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Generating Low-Carbon Heat from Biomass: Life Cycle Assessment of Bioenergy Scenarios

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The UK's Renewable Energy Roadmap [1] confirms the high likelihood that energy from biomass will play an increasingly important role in the UK achieving its climate change, emission reduction and renewable energy contribution targets. One of the key requirements for bioenergy being a viable renewable energy option for any country, is that is delivers energy with comparatively lower levels of greenhouse gas (GHG) emissions compared to energy generated from conventional fossil fuels. As such the sustainability and potential GHG impact of utilising increasing levels of biomass for energy has become a vital area of discussion for Governments and energy and environmental stakeholders. The UK Department of Energy & Climate Change (DECC) developed the 'Bioenergy Emissions and Counterfactual' (BEAC) model to provide a scientific tool for investigating the GHG impact of a series of biomass supply chains. This analysis focused on evaluating the GHG intensity of UK bioenergy, generated from imported North American forestry sourced biomass resources [2].

This research reflects work carried out by the authors working closely with DECC to apply the BEAC analysis methodology to evaluate the GHG performance of generating heat energy from key categories of UK biomass: agricultural wastes (animal slurries); food wastes; agricultural residues (straws); and purpose grown energy crops. Bioenergy from UK forestry sourced biomass were not analysed within this research. A series of unique 'bioenergy scenarios' were developed with DECC to reflect variations of activities and processes inherent to biomass mobilisation and bioenergy generation. Further 'counterfactual scenarios' were developed to allow comparison of the GHG performance of the bioenergy scenario compared to what would have happened to the land/resource if not used for bioenergy. An attributional life cycle assessment (LCA) analysis approach is applied to evaluate the GHG performance of 2,092 variants of bioenergy scenarios.

The research found that heat with GHG performances meeting the UK sustainability standard of 125.3 $kgCO_2^{eqv.}$/MWh can be generated from each of the categories of UK biomass analysed. As Figure 1 highlights for selected results of heat bioenergy from UK grown energy crop (willow short rotation coppice), the research found high variability in the GHG performance across different bioenergy scenarios. This variability is explained through analysing the emission profiles of the scenarios and breaking down the emissions as attributed to different processes and activities inherent to each scenario. The inclusion of high GHG impact processes or activities within the bioenergy scenarios, or the mitigation of GHG emissions from the assumed counterfactual were found to be highly influential in determining whether a particular bioenergy scenario would generate low carbon heat.

The research finds that it is not possible to accurately benchmark categories of biomass resource in terms of their potential GHG performance, but it is possible to identify specific life cycle processes and activities inherent to biomass resources that may either enhance or reduce the GHG performance of a given bioenergy pathway. Policy should focus on promoting best practice that avoids the most energy intensive steps (e.g. pelleting) where possible; should reward low carbon emissions along the supply chain rather than simply focusing on the resource / technology; and should prioritise bioenergy generation from specific resources that would otherwise have high GHG impact counterfactual pathways, for example focusing on using wastes that would otherwise generate large emissions to the atmosphere as they degrade.

1) DECC, "UK Renewable Energy Roadmap Update 2013," London, 2013.
2) DECC, "BEAC (Biomass Emission and Counterfactual) Model." Department of Energy & Climate Change, London, 2014.

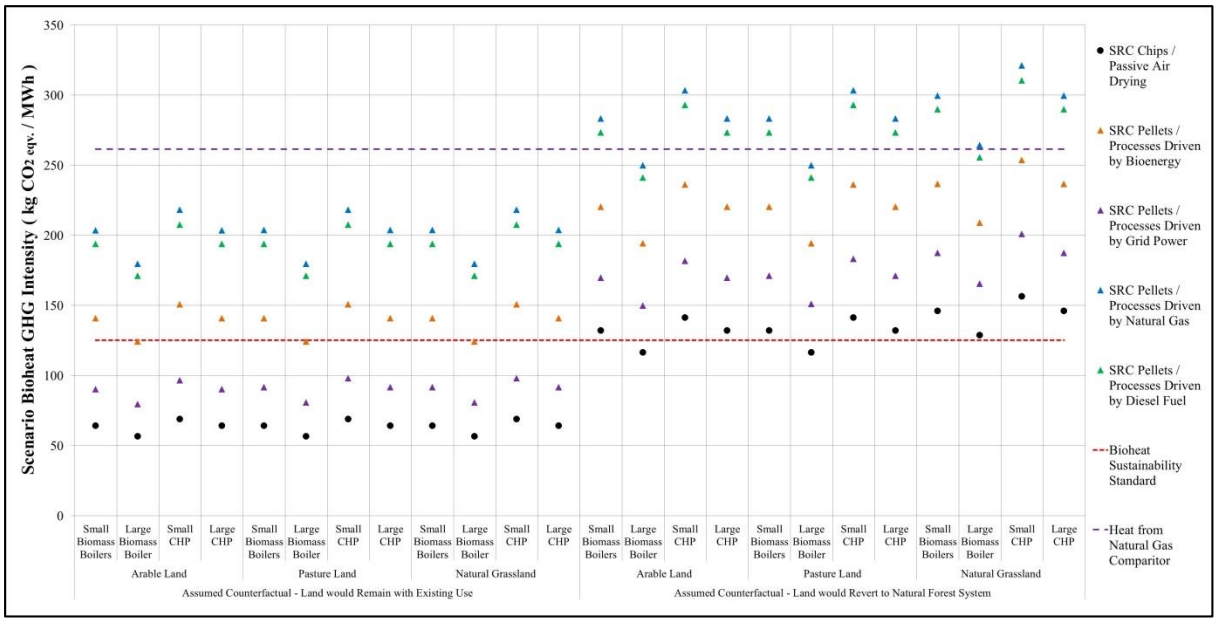

Figure 1: GHG Performance of Selected UK Willow SRC Energy Crop Bioenergy Scenarios - Reflecting Continual Energy Crop Production over a 40 Year Timeframe