based alternatives may have initial problems at entering the market, but strong funding and policy can avoid some of these external impacts.

4. Findings

Comparing both their rankings, the two policies outlined by the CCC based against our criteria appear thus:

Table 9.1: Stronger implementation of monitoring and updating progress on F-gases regulation		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	3
Urgency	3	6
Emissions reduction involved	3	6
Economic credibility	2	6
Long term sustainability	2	2
External impacts	1	6
TOTAL		**29**

Table 9.2: New policy on going beyond the regulatory minimum		
Criteria	**Weighting**	**Score**
Existing level of policy attention	3	9
Urgency	3	6
Emissions reduction involved	3	9
Economic credibility	2	6
Long term sustainability	2	4
External impacts	2	6
TOTAL		**40**

Comparing the two policies, we have chosen to prioritise a new policy going beyond the regulatory minimum rather than stronger implementation of monitoring and updating progress on F-gases regulation. Given the potential withdrawal of the EU F-gases law, we feel it is appropriate to consider stronger UK action regardless of the outcome, to act as a backup policy and take targets further. The lack of attention surrounding creating a new policy is a cause for concern, as is the urgency to update the 2015 legislation to monitor and track results. In conclusion, we support creating a new UK policy, but only above stronger implementation of existing targets by a small amount.

CHAPTER 10: PRIORITISATION OF POLICIES FOR DECARBONISENOW

1. Introduction

Ultimately, establishing a final ranking of these differing policies is the final aim of this report. Therefore this chapter ranks and prioritises these policies against each other across sectors and chapters, showcasing the different strengths and weakness of each recommendation against each other. It also explains how some policies are prioritised over each other despite receiving the same score based on the criteria, as multiple policies have the same score. We then assess the scope to which DecarboniseNow can assist with the adoption of these policies, based on the influence we can exert, and the cost of the policy. Once complete, this will result in a complete ranking and prioritisation of policies from the CCC's 2016 progress report.

2. Inter sector prioritisation

Table 10.1: All policies prioritised according to the analysis and criteria within this report

Ranking	Policy	Score
1)	Ultra-low emissions vehicles	40
1)	Offshore wind and pot 2 technologies	40
1)	New policy for F-gases going beyond regulatory minimum	40
4)	Low cost renewables post 2021	39
4)	Energy efficiency improvements and roadmaps (industry)	39
6)	Conventional vehicle efficiency	37
6)	Low carbon heat in existing buildings	37
8)	Residential energy efficiency	34
8)	Non-residential energy efficiency	34
8)	GHG action plan for agriculture	34
8)	Post 2022 agricultural policy	34
8)	Afforestation	34
13)	Reducing biodegradable waste sent to landfill	33
13)	Coal plants phase out	33
15)	Low carbon heating in new buildings	32
15)	Industrial CCS	32

15)	Aviation and shipping	32
15)	Road freight	32
19)	Flexibility	30
20)	Power sector CCS	29
20)	Biofuels	29
20)	Heat networks	29
20)	Agroforestry	29
20)	Stronger implementation and monitoring of EU F-gases regulation	29
20)	Methane capture	29
26)	New nuclear	28
26)	Hydrogen	28
28)	Low carbon space and process heat	26
28)	Biomass space and process heat	26
28)	Pre-2021 renewables	26
33)	Waste prevention/waste chain	25
33)	Smarter travel choices	25
33)	Smart inventory	25

Above is the complete prioritisation of all the policies analysed within this report. The colour based text is based upon which sector the policy originates from, and can be traced back to individual chapters within this report; red for the power sector, yellow for the buildings sector, ochre for the industrial sector, blue for the transport sector, green for the agriculture and LULUCF sector, black for the waste sector and purple for the F gas sector. An immediately visible factor is the large number of policies that share the same score based on our criteria weighting. This includes the first three ranked policies, ultra-low vehicle emissions, offshore wind and pot 2 technologies, and a new policy for F-gases going beyond the regulatory minimum all belong to sectors which require steep cuts in the short term (e.g., the end of the fifth carbon budget) and these policies all have potential to make some of the deepest cuts per policy within each sector. As the policy gap is widest in the transport sector, we prioritise ULEVs, for not only does this policy have the biggest potential to fill one of these policy gaps, it has also made less respective impact to its sector to date, alongside transport sector emissions actually increasing in recent years compared to the long term decline in power and F-gases. Given the important abatement potential past 2030, not only for its own sector but for electrifying transport and heating, offshore wind and pot 2 technologies are given the higher priority than a new policy for F-gas regulation. While new F-gas regulation is important, especially given the 'easy' emissions reductions involved, and the current legislation becoming uncertain given the referendum on the United Kingdom's membership of the European Union, its overall contribution to emissions reduction is significantly smaller than the other two policies. Of the four large sectors responsible for emissions in the UK, electricity and transport both require large cuts (75% and 43% from 2015-2030 respectively), both significantly larger than buildings and industry (22% and 20%), and as offshore wind and ULEVs both have the potential to cut a majority of emissions based on the individual policy alone, it is considered justified that these two policies are ranked the most highly. F-gases, while a smaller amount, also require drastic emissions cuts in the short term, and current legislation may be vulnerable given the United Kingdom's vote to leave the European Union. If F-gases are practically eliminated as the seventh sector of greenhouse gas emissions, it may also focus climate policy more strongly on harder to treat sectors such as industry.

Low cost renewables post 2021 and energy efficiency improvements and roadmaps within the industrial sector, come joint into second place. Given the lack of policy, urgency in implementing new policy, fast and significant emission reduction and good economic rationale, low cost renewables post 2021 take priority within these two policies. The future of this policy is in doubt however, raising concerns that may not exist in the future. This is tied to concerns over negative externalities, also ranking it down slightly lower. It ranks higher than industrial energy efficiency improvements, due to larger emissions reductions this policy can make, as well the larger emissions reductions needed within the power sector before the end of the fifth carbon budget. They both are polices needing policy clarity urgently, as the CCC projects the latter policy is the most immediate policy for reducing emissions reductions in the industrial sector.

Increasing conventional vehicle efficiency and low carbon heat in existing buildings are the next set of policies. Increasing conventional vehicle efficiency is rated more highly than low carbon heat in existing buildings, due to the greater urgency to reduce emissions from the transport sector and the speed of reduction is a higher priority than that from the buildings sector. Conventional vehicle efficiency has the potential for a large emissions reduction at low expense in a short timeframe, but is rated lower down than ULEVs predominantly due to the lower future potential of this policy once efficiency gains have been met – in short, there is limited scope for this policy further into the future. Increasing low carbon heat is as key a part of reducing emissions from buildings longer term, in a similar way to ULEVs are from reducing emissions from the transport sector. The large, likely publicly funded cost of this policy, as well as the large scale needed for its implementation does raise some questions over its future however, against a backdrop of slow policies for the building sector thus far.

Residential energy efficiency, non-residential energy efficiency, the pre-2022 GHG action plan for agriculture, post 2022 agricultural policy and afforestation are all tied policies, and given their immediacy, the two energy efficiency in buildings policies and implementation of the agricultural greenhouse gas emission reduction plan are prioritised before afforestation and post 2022 agricultural policy. The latter two policies are likely to have high emissions abatement potential and be crucial to reducing emission from the agriculture and LULUCF sector towards 2050, but have longer timescales to implement and are important to develop initially to demonstrate how emissions can be reduced in this sector. Post 2022 agricultural policy is prioritised higher than afforestation due to the need to have some policy reducing a sector representing 8% of the UK's greenhouse gas emissions in 2015, whereas afforestation comparatively 'buys time' for other sectors, and has a smaller emissions abatement potential. Equally, it is important that building's energy efficiency policies are not prioritised too low, for the urgency of developing them alongside other buildings policy is high to capture their full potential and reduce the costs of other buildings emissions abatement policies. The pre-2022 greenhouse gas action plan for agriculture is rated lower than the energy efficiency ratings, for while it is an urgent policy, it has lower emissions abatement potential and many elements that may be missed in the plan can be incorporated into post 2022 policy. Comparably, ambitious energy efficiency policies immediately are needed to mitigate costs from power and building sector policies. Residential energy efficiency is prioritised more highly than non-residential energy efficiency due to the more complicated structure of reaching out to more buildings, and the resultant more complex policies that will be required to develop earlier.

Given the higher emissions abatement potential and closer timeframe, phasing out coal fired power plants may initially seem a more obvious choice for prioritisation than reducing biodegradable waste sent to landfill. But phase out of coal fired power plants possesses an unusually high level of policy support, with the government currently committed and potentially likely to exceed this goal. Therefore, it seems more urgent priority could be given to the alternative policy here, reducing waste going to landfill, alongside potential landfill ban policies already in development in some countries within the UK.

Low carbon heating in new buildings, industrial CCS, aviation and shipping and road freight also share the same score, with low carbon buildings being prioritised due to urgency involved of developing a new policy. The longer this policy is delayed, the greater number of new homes will be built, resulting in them requiring more expensive and intrusive retrofitting of low carbon heating at a later date. Industrial CCS and reducing aviation and shipping emissions, while less immediate, will take long time period to experiment with the technology involved, as well as bring down to a commercial and publicity acceptable level to become widespread within the sociotechnical system of the UK. Industrial CCS is prioritised slightly higher, due to the industrial sector being more reliant on this single policy than the transport sector is on aviation and shipping.

Industrial CCs is also more urgent due to shorter research and development cycles. Comparatively, reducing emissions from freight could implement itself relatively quickly and at any point, and is also less governmentally dependent.

Flexibility in the power sector is one of the most uncertain policies in the report, partly resulting in it receiving a wide range of medium priorities across different criteria. It is unlikely to be as radical or as large a part of the solution as other policies within the report, but nevertheless, it remains a key option to reducing emissions within the power sector due to being able to make renewable power more efficient and reduce use of CCGT power. Coupled with this is the deep uncertainty in future technologies such as the cost of battery storage or the emissions abated by smart meters, both of which could be more or less powerful factors in reducing emissions and strengthening the low carbon power grid than anticipated. This leads to long lead times for these technologies to prove their usefulness, and therefore grid flexibility should not be overlooked as a policy option, particularly in light of the fact that many of the benefits may not become clear until more developmental work is complete.

Power sector CCS, biofuels, heat networks, agroforestry, stronger implementation and monitoring of EU F-gases regulation and methane capture at landfill sites are another wide grouping of policies. All of these policies share the quality that they are all replaceable within their respective sectors by stronger implementation of other policies rated more highly in this prioritisation list. Methane capture and stronger implementation of existing F-gases regulation are rated lowest on this list due to this, for if new legislation covering F-gases in a more ambitious way was followed through in full this would render the other policy redundant, as would zero landfill lead to a drying up of potential methane capture potential. Methane capture is rated lower than stronger implementation of existing F-gas regulation, as the F-gas regulation can act as more of a backup addition to a new F-gas policy, whereas methane capture will inevitably clash with diverting waste from landfill at some later date. Agroforestry covers a different area than standard afforestation policy, but given the much smaller abatement potential it is rated less highly than power sector CCS, biofuels and heat networks. Not only does power sector CCS have a higher emissions abatement potential, but there may in fact already be sufficient policy and funding in place for heat networks, whereas the 2015 withdrawal of the CCS demonstration competition has left uncertainty in the future of the policy. Regarding biofuels, the larger negative impacts than CCS so far has prioritised it lower, although it rates more highly than heat networks in that it requires a greater urgency to pursue the policy, as there is currently a red rating for increasing the share of biofuels in the transport mix.

New nuclear and hydrogen heating are tied with the same prioritisation score, but given the much longer timescale involved in hydrogen heating, new nuclear power is prioritised further, not least due to much ongoing attention to Hinkley Point C and the contingency plans within the power sector should it fail to operate to schedule. Both these policies are longer term solutions than alternative policies within their sector both prioritised further up this report. They also seem to have a likelihood (higher in the case of hydrogen) of fierce competition or elimination by a rival technology that develops more quickly and affordably.

Low carbon space and process heat, biomass space and process heat and pre-2021 renewables are the last tied category on the list. Pre-2021 renewables, given their high policy attention, satisfactory level of rollout and difficulty in withdrawal of this policy given the timeframe, are ranked lower accordingly, as a U-turn on this policy would be difficult to achieve and current rollout is in line with the CCC's indicators. Therefore of the two remaining options for space and process heat in industry, low carbon space and process heat is chosen above biomass, as while biomass is more urgent, other low carbon options have fewer externalities, and with pressure on power, transport and buildings sectors for this resource, this is likely to increase these externalities further. Despite this, the urgency of reducing emissions from industry via biomass should not be underestimated.

Policies preventing waste from accumulating in the waste chain are also ranked lowly on this list, largely because it achieves a low ranking in the most important criteria of policy attention, emissions abatement potential and urgency. While it scores well in the other criteria, the low impact from a climate perspective of this policy coupled with the high level of existing policy attention from other groups makes this policy low priority. It is more highly rated than smarter travel choices and the smart inventory because of the higher potential contribution to its respective sector. Smarter travel choices and the smart inventory are both inexpensive, low risk policies, but also make less of a significant difference than many of the above policies, with low emissions abatement potentials, and being more complementary to other policy solutions than large solutions themselves. Smarter travel choices are prioritised above the rollout of the smarter inventory, due to the fact that the smarter inventory is likely to be imminent in its rollout and does not actually involve any emissions reductions in itself – whereas smarter travel choices is on a longer timescale and will result in a small direct emissions reduction.

3. Limitations of DecarboniseNow

As a small not for profit organisation, it is clearly infeasible for DecarboniseNow to be able to radically cut emissions in the UK using these policies by itself in a short space of time. Our scope as an organisation will have obvious limitations. Ascertaining these limitations per policy listed above though will be difficult given more information is required on the details of individual policies, how to engage with them and the scope and impact of DecarboniseNow at this early stage of its development. Regarding this, it should be noted that this report is based on prioritisation, not elimination of policies – DecarboniseNow will prioritise research and action on Ultra Low Emission Vehicles, but not at the expense of offshore wind, F-gas legislation and all other policies. Therefore, if research and/or action or ULEVs proves difficult for the organisation in its scope, we will still be undertaking research and action into other policies and areas, not having poured all our resources into a single policy. But with this prioritisation report, we will start our research and campaigns based on ULEVs, branching out further down the prioritisation list over time.

This report will not include a section assessing what policies to prioritise based on the impact that DecarboniseNow as an organisation can deliver, largely due to lack of and speculative information currently about what barriers the organisation will face in delivering progress on each of these policies. This would require too speculative an evaluation, and barriers towards DecarboniseNow would be unpredictable – assisting in the rollout of ULEVs may or not may not be faced with opposition within the automotive industry, but it will be difficult to ascertain such a thing before further work starts on research and campaigning. Given the recent nature of DecarboniseNow, it may also be unwise to assess the limitations of the organisation, as these may be larger or smaller than anticipated. The organisation has much future potential for growth, but whether this is realised and the scale to which it could be is highly uncertain, with no reliable parameters for assessing this. The primary scope of this report still extends to assessing which policies to prioritise based on our criteria, and thus this report still serves other organisations and external readers assess what policies should be prioritised based on the criteria used in this report. This report is not an internal document, and should be treated as a publicly visible roadmap for the organisation, laying out what our priorities are and providing compelling evidence and logic for this prioritisation. This report can then be of use to many outside DecarboniseNow. These policies we still rank as the most important policies to be enacted to decarbonise the UK, regardless of the role of DecarboniseNow, so it is still important to us to follow through enacting these policies. This report also outlines how DecarboniseNow can assist the UK government in meeting its legislative targets and Climate Change Act (2008), rather than being a sole political actor out for its own ends. We wish to cooperate fully with government and assist in the implementation of their own climate goals. In keeping with the type of organisation we are committed to running, our duty is to create a semi-immediate, practical type of campaigning, with transparency over what policies we are following and why.

CHAPTER 11: FORWARD LOOK

Chapter 11: Forward look

1. Overview of the report

This report, 'Filling the Policy Gap – Prioritising the UK's Climate Policies' has aimed to investigate and prioritise all the policies recommended by the Committee on Climate Change in its 2016 progress report to parliament to cut greenhouse gas emissions within the UK and to meet the carbon budgets, as well as longer term goals. It has done this by introducing DecarboniseNow, its aims, the Committee on Climate Change and their assessment of the current policy gap, and why this report prioritises these policies that the CCC recommends. It introduces the criteria that each policy recommended by the CCC is assessed on, which include policy attention, urgency, emissions reductions involved, economic credibility, long term sustainability and external impacts. The report then examined the policies in the power sector, which included pre-2021 renewable policy, coal fired power plants phase out, post 2021 renewables, offshore wind and pot 2 renewables, new nuclear power, grid flexibility and power sector Carbon Capture and Storage. The buildings sector contained low carbon heating in new buildings, low carbon heat in existing buildings, heat networks, hydrogen, residential energy efficiency, and non-residential energy efficiency. The industry chapter contained energy efficiency improvements and roadmaps, biomass for space and process heating, low carbon space and process heating and industrial Carbon Capture and Storage. The transport chapter contained the policies of increasing conventional vehicle efficiency, the adoption of ultra-low emission vehicles (ULEVs), biofuels, smarter travel choices, freight transport, and aviation and shipping policies. The agriculture and LULUCF chapter contained rollout of the smart inventory, the pre-and post 2022 agricultural policy for reducing emissions, afforestation, and agroforestry. The waste chapter included the waste prevention policy, reducing waste going to landfill and methane capture rates. The F-gases chapter contained stronger monitoring and implementation of the current F-gases legislation, and new F-gas legislation going beyond the regulatory minimum. The penultimate chapter outlined the final prioritisation and ordering of the policies outlined within the CCC's 2016 progress report, outlining why some policies with the same prioritisation score were ranked more highly than others. Overall it was found that ULEVs, offshore wind and new legislation for F-gases were the top 3 highest rated policies. The work of DecarboniseNow will now prioritise these policies in that order, going further down the prioritisation list as more progress in made on the highest prioritised policies.

2. Rationale

DecarboniseNow has published this report to develop a clear and transparent system for assessing why the organisation is prioritising certain policies, based against criteria we consider important. It also acts a roadmap for the future of the organisation, providing a clear framework for which policies to assess first and to keep prioritising for the immediate future. This report has met those requirements, with a clear criteria system and analysis of each of these policies next to these criteria. While this report has many subjective elements, the structure and analysis brings objectivity also to the ranking of these criteria, and this system is explained and presented transparently. The wide reaching, nonpartisan nature of the report allows a fair analysis of all policies present, and the criteria system allowing subjective judgement coupled with objective analysis.

3. Next steps

Our next steps will be to write a publication on how DecarboniseNow can effectively implement as wide a rollout of ULEVs as possible or is desirable. This will feed into our following campaigns and strategies to do this and implement a wider rollout of ULEVs in the UK. What this will involve will be investigated within the publication, but is likely to involve actively help create further charging infrastructure, collaborating with companies and organisations that can be persuaded to invest in ULEVs, and likely to be centred in one of the five areas the CCC foresees ULEV growth occurring in the short term, most likely London. When this gains sufficient momentum, will follow up a similar strategy with offshore wind and pot 2 technologies, carrying on to support all the policies if possible in the order prioritised and ranked within this report. We will also publicise and promote this publication, showcasing our roadmap and report to others within the environmental policy field and a wider audience. This will ensure early collaboration with others within the field, as well as outside perspective on our report and mutually useful dialogue. As DecarboniseNow grows, we aim for this report to be the equivalent of a foundation stone, allowing the building of further publications and campaigns to be built from the policy rankings shown and discussed within this report. We will also produce a follow up document to assess changes the CCC notes in its 2017 progress report, as well as any updates when policies such as the Clean Growth Plan are published.

Annex

Onshore wind projection

8760 (total number of hours within 2015) ÷ 30 (capacity factor) = 2628 hours

1GW X 2628 = 2628GWh

25GW (highest CCC projection for onshore wind) X 2628 = 65700GWh

65.7TWh of power produced

65.7TWh ÷ 339TWh (total electricity produced in 2015) = 0.193

0.193 X 100 = 19.3

19.3% of the 2015 power mix therefore would come from onshore wind based on 25GW at a capacity factor of 30%.

Solar PV projection

8760 (total number of hours within 2015) ÷ 10 (capacity factor) = 876 hours

1GW X 876 = 876GWh

60GW (highest CCC projection for solar PV) X 876 = 52560GWh

52.560TWh of power produced

52.560TWh ÷ 339TWh (total electricity produced in 2015) = 0.155

0.155 X 100 = 15.5

15.5% of the 2015 power mix therefore would come from solar PV based on 60GW at a capacity factor of 10%.

Offshore wind projection

8760 (total number of hours within 2015) ÷ 40 (capacity factor) = 3504 hours

1GW X 3504 = 3504GWh

40GW (highest CCC projection for offshore wind) X 3504 = 140160GWh

140.16TWh of power produced

140.16TWh ÷ 339TWh (total electricity produced in 2015) = 0.413

0.413 X 100 = 41.3

41.3% of the 2015 power mix therefore would come from offshore wind based on 40GW at a capacity factor of 40%.

(All data is sourced from the CCC’s 2016 progress report).

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