Carbon Emission Estimates for Drax biomass powerplants in the UK sourcing from Enviva Pellet Mills in U.S. Southeastern Hardwoods using the BEAC model

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CONTENTS

Looking for reduced greenhouse gas emissions from the electricity sector, governments across the globe promote biomass as a feedstock to this end. However, GHG emissions from biomass are challenging to calculate based on carbon stock changes on the landscape as well as emissions along the production, transportation, and conversion chain. The UK government has released a model to calculate emissions associated with biomass sourced in the US. This study analyzes emission profiles for the utility company Drax that operates wood pellet-fired power plants in the UK. This feedstock is to a large extent derived from three Enviva operated pellet mills in the Southeastern US, namely Ahoskie and Northampton in North Carolina and Southampton in Virginia.

Using publicly available data on biomass consumption and origin for the three Enviva plants, we created customized emission profiles using default model outputs from the UK's Department of Energy and Climate Change's (DECC) BEAC (Biomass Emissions And Counterfactual) Model.

According to the BEAC model, electricity derived from biomass sourced through additional hardwood harvests in the southeastern US is associated with emissions exceeding the UK's emission standard for coal stations converted to biomass of 285 kg CO_2e/MWh by over eleven times. Based on BEAC model outputs, customized feedstock mixes for the Enviva plants exceed this standard by at least five to nine times. In order to meet the standard of 285 kg CO_2e/MWh, a maximum of 8% of biomass from additional hardwood harvests could be contained in the feedstock mix, assuming i) a minimum analytical timeframe of 40 years and ii) that the remainder of the feedstock mix is derived from low-emission saw mill residues only.

BACKGROUND

The potential greenhouse gas (GHG) benefits of displacing fossil energy with biofuels are driving policy development in the absence of complete information. Getting the accounting correct is particularly important given the recent heavy emphasis on use of biomass energy to meet national and regional emissions reduction goals. For example, by 2020, between 8% and 11% of the UK's primary energy supply should be from biomass (UK DOT, 2012; see Beurskens & Hekkenberg, 2011 for renewable energy projections of other EU states).

UK policies have been instrumental in directing electricity providers to look for sufficient, reliable, and cost-competitive biomass across the globe. The Southeastern US has become a major provider of forest-derived biomass for the UK market, particularly in the form of wood pellets. Drax is one of the UK's largest electricity production companies and sources large amounts of biomass from the southeastern US.

In its 2014 annual report (Drax 2015), Drax states over half (58% or 2,380,347 metric tonnes) of its wood biomass originates from the United States from a variety of sources as categorized by the Office of Gas and Electricity Markets (OFGEM 2015; Table 1). Drax's definitions of biomass categories are identical with OFGEM categories with the exception of forest residues (Drax 2015). While Drax (2015) defines forest residues as "*Branch wood, tops, bark and other residues (collected from forests at harvest, which can include other low grade wood)*", the OFGEM definition is more restrictive and does not mention 'other low grade wood' – OFGEM states only "*Branch wood, tops, bark and stump collected from forests or plantations*" (OFGEM 2015).

Table 1.US sources of biomass for Drax (Drax 2015).

Biomass category	OFGEM (2015) Definition	Metric tonnes	% of total
Sawdust	Powdered particles of wood produced by sawing	168,829	7%
Sawmill residues	Any wood residue in the form of chip, bark, sawdust, etc. that is produced at a sawmill	222,047	10%
Forestry residues	Branch wood, tops, bark and stump collected from forests or plantations	942,039	41%
Diseased wood and storm damage	Timber that is diseased or has been damaged during a storm and is subsequently of little value other than for energy	164,410	7%
Thinnings	Roundwood from a forest or plantation thinning, as long as this practice does not change the land use status of the area	805,815	35%
Long rotation forestry	[Broadleaf or Conifer] tree plantations felled after a growing period of several decades, and then replanted	12,374	1%
Agricultural residues	Not described by OFGEM	64,834	N/A
Total		2,380,348	
Total forest biomass		2,315,514	100%

Table 2. Annual production of Enviva pellet plants in metric tonnes (Enviva 2015).

Plant Location	Annual Production	
	in metric tonnes	in % of total
Amory, MS	110,000	5%
Wiggins, MS	110,000	5%
Ahoskie, NC	370,000	16%
Northampton, NC	500,000	22%
Cottondale, FL (2)	650,000	29%
Southampton, VA	510,000	23%
Total	2,250,000	100%

The focus of this report is on the emissions profiles of the three Enviva plants Ahoskie, Northampton and Southampton. The reasoning behind this focus is four fold:

- **These plants produce the majority of pellets for Enviva**. Drax gets one million metric tonnes per year from Enviva starting April 1 2014 (SEC 2014). Much of this likely comes from two Enviva plants in northeastern North Carolina (Ahoskie, Northampton) as well as one plant in Virginia (Southampton). These three plants in combination provide 1.38 million metric tonnes of wood pellets or 61% of Enviva's total output (Table 2).
- **Their feedstock is best known**. It is assumed that at least 80% of the supply for the Ahoskie plant is from hardwoods (Evans et al. 2013, p74). A comparable hardwood/softwood ratio can be assumed for the Northampton and Southampton locations due to their geographical proximity to Ahoskie. Information from Enviva supports this assumption.
- **Their feedstock can be best matched with a BEAC scenario** The BEAC scenarios for roundwood in the Southeastern US can be separated into scenarios describing hardwood (scenario 13[1]) or softwood origins (scenario 14-25). The hardwood scenario relies on an assumption of decreased rotation length when harvesting for biomass.
- **Their emission profile is more certain**. In contrast to the BEAC hardwood scenario, due to larger uncertainty in management options, the BEAC softwood scenarios describe a wider variety of management choices and counterfactual scenarios, ultimately resulting in larger ranges of potential emission profiles.

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[1] Scenario 13(a): "Electricity from pellets produced from additional wood (compared to cfl [counterfactual]) generated by increasing the rate of harvest of naturally regenerated hardwood forest in the Southern USA from every 70 years to every 60 year. Cfl = continue harvesting every 70 years." Scenario 13(b) was not picked since it seemed unrealistic in that the counterfactual assumption in this scenario is to increase the length of the rotation rate rather than holding it steady.

OBJECTIVE

The purpose of this report is to analyze emissions from Drax biomass sourced by Drax in the southern US through Enviva. The data is derived from a variety of Drax and Enviva originated and/or publicly available documents. The associated emissions were calculated using the UK's Department of Energy and Climate Change's (DECC) BEAC (Biomass Emissions And Counterfactual) Model, version BEAC 2015, last updated on 1/9/2015.

METHODS

BEAC DESCRIPTION

The purpose of the BEAC Model is to help answer the following questions in the context of a UK-based electricity generation plant (BEAC 2015):

- What are the greenhouse gas impacts of different bioenergy pathways, considering the emissions associated with growing, processing and transporting the biomass, as well as the consequences of 'counterfactual' land-uses?
- What is the energy requirement of these different bioenergy pathways?

Table 3: Relevant BEAC scenario descriptions (BEAC 2015).

Scenario #	Full BEAC scenario name
1	Electricity from pellets produced from saw mill residues in South USA. No drying. Cfl = burn as a waste.
2	Electricity from pellets produced from saw mill residues in South USA. Dry from 25 to 10 wt% moisture. cfl = burn as a waste.
3	Electricity from pellets produced from saw mill residues in South USA. Dry from 50 to 10 wt% moisture. cfl = burn as a waste.
4(a)	Electricity from pellets produced from coarse forest residues in South USA, continuously removed over the time frame. cfl = decay in forest.
5(a)	Electricity from pellets produced from fine forest residues in South USA, continuously removed over the time frame. cfl = decay in forest.
6(a)	Electricity from pellets produced from coarse forest residues in South USA, removed for 15 years only. cfl = decay in forest.
7(a)	Electricity from pellets produced from fine forest residues in South USA, removed for 15 years only. cfl = decay in forest.
8(a)	Electricity from pellets produced from forest residues (coarse or fine) in South USA. Cfl = burn at roadside as a waste.
13(a)	Electricity from pellets produced from additional wood (compared to cfl [counterfactual]) generated by increasing the rate of harvest of naturally regenerated hardwood forest in the Southern USA from every 70 years to every 60 years. Cfl = continue harvesting every 70 years.

The BEAC model evaluates the greenhouse gas emissions for power produced in the UK from biomass sourced from North American biomass feedstocks. It applies a life cycle assessment (LCA) method that incorporates land, transport, technology, wood product, reversion and general LCA data to provide a total emission estimate by biomass source over a timeframe of 20, 40, or 100 years. Table 3 describes the feedstock origins offered in the BEAC model for analysis and of relevance to this report while Table 4 provides an overview on the standard BEAC emission profiles for all relevant scenarios.

The BEAC model lets the user choose from 33 feedstock scenarios and provides emission profiles for these scenarios including error estimates. Emissions are depicted on the basis of emissions per electricity unit produced ($kgCO_2e$/MWh) and depicted against the standard of 285 kg CO_2e/MWh for Coal to Biomass Conversion 2014-2020 (UK DECC 2013).

Table 4: BEAC emission profiles by scenario in comparison to Coal to Biomass Conversion Standard 2014-2020.

Time Frame Analyzed (y)	20		40		100		
BEAC Scenario	Total	Error	**Total**	**Error**	Total	Error	Coal to Biomass Conversion Standard 2014-2020
1 Mill residue - no drying	4.95	25.81	**4.95**	**25.81**	4.95	25.81	285
2 Mill residue - 25% MC	3.93	26.53	**3.93**	**26.53**	3.93	26.53	285
3 Mill residue - 50% MC	0.70	29.07	**0.70**	**29.07**	0.70	29.07	285
4(a) Coarse forest residues; continuous removal; cfl = decay	576.55	233.25	**389.15**	**140.78**	228.01	64.19	285
5(a) Fine forest residues; continuous removal; cfl = decay	241.86	70.42	**241.86**	**70.42**	165.02	38.90	285
6(a) Coarse forest residues; 15 yrs removal; cfl = decay	472.02	181.51	**181.86**	**44.90**	114.21	29.26	285
7(a) Fine forest residues; 15 years removal; cfl = decay	240.84	69.96	**116.88**	**29.30**	113.74	29.26	285
8(a) Forest residues (coarse & fine); cfl = burn	8.11	29.26	**8.11**	**29.26**	8.11	29.26	285
13 Additional hardwood harvests	3226.54	1552.55	**3345.67**	**1612.22**	4347.57	2114.74	285

We ran unaltered BEAC scenarios 1-8 and 13(a) and copied emission values including error estimates into a new Excel spreadsheet. This new spreadsheet allowed us to provide emission estimates based on BEAC calculations for a mix of feedstocks instead of one single feedstock.

The example in Figure 1 shows a feedstock mix containing 20% of mill residue at a 50% moisture content (BEAC scenario 3) and 80% of feedstock derived from additional hardwood harvests (BEAC scenario 13).

Scenario #	Scenario name	%
1	Mill residue - no drying	0%
2	Mill residue - 25% MC	0%
3	Mill residue - 50% MC	20%
4(a)	Coarse forest residues; continuous removal; cfl = decay	0%
5(a)	Fine forest residues; continuous removal; cfl = decay	0%
6(a)	Coarse forest residues; 15 yrs removal; cfl = decay	0%
7(a)	Fine forest residues; 15 years removal; cfl = decay	0%
8(a)	Forest residues (coarse & fine); cfl = burn	0%
13(a)	Additional hardwood harvests	80%
		100%

Figure 1: Input table in customized BEAC calculation spreadsheet to calculate emissions from a feedstock mix. Example inputs correspond to a feedstock mix in Scenario A (see below).

SCENARIO DESCRIPTION

The emissions profiles for the three Enviva plants Ahoskie, Northampton and Southampton were calculated based on the following assumptions:

Scenario A (Predominantly additional biomass harvests). This scenario assumes that all pulp-grade hardwood derived from forests is from additional biomass harvests. The rationale behind this scenario is that "[…], since 2009, hardwood consumption for paper has remained stable, and is projected to remain stable over the next 5 years." (Stephenson and MacKay 2014, p79).

- BEAC scenario 13 accounts for 80% of emissions:
    - 80% of its supply (Evans et al. 2013, p74) is assumed to be roundwood of hardwood origin (BEAC scenario 13)
    - Enviva uses 'predominantly pulpwood' (SEC 2014). This is also reflected by the Drax numbers suggesting 35% of all US forest-derived biomass being derived from thinnings and long-rotation forestry as well as the statement that "the only whole trees that Enviva uses are either young commercial softwood thinnings, which are cut to ensure healthy growth of high-value timber, or in some cases *small, diseased or deformed trees that do not meet specifications for sawlogs*". (italics added by authors; Enviva 2015).

- BEAC scenarios 1-3 (sawmill residues) account for 0-20% of emissions,
- BEAC scenarios 4a, 5a, 6a, 7a (forest residues which would have decayed otherwise) account for 0-20% of emissions.

Scenario B (Limited additional biomass harvests). This Scenario is based on the share of biomass categories provided by Drax (see Table 1). Despite representing numbers for all US derived biomass (including other regions than the South and other providers than Enviva), a similar distribution of biomass origin is assumed for the three Enviva pellet mills Ahoskie, Northampton and Southampton:

- BEAC scenario 13 accounts for 35% of emissions (thinnings and long-rotation forestry):
- BEAC scenarios 1-3 (sawmill residues) account for 17% of emissions,
- BEAC scenarios 4a, 5a, 6a, 7a (forest residues including diseased wood and storm damage) account for 48% of emissions.

SCENARIO A: PREDOMINANTLY ADDITIONAL BIOMASS HARVESTS

When assuming that a dominant share (80%) of the feedstock is derived from additional biomass harvests in the southeastern US hardwoods with the remainder coming from sawmill or forest residues, the mean emissions according to BEAC calculations for a 40 year time frame would be at least 2,677 $kgCO_2e$/MWh (20 % of feedstock in scenario 3; Figure 2). Mean emissions under this scenario would be at least nine times above the Coal to Biomass Conversion Standard. Appendix 1 shows the life cycle emissions for all three scenarios examined in this report over 20, 40 and 100 years.

While error estimates for the customized feedstock's mean emissions are relatively high (+/- 1,296 $kgCO_2e$/MWh), even the 'best case' scenario for this feedstock mix would surpass the Coal to Biomass Conversion Standard by a factor of nearly five. See Appendix 2 for an evaluation of this scenario against the New-build Dedicated Biopower Standard of 240 kgCO2e/MWh applicable to biomass power plants that received full accreditation after 31 March 2013 (UK DECC 2013).
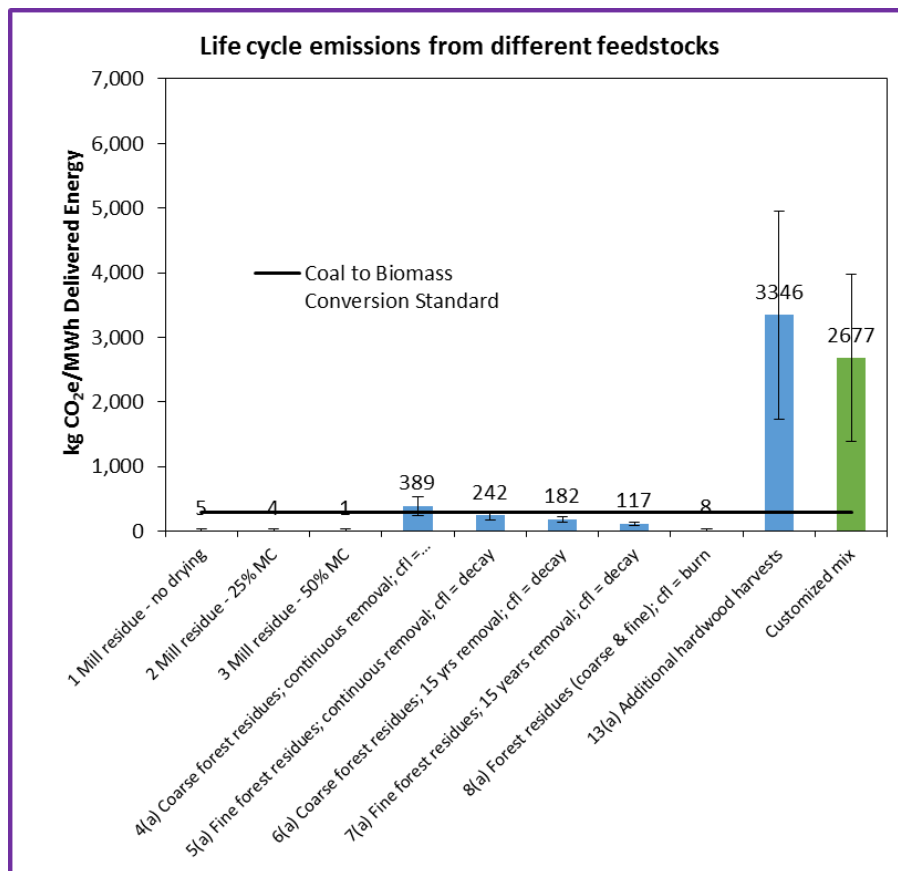

Figure 2: 40 year lifecycle emissions from different BEAC-standardized feedstocks (blue) and customized feedstock mix (green) consisting of 20% from Mill residue (scenario 3) and 80 % from Additional hardwood harvests (scenario 13). Lower and mean emission estimates for the customized feedstock mix would exceed the Coal to Biomass Conversion Standard of 285 kgCO2e/MWh by five to nine times, respectively.

Scenario B assumes that a dominant share (48%) of the feedstock is derived from forest residues that would have otherwise decayed with the remainder sourced from sawmill residues (17%) and additional biomass harvests in the southeastern US hardwoods (35%).

The mean emissions over 40 years for this scenario according to BEAC calculations range from 1,227 kgCO$_2$e/MWh (17 % of feedstock in scenario 3, 48% of feedstock in scenario 7; Figure 3) to 1,359 kgCO$_2$e/MWh (17 % of feedstock in scenario 1, 48% of feedstock in scenario 4). Mean emissions under this scenario would be at least four times above the Coal to Biomass Conversion Standard. See Appendix 3 for an evaluation of this scenario against the New-build Dedicated Biopower Standard of 240 kgCO2e/MWh. (UK DECC 2013).
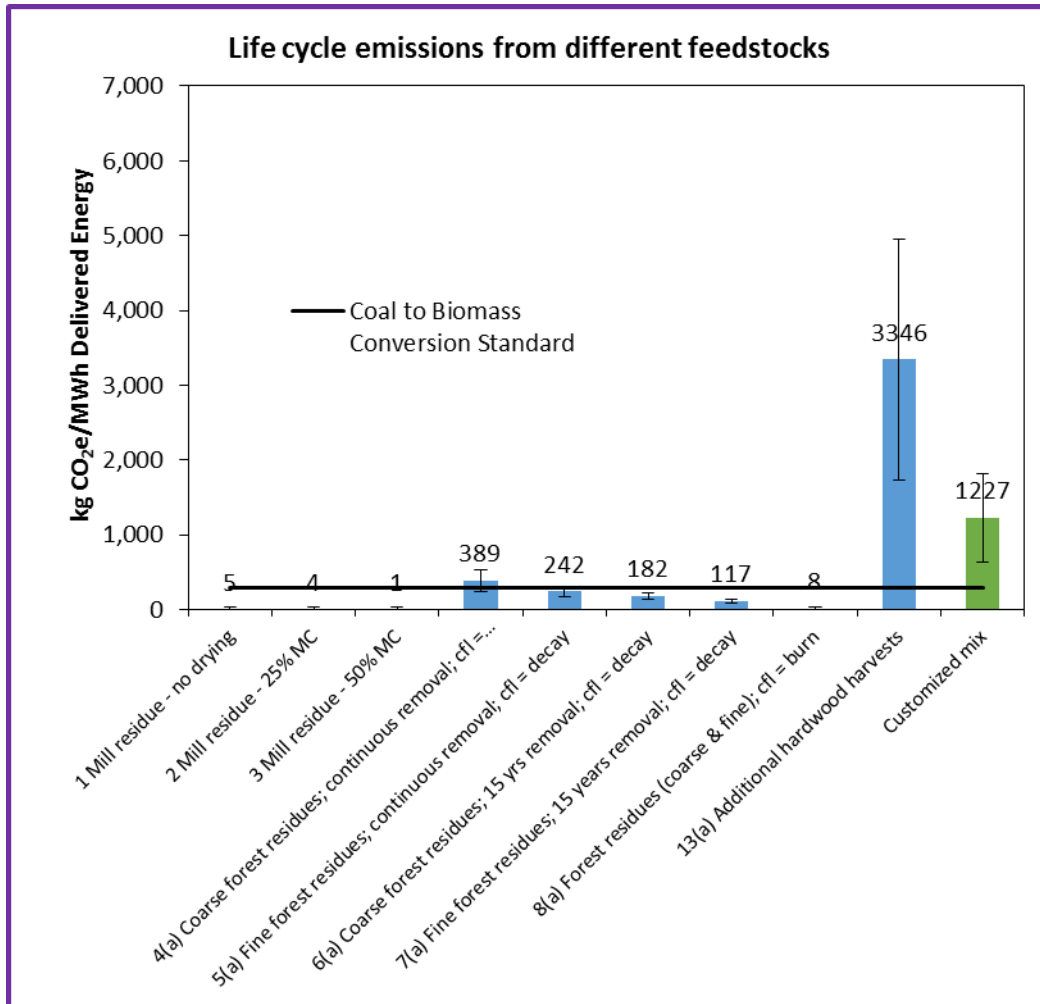

Figure 3: 40 year lifecycle emissions from different BEAC-standardized feedstocks (blue) and customized feedstock mix (green) with 17% Mill residue (scenario 3), 48 % Fine forest residues (7) and 35 % from Additional hardwood harvests (scenario 13). Mean emission estimates for the customized feedstock mix would exceed the Coal to Biomass Conversion Standard of 285 kgCO2e/MWh by at least four times.

This is a very conservative estimate of emissions because Scenario 7 is only applicable to the use of fine residues which are unlikely to be harvested in absence of a simultaneous harvest of coarse residues. First, fine residues are of lower fuel quality since they contain a higher bark content resulting in increased ash and decreased fuel density. Second, it is unlikely that a harvest operation would pick up the fine residues only but leave coarse residues at the harvest site since the latter one is easier to collect and is more abundant in most cases.

Using BEAC estimates this way also allows users to explore, for instance, the maximum share that a high emission feedstock such as additional hardwood harvests could provide while still meeting the Coal to Biomass Conversion Standard of 285 kgCO₂e/MWh. In this instance, additional hardwood harvests could constitute only as much as 6% to 8% of a feedstock mix for a 100 and 40 year analysis time frame, respectively, without exceeding the threshold of 285 kgCO₂e/MWh (Figure 4; Appendix 1). Using as much as 8% of biomass from additional hardwood harvests can only meet the threshold if all remaining biomass is derived from sawmill residues at a 50% moisture content. See Appendix 4 for an evaluation of this scenario against the New-build Dedicated Biopower Standard of 240 kgCO2e/MWh (UK DECC 2013).
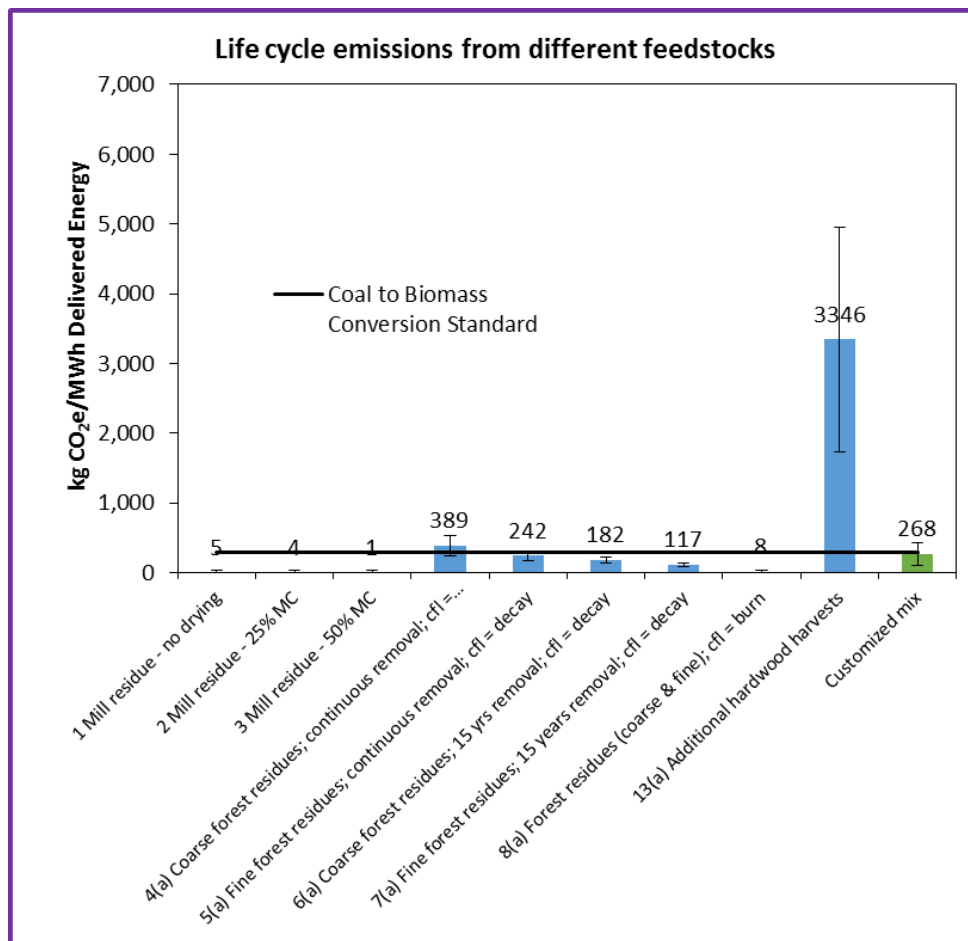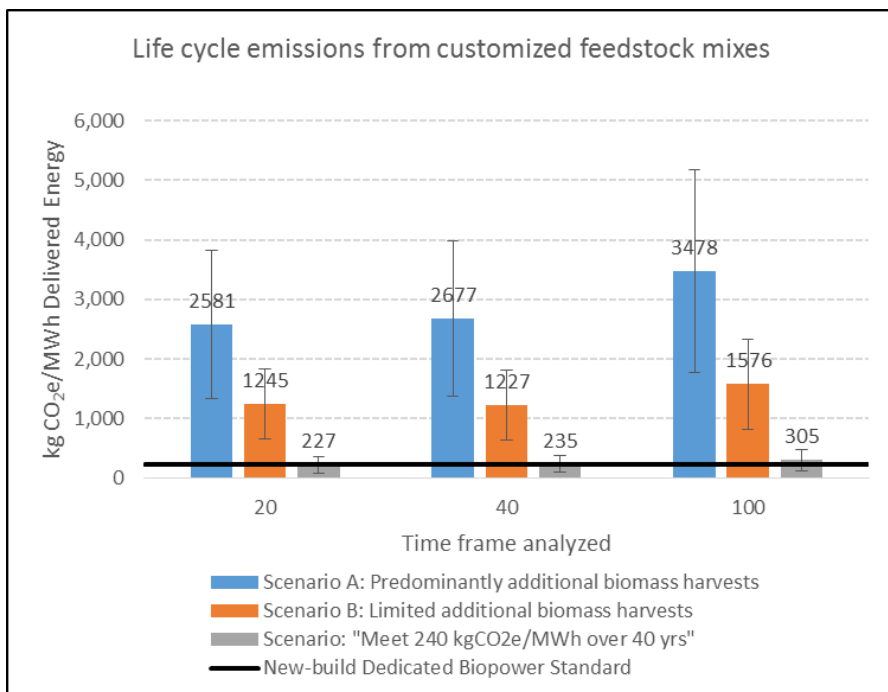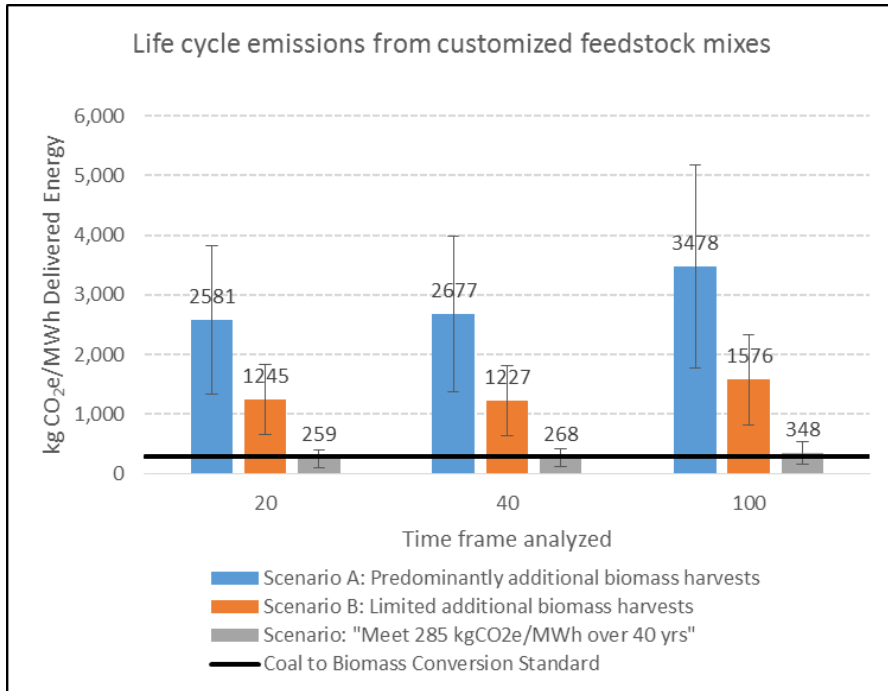

Figure 4: 40 year lifecycle emissions from different BEAC-standardized feedstocks (blue) and customized feedstock mix (green) with 92% Mill residue (scenario 3), and 8 % from Additional hardwood harvests (scenario 13). Mean 40 year emissions from this customized feedstock mix would meet the Coal to Biomass Conversion Standard of 285 kgCO2e/MWh.
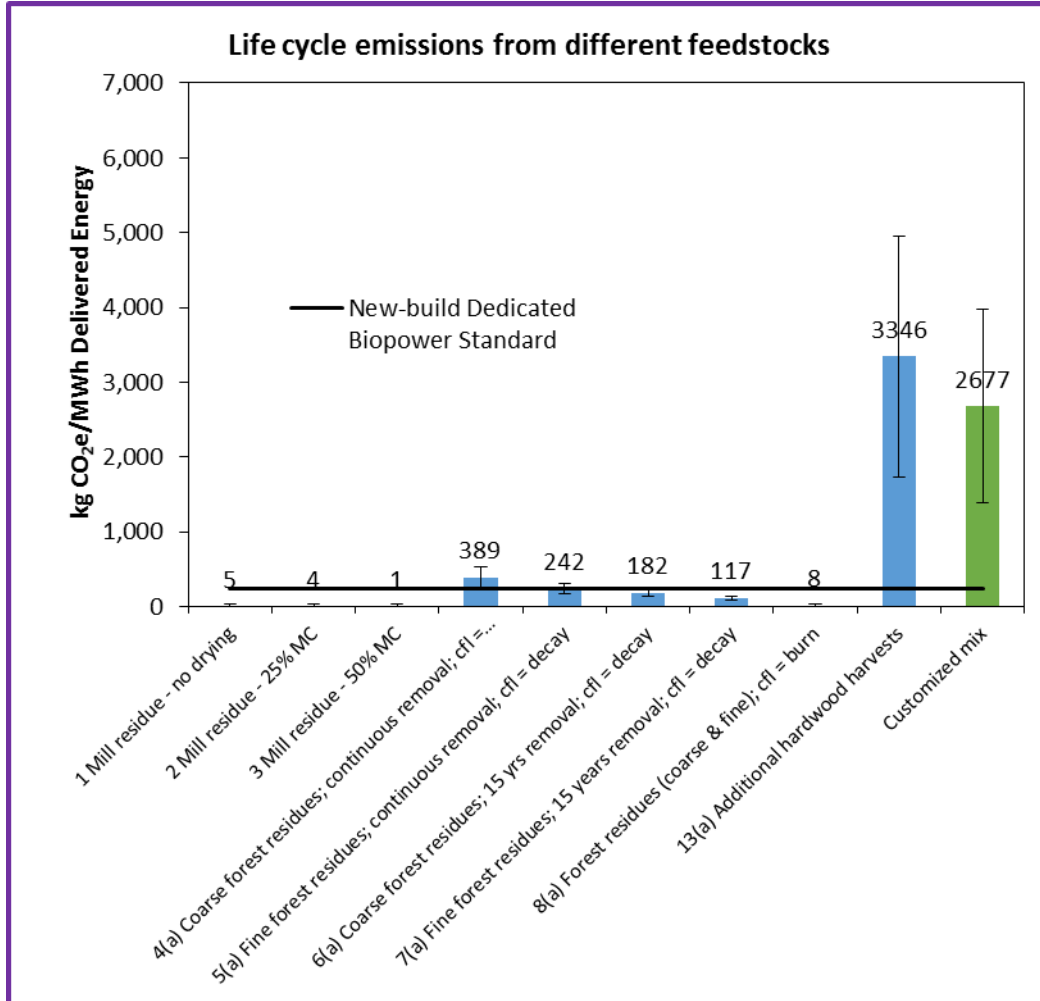
REFERENCES

Beurskens LWM, Hekkenberg M (2011) Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States Covering all 27 EU Member States. ECN-E–10-069, European Environment Agency, Openhagen, Denmark, 244p.

Drax 2015. Biomass supply. http://www.drax.com/media/56583/biomass-supply-report-2014.pdf [Last accessed on May 8 2015]

Enviva 2015. FAQ: Forests & fiber sourcing http://www.envivabiomass.com/faq-forests-fiber-sourcing/#wood [Last accessed on May 8 2015]

Evans, J.M., R.J. Fletcher, Jr., J.R.R. Alavalapati, A.L. Smith, D. Geller, P. Lal, D. Vasudev, M. Acevedo, J. Calabria, and T. Upadhyay. 2013. Forestry Bioenergy in the Southeast United States: Implications for Wildlife Habitat and Biodiversity. National Wildlife Federation, Merrifield, VA, 275p. http://www.nwf.org/pdf/Conservation/NWF_Biomass_Biodiversity_Final.pdf [Last accessed on May 8 2015]

OFGEM 2015. UK Solid and Gaseous Biomass Carbon Calculator (B2C2) User Manual for the Solid and Gaseous Biomass Carbon Calculator v2.0. p99. https://www.ofgem.gov.uk/ofgem-publications/93896/b2c2rhiusermanualv71-pdf [Last accessed on May 8 2015]

Stephenson, A.l., MacKay, D.J.C. 2014. Life Cycle Impacts of Biomass Electricity in 2020 Scenarios or Assessing the Greenhouse Gas Impacts and Energy Input Requirements of Using North American Woody Biomass for Electricity Generation in the UK. Department of Energy and Climate Change, London, UK, 154 p. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/349024/BEAC_Report_290814.pdf [Last accessed on May 8 2015]

UK DECC (2013) Government Response to the consultation on proposals to enhance the sustainability criteria for the use of biomass feedstocks under the Renewables Obligation (RO). Department of Energy and Climate Change, London, UK, 53p.

UK DOT (2012) UK Bioenergy Strategy. Department of Transport, London, UK, 86p.

United States Security and Exchange Comission (SEC) 2014. Forms S-1, Registration Statement under the Securities Act of 1933. Enviva Partners, LP. Washington DC. https://www.sec.gov/Archives/edgar/data/1592057/000119312514383777/d808391ds1.htm [Last accessed on May 8 2015]
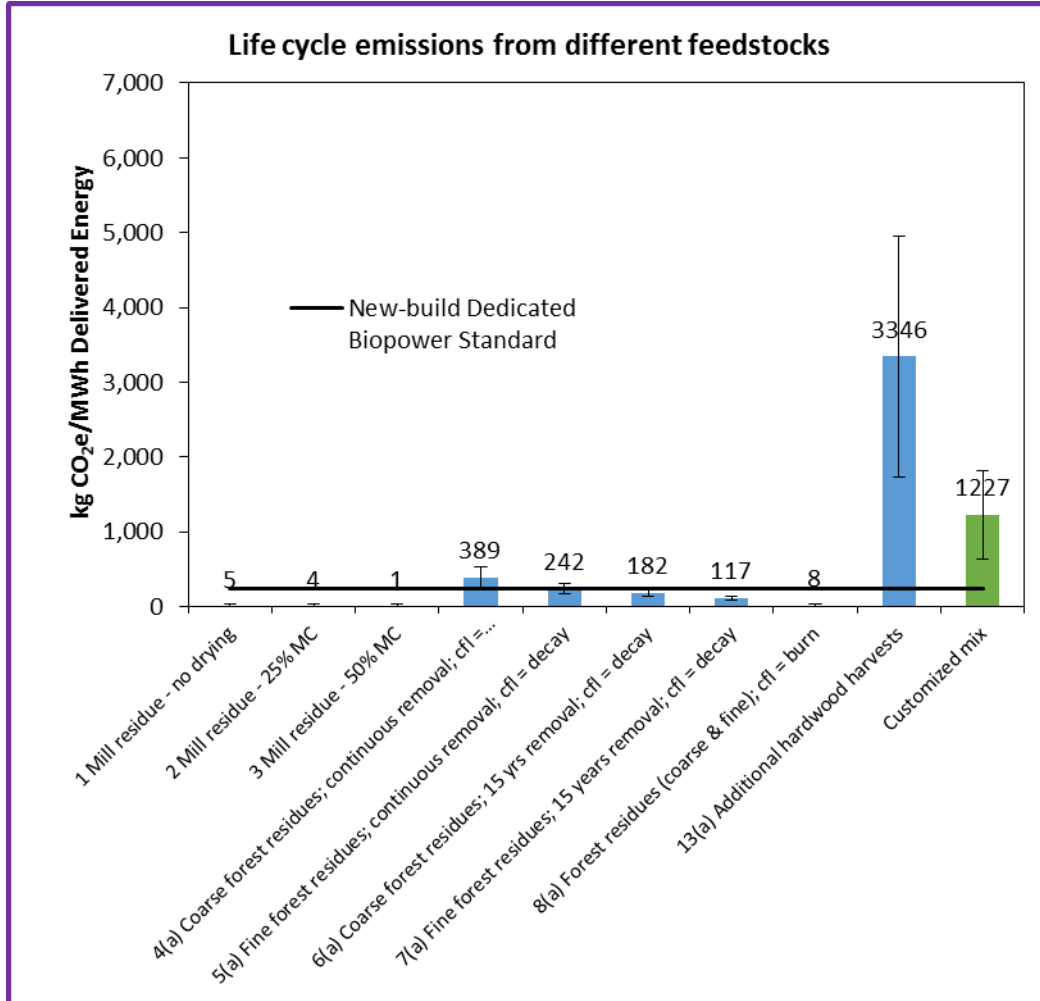
Appendix 1: Life cycle emissions for evaluated scenarios over a 20, 40, and 100 year timeframe.

Life cycle emissions from customized feedstock mixes

(Top chart — Coal to Biomass Conversion Standard)

Scenario A: Predominantly additional biomass harvests
Scenario B: Limited additional biomass harvests
Scenario: "Meet 285 kgCO2e/MWh over 40 yrs"
Coal to Biomass Conversion Standard

Values:
- 20 yr: A = 2581, B = 1245, grey = 259
- 40 yr: A = 2677, B = 1227, grey = 268
- 100 yr: A = 3478, B = 1576, grey = 348

Life cycle emissions from customized feedstock mixes

(Bottom chart — New-build Dedicated Biopower Standard)

Scenario A: Predominantly additional biomass harvests
Scenario B: Limited additional biomass harvests
Scenario: "Meet 240 kgCO2e/MWh over 40 yrs"
New-build Dedicated Biopower Standard

Values:
- 20 yr: A = 2581, B = 1245, grey = 227
- 40 yr: A = 2677, B = 1227, grey = 235
- 100 yr: A = 3478, B = 1576, grey = 305

Appendix 2: 40 year lifecycle emissions from different BEAC-standardized feedstocks (blue) and customized feedstock mix (green) consisting out of 20% from Mill residue – 50% MC (scenario 3) and 80 % from Additional hardwood harvests (scenario 13). Lower and mean emission estimates for the customized feedstock mix would exceed the **New-build Dedicated Biopower Standard of 240 kgCO2$_e$/MWh** by five to eleven times, respectively.

Appendix 3: 40 year lifecycle emissions from different BEAC-standardized feedstocks (blue) and customized feedstock mix (green) with 17% Mill residue (scenario 3), 48 % Fine forest residues (7) and 35 % from Additional hardwood harvests (scenario 13). Mean emission estimates for the customized feedstock mix would exceed the **New-build Dedicated Biopower Standard of 240 kgCO2$_e$/MWh** by at least five times.

Appendix 4: 40 year lifecycle emissions from different BEAC-standardized feedstocks (blue) and customized feedstock mix (green) with 93% Mill residue (scenario 3), and 7 % from Additional hardwood harvests (scenario 13). Mean 40 year emissions from this customized feedstock mix would meet the **New-build Dedicated Biopower Standard of 240 kgCO2$_e$/MWh**.