Committee on Climate Change

Bioenergy Review (2018) - Call for Evidence

Please answer only those questions where you have particular expertise and are able to provide links to supporting evidence.

In 2011 the Committee on Climate Change (CCC) published a Bioenergy Review to provide an assessment of the potential role of bioenergy in meeting the UK's carbon budgets. The Bioenergy Review drew on the best available evidence to address questions relating to the sustainability of bioenergy, lifecycle emissions, resource availability and best-use across the economy. It highlighted the importance of bioenergy for meeting the UK's climate change targets and made recommendations for tightening the sustainability standards for bioenergy resources - recommendations that were subsequently adopted by the UK Government.

The CCC is now planning to update its work on bioenergy, culminating in a new Bioenergy Review to be published in Autumn 2018. This will consider the latest evidence to provide an updated view on the role of bioenergy in decarbonising the UK economy through to 2050. Key themes to be explored include sustainability and certification, GHG emissions accounting, developing sustainable supply, non-energy uses of bioenergy resources, and transitions to future best-uses of bioenergy resources. We will identify recommendations for further action and aim to develop indicators to allow the CCC to monitor progress over time.

Stakeholder engagement will underpin the 2018 Bioenergy Review. This Call for Evidence is the first formal step in the engagement process. It is intended to provide all stakeholders with the opportunity to input to the CCC's work and to enable the CCC to draw on the full range of up-to-date evidence relating to bioenergy production, sustainability and use.

The Call for Evidence will be followed by stakeholder workshops on specific key topics in 2018. In addition, we will be establishing an Expert Advisory Group to provide advice and support to the CCC throughout the review.

Responding to the Call for Evidence

We encourage responses that are brief and to the point (i.e. a maximum of 400 words per question, plus links to supporting evidence), answering only those questions where you have particular expertise. We may follow up for more detail where appropriate.

Please use the website form when responding, or if you prefer you can use this word form and e-mail your responses to: communications@theccc.gsi.gov.uk. Alternatively, if you would prefer to post your response to us, please send it to:

The Committee on Climate Change – 2018 Bioenergy Review Call for Evidence
7 Holbein Place
London SW1W 8NR

The deadline for responses is 9am on 5th February 2018.

Confidentiality and data protection

Responses will be published on the CCC website after the response deadline, along with a list of names or organisations that responded to the Call for Evidence.

If you want information that you provide to be treated as confidential (and not automatically published) please say so clearly in writing when you send your response to the consultation. It would be helpful if you could explain to us why you regard the information you have provided as confidential. If we receive a request for disclosure of the information we will take full account of your explanation, but we cannot give an assurance that confidentiality can be maintained in all circumstances. An automatic confidentiality disclaimer generated by your IT system will not, of itself, be regarded by us as a confidentiality request.

All information provided in response to this consultation, including personal information, may be subject to publication or disclosure in accordance with the access to information legislation (primarily the Freedom of Information Act 2000, the Data Protection Act 1998 and the Environmental Information Regulations 2004).

Information on organisation / individual submitting response

The Renewable Energy Association (REA) is pleased to submit this response to the above consultation. The REA represents a wide variety of organisations, including generators, project developers, fuel and power suppliers, investors, equipment producers and service providers. Members range in size from major multinationals to sole traders. There are around 600 corporate members of the REA, making it the largest renewable energy trade association in the UK.

GHG emissions and sustainability of bioenergy imports

Our 2011 Bioenergy Review concluded that UK and EU regulatory approaches should be strengthened to better reflect estimates of the full lifecycle emissions of bioenergy feedstocks, taking into account both direct and indirect land-use change impacts. Whilst changes have been made to these regulatory frameworks, both life-cycle emissions and the wider sustainability impacts of bioenergy remain highly contested issues, particularly in relation to bioenergy imports. Given the potential role for bioenergy in the UK's low-carbon transition and the potential increase in bioenergy feedstock production in the future, it will be essential that policy is based on the latest available evidence and that bioenergy is genuinely sustainable.

The term 'sustainable' here is used to cover a wide-range of issues relating to GHG emissions, biodiversity, water use, land-use, land-rights, air-quality and other social and environmental issues.

1. What is the latest evidence on lifecycle GHG emissions of biomass and other biofuels imported into the UK? How could this change over time as a function of scaling up supply? We are particularly interested in evidence that considers the full range of relevant issues including changes to forest and land carbon stocks, direct and indirect land-use change and wider market effects.

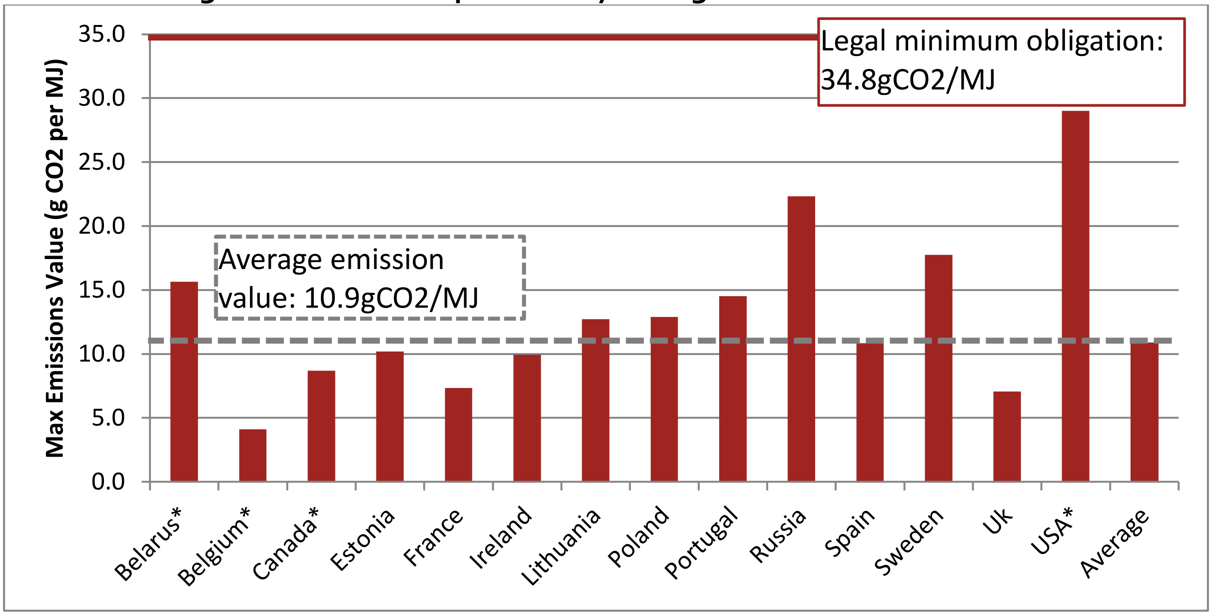
   Biomass heat - GHG
   Since 2011, new sustainability regulation has been implemented for biomass heat fuel, which has allowed increased understanding of the life-cycle emissions related to the biomass heat supply chain. The Government has created the Biomass Suppliers List (BSL), on which self-suppliers and fuel suppliers register their fuels and feedstocks. Non-domestic RHI participants with boilers over 1,000 kW, however, need to self-report to Ofgem, instead of the BSL. To register their fuel on the BSL, biomass suppliers must demonstrate that their woodfuel emissions are at least 60% less carbon intensive than the average EU fossil fuel equivalent and that it meets the *UK Timber Standard for Heat and Electricity*'s definition of legal and sustainable wood. A life-cycle analysis is undertaken for each fuel sold to a Government supported biomass heat boiler under the RHI. Analysis of all fuels registered on the BSL show that most fuels registered originate from the UK, and the most popular fuel type is virgin pellets (table 1).

Table 1: Fuel origin and fuel types on the Biomass Suppliers List, April 2016

Country of origin	Number of fuels	Fuel types	Number of fuels
Belarus	4	Pellets - virgin	2984
Belgium	1	Pellets - waste virgin blend	16
Canada	1	Firewood - virgin force dried	250
Estonia	71	Firewood - virgin force dried	250
France	6	Firewood - virgin naturally seasoned	906
Ireland	19	Firewood - waste virgin blend	30
Lithuania	5	Briquettes - virgin	6
Poland	55	Briquettes - waste virgin blend	98
Portugal	31	Chip - virgin force dried	317
Russia	1208	Chip - waste virgin blend	51
Spain	23	Chip - waste virgin blend	51
Sweden	7	Chip - waste	1
United Kingdom	3770		
USA	3		

The average GHG emission value for Biomass Suppliers List fuels is 10.9gCO_2/MJ, which constitutes an 87.47% GHG saving compared to the EU fossil heat average. On average, the imported fuels have a slightly higher emission value compared to UK fuels, which generate a 91.88% GHG saving in average (chart1).

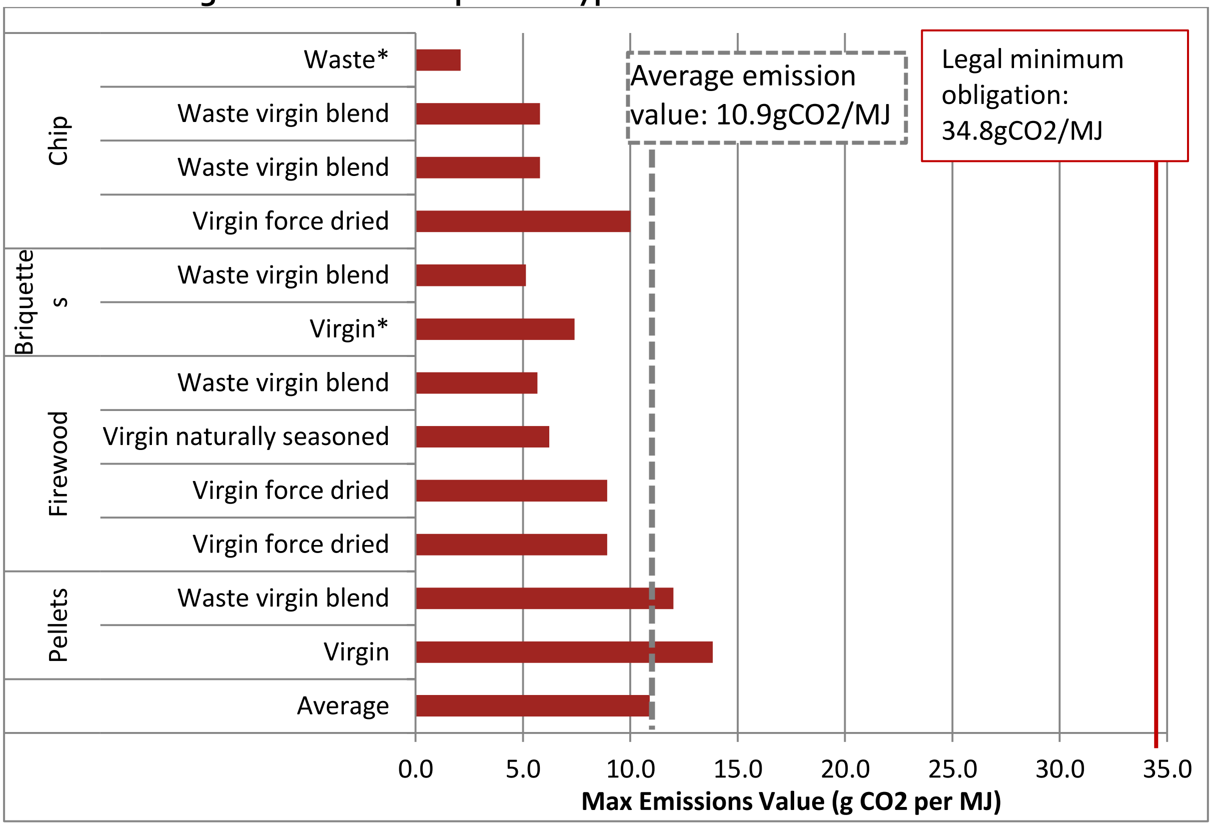
Chart 1: Average GHG emissions per country of origin



Note: * fewer than 5 fuels originate from this country, making the average more susceptible to outliners. Data originate from the BSL and has been analysed by the REA.

On average, looking at the different types of fuel, wood chip usually had a lower GHG emission value than other fuel types, but all fuel types deliver significant carbon savings.

Chart 2: Average GHG emissions per fuel type



Note: * fewer than 5 fuels originate from this country, making the average more susceptible to outliners. Data originate from the BSL and has been analysed by the REA.

This does not weigh the registered fuels by volume sold but assumes all fuels are sold in equal volumes. The REA has been able to obtain data of the 75 most used fuels on the Biomass Suppliers List, where 95% of the volume originate from the UK, 3% from Russia, 1% from Estonia, 0.7% from Portugal, 0.4% from Latvia, and 0.4% from Poland.

Table 2: Fuel origin of the 75 most sold fuels on the Biomass Suppliers List

Country of origin	Number of fuels	Percentage of total volume sold of the top 75 fuels	Average GHG saving per volume (minimum 60% GHG saving)
UK	55	95%	97.7%
Russia	10	2.6%	83.7%
Estonia	3	1.0%	81.8%
Latvia	3	0.4%	86.5%
Poland	1	0.4%	87.9%
Portugal	3	0.7%	83.2%

Note: The average GHG saving is calculated by weighing the GHG saving for each fuel by their volume. E.g. if 900 tonnes have been sold of fuel A with a GHG saving of 60% and 100 tonnes of fuel B with a GHG saving of 70%, then the average GHG emission for the two fuels are 61% ((60%*0.9)+(70%*0.1)=61%).

The 75 most sold fuels under the Biomass Suppliers List have a combined Max Emissions Value of 2.57gCO_2/MJ when weighing the GHG saving by volume sold. This constitutes a 97.0% GHG saving compared to the EU fossil heat average. Even when excluding waste fuels, the most sold fuels delivers a GHG saving of 90.7% compared to the EU fossil heat average. However, excluding waste fuels from the group would not be a fair or accurate reflection of the GHG savings in biomass fuel market, as waste fuels do make up a significant part of the fuel market. This would indicate biomass heat fuels achieve significant GHG savings compared to the fossil average.

Biomass heat - forestry

The UK woodland area has continuously increased every decade, with UK woodland area increasing from 11.3% in 1999 to 13.0% in 2015. Of the area in the EU, 41%, 178 million ha, is covered with forests and other woodland, with about 75 % of that area potentially available for wood supply[1]. The European Commission's *Study on the Wood Raw Material Supply and Demand for the EU Wood-processing Industries* state:

- "In all the analysed products and product groups, the production in Europe is either declining or relatively stable. However, in sawmilling and especially pellet production, there are high hopes among the producers that future demand will be increasing. However, the low price of sawn wood in comparison with the relatively high price of logs keeps sawmilling's competitiveness at a low level, although the increasing demand for the by-products of sawmilling partly compensates.
- "Between 2000 and 2010, wood raw material use in the EU-27 bio-energy sector grew (ca. +82 million m3 RWE) more than double in comparison to the growth of both pulp and paper and of wood products. Following this significant growth, the wood raw material use of the bio-energy sector approached the wood raw material use of the wood product sector.

[1] Study on the Wood Raw Material Supply and Demand for the EU Wood-processing Industries, http://ec.europa.eu/DocsRoom/documents/11920

- "The sawmills are in a key position in this because saw logs are the most valuable parts of the trees and hence the most interesting one from the wood sellers' point of view. To get the market of wood raw material running, it is therefore extremely important that the sawmills are profitable and act as drivers for the wood market. This brings also pulpwood as well as energy wood to the market and other forms of woodworking industries, pulp and paper industries as well as power plants can benefit from this as well as from the industrial residues. This trickle-down effect is often referred to as a "cascade"."

The *State of Europe's Forests 2015 Report*[2] from Forest Europe which concludes:

- "Between 2005 and 2015 the average annual sequestration of carbon in forest biomass, soil and forest products reached about 720 million tonnes, which corresponds to about 9% of the net greenhouse gas emissions for the European region
- "Despite the fact that the European forest sector was affected by the recent global economic recession, it seems now on a steady path of recovery. Europe still remains one of the world's biggest producers of equivalent roundwood and has moved from being a net importer of primary wood and paper products to a net exporter. In particular, as reported in the document, information on total roundwood production was provided by 38 countries, representing 60% of the forests in the Forest Europe area.
- "Sustainable forest management in Europe is directly contingent on sustainable markets for forest products and vice versa. The consumption of roundwood and all of its products and by-products is a factor in the sustainable development of the forest sector. Profitability in most forests is dependent upon sales of roundwood, and, to a growing extent, sales of forest residues for energy. The revenue from sales of wood supports most activities and treatments in forests. The price of sawlogs is particularly important for the profitability of forest operations, thus the demand for solid wood products plays a crucial role in the mobilisation of pulpwood and forest residues. In this context, it is worth noting that the recognition of the environmental benefits of the use of wood in construction is slowly increasing throughout Europe. This could result in far greater consumption in the future.
- "Wood consumption in Europe remains well below forest growth. Thus, harvests fall short of annual growth by approximately 36%."

Finally, Eurostat data show that from 2014 to 2015 EU forest and other wooden land gained 322.800ha, which means that *EU forests are increasing by the size of a football field every minute*.

Biomass Power - GHG

The same is true for biomass power generation, where sustainability regulations have been implemented since the previous bioenergy review. The data released under the

[2] FOREST EUROPE, 2015: State of Europe's Forests 2015, http://www.foresteurope.org/fullsoef2015

RO sustainability reporting indicates a significant GHG saving when using life-cycle calculations (table 3). In the latest reporting year of 2015/2016, the weighted average emissions for production of biomass power constituted an 89% saving compared to coal and 86% compared to the EU fossil fuel comparator.

Table 3: GHG emission reported under the RO 2013 - 2016

RO reporting period		g CO_{2eq} / MJ	GHG saving compared to **EU fossil power average**	GHG saving compared to **coal**
2015/16	**Weighted Average**	**28.28**	**86%**	**89%**
	Average	20.57	90%	92%
2014/15	Weighted Average	32.60	84%	87%
	Average	25.83	87%	90%
2013/14	Weighted Average	36.94	81%	85%
	Average	30.65	85%	88%

Note: Based the RO "Biomass Sustainability Report 2015-16 dataset" released by Ofgem, analysed by the NNFCC. Comparator for EU Fossil power average is 198g CO_{2eq}/MJ, as per the EU Report on Sustainability requirements for biomass[3]. The UK Government's benchmark figure for GHG emission from coal is 250.8g CO_{2eq}/MJ. The weighted average is per tonnage of feedstock.

Other peer-reviewed research articles such as Wang et al. (2015) [4] assessment of US-sourced pellets and Lamers et al. (2014)[5] on pellets sourced from British Columbia, Canada have made similar assessments in terms of potential GHG savings. Other studies looking at lifecycle emissions of biomass power generations also find comparable results, such as Beauregard et al. (2012)[6] on GHG reduction in Quebec, Canada, or Zhang et al. (2009)[7] in Ontario, Canada.

Since 2011, the Government has published two reports on the life cycle impacts of biomass electricity in 2020: Biomass emissions and counterfactual (BEaC) model in

[3] EU comparators for heat and electricity are on p17 of the EU report on the requirement for sustainability criteria for solid biomass and biogas: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0011:FIN:EN:PDF.

[4] Wang, W., Dwivedi, P., Abt, R., & Khanna, M. (2015). Carbon savings with transatlantic trade in pellets: accounting for market-driven effects. Environmental Research Letters, 10(11), 114019, http://iopscience.iop.org/article/10.1088/1748-9326/10/11/114019

[5] Lamers, P., Junginger, M., Dymond, C. C., & Faaij, A. (2014). Damaged forests provide an opportunity to mitigate climate change. Gcb Bioenergy, 6(1), 44-60, http://onlinelibrary.wiley.com/doi/10.1111/gcbb.12055/full

[6] Beauregard, R., Bouthillier, L., Bernier, P. Y., Paré, D., Thiffault, E., Levasseur, A., & St-Laurent-Samuel, A. (2012). Scientific advisory report–The use of forest biomass to reduce greenhouse gas emissions in Quebec, https://www.mffp.gouv.qc.ca/english/publications/forest/forest-biomass.pdf

[7] Zhang, Y., Mckechnie, J., Cormier, D., Lyng, R., Mabee, W., Ogino, A., & Maclean, H. L. (2009). Life cycle emissions and cost of producing electricity from coal, natural gas, and wood pellets in Ontario, Canada. Environmental science & technology, 44(1), 538-544, http://www.canadiancleanpowercoalition.com/files/4312/8330/0349/BM8%20-%20Zhang%20et%20al%202010%20EST%20Wood%20pellet.pdf

2014[8] and a report on the likelihood of the BEaC scenarios in 2017[9]. The initial report investigates the impact on carbon emissions of various ways of sourcing woody biomass from North America to produce electricity in the UK. The calculator estimates the greenhouse gas intensity by taking into account the counterfactual land use for the scenario (i.e. what the land or wood would have been used for if it was not used for bioenergy), outlining many separate scenarios. However, the report did not assess the likelihood of either of those scenarios actually happening in a real-world, market context; hence the second report was commissioned to assess the likelihood of the high carbon scenarios identified in the BEaC model. A key factor that the BEaC model did not consider was the economic drivers influencing forest management, which this study does include.

Rather than looking at the most likely impact that pellet sourcing will have on North American forestry, the report instead focuses on the risk of high-carbon scenarios occurring, which would not generate the desired carbon savings. Of the 38 scenarios that could lead to high-carbon fuel sourcing, 15 are not occurring now or in the future, with further 18 not being considered, which leaves only five remaining scenarios. When assessing these scenarios in-depth, the study states that regulation would prevent them from occurring, deemed them unlikely to happen, or determined that pellet demand alone will not cause them to happen. The key factor was that it was simply unlikely to happen "as a result of pellet demand alone, because financial return is not adequate and sustainability requirements would not allow this change". In its summary report, the study concludes that the most likely biomass sourcing will use the low- grade materials left by other industries, such as construction or joinery:

> *"Overall the most likely supply strategies are those that can be integrated with other higher value product supply chains, requiring little change or investment. Evidence from the questionnaire was that pellet demand is unlikely to drive rotations or harvest alone. This is because pellets are regarded as a low value product that improves margins but does not drive forest practice and such strategies are likely to be the most financially viable.*

The report contributes to the knowledge and understanding of lifecycle GHG emissions of imported North American biomass for power production and how this could change over time when scaling up supply. It reduced the scientific uncertainty and highlights that pellets are of such low value that it is unrealistic and unlikely that forest-owners would consider felling a tree to produce pellets when the timber production for construction and furniture is much higher value.

A report from Chatham House (2017) similarly did not take into account market impacts and, for example, assumed that forests would remain unharvested in the absence of bioenergy. This report was disputed by over 135 academics and researchers in the forestry, carbon and bioenergy field in a letter from IEA

[8] Life cycle impacts of biomass electricity in 2020, DECC 2014, https://www.gov.uk/government/publications/life-cycle-impacts-of-biomass-electricity-in-2020

[9] Use of high carbon North American woody biomass in UK electricity generation, BEIS 2017, https://www.gov.uk/government/publications/use-of-high-carbon-north-american-woody-biomass-in-uk-electricity-generation

Bioenergy[10], which stated that "this report does not present an objective overview of the current state of scientific understanding with respect to the climate effects of bioenergy".

Peer-reviewed research by Miner et al. (2014)[11] similarly finds that increased demand for wood can trigger investments and increase forest area and forest productivity. Over 100 researchers and academics from leading US university forestry resources programs have signed a letter to underline that economic factors influence the carbon impacts of forest biomass energy; the carbon benefits of sustainable forestry are well established; and, measuring the carbon benefits of forest biomass energy must consider cumulative carbon emissions over the long term[12].
Other resources include:

- Galik, C. S., & Abt, R. C. (2016). Sustainability guidelines and forest market response: an assessment of European Union pellet demand in the southeastern United States. Gcb Bioenergy, 8(3), 658-669, http://onlinelibrary.wiley.com/doi/10.1111/gcbb.12273/
- Hanssen, S. V., Duden, A. S., Junginger, M., Dale, V. H., & Hilst, F. (2017). Wood pellets, what else? Greenhouse gas parity times of European electricity from wood pellets produced in the south-eastern United States using different softwood feedstocks. Gcb Bioenergy, 9(9), 1406-1422, http://onlinelibrary.wiley.com/doi/10.1111/gcbb.12426/abstract

The IEA Bioenergy has also provided an overview of the downstream power generation side[13].

Biofuels
Data on the lifecycle GHG emissions for biofuels (both domestically sourced and imported) can be found in the table titled "Carbon and sustainability data of renewable transport fuel: United Kingdom, 15 April 2017 to 14 April 2018" reference[14].

In summary, 53% of the biodiesel used in the UK was produced from imported feedstocks. None of these were food crops. The GHG emissions per MJ are shown for each type of feedstock in the data tables, and they range from 4 – 17 gCO2e/MJ (i.e. a 95 – 80% GHG saving. 82% of the bioethanol used in the UK was produced from imported feedstocks. The GHG emissions range from 4 – 42 gCO2e/MJ (i.e. a 93 –

[10] IEA Bioenergy (2017), IEA Bioenergy Response to Chatham House report "Woody Biomass for Power and Heat: Impacts on the Global Climate, available at http://www.ieabioenergy.com/publications/iea-bioenergy-response/
[11] Miner, R. A., Abt, R. C., Bowyer, J. L., Buford, M. A., Malmsheimer, R. W., O'Laughlin, J., ... & Skog, K. E. (2014). Forest carbon accounting considerations in US bioenergy policy. Journal of Forestry, 112(6), 591-606, http://www.ingentaconnect.com/content/saf/jof/2014/00000112/00000006/art00007
[12] Bullard et al. (2014), Letter to EPA Administrator Gina McCarthy, 6 Nov 2014, https://nafoalliance.org/images/issues/carbon/resources/NAUFRP-EPA-11-6-2014.PDF
[13] IEA Bioenergy: Task 32 (2016), Biomass Combustion and Cofiring, http://www.ieabcc.nl/publications/IEA_Bioenergy_T32_cofiring_2016.pdf
[14] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/656293/rtfo-year-10-report-1.ods (see sheet labelled RTFO_05_C&S_data). NB Data is for information received by the DfT as of 15 September 2017 and is not final. The final report for 2017/18 will be published in Feb 2019.

50% GHG saving. The feedstocks comprise corn, food waste, rye, starch slurry, sugar beet, sugar cane, triticale and wheat. There was no biomethane used in transport and a very small amount of biomethanol.

With respect to how this might change in the future:
If the fuel E10 (a 10% blend of bioethanol and petrol) is introduced in the UK in time for the increase of the Renewable Transport Fuel Obligation then the supply of bioethanol is likely to increase, as this is the cheapest means of meeting the obligation. We are hoping that this takes place in October this year, concurrent with new fuel labelling mandated by the Alternative Fuels Infrastructure Directive. However, it is a commercial decision for fuel suppliers.

Until the time that E10 is introduced, the proportion of biodiesel is likely to increase, and whilst none of this is made from food crops at present, the supply of wastes and residues is limited and food crops derived biodiesel may, therefore, enter the market.

The supply of biomethane is likely to increase, which would be welcome for a number of reasons:-

- It would stimulate further deployment of gas-fuelled HGVs which have lower GHG emissions even when running on 100% fossil gas. (A 12-15% according to the Element Energy study[15] or according to the ETI study, the best case scenario indicates that the potential for emissions savings is very significant at 21-22% for LNG and 26-29% for CNG compared to the diesel reference"[16].) When running on biomethane, the Element Energy study quantified the savings at 84%.
- It would save expenditure on the Renewable Heat Incentive, and enable greater deployment of biogas production and biomethane injection projects, as the projects could be financed on the bankability of the RHI payments, but then go on to deploy their output for transport. This would enable the tax-payer funded RHI budget to go further. (The value of RTFCs is variable and insufficiently stable as a basis for raising funds for the construction of new biomethane injection projects.)
- Biomethane (or natural gas) vehicles have lower NOx, particulate and noise levels and therefore improve local air quality.

The REA organised a meeting of industry representatives, DfT officials and staff from the CCC in early January, specifically on the subject of biomethane in transport and have agreed to continue to feed data in on HGV emissions as testing continues. These are early days and innovation is happening at a rapid rate, with new vehicles coming onto the market that have not been tested yet.

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[15] Independent assessment of the benefits of supplying gas for road transport from the Local Transmission System, Final technical report, Cadent, Celine Cluzel, Vlad Duboviks, Sophie Lyons, 15th August 2017. https://cadentgas.com/getattachment/About-us/Innovation/Projects/Revolutionising-Transport/Promo-Full-report-(1)/20170815_Element_Energy_Monitoring_of_Leyland_station_-_final_report.pdf
[16] Natural Gas Pathway Analysis for Heavy Duty Vehicles, Matthew Joss - Principal Engineer, Heavy Duty Vehicles, November 2017. https://d2umxnkyjne36n.cloudfront.net/teaserImages/Natural-Gas-Pathway-Analysis-for-Heavy-Duty-Vehicles-Matthew-Joss.pdf?mtime=20171101113809

With respect to changes to forest and land carbon stocks, direct and indirect land-use change – all these are addressed under the RTFO (or other financial instruments) and unsustainable fuels are not incentivised.

2. Under what circumstances can imported biomass and other biofuels deliver real GHG emissions savings (considering full life-cycle emissions and indirect/wider market effects)? Conversely, what evidence is there for ruling out certain sources on the grounds of lifecycle GHG emissions or sustainability risks?

   As stated above, the 2017 BEaC report[17] outlines the likelihood of the high carbon scenarios identified in the original BEAC model. The scenarios "where carbon impact was lower than coal and gas-fired generation [were] not included in [the] study, as they are not considered to be a threat to the carbon sustainability of the supply chain for pellet use to generate electricity in the UK". It focused only on the scenarios in which biomass power production would not generate the desired carbon savings. These were deemed unlikely to happen, regulation would prevent them from occurring, or pellet demand alone will not cause them to happen. We highly recommend that the findings of the 2017 report are included in the assessment of biomass emission savings. However, the above-mentioned report does show that only the low-carbon scenarios are likely to take place. In combination with the UK sustainability legislation, biomass power delivers significant carbon savings that are independently verified, audited, and regulated.

3. Currently the UK imports a significant proportion of wood pellets for biomass electricity production from North America, particularly the south-east USA.

   a) What are the wider market impacts of demand for wood pellets on forestry management practices and carbon stocks at the landscape level in North America?

      As mentioned in Q1, the *Use of high carbon North American woody biomass in UK electricity generation* report demonstrates that market conditions dictate that "pellet demand is unlikely to drive rotations or harvest alone". Forest practices are unlikely to occur due to increased demand for a low-value product such as wood pellets. It is only cost-effective to use residues, offcuts, or thinnings unsuitable for timber production for biomass power, which at the same time, provides forest owners with additional income.

      Landowners aim to grow wood that attracts the greatest profits. This means timber for construction and joinery, which requires high-quality, straight, long logs. To achieve this, they plant saplings close together, which encourage trees to grow straight. However, this means they compete for light and nutrients and some will not grow tall. Having served their purpose,

[17] Use of high carbon North American woody biomass in UK electricity generation, BEIS 2017, https://www.gov.uk/government/publications/use-of-high-carbon-north-american-woody-biomass-in-uk-electricity-generation

they are removed to allow the larger trees to grow to maturity – a process known as 'forest thinning'. These thinnings can be used for biomass as they can have few other market uses close enough to justify the transport costs for such low-value wood. In the past, paper mills would use some of this low-value wood, but many of these have closed in the UK, US, and Canada, leaving plenty of spare material for biomass industry – which now helps support forests in these areas and makes conversion away from forestry less likely. Trees and other plants die naturally through disease or environmental factors. This leaves dead material in the forest canopy or on the forest floor, which can encourage infestation, disease and wildfires. By clearing the dead material, foresters improve the health of the forest and its overall carbon absorption. Trees do not grow indefinitely – they reach a point of maturity when they stop growing. Younger, growing trees absorb carbon faster. Once mature, trees absorb carbon at a much slower rate. Sustainable forestry practices involve harvesting trees at the point when they are close to maturity, thereby maximising the value of forest products and the rate at which a forest absorbs and stores carbon. These and other measures keep a forest building its carbon stores at an optimum speed. After just a short management period, a previously unharvested forest will begin to absorb more carbon than if it was left unmanaged.

The use of wood for bioenergy has not altered forestry practices (BEaC 2017) but is instead a source of income for forest owner and timber production, which supports the overall forest industry and the use of wood in construction. In the UK, the forest cover has, since the 1900s, continuously increased every decade, with woodland area increasing from 4.7% in 1905 to 13.0% in 2015[18]. EU forest and other wooden land increased by 322,800ha, equivalent to increasing by the size of a football field every minute, or 1440 per day. Forest Europe, a pan-European ministerial level voluntary political process for the promotion of sustainable management of European forests, states that Europe's forest area has expanded to 215 million hectares, or 33 percent of the region's total land area, and continues to expand.

Similarly, the US has 751million square miles of forest land, producing a quarter of the world's usable output. There is estimated to be another 150m tonne per annum extra capacity in just three regions of North America. The EU's recent bioenergy finds total EU pellet imports, used by the power sector, is likely to peak at 20 million tonnes in 2020 and then to level out at a level which is a small fraction of what can be sustainably supplied. In British Columbia, a region of Canada, there is 55 million hectares of forest. 22 million of these are considered for harvesting. Just 200,000 hectares are harvested in an average year, producing around 31 million dry tonnes of timber per year. That is 31 million tonnes produced from harvesting less than 1% of the available forests, constituting less than half the total forest land in

[18] Forestry Commission, Woodland Area, http://www.forestry.gov.uk/website/forstats2015.nsf/0/4E4661416947 5C868025735D00353CC8?open&RestrictToCategory=1

British Columbia alone. By comparison, the whole UK biomass sector's demand is estimated to constitute around 30 million tonnes – less than British Columbia's annual harvest. The US Department of Agriculture Forest Service confirms that the forest cover has been increasing every year since 1950; the level of carbon in US forests is 30% higher now than it was in 1990, despite or maybe because of, rising demand for wood products. This is partly due to increased demand for wood energy, which brings undermanaged forests into active management, benefitting woodland growth, woodland biodiversity, wildlife, and local economies.

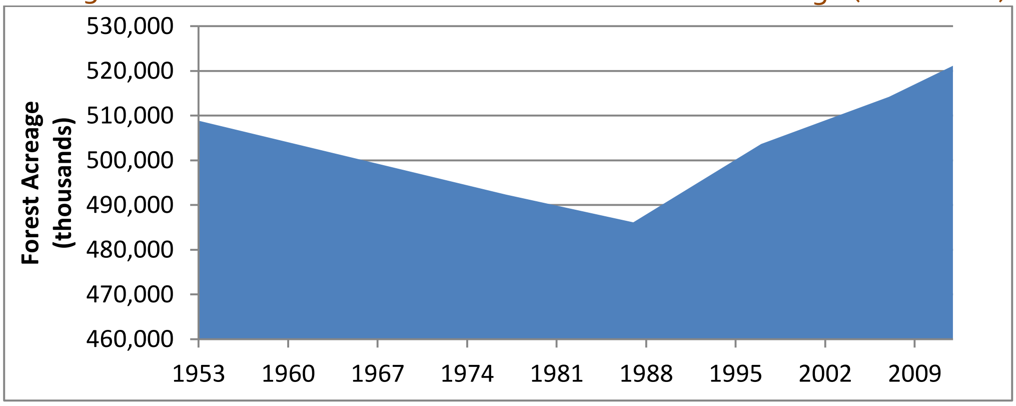
As illustrated in chart 3 and 4, then the US timberland area has increased continuously since 1987, and the US net volume of growing stock since 1953.

Table 4: US forest cover and inventory

Year	Forest Acreage (thousands)	Forest Inventory (million cubic feet)
1953	508,864	615,884
1977	492,366	733,056
1987	486,140	781,655
1997	503,664	835,680
2007	514,213	942,949
2012	521,154	972,397

Notes: Source: Data on forest area and inventory from USDA Forest Service FIA program; collected from "Forest Resources of the United States, 2012: A Technical Document Supporting the Forest Service Update of the 2010 RPA Assessment", tables 10 and 20[19].

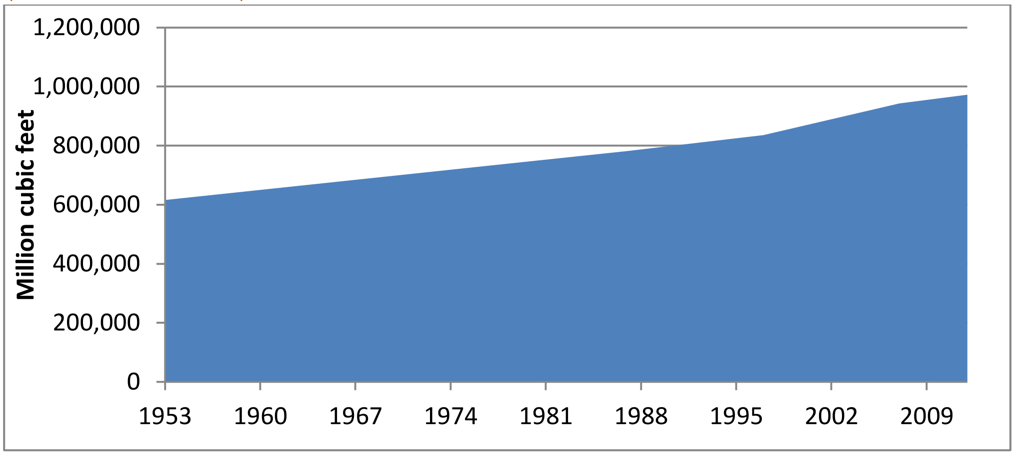
Chart 3: Timberland area in the United States US Forest Acreage (thousands)



Source: Data on forest area and inventory from USDA Forest Service FIA program; collected from "Forest Resources of the United States, 2012: A Technical Document Supporting the Forest Service Update of the 2010 RPA Assessment", tables 10

[19] Oswalt, S. N., Smith, W. B., Miles, P. D., & Pugh, S. A. (2014). Forest resources of the United States, 2012. Washington Office, Forest Service, US Department of Agriculture. https://srs.fs.usda.gov/pubs/47322

Chart 4: Net volume of growing stock on timberland in the United States (Million cubic feet)



Source: Data on forest area and inventory from USDA Forest Service FIA program; collected from "Forest Resources of the United States, 2012: A Technical Document Supporting the Forest Service Update of the 2010 RPA Assessment", tables 20

Most of Canada's forest land (nearly 90%) is public land, owned and managed on behalf of Canadians by provincial and territorial governments. All Canadian commercial forestry operations operating on public land are legally bound by federal, provincial, and territorial legislation. Canada has almost half of the world's PEFC-endorsed certifications and almost a third of the world's FSC certifications. The comprehensive legislative and regulatory framework, which provides regular scrutiny and audits of forest companies, reduces the risk of illegal logging in Canada.

Multiple studies show that increased demand for wood pellets will result in an increase in forest growth and forest inventory:

- Woodall, C. W., Piva, R. J., Luppold, W. G., Skog, K. E., & Ince, P. J. (2011). An assessment of the downturn in the forest products sector in the northern region of the United States. Forest Products Journal, 61(8), 604-613, https://www.nrs.fs.fed.us/pubs/40916
- Abt, K. L., Abt, R. C., Galik, C. S., & Skog, K. E. (2014). Effect of policies on pellet production and forests in the US South: a technical document supporting the forest service update of the 2010 RPA assessment. General Technical Report-Southern Research Station, USDA Forest Service, (SRS-202), https://www.srs.fs.usda.gov/pubs/47281
- Jefferies, Hannah M., & Tracy Leslie (2017), Historical Perspective on the Relationship between Demand and Forest Productivity in the US South, Forest2Market, https://www.forest2market.com/hubfs/2016_Website/Documents/20170726_Forest2Market_Historical_Perspective_US_South.pdf?t=1515424736510
- Dale, V. H., Kline, K. L., Marland, G., & Miner, R. A. (2015). Ecological objectives can be achieved with wood-derived bioenergy. Frontiers in Ecology and the Environment, 13(6), http://onlinelibrary.wiley.com/doi/10.1890/15.WB.011/abstract

- Parish, E. S., Dale, V. H., Tobin, E., & Kline, K. L. (2017). Dataset of timberland variables used to assess forest conditions in two Southeastern United States' fuelsheds. Data in Brief, 13, 278-290, https://www.sciencedirect.com/science/article/pii/S2352340917302391
- Malmsheimer, Robert W., PhD, JD (2014), Letter to President Jean-Claude Juncker, 8th December 2014, Co-signed by 100 academics http://www.theusipa.org/Documents/Malmsheimer_to_Juncker-ScienceFundamentalsLetter.pdf

b) What evidence is there that wood pellet production displaces other uses of forestry products in North America? (e.g. panel board or lumber production)

The European Commission has twice, in connection with State Aid approval of subsidy for biomass power production at Drax and Lynemouth, investigated the impact of pellet production on panel board or lumber production and found no evidence of market distortion[20, 21].

Pöyry Management Consulting analysed the risk of indirect wood use change[22] and found that there is no strong evidence for an increased risk of IWUC in the US South due to the low paying capability of pellet producers and the existing and persisting surplus of lower-value wood fibre in the US South.

c) What are the most likely alternative/counterfactual uses of forestry products used for wood pellet production?

See answers above.

d) How are these wider market impacts (sub-questions a-c) likely to change over time if demand for wood pellets significantly increases?

The *Use of high carbon North American woody biomass in UK electricity generation* report, the updated BEaC report from 2017, finds that:

> *"[…] Analysis showed that even if small roundwood prices doubled, it would not be sufficient income to justify conversion of land to intensive small roundwood only management. […] This study did*

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[20] European Commission (2016), State aid: Commission authorises UK support to convert unit of Drax power plant from coal to biomass, 19th December 2016, http://ec.europa.eu/competition/state_aid/cases/262075/262075_1900066_314_2.pdf; https://ec.europa.eu/commission/commissioners/2014-2019/vestager/announcements/state-aid-commission-authorises-uk-support-convert-unit-drax-power-plant-coal-biomass_en

[21] European Commission (2015), State aid: Commission authorises UK support to convert Lynemouth power station to biomass, 1st December 2015, http://ec.europa.eu/competition/state_aid/cases/257110/257110_1915232_277_2.pdf; https://europa.eu/rapid/press-release_IP-15-6214_en.htm

[22] Pöyry Management Consulting (2014), The Risk of Indirect Wood Use Change, prepared for Energie Nederland July 2014, https://english.rvo.nl/sites/default/files/2016/09/IWUC-Report-20140728.pdf

not find any justifiable link between pellet demand and impact on conservation. [...] What [pellet demand] does not do is decrease rotation."

Biomass feedstocks and wood pellets are simply too low-value a product to impact the North American forest industry.

The US Department of Energy estimates in their 2016 Billion-Ton Report[23] that 1 billion tons of forest and agriculture resources per year are available for a variety of uses, including for energy, without any adverse environmental effects. There has been a decline in the pulp and paper market as a result of the 2008 recession and waning global demand for printed materials. As a result, there is an estimated surplus of an additional 20 million dry tons (40 million green tons) of low-grade harvesting residues available in the US South per year.

4. Aside from GHG emissions, what evidence is there of other sustainability impacts associated with imported biomass or other biofuels? What evidence is there for how these might change as a function of scaling up supply (from the US, and internationally)?

   See research articles provided above.

5. Are there any benefits resulting from importing biomass or other biofuels into the UK (e.g. development benefits)? How might these vary internationally? What are the conditions required for any benefits to be realised?
   There are wider grid benefits from bioenergy generation, as bioenergy is easily dispatchable to meet fluctuations in energy demand and can serve as backup power generation to balance the grid alongside variable renewables. The whole system cost of biomass should be considered when comparing it to other low-carbon generation. This has been highlighted by *Biomass UK* and *USIPA* in their white paper "Bigger picture, lower cost - Lowering the cost of the energy transition through a whole system costs approach"[24]. Update figures, which have been calculated after the latest CfD round by Aurora Energy Research, are available upon request.

   There is furthermore an opportunity for the UK to exports its stringent sustainability standards to other countries and regions through the import of biomass fuels. Every supply chain that feeds into UK biomass import has to comply with the GHG emission criteria and land-use criteria on sustainability and legality. Although wood pellets are a low-value product and are unlikely to impact the wider timber industry, UK

[23] U.S. Department of Energy (2016), 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy, https://energy.gov/eere/bioenergy/2016-billion-ton-report

[24] Biomass UK & USIPA (2017), Bigger picture, lower cost. Lowering the cost of the energy transition through a whole system costs approach, https://biomass-uk.org/wp-content/uploads/2017/09/Bigger-Picture-Lower-Cost-the-case-for-Whole-System-Costs.pdf. Biomass UK is part of the REA and represents its biomass power members.

sustainability standards for pellets and biomass fuels could impact the global standards for sustainability.

Sustainability policy and certification

The sustainability framework for bioenergy in the UK has evolved significantly since 2011. Changes have included the tightening over time of lifecycle GHG emissions limits for bioenergy supported under Government incentive schemes, changes to EU rules on liquid biofuels and the development of certification schemes. Nonetheless questions remain regarding the current framework's capacity to guarantee high sustainability standards.

The term 'sustainability framework' refers here to the policies, regulations and incentives in place to promote bioenergy sustainability in the UK.

6. What are the strengths, weaknesses and gaps of the current sustainability framework for bioenergy in the UK? How could the current sustainability framework for bioenergy in the UK be improved to address these issues?

   The sustainability framework in the UK is implemented through the various support schemes (i.e. the RHI, RO, CfD, RTFO, and soon FiT) and although based on similar principles have slightly different implementation structures.

   Biomass heat (RHI)
   As noted above, for biomass heat implementation primarily takes place through the Biomass Suppliers List (BSL), on where almost all fuel sold to RHI boilers are registered, baring fuels used by large boilers (+1MW). This is the most stringent and thorough sustainability certification scheme in the world for bioheat. The revised EU RED directive for 2020-2030 recommends a 20MW threshold, where domestic, micro and small boilers do not have to undergo life-cycle analysis[25], however, the UK has opted to subject all biomass heat fuels to life-cycle analysis and land criteria regulations, unlike any other EU member state. The BSL certification scheme requires that suppliers submit a GHG life-cycle analysis for each fuel they register and evidence that the fuel complies with the land criteria and UK forestry legislation. Operators of larger biomass (+1MW) boilers and biomethane and biogas heat producers (any size) are required to submit annual sustainability audit report of their GHG life-cycle analysis and submit evidence of land-use compliance to the independent regulator, Ofgem. This needs to be prepared to an adequate standard, being ISAE 3000 or equivalent. The UK's sustainability framework for bioheat is thereby matched by no other in Europe or internationally.

   A potential improvement could be further transparency of data submitted to Ofgem and the BSL. Unlike under the RO, Ofgem is not obliged to publish the sustainability data, and the BSL currently does not publish aggregated data of the fuels registered.

[25] The revised Renewable energy Directive, https://ec.europa.eu/energy/sites/ener/files/documents/technical_memo_renewables.pdf

Increased auditing of imported fuel on the BSL would also be beneficial to verify the GHG life-cycle and land-use compliance evidence.

Biomass Power (RO, CfD)
The UK sustainability framework for biomass power is globally the most rigorous, which has been mandated by the UK Government following months of consultations and stakeholder input. To comply with UK regulations, pellet producers hold chain of custody and fibre sourcing certifications from internationally-recognized forestry certification schemes such as FSC, SFI, PECF, SBP, and others. Fuel suppliers are audited by independent, third-parties on a routine basis to maintain these certifications, in accordance with international auditing standards. Data on GHG emissions and forest legality and sustainability are submitted to the independent regulator, Ofgem, who determines compliance with UK regulations.

The report from Indufor (2016)[26] compares the forest management legal frameworks and certification standards across 14 national or sub-national jurisdictions around the world, including the US, Canada, Finland, Germany, Russia, and Sweden.

Biofuels (RTFO)
The science behind ILUC is uncertain, as suggested below, and on this basis have argued that the crop cap should not be any lower than 7%. The new RTFO has a crop cap starting at 4% and going down to 2%. This is likely to put a strain on the UK's ability to fulfil the Obligation level in the future, and the regulations may need to be revisited to rectify the problem.

According to the European Biodiesel Board

> "As recognised by a study published (1) by the European Commission's DG Energy in August 2017, ILUC factors identified in the literature vary significantly across biofuel pathways, studies, or even within studies. Confirming this understanding, various ILUC studies have highlighted considerably different conclusions: for example, the study conducted by the US California Air Resources Board (CARB) in 2015 (2) established that ILUC values for rapeseed biodiesel are four to five times lower than those established by GLOBIOM, the latest study commissioned by the European Commission (3).
>
> The disparity of the studies mentioned above reinforces the uncertainties in the components of ILUC emissions, which are very difficult to narrow down. Therefore, since ILUC has no robust scientific ground and results from studies can differ by 200-300%, differentiation amongst feedstocks based on alleged levels of ILUC would be illogical and illegal, and should not be accepted."

A useful general observation on ILUC can be found on the Ecofys blog[27], which states

[26] Indufys (2016), International Comparison of Forest Management Legal Frameworks and Certification Standards, 18 May 2016, Washington DC, can be obtain upon request by the REA.
[27] Ecofys (2017), Indirect Land Use Change from Biofuels Explained, https://www.ecofys.com/en/blog/indirect-land-use-change-from-biofuels-explained/

"ILUC impacts from sugar- and starch-based ethanol are small. The contribution of these types of biofuels can be increased without ILUC risks" and "ILUC emissions are very large for soybean and palm oil. It is advised to decrease the volumes of biofuels based on these crops unless they are produced (certified) without ILUC."

For information UK produced bioethanol produce fuel and animal feed from feed wheat grown on surrounding farms that would not be suitable for human consumption, and a by-product of the process (DDGS) substitutes for imported soy feed.

It is important that the UK framework for bioenergy as applied to the RTFO recognises the existence of waste and residues that are not listed in Annex IX of the Revised Renewable Energy Directive. As they are not listed, they are not double counted. The RTFO guidance needs to cover such materials properly.

7. Ofgem has identified a number of certification schemes that it considers appropriate for demonstrating compliance with the 'Land Criteria' under the Renewable Obligation sustainability standards. Are these certification schemes adequate? Why/why not? How could they be improved?
   Yes. The regional approach has been shown to work in other schemes and is the most efficient way of dealing with the issue. The risk-based assessments also remove the financial and administrative burden from the small family landowner and place it on the biomass producer instead. The methodology also requires third-party auditing of the data provided by plant operators. The schemes are based on FSC and PEFC approaches, which meet the highest forestry certification standard internationally.

   However, it should be pointed out that, as highlighted by the BEaC 2 report, biomass fuels do not dictate forest choices or drive markets, as it is a low-value by-product. Setting standards for imported biomass is unlikely to change forestry practices, as the majority of the forest value (e.g. timber products) might not require compliance with certification schemes, which makes it difficult for fuel suppliers to require it for the low-value by-product.

8. What certification schemes currently represent 'best practice'? Why?
   FSC, SFI, SBP, and PEFC are commonly used to comply with sustainability when importing feedstock from abroad. The risk-based regional approach adopted by the BSL is based on FSC and PEFC principles. However, as noted above, biomass fuels are unlikely to be able to dictate forestry certification, as they derive from low-value forest by-product.

9. Ofgem has set out approaches to calculating bioenergy GHG emissions for demonstrating compliance with the 'GHG Criteria' under the Renewable Obligation sustainability standards. Are these approaches adequate? Why/why not? How could they be improved?
   Yes. The criteria offer a robust and well-established method of accounting for emissions, covering these on a comprehensive basis, including transport and handling, therefore, providing a holistic account of emissions associated with

particular plants' operations. The methodology also requires third-party auditing of the data provided by plant operators.

The Renewables Obligation (RO) methodology is sound, however, most new plants will now be developed under Contracts for Difference (CfDs) and the recent consultation on setting new values for these emission levels in the CfD Scheme represents a real challenge to new-projects' viability as they are so far below those previously achieved. Changing the GHG criteria for solid and gaseous biomass-fuelled plants in the scheme as proposed would see GHG emissions requirements changing from a minimum of 180 gCo2/MWh, to one of 25-41 gCo2/MWh for projects commissioning between 2022-2026.

Data from our members indicate the new values will be unachievable by the vast majority of plants based on previous year's generation data. Yet the RO scheme will retain the previous values, which represent an 89% reduction in emissions compared to fossil fuel plant as stated above.

It is worth pointing out that similar approaches are also adopted by Ofgem under other incentives such as Feed-in Tariffs and the Renewable Heat Incentive. However, there is little transparency of the GHG emission data reported to Ofgem by producers registered under these Schemes. Under the Renewable Obligation, a biomass sustainability dataset showing the GHG emissions on a per consignment basis for stations > 1 MW is published by Ofgem annually. Similar information should be made publicly available by Ofgem for other schemes to ensure consistency with other policy areas, transparency and also show how the industry is performing in sustainability terms.

10. Please highlight any further measures you feel are required to ensure bioenergy feedstocks used in the UK are sustainable and deliver significant life-cycle GHG emissions savings. Why are these measures needed?
    REA has approached the Government to facilitate a working group on adjustments of GHG emission calculators used under RO/CfD/RHI to include the latest research and updated default values. This intends to deliver better and more accurate reporting across the industry.

11. Some large UK users of imported biomass use a risk-based approach to assess the sustainability risks associated with importing biomass from specific jurisdictions. What is the role for these approaches?
    Risk-based approached is used in the risk-based regional approach (RBRA) in determining compliance with the land-use criteria for feedstock in evaluating Category B Evidence for legality and sustainability in the forest. Category B evidence is all forms of credible evidence other than certification schemes that indicate that the forest source meets the woodfuel land criteria. It allows suppliers to procure timber from forests that are not certified through certification schemes if they can provide credible evidence showing low-risk of non-compliance with the woodfuel land criteria on a regional level. There are a number of reasons why forest owners do not opt to become certified by certification bodies such as the FSC and PEFC, such as cost, forest

size, rotation frequency, and overall consumer demand. However, these forests are still governed by national and regional legislation on harvesting rights, biodiversity, water, air and soil protection, basic labour rights, health and safety of forest workers, tree felling licensing, replanting/regeneration requirements, waste handling, and disease control, which ensures the legality and sustainability of the forests. The risk-based regional approach "is based on the Forest Stewardship Council (FSC) and Programme for the Endorsement of Forest Certification (PEFC) Controlled Wood and Controlled Sources regional risk assessment and draws from the work of other voluntary schemes"[28]. The approach forms the basis of the UK Timber Procurement Policy and is a widely accepted approach in the forestry industry for timber products. It is also used in UK accepted certification schemes such as SFI and SBP.

As the RBRA is widely used in ensuring the legality and sustainability of other forest-based product such as timber for construction, furniture, paper, plywood and other wood-based panels, it stands to reason that the same should apply to feedstock for bioenergy.

Supply of bioenergy feedstocks

In our 2011 Bioenergy Review we considered scenarios for the amount of sustainable bioenergy resource available to the UK over the coming decades. Our central 'Extended Land Use' scenario suggested that around 10% of the UK's primary energy demand could be met from bioenergy in 2050, with over half coming from domestic feedstocks. We are now looking to develop new supply scenarios through to 2050 to reflect the latest evidence on sustainability and different assumptions about the potential future availability of imported and domestically produced bioenergy resources.

To support the development of these scenarios and our wider work, the CCC is currently undertaking new analysis on how the use and management of land in the UK can deliver deeper emissions reduction and increased sequestration. This analysis will provide updated data on the potential supply of non-waste and non-food bioenergy resources from UK sources. For projections of international bioenergy resources and waste-based UK bioenergy resources we will review the latest evidence and publicly available literature. We are particularly interested in quantitative estimates of resource potential, broken down by feedstock type, that are underpinned by explicit assumptions relating to sustainability.

12. What are the most credible and up-to-date estimates for global bioenergy resource potential through to 2050, broken down by feedstock type? What key assumptions underpin these estimates?
    There have been made many estimates of global bioenergy resources. Deng et al. (2015)[29] have made country-based, bottom-up assessment of the land-based global

[28] Risk Based Regional Assessment: A Checklist Approach, 22 Dec 2014, DECC, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/390148/141222_Risk_Based_Regional_Assessment_-_A_Checklist_Approach_-_Guidance_final.pdf
[29] Deng, Y. Y., Koper, M., Haigh, M., & Dornburg, V. (2015). Country-level assessment of long-term global bioenergy potential. biomass and bioenergy, 74, 253-267, https://www.sciencedirect.com/science/article/pii/S0961953414005340

biofuel (bioethanol and biodiesel) potential, and Wood et al. (2015)[30] from Imperial College London have provided an overview of research of land availability. The U.S. Department of Energy has also made assessments in their *2016 Billion-Ton Report*[31].

The work carried out by Anthesis and E4Tech, sponsored by Cadent, gives a comprehensive review of UK bioenergy resources[32], and also touches on those global resources that may be expected to be available to the UK via imports. The report considers all of the potential feedstocks including waste and UK sustainable biomass that can be used for the production of biomethane from anaerobic digestion (AD) and Bio-Substitute Natural Gas (BioSNG). The results for total bioenergy potential in 2050 are broadly similar to those modelled by the CCC in 2011.

Please provide details of any assessments of global bioenergy resource explicitly tied to sustainability standards (covering GHG emissions, biodiversity, water use, land-use, land-rights, air-quality and other social and environmental issues)

13. What is the latest evidence relating to the availability of 'marginal' and abandoned agricultural land for growing bioenergy crops (where possible, reflecting broader sustainability requirements e.g. water stress, biodiversity, social issues)? Is this evidence adequately reflected in global resource estimates?

14. What are the most credible and up-to-date estimates for the amount of bioenergy resource that could be produced from UK waste sources through to 2050? Where possible please state any assumptions relating the reduction, reuse and recycling of different future waste streams.
    Cadent Gas, one of the largest Gas network suppliers in the UK, recently commissioned an independent study to evaluate the potential of renewable gas to 2050, as well as the bioenergy potential to 2050. This work was carried out by Anthesis Consulting Group PLC and E4tech UK Ltd, to update the CCC scenarios, reflective of more recent data and developments. The report[33] considers all of the potential feedstocks including waste and sustainable energy crops that can be used for the production of renewable gases. These take the form of biomethane from anaerobic digestion (AD) and Bio-Substitute Natural Gas (bioSNG). The forecasts (section 2.4.1 of the Technical report) suggest 65 to 77TWh of bioenergy potential

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[30] Woods, J., Lynd, L. R., Laser, M., Batistella, M., de Castro, V. D., Kline, K., & Faaij, A. (2015). Land and bioenergy. Bioenergy: bridging the gaps, 9, http://bioenfapesp.org/scopebioenergy/images/chapters/bioen-scope_chapter09.pdf

[31] U.S. Department of Energy (2016), 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy, https://energy.gov/eere/bioenergy/2016-billion-ton-report

[32] Anthesis Consulting Group (2017), Bioenergy Market Review, Summary report available at: http://cadentgas.com/getattachment/About-us/The-future-role-of-gas/Renewable-gas-potential/Promo-Downloads/Cadent-Bioenergy-Market-Review-SUMMARY-Report-FINAL.pdf; and technical report at: http://cadentgas.com/getattachment/About-us/The-future-role-of-gas/Renewable-gas-potential/Promo-Downloads/Cadent-Bioenergy-Market-Review-TECHNICAL-Report-FINAL.pdf

[33] Anthesis Consulting Group (2017), Bioenergy Market Review, Summary report available at: http://cadentgas.com/getattachment/About-us/The-future-role-of-gas/Renewable-gas-potential/Promo-Downloads/Cadent-Bioenergy-Market-Review-SUMMARY-Report-FINAL.pdf; and technical report at: http://cadentgas.com/getattachment/About-us/The-future-role-of-gas/Renewable-gas-potential/Promo-Downloads/Cadent-Bioenergy-Market-Review-TECHNICAL-Report-FINAL.pdf

from waste feedstocks by 2050. The report converts this (section 4.2) into a renewable gas potential of 47-56 TWh/a, with 83% coming directly from BioSNG using gasification and 17% from biomethane via AD.

Sections 2.3 and 3.5 of the full technical report are particularly useful as they assess feedstock availability up to 2040 for both waste and non-waste feedstocks.

The key messages which can be drawn from this study can be summarised as follows:

- A range of more up-to-date data and related new assumptions have been employed for this study, but the results for total bioenergy potential in 2050 are broadly similar to those modelled by the CCC in 2011.
- This work suggests that biomethane will continue to make an important contribution to renewable gas generation, but suggests that BioSNG has far greater potential through its greater versatility in respect of the range of feedstocks which might be processed (once the technology has been demonstrated at commercial scale).

Bioenergy, and in particular renewable gas, can make a significant contribution to meeting 2050 climate change targets, in particular when supporting decarbonisation of the heat and transport sectors, which are currently lagging behind the electricity sector.

15. What factors (opportunities, constraints, assumptions) should the CCC reflect in its bioenergy resource scenarios through to 2050?
The CCC should recognise that there is a considerable opportunity for biomethane-fuelled heavy goods transportation between now and 2050. It may not be the enduring solution for decarbonising this sector, but it is readily available now whereas alternatives are not. It represents a no-regrets solution (as even if non-renewable gas is used, significant GHG savings are obtained, along with improved tailpipe emissions). It is thus a bridging technology between now and electrification of heavy vehicles.

For biomass power generation, we refer to our answers to Q1-3.

16. What should be the assumptions on the share of international resource which can be accessed by the UK (e.g. per capita, current or future energy demand)?
We are concerned with the approaches suggested in this question, as it implies a central determination of what proportion of certain goods the UK should be allowed to access globally. In a globalised economy, there are many products where UK supply does not meet UK demand, and many products depend on earth resources such as the production of paper, batteries, cotton, food, and electric vehicles, with bioenergy being no different. There should be no reason why the UK should be restricted in the use of specifically bioenergy feedstock, as long as it is sustainably sourced and complies with regulations. If UK companies can pay for sustainable feedstock that complies with the land-use and GHG criteria, then there should be no restrictions on this, as there are no restrictions for purchase of imported paper products, for example. There is a surplus of timber and wood fibre supply in North America that

they rightly export, which helps support the local forestry sector. In the UK, there is a shortage of wood fibre and timber products, which we, therefore, import in the form of paper, bioenergy feedstock etc. To put an arbitrary limit on the import of one specific product, although sustainably sourced, would be unreasonable.

17. What are the prospects for the development and commercial production of 3rd generation bioenergy feedstocks (e.g. algae)? What are the timescales, costs, risks, opportunities and abatement potential of using algae to make biofuels?
    We suggest the CCC directly approaches companies carrying out research on these types of feedstocks. For example, Neste has been involved in several global research projects on microalgae oil.

Scaling up UK sustainable supply

An objective of our current work on bioenergy is to better understand and reflect the potential for scaling-up of the supply of sustainably produced domestic (UK) bioenergy resources through to 2050. We aim to identify and develop policy recommendations for 'low-regrets' measures/strategies that can be implemented in the near term.

18. What are the main opportunities to scale-up the supply of sustainably-produced domestic bioenergy supply in the UK? Where possible please provide details on the scale of opportunity.
    There are many research papers published on this, such as:
    - ADAS (2017), Refining Estimates of Land for Biomass, https://d2umxnkyjne36n.cloudfront.net/insightReports/160519_BI2012_D12_Extension-report_v2-1_FINAL.pdf?mtime=20170725131030
    - Welfle et al. (2014), Securing a bioenergy future without imports, Energy Policy, Volume 68, May 2014, Pages 1-14, http://www.sciencedirect.com/science/article/pii/S0301421513012093
    - Haughton, A. J., Bohan, D. A., Clark, S. J., Mallott, M. D., Mallott, V., Sage, R. and Karp, A. (2016), Dedicated biomass crops can enhance biodiversity in the arable landscape. GCB Bioenergy, 8: 1071–1081. doi:10.1111/gcbb.12312
    - ETI (2015), Bioenergy Delivering greenhouse gas emission savings through UK bioenergy value chains, http://www.eti.co.uk/insights/delivering-greenhouse-gas-emission-savings-through-uk-bioenergy-value-chains
    - ETI (2015), Insights into the future UK Bioenergy sector, gained using the ETI's Bioenergy Value Chain Model (BVCM). Available at: http://www.eti.co.uk/insights/bioenergy-insights-into-the-future-uk-bioenergy-sector-gained-using-the-etis-bioenergy-value-chain-model-bvcm/
    - ETI (2017). Increasing UK biomass production through more productive use of land. Available at: http://www.eti.co.uk/library/an-eti-perspective-increasing-uk-biomass-production-through-more-productive-use-of-land

- ADAS (2016), RELB: Job implications of establishing a bioenergy market, Available at http://www.eti.co.uk/library/adas-relb-job-implications-of-establishing-a-bioenergy-market

Defra has determined that only 2% of the UK arable area of just over 6 million hectares has been used for cropping for energy applications. When considering the total UK agricultural area of 17.4 million hectares this falls to just under 0.8%.

The ETI's Bioenergy Value Chain Model shows that the UK could convert a total of 1,400,000 ha of UK land to bioenergy crops by the mid-2050s, without impacting on the level of UK-grown food consumed, by planting a mixture of Miscanthus, SRC willow and Short Rotation Forestry (SRF). ADAS estimates that 1.0 – 1.8Mha of land could be spared for bioenergy production with minimal or no impact on food production, with the biggest short-term barrier being market conditions. Welfle et al. (2014) find that "indigenous biomass resources and energy crops could service up to 44% of UK energy demand by 2050 without impacting food systems. [Their research] scenarios show, residues from agriculture, forestry and industry provide the most robust resource, potentially providing up to 6.5% of primary energy demand by 2050. Waste resources are found to potentially provide up to 15.4% and specifically grown biomass and energy crops up to 22% of demand.

Increased production and use of domestic feedstock also have an impact on job creation in the rural economy. ADAS (2016) finds that 9,100 full-time job equivalents (FTE) would be created in the bioenergy sector by 2055, with 5,600 FTE in the short rotation forestry sector, 1,300 FTE in the short rotation coppies sector, and 2,200 FTE in the miscanthus sector, if 1.4Mha is converted to bioenergy production[34]. This does not include ancillary jobs, such as administrative roles, finance, and marketing, with the companies or any jobs beyond the initial journey off the farm.

The benefits of increased use of domestic feedstock are wide-ranging. Cambridge University's report '*The Best Use of UK Agricultural Land*' highlight that "land can deliver multiple benefits – such as forestry or perennial crops providing both a source of timber and energy as well as water management, carbon storage and wildlife benefits"[35]. In particular flood management and water protections have been highlighted by Forestry Research (the Forestry Commission's research agency). They find that "*energy crops can offer additional advantages for water protection, flood risk management and climate change mitigation by enhancing pollutant uptake and sediment retention, more rapid establishment of vegetation roughness (especially for SRC) and increased carbon sequestration, as well as a more attractive and faster economic return for landowners*"[36]. The planting of second-generation energy crops such as Miscanthus and willow can also improve the biodiversity of agricultural landscapes. Haughton et al. (2016) found that replacing annual arable crops with

[34] ADAS (2016), RELB: Job implications of establishing a bioenergy market, Available at: http://www.eti.co.uk/library/adas-relb-job-implications-of-establishing-a-bioenergy-market
[35] Cambridge Institute for Sustainability Leadership (2014), The Best Use of UK Agricultural Land, https://www.cisl.cam.ac.uk/publications/natural-resource-security-publications/best-use-uk-agricultural-land
[36] Forest Research (2011), Woodland for Water: Woodland measures for meeting Water Framework Directive objectives https://www.forestry.gov.uk/pdf/FRMG004_Woodland4Water.pdf/$FILE/FRMG004_Woodland4Water.pdf

perennial, dedicated biomass crops results in significant, large-scale changes to the abundance and composition of plant and invertebrate biodiversity indicators, and there are a "greater abundances of biodiversity indicators in biomass crops at the landscape scale"[37]. Dedicated biomass crops, when intensively managed, can increase the landscape diversity and create "resilient, multifunctional landscapes".

19. What risks are associated with scaling-up domestic supply and how can these risks be managed?

20. What 'low-regrets' measures should be taken now (e.g. planting strategies) to increase sustainably-produced domestic bioenergy supply?

21. What international examples of best-practice should the UK should look to when considering approaches to scaling-up domestic supply?

22. What policy measures should be considered by Government to help scale-up domestic supply?
Annex 3 of the recently published IEA's Technology Roadmap to deliver sustainable bioenergy is a useful reference as it identifies the bioenergy solutions suitable for immediate scale-up.

Best-use of bioenergy resources

Our 2011 review developed a hierarchy of appropriate uses for bioenergy feedstocks based on minimising costs and maximising abatement. We concluded that if CCS technology is available it is appropriate to use bioenergy in applications with CCS, making it possible to achieve negative emissions under the right circumstances. This could include power and/or heat generation, hydrogen production, and biofuels production for use in aviation and shipping. If CCS is not available, bioenergy use could be skewed towards heat generation in energy-intensive industry, and to biofuels in aviation and shipping, with no appropriate role in power generation or surface transport. In either case, we concluded the use of woody biomass in construction should be a high priority given that this can potentially secure negative emissions through a very efficient form of carbon capture.

We are now looking to update this analysis to reflect the latest technological and market developments. We are particularly interested in technologies such as biomass gasification, CCS and advanced second and third generation biofuels as well as the potential role of hydrogen to support decarbonisation across the economy. To support our consideration of these areas, the CCC is currently undertaking analysis into the potential of the hydrogen economy and we are planning to undertake further investigation into non-energy uses of bioenergy resources.

23. Gasification has been identified as a potentially important technology for unlocking the full potential of bioenergy to support economy-wide decarbonisation.

[37] Haughton, A. J., Bohan, D. A., Clark, S. J., Mallott, M. D., Mallott, V., Sage, R. and Karp, A. (2016), Dedicated biomass crops can enhance biodiversity in the arable landscape. GCB Bioenergy, 8: 1071–1081. doi:10.1111/gcbb.12312

a) What are the likely timescales for commercial deployment of gasification technologies?
b) What efficiencies and costs are likely to be achieved? What scope is there for improvement and/or cost reductions over time? Please differentiate between feedstocks where possible/necessary.
c) What are the main barriers and uncertainties associated with the development, deployment and use of gasification technologies?
d) What risks are associated with gasification technologies and how can these be managed?
e) What policies and incentives are required to facilitate commercial deployment?

Commercial scale Advanced Conversion Technologies (ACT) projects, such as gasification, are ready for deployment now if an appropriate policy environment is established to support the transition from demonstration projects to commercial operations.

To date, the main barrier to ACT deployment has been the lack of a stable and reliable policy environment. Poorly delivered routes to market have so far been ineffective in securing deployment or incentivising the most innovative forms ACT that can deliver solutions for the decarbonisation of the heat, transport and green chemical sectors.

The lack of CfD allocation rounds and a prescriptive MW Capacity Cap has, to date, impeded ACT deployment

Over the last five years, the main support mechanism for ACT deployment has been the Contracts for Difference (CfD). In that time there have only been two allocation rounds, with the one in 2017 including a restrictive MW capacity cap on the deployment of fuelled technologies.

The lack of clear projected dates for future allocation rounds has meant that many potentially commercially viable ACT projects have been delayed or abandoned. They have been left unable to secure financial closure while also having to pay significant ongoing costs, such as staff, while not knowing when they would next be able to bid for a CfD to move the project forward.

Similarly, we are aware of a number of high-quality gasification projects that bid lower strike prices than the final clearing price for ACTs in the 2017 allocation round but were blocked from clearing the auction due to breaching the MW capacity cap. The last auction could have seen a greater capacity of ACTs secured, at a lower price to the consumer, had the cap not been in place. Modelled analysis of the 2017 allocation round, produced by one of our members (available on request), suggests that if BEIS had opted for a financial cap, rather than MW cap, then as much as 300 MW of ACTs could have been secured in the last auction at an auction price of around £70/MWh. This would have meant higher quality projects and better value for the consumer.

As such, The UK in the last allocation round missed a valuable opportunity to see commercial gasification projects realised as early as 2021/22.

Realising Cost Reductions

As is the case with all less established technologies, significant cost reductions in ACT will be delivered as increasing numbers of projects are successfully built. The successful deployment of the first couple of commercial-scale projects allows for the growth of industry expertise and allows for increases in electrical net efficiencies; in turn, this helps establish investor confidence as well as creating an affordable supply chain for machinery and feedstock. Investor confidence will deliver a virtuous circle. Due to the limited deployment of ACTs so far, funders lack a number of operational projects to see in action and are, in effect, de-risked.

The cost of capital is therefore currently much higher than other comparator technologies in pot 2 of the CfD. One can look at technologies like offshore wind to see how their financing costs came down as more units have been deployed. Within offshore wind it took 15 to 20 successful projects, delivered over several years, to reach current day costs. The ACT industry fully expects to deliver similar levels of cost reductions if given the opportunity to deploy the same critical mass. For example, in terms of net electrical efficiencies (NEE) it will only require the ACT industry to see an achievable 10% uplift in efficiency over these initial projects in order to be at a level equal to NEEs of other more established technologies, reaching a net efficiency of 24 – 30% by the 2020s.

Technical Deployment Barriers

The industry recognises, as is the case with all emerging and innovative activities, that some projects (including high profile ones) have failed. Importantly, this is not endemic to the sector but representative of some of the boundaries being pushed together with some elements of poor delivery leading to cash flow or board-commitment issues. Important lessons have already been learned from these projects.

Significant progress has been made in relation to the development of tar cracking technologies, which is key to allowing syngas produced by gasification to be used for higher value applications including renewable transport fuels. There are already well advanced commercial projects being developed that are aiming to deliver in the next few years, these however also depend on a stable policy environment being maintained. For comparison, in the USA and other countries in Europe support from domestic governments is being used to deploy commercial-scale projects using waste as a feedstock and gasification/pyrolysis combined with other technological components to deliver fuels or chemicals.

Clearly stated government ambitions, supported by a stable policy environment, will allow ACT to deliver decarbonisation in the transport, green chemicals and heat sectors.

As already discussed the primary support mechanism for ACT to date has been the CfD, however, the delivery of this mechanism has been ineffective in delivering a sizable number of projects. Despite this, the REA believe that there remains a role for ACT within the CfD, in order to get that initial critical mass of power ACT projects built which will help to establish supply chains, realise efficiencies and deliver cost reductions for the delivery of more advanced systems. Significantly, the latest reforms proposed to the CfD will likely fail to achieve this goal. While it is positive that BEIS understand the need to support the highest quality forms of Gasification, the CfD remains a support mechanism focused on power capacity and, as such, the reforms are potentially an inefficient way of trying to adopt an unsuitable power policy into a vehicle for delivering alternative sustainable products. The CfD should remain focused on delivering initial commercial ACT power projects.

Policy development, therefore, needs to recognise a clear pathway from the delivery of Power ACT, the most efficient uses of waste in the delivery of renewable gas, transport fuels and chemicals. Support mechanisms are currently inconsistent in their treatment of ACT and Government is unclear what it wants to be delivered from the technology. Future reforms must make clear what they are trying to achieve and set out a pathway to achieving it.

A recent positive policy development has been the reforms to The Renewable Transport Fuels Obligation (RTFO). The development fuel target, which includes Biomethane from bioSNG, should provide a strong stimulus and a market-driven incentive for ACT projects to produce renewable transport fuels. A strong RTFC price could prove more valuable than a CfD, thereby incentivising decarbonisation of the transport sector, including aviation. It should, however, be noted that, at this stage, the RTFO may not be regarded as bankable as other support mechanisms due to the price volatility. This is something that BEIS and the DFT should be encouraged to address in order to help the promotion and use of the RTFO. From an industry point of view, there are some notable ACT projects that are already intending to utilise the RTFO and, if proven successful, will play a significant role in encouraging other developers and investors into the market.

Overall, Government lacks an overarching strategy, with clearly stated aims of what they want to achieve from ACT. The current policy mechanisms are confused and not well aligned with an ambition to see ACT deliver the most advanced forms of sustainable products and deliver decarbonisation where it is most required. The CfD reforms are trying to deliver transport fuels while still focusing on delivering power capacity. At the same time the RTFO provides a new attractive option, but more needs to be done to encourage ACT developers to consider it. The Governments Bioeconomy Strategy and Waste and Resource Strategy, currently being developed by BEIS and DEFRA respectively, provide an opportunity for Government to clearly set out both its aims for ACT and policy mechanisms. The CCC's involvement in that process will be crucial to ensure a clear pathway to delivering the most efficient forms of ACT for the UK.

Possible Future Policy Mechanisms

More focused policies that will help with the delivery of ACTs could include:

- suitable tax breaks (including for R&D commercialisation),
- enhanced capital allowances,
- enterprise investment funding or new grants,
- access to long-term market stabilisation contracts (a.k.a. "a subsidy-free CfD") that appropriately finance and commensurate for the lifetime of the asset. This can be technology neutral and still provide support to ACT technologies that may fall outside of other support mechanisms
- A strong carbon price, set at a sufficient level that will enable low carbon fuels to compete.

This will establish a range of value streams, allowing the industry to establish itself and get to a stage of delivering commercial projects that deliver a wide range of sustainable products.

24. Bioenergy with Carbon Capture and Storage (BECCS) has been identified as a key potential mechanism for achieving the UK's 2050 carbon target due to the 'negative emissions' it could offer.
    a) What are the potential timescales for commercial deployment of BECCS technologies?
    b) What are likely to be the optimal uses of BECCS (e.g. electricity generation, hydrogen production)?
    c) What efficiencies and costs are possible?
    d) How will performance and cost differ according to feedstock type? What are likely to be the optimal feedstock types for BECCS? What are the implications for domestic supply vs imports (e.g. feasibility, considerations in scaling up over time)?
    e) What are the main barriers and uncertainties associated with the development, deployment and use of BECCS?

It is a prerequisite for deployment of BECCS to have an existing and thriving biopower industry and developers. It is therefore vital that biopower is included in support schemes and continues to be supported to further improve supply chains, drive down costs, increase efficiencies, and lower emissions, otherwise BECCS will be more costly to achieve.

It is, consequently, concerning that BEIS continues to limit biopower and other fuelled technologies in the Contracts for Difference scheme. Biomass power is currently constrained in routes to market, as the CfD scheme does not support conversion of coal to biomass power or new-build biomass power-only projects, while Biomass CHP projects are subject to a 150MW cap, which prevents larger, more efficient projects from bidding into the auctions.

Similarly, the Government is currently exploring setting very tight GHG emission limits for new biomass power projects in the CfD scheme[38], which would see the GHG saving requirement raised from 80% compared to EU fossil power average to 95-96%. Analysis of the RO sustainability data would suggest that this would only be achievable for 14% of the total tonnage being reported (and 28% of all consignments) under the RO should similar projects apply again. If the even stricter <25kg CO_2eq/MWh proposal would be applied, then only 7% of the total current tonnage (and 17% of consignments) would be able to meet the requirements.

Finally, biomass has been disadvantaged by artificial walls that prevent it from achieving financial returns in recognition of its multi-functional value to the electricity grids. Integrating variable renewable technologies into the electricity grid can result in added costs, which are then passed on to businesses and consumers, including the costs of transmission, balancing, increasing costs to remaining users of the distribution network, financial support schemes, and the Capacity Market. To account for all of the costs of a reliable energy system, it is necessary to view the system as a whole, considering the "whole system costs" associated with deploying each low-carbon technology and assigning a value to technologies that provide both security and dispatchability. The biomass sector is primarily upstream (i.e. focused on electricity generation), but it has a significant role to play in the midstream (transmission, distribution and ancillary services), and thereby creates cost benefits to the downstream (i.e. retail) market. Biomass power is currently the only large-scale renewable technology that provides consistent power that is easily dispatchable to meet fluctuations in energy demand and can serve as backup power generation to balance the grid alongside variable renewables. Without biomass as a backup, generators must rely on fossil fuels – whether gas, coal, or diesel – to produce on demand energy. The full cost (both monetary and environmental) of security to the grid, ensuring flexibility, and keeping the lights on is not considered. The UK should use a whole system costs analysis to evaluate the costs of different energy projects within the CfD to minimise cost to the consumer and overall cost of GHG mitigation. The GHG emissions from gas or diesel generators within the capacity market should be considered when

[38] Contracts for Difference (CfD): proposed amendments to the scheme, BEIS, https://www.gov.uk/government/consultations/contracts-for-difference-cfd-proposed-amendments-to-the-scheme

comparing variable renewables with bioenergy in addition to the cost of variability, security of supply, balancing, and transmission.

The work going into the creation of an international biomass pellet supply trade, which is led by the UK biomass power sector, is, therefore, the first step along the path to biomass with CCS and negative emissions.

The CO_2 and H_2 from CCS technologies do not have to be directly stored to be environmentally advantageous. For example, these could be feedstocks for fuels of non-biological origin, and results in the production of more fuel whilst fossil carbon-based feedstocks are left in the ground.

f) What are the risks associated with the pursuit of BECCS that go beyond the risks that relate to supplying sustainable feedstocks and CCS more generally? How can these be managed?

25. Once developed BECCS is a technology that could be deployed in many different countries around the world. What principles and mechanisms should be used to determine where BECCS is deployed and how any associated negative emissions are accounted for? Should any UK participation in any international BECCS scheme be counted as additional to efforts to meet domestic carbon budgets?

26. There is currently substantial interest in the development of 'advanced' biofuels for use in sectors such as aviation, shipping and/or heavy duty transport.
    a) What are the most promising technologies/processes for advanced biofuel production up to 2050? Please provide details on each technology/process including advantages/disadvantages, timescales for commercial deployment, feedstock type, fuel type and end-user.
    b) What efficiencies and costs are likely to be achieved? What scope is there for improvement and/or cost reductions over time? Please differentiate between technologies/processes.
    c) What are likely to be the optimal feedstock types for advanced biofuel technologies?
    d) What are likely to be the optimal end-uses of advanced biofuel technologies?
    e) What are the main barriers and uncertainties associated with the development, deployment and use of advanced biofuel technologies?
    f) What risks are associated with the pursuit of advanced biofuel technologies and how can these be managed?
    g) What policies and incentives are required to facilitate commercial deployment of advanced biofuels?
    We suggest you refer to the 133-page document "Building up the future Sub group on advanced biofuels: final report – Study" published on 8th June 2017[39].

[39] EU Commission (2017), Building up the future. Sub group on advanced biofuels : final report – Study, https://publications.europa.eu/en/publication-detail/-/publication/422218de-4cbd-11e7-a5ca-01aa75ed71a1/language-en/format-PDF/source-61702023

27. In 2015 the Government published the Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050. These Roadmaps explored decarbonisation options across multiple industrial sectors and the estimated deployment potential, timescales, cost data and abatement for each option (including bioenergy). Are there any substantial changes from these estimates that the CCC should consider when assessing abatement options in industry? If so please provide your reasoning and details of any recent evidence that relates to these changes.

28. In our 2011 review we identified wood in construction as a potentially effective method of CCS and a high priority 'non-energy' use in our best-use hierarchy.
    a. What lifecycle GHG emissions savings can be achieved by using WIC? Under what circumstances does WIC fail to deliver GHG emissions savings? Please consider the full range of impacts associated with using WIC including substituted product emissions (e.g. cement), product equivalence (impacts on co-products), end-of-life options and biogenic carbon storage.
    Wood in construction is a great opportunity to sequester carbon and should be encouraged, as the use of wood in construction is lower in the UK compared to North American, for example. However, it is worth stating that bioenergy and WIC are not competing but supplementary products, as bioenergy does not use wood that can be used for timber or furniture.

    The Forestry Commission's 50-year forecast of timber availability does not suggest any concern with biomass availability[40,41], but this does not include the positive impact of demand for biomass fuel. With increased demand for biomass, previous undermanaged forests would be brought into management and thereby increase its availability[42]. It is a common misconception that the increased use of biomass will lead to reduced use of wood in panel board and construction, but Forestry Commission statistics show that as softwood deliveries to energy markets have increased, deliveries to sawmills have increased and deliveries to panel board mills have remained broadly stable between 2005 and 2014[43]. Increased demand for biomass fuel creates an economic signal to the forestry market that devalued residue and by-products also have an economic value, thereby supporting increased forestry growth.

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[40] Forestry Commission, hardwood availability forecast http://www.forestry.gov.uk/pdf/50_YEAR_FORECAST_OF_HARDWOOD_AVAILABILITY.pdf/$FILE/50_YEAR_FORECAST_OF_HARDWOOD_AVAILABILITY.pdf
[41] Forestry Commission, Softwood availability forecast http://www.forestry.gov.uk/pdf/50_YEAR_FORECAST_OF_SOFTWOOD_AVAILABILITY.pdf/$FILE/50_YEAR_FORECAST_OF_SOFTWOOD_AVAILABILITY.pdf
[42] Forestry Commission, Millions of tonnes of wood being wasted every year http://www.telegraph.co.uk/news/earth/earthnews/8603921/Millions-of-tonnes-of-wood-being-wasted-every-year.html
[43] Forestry Commission, Forestry Statistics 2015 - UK-Grown Timber, Deliveries of UK-grown roundwood, http://www.forestry.gov.uk/website/forstats2015.nsf/LUContents/824A4E0E2DDEDC858025731B00541EFF

As demonstrated in the 2017 BEaC report[44], timber products for construction are of significantly higher value than fibre for bioenergy and there is, therefore, no competition between the two for wood. Bioenergy producers are unable to pay for 'whole' trees (defined as suitable for lumber markets) for feedstock, as the forest owners get a much higher price when selling the wood for timber products. This is also illustrated by the Ofgem RO sustainability data, which shows that primarily residues, thinnings, low-grade roundwood, branches, tops, and bark are being used for biomass power production, rather than high-value roundwood.

Demand for wood whether for paper or biomass has only ever resulted in a positive response from the forestry industry. It is an absence of demand for wood which leads to deforestation, land conversion and poor carbon outcomes.

b. What is the potential for increasing the amount of wood used in construction in the UK? What are the barriers and how can they be overcome?
c. What is the potential for using UK-produced timber in construction rather than imports? What are the barriers and how can they be overcome?
d. What is the expected lifetime of different wood products in construction (e.g. cross-laminated timber)?
e. What currently happens to wood in construction at the end of its useful life? What other viable options should be developed?

29. There are also a number of other potential non-energy uses of bio-feedstocks including bio-based plastics and bio-based chemicals.
    a. What other non-energy uses of bio-feedstocks have the most potential through to 2050 in terms of GHG abatement, cost, timescales and market size?
    b. What are the barriers to increasing these non-energy uses and how can these barriers be overcome?
    c. What risks are associated with the pursuit of other non-energy uses of bio-feedstocks and how can these be managed?

Non-energy uses of bio-feedstocks that have the most potential through to 2050 include, but are not limited to, manufacturing of primary form plastics/plastic packing goods, organic basic chemicals, perfume & cosmetics, fertiliser & nitrogen compounds, industrial gas, and soap & detergent manufacturing.
The Industrial Biotechnology Landscape Report, released in October 2017 and produced by the BBSRC Networks in Industrial Biotechnology and Bioenergy (NIBBs), highlights the potential for industrial biotechnology (defined as the use of biological resources for producing and processing materials, chemicals and energy), and also identifies the key barriers to

[44] Use of high carbon North American woody biomass in UK electricity generation, BEIS 2017, https://www.gov.uk/government/publications/use-of-high-carbon-north-american-woody-biomass-in-uk-electricity-generation

realising this potential and provides key recommendations to Government on how to overcome these barriers.

The Biobased Industries Consortium and the Nova Institute have identified and mapped over 200 biorefineries across Europe[45]. They defined a biorefinery as "an integrated production plant using biomass or biomass-derived feedstocks to produce a range of value-added products and energy".

The use of bio-feedstocks for non-energy uses is consolidated in time and varies from country to country. Examples are the production of starches and sugars to convert into chemicals that are used for a variety of production processes; animal feed; use of agricultural and human food waste for animal feed and chemicals; use of lumber as a solid domestic fuel, construction and timber material; use of cotton, wool, hemp, flax for textiles and insulation materials; animal waste (bones, fats, skins) through rendering and hide production; use of fish waste as animal feed; waste from the brewery and distilling industries that is used as animal feed or as chemical feedstock. Some of these non-energy uses are well-known and require no particular policy mechanisms at present to enhance their market potential; for example, rendering and the use of animal bones and fats, and the use of animal skins as hides, are industries that operate globally and are (in the UK) subject to stringent health, safety and environmental regulations. The use of fish waste as a feedstock for animals is long established. Through the use of biorefineries, plant materials can be converted into chemicals that are the base materials for chemical polymers used for:

- bioplastics
- chemical building blocks within the chemical industries
- surfactants
- coatings and paints
- cosmetics
- pesticides
- lubricants
- medical applications
- engineered applications such as in the automotive industries (fluff)
- insulating fibres, and others.

New horizons have opened in the last decades due to changes in technologies and processes. The use of biomaterials for the production of chemicals in replacement of fossil-fuel chemicals has developed over the last two decades and has become a feedstock for several industries.

UK examples include the recent announcement of the building of a full-scale plant for the use of whisky by-products to be converted into bio-butanol by the Scottish company Celtic Renewables; the recently announced use of biomaterials by chemical giant Azko Nobel in the production of chealates for

[45] http://biconsortium.eu/media/mapping-european-biorefineries

consumer and industrial detergents and cleaners markets; Fuchs Lubricants of Stoke on Trent who make lubricants and greases using biopolymer feedstocks; Ecospray of Thetford, Norfolk who use garlic extracts to make pest-specific pesticides; Biome of Southampton, who use biopolymers for bio-plastic production; Woolcool of Stone , Staffordshire, who use low- grade wool fleeces to produce high quality insulation materials for pharmaceutical packaging. There are many other examples but the UK has not developed this industrial sector to its full potential; other countries are far ahead in terms of investments, size of industrial production, numbers of people employed, such as Germany, France, Netherlands, Sweden, Italy, USA.

The use of biomaterials can reduce the emissions of GHG during the production phases, as the source feedstock used is renewable and non-fossil in origin. The major gain to be made in using renewable plant-based materials is through the reduction of biogenic waste allowed to biodegrade in an uncontrolled manner, such as in landfills; or through the avoidance of GHG emissions from incinerating these materials. Where they are captured and driven into the production of biogas, they can achieve their full potential in reducing GHG emissions. However, this partially misses the point. Further gains in GHG emission reductions are to be found in the use of the materials themselves, and fulfilling the potential they are designed for, rather than in the production itself.

Bioplastic packaging materials are ideal for uses where fresh food is packaged and has a short shelf life. For example, fruit and vegetables, bread and cakes, sandwiches. By recovering bioplastic materials with food waste collections we can a) raise the volumes and quality of food waste collected b) reduce contamination by non-compostable plastics c) increase through organic recovery the volumes of paper and bioplastic currently destined for disposal, through composting d) increase the stock of organic carbon in soils through spreading compost to them.

Within the UK, England has low recovery rates for domestic food waste; whereas Merthyr Tydfil in Wales collects over 100 kg/inhabitant of food waste annually, the England average is around 25 kgs. The use of bioplastic bags for food waste collection helps drive up both the quantity and purity of the waste collected and improves overall recovery, production of biogas and compost[46].

Barriers to the introduction of biobased materials into UK markets are essentially about lack of market-places for these materials. Whereas, for example, France, Italy, and Belgium, mandate the use of bioplastic materials in certain uses (carrier bags, food waste collections, fruit and vegetable bags) the UK does not. The use of biolubricants on waterways would be one way of ensuring greater water quality protection as well as developing a UK

[46] http://www.recycleformerthyr.co.uk/media/1038/merthyr-waste-leaflet.pdf

industry[47]. So whilst private initiatives are commendable (the COOP Food Group sells compostable carrier bags for dual use as food waste collection bags) the volumes represented by these are insufficient to make market changes. The use of governmental powers is needed to open new markets. In this sense, financial subsidies are not required.

Use of plant materials to substitute fossil fuel materials is often subject to accusations of competing land use. The argument is that by making (for example) bioplastic bags from sugar and starches, land is used that could have been used to feed people. Similarly, the argument is used for biofuels and biogas from agricultural feedstocks. The industries making bio-chemicals are well aware of these accusations and indeed the Holy Grail of biochemical production is to use agricultural and domestic food wastes as a feedstock, thereby closing the loop on food production. The EU has funded several research projects on this subject through its Horizon 2020 and Biobased Industries Joint Undertaking research funds. The project Res Urbis[48] is financed specifically to set up a pilot plant using biowaste and sewage sludge as a feedstock for bioplastic PHA. When leaving the EU, the UK puts such research partnerships and funds at risk. However, the technologies are not yet mature and virgin feedstocks are still generally required to make high-grade bio-materials (though see above Celtic Renewables).

A barrier to using domestic food waste as a feedstock is the legislative framework: the end of life of food waste in renewable materials needs to be approved; moreover, consumers and fast-moving consumer goods companies would be reluctant to use packaging derived from food waste in many uses, such as in food itself. Ethical issues around using food waste containing meat, pork, dairy products, alcohol as a renewable feedstock for materials, also need to be addressed. However, the principal barriers to the extension of biomaterial use in mainstream markets revolve around marketplaces for these materials (i.e. entering into and disrupting existing, consolidated market leaders). Government assistance in terms of mandates/obligations is essential, just as they were for the introduction of renewable energies.

GHG emissions reporting and accounting

GHG emissions reporting rules for bioenergy are different to those for other forms of energy. Emissions relating to the use (combustion) of bioenergy resources are not reported in the country of use but rather in the country where bioenergy resources are produced. Only Annex 1 countries under the Kyoto Protocol currently account for land-use emissions

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[47] See http://www.totaloil.com.au/total-oil-in-australia/sustainable-development/biolubricants-automotive.html for an explanation of uses
[48] www.resurbis.eu

as part of binding emission reduction targets. In addition under Paris Agreement rules emissions (as under the Kyoto Protocol) will be reported against land-use baselines that may already assume a degree of land-use change. For these reasons and others, bioenergy GHG accounting has been criticised for not properly reflecting the impacts of bioenergy.

30. What are the strengths and weaknesses of the current approach to GHG emissions accounting for bioenergy in the UK and internationally? Specifically, what are the main gaps in the current land use emissions accounting rules?
31. What are the risks, in terms of GHG emissions, associated with importing biomass or other biofuels from countries that have not committed to limiting or reducing emissions under the Kyoto Protocol or Paris Agreement? How can these risks be managed?

    Whether the US Government decides to leave the Paris Agreement, it does not change the sustainable practices of the wood fuel industry or the forest industry overall. The US still monitors overall forest carbon stocks and forest inventory, and fuel will still need to comply with UK sustainability requirements.

32. What alternative method(s) for bioenergy emissions accounting should be considered? What would the implications of these alternative method(s) be?

    Some have been concerned with the carbon accounting of biomass due to the so-called carbon debt assertion. This is understood as once a tree is felled and the sequestered carbon is released during bioenergy production, there is a carbon debt, as it takes decades for a new tree to absorb the carbon released. However, this ignores the continuous growth of the entire forest and the other surrounding trees. Biomass takes carbon out of the atmosphere while it is growing, and returns it as it is burned. When managed on a sustainable basis, biomass is harvested as part of a constantly replenished crop. This is either during forest, arboricultural management, coppicing, or as part of a continuous programme of replanting with the new growth taking up CO_2 from the atmosphere at the same or greater rate than the harvest level of the forest as it is released by combustion of the previous harvest.

    Any worry regarding the potential carbon debts should be put to rest by the forest inventory statistics illustrated in table 4 (and chart 3 & 4) for US forests, and the UK Forestry Commission statistics showing that UK woodland area has increased every decade since 1905, with UK woodland area increasing from 11.3% in 1999 to 13.1% in 2017[49]. Not only does the woodland cover increase every decade, but the net volume of growing stock also increases, which would indicate that the replanting is occurring at a greater rate than the harvest level. This would thereby dispel the concern of any carbon debt of woody bioenergy.

[49] Forestry Commission (2017), Forestry Statistics 2017, https://www.forestry.gov.uk/pdf/Ch1_Woodland_FS2017.pdf/$FILE/Ch1_Woodland_FS2017.pdf, table 1.2

Indicators

As part of the 2018 Bioenergy Review the CCC is planning to develop a set of indicators to track progress towards key bioenergy outcomes. We envisage these will cover key areas such as sustainability, policy development, supply and best-use.

33. What key areas should be reflected in these indicators?
There are already many useful indicators already for general deployment of bioenergy (such as the RED targets, deployment statistics within support schemes, and overall carbon budgets). However, it would be useful to have new indicators specifically on bioenergy deployment rather than overall renewable deployment, and indicators on development of new regulation (such as WIC building standards) could be useful.

34. Please provide details of any examples of international best-practice in the area of bioenergy indicators.

Other

35. Please submit any further evidence that you would like us to consider.

The International Energy Agency has recently published a Technology Roadmap looking at the long-term vision for clean energy technologies and providing guidance on the near-term priorities and key steps to accelerating technology and deployment. The report is useful as it identifies the key opportunities and the obstacles that need to be resolved[50].

Modern bioenergy plays an essential role in the IEA's 2°C scenario (2DS), providing nearly 17% of the final energy demand in 2060 compared to 4.5% in 2015. It would be difficult to replace this important contribution and bioenergy is particularly important in sectors for which other decarbonisation options are not available.

[50] https://www.iea.org/publications/freepublications/publication/technology-roadmap-delivering-sustainable-bioenergy.html