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.*

The supply chain GHG accounting methodology used within the UK follows the methodology set out by the EU and is generally accepted to be accurate, although some improvements and modifications are necessary (see question 9). Within this accounting framework Drax has historically achieved an average supply chain GHG emissions level of around 33-35 gCO_2eq/ MJ. This represents a saving of around 86-87%[1] when compared to the coal benchmark and is also within the current and future thresholds determined by UK regulation.

Within the existing wood pellet supply chain, the GHG emissions can vary substantially, depending on transport distances, feedstock type and energy used in processing[1]. The current range is typically between 20-50 gCO_2eq/ MJ. At the lower end of this spectrum we would see sawmill processing residues produced in Europe (e.g. Baltic countries, NW Russia etc.) and shipped to a market within Europe. Biomass at the higher end of the spectrum is likely to be pulpwood from thinning in the US gulf states. This type of feedstock has a higher GHG footprint as the forestry and processing inputs are also included (but excluded for sawmill residues). The energy used in pelletisation in the US is typically generated from coal and therefore has a higher emissions factor than countries that have more renewables. The shipping distance from the US gulf is further than intra-European trade distances. Therefore, the likely future change to the average GHG emissions factor would depend on the proportion of additional supply from each region.

There is considerable potential to increase biomass supplies from both Europe (including NW Russia) and North America. Analysis by Pöyry Management Consulting demonstrates that there are currently 140 million oven dry tonnes (ODTs) of surplus low-grade biomass that could be used for wood pellets in the current pellet supply regions[2]. This is expected to decrease slightly to around 133 million ODTs by 2035 considering changes in future demand. Given the geographic distribution of this surplus, the current relative proportions are likely to be maintained, therefore any future increase in wood pellet demand is likely to have a similar GHG footprint at around 35 gCO_2eq/ MJ.

Wood pellets and biomass that are derived from processing and harvesting residues, thinnings and low grade roundwood - harvested from sustainably managed working forests – has a positive impact on the forest industry, forest carbon stocks[3] and helps to ensure that forests stay as forests rather than being converted to agriculture or for urban development[4]. Recent analysis of historical trends in the US South has shown that, as demand for wood products increased over the last 60 years, management practices have also improved to increase forest growth rates and more than double the amount of carbon stored in the working forests from 4 billion m^3 to 8.4 billion m^3. This improvement is statistically correlated to increasing demand[3].

[1] https://www.drax.com/sustainability/sustainability-reporting/#greenhouse-gas-savings

[2] https://www.drax.com/wp-content/uploads/2017/12/Future-biomass-renewables-portfolio-Poyry-Drax.pdf

[3] https://www.forest2market.com/hubfs/2016_Website/Documents/20170726_Forest2Market_Historical_Perspective_US_South.pdf

[4] https://www.drax.com/sustainability/active-management-forests-increases-growth-carbon-storage/

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?*

Healthy markets for wood products has led to an increase in forest growth (carbon sequestration) and stored carbon. The total growing stock in the forests of the EU28 increased by 7.4 billion m^3 between 1990 and 2015[5], an increase of 38%. Over this same period, total production of roundwood (harvesting) also increased by 103 million m^3, around 29%[6]. This demonstrates that increasing demand for wood products and increased harvesting does not lead to deforestation or lower forest carbon stocks when sustainably managed, within well-regulated forest industries. Biomass has been, and should continue to be, an integral component of this demand.

In 2015 around 42% of the EU harvest was utilised for saw-timber which is stored in longer term wood products, 33% was pulpwood used primarily for paper and board products, the remainder was other industrial roundwood and wood fuel[6]. The proportion of wood fibre used for saw-timber is expected to increase, creating additional processing residues that can be used for energy.

The continual cycle of sustainable forest management, production of wood products, improving management practice and increased sequestration of atmospheric carbon leads to substantial GHG benefits[7]. These benefits are even greater when compared to the linear emissions associated with burning coal.

Many studies modelling carbon parity and payback times show that sustainable biomass has a positive GHG impact[8] and any apparent 'debt' is quickly repaid by the continuing growth of the forest landscape.[9]

Biomass should not be sourced from primary or virgin forests, sites identified as having high bio-diversity value, or protected sites. Biomass should be utilised from sustainably managed working forests and processing residues.

Utilisation of any biomass sourced directly from the forest should be in accordance with Best Management Practice guidelines[10] and existing regulations to ensure sustainability[11] and environmental protection.[12]

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5 http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=for_vol&lang=en

6 http://www.fao.org/faostat/

7 http://www.rothforestry.com/Resources/Fox%20et%20al.%202007.pdf

8 http://onlinelibrary.wiley.com/doi/10.1111/gcbb.12426/full

9 https://dspace.library.uu.nl/bitstream/handle/1874/308693/Jonker_et_al_2014_GCB_Bioenergy.pdf?sequence=1

10 Note: each State has its own BMP included on their website https://www.fs.fed.us/biology/watershed/BMP.html

11 https://www.forestry.gov.uk/pdf/FCFC001.pdf/$FILE/FCFC001.pdf

12 https://www.drax.com/wp-content/uploads/2017/11/THE_7_PRINCIPLES_OF_A_SUSTAINABLE_BIOMASS_POLICY_v3.pdf

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?

Biomass and the production of wood pellets in the US South for export to Europe is strongly supported by both forest owners[13] and by the US Department of Agriculture[14] particularly in wake of the decline of the pulp and paper sector[15] and the slowdown in panel board production that reduced demand for pulpwood by around 30 million tons p.a.[16] There is also substantial potential to expand biomass utilisation within the US.[17]

The current low scale of demand for industrial wood pellets in the US (at just 2.5% of total harvest[18]), and the low value of the wood pellet market[17], is not sufficient to influence the rotation length or the production of higher value end products (e.g. saw-timber for the solid-wood market). The wood pellet sector provides an additional market for pulpwood from thinning operations, for low grade roundwood and residues, and incentives for continued forest management.

Every forest owner (whatever their principal management objectives) will try to maximise revenue at the point of sale. Therefore logically, when making management decisions, a forest owner will always prioritise the highest value markets. Saw-timber is typically 3 times more valuable to a forest owner than pulpwood (low grade roundwood)[19] and will always be the principal driver of forest management decision making.

Any expansion of biomass demand (even a doubling of current utilisation) is still likely to have little impact on the primary objectives of forest management. Extra demand will be met by surplus mill residuals (from increased saw-timber production), surplus low grade roundwood and additional thinning operations to improve the quality of the final crop (where thinning is currently not viable due to a lack of market demand).

The impact on carbon stocks is referenced in Q1.

[13] https://nafoalliance.org/issues/carbon/

[14] https://www.eenews.net/assets/2016/06/14/document_cw_01.pdf

[15] https://www.srs.fs.usda.gov/pubs/ja/2015/ja_2015_wear_003.pdf

[16] See Appendix I

[17] https://energy.gov/eere/bioenergy/2016-billion-ton-report

[18] See Appendix II (Data from FAOSTAT)

[19] See Appendix IV

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)*

Wood pellet mills have the lowest wood paying capability in the market[20] and cannot compete with other users of low grade fibre, therefore they must locate in areas of surplus supply and avoid undue competition with other markets. In fact, 72% of pellet mills in the US South are located within 65 miles of a closed wood using facility and pellet mills have attempted to avoid competition such that 61% are located more than 30 miles distant from a competitor.[21]

Analysis has been carried out by several forest industry consultants, experts in timber market and pricing trends, that clearly demonstrates that the development of new pellet mills in the US South has had no significant long-term impact on wood prices and availability of fibre for existing markets.[22]

As previously demonstrated, there is a substantial surplus of fibre in the US South and wood pellet markets have the lowest paying capacity, therefore they are unable to displace existing markets. US Forestry consulting company Forisk comments that: *the wood pellet industry in the US South is not exploding, it is a tiny component of the overall market. Forest volumes in the South in total will continue to grow for decades no matter what bioenergy markets or housing markets do. The wood pellet sector simply and unequivocally cannot compete economically with US pulp and paper mills (80% of pulpwood demand in South) for raw material on a head-to-head basis.*[23]

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

Wood pellets are being manufactured primarily from sawmill residuals, thinnings, low grade roundwood and forest residues (branches, tops and bark).[24] In the case of sawmill residuals, these may have been burnt as waste if there was no viable market nearby (i.e. British Columbia), alternatively they may have been transported over a longer distance to a pulp or panel mill. If a pellet mill is located close to a sawmill the residuals may be sold to the pellet mill, rather than transport over longer distances, if it is the closest market with the cheapest transport cost. In this instance the previous market would source alternative fibre from closer to their plant.

In many cases, without a pellet market, thinning would not take place as it is not cost effective unless there is an economically viable off-take for the fibre produced. Thinning is primarily aimed at increasing the size and quality of the final crop to generate increased revenue from saw-timber, however there are other benefits associated with thinning[25] which would not be realised without the presence of wood pellet markets or other off-take for this fibre.

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[20] See Appendix III

[21] http://www.theusipa.org/Documents/USSouthWoodSupplyTrends.pdf

[22] See Appendix IV (please note that this data is confidential as price information is subscription only, please do not share publicly)

[23] http://www.forisk.com/blog/2015/10/23/nibbling-on-a-chicken-or-nibbling-on-an-elephant-another-example-of-incomplete-and-misleading-analysis-of-us-forest-sustainability-and-wood-bioenergy-markets/

[24] https://www.drax.com/sustainability/sustainability-reporting/#drax-biomass-feedstock-mix-by-fibre-type-2016

[25] https://sdda.sd.gov/legacydocs/Forestry/publications/PDF/Thinning-Benefits.pdf

Low grade roundwood is usually produced as a bi-product of harvesting for saw-timber production, this can constitute around 30-40% of the final harvest. It will usually be sold and transported to the closest economically viable market (this could be a pellet mill, pulp mill or panel mill). If no market exists within a reasonable transport distance, then this material can sometime be left on site to rot or burned on site to clear the ground for the next rotation of forest. The same can be said for forest residues, although this type of fibre is usually only suitable for biomass and therefore is much more commonly burned or wasted in the absence of a biomass market.

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

Given the substantial surplus of fibre and the forecast increase in availability of mill residuals, pulpwood and forest residues,[26] increasing from 28.2 million ODTs in 2015 to 61.5 million ODTs in 2050, there is significant potential to increase the use of biomass with positive outcomes for forests, forest economics and forest carbon, and no adverse effects on alternative markets.

In fact, it is essential that viable markets are developed to utilise this surplus fibre to ensure that forest owners continue to invest in forest management and good silviculture, increasing both carbon storage and sequestration.[3]

The US South is forecasted to lose between 11 million and 23 million acres (7 and 13 percent, respectively) of forests as a result of pressure from urban development.[27] Strong timber markets can ameliorate forest losses somewhat, by shifting urbanization to under-performing agricultural lands.

The availability of suitable, sustainable biomass is not infinite, but a substantial surplus currently exists from established working forests that are being under-manged as a result of limited markets.

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)?*

The increase in demand for wood pellet production in the US (and internationally) has had a very positive impact on wider sustainability performance and transparency of forestry operations and practices.[28] The UK Renewables Obligation (RO)[29] sets out strict controls about the type of biomass that can be used, in particular ensuring that:

1. Harm to ecosystems is minimised
2. Productivity of the forest area is maintained
3. Bio-diversity is maintained and protected
4. The health and vitality of the ecosystem is maintained
5. Customary and legal rights, including health and safety standards, are observed
6. Land use change is not caused by biomass demand
7. Biomass from land that has been converted since 2008 cannot be used for bio-energy

[26] See Appendix VI

[27] Wear, David N. and John G. Greis, eds. 2013. “The Southern Forest Futures Project: Technical Report.” Gen. Tech. Report SRS-GTR-178. Asheville, NC: USDA-Forest Service, Southern Research Station.

[28] http://www.envivabiomass.com/sustainability/track-and-trace/

[29] http://www.legislation.gov.uk/uksi/2015/1947/pdfs/uksi_20151947_en.pdf

Any claimant under the RO must have clear evidence to show that these criteria are being met. One of the impacts of this is the development of the Sustainable Biomass Program (SBP)[30] to provide independent third-party auditing of biomass supply chains and impacts.

The high profile of the biomass sector, in comparison to traditional forest industries, and the scale of debate around biomass issues has ensured that there is a high degree of transparency and scrutiny over biomass supplies and that large-scale importers of wood pellets are meeting the highest standards of sustainability performance and traceability, in comparison to other wood using industries. The impact of this is that the overall standards of sustainability in the forestry sector are driven upwards.

Drax has worked directly with NGOs[31] to protect sensitive sites and environmental campaigners[32] to be open and transparent about the type of biomass it uses and the impacts (positive or negative) of its operations. The biomass market makes a very real and positive contribution to forest health and biodiversity by enabling landowners to market small low-grade roundwood generated from thinning. Pine stands in the southern US undergo predictable succession from thick over-stocked stands to mature open canopy forests. This natural process was historically aided by frequent fires which cleaned out deadwood, reducing the threat of insect infestation and disease, and speeding the development of open-canopy conditions. Fire is no longer a predictable part of the landscape, therefore active thinning and understory brush control are considered important for maintaining forest productivity and restoring habitat for a suite of endemic species depended on open pine conditions. In the absence of a market for this small diameter material, many forest owners can't afford to thin their forest. The biomass market has bolstered the demand for this low-value material and positively contributed to biodiversity and forest vigour.

5. *<u>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?</u>*

One of the key benefits of increased biomass demand in the US South, and internationally, is the provision of a market for low grade wood fibre that otherwise would not be fully utilised. In British Columbia the wood pellet producers are utilising sawmill residues that were previously burned as waste[33]. In the Baltics there have historically been limited markets for low grade wood and thinnings, with much of this material being left in the forest to rot. The wood pellet sector is now providing a market for this fibre[34] to displace coal fired electricity generation and to provide jobs and revenue to rural communities in Estonia and Latvia. Utilisation of this material is also better for the forest, allowing thinning to take place and clearing away debris to allow the next generation of trees to grow.

In the US South, the pulp and paper sector has declined significantly in recent years, many rural communities have been decimated by the closure of large scale pulp and board mills. Forest owners have been unable to find a viable market for their low-grade wood. The development of the wood

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30 https://sbp-cert.org/

31 https://www.draxbiomass.com/setting-standard-responsible-sourcing/

32 https://vimeo.com/244685668

33 https://www.drax.com/sustainability/one-company-helped-transform-biomass-business/

34 https://www.drax.com/sustainability/forestry-industrys-cleaning-company/

pellet sector has had a very positive impact in these areas; providing jobs, not just in the mills but in the forests, in transport, administration and providing important revenue for these rural communities.

The wood pellet sector also provides a longer term stable market for forest owners, entering into long term contracts (e.g. 10 years) with suppliers. This gives greater long-term security to forest owners and allows them to plan and manage their resource more effectively. Many traditional markets in the pulp and paper sector can be volatile and irregular with significant price and volume fluctuations. This is another benefit that the wood pellet sector can offer, e.g. as with one of Drax's suppliers in Brazil.[35]

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?*

Strengths: the risk based approach – this avoids perverse impacts of paying the additional costs for certification on the lower value material. The benefits of a risk based approach mean that you can identify areas of weakness in a region and ensure that your suppliers mitigate those risks – driving sustainability improvements through the supply chain. The SFI Fibre Sourcing Standard, just recognized as satisfying PEFC CoC, is a good example of a program which has contributed to the overall health of the wood basket in the southern US. SFI Fibre Sourcing participants form an extensive network of wood purchasing facilities which require supplier training, provide outreach materials to landowners, and directly police bad actors through State Implementation Committees.

Weaknesses: the land criteria in the UK focusses only on sustainable forest management and does not cover sustainability throughout the supply chain (e.g. health and safety requirements in the processing plant). Responsible companies will of course cover these issues through their sustainability policies and codes of conduct, but it is an area which is lacking in the legislation.

There is inherent sustainability in using mill residuals which are a by-product of manufacturing and might otherwise go to waste. Requirements for residual fibre to meet the same sustainability standards as fibre direct from the forest provides little additional sustainability assurances and may result in the exclusion of fibre that could provide a very positive carbon outcome.

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?*

Certification schemes selected by OFGEM - FSC, SFI & ATFS (PEFC umbrella) and SBP - are appropriate for satisfying the Land Criteria. SBP is particularly valuable because it captures and recognizes existing standards and takes a supply-base approach to evaluating sustainability. The area of land certified to land management standards (i.e. FSC and SFI FM Standards) is not a good measure of regional sustainability, especially in the US South where most forestland is in private non-corporate ownership. On these lands, certification is not viewed as essential to sustainable management and is often avoided due to the additional cost burden. Cost is significant for owners of smaller forests, for instance average ownership in Louisiana is just 70 acres. Therefore, standards which can be applied at the supply base level, such as SBP (Supply Base Evaluation), the SFI's fibre Sourcing Standard, and FSC Controlled Wood Standard are valuable.

[35] https://www.drax.com/sustainability/sustainable-partner-brazil/

The lack of uptake of some forest level certification schemes means it is difficult to utilise them for meeting the RO sustainability standards. For example, the levels of FSC certification across North America, the US South specifically, are fairly low with 77% of FSC trademark licence holders are based in Europe, with only 4% in North America.

8. *What certification schemes currently represent 'best practice'? Why?*

The Sustainable Biomass Programme[30] could be considered to represent 'best practice', as it is the only certification scheme which is specifically designed to address the sustainability of bioenergy and which covers both the land criteria and the greenhouse gas criteria. SBP also has the greatest requirement for stakeholder consultation of the major certification schemes. However, its governance structure needs to be addressed, to include more stakeholders at board and committee level. There is transition process under way to move to a multi-stakeholder governance.

FSC, PEFC and SFI as forest level certification provide a high level of assurance that the forest is managed in accordance with sustainable principles.

In the US South, SFI has had a key role in compliance with state Best Management Practices (BMPs) developed to meet the federal Clean Water Act (CWA). With the advent of SFI certification in the mid 1990's, SFI developed mandatory logger training programs in partnership with state forestry agencies. Mills which were certified to the SFI fibre Sourcing standard required suppliers to maintain up-to-date training status to deliver wood. Forest Certification's role in BMP compliance was recently recognized by the EPA in their decision to require no additional regulation of forest roads due to effective implementation of state BMPs.[36]

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?*

The approach outlined by Ofgem is appropriate, however, the tool recommended by the regulator could be improved to include greater flexibility and accuracy in calculations.

Drax is aware of one key differences between the approach taken by the UK compared to that of the rest of the EU. EU methodology advises that a 1.2 conservative factor should be placed on any transportation or processing modules. In contrast, the UK recommended model[37] uses a 1.4 conservative factor, applied on the processing modules only.

LCA methodology is subject to scrutiny and results can vary significantly depending on the assumptions used. In order to calculate the most accurate GHG intensity, the calculator must be kept up to date with the best data. The current B2C2 model has several areas where updates are necessary, including default values which are based on out of date data. Therefore, Drax has begun the process of funding changes to the model to improve flexibility and accuracy in calculations, while still retaining the confidence that EU methodology has been complied with. The update will bring a higher level of accuracy and a degree of flexibility in the model which will enable users to enter more site-specific data.

[36] 81 Federal Register 43492-43510 https://www.gpo.gov/fdsys/pkg/FR-2016-07-05/pdf/2016-15844.pdf

[37] http://www.e4tech.com/b2c2temp/

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?*

The current GHG limits in the UK, with the downward trajectory in 2020 and 2025, have ensured that bioenergy feedstocks are providing significant life cycle savings compared to burning fossil fuels. There is an intrinsic connection between reducing life cycle emissions and reducing operating costs. For example, using less fuel in transport reduces logistical costs, while also reducing emissions. Lowering the electricity used in processing reduces processing emissions, but also reduces the operator's electricity bill. Therefore, there is a market driver to search for efficiencies, but the regulatory limits on supply chain GHG also ensures that bioenergy is a low carbon source.

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?*

The UK regulation permits two approaches: evidencing sustainability through certification, or evidencing sustainability on a risk based approach.

Using a risk-based approach is permitted in any jurisdiction, although in a high-risk region, this approach becomes less feasible. At Drax, we have had a history of only sourcing from relatively low risk regions. It is only recently that we have contracted with one supplier in Brazil, and high levels of FSC Forest Management certification and signification documentation of risk mitigation processes were required.

The key role for a risk based approach is to enable a bioenergy market to make use of abundant residue material where there are low levels of certification. For example, there may be sawmills where only a proportion of the material is purchased with a certified claim. In these cases, the sawmill would not be able to sell these residues to the pellet industry, which means the material may go unused. Another example might be countries which are well regulated, but do not perhaps have high levels of certified land. The lack of certification does not mean that the material is not sustainable, or the land has not been managed properly, it simply means that the purchaser of the material must do their own assessment to verify that the raw material came from sustainable sources.

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)?

a. What are the main barriers and uncertainties associated with the development, deployment and use of BECCS?

b. 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?

Drax agrees that capturing and storing, or using, the emissions of CO_2 released from combustion of bioenergy could be crucial in off-setting those produced in other sectors that are difficult or very costly to decarbonise. However, government funding for R&D and involvement in projects as recommended by the Parliament Advisory Group is needed to kick-start this industry.

According to a report by the IEA, there are currently thirty-seven large scale Carbon Capture Utilisation and Storage (CCUS) facilities in operation or development globally. Although most of these are used on fossil fuel plant, the same technology could be applied to bioenergy sources. In future, innovation or new technologies could provide a breakthrough in lowering the operational cost of CCUS through increased efficiency, reduced energy consumption, alternative absorption chemicals or creating valuable by-products from the process. However, the capital costs are still high, so demonstration projects will require R&D support for the new technologies to develop through the traditional 'valley of death'. If they are proven, then the value of the by-products and income from 'negative emissions' could make them commercially viable. Further cost savings should be possible through experience gained from deployment, as witnessed in the offshore wind sector.

A report by the ETI[38] indicated that with significant support over the next 5-10 years to demonstrate commercial viability then BECCS deployment in the UK should be achievable by 2030. Experience from previous initiatives to develop a CCS demonstration project suggest that this process would need to start soon for such a timescale to be realistic.

Drax is mainly interested in the use of BECCUS applied to electricity generation. There is a clear demand for low carbon electricity, particularly from flexible sources to balance the intermittent output from wind and solar. The demand for hydrogen could increase significantly if it is used to displace fossil fuels to decarbonise the heat and transport sectors.

The current focus should be on proving that BECCUS is commercially viable and the optimal use will be determined by the competition with alternative low carbon sources in each sector. Similarly, the optimal feedstock and balance between imported and domestic sources will be resolved by the relative costs and availability of sustainable bioenergy supply versus demand as the deployment of BECCUS increases.

In their report on the role of CCS, the Parliamentary Advisory Group[39] recommended that an initially state-owned enterprise should deliver full-chain CCS power projects and associated over-sized transport and storage infrastructure. In future these could be privatised but they highlight that long-term storage liability could be an unacceptable risk for the private sector. The development of capture technologies that enable the CO_2 to be used may be preferable for private sector investors but the demand for such by-products may not be sufficient for BECCUS to be developed at large scale. The other issue that will need to be resolved for private sector investors will be a predictable price for CO_2 so the value of 'negative emissions' can be included in the business case.

38 https://d2umxnkyjne36n.cloudfront.net/insightReports/The-Evidence-for-Deploying-Bioenergy-with-CCS-in-the-UK.pdf?mtime=20161107110603

39 http://www.ccsassociation.org/news-and-events/reports-and-publications/parliamentary-advisory-group-on-ccs-report/

25. *<u>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?</u>*

BECCUS will be deployed in countries where it is competitive with other technologies used to meet that country's decarbonisation targets and suitable geological formations exist for storage or there is a demand for by-products that use the CO2 that is captured.

27. <u>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. Chris</u>

Drax was not involved in the preparation of the Roadmaps but they appear to have been produced in a rigorous manner and the involvement of sector specialists adds to their credibility.

The Roadmaps highlight that biomass and CCS could both have a significant direct impact on CO_2 emission reductions across all manufacturing sectors. Both technologies can also have an indirect impact through decarbonising electricity, which the report highlights are the most influential intervention after CCS. It is interesting to note that reassurance on security of electricity supply is important to industrial decarbonisation. Biomass and CCS power stations will provide the dispatchable and flexible generation that will be required to maintain security of supply as the amount of intermittent generation increases.

We are not aware of any substantial change, but it may be worthwhile reviewing the potential for CCS in light of more recent work on potential clustering of sites. Also, the pathways could be updated with any potential uses of CO_2 that have been and progress by Government on the recommendations in the Parliamentary Advisory Group to establish the enablers for CCS to be deployed.

Although the Roadmaps highlight that replacing fossil fuels with biomass could significantly reduce CO_2 emissions from industry it appears to have been constrained to CHP, gasification and pyrolysis technologies. Over recent years Drax has gained a lot of experience in the combustion of biomass which could be applied to producing high temperature heat or steam for industry. If the Roadmaps are to be updated it would be useful to share this knowledge.

The Roadmaps also consider the potential benefits of using biomass as a feedstock. The research and development in this field means that the assumptions made for a report in 2015 are likely to be outdated. It would be useful to review the current status of this work and update the Roadmaps if the potential value of biomass as a feedstock has changed significantly.

APPENDIX I

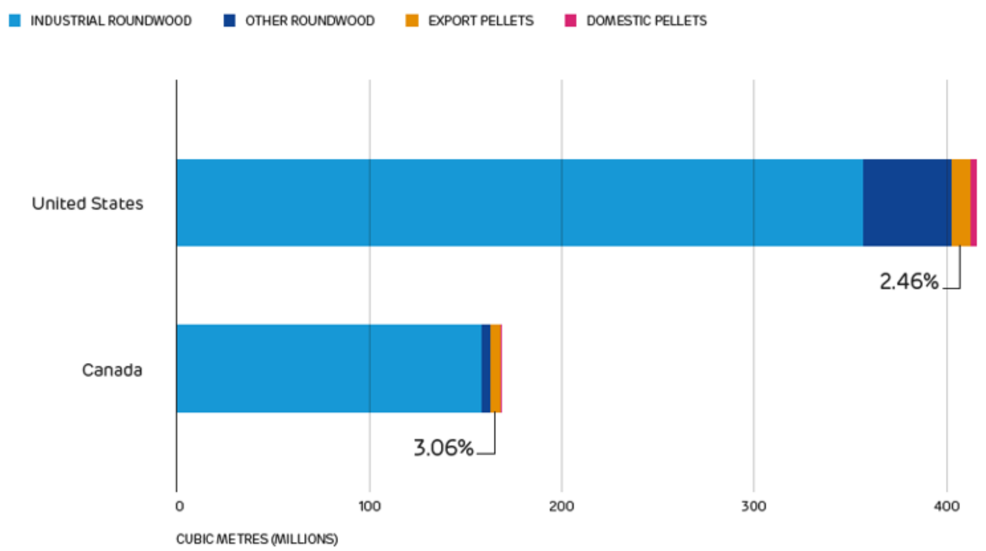
Closed Pulp/Paper and OSB Facilities
Source: Forisk

Mill Name	Company Name	City	State	Type	Annual Capacity	Units	Demand at Capacity (Roundwood and Chips), green tons	Status	Year Closed
Kimberly - Clark Corp.		Mobile	AL	pulp/paper	600	M tons	2,154,000	Closed	1999
Alabama River Newsprint	AbitibiBowater Inc.	Perdue Hill	AL	pulp/paper	216	M tons	775,440	Closed	2008
International Paper Co - Mobile Mill	International Paper	Mobile	AL	pulp/paper	548	M tons	1,967,320	Closed	2000
International Paper Co - Courtland	International Paper	Courtland	AL	pulp/paper	760	M tons	2,728,400	Closed	2014
Georgia-Pacific Co	Georgia-Pacific Co	North Little Rock	AR	pulp/paper	110	M tons	394,900	Closed	2000
International Paper Co - Camden Paper Mill	International Paper	Camden	AR	pulp/paper	264	M tons	947,760	Closed	2001
Florida Coast paper Co. LLC		Port Saint Joe	FL	pulp/paper	620	M tons	2,225,800	Closed	1998
Durango-Georgia Paper Co.		St. Mary's	GA	pulp/paper	405	M tons	1,453,950	Closed	2002
International Paper Co - Bastrop	International Paper	Bastrop	LA	pulp/paper	410	M tons	1,471,900	Closed	2008
International Paper Co - Pineville	International Paper	Pineville	LA	pulp/paper	385	M tons	1,382,150	Closed	2009
Domtar	Domtar	Columbus	MS	pulp/paper	77	M tons	276,430	Closed	2010
International Paper Co - Moss Point	International Paper	Moss Point	MS	pulp/paper	200	M tons	718,000	Closed	2001
International Paper Co - Natchez	International Paper	Natchez	MS	pulp/paper	420	M tons	1,507,800	Closed	2003
Georgia-Pacific Co	Georgia-Pacific Co	Pryor	OK	pulp/paper	9	M tons	32,310	Closed	2008
Weyerhaeuser	Weyerhaeuser	Broken Bow	OK	pulp/paper	330	M tons	1,184,700	Closed	1990
International Paper Co	International Paper	Sellers	SC	pulp/paper	164	M tons	588,760	Closed	1998
Abitibi Consolidated		Lufkin	TX	pulp/paper	425	M tons	1,525,750	Closed	2007
Equitable Bag Co., Inc.		Orange	TX	pulp/paper	35	M tons	125,650	Closed	2000
Pasadena Paper Co.		Pasadena	TX	pulp/paper	279	M tons	1,001,610	Closed	2005
Abitibi Consolidated	Abitibi Consolidated	Sheldon	TX	pulp/paper	365	M tons	1,310,350	Closed	2005
Martco Le Moyen	Martco	Le Moyen	LA	OSB	350	MM SqFt	640,500	Closed	2007
LP Athens	Louisiana-Pacific Corp	Athens	GA	OSB	465	MM SqFt	850,950	Closed	2008
LP Silsbee	Louisiana-Pacific Corp	Silsbee	TX	OSB	350	MM SqFt	640,500	Closed	2002
GP Dudley	Georgia-Pacific Co	Dudley	NC	OSB	226.25	MM SqFt	414,038	Closed	2006
Norbord Huguley	Norbord	Lanett	AL	OSB	500	MM SqFt	915,000	Closed	2009
Huber Whites Creek	Huber Engineered Wood	Whites Creek	TN	OSB	465	MM SqFt	850,950	Closed	2011
GP Grenada	Georgia-Pacific Co	Grenada	MS	OSB	375	MM SqFt	686,250	Closed	2010
GP Skippers	Georgia-Pacific Co	Skippers	VA	OSB	423.125	MM SqFt	774,319	Closed	2011
						Total Demand	29,545,487		

APPENDIX II

North American production of roundwood and pellets, 2016

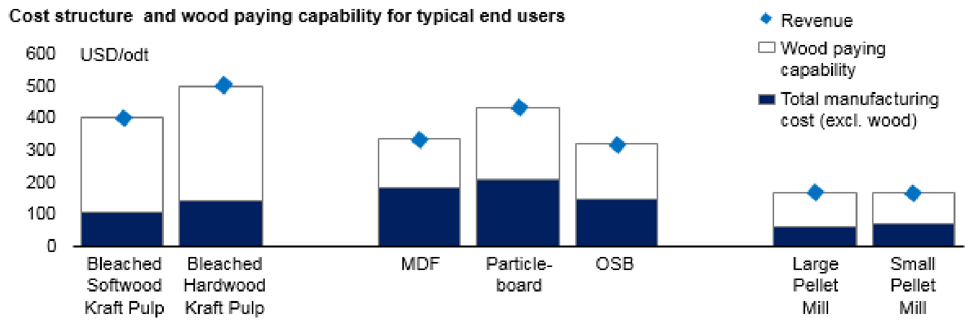
In 2016 the total US harvest of roundwood was around 400 million m³, the production of wood pellets for export represented just 2.5% of this total. In Canada export pellets represented an equivalent of 3% of the total harvest.



APPENDIX III

WOOD PAYING CAPABILITIES – 2017

Pellet mills have the most marginal WPCs, especially considering any capital costs that need to be recovered. Mills in both the pulp & paper and wood based panels sectors are well established and do not have the same investment costs to recover



Wood Paying Capability (USD/odt)

	Bleached Softwood Kraft Pulp	Bleached Hardwood Kraft Pulp	MDF	Particle-board	OSB	Large Pellet Mill	Small Pellet Mill
	296	360	151	227	175	106	97
Incl. capital cost:						73	64

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APPENDIX IV

removed as containing confidential information. Requested to share with Ricardo, awaiting reply

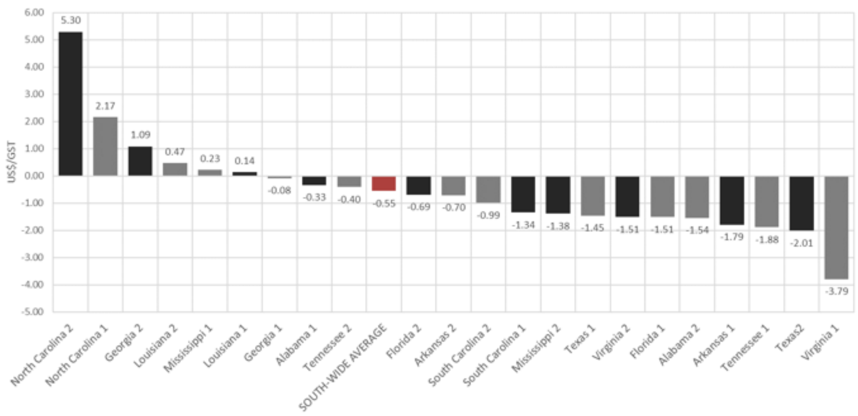
APPENDIX V

(NOTE: the original version of these slides can be provided upon request)

Pine pulpwood stumpage prices, Q3 2015 v Q3 2017

The chart below shows the change in pine pulpwood stumpage prices over the past two years as reported by TimberMart South (TMS), a price reporting service allied to the University of Georgia. TMS collects quarterly price data in two zones in each of the eleven states of the US South. (See the map on Slide #4.)

The purpose of this chart is to reveal any correlation between the presence of a large pellet mill in a TMS zone and a change in the price of pulpwood in each zone over the past two years. If there is such a correlation, we would expect to see the zones with pellet mills (the dark grey bars) clustered at the left-hand end of the chart. In practice, of the ten zones that are home to large pellet mills, seven have seen pine pulpwood stumpage prices decline during the period, and in six of them prices have dropped by more than the regional average (the red bar).



Coastal North Carolina (NC2) has seen the greatest increase in pine pulpwood stumpage prices during the period. NC2 is home to three Enviva pellet mills, and is also home to International Paper's Riegelwood pulp mill where, in 2016, a graphic paper mill was converted to a fluff pulp mill, significantly increasing the pulp mill's consumption of pine pulpwood. Riegelwood's increased demand for pine pulpwood seems likely to have contributed to the rise in pine pulpwood prices.

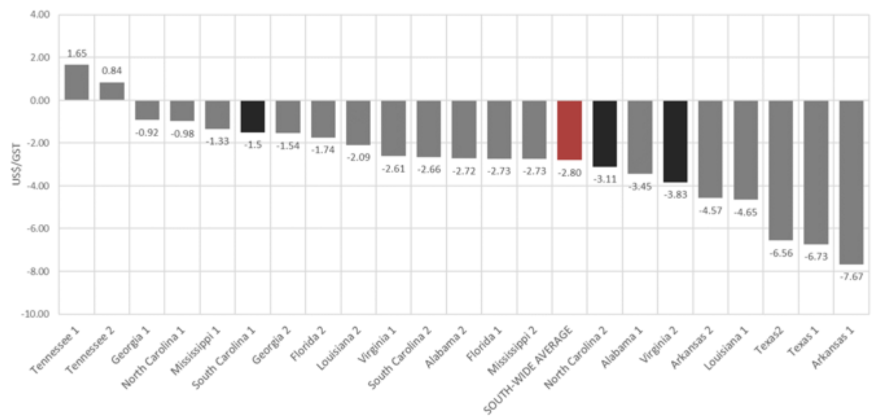
2 CONFIDENTIAL HAWKINS WRIGHT

Hardwood pulpwood stumpage prices, Q3 2015 v Q3 2017

This chart is similar to the one on the previous page, in this case showing the change in hardwood pulpwood stumpage prices over the past two years. Again, TimberMart South (TMS) is the source of the price data.

Hardwood species are an important source of pellet manufacturers' feedstock only in the north eastern states of the US South: Virginia, North Carolina and South Carolina. The zones where most hardwood pulpwood is used in pellet production are coloured dark grey in the chart.

As with pine pulpwood, there is no visible correlation between the existence of a pellet mill in a TMS zone and the change in hardwood pulpwood prices over the past two years. In all three zones where hardwood pulpwood constitutes a significant proportion of the fibre mix, hardwood pulpwood prices have declined. In two of the three zones, NC2 and VA1, the decline has been greater than the south-wide regional average.



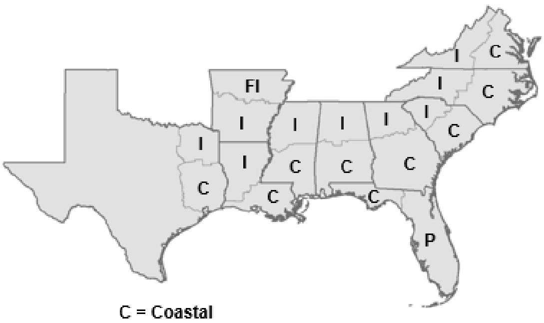
3 CONFIDENTIAL HAWKINS WRIGHT

IMPACT OF PELLET MILLS ON BIOMASS PRICING IN THE US

Comparing pellet mill start-up dates to historical biomass prices allows for the identification of any upwards price pressure that may have been caused by the pellet industry

- We have compared historical biomass prices across nine states in the US Southeast, where large-scale industrial pellet mills have been constructed, to the start-up dates of these large-scale mills, so that any impacts of these mills on biomass prices can be identified.
- This analysis covers the period from Q1 2010 to Q4 2017, and is focused on softwood prices, as softwood is the most prevalent feedstock in this region and is often the feedstock of choice of pellet mills.
- Each state is separated into two areas, inland and coastal, to allow for better granularity based on the actual locations of each mill. The two exceptions are Arkansas, which is landlocked and therefore has an inland and far-inland region, and Florida, which has a peninsula and coastal region.
- Average sawmill chip prices per state have also been shown for comparison

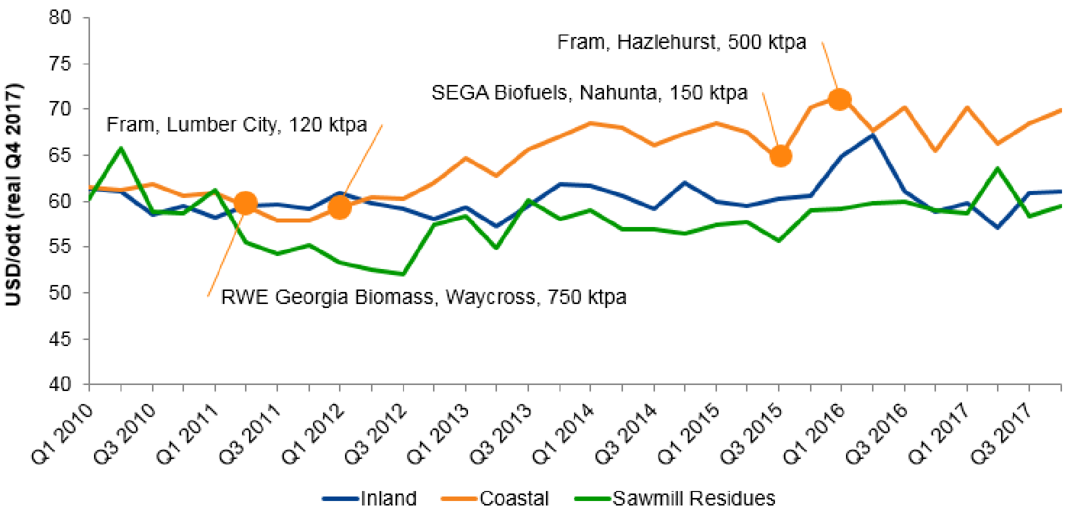
US states and regions



C = Coastal
I = Inland
F = Far Inland
P = Peninsula

BIOMASS PRICES AND PELLET MILLS IN GEORGIA

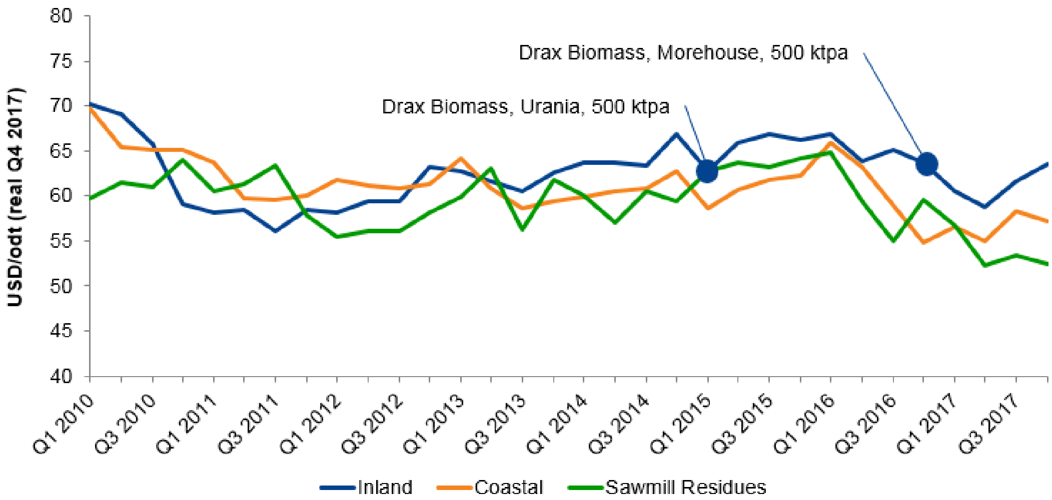
Prices increased following the start of the Fram and RWE Georgia Biomass mills, but are unlikely to have been caused by these mills, given the time delay seen. Neither SEGA Biofuels or Fram Hazlehurst appear to have had long-term impacts



Source: Timber Mart South, Pöyry database

BIOMASS PRICES AND PELLET MILLS IN LOUISIANA

Neither the Drax Urania mill (built by German Pellets) or the Drax Morehouse mill show any lasting impact on biomass pricing in Louisiana, with prices actually decreasing after the start of the Morehouse mill



Source: Timber Mart South, Pöyry database

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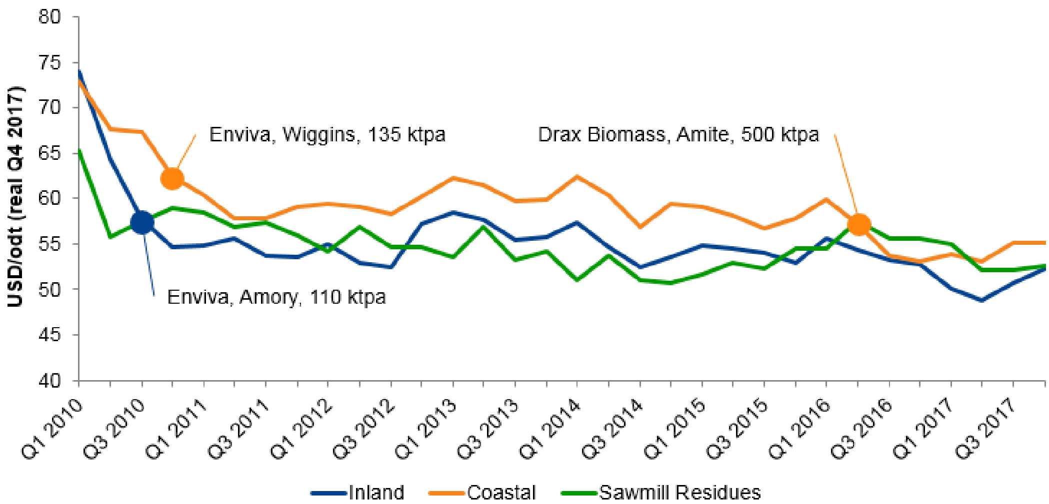
BIOMASS PRICES AND PELLET MILLS IN MISSISSIPPI

Biomass prices in Mississippi have remained stable following a dip in 2010, and fell slightly after the start up of both the Enviva Amory and Wiggins mills and the Drax Amite mill



Source: Timber Mart South, Pöyry database

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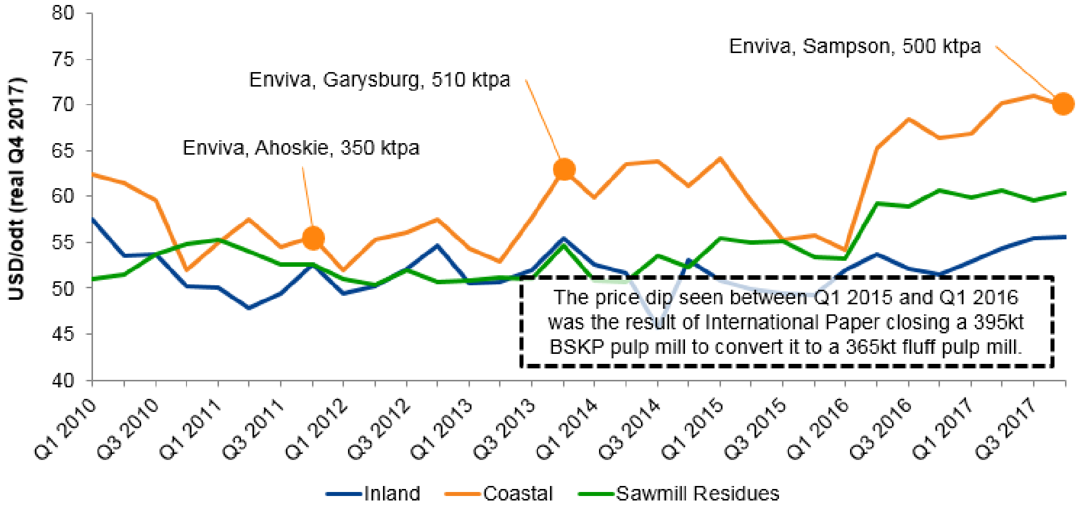
BIOMASS PRICES AND PELLET MILLS IN NORTH CAROLINA

The Enviva Ahoskie mill did not impact prices in North Carolina. Prices may have increased pre-emptively before the Enviva Garysburg mill was completed. It is too soon to see any impacts from the Enviva Sampson mill



Source: Timber Mart South, Pöyry database

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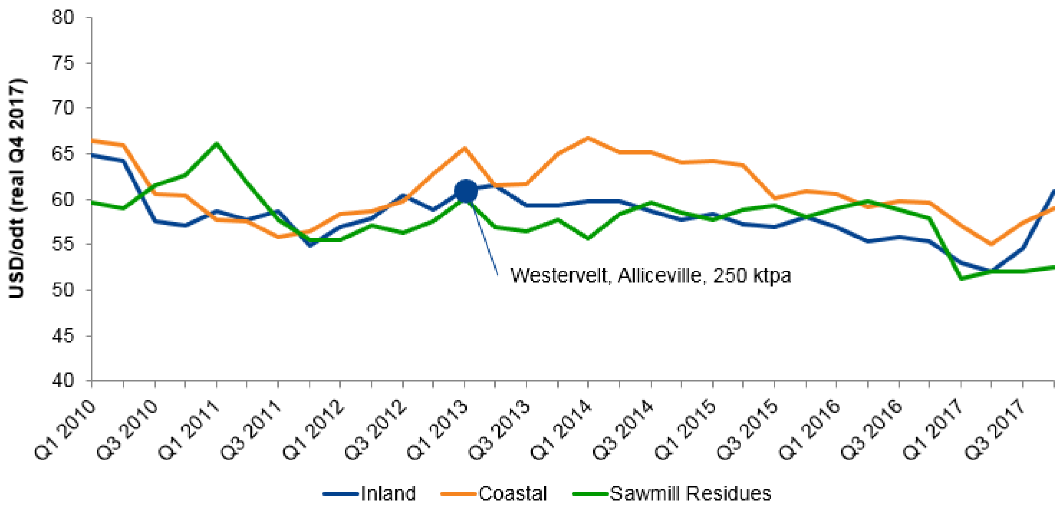
BIOMASS PRICES AND PELLET MILLS IN ALABAMA

The construction of the Westervelt mill in Alliceville has had no noticeable impact on biomass prices in Alabama, which have even decreased in real terms since Q1 2013



Source: Timber Mart South, Pöyry database

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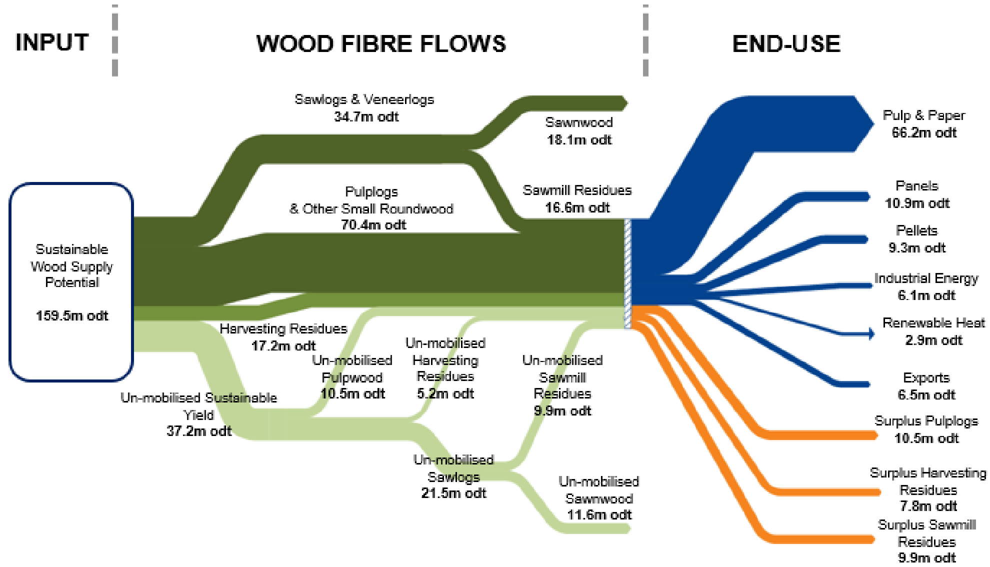
APPENDIX VI

BIOMASS AVAILABILITY – 2015

The US Southeast has considerable areas of un-mobilised forest, provided suitable off-take for the sawlogs from these forests can be found, they could provide an additional 10.5m odt to the market alone



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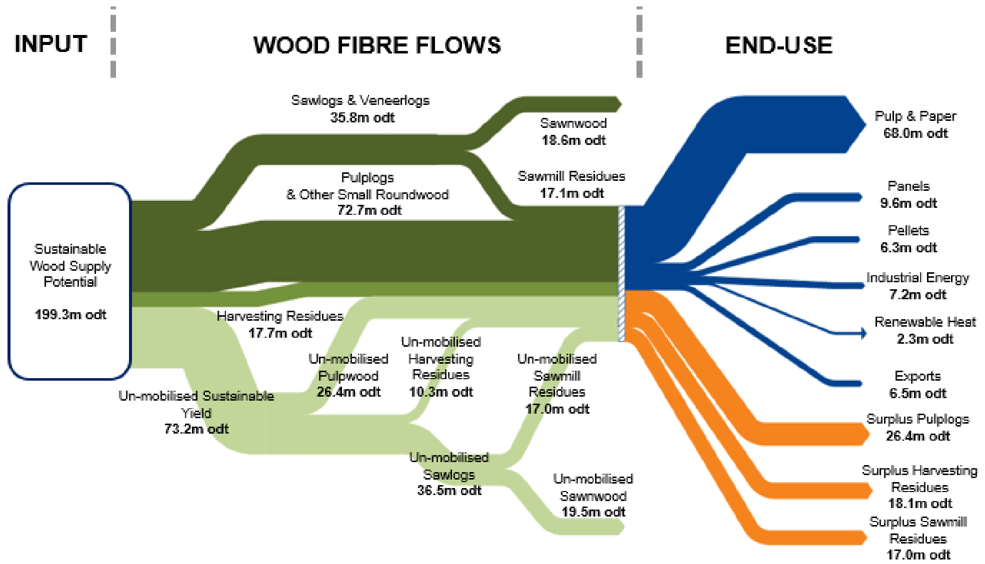
BIOMASS AVAILABILITY – 2050

Assuming 'business as usual' growth out to 2050, demand for biomass will remain fairly stagnant, while supply could increase further, due to increased planting and improved management. This could help to lower price pressure on biomass feedstocks in regions with a tight surplus



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