A Vision for Britain: Clean, Green and Carbon Free

How to achieve a Net-Zero Carbon Britain by 2050

And a pathway to alignment with 1.5 degrees

Produced for Baroness Featherstone,

Energy and Climate Change Spokesperson,

The Liberal Democrats

By Culmer Raphael and Iken Associates

September 2017

Foreword


Sir Vince Cable MP, Leader of the Liberal Democrats, and

Baroness (Lynne) Featherstone, Energy and Climate Change Spokesperson

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WE are at a pivotal moment in the fight against climate change. Just two years ago, world leaders from across the globe gathered in Paris and committed to an ambitious plan to tackle global warming. Yet now we face the withdrawal of the world's largest economy from the agreement, while Brexit threatens to weaken action on climate change in the UK and across Europe.

Meanwhile, the urgency of tackling climate change is increasing. Extreme weather is becoming more common, reducing crop production and pushing up food prices. As this report was being finalised, Hurricane Harvey was inflicting billions of dollars' worth of damage in the US, while unusually heavy monsoon rains in India, Nepal and Bangladesh killed more than 1,000 and affected, in some way, over 41 million people.

The impacts are not only increasing, they will soon reach a tipping point beyond which global warming will become irreversible

How should Britain respond? We must do everything in our power to get our own house in order and set an example to the world. What is needed now is a radical plan to decarbonise our economy and set Britain up for a clean and green future. Over recent years, the UK has been seen as a world leader in sustainability, innovation and cutting-edge technologies. The Coalition was the greenest government ever, tripling electricity generation from renewable sources and establishing the Green Investment Bank. But in the last two years the Conservatives have done their best to unravel this progress and Britain is slipping quickly behind.

This is why so many of the ideas in this ground-breaking report are so desperately needed. The report takes a comprehensive look at each sector and shows that becoming carbon-free by 2050 is both possible and necessary in order to meet the Paris Agreement's ambitious target of limiting temperature rise to 1.5 degrees. Furthermore, it sets out how this ambition can be delivered.

The report also demonstrates the clear economic advantages to investing in the green economy, as well as the environmental benefits. Such investment will create jobs in every region of the UK and develop expertise and skills that can be exported to the world. Restoring investor confidence, which has been so deeply undermined by recent legislative changes, is also imperative.

Above all, the fight against climate change needs political will. The Conservatives have shown that they lack it and have failed to act.

If climate change is to be taken seriously, Britain needs the Liberal Democrats – a party that understands what bold measures must be taken and has the will to press ahead to a clean, green and carbon-free future.

We hope you enjoy reading the report.

Sir Vince Cable MP

Baroness Featherstone

About this Report

The Liberal Democrats have an established aim of a Zero Carbon Britain (meaning a UK which is a net-zero emitter of greenhouse gases) and have made a manifesto pledge to reach this goal by 2050. Commissioned by the Liberal Democrat spokesperson on Energy and Climate Change, Baroness (Lynne) Featherstone, this report reviews existing evidence on how to meet this target and explores whether and how it could be achieved.

The review assembles a body of evidence and opinion drawn over a six-month period from published reports, a series of in-depth bilateral meetings with a range of experts, input from four roundtables, and meetings with the Liberal Democrat Climate and Energy Advisory Group. It describes scenarios and pathways that potentially align with zero carbon ambitions and associated challenges and opportunities, with particular emphasis on near term actions supporting the objective.

It is important to emphasise that the scenarios set out in this document are not predictions and that success in meeting climate change objectives will ultimately rely on a huge amount of commitment and endeavour – in terms of policy design, science, technology, investment and individual and societal behaviour change.

About the Authors

This report was compiled by Culmer Raphael and Iken Associates between December 2016 and August 2017.

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HOW THE REPORT IS STRUCTURED

The **Introduction** sets out:

i. Summary of key findings and considerations
ii. Scenarios for a UK transition pathway to net zero carbon emissions by 2050
iii. Key policy implications

Chapters 1-5 each tackle one, or a group of related sectors together (on account of the close relationship between them). Each of these is structured as follows:

i. Summary of current emissions
ii. "The Way Ahead": Summary of considerations for the sectors concerned
iii. The Challenge
iv. Recent UK and EU policy developments
v. Potential Solutions
vi. Conclusions

There are two Appendices which address issues of clear relevance to the UK decarbonisation challenge namely: the role for *finance and investment* and the potential implications of *Brexit.*

ACKNOWLEDGEMENTS

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- Tony Juniper, Fellow, Cambridge Institute for Sustainability Leadership
- Michael King, Strategic Adviser working with The Carbon Trust
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- Professor Jim Skea, Chair in Sustainable Energy at Imperial College London
- Dr Tim Thom, Yorkshire Peat Partnership
- Stephen Tindale, Climate campaigner
- Richard Twinn, Policy Advisor at the UK Green Building Council
- David Vincent, Independent strategic energy consultant
- Paul Westacott, Origami Energy
- Members of the Liberal Democrat Energy Advisory Group

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Glossary of key terms

ADE	Association for Decentralised Energy
BECCS	Bioenergy with Carbon Capture and Storage
BEIS	Department for Business, Energy and Industrial Strategy
CAT	Centre for Alternative Technology
CCC	Committee on Climate Change
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
CIE-MAP	Centre for Industrial Energy, Materials and Products
CMA	Competition and Markets Authority
CO_2	Carbon Dioxide
CO_{2e}	Carbon Dioxide Equivalent
DSO	Distribution System Operator
EEA	European Environment Agency
ESOS	Energy Savings Opportunity Scheme
ESR	Effort Sharing Regulation
ETI	Energy Technologies Institute
ETS	Emissions Trading Scheme
F-gases	Fluorinated gases (such as hydrofluorocarbons)
FiT	feed-in tariffs
FSB	Financial Stability Board
GHG	greenhouse gases (CO2, methane, nitrous oxide etc.)
GHGAP	Greenhouse Gas Action Plan
GIB	Green Investment Bank
GSA	General Services Administration
GW	Gigawatt
IEA	International Energy Agency

ILUC	Indirect Land Use Change
INDC	Intended Nationally Determined Contributions
LULUCF	Land Use, Land Use Change and Forestry
Mt	Megatonnes
MtCO2e	Megatonnes carbon dioxide equivalent
NEP	National Energy Program
NIC	National Infrastructure Commission
NIDP	National Infrastructure Delivery Plan
PiP	Pensions Infrastructure Platform
PV	Photovoltaic
RAP	Regulatory Assistance Project
REP	Regional Electricity Partnerships
RTP	Realising Transition Pathways
TPI	Transition Pathway Initiative
TCFD	Task Force on Financial-related Disclosures
TWh	Terawatt hours
ZCB	Zero Carbon Britain

Introduction

STRONGER LONG-TERM TARGETS AND SHORT-TERM ACTION

The current UK policy of 80% emissions cuts, on 1990 levels, by 2050, while ambitious and enshrined in law by the Climate Change Act (2008), is not in line with the aims of the 2015 Paris Agreement, which requires developed countries to move as quickly as possible towards negative emissions. As such, the current UK target should actually be to reduce the UK's current emissions to net negative. The UK is a party to the Paris Agreement in its own right, but has submitted a joint decarbonisation plan (Nationally Determined Contribution) through its current membership of the EU. The Paris Agreement's central aim is to "strengthen the global response to the threat of climate change by keeping average global temperature rises this century to well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further, to 1.5 degrees Celsius". In 2018 the *Intergovernmental Panel on Climate Change* (IPCC) will publish its assessment of the global "emissions budgets" remaining to meet the Paris Agreement's ambition to work towards holding average warming to below 1.5 degrees. The findings are widely expected to be arresting in their stringency and are likely to prompt global calls for more urgent action in the coming years. In 2017, an analysis of IPCC figures by Carbon Brief estimated that a mere four additional years of current global greenhouse gas (GHG) emissions could be enough to "blow what's left of the carbon budget for a good chance of keeping global temperature rise to 1.5C"[1]. Globally, we have seen the third consecutive year of stalling emissions growth, suggesting that global emissions *may* have peaked at around 40 billion tonnes in 2016 (including net emissions from land use change). Across the whole world, the 2020s will, therefore, be a crucial decade in ensuring the world rises to the challenge of climate change.

In order to live up to its share of the responsibility to act, the UK must set more ambitious targets in line with the Paris Agreement and – importantly – provide much clearer policy direction to spur the real economy changes we need. This finding was echoed in June 2017 by the government's own climate change advisory body, the Committee on Climate Change (CCC) which stated in its 2017 annual report that:

> The UK's transition to a resilient, low-carbon economy is in danger of being derailed by a lack of Government action on climate change...[this] inaction is making it difficult for businesses and the UK public to grasp the opportunities of the transition.[2]

In the same report, the CCC went on to say that:

> UK emissions are about 42% lower than in 1990, around half way to the 2050 commitment to reduce emissions by at least 80% on 1990 levels. As emissions have fallen since 1990, GDP has increased by more than 65%...*However, progress is stalling. Since 2012, emissions reductions have*

been largely confined to the power sector, whilst emissions from transport and the UK's building stock are rising [emphasis added].[3]

These very recent statements from the CCC underline the importance both for more ambitious long-term targets and for immediate policy action to ensure that UK emissions begin to fall rapidly in the 2020s.

HIGHER TARGETS: 80% EMISSIONS CUTS BY 2040-45, 93% CUTS BY 2050

This review draws heavily on CCC work, in particular their 'max scenario' for 2050. While the current official UK target of an 80% reduction in emissions (on 1990 levels) by 2050 is challenging, it should be feasible to bring this target forward to 2040-2045 to align with the Paris Agreement. This would then put the UK on track to very nearly meet the Liberal Democrat goal of "a Zero carbon Britain" by 2050, delivering a 93% cut. Accordingly, much of the pathway and associated action to net zero (and beyond that to net negative) is feasible given current technology. Significant innovation can reasonably be expected to yield solutions in the 2020s and 2030s to the emissions that remain. The UK is fortunate to have both a legal framework (in the Climate Change Act) and robust scientific support (exemplified by the work of the CCC) that allow identification of practical scenarios and actions that are informed by the requirements of public expenditure. Of course, there are many uncertainties in all areas of this endeavour and scenarios should not be treated as predictions. Throughout this report, we emphasize the benefits of early action, while retaining the flexibility to pursue a range of options. Should progress not be sufficient in the 2020s, more radical future action, implying greater cost and/or changes to lifestyle, will be required to reach net zero. The possibility of acquiring carbon credits in the international market will remain an option, of course, albeit one we would only advocate following robust domestic reduction action.

The focus on bringing forward current official targets is in line with suggestions from the UNFCCC itself that developed countries should bring forward their emissions reductions targets in order to achieve the necessary global cuts. In this report, our assessment is based on *current technology*, in the expectation that research and development will eventually provide us with answers to difficult challenges, such as the use of fossil fuels in certain industrial processes and aviation. We say more below about how to achieve the additional 7% cuts which would put the UK on a path to 100% emissions reductions (on 1990 levels) by 2050.

Consistent with the principle that the UK should actually be looking to achieve *net negative* emissions by 2050, we strongly recommend the inclusion of *all* relevant carbon sinks and sources in the assessment of real emissions, especially those currently unaccounted emissions coming from UK peatland.

As set out below, our modification to the CCC's most ambitious emissions-abatement scenario for 2050 (the CCC max scenario), provides an additional 8 MtCO2e worth of emissions cuts to UK annual emissions by

2050. However, this cannot be achieved without additional emissions abatement from carbon removal/negative emissions, as we set out in a dedicated section in chapter five.

THE URGENT NEED FOR CARBON REMOVAL/NEGATIVE EMISSIONS

It is unrealistic to think that all activity in the UK can be made GHG-emissions-free, and it is certainly economically undesirable to consider moving high carbon activities to other countries, not least because many operate to lower environmental standards than the UK. This means that to achieve net-zero emissions by mid-century, there is a need for considerable carbon removal (also known as 'negative emissions') to complement the decarbonisation effort. Our review has found a striking degree of consensus that investment in Carbon Capture and Storage (CCS) in some form is also essential. This view is reinforced by the recent report from the House of Commons *Public Accounts Committee* which is strongly critical of the cancellation of CCS investment support in the UK[4].

A PORTFOLIO APPROACH

The 2020s are likely to be a decade of fast and comprehensive technological development in low carbon technologies of all kinds. As we do not yet know which ones will develop into the most economically viable options at scale, we recommend backing a portfolio of technologies to avoid any kind of technological lock-in.

Moreover, full account should be taken of the co-benefits of all options; from jobs to exports, to health, to natural capital, to quality of life.

DIFFICULT DECISIONS FOR THE 2020S

There are a number of potentially controversial decisions that the UK government will have to take in order to set the trajectory for realistic and ambitious emissions cuts in the 2020s and beyond. To avoid technology lock-in and stranded assets, these decisions are becoming urgent. We deal with each of them in the core chapters of the report. They include:

- The role for and sources of bioenergy and bioenergy with CCS (BECCS)
    - Given the current debate around the degree to which bioenergy should be considered a low carbon source of energy, we have included a low-biomass option in our research
- The need to decarbonise the UK's share of aviation and shipping
- The role of nuclear power in the UK and the prospects for new nuclear
- The role for any sort of fossil fuel generations (e.g. CCS fitted gas generation, and "the hydrogen economy") in the 2030 generation mix

- The role of effective financing in delivering a cost-effective low carbon transition and the role for the UK financial services sector in providing exports in this area.
    - The role for private finance supported by public finance de-risking efforts
    - The urgent need to increase investment levels in energy efficiency while maintaining growth in investment levels for low carbon power, heat and transport
- The need to decarbonise UK industry without incentivising offshoring, or "carbon leakage"
- The role of lifestyle changes and reforms to public services which can deliver carbon emissions savings through reductions in demand
- The role of public procurement and standards in incentivising economy-wide decarbonisation
- The UK's relationship with the EU after Brexit, particularly its interaction with post-2020 EU climate policies such as the next phase of the EU *Emissions Trading Scheme*, the *Effort Sharing Regulation* and the numerous regulations contained in the European Commission's *Clean Energy for all Europeans* package (2016)

CURRENT DECARBONISATION PATHWAYS IN THE UK

This section explores the CCC scenarios for 2030 and 2050 and goes on to set out a feasible scenario (based on current technology) drawing on 'CCC Max' (which it describes as 'feasible'). We *uprate* the CCC Max scenario using more up-to-date bioenergy with CCS (BECCS) data, along with a scenario for further emissions savings from resource-efficiency in businesses.

Our 'Modified Max Scenario' leaves a small amount of CO2 by 2050, but at 93% GHG reduction, does align with the Paris Agreement's 1.5 degree aims. Pathways that aim for 1.5C imply the need for a UK GHG reduction of at least 86-96% below 1990 levels by 2050. *This is reflected in our scenario.* We also set out how the residual, 7% of emissions, can be addressed, putting the UK on a path to a 100% cut on 1990 emissions levels and beyond, to becoming a net-negative emitter.

UK emissions, CCC carbon budgets and targets under the Climate Change Act

Current net UK GHG emissions are around 466 $MtCO_{2e}$. The decline of around one third since 1990 can be largely attributed to the decrease in the use of coal in UK power stations as well as in greater energy efficiency across the economy.

Through the Climate Change Act (2008), the government has committed to:

- "Reducing emissions by at least 80% of 1990 levels by 2050"
- "Contributing to global emissions reductions, to limit global temperature rise to as little as possible above 2°C." [*This needs to be amended to reflect the aims of the Paris Agreement, as the EU is doing with its own 2030 emissions targets].*

To meet these targets, the government has set five-yearly carbon budgets which currently run until 2032. They restrict the amount of greenhouse gas the UK can legally emit in a five-year period. The UK is currently in the second carbon budget period (2013 to 2017).

Carbon Budget	Reduction below 1990 levels	
1st carbon budget (2008 to 2012)	3,018 $MtCO_{2e}$	25%
2nd carbon budget (2013 to 2017)	2,782 $MtCO_{2e}$	31%
3rd carbon budget (2018 to 2022)	2,544 $MtCO_{2e}$	37% by 2020
4th carbon budget (2023 to 2027)	1,950 $MtCO_{2e}$	51% by 2025
5th carbon budget (2028 to 2032)	1,725 $MtCO_{2e}$	57% by 2030

The EU's current proposal for 2030 is to reduce total EU emissions by 40% on 1990 levels, so the UK's 2028-2030 emissions target is currently more ambitious (and Paris-compatible).

The CCC scenarios indicate that (to meet the statutory 80% reduction in 2050) net emissions in 2030 should be around 350 $MtCO_{2e}$ and 100-150 $MtCO_{2e}$ in 2050. The figures below are all taken from the CCC's most recent (June 2017) report to parliament on meeting the carbon budgets[5].

Figure 1: 1990-2016 UK emissions versus GDP

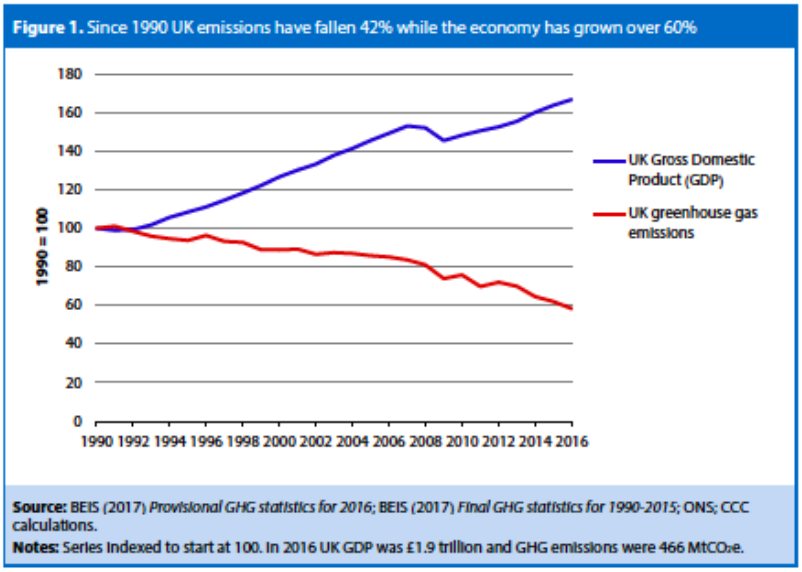


Figure 2: Sources of and trends in current UK GHG emissions ($MtCO_{2e}$)

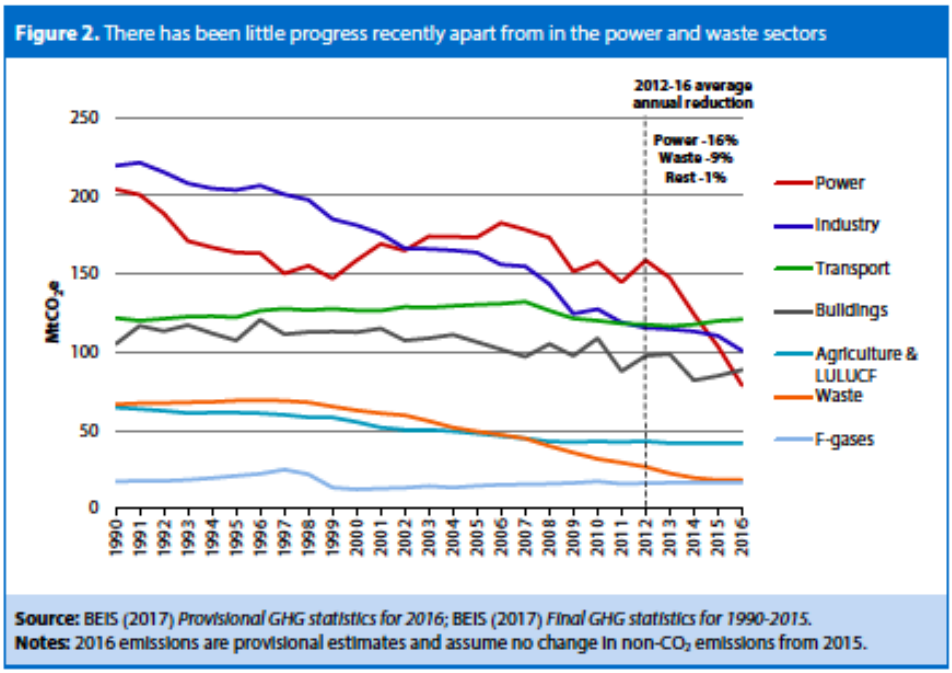
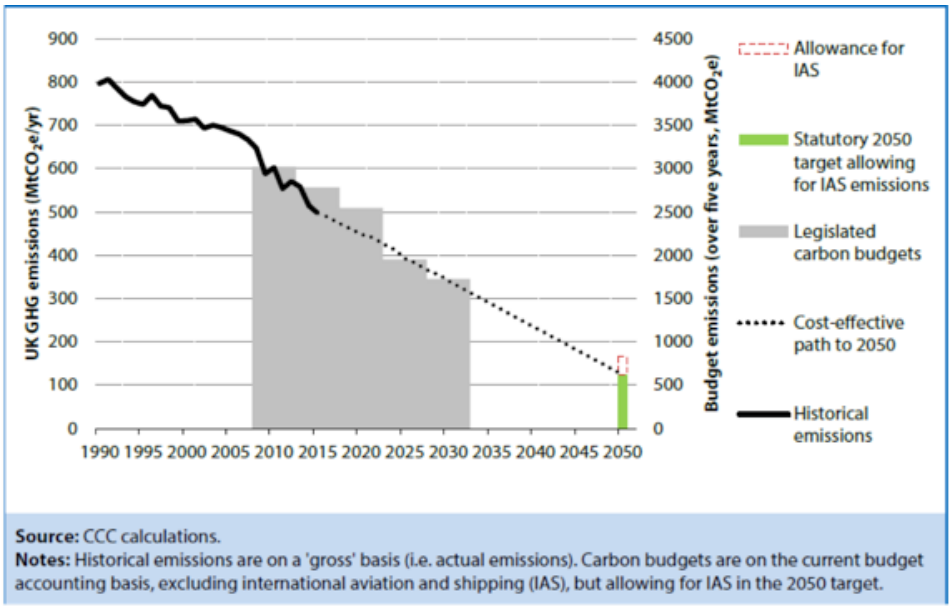


Figure 3 – Screengrab showing CCC pathway to 2050



WHEN SHOULD *GLOBAL* EMISSIONS FALL TO NET-ZERO?

The Paris Agreement has prompted research into global "carbon budgets" and the timeframes compatible with its global average temperature targets. To hold warming to below 1.5 degrees, the following actions are needed[6]:

- Global energy and industry emissions to reach zero by around 2050
- Total global GHG emissions to reach zero before 2080
- Total global GHG emissions by 2050 are 80% below 1990 levels

For limiting warming to below 2°C with a likely (greater than 66%) chance the following actions are needed:

- Global energy and industry CO2 emissions to reach zero around 2065[7]
- Total global GHG to reach zero by 2100
- Global GHG emissions by 2050 are 40% below 1990 levels

ALIGNING UK TARGETS WITH THE PARIS AGREEMENT

The CCC notes that 'while relatively ambitious, the UK's current emissions targets are not aimed at limiting global temperatures to as low a level as in the [Paris] Agreement, nor do they stretch as far into the future'. 'Reaching net zero (and possibly net negative) emissions will require technologies to *remove greenhouse gases* from the atmosphere. The UK should, therefore, pursue a strategy to develop options in both hard-to-treat sectors and in greenhouse gas removals, domestically and in collaboration with wider global efforts'.

Furthermore, models identifying pathways arising out of the Paris Agreement generally assume global net CO2 emissions become net negative later in the century (through removal of CO2) and that total emissions of greenhouse gases (CO2 plus non-CO2 emissions) fall to net zero before 2100. For the objectives set out by the Paris Agreement to be achieved, global net CO2 emissions should reach zero in the 2040s, with net zero emissions for all greenhouse gases somewhere between the 2060s to 2080s. As noted above, the IPCC will provide an update on the global carbon budgets needed to achieve the 1.5 degree aim in 2018. They are expected to be even more stringent than those indicted by current modelling.

Using a similar rationale to that underpinning the current 2050 targets set out in the Climate Change Act, which is that the UK would need to reach net zero emissions no later than the rest of the world, pathways that aim for 1.5 degree-compatibility would imply the need for a UK GHG reduction of at least 86-96% below 1990 levels by 2050, which is what our modified and updated scenario envisages.

Two CCC reports form the foundation for both the data and related information used subsequently in our discussion of UK emissions pathways to 2050:

- **'Sectoral scenarios for the Fifth Carbon Budget', Technical report (November 2015)[8] and**
- **'UK climate action following the Paris Agreement' (October 2016)[9].**

Our report acknowledges the CCC as the UK Government's advisers and the report's principal source of information, whilst accepting that much can be learnt from consideration of other work in the UK and internationally.

THREE CCC SCENARIOS: 1) 'CENTRAL', 2) 'BARRIERS', 3) 'MAX'

The CCC has developed a set of scenarios for UK emissions reductions based on a sector-by-sector analysis. The '**Central scenario'** represents their best assessment of the technologies and behaviours required to meet the 2050 target, with the **'Barriers option'** reflecting unfavourable conditions for key measures. The '**Max scenario'** represents 'higher, but still feasible, deployment of key measures'. It is to be emphasised that these are scenarios and not *predictions* for emission-reduction pathways.

The implementation of measures set out in the CCC's fifth carbon budget "Max scenarios" would lead to net UK emissions of around 64MtCO_{2e}/year in 2050 (i.e. 92% below 1990 levels of emissions). This includes the UK share of international aviation and shipping. This would represent a 66% reduction by 2030 and 92% reduction by 2050.

The CCC Max scenario aligns well with the Liberal Democrats' low carbon policy, as well as the ambition of the Paris Agreement. It is, nonetheless, important to recognise that the realisation, even of the Central scenario, poses significant challenges which are only heightened by pursuing the Max scenario, reflecting a reduced degree of flexibility in how the target is met. In the Max scenario, *everything* must 'go to plan'.

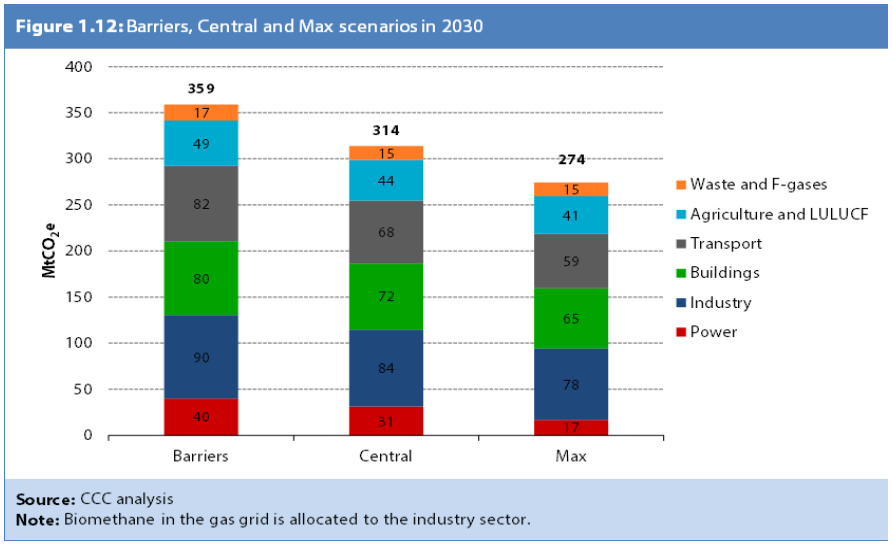
Big implications for the UK power sector by 2030

Under any of the feasible scenarios perhaps the greatest impact by 2030 will be visible in the power sector, with emissions from power generation needing to fall below 100gCO_{2e}/kWh in 2030. This would mean that at least 75% of power generation in the UK would need to come from low or zero carbon sources. The current figure is around 20% on average, although this has risen to as high as 50% on certain days of the year[10].

If this level of carbon intensity is to be achieved by 2030, the importance of attracting even higher levels of investment in the 2020s cannot be overstated. There is a pressing need to replace retiring coal and nuclear generation and to meet increasing demand for electricity. The CCC states that 'the 2020s are therefore a

crucial decade for the future of the power sector.' They note that low carbon options are likely to be cost competitive and recommend a portfolio approach to generation. Sustainable biomass, tidal lagoons and nuclear (as well as onshore wind and solar) are seen as mature options for a portfolio approach with CCS and offshore wind as 'less mature', requiring extra support beyond 2020.

Figure 4 – Screengrab of CCC 2030 scenarios



We examine the 2030 and 2050 implications for the power sector in much greater detail in the next chapter. However, it should be noted that the CCC concludes that a deeply decarbonised UK power system in 2030, with high levels of intermittent renewables (c.40% of total generation), is possible while maintaining security of supply. Managing this transition at lowest cost will involve investment in flexible gas-fired generation capacity alongside the expansion of international interconnection, demand response and electricity storage.

The CCC views the key to achieving the necessary power-sector investment in the 2020s as being long-term contracts supported by competitive auctions. ***This would include confirming low carbon generation funding to at least 2025.***

They recommended setting out an approach to commercializing CCS through up to four clusters and working with Ofgem and National Grid to ensure the full benefits of demand response, interconnection and storage are realised.

It is possible that there will be a small future role for fossil fuel generation in 2030. Modelling from Imperial College London[11] indicated that coal is likely to disappear completely from the generation mix (in line with the UK's coal phase-out ambitions), but gas (potentially fitted with CCS) could still play a role in meeting peak demand. Given the need to use the capacity only rarely, means associated emissions need not jeopardise decarbonisation.

As discussed below, the CCC has identified a range of scenarios with different 2030 generation mixes and demand levels that could still be consistent with 2050 pathways. In a high renewables scenario, renewables contribute 61% of generation (compared to around 45% in other scenarios). It is also possible to use CCC data to construct, for example, a 'no new nuclear' scenario that increases offshore wind, tidal energy and solar power to meet the 100g/kWh target. However, as noted above, we recommend keeping options open, particularly in a time of rapid technological change.

OUR MODIFICATIONS TO THE CCC 'MAX' SCENARIO

The CCC Max scenario envisages UK emissions to be 66% below 1990 levels by 2030 and just over 90% by 2050 – which is compatible with the specified range of a 1.5C target. Including the UK share of aviation and shipping would result in net economy wide emissions of 64$MtCO_{2e}$/year in 2050 (92% below 1990 levels).

Figure 5 – CCC Max Scenario: annual emissions per sector (including carbon sinks) by 2050

Source/Sink	2016 $MtCO_{2e}$	2050 $MtCO_{2e}$
Power *75% decarbonized with peaks met by storage and hydrogen*	79	3
Heating for Buildings *provided by heat pumps, heat networks, electric heating and gas:*	89	4
Surface Transport *All cars and vans are electric. Buses and HGVs rely on hydrogen and electricity*	121	5
Industry *After wide-ranging electrification and deployment of CCS*	100	32
Agriculture and food (including non-CO2 GHG emissions) *based on diets shifting away from red meat and a ban on F gases*	84 (2015)	47
Peatland *Not currently included in UK accounting or CCC scenarios*	N/A	0
Aviation and Shipping (UK Share)	N/A	40
LULUCF *NEGATIVE EMISSIONS from Land use, land-use change and forestry (LULUCF) as well as measures including the creation of 30,000 ha/year of UK woodland and agroforestry*	-7	-16
BECCS *NEGATIVE EMISSIONS: 50 Twh/year of bio-energy and Carbon Capture and Storage (BECCS), based on UK domestic production and UK share of sustainable global bioenergy*	N/A	-47
Wood in construction *NEGATIVE EMISSIONS*	N/A	-4
Total:	c.466	64

It is clear, then, that even with very significant emissions reductions, substantial emissions remain: principally in industry and agriculture. The high role envisaged for carbon recovery/negative emissions is also stark.

The CCC Max scenario forms the basis of our modified scenarios. These include some relatively small adjustments that have been made to the budget in the context of recent developments. It is our view that the inclusion of related emissions is both good accounting practice and a prompt for timely UK action. Furthermore, we draw on recent work[12] that points to a *greater sequestration potential* for technologies associated with BECCS (see chapter five for further detail). A third scenario, meanwhile, draws on the recent study from the UK's Department for *Business, Energy and Industrial Strategy* (BEIS) study into biomass potential[13]. These changes are considered along with a more significant role for industry in delivering reductions. ***Our modified max scenario results in net 2050 emissions of 56$MtCO_{2e}$ rather than the CCC figure of 64$MtCO_{2e}$.***

Including Peatland in carbon accounting

Peatland is currently a significant source of UK GHG emissions that is not included in the UK's figures. It is believed that UK peatlands current emit around **21 $MtCO_{2e}$** per year[14]. The CCC have acknowledged that degraded peatlands risk significant carbon emissions and support the House of Commons Environmental Audit Committee's recommendations for peatland to be included in the UK's carbon inventory by 2018[15]. The Soil Association has called for special protection areas in the Fens which included provision for an 80% GHG reduction target[16]. A UK peatland strategy covering both upland and lowland peat might therefore adopt a reduction target in the region of 75%, meaning that emissions in 2050 would be reduced to **5 $MtCO_{2e}$**. This estimate should of course be updated as better data becomes available.

Additional negative emissions from bioenergy with CCS (BECCS): a controversial debate

The CCC scenarios for BECCS are derived from a 2011 bioenergy review. However, more recent modelling work from the Energy Technologies Institute[17] has indicated that bioenergy in the UK could deliver 130TWh annually along with carbon recovery/negative emissions of around -55 $MtCO_{2e}$ (an allowance for supply chain emissions is built into this estimate) which compares to the -47 $MtCO_{2e}$ that the CCC uses for its 2050 Max scenario. On the other hand, there is developing evidence of the amount of the genuinely sustainable (i.e. low carbon) bioenergy the UK could rely on in the world market. The evidence is currently suggesting that this figure could be *considerably lower* than previously thought, as we discuss in chapter five.

Additional emissions savings from resource efficiency across businesses (circular economy practices)

A recent study from *the Centre for Industrial Energy, Materials and Products* (CIE MAP)[18] found that further efforts by business in the areas of resource efficiency could lead to significant additional carbon savings. Annual savings of around **5 $MtCO_{2e}$** should be achievable across the economy by extending the scope beyond the six business sectors studied. We therefore adjust the industry 2050 max contribution by that

amount in our "modified max" scenario, based on the understanding that there will be efforts by business across many sectors to reduce material inputs and increase product life etc.

Figure 6 – Our "Modified Max" scenario: annual emissions per sector in 2050

Source/Sink	$MtCO_{2e}$
Power	3
Heat in Buildings	4
Surface Transport	50
Industry*	27 (-5)
Non-CO2	47
Peatland*	5 (+5)
Aviation and Shipping	40
LULUCF	-16
Carbon recovery & BECCS*	-55 (-8)
Wood in construction	-4
Total:	**56 (-8)**

* Modification to CCC max scenario +/- presented in parentheses

As shown in the table above, plugging in these additional savings to the CCC's 2050 Max scenario results in net UK annual emissions of **56 $MtCO_{2e}$**, representing a reduction of around 93% on the UK's emissions levels in 1990 (using a baseline of 823 $MtCO_{2e}$ – including aviation and shipping – plus an extra 21 $MtCO_{2e}$ for peatland[19]). Net-zero emissions are not currently feasible *without* significant carbon removal/negative emissions.

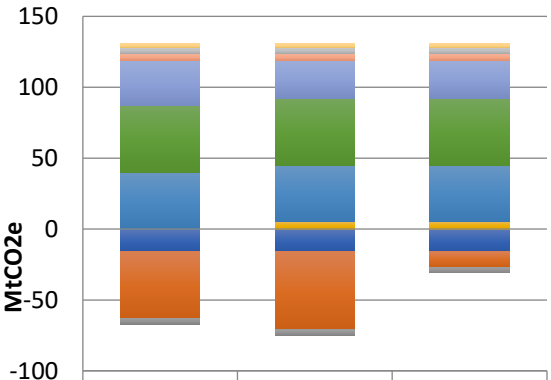
It is important to acknowledge that these scenarios are not predictions and are subject to high levels of uncertainty. Furthermore, they take no account of major technological breakthroughs. Nonetheless, a UK *Zero Carbon Britain* target aligning with the Paris Agreement **does not appear feasible at this moment without significant contributions from carbon removal/negative emissions.** With regard, specifically, to BECCS, it should be noted that the CCC projections only show BECCS making significant contributions to emissions reductions after 2035 and so BECCS is less relevant to the early reduction pathways. Of course, there is still the need to develop technologies in the 2020s if they are to be ready for full-scale deployment by 2030.

The negative emissions, which could be delivered in conjunction with BECCS, are clearly very significant in achieving 2050 net zero targets utilising either CCC data and/or ETI research. So a recent update[20] to BEIS's estimates of UK biomass availability needs to be considered carefully in scenario construction. As mentioned above, the BEIS study shows that there could be large reductions (of around 80%) in the availability of biomass for BECCS. ***Utilising the Modified Max scenario described above while reflecting an 80% reduction in the negative emissions associated with BECCS to 11 $MtCO_{2e}$ results in total 2050 GHG emissions of 102 MtCO2e and CO_2 emissions of 55MtCO2e[21].***

These three scenarios ("CCC Max", "Modified Max "and "Modified Max Low Carbon Removal") are presented together in figure 7. That figure illustrates starkly that, while a 2050 zero carbon target (for CO_2) could be feasible based on slightly modified CCC scenarios, **the restricted contribution from *carbon***

removal/negative emissions would mean that net zero would not be achievable. A question for further research would be the degree to which increased carbon removal technologies are economic in the absence of BECCS and the degree to which a low carbon power sector (post-2035) would be able to do without BECCS as a source of flexible, low carbon power.

Figure 7: 2050 emissions levels $MtCO_{2e}$: (CCC Max, Modified Max and "Modified Max Low carbon removal")



	CCC Max scenario	Modified zero carbon	Reduced biomass
Power	3	3	3
Heat in buildings	4	4	4
Surface transport	5	5	5
Industry	32	27	27
Non CO2	47	47	47
IAS	40	40	40
Peatland	0	5	5
Wood in construction	-4	-4	-4
BECCS	-47	-55	-11
LULUCF	-16	-16	-16

From a 93% emissions reduction to 100%, by 2050

This report is based on pathway scenarios that are themselves based on current levels of technological feasibility and observed trends in behaviour and demand patterns. For example, we do not include scenarios based on a wholesale shift of diets away from meat consumption and we – as well as the CCC – do take into account expected rises in demand for aviation and shipping in the decades to come. This is part of the reason why our chapter on transport highlights that the electrification of surface transport in the UK is no "silver bullet" for decarbonising UK transport in line with the aims of the Paris Agreement. Finally, it is to be emphasised that the aim of the Paris Agreement is for developed countries to get *as near as possible* to net negative emissions *as fast as possible*, so the pace of decarbonisation is very important. This is the significance of bringing forward the UK's current official targets.

Provided the UK is able to deliver the substantial carbon recovery/negative emissions included in our "modified max scenario", it will be on a path to compliance with the Paris Agreement. Nonetheless, this would still leave a small residual amount of emissions – representing only 7% of 1990 emissions by 2050. There is reason to be optimistic that if our CCC "modified max" scenario can indeed be achieved, as we believe it can be, it will be *overshot* by a degree that will in reality deliver a full 100% cut on 1990 emissions in the UK by 2050. The reasons for this are as follows:

Technological innovation in the 2020s and 2030s. We fully expect technological innovation to fill the remaining gap in emissions mitigation by 2050 and allow for the UK, if pursuing an ambitious enough emissions reduction pathway, to reduce its 1990-level emissions by 100%, to net-zero and beyond. It is highly likely that the investment and R&D going into clean tech will trigger unforeseen technological innovation in a huge range of technologies, from electric vehicles to electricity storage and demand response – but also in several, difficult to mitigate, industrial and agricultural emissions. If the UK takes up the challenge of developing a genuinely low carbon industrial strategy, along with the requisite investment in skills and R&D (as we outline in chapter 4), British companies could benefit from a vast array of export opportunities in low carbon technology and expertise, as well as its expertise in green finance.

Lifestyle changes. An important component of the technological change we expect in the 2020s and 2030s will come in the ICT sector – broadly defined – and this will enable further savings in carbon emissions through lifestyle changes such as e-health, e-learning and additional e-working, which could radically arrest or even reverse the expected growth in demand for transport and aviation especially. For example, a 2015 report from the *Global eSustainability Initiative* (GeSI)[22] found that rolling out six ICT-enabled solutions across the economy (smart grids; optimised traffic control; e-working; e-commerce; smart agriculture and smart buildings), could save the UK a huge 0.18 Gt CO_{2e} *per year* by 2030.

International carbon offsets. To cope with any remaining, very difficult to reduce emissions, there is also the option of buying high-quality carbon offsets from the international market that is coming in to replace the Clean Development Mechanism under the Paris rulebook. Although this should be seen as a last resort, carbon offsets will still be a viable source of income for developing world projects and so are not to be ignored as an option once all domestic decarbonisation options have been exhausted.

RESPONDING TO THE PARIS AGREEMENT'S 1.5 DEGREE AMBITION

This leaves us with the challenge of an appropriate response to the Paris Agreement. In their assessment of the consequences of the Paris Agreement for the UK, the CCC[23] indicate that 'the priority for now should be robust near-term action to close the gap to existing targets and open up options to reach net zero emissions'. They also describe further action (above the 2 degree pathway already in place) to meet a 1.5 degree target. These actions include greater and earlier CO_2 emissions reductions (as opposed to other

GHGs), primarily from the power sector. There would also be deeper emissions reductions before 2030 in which energy efficiency plays a 'crucial' role. A recent UCL paper[24] also explicitly addresses the post-Paris UK response, recommending earlier action on emissions reduction.

This greater focus on early action aligns with the CCC Max scenario (and our amended version) and leads to lower emission levels at both 2050 and earlier. Applying the logic of early action, **it seems appropriate to set an earlier date for achievement of the 80% current target, moving it forward to the 2040-2045 timescale**. Applying the linear reduction pathway used by the CCC (shown in figure 3) also indicates an earlier adoption date for the 80% target.

As already noted, as a final option within a traditional carbon hierarchy, there always remains the possibility of purchasing international credits provided 'additionality' challenges can be overcome. But this should be pursued only after all other options have been delivered.

Relevant comparisons: three EU member states

Sweden brings forward key 2050 target to 2045

The Swedish Climate Minister has recently pledged to bring the country's long-term climate target forward from the current 2050 deadline saying, '2045 is a good year...I personally believe we could get there even earlier.' The initiative – moving from 2050 to 2045 with a minimum of 85% reduction against 1990 emissions (and offsets to cover the remainder) – was reported by Business Green as a 'significant step change for the country'. It noted that '… setting the long-term target was the easy bit – the committee is now tasked with laying out exactly how it will be met, including which intermediate targets should be set, how the cuts should be distributed between Sweden's various sectors, and how to integrate the goals into government policy and ensure efforts to meet them are properly funded.'

Germany's ambitions under the *Energiewende*

The key emissions-reduction ambition of the *Energiewende* is to reduce GHG emissions by 80-95% by 2050 (again on a 1990 baseline).

Following the Paris Agreement, the German Federal Government adopted a 'Climate Action Plan, 2050' which describes an emissions reduction pathway against the 2050 target of 80-95% lower greenhouse gas emissions. Key areas for action are energy, buildings, transport, trade and industry, agriculture and forestry. The long-term target based on the guiding principle of "extensive greenhouse gas neutrality in Germany by 2050" is complemented by individual sector targets up to 2030. These include a 50% reduction target for industry, 67% in buildings, 41% in transport and 33% in agriculture.

France's *<<Loi de la transition énergétique pour la croissance verte>>*

The French 'Energy Transition for Green Growth' legislation was enacted in 2015 with medium and long-term objectives for energy production and consumption that involve increasing the share of renewables,

reducing energy consumption and taxing emissions. The legislation, which is set to continue being enacted under the Macron presidency, includes the headline ambition to reduce GHG emissions by 40% by 2030 and 75% by 2050 (from a 1990 baseline). The Act also introduces multi-year energy plans that set sector and region-specific objectives. Following a first plan that will run until 2018, subsequent plans will run on a five-year basis.

It is to be noted, therefore, that our "modified max scenario" (at 93% GHG reduction) not only aligns with 1.5C aims of the Paris Agreement but is also at the upper end of German ambitions – which give a broad spread of 80-95% emissions abatement on 1990 level (which the German Federal government terms 'climate neutral').

If we then make the reasonable assumption that the world will see significant technological innovation in a range of low carbon technologies it is perfectly acceptable to suggest that the additional 7% of 1990-level emissions remaining by 2050 under our favoured scenario, "CCC modified max", would in fact be wiped out.

To be clear, a 93% cut on 1990 emissions levels is feasible under current technological horizons (provided the UK develops enough capacity for carbon recovery). This would bring the UK into line with its obligations under the Paris Agreement. **We expect the residual 7% of emissions (on 1990 levels) to be achieved via low carbon technological innovation in the 2020s and 2030s. This would bring the UK onto a net-zero emissions footing (or beyond) by 2050. If enacted into law, this plan would, probably, make the UK the most ambitious country in Europe on GHG mitigation ambitions to 2050, surpassing even Germany.**

KEY POLICY IMPLICATIONS

CCS – support programmes

There is an overwhelming consensus that Carbon Capture and Storage will need to be used in some form for the UK to have any chance of meeting its 2050 decarbonisation goals. It will support certain industrial sectors and hydrogen uptake as well as, potentially, enable Bioenergy with CCS (BECCS). Investment and development of CCS, therefore, needs to be supported now and in the 2020s for it to be deployed at scale in the 2030s. It is important to note that industrial CCS cannot substitute for genuine low carbon innovation in industrial materials but, as noted above, there will still be residual emissions from industry even in 2050. We therefore recommend the Liberal Democrats consider supporting a CCS programme in some form. The CCS cluster in Teesside will be an important test case in UK and there are other plans for industrial clusters across Europe.

Invest heavily in Research & Development – especially in carbon removal/ negative emissions but also in energy storage technology

Our review notes that there are a dozen or so technologies (including CCS) which could create negative emissions by 2050 and that investing significantly now in R&D for these technologies will create the conditions for one or more of them to succeed. There is also a very clear need for faster progress on afforestation across the UK if the UK is to vastly augment its domestic carbon sinks in line with the CCC's pathways.

As our chapter on the power sector details, the importance of energy storage technologies suggests that these technologies should receive special support in the near term, particularly as they are expected to be cost competitive relatively soon. Action is essential now to improve the UK's capacity for effective clean energy storage. Additional support for rapid R&D and deployment of battery storage, as well as other kinds of pumped storage, will be necessary in the 2020s in order to support much greater grid flexibility and the integration of intermittent renewable energy sources.

Ensure current action on transport aligns with long term goals

The current concerns around urban air quality and health (and the associated issue of diesel engine emissions testing) are important factors in near-term transport policy. While many policy actions, such as the encouragement of low-emission vehicles, will address both health and decarbonisation issues, any proposed policy should be assessed against near-term and longer-term goals.

Further Nuclear may not be the best option

The review recognises that while it is a mature technology and should be considered along with other generation options, there are legitimate concerns around the cost of nuclear and its ability to deliver

projected capacity, while addressing technical and safety challenges. Part of a portfolio approach to the generation mix should include assessing the non-delivery risk of nuclear power compared to alternatives such as combined tidal and offshore wind, whilst recognising that account must be taken of the need to address supply intermittency issues with the associated technologies. As we know, three issues need to be viewed together when looking at energy options: security of supply, GHG emissions and cost. Nuclear power should be kept open as an option – but there is a risk that it may not be able to keep the lights on and that it may not be the lowest cost option.

Energy efficiency is the 'first fuel'

Efforts to achieve energy efficiency are an early priority and have already been clearly set out by the Liberal Democrats. A comprehensive plan to implement energy efficiency, particularly in UK buildings, needs to be initiated urgently. Beyond the health benefits and lower energy bills for consumers, the evidence shows that a comprehensive energy efficiency programme would make a significant difference to emissions. To minimise its cost and maximise its benefit, it needs to begin in the near-term – an immediate focus.

Look at more regionalised approaches to energy generation

A lot of research points to the benefits of looking at increasingly regionalised energy generation for the UK. This could offer multiple benefits in terms of creating new economies, skills and stimulating competition and growth, as well as helping to pilot new technologies and tailored solutions for local areas. This could, for example, support the development of hydrogen infrastructure – another key technology in the zero-carbon portfolio. Within this context, reviewing the current energy system governance is a critical factor (both in terms of electricity markets but also markets for heating), and future regulation should fully support localised energy solutions.

Don't assume complete electrification of surface transport is the silver bullet

Complete electrification of surface transport (transport by road and rail) is not a 'silver bullet'. Use of hydrogen and sustainable biofuels, in addition to conventional technology developments and demand related measures, should also be key considerations for the future – sustainable biofuel may also be considered for the aviation sector. Furthermore, measures that increase electricity demand or change its profile, need to be considered along with overall energy system governance.

UK bio-economy strategy set alongside CAP reform, agriculture and land use

It is important to develop a genuinely sustainable bio-economy strategy for the UK that draws together the carbon, food, fuel and water nexus, alongside positive environmental reforms to agricultural policy (which are also highlighted by possible Brexit scenarios). This would also serve to illustrate the multiple connections, and potential social, environmental and economic co-benefits, from joined-up action across

differing policy spheres. This approach also reflects the desirability of including relevant emissions such as those from peatland within the UK inventory.

Focus on early action, remain nimble and be open to new thinking

Acting early will reduce costs and entrench progress, however switching or adapting to new or emergent technologies as they develop – "being nimble" – will also be important in a successful (cost effective) zero carbon strategy, as we cannot realistically foresee what the successful emerging and radical technologies in twenty or thirty years' time will be.

Grasp the significant wider opportunities that come from decarbonisation

Much discussion on decarbonisation focuses on the challenges and costs incurred, however it is clear that there are also significant benefits beyond dealing with climate change impacts. The low carbon transition places UK business – including financial services firms – in a good position to take advantage of growing global markets, and there are also potential wider benefits in areas such as health, mobility and wellbeing.

Consider innovative, private-sector as well as fiscal and monetary policy to finance the low carbon transition

As we set out in appendix 1, below, now is a crucial time to ensure the finance sector is able to deliver the huge amount of capital needed for the transition. There are also important opportunities for the UK financial sector when it comes to the increased focus on risk and disclosure. Added to this could be the imperative for a greater level of public sector funding, either through fiscal policy for investment or through some of the unorthodox tools being discussed in the financial literature at the moment such as "Green Quantitative Easing" or "Green Helicopter Money".

REFERENCES

[1] Carbon Brief (April 2017), "Carbon Countdown": https://www.carbonbrief.org/analysis-four-years-left-one-point-five-carbon-budget
[2] The CCC (2017) Annual Report to Parliament - https://www.theccc.org.uk/publication/2017-report-to-parliament-meeting-carbon-budgets-closing-the-policy-gap/
[3] Ibid.
[4] The Public Accounts Committee published it report on 28 April, 2017: 'Halting CCS's deployment means that the UK will have to pay billions of pounds more to meet its decarbonisation targets, has missed opportunities to be at the forefront of a growing global industry, and has damaged investors' confidence in working with the government on CCS in the future.'https://www.parliament.uk/business/committees/committees-a-z/commons-select/public-accounts-committee/inquiries/parliament-2015/carbon-capture-storage-16-17/
[5] The CCC (2017) 'Meeting Carbon Budgets, closing the policy gap: report to parliament': https://www.theccc.org.uk/wp-content/uploads/2017/06/2017-Report-to-Parliament-Meeting-Carbon-Budgets-Closing-the-policy-gap.pdf
[6] See Climate Analytics: http://climateanalytics.org/files/ca_briefing_timetables_for_zero_emissions_and_2050_emissions_reductions.pdf
[7] Whereas CO2 is primarily associated with fossil fuel combustion for power generation, heating, transport etc, there are other greenhouse gas emissions such as methane and F (fluorinated) gases that also contribute to climate change

principally associated with hard to treat sectors such as agriculture and industry. The non-CO2 emissions are typically reported as CO_{2e} (carbon dioxide equivalent).

[8] CCC, Sectoral scenarios for the Fifth Carbon Budget, Technical report, November 2015: https://www.theccc.org.uk/publication/sectoral-scenarios-for-the-fifth-carbon-budget-technical-report/

[9] CCC October 2016, UK climate action following the Paris agreement: https://www.theccc.org.uk/wp-content/uploads/2016/10/UK-climate-action-following-the-Paris-Agreement-Committee-on-Climate-Change-October-2016.pdf

[10] https://www.theguardian.com/environment/2016/dec/22/uk-hits-clean-energy-milestone-50-of-electricity-from-low-carbon-sources

[11] Oxford Review of Economic Policy, Volume 32, Number 2, 2016, pp. 282–303 Electricity in Europe: exiting fossil fuels? Richard Green* and Iain Staffell*: https://spiral.imperial.ac.uk/bitstream/10044/1/29487/11/Oxf%20Rev%20Econ%20Policy-2016-Green-282-303.pdf

[12] More detail on the BVCM model and potential locations for CCS hubs can be found in the insights paper: http://www.eti.co.uk/insights/bioenergy-insights-into-the-future-uk-bioenergy-sector-gained-using-the-etis-bioenergy-value-chain-model-bvcm

[13] The UK and Global Bioenergy Resource Model estimates the potential sustainable bioenergy resource that may be available to the UK to 2050: https://www.gov.uk/government/publications/uk-and-global-bioenergy-resource-model

[14] House of Commons Environmental Audit Committee, Soil Health: Government Response to the Committee's First Report of Session 2016–17, Third Special Report of Session 2016–17: https://www.publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/650/650.pdf

[15] https://www.theccc.org.uk/publication/meeting-carbon-budgets-2016-progress-report-to-parliament/

[16] House of Commons Environmental Audit Committee, Soil Health, First Report of Session 2016–17: https://www.publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/180/180.pdf

[17] More detail on the BVCM model and potential locations for CCS hubs can be found in the insights paper: http://www.eti.co.uk/insights/bioenergy-insights-into-the-future-uk-bioenergy-sector-gained-using-the-etis-bioenergy-value-chain-model-bvcm

[18] Resource consumption, industrial strategy and UK carbon budgets, CIE-MAP, November 2016

19 All references to 1990 baseline figures are based on BEIS, '2015 UK Greenhouse Gas Emissions, Final Figures', February 2017: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/604350/2015_Final_Emissions_statistics.pdf

[20] The UK and Global Bioenergy Resource Model estimates the potential sustainable bioenergy resource that may be available to the UK to 2050: https://www.gov.uk/government/publications/uk-and-global-bioenergy-resource-model

[21] An immediate observation with respect to timing for zero emissions targets is that they might refer to CO2 alone and/or all greenhouse gases. Whereas CO2 is primarily associated with fossil fuel combustion for power generation, heating, transport etc, there are other greenhouse gas emissions such as methane and F (fluorinated) gases that also contribute to climate change principally associated with hard to treat sectors such as agriculture and industry. All GHG emissions are typically reported by weight (typically megatonnes, Mt) with non-CO2 emissions as CO2e (carbon dioxide equivalent).

[22] GeSI, 2015, #SMARTer2030 – ICT Solutions for 21st Century Challenges: http://smarter2030.gesi.org/downloads.php

[23] CCC October 2016, UK climate action following the Paris agreement: https://www.theccc.org.uk/wp-content/uploads/2016/10/UK-climate-action-following-the-Paris-Agreement-Committee-on-Climate-Change-October-2016.pdf

[2424] Nature Energy, March 2017, http://www.nature.com/articles/nenergy201724.epdf?author_access_token=52hka49eYSFBJmHi0JneudRgN0jAjWel9jnR3ZoTv0MPp_yW8_AtjmLMFEjPHLHK4yDWZT2RVE7DIupUSJ_dpH93cAB016r8tR0np3GYLgLvlFxkMrOZ1yBG2-AAmrVbtWqveVj2jngXv2lelwXh7A%3D%3D and https://www.ucl.ac.uk/bartlett/energy/news/2017/mar/uk-fail-meet-paris-agreement-unless-emissions-more-rapidly-cut-research-suggests

CHAPTER 1: The Power Sector

	1990	2016	2050 CCC Max	2050 Modified Max "MM"	2050 "MM" Low carbon removal
Power	277.9	79	3	3	3
Heat in buildings	93.6	89	4	4	4
Surface transport	121.9	121	5	5	5
Industry	174.4	100	32	27	27
Non-CO2	125.5	84	47	47	47
International Aviation and Shipping (UK share)	24.1	N/A (41)	40	40	40
Peatland	21	N/A	N/A	5	5
Wood in construction	N/A	N/A	-4	-4	-4
Carbon Removal (associated with BECCS)	N/A	N/A	-47	-55	-11
LULUCF	5.4	-7	-16	-16	-16
Totals:	**844**	**466**	**64**	**56**	**100**

All figures refer to $MtCO_2$

1990 Figures[1], source: BEIS (February 2017), *2015 UK Greenhouse Gas Emissions, Final* Figures
2016 figures, source: The CCC (June 2017), *2017 Report to Parliament – Meeting Carbon Budgets: Closing the policy gap*
CCC Max Scenario figures, source: The CCC (October 2016), *UK climate action following the Paris Agreement*

SUMMARY

To meet its emissions targets, the UK needs to cut emissions from its power sector (i.e. from electricity generation) from their current (2015) levels of 122 $MTCO_2$ per year to just 3$MTCO_2$ per` year by 2050. This radical reduction can be achieved through a massive shift to renewable electricity sources; a large additional contribution to demand reduction from new smart grids and demand-response technology (alongside consumer behaviour change) as well as Carbon Capture and Storage for residual emissions from electricity generation. There are no differences in the 2050 pathway for UK power sector decarbonisation to 2050 between our review and the CCC Max scenario, as set out in the table above. Both are extremely ambitious, requiring very significant cuts to power sector emissions between now and 2030. We deal with the additional considerations around the feasibility of achieving negative emissions through the deployment of bioenergy with CCS (BECCS) in a dedicated chapter below, chapter 5.

It is often noted that the challenge to policymakers of designing an electricity sector fit for 2050 presents itself as a "trilemma": the need to deliver an affordable, secure and low carbon electricity sector by 2050 – and be well on the way to it by 2030.

THE WAY AHEAD

- **The roll-out of 'Smart Power' –** Rapid technological innovation means that a combination of better interconnection, storage, and demand flexibility could combine to save consumers billions of pounds by 2030, help the UK meet its 2050 carbon targets, and secure the UK's energy supply for generations, given action now and through the 2020s.

- **Speeding up deployment of renewable power –** Despite the significant development of renewables in the UK, and the now considerable part they play in the UK energy mix, in order to meet a zero-carbon vision, deployment needs to be accelerated. The UK has great renewable energy potential, particularly with wind. But this depends on addressing the perception that intermittency is a limiting factor and, therefore, designing a system that does facilitate intermittency. There is an increased need to design financial instruments that better suit the needs of community level, decentralised, renewable generation

- **A reformed regulator** – There is now widespread consensus that OFGEM's role should shift from detailed investment evaluation to a focus on the need for appropriate market design and business models. The idea of moving towards an independent system operator and *distribution system operators* (DSOs) - which no longer own the assets - has been put forward. It is appealing both in terms of operations and planning, as well as in resolving conflicts of interest. In order to deliver this, there is a need for further UK electricity market reform in the 2020s.

- **A new governance structure for electricity, with explicit provisions for decentralised energy services**. Decentralised, community-scale electricity generation will play a big part in the generation mix of 2030 and 2050, in contrast to the highly-centralised power sector of today. However, in its current form, it is hard to see Ofgem putting in place the necessary structures to support and incentivise decentralised energy structures and the government's community energy strategy seems to have faded away. New governance arrangements, including DSOs acting as integrators of various distributed generation and demand-side services should receive early attention. Experience from Germany suggests that community ownership can be successful in promoting local renewable energy development and help in overcoming NIMBYism, especially over onshore wind (as we discuss below).

- **Support for the rapid roll-out of storage technologies** – It is important to ensure that policies to 2030 and beyond avoid technological lock-in, especially at a time of rapid innovation. However, the importance of carbon capture and energy storage technologies suggests that these technologies should receive special support in the near term, particularly as they are expected to be cost competitive relatively soon. There have been suggestions that the review of the UK *capacity market* rules for storage could make the UK a 'world-leader in storage'. Action is essential now to

improve the UK's capacity for effective clean energy storage. Additional support for rapid R&D and deployment of battery storage, as well as other kinds of pumped storage, will be necessary in the 2020s in order to support much greater grid flexibility and the integration of intermittent renewable energy sources

- **Low carbon centralised generation** will still exist in the energy mix. Despite a significant role for local generation and demand reduction, there will remain a role for low carbon centralised generation, particularly for meeting peak demand, system balancing and other necessary grid services.

THE CHALLENGE

A low carbon energy system that is affordable and reliable presents a major challenge to policymakers. In 2013, the *Institution of Engineering and Technology* (IET) identified the decarbonisation of energy as probably the biggest peace-time change to national infrastructure that the UK will have seen by 2030, noting that "Within a few years, the current system will be looking remarkably outdated".[2] Four years after the IET's report, progress has been too slow both on renewables deployment, despite rapid increases, demand reduction (see next chapter) and storage roll-out and integration.

The headline problem remains that it is still currently very difficult to store significant amounts of electricity cost-effectively. Demand for electricity continues to fluctuate hugely on a daily and seasonal basis making it a continual challenge to balance demand with supply, which need always to be matched to within a few per cent over on a second-by-second basis to avoid system collapse[3]. The increasing integration of intermittent electricity sources, such as wind and solar, requires smarter grid balancing and demand response as it cannot be simply called-up as required. On top of this, there is the question of how to store electricity that is being generated in excess of demand, so as to avoid surges onto grids. The obvious way to deal with this is to improve storage capability.

Historically, electricity supply systems were vertically integrated (often state-owned) monopolies that maintained a reserve (or buffer) to ensure security of supply and network stability. The UK was at the forefront of later efforts to establish markets in electricity supply wherein a small number of major utilities provided the majority of generation and were overseen by an economic regulator (Ofgem) and a system operator (National Grid) who operated the transmission network that takes high voltage electricity to where it is needed. There are also (monopoly) regional transmission companies.

A number of policy instruments can be used to support the many requirements of a market based system. One of the most important *is feed-in tariffs with contracts for difference* (FiT with CfD) where a variable payment is agreed above the market price to provide additional revenue guarantees to selected producers. Capacity markets act as insurance for the whole system, whereby generators are given a guaranteed

payment to provide emergency generation capacity. Capacity markets must be designed very carefully to avoid unintended consequences. For example, they have been cited as a 'hidden subsidy' to keep coal generation online. [4]

Recent UK Government developments on energy systems

BEIS and Ofgem have recently completed a consultation[5] on a 'smart, flexible energy system'. The National Infrastructure Delivery Plan March 2016 has also identified a number of commitments related to future energy systems[6] including:

- Allocation of 'at least £50 million for innovation in energy storage, demand-side response and other smart technologies over the next five years'
- An ambition for 'greater electricity interconnection by 80%' and
- £100 million of funding for innovation competitions.

The UK's Capacity Market auctions also give us a forward-looking insight into the likely future role of demand-side reduction and similar innovative approaches. Unfortunately, the recent auction to secure capacity for winter 2017 revealed that the majority of contracts were awarded to gas, coal and nuclear operators with only a very small award being made to demand response (0.4% of capacity).[7] It is a similar story with the National Infrastructure Pipeline[8] where there is little obvious expenditure on demand reduction at the moment.

POTENTIAL SOLUTIONS

Reforming the institutional and governance structure for the electricity market

In terms of overall governance, a major critique of the current UK set-up, led by Exeter University, argued that the delegation of policy making, regulation and delivery to different bodies has led to a highly fragmented institutional system for energy:

> "These characteristics mean that the changes across different spheres of policy, which are needed for a rapid and cost-effective transformation, are extremely difficult. Policymaking is nowhere near nimble enough to take account of rapidly changing technological developments and cost reductions. Unintended consequences and unanticipated interactions between policies are commonplace."[9]

Likewise, the *Competition and Markets Authority* has identified a range of concerns around the broader regulatory framework including 'a lack of effective coordination between DECC and Ofgem when it comes to implementing key policies'.[10]

The challenges referenced above have been widely acknowledged, with the recent Ofgem consultation[11] noting that 'a smarter and more flexible system offers significant benefits for consumers and the economy. If we do this in the right way, such a system will ensure the UK has a secure, affordable and clean energy system now and in the future'.

Reforming the regulator and the market to better incentivise 'Smart Power'

The National Infrastructure Commission (NIC) has explored in detail how the UK might better balance supply and demand with an electricity market in which prices reflect costs to the overall system.[12] Their central finding was that 'Smart Power' – built around better *interconnection*, *storage*, and *demand response* – could save consumers up to £8 billion a year by 2030, help the UK meet its 2050 carbon targets, and secure the UK's energy supply for generations. They also noted that the 'consensus developing worldwide' is for the regulator's role to move from detailed investment evaluation to a focus on the need for appropriate market design and business models. The idea of separating responsibilities for overall system direction and control, ownership of assets and development of new services (reflecting a need for avoidance of conflicts of interest) has lead to proposal for a new independent system operator as well as separate distribution system operators. (There appears to have been recognition of the potential for conflicts of interest with Ofgem reported to have recently asked National Grid to separate out relevant functions)[13].

The role of a DSO could, therefore, be at the centre of new governance arrangements[14], acting as an integrator of a range of distributed generation and demand-side services, including energy efficiency, demand response, energy storage and electric vehicles.

The House of Commons Energy and Climate Change Select Committee, in thinking about a 'systems architect' role, has also recently noted that 'implementing a whole-systems approach could produce better solutions for the kinds of challenges the UK faces'[15].

Considering an *integrated* system operator

The research group led by Exeter University, IGov, have also proposed the creation of an *integrated system operator* that works across gas, electricity and heat networks anticipating much greater interconnection between them in a future energy system[16]. The Smart Power study for the National Infrastructure Commission, meanwhile, came to the view that the creation of an independent system operator was 'not an immediate priority but one that should be kept under review in light of progress towards strengthening National Grid's independence[17].'

Commenting on the reformed governance system proposed by IGov, with its focus on a more decentralised approach, The National Infrastructure Commission concurred, arguing that:

> It is actually a combination of what the UK has already and similar governance arrangements are in place elsewhere, in Denmark and in New York State. Moreover, by confronting the problems of the current framework, it is saving Great Britain from greater disruption in the future.' [18]

The associated cost of the institutional change required would, according to the Commission: 'be of the order of tens of millions of pounds *at most* and will lead to quick returns when put against the problems governments will otherwise have to deal with in the form of increasingly expensive and dysfunctional energy systems'.

Investing in all types of storage and in system flexibility

Storage technologies and Carbon Capture and Storage (CCS) should receive more support in the near term, particularly as it is possible that they could become cost competitive relatively soon.[19] CCS is considered in more detail in the Industry chapter of this report, chapter 4, and in combination with bioenergy, in chapter 5.

Electricity storage, meanwhile, was identified by the House of Commons Energy and Climate Change Committee[20] as presenting a real opportunity for the UK as well as potentially playing an important role in supporting system flexibility. The Committee recommended that the Government review the 'outdated' Capacity Market rules for storage, commit to making the UK a 'world-leader in storage and set a storage procurement target for 2020. The Electricity Storage Network has also talked about the urgent need for a new approach to storage 'removing barriers that impede the most cost-efficient and strategically beneficial approach to deployment'[21].

Increasing support for community-owner and decentralised energy

The longstanding model of electricity being fed into a 'top down', central, transmission network is being challenged by the rapid uptake of renewable technologies. The merits of a decentralised system where generation and distribution can be met at a local level have been noted by the House of Commons Energy and Climate Change Committee[22].

The committee's position was echoed by a National Infrastructure Commission (NIC) report[23] that identified local networks as being the most appropriate way to harness the potential for storage and demand flexibility. The NIC recommended that: 'by Spring 2017, DECC [now BEIS] and Ofgem should consult and set out how, and under what timeframe, this transition should take place.'

Support for decentralised generation networks and community energy has also come from the research group IGov[24], indicating that a future framework should help create local markets for energy services of all kinds, including community groups, cooperatives, local authorities and private companies. It has also featured in regional development studies[25] (supporting regional champions of the low carbon economy with local community participation).

For example, the 'Thousand Flowers decarbonisation pathway for the UK' is based on a comprehensively decentralised energy system.[26] It describes a potential governance approach where there is a managed reduction of centralised generation to provide 50% of UK electricity'

This provides baseload, peaking and balancing capacity in a regulated asset base. The scenario envisages dividing Ofgem into two: with 'the National Energy Programme (NEP) overseeing largescale electricity generation and [the] Regional Energy Partnerships (REPs) overseeing distributed, smaller-scale generation across the country'.

BOX 1.1 – The UK's experience of community-level energy projects

The UK has enjoyed some success with community-level generation projects, for example through the grassroots 'Transition Network'[27].

With support from an EU regional development grant as well as Centrica and National Grid, a three-year trial has recently been launched in Cornwall.[28] In addition to micro-Combined Heat & Power (CHP) units and battery storage for around 100 homes there will be energy audits and free technology upgrades for around 60 businesses. Automated systems call up energy from the CHP units at times of high demand, generating income for households.

At city scale, meanwhile, collaboration networks such as the international C40 are sharing expertise on energy efficiency and heat networks as well as on community engagement.[29]

A UK community energy strategy was launched by DECC in 2014 with the aim of expanding the volume and capacity of the community energy sector. A 2015 update[30] sought to understand the barriers and the routes to success, indicating that 'The Government's vision is for communities and other local actors, such as local authorities, to play a major role in driving the social innovation and technical diffusion needed for the UK's low carbon transition, helping people change the way they think and act about energy'.

However, there remain significant concerns that these ambitious aims may not be realised, as highlighted by the House of Commons Energy and Climate Change Committee: 'We consider Government's approach to supporting community energy groups and projects to be under-scrutinised'.[31]

In confirmation of these fears, a study by Co-operatives UK found an 80% decline in community energy start-ups in the first nine months of 2016 compared to 2015, citing changes in policy such as tax reliefs as the reason.[32]Around half of the renewable electricity capacity in Germany is now owned by local communities schemes.

BOX 1.2 – "Intermittent" and "dispatchable" renewable generation

A number of understandable concerns have been made around the dispatchability of renewable generation. That is, the ability of renewable sources of power to meet sudden peaks in electricity demand and the ability of a low carbon generation mix to provide reliable power to grids at all hours of the day, and all times of year.

Noting their predictability, the recent Hendry Review made a strong case for tidal lagoons forming part of the UK energy mix[33], with the UK having around 50% of Europe's tidal resources[34] . Tidal power could have a major role to play in softening the peaks and troughs associated with intermittent renewable electricity generation.

While there have been concerns expressed that Charles Hendry's choice of potential sites for tidal lagoons may in fact serve to *accentuate* rather than smooth the peaks and troughs in tidal generation[35], it is important to note that the ability to provide "dispatchable" generation is more important than predictability. The recent obituaries for former DECC adviser Professor David Mackay have highlighted his many contributions to practical UK renewables integration, including a 2007 study[36] on how tidal lagoons could provide both *pumped storage* and generation capabilities to meet demand peaks.

Addressing intermittency concerns, an Imperial College London study[37] found that the power system can operate securely and *at least cost* with more than 50% of electricity demand being met from variable renewable sources. Greenpeace modelling[38] has also indicated that 85% of energy could come from renewable sources while maintaining security of supply.

Likewise, simulation work in Germany[39] has indicated that a grid running on 100% renewables might be feasible, using a variety of responses to match demand and supply including dispatchable biogas. One of the researchers suggests in an interview with the New Scientist[40] that the UK grid could 'definitely' be based on 100% renewables, such as wind and solar, with a suitable backup. The term "flexibility is the new baseload" is rapidly gaining currency.

On the economics of our high-renewables scenario, Bloomberg also noted in their 2016 New Energy Outlook[41] that 'by around 2027, new wind and solar gets cheaper on average than running existing coal and gas generators, particularly where carbon pricing is in place. This is a tipping point that results in rapid and widespread renewables development'.

Box 1.3 – The "No new nuclear" option

As noted throughout this report, the CCC has developed a range of different scenarios relating to the power sector for 2030, reflecting both different generation mixes and demand levels[42]. Although not explicitly considered within the CCC reports, it should also be possible to construct other power-sector scenarios that meet certain policy requirements. For example, a combination of lower demand with higher renewables contribution from offshore wind and tidal energy might also be successful as part of an overall 'no new nuclear' approach. This possibility was alluded to in the CCC's 2016 progress report:

> 'It is important that Government consider alternative strategies to replacing the existing nuclear fleet, without increasing carbon emissions. The Government should, therefore, develop a contingency plan for decarbonising the power sector if planned projects, including new nuclear capacity, are not deployed.' [43]

The CCC considered a potentially significant role in this contingency for tidal energy, offshore wind (with potentially comparable prices to Hinckley Point) as well as role for other renewables (or CCS and small modular nuclear reactors in the longer term).

CONCLUSIONS

As far as the power sector is concerned, there is a significant need for faster "ground-level" deployment of technologies, for additional market design and for addition support to demand-response, storage and carbon capture technologies, as we have outlined.

A key factor is also interconnection with Europe - both the ability to import as we do currently but also export when we can.

REFERENCES

[1] Given its central role in setting carbon budgets, the UK greenhouse gas inventory is subject to continual review. An estimated 3% uncertainty in the current figures makes it one of the more reliable national datasets: (May 2017 NPL report for the CCC https://www.theccc.org.uk/wp-content/uploads/2017/06/Understanding-the-UK-Greenhouse-Gas-Inventory.pdf). This ongoing process also involves applying improved methodologies to historic inventories to arrive at updated 1990 baseline figures. In February 2017 BEIS published: (https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2015) an updated greenhouse gas inventory with a 1990 baseline revised up from 797 to 799 $MtCO_{2e}$ for example. It is important therefore to exercise care when looking at percentage reductions against baseline (especially in older reports) to ensure comparisons are made consistently. For the purposes of these tables, we have made our own assessments of how to allocate the figures so as to aid comparison alongside the five chapters. We have done our best to ensure comparability

[2] Analysis by the Institution of Engineering and Technology in 2013 highlighted the need for a system architect for a future incorporating more distributed energy generation, December 2013:
http://www.theiet.org/factfiles/energy/pnjv-page.cfm

[3] Oxford Review of Economic Policy, Volume 32, Number 2, 2016, pp. 282–303 Electricity in Europe: exiting fossil fuels? Richard Green* and Iain Staffell*
https://spiral.imperial.ac.uk/bitstream/10044/1/29487/11/Oxf%20Rev%20Econ%20Policy-2016-Green-282-303.pdf

[4] Payments to keep coal capacity online can be seen as a hidden subsidy, E3G, July 2014
https://www.e3g.org/docs/E3G_Briefing_-_Keeping_coal_alive_and_kicking_-_hidden_subsidies_and_preferential_treatment_in_the_UK_capacity_market.pdf

[5] BEIS-Ofgem: A Smart, Flexible Energy System, November 2016:
https://www.gov.uk/government/consultations/call-for-evidence-a-smart-flexible-energy-system

[6] National Infrastructure Delivery Plan, March 2016:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/520086/2904569_nidp_deliveryplan.pdf

[7] 2017 demand response received 0.4% of awarded capacity, Smartest Energy, February 2017:
http://www.smartestenergy.com/info-hub/blog/dsr-misses-out-in-the-capacity-market/

[8] National Infrastructure Pipeline, April 2016:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/517141/National_Infrastructure_Pipeline_Spring_2016_15April2016.xlsx It shows that for energy pretty much no money is in there for the demand side.

[9] Governing for Innovation, Sustainability and Affordability: An institutional framework
Catherine Mitchell, Matthew Lockwood, Richard Hoggett, Caroline Kuzemko, November 2016:
http://projects.exeter.ac.uk/igov/wp-content/uploads/2016/11/Final-Framework-Paper.pdf

[10] CMA, Modernising the Energy Market, June 2016 :
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/531204/overview-modernising-the-energy-market.pdf

[11] OFGEM, November 2016: https://www.ofgem.gov.uk/publications-and-updates/smart-flexible-energy-system-call-evidence

[12] Smart Power NIC, March 2016:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/505218/IC_Energy_Report_web.pdf

[13] Ofgem plans for separation of system operator role, Utility Week, January 2017: :
http://utilityweek.co.uk/news/ofgem-plans-for-separation-of-system-operator-role/1292592#.WLnf4IusPKE

[14] Delivering future-proof energy infrastructure, Report for NIC
Goran Strbac, Ioannis Konstantelos, Marko Aunedi, Michael Pollitt, Richard Green, February 2016

[15] House of Commons Energy and Climate Change Committee, June 2016
https://www.publications.parliament.uk/pa/cm201617/cmselect/cmenergy/267/26707.htm

[16] Governing for Innovation, Sustainability and Affordability: An institutional framework
Catherine Mitchell, Matthew Lockwood, Richard Hoggett, Caroline Kuzemko , November 2016:
http://projects.exeter.ac.uk/igov/wp-content/uploads/2016/11/Final-Framework-Paper.pdf

[17] Smart Power NIC, March 2016:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/505218/IC_Energy_Report_web.pdf

[18] Governing for Innovation, Sustainability and Affordability: An institutional framework
Catherine Mitchell, Matthew Lockwood, Richard Hoggett, Caroline Kuzemko , November 2016:
http://projects.exeter.ac.uk/igov/wp-content/uploads/2016/11/Final-Framework-Paper.pdf

[19] CCS cost reduction taskforce, DECC, May 2013:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/201021/CCS_Cost_Reduction_Taskforce_-_Final_Report_-_May_2013.pdf

[20] House of Commons Energy and Climate Change Committee, The energy revolution and future challenges for UK

energy and climate change policy, October 2016:
https://publications.parliament.uk/pa/cm201617/cmselect/cmenergy/705/705.pdf
[21] The Electricity Storage Network, January 2017
http://www.electricitystorage.co.uk/files/3814/8443/1119/ESN_BEIS_Ofgem_response_12th_January_2017.pdf
[22] House of Commons Energy and Climate Change Committee, The energy revolution and future challenges for UK energy and climate change policy, October 2016:
https://publications.parliament.uk/pa/cm201617/cmselect/cmenergy/705/705.pdf
[23] Smart Power NIC, March 2016 :
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/505218/IC_Energy_Report_web.pdf
[24] Governing for Innovation, Sustainability and Affordability: An institutional framework
Catherine Mitchell, Matthew Lockwood, Richard Hoggett, Caroline Kuzemko , November 2016:
http://projects.exeter.ac.uk/igov/wp-content/uploads/2016/11/Final-Framework-Paper.pdf
[25] Setting the Pace: Northern England's Low Carbon Economy, Aldersgate Group, September 2016:
http://www.aldersgategroup.org.uk/events/unlocking-potential-the-northern-powerhouse-and-its-low-carbon-future
[26] Distributing Power, A transition to a civic energy future , Report of the Realising Transition Pathways Research Consortium 'Engine Room', 2015: http://opus.bath.ac.uk/48114/
[27] Transition Network: https://transitionnetwork.org
[28] BEIS-Ofgem: A Smart, Flexible Energy System, November 2016:
https://www.gov.uk/government/consultations/call-for-evidence-a-smart-flexible-energy-system
[29] http://www.c40.org
[30] DECC 2015 community energy update - looking to understand barriers and route to success, March 2015:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/414446/CESU_FINAL.pdf
[31] House of Commons Energy and Climate Change Committee, The energy revolution and future challenges for UK energy and climate change policy, October 2016:
https://publications.parliament.uk/pa/cm201617/cmselect/cmenergy/705/705.pdf
[32] http://www.thenews.coop/108761/news/co-operatives/80-drop-community-owned-energy-following-government-u-turns/
[33] The role of tidal lagoons, Charles Hendry, December 2016: https://hendryreview.wordpress.com
[34] Wave and tidal energy: part of the UK's energy mix, BEIS, January 2013:
https://www.gov.uk/guidance/wave-and-tidal-energy-part-of-the-uks-energy-mix
[35]See Euan Mearns Blog, January 2017: http://euanmearns.com/swansea-bay-tidal-lagoon-and-baseload-tidal-generation-in-the-uk/
[36] Enhancing Electrical Supply by PumpedStorage in Tidal Lagoons, David J.C. MacKay: March 2007:
(http://www.inference.phy.cam.ac.uk/sustainable/book/tex/Lagoons.pdf
[37] Plugging the Energy Gap, Fulfilling the UK's need for a secure 21st century power system at least cost, E3G, November 2016: https://www.e3g.org/docs/Plugging_the_Energy_Gap.pdf
[38] Greenpeace 2030 energy scenarios, July 2015: https://www.greenpeace.org.uk/wp-content/uploads/2017/06/Greenpeace_2030_Public_July_2015_LowRes.pdf
[39] Energy and Climate Intelligence Unit, July 2015: http://eciu.net/blog/2015/does-the-uk-need-baseload-power-maybe-not
[40] New Scientist, July 2015: https://www.newscientist.com/article/mg22730312-000-uk-is-perfectly-placed-to-use-100-per-cent-renewable-power/
[41] Blomberg New Energy Outlook 2016: https://www.bloomberg.com/company/new-energy-outlook/#summary
[42] Meeting Carbon Budgets – 2016 Progress Report to Parliament on Climate Change, June 2016:
https://www.theccc.org.uk/publications/
[43] Meeting Carbon Budgets – 2016 Progress Report to Parliament on Climate Change, June 2016:
https://www.theccc.org.uk/publications/

CHAPTER 2: Heat in Buildings

	1990	2016	2050 CCC Max	2050 Modified Max "MM"	2050 "MM" Low carbon removal
Power	277.9	79	3	3	3
Heat in buildings	93.6	89	4	4	4
Surface transport	121.9	121	5	5	5
Industry	174.4	100	32	27	27
Non-CO2	125.5	84	47	47	47
International Aviation and Shipping (UK share)	24.1	N/A (41)	40	40	40
Peatland	21	N/A	N/A	5	5
Wood in construction	N/A	N/A	-4	-4	-4
Carbon Removal (associated with BECCS)	N/A	N/A	-47	-55	-11
LULUCF	5.4	-7	-16	-16	-16
Totals:	**844**	**466**	**64**	**56**	**100**

All figures refer to $MtCO_2$

1990 Figures[1], source: BEIS (February 2017), *2015 UK Greenhouse Gas Emissions, Final* Figures
2016 figures, source: The CCC (June 2017), *2017 Report to Parliament – Meeting Carbon Budgets: Closing the policy gap*
CCC Max Scenario figures, source: The CCC (October 2016), *UK climate action following the Paris Agreement*

SUMMARY

To meet its emissions targets, the UK needs to cut emissions associated with the heating of its buildings from 91 to 4 $MTCO_2$ per year. Although this is not as large a cut as that needed for power-sector decarbonisation, it is a very significant cut, especially for a country which often suffers cold winters, has poor building insulation and an ageing housing stock and which currently relies heavily on fossil fuels (mainly natural gas) for residential and commercial heating. There is no way that the UK can meet its targets without a very clear focus on building insulation and energy efficiency of all kinds. There will also be a role for hydrogen.

As with the previous chapter on the power sector, there is no difference between our modified max scenario and the CCC max scenario in terms of decarbonising pathways, although (as with above) we set out the policy implications for ensuring that this ambitious pathway can be met.

The solution to decarbonising the heating of British buildings is not particularly technically complex. But policy has been operating in reverse over the last few years, including a relaxation of standards and regulations, an example of which is the abolition of the rules on zero carbon homes nationally. The long-term approach needed, coupled to a number of policy disappointments (such as the Green Deal), mean that progress on energy efficiency has been too slow.

The main opportunities for emissions reductions in buildings will come from three areas: switching away from fossil-fuel based heating; increasing the energy efficiency of the building stock; and improving the energy efficiency of electrical appliances.

Just under half of the abatement potential in residential buildings to 2030 comes from the rollout of low-cost energy-efficiency measures and solid wall insulation. The remainder comes from replacing high-carbon heating technologies with low-carbon technology, such as electric heat pumps.

THE WAY AHEAD:

- **Energy efficiency measures become a clear priority for the UK** over the next decade. Numerous studies have shown that large-scale programmes, such as those involving retrofitting, have additional co-benefits, including giving a boost to several industries and creating jobs. The UK Green Building Council suggests that 260,000 jobs could come from a comprehensive retrofitting programme. *There is a need for action now and throughout the 2020s.*

- **Short-term financing becomes much more readily available.** The current government lacks a coherent strategy on energy efficiency. It may see the issue as involving large scale public spending, but most evidence shows that investment in energy efficiency offers substantial social and economic returns. *The political case needs restating now, with an associated speeding up of action over the next decade.*

- **Electric heat pumps are installed in homes, off the gas grid.** There are huge opportunities for heat pumps to be installed in heat-dense areas (e.g. cities) and for increased volumes of biomethane to be injected into the gas grid. The funding for these opportunities has already been agreed but we must learn the lessons from previous UK and international experience. *Deployment of low-carbon heat cannot wait until the 2030s.*

- **The *National Infrastructure Pipeline* offers much more on energy efficiency.** Energy Efficiency should be a priority of the National Infrastructure Commission's. Many experts have told us that there was no coherent strategy at the inception of the NIC and that it did not sufficiently include carbon and environmental considerations within its initial objectives. *The political case needs making as soon as possible.*

- **Hydrogen pilots are of sufficient scale and diversity to enable a real understanding of large-scale roll-out**. As large-scale hydrogen deployment would require the use of carbon capture and storage (CCS), a strategy for CCS deployment remains an urgent priority and the same timeline for action (*no later than the early 2020s) is recommended* (CCS is addressed in chapters 4 and 5, below).

- **The UK develops of workforce with appropriate "low carbon skills".** The importance of developing a workforce with low carbon skills is being promoted by the TUC and many others. But the existing sector-based approach needs updating to cope with requirements which cut across sectors.

THE CHALLENGE

Direct emissions from buildings, arising primarily from the use of natural gas, accounted for 19% (rising from 17% in 2014) of UK GHG emissions in 2016, split between homes (76%), commercial buildings (15%) and the public sector (10%). Electricity demand from buildings was 66% of total UK electricity consumption.

Without further policy intervention, the emissions in public and commercial buildings are forecast to remain flat to 2035. Progress in reducing emissions in homes has stalled and emissions from residential buildings will remain fairly flat to 2035 with impacts from new homes being largely offset by the turnover of boiler stock. All this means that there is now overwhelming expert consensus that the UK strongly needs to decarbonise heat delivery and act faster on energy efficiency[2]; the CCC has noted that it will be necessary to 'largely eliminate' UK buildings emissions by around 2050 to meet existing statutory targets.[3] This may seem like one of the least challenging of the many aspects of the low carbon transition, given the potential of proven technology and the cost-effectiveness of energy efficiency, but the ineffectiveness of many energy efficiency programmes across the whole world is a cause for concern.

Nonetheless, the potential savings are vast and feasible. The significant energy savings potential in buildings, across Europe, has been highlighted in a recent study where potential energy savings at 2030 ranged from 15-49% and 51-75% at 2050, against a 2010 baseline with 'deep renovation' giving annual reduction rates of 2.3 to 2.5%[4].

The UK has a low level of current policy ambition

The CCC have identified that some current policy savings are at risk due to design and delivery problems and the fact that the abandoned Green Deal and Zero Carbon Homes initiatives have not been replaced.

Experts perceive the UK as lagging behind most other countries in its efforts on energy efficiency, placing it 27 out of 28 among EU Member States, down from 13th in 2012[5]. It has also been noted that there is a low overall level of policy ambition in the UK and that 'present policymakers do not see energy efficiency as an opportunity', focusing instead on supply side policies[6]. One report has cited expert views that Germany, the Netherlands and France had all recently adopted significantly better energy efficiency policies than the UK[7].

The CCC has highlighted, in successive years now, that 'the necessary progress is not being made in shifting to low-carbon heating or improving energy efficiency'[8] and a more comprehensive approach is needed, addressing the behavioural barriers and capable of delivering sustained uptake of energy efficiency, heat pumps and district heating far above current levels. They also observed that 'there is a lack of progress across the board in buildings, with insufficient uptake of low-carbon heat and insulation, and a failure to make any meaningful reduction in non-residential buildings emissions in recent years'[9].

Relevant issues highlighted included that:

- Low-carbon heat accounted for only 2.5% of heating supply - less than 0.5% of what is required to 2020. Within this, heat pumps and low-carbon district heating were particularly low, around a third of demand;
- Recent policy changes for home insulation have resulted in stalled progress since 2012, with the rate of uptake falling further in 2015. There have also been significant setbacks in policies for *able-to-pay* homes, the private-rented sector and new-build properties;
- UK emissions from non-residential buildings increased 6% in 2015, with limited information available on actual installations of insulation or other improvements in thermal efficiency.

The CCC also referenced the 2015 cancellation of the Zero Carbon Homes policy 'which could have been used to drive low-carbon heat in new homes', noting that: 'Neither the current Part L building regulations, nor any proposed future regulations, are well designed to support low-carbon heat measures'. In the view of the CCC, progress to date has stalled. The consensus view is that Government needs a credible new strategy and a much stronger policy framework for buildings decarbonisation over the next three decades.[10]

RECENT UK GOVERNMENT DEVELOPMENTS ON ENERGY EFFICIENCY AND HEAT

Pledges by the UK government currently focus on: 'low-cost measures on energy efficiency, with the goal of insulating a million more homes over the next 5 years' from 2017 through a new, cheaper, domestic energy efficiency supplier obligation which will run for 5 years.'[11]

£295 million has also been allocated for investment in energy efficiency measures in schools, hospitals and other local public services and funding for the Renewable Heat Incentive has increased to £1.15 billion by 2020-21 alongside £300 million for up to 200 heat networks.

£25 million was recently pledged by BEIS to further research hydrogen gas heating for buildings[12]. The recent Government Industrial Strategy Green Paper[13] also described funds for energy innovation, including up to £9m on a competition for an 'industrial energy efficiency accelerator'.

POTENTIAL SOLUTIONS

Making energy efficiency a UK infrastructure priority

Numerous campaigners are arguing that energy efficiency should be made a national infrastructure priority for the UK[14] [15] [16] [17] as it has been in Scotland, and that energy efficiency has comparable benefits to other major infrastructure investments. Indeed, a programme to make British buildings more energy efficient could generate £8.7 billion of net benefits (comparable to benefits delivered by the first phase of HS2, Crossrail, smart meter roll out, or investment in new roads)[18].

Cost effective options for heat decarbonisation, including hydrogen

On heat decarbonisation in buildings, a recent Imperial College report[19] explored the cost-effective options for the UK. A challenge is the large seasonal variation in demand for heating, meaning that a purely electricity-based solution (e.g. based on heat pumps) would be extremely challenging, not least in terms of the total peak demand. Accordingly, there is likely to be a significant role for *hydrogen* in a repurposing of the existing network (facilitated by the existing Iron Main Replacement Programme). As mentioned, the government has already given some investment into further research in hydrogen heating, and Northern Gas Networks (NGN) is already seriously exploring the potential for conversion to Hydrogen in Leeds before looking at other parts of the UK. NGN has already concluded that conversion of Leeds' existing gas grid to hydrogen by the late 2020s is "feasible and desirable"[20]. With this option, access to the gas network is key, as is a low carbon means of producing hydrogen. Applying steam methane reformation to natural gas will require the application of CCS technology in this instance. Indeed, the CCC has stated that low carbon sourced hydrogen could play *'an important role in the decarbonisation of residential and commercial heating…and increasing the flexibility of electricity generation'* whilst adding that further immediate government action is needed to plan progress in the area, if a realistic assessment of its costs is to be made[21]. It will be publishing further analysis of hydrogen in 2018. District heating could also be very effective where there is a suitable supply of fuel.

Reducing demand

The CCC emphasise the need for further intervention on energy efficiency overall: 'In the absence of future policy commitment, the market alone will not deliver the significant improvements in energy efficiency and a shift to low-carbon heating systems that is needed, even where there are economic benefits to change and where financial barriers are addressed'.

They and other major reports on energy efficiency[22] identify the available levers for action as:

- **Taxation** - introducing a carbon price for heat in homes would favour low-carbon heat and make energy efficiency more cost-effective.

- **Incentive-based support for emerging low-carbon heat markets** in order to support delivery at scale through the 2020s and 2030s.
- **Regulations and standards for energy efficiency need to be raised and enforced** and should be either linked to heating system replacement or to sales, lettings and extensions/refurbishments. Regulation of new-build properties should be relatively straightforward and could help develop supply-chains and improve consumer awareness. On existing buildings: 'A stable framework and direction of travel for improving the energy and carbon efficiency of existing buildings joining up energy efficiency and low-carbon heat'[23], with attractive incentives for households and SMEs; and simple, highly visible information and certification, including enhanced business reporting, alongside installer training;

The immediate priorities were identified as:

- **Low-carbon heat:** Developing an action plan to address the significant shortfall in low-carbon heat. The revised RHI has gone some way to address this concern although it does not link support for low-carbon heat with energy efficiency
- **Energy efficiency:** Setting out the future of the Energy Company Obligation (ECO) beyond 2017, ensuring it delivers energy efficiency while also meeting fuel poverty targets
- **Zero Carbon Homes:** Acting on the policy gap on new-build properties.

There are also technology-specific implications including government intervention to achieve the correct operation of condensing boilers, exploring new approaches to achieve scale deployment of heat pumps along with the potential role of heat networks and also hydrogen in existing gas infrastructure.

The CCC says that to meet the fourth and fifth carbon budgets there must be inclusion of:

- 2.5 million heat pumps in homes by 2030
- Around 40 TWh of low-carbon heat networks by 2030
- Around 20 TWh of biomethane to the gas grid by 2030

The June 2016 CCC Progress Report[24] identified the need for a stronger policy framework to drive residential energy efficiency by addressing gaps and strengthening existing policies, including a comprehensive set of incentives to drive energy efficiency improvements in able-to-pay households. In relation to ESOS audits (Energy Savings Opportunity Scheme) for businesses they observed 'We have previously recommended that the Government should assess the case for enhancing the ESOS audits (e.g. through signposting to finance, follow-up support and benchmarking) to ensure uptake of recommendations.'

CONCLUSIONS

The CCC Max scenario, from which our own pathway scenario does not differ for buildings decarbonisation, has identified the potential for 1.1 million heat pumps to be retrofitted in homes by 2030 if they are also installed in 50% of new homes from 2020, that would give a total of 3.3 million heat pumps in 2030.

Their high rollout scenario achieves 54 TWh of heat from heat networks in 2030, of which 20 TWh is domestic heat (around 2 million homes) and solid wall insulation fitted to 2.75 million homes. The max scenario reduces emissions from 71 $MtCO_2$ in 2014 to 56 $MtCO_2$ in 2030.

In public and commercial buildings, meanwhile, heat pumps could displace electric and oil heating from 2020 and gas heating from 2030, with biomass boilers also an off-grid option. They also serve as key anchor-loads for heat networks which supply 34 TWh of heat in the CCC max scenario in 2030, around a third of demand. This includes a larger share of biomass-heat. Residual emissions in 2030 are 9 MtCO2, down from 23 MtCO2 in 2014 on a temperature-adjusted basis.

There is no question that serious action is required on energy efficiency if any of the ambitious emissions pathways are to be met. On top of addressing low carbon heating policy, more policy action - including stringent regulations, householder incentives, and major government action on retrofitting and ensuring newbuilds are energy efficient- will be required if any significant inroads into this area are to be made.

REFERENCES

[1] Given its central role in setting carbon budgets, the UK greenhouse gas inventory is subject to continual review. An estimated 3% uncertainty in the current figures makes it one of the more reliable national datasets: (May 2017 NPL report for the CCC https://www.theccc.org.uk/wp-content/uploads/2017/06/Understanding-the-UK-Greenhouse-Gas-Inventory.pdf). This ongoing process also involves applying improved methodologies to historic inventories to arrive at updated 1990 baseline figures. In February 2017 BEIS published: (https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2015) an updated greenhouse gas inventory with a 1990 baseline revised up from 797 to 799 $MtCO_{2e}$ for example. It is important therefore to exercise care when looking at percentage reductions against baseline (especially in older reports) to ensure comparisons are made consistently. For the purposes of these tables, we have made our own assessments of how to allocate the figures so as to aid comparison alongside the five chapters. We have done our best to ensure comparability

[2] The World Bank report on 'Decarbonizing Development'[2] describes ensuring the global energy transition includes 'a massive shift to electrification' to 'displace polluting fuels', alongside improving energy efficiency to help lower overall demand.

[3] CCC, UK climate action following the Paris agreement, October 2016: https://www.theccc.org.uk/wp-content/uploads/2016/10/UK-climate-action-following-the-Paris-Agreement-Committee-on-Climate-Change-October-2016.pdf

[4] The Regulatory Assistance Project - Realising Europe's Efficiency pipeline, June 2015: http://www.raponline.org/wp-content/uploads/2016/05/bayer-eceee-realisingeuropesefficiencypipeline-2015.pdf

[5] Similarly, in Clean Energy News, April 2016: http://www.cleanenergynews.co.uk/news/efficiency/uk-reaches-new-low-in-eu-energy-efficiency-rankings-6432

[6] Clean Energy News, April 2016: http://www.cleanenergynews.co.uk/news/efficiency/uk-reaches-new-low-in-eu-energy-efficiency-rankings-6432

[7] Association for Decentralised Energy, 2016 UK Energy Productivity Audit, November 2016: https://www.theade.co.uk/resources/publications/the-2016-uk-energy-productivity-audit

[8] CCC 2017 Annual report, July 2017: https://www.theccc.org.uk/publication/2017-report-to-parliament-meeting-carbon-budgets-closing-the-policy-gap/

[9] CCC, Meeting Carbon Budgets – 2016 Progress Report to Parliament on Climate Change, June 2016: https://www.theccc.org.uk/publication/meeting-carbon-budgets-2016-progress-report-to-parliament/

[10] CCC, Next steps for UK Heat policy, October 2016: https://www.theccc.org.uk/wp-content/uploads/2016/10/Next-steps-for-UK-heat-policy-Committee-on-Climate-Change-October-2016.pdf

[11] National Infrastructure Delivery Plan, March 2016: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/520086/2904569_nidp_deliveryplan.pdf

[12] BEIS, April 2017: https://www.gov.uk/government/publications/funding-for-innovative-approaches-to-using-hydrogen-gas-for-heating

[13] BEIS, January 2017 https://www.gov.uk/government/news/innovation-to-drive-affordable-energy-and-clean-growth-under-industrial-strategy

25th January, 2017

[14] Energy efficiency: An infrastructure priority: https://www.e3g.org/docs/Frontier_Economics_-_Energy_Efficiency,_an_Infrastructure_Priority.pdf

[15] Citizens Advice, Generating Value? A Consumer-friendly electricity generation policy, November 2016: https://www.citizensadvice.org.uk/Global/CitizensAdvice/Energy/GeneratingValue.pdf

NB: Citizens Advice (in the context of keeping costs down for consumers) recommended re-establishing energy efficiency policy as a matter of urgency (in the wake of the cancellation of the Green Deal).

[16] NB A new campaign group, the Energy Efficiency Infrastructure Group (EEIG), has also been set up: www.theeeig.co.uk. It is composed of major UK trade and business bodies, energy companies, engineering groups and charities and says that a comprehensive infrastructure programme could "save a quarter of the energy used in UK homes and businesses - equivalent to the energy produced by 6 nuclear power stations the size of Hinkley C"

[17] This idea was also proposed by a range of respondents to the National Infrastructure Assessment of October 2016suggesting it be linked to a UK heating decarbonisation strategy: The National Infrastructure Assessment Consultation response, October 2016: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/563529/NIA_consultation_response_October_2017.pdf

[18] E3G and Frontier Economics, September 2015: https://www.e3g.org/docs/Frontier_Economics_-_Energy_Efficiency,_an_Infrastructure_Priority.pdf

[19] Imperial College London, Comparing the impacts and costs of transitions in heat infrastructure, April 2016: http://provpol.com/wp-content/uploads/2016/05/Heat-infrastructure-paper.pdf

[20] Network, July 2016: https://networks.online/gphsn/news/1000189/100-hydrogen-gas-grid-feasible-ngn

[21] CCC 2017 Annual report, July 2017: https://www.theccc.org.uk/publication/2017-report-to-parliament-meeting-carbon-budgets-closing-the-policy-gap/

[22] Rosenow, Cowart, RAP, April 2016 http://www.raponline.org/blog/energy-efficiency-in-the-uk-time-to-get-out-of-reverse-gear/ - April 2016; Also see the new report from Frontier Economics, Affordable Warmth and Clean Growth, September 2017

[23] CCC, June 2016: https://www.theccc.org.uk/wp-content/uploads/2017/06/Reducing-emissions-and-preparing-for-climate-change-2017-Report-to-Parliament-Summary-and-recommendations.pdf

[24] CCC, Meeting Carbon Budgets – 2016 Progress Report to Parliament on Climate Change, June 2016: https://www.theccc.org.uk/publication/meeting-carbon-budgets-2016-progress-report-to-parliament/

CHAPTER 3. Transport

	1990	2016	2050 CCC Max	2050 Modified Max "MM"	2050 "MM" Low carbon removal
Power	277.9	79	3	3	3
Heat in buildings	93.6	89	4	4	4
Surface transport	121.9	121	5	5	5
Industry	174.4	100	32	27	27
Non-CO2	125.5	84	47	47	47
International Aviation and Shipping (UK share)	24.1	N/A (41)	40	40	40
Peatland	21	N/A	N/A	5	5
Wood in construction	N/A	N/A	-4	-4	-4
Carbon Removal (associated with BECCS)	N/A	N/A	-47	-55	-11
LULUCF	5.4	-7	-16	-16	-16
Totals:	**844**	**466**	**64**	**56**	**100**

All figures refer to $MtCO_2$

1990 Figures[1], source: BEIS (February 2017), *2015 UK Greenhouse Gas Emissions, Final* Figures
2016 figures, source: The CCC (June 2017), *2017 Report to Parliament – Meeting Carbon Budgets: Closing the policy gap*
CCC Max Scenario figures, source: The CCC (October 2016), *UK climate action following the Paris Agreement*

SUMMARY

Transport was the largest emitting sector in the UK in 2016, with 26% of total UK GHG emissions (121 $MtCO_2$) and so there are significant challenges for the sector. Whilst not the "silver bullet", electrification associated with a decarbonised grid presents itself as the major solution for Surface Transport, and emissions could be cut from 110$MTCO_2$ to 5$MTCO_2$ by 2050. Greater international collaboration and regulation is likely to be the only realistic solution for cutting emissions from international aviation and shipping from 41$MTCO_2$ to 40$MTCO_2$[2]. The modest reduction mainly reflects expectations of future demand growth. However, significant growth in aviation activity, in particular, could be offset by technological advances in fuels, design and smarter logistics.

There is no available research that points us to differ our scenario from that of the CCC, so it remains the same. Abatement is primarily due to conventional vehicle efficiency and the uptake of ULEV (Ultra Low Emissions Vehicles), with smaller reductions from biofuels, behaviour change in passenger transport, improvements to freight operations and further rail electrification., After 2030, we see emissions reducing to 5$MTCO_2$ by 2050 through widespread electrification. CCC analysis has concluded that aviation emissions will be around 2005 levels at 2050 (37.5MtCO2e), contingent on improvements in fuel efficiency, biofuel take up and constraining demand growth to around 60% above 2005 levels.

Demand for mobility, irrespective of mode of transport, continues to climb rapidly meaning that to keep pace with demand, innovation must also move quickly. The need for fast and widespread electrification is required for surface transport and recent initiatives from the UK government – although by international standards not pioneering – demonstrate a consciousness that measures need to be undertaken quickly to have a chance of significant reductions. Finding alternatives to fossil jet fuels is one of the biggest transport and decarbonisation challenges and increasing use of biofuels could prove contentious where by 2050 there may be a limited supply of sustainable bioenergy as international demand grows. There is scope for reducing the carbon intensity of ships by up to 65% through use of alternative fuels, larger ships and operational innovation.

THE CHALLENGE

There is clearly much work required in this sector where 95% of emissions last year came from surface transport and the remainder from domestic aviation and shipping. 2013 figures show cars amounted for the majority of surface transport emissions at 57% followed by HGVs (22%), with rail contributing 2%. 2013 emissions from international aviation and shipping were 41MtCO2e and although included in the UK's 80% target are not included in carbon budgets[3].

Aviation and Shipping

Other than investment in research into bio jet-fuels, which may contribute to decarbonisation and is still in its infancy[4], there remains a dearth of solutions for tackling aviation sector emissions (22% of total UK transport emissions in 2015).[5]

In principle, emissions from international aviation should be included in carbon budgets and at present only domestic emissions are. Currently, inclusion of international aviation remains impractical, given the design of the EU ETS for aviation and ongoing uncertainty about how this will be treated in future. The CCC recommended review of ICAO progress with the CORSIA[6] scheme to see whether it is appropriate to include international aviation emissions in carbon budgets (whilst remaining part of 2050 targets, regardless of inclusion in five-year budgets).

The key drivers of aviation emissions will be demand for air travel where there is high sensitivity to changes in income (rather than ticket prices) and the availability of alternatives to flying such as rail or teleconferencing.

The shipping sector – 6% of total UK transport emissions in 2015[7] – has had a bad press related to carbon intensity and successful industry efforts to exclude it from the Paris Agreement[8] and instead review its emissions through the International Maritime Organisation. Key drivers of future shipping emissions are shipping demand and carbon intensity of ships, and shipping demand drivers include GDP growth, fossil fuel and carbon prices.

Surface Transport

Developing adequate UK infrastructure, investing in research for ULEV, and issues around significant electrification and battery storage represents the biggest challenge in tackling surface transport emissions. There has not yet been marked progress and the CCC's latest 2017 annual report shows that emissions from cars, vans and HGVs all rose in 2015.

Fuel emissions policy in cars are also currently set at EU level and are arguably insufficient, with 95 grams of CO_2 per kilometre the new target limit for all new cars emissions by 2021 and no target set beyond this date[9]. More ambitious and long-term targets are needed at national and international level for all land vehicles. This perhaps also mirrors a lack of specific government targets set for the 2020s at the time of writing.

RECENT UK GOVERNMENT DEVELOPMENTS ON TRANSPORT

Surface Transport

As mentioned above, UK policy measures in place when the CCC produced its last sector report at the end of 2015 included adherence to EU driven targets to reduce test-cycle emissions from new cars to 95 gCO2/km and new vans to 147 gCO2/km by 2021 and an anticipated increase in biofuel use. Plans were also in place to increase rail electrification.

There have been several recent developments in relation to Government support for electric and hydrogen vehicles. New funding of £35 million was announced in October 2016 for the installation of more electric vehicle charging points[10]. In March 2017, a new £23 million matched-funding scheme was launched to support the take up of hydrogen vehicles including vehicles and fuel infrastructure[11].

This was followed in April 2017 by a commitment of £109 million to develop next generation driverless and low carbon vehicles as part of the UK Industrial Strategy. The grants will be distributed amongst projects including development of high power batteries for performance vehicles and measures to strengthen the UK supply chain[12].

Most headline-grabbing, however, is the most recent announcement by DEFRA (see more in the air pollution section) as part of its pledge to tackle air pollution, on the ban on the sale of all new conventional petrol and diesel cars and vans by 2040[13].

Aviation

In October 2016, ICAO agreed to a market based emissions scheme. The *Carbon Offset and Reduction Scheme for International Aviation* (CORSIA) which will commence in January 2019, aims to offset growth in emissions from 2020. According to ICAO, as of 10th May 2017, 67 States, representing more than 87.5 per

cent of international air traffic, had indicated their intention to participate in the scheme[14]. The government has also just launched an aviation strategy, but plans vis-à-vis decarbonisation are so far vague apart from calling for an international approach. It states that its current actions for decarbonisation are: "accelerating the introduction of new technologies, supporting the uptake of sustainable alternative fuels, committing to airspace modernisation both at the UK and international level", and finally in reference to CORSIA, "shaping international market-based measures". The consultation asks for views on "what the best approach and combination of policy measures are to ensure we effectively address carbon emissions from aviation"[15].

Shipping

There has been a nod to progress made through the formation of the Sustainable Shipping Initiative which now has a vision for making shipping sustainable by 2040[16] (SSI2040). Because of the international and cross-border nature of the industry, individual and UK government initiatives have however been minimal and there is ample room for improvement.

POTENTIAL SOLUTIONS

Surface Transport

The CCC had identified key near-term policy requirements for surface transport of that include:

- Providing motor industry with greater certainty to 2030. There is a need for clear, stretching targets for new car and van CO2 beyond 2020 using realistic testing procedures and take account of the need to increase uptake of ULEVs. Standards for new HGV CO2 should also be introduced as soon as is practical.
- Tackling barriers to EV uptake. Support for the upfront costs of EVs should be maintained while it is required to incentivise their uptake. Measures to help overcome non-financial barriers to EV uptake should be continued, including the roll-out of a national network of charge points and the provision of local incentives such as access to parking.
- Ensuring the tax regime keeps pace with technological change. Vehicle taxation should be aligned to ongoing improvements in new vehicle CO2 to incentivise uptake of the lowest emitting vehicles.
- Extending successful emissions-reduction schemes for freight operations. Existing schemes to help freight operators reduce their fuel costs and emissions should be rolled out to include small operators.
- Ensuring lessons from schemes to reduce travel demand are applied. Sustainable travel scheme schemes should be properly evaluated and extended if they provide cost-effective emissions reductions.

Aviation

Potential solutions for aviation include the following:

- With a strong reliance on international collaboration, there is a role for UK leadership, in pressing for strongest possible model and implementation of the ICAO market based mechanism.
- Pushing for successful negotiations to reduce emissions from international aviation. This should ensure the agreement for international aviation delivers a policy framework consistent with the longer-term climate objective.
- Carbon intensity incrementally reduced through improved aircraft efficiency and operational practices, such as international collaboration on airspace design.
- Biofuels offer a potential solution for sectors with difficult decarbonisation challenges, such as aviation. However, by 2050 demand for sustainable bioenergy may be highly intensive[17]. To note that we also talk about bioenergy as a whole - including its sustainability as a low carbon fuel - in chapter 5.

Shipping

Potential solutions for the shipping industry may include:

- Backing a global approach for emissions reduction led by the International Maritime Organisation.
- Pushing for successful negotiations to reduce emissions from shipping. This should ensure that cost-effective abatement is incentivised in shipping.
- There is scope for reducing the carbon intensity of ships by up to 65% through the use of alternative fuels as a substitute for fossil fuels, use of larger ships, technology and operational innovation.

CONCLUSION

Surface transport efficiency improvements expected

The efficiency of new conventional cars and vans has been improving and CCC analysis identifies further scope for improvement through aerodynamics, hybridisation and engine downsizing. There are also significant opportunities to improve the efficiency of conventional HGVs through measures such as heat recovery, low rolling resistance tyres and weight reduction. Efficiency improvements of around 13% for small HGVs and 33% for larger, articulated HGVs could be realised by 2030.

In terms of Ultra-Low Emission Vehicle (ULEV) uptake, electric cars, vans, small HGVs and buses are expected to become cost-effective in the mid-2020s. The average electric range of battery electric vehicles could reach 175km, 240km and 300km for small, medium and large cars respectively and 300km for vans by 2030. Large, heavy batteries mean long-distance HGVs and buses are difficult to electrify but plug-in electric small urban delivery trucks and buses are a technically feasible option with CCC analysis suggesting they could become cost-effective during the 2020s. Battery capacity is an area where we expect significant and rapid improvement in the next few years.

Hydrogen fuel cells are likely to become a feasible zero-emission solution for longer range and heavier vehicles. However, barriers to the adoption of fuel cell vehicles are significant given the new infrastructure required to produce and distribute the hydrogen.

There are opportunities to moderate the expected growth in demand for car travel, particularly in urban areas. There are also opportunities for freight operators to reduce their fuel consumption and CO2 emissions through improved logistics, driver training and use of fuel saving technologies fitted to existing vehicles.

Rail

Currently around 60% of rail passenger journeys are on electric trains and further electrification could reduce emissions through displacement of diesel trains. Currently planned schemes will increase electrification to 51% of track mileage, while additional schemes with a reasonable business case would raise this to 56%. Roll-out of battery technology would help to electrify trains on stretches of the track not suitable for overhead cables. Further diesel energy efficiency improvements are likely to be made through improvements in transmission systems, engine modifications, on-board energy storage and Driver Advisory Systems. Energy efficiency savings could be 5-20%.

Overall surface transport sector abatement

Taken together the measures in the CCC max scenario reduce surface transport emissions from 126 to 54 MtCO2 by 2030. The abatement is primarily due to conventional vehicle efficiency and uptake of ULEV, with smaller reductions from biofuels, behaviour change in passenger transport, improvements to freight operations and rail electrification. This includes improved testing of cars and vans to achieve further conventional new vehicle efficiency, resulting in improvements of 44% for new cars and 40% for new vans between by 2030. With falling battery prices there is potential for a sales share of 65% for electric cars and vans. It should be noted that electrification of surface transport is an integral part of decarbonisation but will not in itself deliver the required reductions in the transport sector.

Efforts to reduce emissions using demand-side measures lead to greater shifts in behaviour include reducing the speed limit to 60mph on motorways and dual carriageways. Improved freight logistics provide and further use of driver training also contribute. Rail emissions fall through electrification, use of battery powered trains and improvements to the efficiency of diesel trains.

Aviation

Adoption of CORSIA[18] through the International Civil Aviation Organisation (ICAO) may help to reduce emissions with respect to 'business as usual' from the early 2020s. CCC analysis has modelled aviation emissions at around 2005 levels at 2050 (37.5MtCO2e) contingent on improvements in fuel efficiency, biofuel take-up and through constraining growth in demand to around 60% above 2005 levels.

Shipping

The CCC max scenario assumes strong policy action to incentivise full take-up of abatement potential from technological and operational measures, increasing ship size and further, but still limited, penetration of biofuels and LNG.

In the CCC central demand scenario, tonne-miles increase by 0.4% per year from 2010 to 2050 if a carbon price is introduced, and otherwise by 0.6% per year. The scenario also identifies scope for reducing the carbon intensity of ships by up to 65% via the use of alternative fuels, use of larger ships and operational innovation. Under the central CCC scenario 2050 international shipping emissions are 5.1 MtCO2e and domestic shipping emissions are 1.3 MtCO2e.

BOX 3.1 – The "Co-Benefits" of Transport Decarbonisation

Combustion emissions, including those from transport, are a contributor to reduction in air quality and pose a risk to human health. Actions that reduce emissions, with a particular focus on urban settings, are therefore likely to realise health co-benefits. A major Lancet study on health and climate change[19] proposed a global phase out of coal from the energy mix as a measure to protect cardiovascular and respiratory health. In a UK context, a 2012 report[20] modelled the public health impacts of combustion emissions, with particular reference to particulates, finding around 13,000 premature deaths per year, where the leading domestic contributor is transport responsible for around 7,500 of the total. A 2015 report for the GLA and Transport for London[21] focused more narrowly on the health impacts of air pollution in London, considering the impacts of both particulates and nitrogen oxides, quoting a range of 3,500- 9,400 for premature deaths (more properly expressed as 'equivalent deaths at typical ages') with the largest contribution coming from nitrogen dioxide sources within London (from both road transport and other sources). A spreadsheet based model was also presented which allows for modelling of the impacts of policy related decisions as they impact transport and other emissions.

The oft quoted figure of 40,000 UK deaths attributable to outdoor air pollution comes from a comprehensive 2016 Royal College of Physicians (RCP) and Royal College of Paediatrics and Child Health (RCPCH) report on the lifetime impacts of air pollution. The annual UK costs of health problems arising from health problems resulting from exposure to air pollution were estimated at over £20 billion.

They proposed a range of actions including giving powers to local authorities to close or divert roads when pollution is high and proactively communicated results of effective air pollution monitoring. Government, employers and schools were directed to encourage the use of public transport and active travel options like walking and cycling alongside the use of electric and hydrogen powered vehicles

The report highlighted social aspects related to air quality with deprived communities being exposed to some of the worst outdoor and indoor air quality. They recommended that 'Regulators, local government and NHS organisations must prioritise improvements in air quality in our most deprived areas, setting high standards of emission control across all sectors of industry'.

Drawing an explicit link to decarbonisation they observed that 'If we act now to reduce greenhouse gas emissions to target levels by 2050, we can have a real impact. An analysis for the European Commission suggests that, each year in the UK, this would prevent the following impacts related to local and regional air pollutant exposure: 5,700 deaths, 1,600 hospital admissions for lung and heart problems, 2,400 new cases of bronchitis.

Reducing air pollution would also allow vulnerable people to be more active, take less medication, and live longer.'[22]

The House of Commons Environment, Food and Rural Affairs report on Air Quality summarised the problem as follows: 'Poor air quality is damaging the UK's environment and harming the nation's health: emissions have declined significantly over many decades, but not far enough to prevent the early deaths of 40-50,000 people each year from cardiac, respiratory and other diseases linked to air pollution.'

They made a series of recommendations including devolving greater flexibility to councils in how they implement Clean Air Zones and allowing any supportive community to utilise powers on charging vehicles for access. They

encouraged Government to ensure vehicle company marketing claims are fully accurate and develop ideas for a scrappage scheme for diesels more than ten years old.[23]

The Government consultation on air quality published on 5th May identified the majority of roadside nitrogen oxides coming from diesel vehicles. It also placed much emphasis on the role of local authorities indicating that they 'will now be expected to develop new and creative solutions to reduce emissions as quickly as possible, while avoiding undue impact on the motorist.' It proposed that local authorities will be required to develop plans specifically to deal with emissions from diesel road traffic. A range of potential measures for Clean Air Zones (associated with lower vehicle emissions) were described including: encouraging the use of low emission vehicles, promoting use of public transport and cycling, walking, car sharing with the use of charging zones only being used where they fail to identify effective alternatives[24].

The Government published a long awaited "UK plan for tackling roadside nitrogen dioxide concentrations" in late July 2017 with a headline-making pledge to ban the sale of diesel and petrol cars and vans from 2040 onwards. Continuing the theme laid out at consultation phase, the government proposed local strategies for tackling air pollution and "local hotspots" with low air quality. The government also says a further strategy on the pathway to zero emission transport for all road vehicles will be published in 2018 alongside a "wider Clean Air Strategy" that addresses "international commitments to significantly reduce emissions of five damaging air pollutants by 2020, and 2030"[25].

REFERENCES

[1] Given its central role in setting carbon budgets, the UK greenhouse gas inventory is subject to continual review. An estimated 3% uncertainty in the current figures makes it one of the more reliable national datasets: (May 2017 NPL report for the CCC https://www.theccc.org.uk/wp-content/uploads/2017/06/Understanding-the-UK-Greenhouse-Gas-Inventory.pdf). This ongoing process also involves applying improved methodologies to historic inventories to arrive at updated 1990 baseline figures. In February 2017 BEIS published: (https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2015) an updated greenhouse gas inventory with a 1990 baseline revised up from 797 to 799 $MtCO_{2e}$ for example. It is important therefore to exercise care when looking at percentage reductions against baseline (especially in older reports) to ensure comparisons are made consistently. For the purposes of these tables, we have made our own assessments of how to allocate the figures so as to aid comparison alongside the five chapters. We have done our best to ensure comparability

[2] A relatively modest reduction (from 41 to 40 MTCO2) is largely because of the anticipated future growth in the aviation sector where emissions will be going up, and are modelled to come back down to 2005 levels by 2050.

[3]See CCC Report to Parliament, June 2017https://www.theccc.org.uk/wp-content/uploads/2017/06/2017-Report-to-Parliament-Meeting-Carbon-Budgets-Closing-the-policy-gap.pdf

[4] See NASA research on biofuels, March 2017: https://www.nasa.gov/press-release/nasa-study-confirms-biofuels-reduce-jet-engine-pollution

[5] See, July 2017 DfT: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/631036/aviation-strategy-call-for-evidence.pdf

[6] See: http://www.iata.org/policy/environment/Pages/corsia.aspx

[7] See DfT Aviation Strategy consultation, July 2017: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/631036/aviation-strategy-call-for-evidence.pdf

[8] See this piece for a succinct summary: October 2016, http://shippingtoday.eu/shipping-carbon-strategy/

[9] See: https://ec.europa.eu/clima/policies/transport/vehicles/cars_en

[10] https://www.gov.uk/government/news/35-million-boost-for-ultra-low-emission-vehicles

[11] https://www.gov.uk/government/news/23-million-boost-for-hydrogen-powered-vehicles-and-infrastructure

[12] https://www.gov.uk/government/news/over-109-million-of-funding-for-driverless-and-low-carbon-projects

[13] See DEFRA, July 2017, which includes a summary of DEFRA' air pollution plans and its recent efforts on vehicle electrification: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/633269/air-quality-plan-overview.pdf
[14] ICAO, May 2017: https://www.icao.int/Meetings/CORSIAHQ17/Documents/2017%20ICAO%20HQ%20Seminar%20-%20PRES%20Opening%20Remarks_V04.pdf
[15] See Department for Transport Aviation Strategy consultation, July 2017: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/631036/aviation-strategy-call-for-evidence.pdf
[16] See the SSI's vision 2040: http://www.ssi2040.org/wp-content/uploads/2017/01/SSI_Vision_doc_web.pdf
17 The International Energy Agency (IEA) has worked with various Nordic research institutes to produce scenarios for a Nordic Carbon Neutral Scenario that envisages a fourfold increase in net biofuel imports to the Nordics, with biofuels representing two thirds of total final energy use in transport in 2050. They acknowledge that this depends on a well-functioning international biomass market, having decided that this is preferable to diverting domestic biomass production away from higher value uses in industry.
[18] http://www.icao.int/environmental-protection/Pages/market-based-measures.aspx
[19] http://thelancet.com/journals/lancet/article/PIIS0140-6736(15)60854-6/abstract
[20]PUBLIC HEALTH IMPACTS OF COMBUSTION EMISSIONS IN THE UNITED KINGDOM, STEVE H. L. YIM AND STEVEN R. H. BARRETT, MARCH 2012: HTTP://PUBS.ACS.ORG/DOI/ABS/10.1021/ES2040416
[21] Understanding the Health Impacts of Air Pollution in London, July 2015: https://www.kcl.ac.uk/lsm/research/divisions/aes/research/ERG/research-projects/HIAinLondonKingsReport14072015final.pdf
[22] https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution
[23]The House of Commons Environment, Food and Rural Affairs report on Air Quality https://www.publications.parliament.uk/pa/cm201516/cmselect/cmenvfru/479/479.pdf
[24] https://www.gov.uk/government/news/new-air-quality-plan-published-for-consultation
[25]See the new DEFRA report, July 2017 https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017

CHAPTER 4: Industry

	1990	2016	2050 CCC Max	2050 Modified Max "MM"	2050 "MM" Low carbon removal
Power	277.9	79	3	3	3
Heat in buildings	93.6	89	4	4	4
Surface transport	121.9	121	5	5	5
Industry	174.4	100	32	27	27
Non-CO2	125.5	84	47	47	47
International Aviation and Shipping (UK share)	24.1	N/A (41)	40	40	40
Peatland	21	N/A	N/A	5	5
Wood in construction	N/A	N/A	-4	-4	-4
Carbon Removal (associated with BECCS)	N/A	N/A	-47	-55	-11
LULUCF	5.4	-7	-16	-16	-16
Totals:	**844**	**466**	**64**	**56**	**100**

All figures refer to $MtCO_2$

1990 Figures[1], source: BEIS (February 2017), *2015 UK Greenhouse Gas Emissions, Final* Figures
2016 figures, source: The CCC (June 2017), *2017 Report to Parliament – Meeting Carbon Budgets: Closing the policy gap*
CCC Max Scenario figures, source: The CCC (October 2016), *UK climate action following the Paris Agreement*

SUMMARY

To meet its 2050 ambitions, the UK needs to cut emissions from UK industries from 100 $MTCO_2$ to around 27 $MTCO_2$ in 2050, primarily through the use of energy efficiency, supply chain optimisation and the application of *circular economy* principles. The CCC classify the industrial sector as comprising all manufacturing sectors, construction, water and waste management, refining and other energy supply activities (with over 80% of its CO_2 emissions associated with only eight industries).

Reducing emissions from industrial processes (which currently make up around a quarter of all UK emissions) will be challenging, as certain materials (such as steelmaking) require a lot of energy to produce the temperatures they need. Similarly, the chemical process by which certain materials are developed for industrial use (such as in the cement sector) create emissions by nature of the chemical process they undergo. In these cases, the aim will be to find suitable, low emissions substitutes for certain materials. Combined with a radical programme of resource efficiency and reverse-supply-chains, as well as energy efficiency for industrial plants and a CCS programme for industry (ICCS), it could be possible to reduce emissions in the industrial sector to lower than that envisioned by the CCC. Indeed, it has been suggested that low carbon innovation for all industrial sectors and materials could be a major source of comparative advantage for Europe's mature economies, such as the UK[2].

In our modified scenario ("CCC-modified-max"), we identify an additional 5 $MTCO_2$ of emissions reduction potential compared to the CCC max scenario. Our additional savings are drawn from recent work on the additional potential for resource efficiency (or "circular economy principles") to reduce the demand for "virgin" industrial materials in the economy, many of which are sources for a lot of GHG emissions.

THE WAY AHEAD

- **Sector-based alignment of resource productivity and sustainability strategies** could save an additional 62-100 MtCO2e over the period 2013-32. Current strategies have already made a significant impact on industrial decarbonisation in Europe but it is important that future strategies are able to fully decarbonise all industrial value chains rather than relying on individual companies to develop and implement ambitious plans and sourcing strategies.

- **Public procurement and public-sector supply chains** need to pull in the same direction of the sector strategies and ensure that they are fully incentivising low carbon innovation in industry. There is a lot of work currently being done in this area to identify best practices whilst staying within EU procurement law.

- **Emissions disclosure should become a core part of public sector procurement,** properly embedded in public sector procurement activities for both local and central and devolved government.

- **The Industrial Strategy for the UK** must treat industrial decarbonisation as a major priority and potential source of UK competitiveness both in the EEA and in global markets. The current Green Paper lacks a detailed discussion of decarbonisation and of CCS funding. A Liberal Democrat Industrial Strategy should include emissions reduction as an economic opportunity with support for sector specific reduction pathways as well as UK based innovation around collaboration and carbon disclosure.

- **The UK should, provide specific support for low carbon technologies**, products and innovation in order to incentivise lower-emissions alternatives (e.g. increased re-use of products and materials, and further shifts towards virtual conferencing in place of international travel).

- There are economic as well as environmental benefits to be gained from better aligning industrial strategy on decarbonisation with business action to raise resource productivity. This is what is known as the Circular Economy. An important recent study from CIE MAP has indicated that pursuing resource productivity could provide significant opportunities to plug shortfalls in climate polices, saving an additional 62-100 MtCO2e over the period 2013-32. **Resource productivity should be placed at the heart of the UK's decarbonisation strategy**.

- **A focus on low carbon skills.** The TUC sees a key role for revitalised sector skills bodies and also indicates the Institute for Apprenticeships could plan for apprenticeship provision to meet the needs of a sustainable industrial policy.

- **A renewed focus on the export opportunities.** There is considerable potential for low carbon business opportunities for the UK. The Carbon Trust, for example, forecasted (in 2014) that '[by 2020], the UK has a credible opportunity to triple its [low carbon] exports from £12 billion to around £30 billion and double its share of the global low carbon export market from around 5% to around 10%'[3].

THE CHALLENGE

The UK industrial sector is a major emitter, representing around a quarter of the UK's total emissions[4]. Around 80% of industrial emissions are made up of CO_2, with around 70% occurring due to the direct combustion of fossil fuels as part of industrial and chemical processes and 30% occurring indirectly from the use of additional electricity[5].

While some emissions abatement opportunities apply across the whole industrial sector, for example the greater application of energy efficiency, supply chain optimisation and the application of circular economy principles, there are also significant particularities between sectors[6] which should be reflected in an overall strategy. Energy intensive sectors are, of course, particularly sensitive to the cost of energy and are typically regulated through trading schemes, such as the EU Emissions Trading System (ETS), which aim to find the lowest cost routes to decarbonisation. Moreover, in some sectors such as cement, fossil fuels form part of the industrial process itself and are difficult to substitute. Nonetheless, it will be important for the UK materials sector to continue to invest in low carbon substitutes for materials where this is feasible. For example, there is already a significant drive to increase the use of sustainably-sourced wood in building materials as a substitute for higher-emissions materials. Even the European cement sector is experimenting with ways to reduce the carbon intensity both of its processes and also its end product, often through highly innovative techniques. But progress is too slow.

There has been limited progress on energy reduction from industrial sectors beyond energy efficiency and participation in the EU ETS (in which many industrial sectors enjoy free allowances). It has proved challenging to engage the wider business community on energy use reduction, perhaps reflecting the proportionately lesser role played by energy in their overall cost base. And it has also proved difficult to track or record progress.

Recent UK Government developments - The Green Paper on Industrial Strategy

The Government's January 2017 Green Paper – Building our Industrial Strategy – includes a goal to 'improve living standards and economic growth by increasing productivity and driving growth across the

whole country'. While there is scant coverage of decarbonisation as a strategic opportunity for business, one of the ten key pillars identified is 'Delivering affordable energy and clean growth'.

With respect to emissions reductions, the Green Paper states: 'On climate change, the settled policy position is reflected in the Government's commitment to meeting its legally-binding targets under the Climate Change Act. How we will continue to meet our legal obligations will be set out, as required, in the forthcoming Emissions Reduction Plan and we have an exemplary record of meeting our obligations.' This plan is now expected to be published in Autumn 2017. This means that it was impossible for us to scrutinise it in the context of the current report.

Given the need for a clear strategy to marry industrial competitiveness with decarbonisation, there is a welcome recognition of the opportunity afforded by the integration of the climate change and energy brief into the new *Department of Business, Energy and Industrial Strategy (BEIS)*: 'The industrial strategy – and the combination of the policy portfolio of the former energy and climate change ministry with the business and industrial strategy brief, allows a more explicit strategic set of connections to be made'. As an example, the emissions reduction opportunity afforded by greater use of wood in construction might well be missed should a narrower industrial strategy approach have been adopted.

The Green Paper has an emphasis on short-term affordability which raises concerns that efforts to decarbonise energy, and concerted efforts to reduce demand, could be delayed. Through its modelling exercises the Energy Transitions Commission stated that:

> It would be a mistake to think the UK can wait until efficiency measures have been exhausted before we turn to alternative, low carbon solutions. If the UK waits until the mid-2020s, a lack of supply chain capacity is likely to mean that preferred solutions have to be supplemented by second-choice technologies at far greater expense. In our model, failure to prepare properly leads to a significant escalation in the cost of abatement action by 2050 (to around 3-4% of GDP).

The ETI highlights the potential loss of opportunity: 'Abandoning or weakening climate targets in the near term would represent a lost opportunity for the UK to position itself as a market leader for low carbon technology. Delays produce a very bleak outcome where the UK is trying to play catch-up without effective preparation.'

Should the proposed aim within the Green Paper be to minimise short-term expenditure it would appear to run contrary to one of the questions explicitly asked in the Paper 'What are the most important steps the Government should take to limit energy costs over the long term?'

Setting out a long-term roadmap in 2017 to minimise business energy costs is a welcome step particularly as it will be informed by a review of the 'opportunities to reduce the cost of achieving our decarbonisation goals in the power and industrial sectors'. Achieving improved energy efficiency/productivity in business

is correctly highlighted as a priority, but the cost should be viewed over the long term, otherwise action could be put off that will incur a much higher price later.

The Government proposes an 'open door' challenge to industry to come with proposals to transform their sectors through 'Sector Deals' 'to help deliver upgrades in productivity.' It has also indicated it will create a new Industrial Strategy Challenge Fund to help Britain capitalise on its strengths in research and innovation in areas such as robotics, clean energy and biotechnology.

Early sector deals on ultra-low emission vehicles and nuclear power, along with explicit recognition of the importance of 'Smart, flexible and clean energy technologies (such as storage, including batteries, and demand response)' is consistent with advice coming from the CCC, who assessed that the UK should:

- Develop and deploy offshore wind, CCS for electricity generation and industry, marine, smart grids, aviation, and electric vehicle technologies.
- Deploy nuclear power and heat pumps.
- Research and develop advanced solar PV, energy storage, hydrogen fuel cell vehicles, advanced biofuels, and technologies in agriculture and industry.

BOX 4.1 – The Absence of CCS for industry in the Green Paper on Industrial Strategy

The absence of any consideration of CCS within the industrial strategy is a concern. The CCC has stated that 'CCS is of critical importance to meet the UK's climate targets at least cost, and requires a strategic approach to its development', further stating that 'CCS is the only option to reduce CO2 emissions from segments of important industrial sectors including steel, cement and chemicals'.

Therefore, the absence of a UK strategy to develop CCS for industry is an issue that must be addressed urgently – as a number of options to reduce emissions that are being actively considered by Government and industry depend on it (e.g. use of hydrogen in heating and transport). CCS is also likely to play a key role in the longer-term (such as in combination with sustainable bioenergy and for seasonal/flexible power generation)'.

This point was reiterated by the CCC in their letter to Government highlighting the cancellation of funding for the CCS commercialization programme and noting that CCS can play a role in industrial decarbonization post-2030 only if there has been sufficient development in the 2020s.

BOX 4.2 – Carbon trading and the EU Emissions Trading System (ETS)

The ETS has been valued as a policy instrument for reducing greenhouse gas emissions across a number of sectors[7], although doubts remain as to its overall effectiveness for industry. Given some optimism regarding the revised form of the ETS, the House of Commons Energy and Climate Change Committee noted there is a case for the UK's continued participation in the system after it has left the EU. More specifically the potentially costly and complex option of establishing a UK ETS linked to the EU system and/or the politically difficult creation of a direct carbon tax as alternatives need to be viewed in the context of cost and difficulty for business (and consumers). The House of Lords EU Committee echoed this concern recently[8] noting that well-functioning emissions trading schemes are a cost-effective means of reducing carbon emissions with the ETS as 'one of the flagship policies for mitigating climate change' and if continued UK participation is sought, it should also seek to retain influence over its operating rules, to ensure that the system works effectively. The spring 2017 budget also cites the possibility of a carbon tax[9].

ETS to help prevent carbon leakage

A particular concern in energy-intensive industries, such as iron, steel, aluminium and paper is 'carbon leakage' whereby energy-intensive manufacturing moves to less regulated economies (potentially meaning higher overall emissions). The Liberal Democrats have supported the continued use of assistance related to the ETS, where there is significant risk of carbon leakage and the levels are proportionate to need. This would include assistance in helping with the capital costs of moving to lower-energy production methods and support for research and development that will lead to further efficiency gains.

POTENTIAL SOLUTIONS

Circular Economy and emissions reductions in industry

In an international study of the benefits of a more resource efficient economy[10], the Club of Rome predicted lower emissions in all countries studied of 3-10% (with associated gains in employment). This is based on a 2030 scenario which is 25% more material-efficient than today, substituting half of the virgin material currently used in the economy with recycled materials ('secondary raw materials'), and doubling the product life-time of certain consumer products.

A more recent report[11] focuses on the opportunity within the mobility, food & drink and property sectors (together accounting for over 80% of resource use). Investment hot spots within these sectors were identified which might result in 17% lower annual CO_2 emissions by 2025 (along with 7% additional GDP growth) compared to business as usual. They also emphasised the key role of technology, noting that 'the digital revolution is a crucial enabler for many parts of the circular economy transition, for example sharing, virtualisation, managing complex reverse logistics chains, and keeping track of valuable assets.'

Key areas for further development identified were:

- integrating public transport systems with shared vehicles
- designing and producing zero-emission cars with re-usable components
- remanufacturing car components at scale
- shifting to agricultural practices that regenerate soil and ecosystems
- scaling nutrient and energy recovery from waste
- scaling indoor urban farming methods
- developing new protein sources
- designing and producing multi-usage, modular, energy-positive buildings from durable, non-toxic materials
- boosting re-use of building materials.

BOX 4.3 – Circular economy strategies for UK industry

A recent UK study from *Centre for Industrial Energy, Materials and Products (CIE-MAP)* found that a **sector-based alignment of industrial policy and business action on resource productivity** 'can meet anticipated shortfalls in climate policies and provide opportunities for resource productivity and innovation' saving an additional 62-100 MtCO2e over the period 2013-32. We find these findings convincing and so have added the emissions savings they generate to our "CCC modified max scenario".

Alongside the cross-sector opportunities for reducing supply chain waste CIE-MEP identify a series of sector-specific interventions including increasing the lifetime of clothing and shoes, reducing food waste, increasing packaging recycling rates, light-weighting vehicles, reusing still functioning electronic items and – importantly – design optimisation to reduce material inputs in construction ("eco-design for buildings").

An example of Government working with a business sector to produce a sustainability strategy is the 2013 'Construction Vision for 2025', the aims of which included 'an industry that leads the world in low-carbon and green construction exports with 50% reduction in greenhouse gas emissions in the built environment'. This approach sought to develop 'market and technology based plans to secure the jobs and growth opportunities from driving carbon out of the built environment', emphasising the important role of procurement, seeking to 'drive procurement efficiency and explore options for further efficiency gains in the procurement process'.

The results from these studies align with the suggestion from the CCC that higher demand for less carbon-intensive industrial products and the increased reusability of products and materials could be ways to further reduce emissions in the industrial sector. A robust regulatory framework – such as the package of measures contained in the EU's Circular Economy package – will be needed to ensure that each sector and value-chain makes the most of circular economy principles. Organisations like the Ellen MacArthur Foundation have already done a lot of work in identifying the practical options for much higher resource efficiency through materials innovations, while WRAP continues to pioneer understanding in the field of municipal recycling and food waste.

Boosting 'Innovation clusters'

The Liberal Democrat Green Manifesto[12] identified opportunities for local authorities to create innovation hubs, allowing for mutual learning and encouraging the exchange of ideas. More specifically 'carbon clusters' were recommended to ensure resource-efficient development of the necessary infrastructure on energy efficiency and – especially – industrial CCS.

In 2016, an Aldersgate Group report[13] made a strong case for much greater local government support to strengthen the low carbon economy as part of the UK's strategy for regional development, thereby creating more jobs in the North of England especially. Aldersgate Group highlighted how Siemens, ABP and DONG Energy are transforming the Port of Hull with investment in a clean energy cluster of offshore wind farms, turbine manufacturing and port facilities. This project clearly has numerous co-benefits as well as simply

its contribution to the UK's low carbon targets. The proposed CCS cluster at Teesside could also be an interesting case study of how decarbonisation and regional development could go hand-in-hand.

Tangible *Decarbonisation Pathways* for energy-intensive industries and better collaboration between businesses across sectors

In 2015, DECC and BIS produced a set of eight reports[14] providing individual sector information on potential decarbonisation pathways to 2050 for the most energy intensive industrial sectors in the UK, such as iron and steel and chemicals. These reports were intended to inform future decarbonisation policy and should certainly be considered within the context of a wider industrial strategy. The reports followed a standard format and arrived at several conclusions that were common across sectors. These included the necessity of viewing the industry and its cost competitiveness within a global context as well as a desire for a stable long-term policy framework. Collaboration within sectors or clusters was also highlighted as being relevant to carbon capture development. The iron and steel report also concluded that, although energy efficiency and decarbonisation are regarded as mechanisms for reducing cost, they are not considered as high-priority business goals *in their own right* (thereby reinforcing the need for supportive policy mechanisms).

Platforms such as the 'Innovation Gateway'[15] - initially established by RBS and now involving Sainsbury's, Carillion and BaxterStorey - allow companies in the same supply chain to put forward energy efficiency innovations that are trialled within the business estate in ways that would otherwise prove challenging for smaller businesses. This not only leads to better uptake of new low carbon ideas but also supports SMEs as they aim to develop new products and access the supply chains of large purchasers.

Germany is establishing[16] an 'Energy Efficiency Network Initiative', intended to improve knowledge sharing and co-ordination between companies within localities, the plan is to establish 500 *energy efficiency networks* of between 8 and 15 businesses with collective energy efficiency targets and the introduction of energy management systems in its members.

Better use of public procurement and supply chains

Public procurement can be a powerful means for Government to incentivise the low carbon transition, not only through its direct annual procurement budget of around £268 billion (approximately 14% of GDP)[17] but also in the wider encouragement of relevant supply chain activity across industry.

The Public Contracts Regulations 2015 (which implement the EU Public Procurement Directive in the UK) came into force in 2015 and encourage the consideration of the lifecycle costs of products, including carbon footprints[18]. This approach should support competitive improvements (as opposed to simply setting minimum performance standards for example) thereby encouraging suppliers to pitch new ideas.

In Scotland, the Procurement Reform (Scotland) Act 2014[19] includes a Sustainable Procurement Duty on public bodies to consider how they can improve economic, social and environmental wellbeing; facilitate the involvement of SMEs and the third sector and to promote innovation.

There are also increasing examples of global best practice which offer the opportunity for governments to engage in improved procurement practice while avoiding concerns over duplication of private sector effort. For example, in 2015 the US General Services Administration (GSA) – supporting the federal government with an annual budget of around $20 billion joined the *CDP (formally the Carbon Disclosure Project*) Supply Chain initiative (supplier participation is voluntary and by invitation)[20].

It is also important for the private sector to pull its weight here and it may benefit from much wider and more detailed guidance on the best practice from businesses of all sizes in the UK and beyond.

The Encouragement of more carbon emissions disclosure

Supply chain efforts formed part of a wider CDP study[21] in 2016 that investigated the potential contribution that voluntarily disclosure by businesses could make to limiting climate change (and they explored how much bigger the contribution could be in a supportive policy environment). The CDP, a global leader in its field, estimated that global emissions could be reduced by 7-9% below current trends simply through businesses joining voluntary climate change initiatives. With supportive government policies in place, they estimated the savings could be over twice that amount.

Potential policy support suggested by CDP included encouraging utilities to offer renewable energy contracts, helping companies build their own renewable energy installations, offering grants and capital depreciation to make energy efficiency investments more attractive and creating incentives for buyers and sellers of sustainable products. Promoting transparency on energy consumption for residential and commercial buildings (through audits, benchmarking and labelling) was also seen as important.

The voluntary corporate sourcing of renewable electricity has also been cited as a major driver of the low carbon transition by the RE100 initiative (a global collaboration of private businesses committed to using 100% renewable power)[22].

In relation to infrastructure spending, the UK Government has indicated that it is 'building on good practice adopted in major programmes by encouraging procurement to take account of social and economic factors in a 'balanced scorecard' approach'. Although transition considerations were not mentioned in this context, like many other management tools, balanced scorecards readily allow for the consideration of a range of non-financial issues such as sustainability, making them another important public-sector lever in sector decarbonisation.

Skills development for low carbon industry

A recent study on skills constraints in the low carbon transition[23] has found that there is a need for greater integration of skills and employment issues into low carbon transition pathways, not least because of their potential to disrupt the existing mechanisms.

Local government is in a good position to champion partnerships between the public sector, private sector and local educational bodies to produce coordinated local strategies on skills.

There are also likely to be sector specific requirements as reflected by the CCC in their observations[24] on the building and heat supply trades, where a nationwide training programme may be needed to develop high professional standards for implementation of low-carbon choices. The TUC have also highlighted the importance of skills in the transition, terming it the 'fourth policy pillar'[25], seeing a revitalised role for sector skills bodies.

BOX 4.4 – "Green jobs" in the UK

There are challenging aspects to measuring both the number and quality of green jobs associated with "green" policy initiatives. A Grantham Institute report[26] has highlighted some of these challenges: 'Many jobs are not counted as green, despite the nature of the goods and services they help produce. For example, jobs in the car industry are excluded (from official figures), even though some may be devoted to developing low-carbon vehicles.' With these caveats, the report cited European Commission figures that green jobs currently constitute a small but significant proportion (1.7%) of total paid employment in the EU and a US figure of 2.1% in 2011.

A 2015 European Parliament report[27], meanwhile, on job creation potential of the green economy which featured significant UK involvement, cited European Environment Agency evidence that 'the green goods and services sector grew by more than 50% between 2000 and 2011, generating over 1.3 million jobs and whereas, according to the Commission's calculations, the renewable energy economy will create 20 million new jobs in Europe by 2020.' The EP also stressed the significant employment potential of the circular economy stating that 'improving resource efficiency could create between 1.4 and 2.8 million jobs in Europe, and that transitioning to an economy based on the durability and reparability of products can create jobs along the whole product lifecycle in the sectors of maintenance, repair, upgrade and reuse.' A recent report by Green Alliance and WRAP suggests that with a correct circular economy strategy in place, up to 500,000 jobs could be created in this sector in the UK[28].

'Skills for a Green Economy' published by the UK Government in 2011[29] described potential job creation across the economy. It saw significant employment opportunities in renewables, with the offshore wind supply chain needing up to 70,000 more workers and the biomass industry offering 15,300 jobs (both by 2020). Beyond 2020 they saw as many as 30,000 jobs in the CCS sector (with evidence that the skills needed might already be found in the chemicals and oil and gas sectors). Civil nuclear power was said to offer an additional 10,000 jobs annually (in addition to the 44,000 already employed). That report also predicted that the numbers of people employed in insulation activity in the UK would grow from 27,000 in 2011 to 100,000 in 2015 and 250,000 by 2025 (within the context of the Green Deal). The *UK Green Building Council* has also indicated that an extra 140,000 jobs could be created in the UK from investing in a genuinely national energy efficiency programme for homes.[30]

Recognising the low carbon business opportunities for the UK

There is general agreement on the considerable potential of low carbon business opportunities for the UK with a number of reports suggesting that the UK has strong export potential in this area.

As noted above, the Carbon Trust[31] forecasted in 2014 that the global export market for low carbon goods and services will be worth more than £1 trillion by 2020 alone. They also noted that 'in the same timeframe, the UK has a credible opportunity to triple its green exports from £12 billion to around £30 billion and double its share of the global low carbon export market from around 5% to around 10% (similar to the UK's share of the global pharmaceuticals industry).'

The House of Commons Energy and Climate Change Committee has recently echoed this, noting that:

> 'The energy revolution presents a huge economic opportunity for the UK. With the appropriate strategy, policies and regulatory framework in place, Britain can become a world leader in the green technology sector. The Government should make green technology a top priority in its forthcoming industrial strategy.'[32]

CONCLUSIONS

As stated at the start of this chapter, direct emissions from industry accounted for around a quarter of UK greenhouse gas emissions in 2014 (109 MtCO2e) of which over 90% were CO2. The CCC scenarios for the sectors it counts as "industry" are underpinned by a series of business-specific roadmaps to 2050, relating to the major CO2 contributors focusing on energy efficiency, bioenergy as fuel, electricity for process heat and industrial CCS.

The CCC's key observations are that:

- Industrial CCS development and deployment on a large scale is required to decarbonise industry and meet the 2050 target.
- For the private sector to invest in large scale, longer term, energy efficiency projects there needs to be confidence that an appropriately supportive policy framework is in place.
- Government intervention to 2030 will be required to support low-carbon space and process heat through fuel switching to bioenergy and electricity (as the power sector decarbonises).

The CCC consider that application of CCS to large industrial sites may be feasible and cost-effective in energy-intensive sectors where there are few, existing abatement options, such as: iron and steel, refining, cement, chemicals and industrial Combined Heat and Power (CHP).

Furthermore, hydrogen could be used to supply low-temperature heat and significant quantities of high-temperature heat for industrial processes in the future particularly in the iron and steel sector.

The EU Emissions Trading System is a fundamental component of industrial decarbonisation, *notwithstanding the CCC assessment that it is currently only providing weak incentives for long term investments in carbon reduction*. They identify a need for structural reform of the system, however, the wider question of how the UK might interact with the ETS following its exit from the EU is now the major question.

In relation to energy efficiency, important instruments include Products Policy, Climate Change Agreements (CCAs) and the Carbon Reduction Commitment (CRC). The CCC has suggested the rationalisation of business energy taxes and policies to promote energy efficiency as well as suggesting that the voluntary CCAs are not sufficiently challenging. The Energy Savings Opportunity Scheme (ESOS) makes it mandatory for large businesses to undertake assessments of energy use and energy efficiency

opportunities. Many elements of policy such as these are derived from EU requirements and their future application needs to be considered.

The Renewable Heat Incentive (RHI) encourages the installation of renewable heating in place of fossil fuels. But a lack of post 2016 RHI funding has been one of the major policy gaps of UK low carbon policy, which has recently been addressed in a 'reformed and refocused' scheme running through to 2021. Indeed, Government have indicated that they expect spending on the RHI to rise from £430m in 2015/16 to £1.15bn in 2020/21 although it is not clear that even this level will be sufficient to galvanise the action needed.[33]

The CCC max scenario identified 19 MtCO2e abatement resulting in overall 2030 industrial emissions of 81MtCO2e. The savings come from improved energy efficiency (including retrofitting a steel plant) upgrading machinery and further waste heat recovery. There is greater uptake of bioenergy for process heat and an initial CCS cluster will have been deployed. It also includes for electrification of process heat. Our scenario has identified greater abatement potential from the roll-out and intensification – across industrial sectors – of resource efficiency measures, product-recovery and eco-design in buildings. However, we note that the current regulatory framework is not sufficient to encourage large scale action in the 2020s.

REFERENCES

[1] Given its central role in setting carbon budgets, the UK greenhouse gas inventory is subject to continual review. An estimated 3% uncertainty in the current figures makes it one of the more reliable national datasets: (May 2017 NPL report for the CCC https://www.theccc.org.uk/wp-content/uploads/2017/06/Understanding-the-UK-Greenhouse-Gas-Inventory.pdf). This ongoing process also involves applying improved methodologies to historic inventories to arrive at updated 1990 baseline figures. In February 2017 BEIS published: (https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2015) an updated greenhouse gas inventory with a 1990 baseline revised up from 797 to 799 $MtCO_{2e}$ for example. It is important therefore to exercise care when looking at percentage reductions against baseline (especially in older reports) to ensure comparisons are made consistently. For the purposes of these tables, we have made our own assessments of how to allocate the figures so as to aid comparison alongside the five chapters. We have done our best to ensure comparability

[2] i2-4c and Bruegel, 2016 "An approach to identify sources of low carbon growth for Europe"

[3] Carbon Trust, A Must Win, CAPITALISING ON NEW GLOBAL LOW CARBON MARKETS TO BOOST UK EXPORT GROWTH, May 2014: https://www.carbontrust.com/resources/reports/advice/a-must-win-capitalising-on-new-global-low-carbon-markets-to-boost-uk-export-growth/

[4] Meeting Carbon Budgets – 2016 Progress Report to Parliament on Climate Change, June 2016: https://www.theccc.org.uk/publications/

[5] Green Growth and Green Jobs: Transition to a Zero Carbon Britain, Liberal Democrat Policy Paper 109, Sep 2013: https://www.libdemnewswire.com/files/2016/02/109-Green-Growth-and-Green-Jobs-Transition-to-a-Zero-Carbon-Britain.pdf

[6] *On the one hand, there are energy intensive users in industry who know all about efficiency because fuel costs are important and then there is a huge swathe of other sectors others (such as for example, the entire service sector) where energy costs are less significant so there tends to be little action even if cost savings might be made.*

[7] House of Commons Energy and Climate Change Committee: The energy revolution and future challenges for UK energy and climate change policy, Third Report of Session 2016 – 2017, October 2016: www.parliament.uk/ecc

[8] House of Lords, European Union Committee, 12th Report of Session 2016–17, HL Paper 109, Brexit: environment and climate change, February 2017: http://www.parliament.uk/business/committees/committees-a-z/lords-select/eu-energy-environment-subcommittee/news-parliament-2015/brexit-env-cc-rpt/

[9] HM Treasury, Spring Budget 2017: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/597467/spring_budget_2017_web.pdf

[10] Club of Rome report, 2015: http://www.clubofrome.org/wp-content/uploads/2016/03/The-Circular-Economy-and-Benefits-for-Society.pdf
[11] Achieving growth within, Systemiq, January 2017: https://static1.squarespace.com/static/57189cee2b8dde43af06d282/t/5878f27159cc68c9302e2727/1484321409565/SYSTEMIQ_EMF_REPORT+COMPLETE+120117+AW+A.pdf
[12] The Green Manifesto, How to increase living standards, improve quality of life and future-proof the economy, Boyle et al, March 2014: https://www.mrw.co.uk/Journals/2014/03/11/h/y/b/20140311-Lib-dems-Green-Manifesto.pdf
[13] Setting the Pace: Northern England's Low Carbon Economy, Aldersgate Group, September 2016: http://www.aldersgategroup.org.uk/events/unlocking-potential-the-northern-powerhouse-and-its-low-carbon-future
[14] BIS/DECC – Industrial Decarbonisation and Energy Efficiency Roadmaps, December 2015: https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050
[15] The Innovation Gateway: http://innovationgateway.com/innovators
[16] Governing for Demand Management Innovations in Germany: Politics, Policy and Practice, Caroline Kuzemo: EPG Working Paper: 1601 December 2015: http://projects.exeter.ac.uk/igov/wp-content/uploads/2016/02/CK-Governing-for-Demand-Mangement-Innovations1.pdf
[17] Building our Industrial Strategy, Green Paper, January 2017: https://www.gov.uk/government/consultations/building-our-industrial-strategy
[18] The Public Contract Regulations 2015, Guidance on Social and Environmental Aspects, Crown Commercial Service: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/558032/20160912socialenvironmentalguidancefinal.pdf
[19] The Procurement Reform (Scotland) Act 2014, http://www.legislation.gov.uk/asp/2014/12/contents
[20] GSA Supply Chain Energy and Environmental Management: https://www.gsa.gov/portal/content/133747
[21] The Business End of Climate Change, CDP 2016: http://www.businessendofclimate.org/
[22] *Corporate sourcing of renewable electricity can be a major driver of the transition to a robust, zero-emissions economy, according to this year's RE100 Annual Report*, January 2017: http://there100.org/news/14243463
[23] Skills constraints for low-carbon transitions, Nicholas Jagger, Timothy J. Foxon and Andrew Gouldson, June 2012: https://www.see.leeds.ac.uk/fileadmin/Documents/research/sri/workingpapers/SRIPs-31.pdf
[24] Next steps for UK Heat policy, October 2016: https://www.theccc.org.uk/wp-content/uploads/2016/10/Next-steps-for-UK-heat-policy-Committee-on-Climate-Change-October-2016.pdf
[25] TUC, Powering Ahead: How UK Industry can Match Europe's Environmental Leaders - Economic Report Series, 2016: https://www.tuc.org.uk/sites/default/files/Powering_Ahead_Report.pdf
[26] Grantham Institute, March 2015: http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/03/Looking-for-green-jobs_the-impact-of-green-growth-on-employment.pdf
[27] European Parliament, June 2015: http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+REPORT+A8-2015-0204+0+DOC+PDF+V0//EN
[28] Green Alliance and WRAP, January 2015: http://www.green-alliance.org.uk/employment-and-the-circular-economy.php
[29]BIS, Skills for a Green Economy, October 2011: https://www.gov.uk/government/statistics/skills-for-a-green-economy-report-on-the-evidence
[30] A housing stock fit for the future: Making home energy efficiency a national infrastructure priority, June 2014: http://www.ukgbc.org/resources/publication/housing-stock-fit-future-making-home-energy-efficiency-national-infrastructure
[31] Carbon Trust, A Must Win, Capitalising On New Global Low Carbon Markets To Boost Uk Export Growth, May 2014: https://www.carbontrust.com/resources/reports/advice/a-must-win-capitalising-on-new-global-low-carbon-markets-to-boost-uk-export-growth/
[32] House of Commons Energy and Climate Change Committee www.parliament.uk/ecc : The energy revolution and future challenges for UK energy and climate change policy, Third Report of Session 2016 – 2017, October 2016: https://publications.parliament.uk/pa/cm201617/cmselect/cmenergy/705/705.pdf
[33] *For the Renewable Heat Incentive see:* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/505972/The_Renewable_Heat_Incentive_-_A_reformed_and_refocussed_scheme.pdf

CHAPTER 5: Sustainable Bioenergy, Agriculture and Land Use Change

	1990	2016	2050 CCC Max	2050 Modified Max "MM"	2050 "MM" Low carbon removal
Power	277.9	79	3	3	3
Heat in buildings	93.6	89	4	4	4
Surface transport	121.9	121	5	5	5
Industry	174.4	100	32	27	27
Non-CO2	125.5	84	47	47	47
International Aviation and Shipping (UK share)	24.1	N/A (41)	40	40	40
Peatland	21	N/A (21)	N/A	5	5
Wood in construction	N/A	N/A	-4	-4	-4
Carbon Removal (associated with BECCS)	N/A	N/A	-47	-55	-11
LULUCF	5.4	-7	-16	-16	-16
Totals:	**844**	**466**	**64**	**56**	**100**

All figures refer to $MtCO_2$

1990 Figures[1], source: BEIS (February 2017), *2015 UK Greenhouse Gas Emissions, Final* Figures
2016 figures, source: The CCC (June 2017), *2017 Report to Parliament – Meeting Carbon Budgets: Closing the policy gap*
CCC Max Scenario figures, source: The CCC (October 2016), *UK climate action following the Paris Agreement*

SUMMARY

In order to meet its emissions reduction targets for the land-use and agriculture sector, the UK needs to find significant reductions in a range of different (and complex) sources of GHGs associated with land use and agriculture. In addition to this, the UK needs to preserve its currently existing carbon sinks and then rapidly augment them in order to deliver the very significant carbon removal (or "negative emissions") set out in the table above.

This will be a very significant challenge. The headline emissions reduction targets are as follows:

- Cut emissions from peatland from 21 $MTCO_2$ to 5 $MTCO_2$ through the restoration of the UK's extensively degraded peatland, particularly in upland areas
- Ensure that carbon removal/negative emissions from the rest of UK LULUCF amounts to -16MTCO2
- Deliver additional carbon removal/negative emissions to the tune of -4 $MTCO_2$ through promoting the use of timber in construction

- Deliver additional carbon removal/negative emissions of between 11 and 55MTCO$_2$ through afforestation or alternatives such as algae cultivation – potentially in conjunction with Bioenergy with Carbon Capture and Storage (BECCS)

Our differences with the CCC centre around the use of BECCS. In our "modified-max" scenario we identify an additional saving of 8 MTCO$_2$ based on research by the *Energy Technologies Institute* that suggests a *greater* availability of sustainable algae than previously assumed (also reliant to some extent on energy crops). On the other hand, our 'low carbon removal" scenario is driven by findings from the March 2017 Department for *Business Energy and Industrial Strategy* report which indicated that the UK's share of the global sustainable biomass market could be as much as 80% *smaller* than originally thought. This, obviously, has major implications for any decarbonisation strategy that includes BECCS and, therefore, makes BECCS the most controversial aspect of this review.

It is to be emphasised that carbon removal/negative emissions are a non-negotiable when it comes to ensuring that the UK is a net-zero emitter of GHG by 2050. The question of whether to combine the negative emissions potential of certain sustainable feedstocks (such as woody biomass) with low carbon heat and electricity from *Bioenergy with CCS* (BECCS) is an important one for policymakers and the debate around this issue is a rapidly developing one. We address some aspects of that debate in the section on BECCS, below, although it is beyond the scope of this report to evaluate the varied literature and/or to pronounce either way. As we have recommended a portfolio approach for the 2020s, BECCS should remain an important consideration.

In addition to decisions around sustainable bioenergy, there is a wide consensus on the huge potential for peatland restoration for reducing emissions whilst delivering a number of additional benefits such as reducing flood risk and supporting biodiversity. With no action, degraded peatland will be a large source of GHG emissions.

THE WAY AHEAD

- **Peatland** to be included in national carbon accounting

- A **comprehensive bio-economy strategy** covering agriculture, land use and forestry in relation to climate change is developed, enabling an informed conversation about the many inter-related aspects which must be considered *together* in order to derive the greatest benefit and understand the trade-offs

- Central to this will be an **ambitious programme of afforestation** in the UK, in order to deliver the carbon removal/negative emissions associated with the CCC's max scenario (and our "modified

max" scenario) – which the CCC estimates to require up to 30,000ha of additional woodland coverage in the UK *per year* by 2050 (for context, this is around half the total coverage of the New Forest).

- Connected to this is a recognition that **alternatives to woody biomass**, such as organic waste, agricultural residues, algae and domestic energy crops could play an important role (and contribute to landfill reduction strategies)

- A bio-economy strategy must also take into account the need to develop tangible policies to support the increased use of **wood in construction**, working with industry and forestry sectors to ensure this occurs effectively and sustainably, delivering carbon removal/negative emissions in the place of carbon intensive materials such as concrete

- For agriculture, a clear objective is to reduce fossil fuel use in the sector and improve **land management practices for natural carbon sequestration**, including following France's lead in promoting a **'4 per 1000' soil initiative** to increase the amount of CO_2 captured by soil by four grams per kg

- The **Greenhouse Gas Action Plan (GHGAP) for farmers** should be revisited in light of Brexit. As outlined in the annex on Brexit, there are environmental and emissions abatement opportunities that may arise from refocusing on agricultural policy following CAP exit

- Develop **innovation clusters for sustainable biofuels and bioenergy**. More research into sustainable **biofuels** should be undertaken, such as identified by the Carbon Trust including into woody/grassy crops with higher yields on marginal land; advanced biofuels demonstration; and demonstration of integrated gasification systems at scale. This could align with a policy for the development of innovation clusters supported by regional higher education providers.

THE CHALLENGE

We consider bio-materials for power and heat generation in this section, as well as biofuels for transport and other applications, because there is a clear need to take a holistic view of a whole 'bio-economy. There may also be considerable political and economic advantages to such an approach, not least in the context of Brexit.

Agriculture

Agriculture accounts for around 10% of UK greenhouse gas emissions. With appropriate policy measures in place, the CCC estimate that emissions could fall by 14% to 46 MtCO2e by 2030. This would then represent around 15% of UK emissions in 2030. The savings are based on realising the opportunity from

the existing GHG Action Plan (delivering 2.6 MtCO2e of savings in 2030) along with measures based around mitigating nitrogen oxides from crops and soils such as addressing soil compaction. Manure planning and the increased use of nitrogen-efficient plants (delivering 3.1 MtCO2e in 2030) will also contribute. The livestock sector, meanwhile, must deliver an abatement of around 3.8 $MtCO_{2e}$.

Land use and Forestry

The UK's land use and forestry sector is currently a carbon sink (of around 7 MtCO2e in 2015) but – concerningly – the pace of carbon removal is declining, according to a recent assessment by the CCC[2]. Furthermore, as discussed, peatland is currently acting as a significant source of emissions, albeit one which is not currently included in the accounts.

Achieving Negative Emissions alongside Bioenergy with CCS (BECCS)

There are significant interactions between bioenergy, agriculture and land use that complicate the consideration of their role in the zero-carbon transition. Nonetheless, there is global consensus on the fact that all countries need to improve the management of their landscapes, including forests and soils in order to boost their ability to act as carbon sinks. This goes well beyond the need simply to act against depletion and deforestation. It requires active polices to reverse the decline in carbon sinks and increase their potential to remove GHGs from the atmosphere (carbon removal/negative emissions).

On bioenergy explicitly, the CCC has acknowledged that its role in climate change mitigation is controversial, but sees a role for it combined with CCS from the 2030s onwards. In their scenarios, the CCC plots bioenergy displacing fossil fuels in a range of applications up to 2030, after which it is diverted to CCS 'as this provides the greatest reduction in GHG emissions'. Achieving optimal deployment of bioenergy has been identified as having the potential to reduce UK energy system costs by £42bn by 2050.

However, simple assumptions around the carbon neutrality for biofuels are proving controversial and the wider environmental and economic impacts need to be scrutinized very carefully. Following this, an improved regime for the accounting of biomass used in low carbon energy generation is urgently needed.

In a global context, WWF has previously observed[3] that bioenergy has the 'potential to provide sustainable livelihoods for millions of people, particularly in Africa, Asia and Latin America. However, if produced unsustainably its environmental and social impacts can be devastating'. In their scenario for a renewable energy system in 2050 WWF noted that the 'apparent need for large amounts of land for bioenergy is the hardest part of the scenario, that produces the hardest challenges and raises the hardest questions'. On the one hand, they envisaged biomass providing 60% of industrial fuel and heat requirements (as well as significant transport needs) in areas such as aviation and shipping, but acknowledged that without proper safeguards these may displace food crops, reduce biodiversity and drive deforestation (as well as competing for water resources). WWF had estimated that there is enough agriculture and forestland available globally to grow biofuels sustainably, utilising around one sixth of total global cropland.

Nonetheless, *this assumption rests on a constrained growth in meat consumption and limited growth in areas such as aviation and shipping.*

In June 2017, however, WWF published a new position paper[4] as part of the discussion around the European Commission's proposed new criteria for sustainable bioenergy. The policy brief that accompanied it called for a full lifecycle assessment on all biomass used in the EU, in the absence of which the Commission should substantially tighten the regulatory oversight for bioenergy in the EU.

It is highly plausible that the technical debate over sustainable bioenergy will spill over into global political debates on many other issues related to decarbonisation strategies for "green growth". However, as already noted, a full consideration of the developing technical literature on all the wider, global implications, is beyond the scope of the current report.

Emissions from Waste and F-gas reduction – (Non-CO_2)

Emissions from waste account for almost 4% of total UK GHG emissions. These are mainly made up of methane emissions from the decomposition of biodegradable waste in landfill sites, in the absence of oxygen. Waste emissions fell by 7% in 2015, a slower reduction than in the recent past as emissions fell by 11% on an annual average basis between 2009 and 2014. Since 1990, however, emissions from waste have fallen by 73% and these reductions have mainly been due to a large reduction in organic waste going to landfill, as well as investment in methane capturing technology and improved management at landfill sites. CCC analysis suggests that between 2015 and 2030, waste emissions could fall by 53% driven by measures to reduce landfill emissions. But as separate collection and recycling rates in the UK begin to plateau, continued pressure will be needed.

Fluorinated gases (F-gases), meanwhile, accounted for around 3% of total UK emissions in 2015. While F-gas emissions come from various sources, they are mainly used as refrigerants in air conditioning and refrigerators, and are typically released due to leakage from appliances. According to the CCC's analysis from June 2017, emissions from F gases remained largely flat in 2015. The EU-F-gas regulation is aiming to cut hydrofluorocarbons (HFCs) sales, the main source of emissions, by 79% from 2015 EU levels by 2030.

RECENT UK AND EU POLICY DEVELOPMENTS

Agriculture and LULUCF

As with many other sectors the role of EU policy, particularly the Common Agricultural Policy (CAP), has been central to shaping UK policy. Indeed, the House of Commons Environmental Audit Committee has called on the Government to commit to a new Environmental Protection Act at the early stages of leaving the EU to maintain strong environmental and related standards, particularly related to the agricultural sector[5].

The voluntary Greenhouse Gas Action Plan (GHGAP) is the UK's principal mechanism for delivering the farming industry's commitment to a reduction in annual emissions of 3MtCO2e by the third carbon budget period (2018 – 2022). Established in 2010 this partnership aims to improve awareness amongst farmers and growers of GHG emissions and to drive the implementation of on-farm education practices[6]. This partnership should be re-examined in light of Brexit.

Note should also be taken of Dieter Helm's paper on the distortions of a subsidy system for farmers and the need for change to a public good model post CAP[7] (see Brexit appendix below).

BOX 5.1 – The Scottish Government's Focus on Forestry and Peatland

The Scottish Government has signalled its ambition[8] for Scotland to be among the lowest carbon and most efficient food producers in the world. They plan to help farmers use fertiliser efficiently and undertake farm carbon audits.

The Scottish Government's LULUCF ambitions focus on forestry and peatland. For peatland, by 2030, 250,000 hectares of degraded peatland will have been restored. By 2032, Scotland's woodland cover will increase from around 18% to 21% based on increasing planting rates. There will also be a planned increase in the use of Scottish timber in UK construction, up from 22 to around 3 million cubic metres by 2031/32. The CAT zero carbon scenario for the UK also involves restoration of peatlands and substantially expanding forested areas. It also includes a significant shift in agricultural land use *away from livestock grazing* towards growing second generation energy crops (while all cropland would continue to be used for food production).

Sustainable Bioenergy: electricity, heat and transport

UK policy on bioenergy has also been heavily shaped by EU policy, not least the binding 20% target for final energy consumption target from renewable sources by 2020 contained in the current EU Renewable

Energy Directive. In November 2016, the European Commission published its proposals for new sustainability criteria for most types of bioenergy. The proposal included the following:

> To be considered sustainable, biofuels must achieve GHG savings of at least 35% in comparison to fossil fuels. This savings requirement rises to 50% in 2017. In 2018, it rises again to 60% but only for new production plants[9].

Building on this, a target of 27% renewable energy by 2030 was proposed by the European Commission in late 2016. The EU has aimed for 10% of the transport fuel of every EU member to come from renewable sources such as biofuels. There are sustainability criteria for biofuels, indicating the need for them to represent a 50% GHG lifecycle saving compared to fossil fuel along with restrictions on the land from which they may be obtained[10]. There has also been an EU directive on indirect land use change[11] aiming to minimise the impacts associated with the diversion of land to biofuel from food production and discussion on its inclusion within relevant carbon accounting processes.

POTENTIAL SOLUTIONS

Increasing the carbon-absorption of soils

Reducing nitrogen oxide emissions from soils could be achieved through the better application of manure and fertilizer whilst soil compaction (which can reduce the ability of soils to absorb methane and other GHGs) should be addressed as a priority, with over 20% of the UK's arable and grassland area assumed to be compacted.

Reducing emissions from crops, meanwhile, would involve improving the efficiency of nitrogen use through the planting of specialized crop varieties, the targeted timing of fertilizer uptake and the accurate matching of crop requirements to soil and climate conditions, through the use of precision farming and other technologies.

The French Ministry of Agriculture is currently promoting a '4 per 1000' initiative[12]. This aims to increase the amount of CO_2 captured by soil by four grams per kilo. Alongside restoration of degraded soils, it looks to work the soils in less damaging ways, plant more hedges and increase the amount of grazing land and plant cover. These measures are part of the solutions the CCC envisage for the UK in increasing the carbon removal capacity of LULUCF.

Considering UK food self-sufficiency and dietary changes

In the CAT 2030 'zero carbon Britain' scenario[1314] there is recognition of the need to reduce emissions from agriculture and to take account of new demands on land to fuel some parts of the transport system, and to capture carbon. Their proposed use of domestic land only to provide food, energy and resources for the UK sets a challenging criterion for a truly net zero carbon UK. CAT also envisage significant changes in agriculture use, with grassland used for grazing livestock reduced by 75% (reflected in dietary changes) and constrained air travel. They also envisage restoration of important habitats such as peatland and the substantial expansion of forested areas to capture carbon and provide wood for buildings and infrastructure.

In its sectoral analysis report, the CCC notes that there are significant opportunities to reduce emissions through changed consumer behaviour. Specifically, on dietary change it notes that:

> A rebalancing of diets away from more carbon-intensive products *such as red meat and dairy products* can potentially deliver emissions savings, while providing research would be required to understand the links between diet and emissions, and to understand how changes in the domestic diet alone influence UK agricultural emissions. UK farmers may respond by increasing exports, rather than changing to less carbon-intensive production.'

The CCC drew on a significant study from the Netherlands which reported a 4-11% GHG reduction based on a cohort study, substituting 35g per day of vegetables/fruit-nuts-seeds/pasta-rice-couscous/fish for 35g of meat[15].

Reducing emissions from UK farms and livestock

Emissions from livestock could be reduced by improving the diets of sheep and cows to reduce enteric methane through specialist advice, the CCC indicates that there is scope for improvement particularly in the 58% of grazing farms who rarely use nutritional advice. Other dietary factors such as additives can also reduce methane.

Adding acid to slurry can also reduce methane formation and improve nitrogen content and there is also scope for the wider application of anaerobic digestion.

The CCC has also identified measures for improved energy efficiency in agricultural buildings and stationary machinery, including glazing greenhouses, improved insulation and temperature control in pig housing and grain stores.

Reducing emissions from waste and F-gases

In terms of emissions from waste, the landfill tax and much better municipal collection of organic waste has contributed to a serious reduction of direct emissions of methane from landfills, the increased prevalence of anaerobic digestion and energy-from-waste plants is a testament to this – even though the later may always align with the principles of the waste hierarchy.

The CCC noted that the polices required in order to meet fourth and fifth carbon budgets included:

- Strengthened approaches through the waste chain, from creation to disposal, including reducing waste arising, more separate collections (e.g. of food waste), stopping biodegradable waste going to landfill, and maintaining or increasing methane capture at landfill sites

The UK needs to reduce its F-gas emissions by at least 68%, in line with the EU regulatory minimum and the CCC has called on the government to investigate and pursue any further cost-effective opportunities. In terms of F-gases from agriculture specifically (where a large amount occur), the existing approach agreed at EU-level must be clarified and participation should either continue in the EU scheme, or should be replicated in the UK to deliver emissions reduction in-line with the target.

Increasing afforestation and restoring peatland

Increased afforestation is the best-known way to boost carbon sequestration from land use and there are a number of plans in place in the UK already. For example, England plans to increase its woodland coverage from 10 to 12% by 2060, even though current progress is said to be falling well short of this ambition.

The CCC Max scenario involves increasing the rate of tree planting to around 30,000ha per year to deliver 3.7MtCO2e of savings by 2030. This is, clearly, an ambitious target.

As discussed elsewhere in this document, peatland restoration offers significant abatement potential. This assumes that policy support would include both finance and awareness raising.

Encouraging wood in construction, as a carbon sink

There is a significant opportunity to increase the rate of carbon removal *and decrease emissions* from the construction sector by the innovative and more widespread use of wood in construction, as a substitute for more high-emissions materials. A core benefit of using sustainably-sourced wood in construction is its ability to capture carbon from the atmosphere and store it for long periods in the timber used in buildings. In some cases, it can also have the additional benefit of displacing the use of cement and steel, which are much more carbon intensive in their production.

A study by the Edinburgh Centre for Carbon Management commissioned by the Forestry Commission Scotland[16] examined the carbon reduction benefit of using increased timber in the construction of new homes, by comparison with typical building materials. It shows that it is possible to achieve up to an 86% reduction in GHG by increasing the specification of timber. The analysis also indicates that the greatest carbon savings occur when timber is sourced locally. Overall, this serves to illustrate important relationships between sectors and therefore the value in a holistic and strategic assessment of the opportunities associated with UK land use.

SUSTAINABLE BIOENERGY WITH CCS (BECCS)

As noted in the introduction, a key finding of our review into the possibility of reaching net-zero emissions (or very near net-zero) by 2050, in the UK, is that significant negative emissions (or "carbon removal") will be required. An option for the UK is to combine the need for additional carbon sinks, in the form of afforestation and other potential options (discussed below), with the production of sustainable feedstock which could then be used for power or heat generation – or even as fuel for transport. If fitted with Carbon Capture and Storage (CCS) technologies this could provide an additional source of renewable energy for the UK. The suite of technologies, including the specific feedstuff that would suit combustion is known as *Bioenergy with Carbon Capture and Storage* (BECCS).

As noted in the power chapter, the CCC do not envision BECCS as a power source for the UK until well into the 2030s. Although this would mean that significant policy and investment decisions would need to be taken in the 2020s. CCS is far from being a mature technology at scale, as discussed in the industry chapter. Investment is urgently required here as well, as noted by the CCC in its sector analysis.

It is to be emphasised that BECCS is only *one* potential source of low carbon generation, although opinions vary as to what form baseload capacity will take in 2050, as we explain in our power chapter, above. As noted in the section on afforestation, however, the additional *carbon sinks* (equivalent to around 30,000 ha per year of additional woodland), up to 2050, are a non-negotiable when it comes to delivering the carbon removal the UK needs to achieve net-zero emissions by 2050. The extent to which these 30,000 ha then become feedstock for BECCS (in the context of a global market) is a key question for policymakers in terms of attracting the required investment and technologies progress needed. And woody biomass is, of course, only one potential feedstuff for BECCS. As this report suggests a portfolio approach to low carbon technologies, we now consider the potential opportunities and challenges that BECCS presents. A full strategy for the bio-economy – which we argue is needed – would be able to "join the dots" between the complex needs of the power, heat, transport and construction sectors and the huge variety of different potential options for carbon sinks that the UK could seek to develop between now and 2050: from forestry to algae and other energy crops.

In this section, we briefly re-cap our main scenarios, noting that our "Modified Max, Low carbon removal" scenario does *not* achieve zero emissions by 2050. Barring an unforeseen technological breakthrough, this

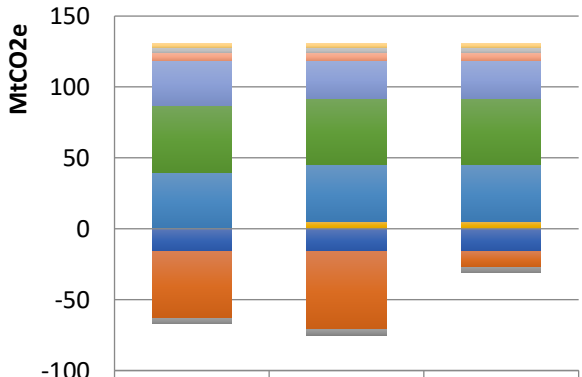
is the basis for our claim that *zero emissions by 2050 for the UK will not be possible without recourse to significant carbon removal*. In terms of BECCS, questions as to whether woody biomass and other sources of bioenergy are indeed low-carbon sources of electricity, as well as questions around the share of the global market for *sustainable* biomass the UK could rely on, are central to policymaking.

Below we reproduce the pathways for UK carbon sinks based on the three scenarios considered in this report: the CCC max scenario, our "Modified Max" scenario and our "Modified Max, low carbon removal" scenario. We include Peatland as a *source* of emissions from LULUCF, for the reasons given above. As Peatland does not appear in the current CCC figures, this does not apply to the CCC Max scenario. For the reasons explained below (and stated briefly in the introduction), our "Modified Max" scenario contains a *greater* potential for BECCS in the UK, and so a gives a higher figure for negative emissions than the CCC Max Scenario, despite the inclusion of Peatland as an extra source of emissions.

	2050 CCC Max	2050 Modified Max (MM)	2050 MM Low carbon removal
Peatland	**N/A**	**5**	**5**
Wood in construction	**-4**	**-4**	**-4**
BECCS	**-47**	**-55**	**-11**
LULUCF	**-16**	**-16**	**-16**
2050 – TOTAL CARBON SINKS ("negative emissions")	**-67**	**-70**	**-26**

When we add these scenarios for LULUCF, Peatland, Wood in Construction and BECCS to the other sources of emissions for 2050 we arrive at the following, illustrated by Figure 7 (shown also in the introduction).

Figure 7: 2050 emissions levels $MtCO_{2e}$: (CCC Max, Modified Max and "Modified Max Low carbon removal")



	CCC Max scenario	Modified zero carbon	Reduced biomass
Power	3	3	3
Heat in buildings	4	4	4
Surface transport	5	5	5
Industry	32	27	27
Non CO2	47	47	47
IAS	40	40	40
Peatland	0	5	5
Wood in construction	-4	-4	-4
BECCS	-47	-55	-11

From this, it is clear to see that discounting the negative emissions often associated with BECCS up to 2050 gives a much higher 2050 net-emissions value than in the CCC Max or "Modified Max" scenarios. Far from achieving a Paris-compliant net-zero emissions ambition by 2050, then, without these negative emissions, the UK would still be emitting substantial net GHG in 2050 based on these scenarios.

It is, therefore, to be underlined that the carbon removal/negative emissions the CCC has included in their scenarios are critical to achieving the UK's ambitions under the Paris Agreement, *with or without* BECCS for heat or power.

We now survey the state of the debate as to the sustainability of bioenergy as a long-term source of low carbon power and/or heat. The debate is a rapidly evolving one with new evidence and opinion emerging at regular intervals. It would be beyond the scope of this report to give a full evaluation of the state of the literature and to pronounce one way or the other. What we aim to do, in what follows, is to summarise the major issues at stake.

Biomass – a polarised debate

Responses to the European Commission's recent policy packages have included the accusation that it is greenwashing existing practice[17] by failing to include lifecycle carbon from forests and fields as well as carbon from indirect land use change. It has also been reported that the fall in Europe's carbon sinks (in modelling) from 2020 to 2030 of around 100m tonnes is partly accounted for by the expected logging for bioenergy where 'industrial scale demand from large power plants was a key contributor.'[18]

A recent Europe-wide study found that the bioenergy potential from any 'spare' land is very low, recognising that land currently under environmental protection and/or currently used for food related production should not be made available for bioenergy[19].

Potential challenges with biomass had been identified in 2011 by the Scientific Committee of the *European Environment Agency*[20] who noted that 'legislation that encourages substitution of fossil fuels by bioenergy, irrespective of the biomass source, may even result in *increased* carbon emissions'. They underlined that to reduce atmospheric carbon (without sacrificing other human needs) bioenergy must increase *the total amount of plant growth*, thereby making more plant material available for energy use, or it must be sourced from waste material that would not otherwise sequester carbon. In conclusion, they stated that 'The potential consequences of this bioenergy accounting error are immense'.

The recent European Commission working document on the sustainability of bioenergy[21] noted the wide variation in greenhouse impacts found in studies (from very positive to very negative) and concluded that:

> While an assessment of the overall greenhouse gas impact of an increase of demand in forest biomass is possible, and has been modelled, a reliable assessment of lifecycle biogenic emissions of specific consignments or pathways of forest biomass would be extremely difficult, notably because it would have to be based on subjective choices. In addition, it would pose difficulties linked to verification. Therefore, this option is discarded.'

Meanwhile, a major study by a collaboration of NGOs in 2014[22] examined the potential for woody biomass supply in the EU to 2020 and 2030 based on three scenarios; examining the overall bioenergy system including both life-cycle emissions and changes to carbon stock emissions. The reference scenario envisaged overall demand for wood increasing, whereas the GHG reduction and sustainability regimes assume that more stringent energy efficiency measures are in place and higher renewable energy targets (with the sustainable scenario reducing forest bioenergy use to avoid associated risks while mobilising roundwood for additional wood use e.g. in new buildings). In the reference scenario, net sector emissions were 59-116 MtCO2e with ranges of -40 to +8 Mt and -45 to -33Mt in the GHG and SUS calculations. The report concludes that sustainable forest biomass *could* meet woody material demands if resource efficient cascades were used in conjunction with energy efficiency action.

A group of NGOs led by Birdlife published a report in 2015[23] echoing the need for making resource efficiency and the cascading use of limited biomass resources a priority. Relatedly they also cited evidence that growing crops on arable land to produce biofuel is linked to displacement of food production and emissions from indirect land use change. Furthermore, biodiesel produced from crops has a carbon footprint that is worse or not much better than fossil fuels, when accounting for direct and indirect land use change emissions. They also favoured district heating systems using locally sourced sustainable biomass as a more efficient use when compared to biomass in existing coal fired plants (either alone or co-fired with coal).

In February 2017, Chatham House published a series of reports on the impacts of global demand for woody biomass on climate and forests. The report author concluded that current biomass policy frameworks are not fit for purpose[24], leading to higher emissions once emissions from the combustion of woody biomass were properly accounted for and the carbon payback period taking into account. The report's conclusions were broadly supported by a *European Academies Science Advisory Council* report, published in May 2017[25].

Energy Technologies Institute (ETI) - Prospects for more biomass

On the other hand, a recent study by the Energy Technologies Institute[26] highlights the possibility of significant *additional* carbon removal/negative emissions coming from BECCS in an application that could be deployed by 2030, based on a 'feedstock planting rate of 30,000 ha per annum combined with moderate imports'. The study envisages scenarios in which second generation feedstocks, such as Miscanthus, are employed. This approach was said to offer potential advantages over current crops in terms of yield, potential greenhouse gas savings, as well as offering wider biodiversity benefits. This study forms the basis of our calculation in our "Modified Max scenario".

The CCC's sector analysis (referenced above) had the following to say about sustainable bioenergy:

> Sustainable bioenergy can play an important role in reducing emissions where alternative options are very limited. However, there are limits to sustainable supply (e.g. this could provide around 10% of primary energy in 2050), so its role must be supplementary to other measures. It should be targeted at options where it has the largest impact on reducing emissions. Our analysis to date indicates that use should preferentially be as wood in construction or use of bioenergy with CCS and/or displacing coal, with further potential for use where alternative low-carbon options are not available (e.g. aviation). The Committee's estimates of sustainable bioenergy supply suggest that use with CCS would provide an extra emissions reduction of around 20 to displace gas in heat for industry and buildings.

Alternatives sources of carbon removal: e.g. algae

While BECCS and afforestation are commonly proposed as means of achieving emissions reductions, there are alternative approaches which may develop into preferred options. For example, a recent review of CO_2

removal methods[27] referenced ocean based methods (including the cultivation of seaweed) and suggested that the most environmentally benign option for large scale CO_2 removal might be through direct air capture. Gas that is captured on ion-exchange resins can be subsequently released and stored underground.

Algae have also received considerable attention in terms of bioenergy potential. Advantages cited (when compared to 'traditional' energy crops) include higher productivity and the lack of competition for arable land.[28] The Global CCS Institute has also noted algae's particular advantages as being faster growth rates, the ability to use saline or waste water and the lack of reliance on arable land (thereby avoiding competition with food crops). They also note, however, that algae costs more than other second generation biofuel crop, due to high capital and operating costs.[29]

Areas for further biofuel research and development identified by the Carbon Trust[30] included woody/grassy crops with higher yields on marginal land, advanced biofuels demonstration, proof of integrated gasification systems at scale, and high efficiency bio-power systems that are robust to a variety of feedstocks and ready for CCS. These complement areas identified by the Liberal Democrats for further research[31].

Global demand pressures on sustainable woody biomass

The UK's forests don't currently produce enough material to use in biomass electricity generation, one reason that the UK has become the world's largest importer of wood pellets, at 15.5 million tonnes in 2015[32]. Concerns have been raised about its sustainability, particularly in relation to US forests, which represent the single biggest source of feedstock. A study of the forests in several South-Eastern states of the US[33] explored the amount of biomass (primarily wood) that is available on a sustainable basis for large-scale electricity generation and the impacts of its use over time in terms of GHG emissions. They found that, notwithstanding a lack of information in key areas, that there is likely to be enough wood supply consistent with US federal renewable standards requiring increased biomass. They note that the capacity to access and utilise residues (for generation) is, naturally, also a function of the total amount of roundwood being grown and harvested and, therefore, the extent to which biomass plants transition from residues towards roundwood is a function of the strength of the rest of the forest industry.

Of particular relevance to the UK is the related observation that 'pellet production, especially the export market to Europe, will continue to be the wild card in future wood fuel markets.' In terms of global emissions, the report authors found that the projected expansion of biomass for electricity generation produced a significant long-term atmospheric benefit, *with a 35-50 year carbon debt period before yielding on-going benefits relative to fossil fuels*. It is important to note that this is a very significant caveat, since it may indicate increased (rather than reduced) near-term atmospheric carbon emissions. Clearly there is more work required in this area.

The European Environment Agency (EEA) concluded[34] that bioenergy policy and targets should only be based on *additional* biomass that reduces greenhouse gas emissions, without displacing other ecosystem-services such as food production. A coalition of NGOs has built on the EEA work to develop a set of overall policy recommendations[35]. These include:

- Implementing a cap on the use of biomass for energy production to levels consistent with sustainable supply
- Ensuring the optimal use of biomass resources, in line with the principle of cascading use
- Utilising full carbon lifecycle accounting
- Introducing comprehensive sustainability criteria

They also highlighted the importance of complementary policies to reduce the pressure on biomass resources such as reuse and recycling of biomass resources, reducing energy demand, improving agricultural yields, and investing in integrated food/energy systems.

A very recent, and important, contribution to the bioenergy debate was the March 2017 report for the *Department for Business Energy and Industrial Strategy (BEIS)* 'Biomass Feedstock Availability'[36]. This work is an update of the 2011 bioenergy study that has been used as the basis of CCC BECCS scenario formulations. An improved and updated model is described alongside an assessment of its application to UK and global bioenergy resource availability to 2050. It includes additional consideration of feedstock and land use issues and makes allowance for inclusion of emissions arising from indirect land use change (ILUC). In the current assessment, ILUC values have not been included 'as there are currently no widely accepted values for ILUC emissions'.

The updated BEIS modelling shows a significant *reduction* in the amount of sustainable biomass that is likely to be available to the UK as well as significant reductions of UK sourced biomass such as perennial energy crops. Taking central estimates from across the various scenarios yields an estimate of *overall reduction of available biomass of around 80% compared to the 2011 study*.

CONCLUSIONS

Clearly the discussion around sustainable biomass and the role of BECCS in a post-2030 decarbonised energy mix are central to the policy debates to come. Whatever is decided, it is necessary that the right policies are in place as soon as possible to attract the investment required. This may well require further research into carbon payback periods.

Alongside the need for energy efficiency to be given the status of national priority, afforestation rates need to rise very substantially across the whole of the UK almost every year for the coming decades. The Forestry Commission has already highlighted its concerns of the current low rate of afforestation in the UK, which has been falling in the last few years. The increased carbon removal/negative emissions associated with

increased woodland coverage are essential if the UK is to meet its targets under the Paris Agreement. A target of 30,000ha per year of additional woodland coverage will be a significant challenge for the UK to deliver – whether or not this is combined with BECCS.

The complex impact of Brexit on UK agriculture can provide an impetus for action in the sector to help it decarbonise in the ways described above.

On top of this, the CCC has identified the following as major priorities for LULUCF, Bioenergy and Agriculture.

- Setting out a clear and strong ambition, providing a credible signal to the future path for these sectors.
- Engaging agricultural industry bodies to develop effective action particularly where measures could also save farmers money, improve productivity and increase resource efficiency.
- Addressing the non-financial barriers preventing the industry from moving towards low-carbon practices (e.g. lack of awareness of options, uncertainty and scepticism over outcomes).
- Coordinating efforts across the devolved administrations to ensure all nations play a part in delivering the overall UK ambition.

REFERENCES

[1] Given its central role in setting carbon budgets, the UK greenhouse gas inventory is subject to continual review. An estimated 3% uncertainty in the current figures makes it one of the more reliable national datasets: (May 2017 NPL report for the CCC https://www.theccc.org.uk/wp-content/uploads/2017/06/Understanding-the-UK-Greenhouse-Gas-Inventory.pdf). This ongoing process also involves applying improved methodologies to historic inventories to arrive at updated 1990 baseline figures. In February 2017 BEIS published: (https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2015) an updated greenhouse gas inventory with a 1990 baseline revised up from 797 to 799 $MtCO_{2e}$ for example. It is important therefore to exercise care when looking at percentage reductions against baseline (especially in older reports) to ensure comparisons are made consistently. For the purposes of these tables, we have made our own assessments of how to allocate the figures so as to aid comparison alongside the five chapters. We have done our best to ensure comparability

[2] The CCC, Fourth Carbon Budget, Chapter 7. https://www.theccc.org.uk/archive/aws2/4th%20Budget/4th-Budget_Chapter7.pdf

[3] WWF, The energy report WWF 2011: http://www.ecofys.com/files/files/ecofys-wwf-2011-the-energy-report.pdf

[4] WWF Policy Briefing: (2017) "EU Bioenergy Policy" http://www.wwf.eu/media_centre/publications/?302612/EU-bioenergy-policy---position-paper

[5]House of Commons, Environmental Audit Committee, January 2017: https://www.publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/599/599.pdf

[6] The Greenhouse Gas Action Plan, Roadmaps for different sectors, Progress report and Phase II Delivery, April 2012: http://www.ahdb.org.uk/projects/GreenhouseGasActionPlan.aspx

[7] British Agricultural Policy after BREXIT, Natural Capital Network – Paper 5, 1st September 2016, Dieter Helm: http://www.dieterhelm.co.uk/natural-capital/environment/agricultural-policy-after-brexit/

[8] Scottish Government, DRAFT CLIMATE CHANGE PLAN, The draft third report on policies and proposals 2017-2032: http://www.gov.scot/Publications/2017/01/2768

[9] European Commission 2016: http://ec.europa.eu/energy/en/topics/renewable-energy/biofuels/sustainability-criteria

[10] Biofuel sustainability criteria: https://ec.europa.eu/energy/node/73

[11]EU Directive on indirect land use: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015L1513

[12] The '4 per 1,000' initiative brings climate action and agriculture together: http://4p1000.org/understand

[13] Zero carbon rethinking the future, CAT 2013
[14] Zero Carbon Making it Happen CAT
[15] Biesbroek S et al (2014) 'Reducing our environmental footprint and improving our health: greenhouse-gas emissions and land use of usual diet and mortality in EPIC-NL: a prospective cohort study'
[16] August 2006, http://scotland.forestry.gov.uk/images/corporate/pdf/carbon-benefits-of-timber-in-construction-2006.pdf
[17] *Sini Eräjää, EU Bioenergy Policy Officer,* Birdlife Europe and Central Asia *and the* European Environmental Bureau*, November 2016*: http://www.eubioenergy.com/2016/11/30/a-dirty-day-for-the-commissions-clean-dream/
[18]Guardian article on bioenergy problems, November 2016: https://www.theguardian.com/environment/2016/nov/24/protected-forests-in-europe-felled-to-meet-eu-renewable-targets-report
[19] Space for energy crops, 2014: http://www.eeb.org/EEB/?LinkServID=F6E6DA60-5056-B741-DBD250D05D441B53 This study focuses on the scope for additional production of energy crops in Europe
[20]SC OPINION ON GREENHOUSE GAS ACCOUNTING IN RELATION TO BIOENERGY - 15 SEPTEMBER 2011: HTTP://WWW.EEA.EUROPA.EU/ABOUT-US/GOVERNANCE/SCIENTIFIC-COMMITTEE/SC-OPINIONS/OPINIONS-ON-SCIENTIFIC-ISSUES/SC-OPINION-ON-GREENHOUSE-GAS/VIEW
[21] Sustainability of Bioenergy, European Commission, November 2016: http://eur-lex.europa.eu/resource.html?uri=cellar:1bdc63bd-b7e9-11e6-9e3c-01aa75ed71a1.0001.02/DOC_1&format=PDF
[22] Forest biomass for energy in the EU: current trends, carbon balance and sustainable potential for BirdLife Europe, EEB, and Transport & Environment, 2014: http://www.eeb.org/EEB/?LinkServID=FE1EAF33-5056-B741-DBEF3F46BC26A1E1
[23] pitfalls and potentials, the role of bioenergy in EU climate policy post 2020: http://www.birdlife.org/sites/default/files/attachments/Bioenergy_post_2020_NGO%20recs.pdf
[24] Duncan Brack, Chatham House, 2017, https://www.chathamhouse.org/publication/woody-biomass-power-and-heat-impacts-global-climate
[25] European Academies Science Advisory Council (2017): http://www.easac.eu/home/press-releases/detail-view/article/managing-eu.html
[26] Bioenergy with CCS, ETI, November 2016: https://d2umxnkyjne36n.cloudfront.net/insightReports/The-Evidence-for-Deploying-Bioenergy-with-CCS-in-the-UK.pdf?mtime=20161107110603
[27] Nature, February 2016, http://www.nature.com/news/emissions-reduction-scrutinize-co2-removal-methods-1.19318
[28] Placing microalgae on the biofuels priority list: a review of the technological challenges, H. C. Greenwell, L. M. L. Laurens, R. J. Shields, R. W. Lovitt, K. J. Flynn, December 2009: http://rsif.royalsocietypublishing.org/content/7/46/703
[29] Global CCC Institute: https://hub.globalccsinstitute.com/publications/novel-co2-capture-taskforce-report/211-algal-bio-sequestration
[30] Carbon Trust, Key findings of the Technology Innovation Needs Assessments (TINAs), 2012: https://www.carbontrust.com/resources/reports/technology/tinas-low-carbon-technologies/
[31] The Green Manifesto, How to increase living standards, improve quality of life and future-proof the economy, Boyle et al , 2014: https://www.mrw.co.uk/Journals/2014/03/11/h/y/b/20140311-Lib-dems-Green-Manifesto.pdf
[32] Carbon Brief, February 2017: https://www.carbonbrief.org/biomass-subsidies-not-fit-for-purpose-chatham-house
[33] SE USA Forests, 2012: https://www.southernenvironment.org/uploads/publications/biomass-carbon-study-FINAL.pdf
[34] EEA scientific opinion on bioenergy, 2011: http://www.eea.europa.eu/about-us/governance/scientific-committee/sc-opinions/opinions-on-scientific-issues/sc-opinion-on-greenhouse-gas/view
[35] Pitfalls and potentials, the role of bioenergy in EU climate policy post 2020:
[36] The UK and Global Bioenergy Resource Model estimates the potential sustainable bioenergy resource that may be available to the UK to 2050: https://www.gov.uk/government/publications/uk-and-global-bioenergy-resource-model

APPENDIX 1: Financing the Transition

THE NEED FOR SPEED ON GLOBAL LOW CARBON INFRASTRUCTURE

"The next couple of decades, and particularly the next two or three years, will be critical to the future of sustainable development." Lord Stern, Global Commissioner for Economy and Climate, 2016

If it is to have any chance of meeting the ambitions of the Paris Agreement without giving up on continued economic growth, the global economy needs to rapidly increase the amount of capital going into low carbon infrastructure. In autumn 2016 the Global Commission on Economy and Climate, which is partly led by Lord (Nicholas) Stern estimated that even to continue on a high-carbon "business as usual" scenario, investments totalling about US$90 trillion would be needed in infrastructure over the next 15 years, *more than is in place in our entire current stock.* The good news, the report went on to say, is that making sure that these investments went into low carbon infrastructure would not require a great deal of *additional* investment.

On the downside, the Global Commission recognised that "a single green infrastructure project can require dozens of financial institutions, all with their own demands, and take more than a decade to build. The cost of project preparation is substantial, typically 2.5–5% of total investment. And the risk-return ratio for sustainable infrastructure is often too high to attract private capital."

The headline recommendations coming out of the report "Financing for Better Growth and Development" were as follows:

1. **Tackle fundamental price distortions through fossil fuel subsidy reform** and carbon pricing. Fossil fuel subsidies amounted to around US$550 billion in 2014, skewing investment away from sustainable options.
2. **Strengthen policy frameworks and institutional capacities**. Better planning and governance can ensure the right projects are selected in the first place, and the right financing is used at the right time.
3. **Transform the financial system** through new tools like green bonds and green investment banking, and by greening the existing financial system, including through corporate climate risk disclosure.
4. **Ramp up investments in innovation** and deployment of clean technologies to reduce the upfront costs of sustainable infrastructure.[1]

We think these recommendations are a good place to start – and a good way to consider the specific challenges and opportunities facing the UK as it steps up efforts to meet its legally binding climate ambitions and – ideally – go beyond them.

THE UK'S INFRASTRUCTURE NEED

The ongoing challenge of meeting investment from public funds means that there has been a recognition that around 50% of the UK's required infrastructure pipeline will be delivered through private sector finance[2].

Despite the need to reform some aspects of the UK's financial services (FS) sector following the financial crisis of 2008, there is widespread recognition of the positive role the UK's well developed financial services sector can play in supporting (or even driving) the UK's low carbon transformation. Moreover, the development of specific suite of skills, running across the whole FS ecosystem in the UK, should offer significant future opportunities in terms of the global need for low carbon financing and project management, notwithstanding the potential impact of Brexit on the UK's FS sector.

There is cause for optimism on this front when we recognise the recent global progress on integrating sustainability into financial services activity, including a near doubling of green bond issuance to $81billion last year (compared to 2015). 2016 was accordingly termed 'the year of green finance'[3]. The London has been acknowledged as a global hub for green finance although sustainability has still been classified as a 'sleeping giant' of the financial system[4].

BARRIERS TO FINANCING DECARBONISATION

Notwithstanding recent progress there are concerns about the barriers faced to financing decarbonisation through the private sector. Chief among these is the need for urgency and very clear policy direction to avoid technological lock in and stranded assets. For example, to effectively decarbonise electricity generation, transport and heat (while taking into account stock turnover), it has been reported that all new investment needs to be "green" by around 2020 for electricity (and by around 2035 for transport and heat)[5]. As we have regularly highlighted throughout this report. The 2020s are a critical decade for the low carbon transition and the FS sector needs to step up quickly to respond to the challenges. In order to ensure this can happen, policymakers need to ensure they keep the needs of investors firmly in mind.

For example, the market-based regime that was introduced into UK electricity generation has been said to have been configured[6] for investment in fossil fuel based generation. The capital intensity of electricity assets such as generators, transmission lines or transformers, led to the development of financing relationships with utilities and regulators that has favoured large electricity sector businesses and less engagement with private investors such as pension funds.

Furthermore, a relative lack of private finance in clean energy has also been attributed to clean energy's immaturity as an investment class, meaning there is little historical data, leading to higher due diligence costs and/or unfavourable investment terms like higher interest rates[7].

Policy uncertainty over longer term Government commitment has also contributed to increasing the investor perception of risk. The Public Accounts Committee report published on 28th April 2017 has highlighted the potential impact of *unpredictable* decarbonisation policy:

> Throughout this Parliament, several energy policy decisions have similarly damaged investors' confidence. These include cuts to demand-led green tariffs and sudden changes to low carbon support prompted by the failure to forecast an overspend on the Levy Control Framework. Investors are now likely to require greater incentives to engage with the government again on CCS and other low-carbon projects, which will mean higher costs.[8]'

Gaps in SME finance compared to the rest of Europe

There are also specific problems in the UK in getting finance to smaller projects – of the kind the Liberal Democrats are keen to support, e.g. citizen owned renewable energy systems or cooperatives. Recent work by the Carbon Trust has found that low carbon SMEs are facing disproportionate challenges in securing funding – and the situation is getting worse[9].

In 2013, the Government estimated that there was a gap of £22 billion in SME finance and the British Business Bank was set up as a government-owned development bank dedicated to making financial markets work better for smaller businesses.

The Bank's operations cover a range of financial service providers including higher risk/return operations such as venture capital. Nevertheless, a recent study[10] indicated that credit conditions for SMEs remain *less favourable* in the UK than in several comparable countries in Europe. It went on to examine the local banking models outside the UK that operate with a specific remit to promote local economies and recommended that the British Business Bank should act as an investor in local banks in the UK, in a supportive network based on the *Sparkassen* model in Germany.

The Sparkassen model is viewed as being favourable to smaller enterprises (such as those that might be engaged in community energy and retrofitting) since it has an explicit remit to support communities, built on local knowledge and, while still profit making, is not under the same pressure exerted on large listed banks. An early example of this approach being undertaken in the UK would be the Hampshire Community Bank[11] which was first unveiled in 2013 and is expected to launch in 2017.

POLICY CONSIDERATIONS

The Green Investment Bank (GIB)

In Government, the Liberal Democrats set up the Green Investment Bank (GIB) to mobilise finance from institutional investors and address the significant financing gaps for green technologies[12]. Launched in 2012, it has[13] backed 84 green infrastructure projects, committing £2.7bn to the green economy and has worked with a number of pathfinder organisations to develop financial products that can help accelerate the development of the market.

The current Government's sale of the Bank to Australian bank Macquarie[14], has been met with criticism throughout the process. For example, the TUC commented[15] that privatisation should be halted, and instead it should be given additional borrowing powers while remaining in public hands (echoing the views of Liberal Democrats). A special share arrangement has been made such that, once in private ownership, the banks green remit could only be changed with the agreement of the independent special shareholder. Nonetheless concerns have been raised over restructuring arrangements[16].

By way of contrast Nick Butler has suggested, in the *Financial Times*[17], that a privately owned specialist bank could thrive in the future, by being able to bring in significantly *more* capital and drawing on a global scale of investment to support the renewable energy sector. Even so, Butler noted that:

> [While the energy sector is moving very quickly] the financial sector, with a very few exceptions, has not caught up…conventional financial institutions do not know how to differentiate one possible advance in the business from another and do not understand the market such advances are meant to penetrate. Specialist skills are required, which is the whole justification for a dedicated financial institution.

Building trust between government and market actors had been viewed as a central role of the Bank[18], thereby helping to develop wider skills and capabilities within the private sector. This is a role which might prove more challenging when in private hands and the development of skills across financial services should feature in any overall plan for sustainable finance. It will important to ensure that the GIB remains a source of low carbon financial expertise as well as capital itself.

Pensions Infrastructure Platform

The Pensions Infrastructure Platform (PiP) has also been set up with the support of Government to make infrastructure investment more accessible to UK pension schemes who, despite having total assets of over £190 billion, have not to date invested significantly in infrastructure[19]. The Insurers' Infrastructure Investment Forum was also set up to give Association of British Insurers members a direct link to Government. For example, in December 2016 it announced it had provided £20 million of inflation linked

debt capital to refinance 1911 rooftop solar assets and also acquired a portfolio of 31 individual wind turbines[20].

Fiscal and Monetary activism

Although beyond the scope of his report, there is an interesting and high-level debate taking place surrounding the degree to which government should be using fiscal policy tools to provide a "green stimulus". This is connected to the debates around the leverage available to a now privatised Green Investment Bank. Deficit funded green infrastructure spending has also been discussed in the context of unorthodox monetary policy such as "Green Helicopter Money" or "Green Quantitative Easing[21]" whereby the Bank of England could be given a mandate to "create" money for the purposes of providing long-term capital for green innovations. This is something worth exploring, especially as the literature becomes more sophisticated.

Green Bonds

Liberal Democrat policy[22] to date has also recognised the significant potential of green bonds. Climate bonds (as a more specific type of green bond is called) facilitate investment in climate change measures such as decarbonisation while offering similar risk and return characteristics to regular fixed income investments and have been described by CAT[23] as central to a Green New Deal, for example.

The London based Climate Bonds Initiative have identified a number of ways in which Governments can support and promote the green bond market[24]. They can support work on the development of principles and standards for green bonds and grow demand through guidance to state investment/ infrastructure funds. Tax incentives were viewed as particularly attractive with examples of best practice being cited as the US Government's *Clean Renewable Energy Bonds* (CREBs) and *Qualified Energy Conservation Bonds* (QECBs) where investors receive tax credits instead of interest payments. They also identified channels for public issuance of green bonds including municipal bonds used to finance public transport, water management, and energy and waste management projects.

Green Bonds can also play an important role in supporting energy efficiency projects[25]. For example, *Property Assessed Clean Energy* (PACE) loans in the US have led to the securitisation of energy efficiency finance. Local legislation allows energy efficiency loans on commercial and residential properties to be repaid as part of the property tax bill. These loans can then be pooled together by a local tax authority and subsequently packaged as green bonds.

China became the largest issuer of green bonds in 2016[26] underpinned by the 2015 release of the *Green Financial Bond Guidelines*, accompanied by an Endorsed Project Catalogue making China the first country in the world to have official rules on green bond issuance. The guidelines are accompanied by an Endorsed Project Catalogue defining eligible project types. This is something the UK should watch with interest.

ASSESSING AND MANAGING CLIMATE RISK

The FS sector can support decarbonisation in ways that go beyond just providing capital – they could bring their skills to bear in shaping the transformation itself, ensuring it is as cost-effective as possible. For example, WWF has noted[27] that 'Renewable energy may be carbon free but it's certainly not risk free' adding that 'the skill and experience of insurers is crucial to ensuring that risks are effectively managed and manufacturers are supported to develop the next generation of renewable energy.' Examples of energy efficiency insurance policies are also now appearing whereby the policyholder is compensated when there are shortfalls in energy savings[28] [29].

The LENDERS project, with partners including Nationwide, BRE, UCL and the Green Building Council, is considering the potential for improved domestic energy efficiency to affect lending conditions.[30] This should result more energy efficient homes being allowed larger mortgages. The project uses Energy Performance Certificates as part of the affordability calculations for households on the basis that lower fuel bills would facilitate higher mortgage repayment amounts. The final project report is due to launch shortly and could help stimulate the wider uptake of domestic energy efficiency.

Improved, "Green" Disclosure

There have also been significant developments in terms of financial sector disclosure and climate change. G20 Finance Ministers have recognised[31] that the transition to a low-carbon economy requires potentially disruptive changes across economic sectors and industries in the near term. It thereby poses a potentially systemic risk to financial services. The Financial Stability Board was accordingly tasked with reviewing (through the Taskforce on Climate-related Financial Disclosures) how the global financial sector could take account of climate-related issues, leading to December 2016 guidelines that support voluntary, consistent climate-related financial disclosures[32].

The TCFD recommended broad implementation across financial *and non-financial organisations* over a certain size. In addition, it stated that public- and private-sector pension plans, insurance companies, endowments should provide information to clients and beneficiaries so that they may better understand the performance of their assets and any associated risks. Complementing this work are other financial sector disclosure initiatives such as that of the *Institutional Investors Group on Climate Change*/PRI who have recently developed a climate change framework for private equity[33] that can be used in due diligence.

The adoption of standardised reporting of transition related risks should not only act to provide better information to clients but should assist efforts in the improved, consistent identification and understanding of such risks across financial services, as reflected in Aviva's recent statement that 'We believe that in the first year or two, up-take of the recommendations will be significantly impeded by a lack of sufficiently expert internal staff and external consultants'[34].

Several voluntary initiatives are also now appearing[35]. In January 2017, a group of international asset owners and asset managers launched the Transition Pathway Initiative (TPI) to better understand how the transition to a low-carbon economy affects their investments. The TPI assesses how individual companies are positioning themselves for the transition to a low-carbon economy through a public online tool.

In considering the TCFD disclosure recommendations[36], a recent study by Carbon Tracker and the Grantham Institute[37] explored how ongoing cost reductions in solar photovoltaics and electric vehicles could impact demand for coal, oil and gas. Applying a transition-risk lens highlighted shortcomings in energy company business plans which could have significant consequences for investor confidence.

Public policy and the financial sector

A number of studies have explored how governments can promote financial sector involvement in decarbonisation[38]. McKinsey, to take one, examined how financial instruments might be adapted to enhance liquidity. They concluded that governments should strengthen *sustainability criteria* in both public-procurement processes and public-private partnerships and increase the syndication of the loans that finance sustainable infrastructure projects. On a more local level, Energy for London has been encouraged the provision of support for generation and heat and efficiency networks with potential funding sources including issuance of green bonds and the London Pension Fund Authority, as well as crowdfunding platforms[39].

The Liberal Democrat Green Manifesto has already considered several related elements[40] including the extension of mandatory corporate reporting on social and environmental impacts. In addition, further steps could be taken to institutional investors to integrate environmental, social and governance (ESG) factors into their investment analysis (including stranded asset considerations) along the lines suggested by the TCFB, above. It could be possible to go further in requiring state-owned pension funds to adopt a long-term approach in their investment decisions.

A major UNEP study has also produced a set of priorities for an overall UK Sustainable Financial Strategy in their report on the UK as a leader in green financial services. The UNEP recommendations are broadly consistent with many established Liberal Democrat policy aims. They include:

- Establishing a **Green Bond hub** to take forward the UK's position as one of the top issues of bonds focused on environmental solutions
- **Empowering individuals** with the right information on the sustainability performance of their investments
- **Rethinking mortgage finance** to help reduce energy costs and environmental impacts
- Taking a **system-wide view on environmental risk**, extending the Bank of England's review of insurance to other sectors, such as banking

- Exploring the **green potential of alternative finance**, building on the UK's leadership in areas such as peer-to-peer lending

As mentioned above, a model for this work could be the Chinese guidelines for Establishing the Green Financial System said to represent the most comprehensive policy package globally to support green finance development[41].

An overall financial services strategy for the UK should certainly explore the potential for growth outside the UK, developing on the approach already adopted by HM Treasury for the UK insurance sector. For example, in their 2013 *UK Insurance Growth action plan*, the Treasury committed to training Government officials in the sector to promote its interests (noting that the UK insurance sector is already the largest in Europe and employs around 300,000 people in the UK).

In what follows, we sketch an outline of what a comprehensive green financial services strategy could include.

A COMPREHENSIVE GREEN FINANCIAL SERVICES STRATEGY

As noted in the introduction to this appendix, the transition to a "Zero Carbon Britain" is going to need very significant private sector capital. With this in mind, there are clear opportunities for the Liberal Democrats to develop a comprehensive green financial services strategy.

The primary goal would be to energise parts of the economy that have been less able to raise finance and to grow the sustainable and carbon-neutral parts of their businesses, while ensuring that markets as a whole take climate risk and climate neutrality into account in their overall decision making processes, including in their long-term investment and growth strategies.

A low carbon strategy for the FS sector would draw on the highly-developed UK financial services ecosystem which ranges from asset management and project finance, through to venture capital, private equity and insurance. Development of *expertise* in this area should also offer significant export opportunities for UK businesses as other countries globally pursue decarbonisation, and can help to position the industry as one which provides a genuine benefit to society.

Such a strategy might include:

- Maximising the engagement of UK pension funds to provide long-term, patient capital
- Exploring policy incentives in the use of green bonds
- Winding down the system of fossil fuel subsidies
- Sustainability should be built into the remit of a *new infrastructure bank* - proceeds from the projected £2bn sale of the GIB should be ring-fenced to support energy transition activities.

- The FSB guidelines on risk disclosure for financial services should be adopted by all public-sector bodies as well as pension funds. A keen eye should be kept on developments on mandatory reporting and disclosure in France, with a view to using similar measures in the UK.
- Consideration of UNEP's recommendations for an overall UK Sustainable Financial Strategy
- Local banks should be set up with a supportive network to share information (and risk).

REFERENCES

[1] The Sustainable Infrastructure Imperative: Financing for Better Growth and Development, October 2016, http://newclimateeconomy.net/content/release-transform-financial-system-deliver-sustainable-infrastructure-and-reignite-growth
[2] National Infrastructure Delivery Plan, March 2016 : https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/520086/2904569_nidp_deliveryplan.pdf
[3] http://www.huffingtonpost.com/nick-robins/2017-what-next-for-green_b_14203706.html 2017 what next for green finance
[4] The United Kingdom: Global Hub, Local Dynamics, 2016 - The report concludes that UK leadership in many areas is clear, yet sustainability could be classified as a 'sleeping giant' of the financial system.
[5] Energy Research and Social Science 12 (2016) 5 15 - Financing the civic energy sector: How financial institutions affect ownership models in Germany and the United Kingdom Stephen Hall,, Timothy J. Foxon, Ronan Bolton
[6] Energy transitions and uncertainty: Creating low carbon investment opportunities in the UK electricity sector, Environment and Planning C: Government and Policy - 0(0) 1–17: 2015 - Ronan Bolton, Timothy J Foxon, Stephen Hall
[7] US Department of Energy, Washington, DC (United States) OE/EE—1189 - 7510 2015: http://www.osti.gov/scitech/biblio/1331043
[8] https://www.parliament.uk/business/committees/committees-a-z/commons-select/public-accounts-committee/inquiries/parliament-2015/carbon-capture-storage-16-17/
[9] Carbon Trust, A Must Win, CAPITALISING ON NEW GLOBAL LOW CARBON MARKETS TO BOOST UK EXPORT GROWTH, May 2014: https://www.carbontrust.com/resources/reports/advice/a-must-win-capitalising-on-new-global-low-carbon-markets-to-boost-uk-export-growth/
[10] Community Chest , Duncan O'Leary, Demos. 2015: https://www.demos.co.uk/wp-content/uploads/2015/10/476_1508_Community_Chest_web.pdf
[11] Reference 102 TBC
[12] Green Growth and Green Jobs: Transition to a Zero Carbon Britain, Liberal Democrat Policy Paper 109, 2013
[13] http://www.greeninvestmentbank.com
[14] Financial Times, April 2017: https://www.ft.com/content/360c1478-25a5-11e7-8691-d5f7e0cd0a16
[15] TUC, Powering Ahead: How UK Industry can Match Europe's Environmental Leaders - Economic Report Series, 2016: https://www.tuc.org.uk/sites/default/files/Powering_Ahead_Report.pdf
[16] Concerns over GIB, Business Green, February 2017: http://www.businessgreen.com/bg/news/3003977/mps-raise-formal-concerns-over-green-investment-bank-restructuring-ahead-of-sale
[17] Financial Times, 27 March 2017: https://www.ft.com/content/81c50c2c-83d5-32a1-bd27-bb97cd46a691)
[18] Energy transitions and uncertainty: Creating low carbon investment opportunities in the UK electricity sector, Environment and Planning C: Government and Policy - 0(0) 1–17: 2015 - Ronan Bolton, Timothy J Foxon, Stephen Hall
[19] National Infrastructure Delivery Plan, March 2016: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/520086/2904569_nidp_deliveryplan.pdf
[20] http://www.institutionalassetmanager.co.uk/2016/12/12/246685/pip-completes-debt-refinancing-rooftop-solar-assets-portfolio
[21] Victor Anderson, 2015"Green Money: Reclaiming Quantitative Easing",
[22] Green Growth and Green Jobs: Transition to a Zero Carbon Britain, Liberal Democrat Policy Paper 109, 2013
[23] Centre for Alternative Technology's Zero Carbon Britain
[24] Climate Bond Initiative: http://www.climatebonds.net/policy/policy-areas
[25] IEA Energy Efficiency Market Report 2016
[26] IPEEC 2016 Activity Report: G20 Energy Efficiency Finance Task Group
[27] http://assets.wwf.org.uk/downloads/insurance_renewable_energy.pdf

[28] https://www.munichre.com/HSBEIL/products/energy-efficiency-insurance/index.html
[29] https://www.hannover-re.com/45299/press-releases?show=219146#/overlay/219146
[30] The LENDERS project: http://www.epcmortgage.org.uk/
[31] https://www.fsb-tcfd.org/publications/recommendations-report/
[32] Recommendations of the Task Force on Climate-related Financial Disclosures - December 14, 2016: https://www.fsb-tcfd.org/wp-content/uploads/2016/12/TCFD-Recommendations-Report-A4-14-Dec-2016.pdf
[33] IIGCC PRI, A guide on climate change for private equity investors, June 2016: https://www.unpri.org/news/updated-guide-on-climate-change-for-private-equity-investors
[34] Seeing Beyond the tragedy of horizons: an investor perspective: www.aviva.com/media/upload/Aviva_Tragedy_of_Horizons_Report.pdf
[35] January 2017, Thirteen leading international asset owners and five asset managers with over £2 trillion under management launched the Transition Pathway Initiative (TPI) http://www.lse.ac.uk/GranthamInstitute/tpi/wp-content/uploads/2017/01/Press-Release.pdf
[36] Recommendations of the Task Force on Climate-related Financial Disclosures - December 14, 2016: https://www.fsb-tcfd.org/wp-content/uploads/2016/12/TCFD-Recommendations-Report-A4-14-Dec-2016.pdf
[37]Expect the Unexpected: The Disruptive Power of Low-carbon Technology, Carbon Tracker, March 2017: http://www.carbontracker.org/report/expect-the-unexpected-disruptive-power-low-carbon-technology-solar-electric-vehicles-grantham-imperial/
[38] Financing change: How to mobilize private- sector financing for sustainable infrastructure McKinsey Center for Business and Environment, January 2016: http://newclimateeconomy.report/2015/wp-content/uploads/sites/3/2016/01/Financing_change_How_to_mobilize_private-sector_financing_for_sustainable-_infrastructure.pdf
[39] London: Global Green City, IPPR, April 2016: http://www.ippr.org/files/publications/pdf/london-global-green-city_Apr2016.pdf?noredirect=1
[40] The Green Manifesto, How to increase living standards, improve quality of life and future-proof the economy, Boyle et al , 2014: https://www.mrw.co.uk/Journals/2014/03/11/h/y/b/20140311-Lib-dems-Green-Manifesto.pdf
[41] IPEEC 2016 Activity Report: G20 Energy Efficiency Finance Task Group: https://ipeec.org/cms/21-energy-efficiency-finance-task-group-eeftg-.html

APPENDIX 2 - Brexit and its possible impact

THE IMPACT OF BREXIT – SUMMARY

The decision to leave the European Union throws up several questions around future decarbonisation policy – despite the UK's Climate Change Act and carbon budgets currently committing the UK to more ambitious decarbonations plans than EU policy. The decision will in many areas increase uncertainty around decarbonisation investment and research, where there was already insufficient policy certainty for the coming decade.

The questions are around:

- The UK's continued participation in EU Energy Union and the extent to which interconnection in energy systems will be continued after EU exit
- To what extent the UK will decide to remain in sync with the EU's decarbonisation plans
- Whether the UK remains part of the EU Emission Trading System or if it decides to set up its own parallel emissions trading system to cover UK-only emissions
- If the UK will continue to be part of the Effort Sharing Regulation (ESR), which covers some areas not in the ETS including high emitting sectors such as transport (apart from aviation and shipping) buildings, waste and land use
- Whether or not the UK will seek equivalence with EU standards on fuel quality and efficiency for vehicles
- The extent to which the UK will participate in the EU Circular economy package. Business has developed to a large extent without the support from policymakers on the circular economy, but many had thought that future EU policy in this area would help further circular economy gains.
- It is unclear exactly how Brexit will impact the UK's policy on forestry – both globally and domestically. As well as relinquishing its ability to determine the EU's sustainability criteria on biomass it will also lose the ability to influence EU policy on climate accounting and LULUCF more broadly.
- What the UK's departure from the CAP will mean for environmental policy within agriculture. There are a number of possibilities on how policy could develop – depending on UK policy decisions – some avenues could be good for decarbonisation, some less good.
- The UK's continued participation in EU research and development is called into question by Brexit. There will be uncertainty around collaboration on R&D into energy.
- The extent to which the UK's overall influence over European climate and decarbonisation issues will endure.

CHALLENGES

The UK's plans to leave the European Union raise several questions for the future of UK decarbonisation policy. As three British parliamentary committees have noted[123], if left unanswered, these questions have the potential to undermine UK efforts towards decarbonisation by creating investor uncertainty. While environmental policy is a shared competence of the EU institutions and member states, in practice much environmental legislation relates to the single market and would thus be affected by a UK decision to leave the *European Economic Area*. Energy policy, meanwhile, remains an "exclusive" member state competence – although the EU's 2030 decarbonisation package, the EU Energy Union and the EU's commitments in the Paris Agreement (of which the UK forms a part) are all currently shaping policy towards an effective framework of governance at EU level, as discussed below.

The UK's Climate Change Act and carbon budgets currently commit the UK to more ambitious decarbonisation plans than EU policy. Indeed, to maintain its current level of ambition with the UK as a member, the EU will need to oblige its remaining 27 member states to take deeper action on decarbonisation than is currently the plan.

EU 2030 Package (Clean Energy for All European) and Energy Union governance

The 2030 package has been decided at EU level with the conclusions of the EU Council of October 2014[4] remaining as the framework for EU policy in this area. The 2030 package of decarbonisation targets also forms the basis of the EU's submission to the Paris Agreement (it's NDC: 'Nationally Determined Contribution). The headlines measures of the 2030 package are as follows:

- 40% cut in overall EU emissions on 1990 levels by 2030.
- 27% share of renewables in EU energy consumption by 2030
- 27% improvement in energy efficiency in 2030 compared to projections of future energy consumption based on the current criteria

As part of the Council conclusions, it was decided to reinforce Energy Union: 'A reliable and transparent governance system without any unnecessary administrative burden will be developed to help ensure that the EU meets its energy policy goals, with the necessary flexibility for Member States and fully respecting their freedom to determine their energy mix'[5] It is to be noted that – unlike the previous 2020 package – the 2030 targets are EU-wide and will not include national targets for renewable energy and energy efficiency. This potentially makes the process of oversight more complex.

The European Commission has published a series of detailed legislative proposals to deliver the 2030 targets: The 'Clean Energy for All Europeans' package.6 As part of the process, each member state will be required to submit a draft National Energy and Climate Plan to the Commission by January 2018 and to consult its immediate neighbours to ensure coordination and interconnection strategy as part of the Energy Union. The UK government has – as it currently stands – agreed to submit its own plans. The question, as the UK prepares to leave the EU, will be the degree to which it continues to remain in sync with the EU energy union and the EU's 2030 decarbonisation plans. There will also be questions around how and by when the UK will move to being a single party to the Paris Agreement and the future of the UK Climate Change Act. The 2018 "global stocktake" (where all pledges to the Paris Agreement are reviewed) will probably occur before Brexit and could – therefore – provide opportunity for the UK to review its own "unilateral" ambitions. One think-tank has recently suggested that for a post-Brexit situation the UK should adopt a "Paris cooperation track" with the EU where "it would identify areas of co-operation between the UK and the EU where there are clear opportunities to meet their corresponding NDCs [Nationally Determined Contributions]. The EU Emissions Trading Scheme, the internal energy market, trading in low carbon goods and R&D on energy and climate are just some of the areas of immediate priority where sustained co-operation will be mutually beneficial"[7].

EU biomass sustainability criteria

The EU is currently developing sustainability criteria for solid biomass as part of the Renewable Energy Directive. There is wide agreement among environmental stakeholders that these are too weak and so the UK has an opportunity to improve the criteria through domestic legislation if it so wished.

EU Emissions Trading System – Phase IV (2021-2030) – is the UK planning on remaining within it?

Since 2005, the UK has been part of the EU Emissions Trading System (EU ETS) which currently exposes the whole of the power sector and – in theory – all industrial sectors to the EU carbon price (currently around €5 per tonne of CO2e). Furthermore, the Coalition government decided to apply a UK-only carbon floor price[8] which raises the carbon price paid by utilities in the UK and has had a significant impact in reducing coal-fired generation in the UK over the last few years. The overall aim of the EU ETS is to cap the level of EU emissions in the sectors it covers (around 50%) to levels compatible with the overall emissions-reductions targets (for Phase IV, a 40% cut on 1990 levels by 2030).

The fourth phase of the EU ETS begins in 2021 and a series of reforms are currently being debated at EU-level with the overall aim of cancelling emissions allowances and raising the overall EU carbon price. There are also separate discussions on including the aviation and shipping sectors more fully in the EU ETS. As the UK is likely to have left the EU by the start of the next phase of the EU ETS, questions are raised as to whether the UK is planning on remaining part of it (as several European countries are which are not EU-

members), setting up a parallel emissions trading system to cover UK-only emissions, or abandoning carbon trading schemes all together. The UK Chancellor of the Exchequer, Philip Hammond MP, noted in his Spring Budget of March 2017 that the government would be coming forward with proposals on carbon pricing at a later date.[9] As other global regions and nations set up their own emissions trading systems, there will be interesting discussions around how the Paris Agreement interacts with the WTO and other trading arrangements to ensure that efforts to prevent carbon leakage do not end up permitting so called 'protectionism by stealth'. The UK could perhaps soon be engaged in the process of negotiating trade deals with countries that may also be in the process of setting up emissions trading systems (e.g. China).

EU Effort Sharing Regulation (2021-2030) – will the UK be involved?

The EU Effort Sharing Regulation (ESR) covers a similar proportion of EU emissions as the EU ETS, taking in sectors not covered by the ETS (transport, apart from aviation and shipping; buildings, waste and land use are the main sectors). The ESR will operate for the period 2021-30 and will replace the *Effort Sharing Decision*. As with ETS reform and the various proposals in the *Clean Energy for all Europeans* package, the ESR is currently under development at EU level. Unlike the renewables target, however, member states have been allocated individual emissions reduction targets under the ESR, with the UK being allocated a 37% cut on 2005 levels by 2030 in sectors covered by the ESR. This is one of the largest allocations among member states. It is up to member states to decide on how they achieve their national targets, supported by EU policies like recycling legislation and ecodesign in the Circular Economy package (below), as well as emission limits for cars (see Transport chapter).

As with the ETS, and indeed the broader nature of all connection with the EU, it is unclear whether the UK will aim to keep in sync with developments and reporting on the ESR and whether or not it will seek equivalence with EU standards on fuel quality and efficiency for vehicles.

EU Circular Economy Package – (including waste and recycling targets)

The EU Circular Economy package comprises a number of directives related to waste treatment, landfill and recycling targets, ecodesign for electrical products and energy labelling of consumer goods. The whole package of legislation is currently ready to go to the European Council, whereupon discussions will commence between the Council the Commission and the European Parliament as to the final shape of the package. As with a number of other environmental regulations – there is also a process underway through the comitology procedure. The UK currently exports a large amount of waste to other EU countries for treatment but is known to have spare capacity for domestic incineration (waste to energy). It will be interesting to see whether DEFRA plans to use Brexit to re-align the UK's waste and recycling targets or whether there will be a move to remain in sync with the new EU waste targets once they are decided. The same would be true for eco-design, which is an especially controversial issue in the UK after a degree of media misrepresentation has characterised the policy as an "attack on British kettles"[10].

Land Use, Land Use Change and Farming (LULUCF)

It is unclear exactly how Brexit will impact the UK's policy on forestry – both globally and domestically. As well as relinquishing its ability to influence the EU's sustainability criteria on biomass it will also lose the ability to influence EU policy on climate accounting and LULUCF more broadly. The UK has traditionally been a strong supporter of high EU ambition on forests and it is unclear how the EU's own position could evolve in the absence of the *UK.*

Farming and the environment post-CAP

For farming, there will also be domestic implications from the UK's departure from the EU's Common Agricultural Policy. In September 2016, Conservative backbenchers asked government to use Brexit to switch farming subsidies towards clearer environmental goals and towards 'paying farmers for delivering services for the environment and public good'[11]. Professor Dieter Helm sets out an engaging vision for post-CAP agriculture[12], where he says 'Brexit provides a unique opportunity to reset farming policy'. He concludes that CAP has 'seriously damaged Britain's natural capital' and caused 'serious environmental damage' and suggests a gradual move away from the system of Pillar one and Pillar two CAP subsidies towards a model where farmers operate without subsidy and where there is direct contracting of public money for designated public goods, and with the possibility of such a system being managed by national parks. This vision might fit with a fresh approach to emissions reductions from agriculture.

UK R&D funding and coordination

The UK's continued participation in EU research and development is also called into question by Brexit. This will include the UK's role in setting the EU's strategic priorities for energy research through the SET Programme as well as a number of other research coordination programmes such as the European Technology and Innovation Platforms. Large EU funding programmes which include R&D like the Horizon 2020 programme and the Life+ programme will also be in doubt in terms both of UK access to the funds but also in helping to set their priorities.

The evolution of EU energy and environment policy without the UK as a member

A pressing question for Brussels policymakers is on how EU energy and environment policy could evolve in the absence of the UK as one of its previously largest and most influential member states. A recent paper from E3G raises questions and makes suggestions on this. It also reasserts the strong influence of the UK on climate negotiations until now, with the UK representing 14% of all diplomats in the EU and with 150 diplomats working full time on climate change [13]. Climate is an issue where the UK has tended to be a "progressive" voice in the Council whereas, on recycling it has tended to be drag on EU policy ambition[14]. The European Commission's strategic discussion paper entitled 'White Paper on the Future of Europe' is already seeking to address the issue.[15]

REFERENCES

[1]House of Commons Environmental Audit Committee, The Future of the Natural Environment after the EU Referendum, January 2017 http://www.parliament.uk/business/committees/committees-a-z/commons-select/environmental-audit-committee/news-parliament-2015/natural-environment-after-eu-report-published-16-17/

[2]House of Lords, EU Energy and Environment Subcommittee - Brexit, environment and climate change, February 2017: https://www.parliament.uk/business/committees/committees-a-z/lords-select/eu-energy-environment-subcommittee/news-parliament-2015/brexit-env-cc-rpt/

[3] AT THE TIME OF WRITING THE HOUSE OF COMMONS BEIS SELECT COMMITTEE IS CONDUCTING AN INQUIRY INTO "LEAVING THE EU: NEGOTIATION PRIORITIES FOR ENERGY AND CLIMATE CHANGE POLICY": HTTPS://WWW.PARLIAMENT.UK/BUSINESS/COMMITTEES/COMMITTEES-A-Z/COMMONS-SELECT/BUSINESS-ENERGY-INDUSTRIAL-STRATEGY/INQUIRIES/PARLIAMENT-2015/BREXIT-ENERGY-CLIMATE-CHANGE-INQUIRY-16-17/

[4] European Council (23 and 24 October 2014), Conclusions on 2030 Climate and Energy Policy Frame Work: https://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145356.pdf

[5] European Council (23 and 24 October 2014), Conclusions on 2030 Climate and Energy Policy Frame Work: https://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145356.pdf

[6] CLEAN ENERGY FOR ALL EUROPEANS – UNLOCKING EUROPE'S GROWTH POTENTIAL, EUROPEAN COMMISSION, NOVEMBER 2016: HTTP://EUROPA.EU/RAPID/PRESS-RELEASE_IP-16-4009_EN.HTM

[7] See the recent Green Alliance report' Negotiating Brexit' on Brexit and Energy and Climate outcomes, July 2017: http://www.green-alliance.org.uk/resources/Negotiating_Brexit_Positive_Outcomes_For_UK_Energy_Climate.pdf

[8] https://sandbag.org.uk/wp-content/uploads/2016/11/CarbonFloorPriceBriefing.pdf

[9] HM Treasury, Spring Budget 2017: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/597467/spring_budget_2017_web.pdf

[10] See the Daily Telegraph as one of many examples, May 2016: http://www.telegraph.co.uk/news/2016/05/10/eu-to-launch-kettle-and-toaster-crackdown-after-brexit-vote2/

[11] Conservative Environment Network, Conservative MPs encourage the PM to put her personal stamp on environment policy, September 2016: http://cen.uk.com/conservative-mps-encourage-the-pm-to-put-her-personal-stamp-on-environment-policy/

[12] British Agricultural Policy after BREXIT, Natural Capital Network – Paper 5, 1st September 2016, Dieter Helm: http://www.dieterhelm.co.uk/natural-capital/environment/agricultural-policy-after-brexit/

[13] E3G Report, April 2017: https://www.e3g.org/docs/E3G_Brexit_and_the_EU_Energy_Union_030417.pdf

[14]From recent UK and UKREP commitment to the EU's circular economy package this has been evidenced, as well as through private and public comment: http://www.euractiv.com/section/sustainable-dev/news/brexit-will-cost-british-businesses-billions-unless-circular-economy-package-is-replaced/ http://www.aldersgategroup.org.uk/latest#new-business-trials-show-need-for-ambitious-circular-economy-package

[15] EUROPEAN COMMISSION PRESENTS WHITE PAPER ON THE FUTURE OF EUROPE: AVENUES FOR UNITY FOR THE EU AT 27, MARCH 2017: HTTP://EUROPA.EU/RAPID/PRESS-RELEASE_IP-17-385_EN.HTM

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