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# *An ETI Perspective*

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How can Life Cycle Assessment  
inform bioenergy choices?

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This Perspective follows an ETI project, Carbon Life Cycle Assessment Evidence Analysis, and introduces the way LCAs have been used to quantify the impacts of producing bioenergy



Analysis by the Energy Technologies Institute (ETI) and others indicates that increasing the sustainable production of biomass resources and the use of bioenergy for energy generation can play an important part in meeting the UK's 2050 greenhouse gas (GHG) emissions reduction target. However, the type, quantity and geographical source of additional biomass feedstock, and how this feedstock is used, will have an impact on the extent to which bioenergy delivers GHG emissions savings at a global level.

Life Cycle Assessment (LCA) is a well-established technique to quantify the GHG emissions associated with different bioenergy scenarios, and can identify those scenarios which deliver the lowest emissions. This Perspective is based on an ETI project, Carbon Life Cycle Assessment Evidence Analysis, and introduces the way LCAs have been used to quantify the impacts of producing bioenergy, along with highlighting some of the key things to consider when defining the scope of a bioenergy LCA or interpreting the results of bioenergy LCA studies.

## HEADLINES

- › LCA is a well-established technique for quantifying the GHG emissions (or other environmental impacts) associated with a product or system. However, its outputs can only be properly interpreted if its scope, methodological approach, assumptions and data have been clearly defined and communicated. This is necessary to establish whether LCAs are comparable, and to identify the source of any differences in results.
- › LCAs which report the emissions directly associated with existing bioenergy systems, such as those from transport and pelleting, are an important part of sustainability compliance, but they do not provide an insight into the whole system impacts of increasing bioenergy production. This requires a different LCA approach, taking into account the indirect impacts a change in bioenergy production could have, for example, on forest carbon stocks. Therefore logically, implementing bioenergy sustainability criteria which deliver GHG reductions at a whole system level, requires more than monitoring of direct emissions. Additional measures are needed to encourage good land and forest management practices and prohibit high-risk practices, not only in relation to bioenergy feedstocks but all bio-based products.
- › Given that the global challenge is to restrain total emissions of greenhouse gases over time to less than a fixed total, the aim of biomass production and bioenergy use should be to help deliver a global system (including energy and land use) that produces the lowest emissions overall. When other factors are taken into consideration, this way of producing biomass and bioenergy may not be the optimum system but it should be the reference case against which other options are compared to find the best use of land and resources.
- › Where uncertainty, because of empirical knowledge gaps or lack of understanding of the bioenergy system, results in a wide range of possible results from an LCA, this is a prompt for developing further evidence. Progress has been made in reducing these knowledge gaps but priority areas for further research include mapping the impact of producing bioenergy feedstocks on wider farming or forest systems in geographical areas where this is not well understood. There are also empirical data gaps, particularly relating to the emissions resulting from biomass storage, where further research could improve best practice guidelines.



- › Where there is a tension between different ecosystem services, it is important for sustainability criteria to consider the value of GHG savings from bioenergy together with the value of the additional ecosystems services forests and other land types can provide, such as biodiversity, regulation of air, soil and water quality, and cultural value. Given the potential to increase or reduce these at the same time as increasing biomass production, a regional strategy for forest and land management is necessary to ensure that ecosystems services are at least maintained, if not increased, on average, across the region under consideration.



# CONTEXT

Analysis by the ETI and others<sup>1</sup>, suggests that bioenergy can be a hugely valuable source of energy because it can be stored and used flexibly to produce heat, power, and liquid and gaseous fuels. When produced sustainably it has the potential to be a low carbon, renewable energy source, and when combined with carbon capture and storage (CCS), it has the potential to deliver net negative carbon dioxide (CO<sub>2</sub>) emissions into the energy system, which are strategically and economically very important as they reduce the cost of meeting a finite GHG emissions limit.

The ETI's Energy System Modelling Environment (ESME)<sup>2</sup>, models the UK energy system out to 2050 to help us understand the combinations of technologies and the types of energy system transitions that are most likely to deliver affordable pathways to meet the UK's 2050 greenhouse gas emissions reduction target (an 80% reduction from 1990 levels). Analysis using ESME suggests that it would

cost up to an additional £200bn<sup>3</sup> to meet the UK's carbon targets if we were to fail to develop the role of bioenergy beyond today's level. This is similar to the additional cost of meeting our 2050 targets if there were no deployment of electric vehicles.

In ESME, the emissions associated with bioenergy are highly aggregated (grouped into 'domestic and 'imported'). In reality, increasing the production of different feedstocks, in different locations, will produce different quantities of GHG emissions. To deliver a biomass production and bioenergy sector as part of a system which delivers the lowest practicable emissions at a global scale, it is vital to quantify the range of GHG emissions that could be associated (directly and indirectly) with likely future supply chains, over different timeframes, to understand which feedstocks and/or practices should be encouraged or avoided.

1 Including HMG (2012). Bioenergy Strategy [online]. Available from: <https://www.gov.uk/government/publications/uk-bioenergy-strategy>  
2 ETI (2017). ESME [online]. Available at: <http://www.eti.co.uk/programmes/strategy/esme>  
3 ESME V4.3 Base Case. NPV 2015-2050 at 3.5% discount rate. As presented in: ETI (2017). ETI 10 – Bioenergy presentation [online]. Available at: [https://d2umxnkyjne36n.cloudfront.net/documents/10YoL\\_Bioenergy\\_ETI.pdf?mtime=20171128092222](https://d2umxnkyjne36n.cloudfront.net/documents/10YoL_Bioenergy_ETI.pdf?mtime=20171128092222)



With this in mind, the ETI commissioned North Energy Associates Ltd (NEA) to lead the Carbon Life Cycle Assessment Evidence Analysis project, working alongside Forest Research and the NNFCC. The purpose of the project was to identify and review the existing evidence base of LCAs which calculate GHG emissions associated with potentially major UK-relevant bioenergy value chains, and to use this review and other data sources to compile a compendium of basic data for use in LCAs. These basic data were to be used to calculate and compare the GHG emissions associated with a range of bioenergy value chains, from which key knowledge gaps could be identified<sup>4</sup>.



4 The review of the existing evidence base is available to download from the ETI's Knowledge Zone: NEA (2017) Bioenergy Life Cycle Assessment Review Report [online]. Available at: [http://www.eti.co.uk/programmes/bioenergy?size=10&from=0&\\_type=eti-document&publicOnly=false&query=&programmeName%5B0%5D=Bioenergy&projectName%5B0%5D=Carbon+Accounting+Evidence+Collation](http://www.eti.co.uk/programmes/bioenergy?size=10&from=0&_type=eti-document&publicOnly=false&query=&programmeName%5B0%5D=Bioenergy&projectName%5B0%5D=Carbon+Accounting+Evidence+Collation)

Due to their size and complexity, other project deliverables are not available for download from the ETI's Knowledge Zone and are now held by the Energy Systems Catapult (ESC). The ESC will consider requests to licence the data for specific research projects. Please contact [info@es.catapult.org.uk](mailto:info@es.catapult.org.uk) FAO: Practice Manager – Bioenergy, for further information.





## WHAT IS LIFE CYCLE ASSESSMENT (LCA)?



LCA is a well-established technique for quantifying the impacts of the life cycle of a product or service on resources or the natural environment. Its origins date back to the 1960s and 1970s, when ‘energy analysis’ was used to evaluate the amount of energy required to deliver products and services. From this, LCA has developed into a wide-ranging tool, used to assess the environmental and resource impacts of different products and services<sup>5</sup>.

There are International Standards for LCAs<sup>6</sup> which set out principles and a framework for undertaking an LCA. This framework includes details on defining the goal and scope of the LCA (see Box 1), assembling the required data in a life cycle inventory, as well as conducting, interpreting and reporting the findings from the LCA.

5 McManus, M.C., Taylor, C.M. (2015). The changing nature of life cycle assessment. *Biomass and Bioenergy*, 82, p13-26. Available at: <https://doi.org/10.1016/j.biombioe.2015.04.024>

6 ISO 14040:2006: Environmental Management – Life Cycle Assessment – Principles and Framework [online]. Available at: <https://www.iso.org/standard/37456.html>; ISO 14044:2006: Environmental Management – Life Cycle Assessment – Requirements and Guidelines [online]. Available at: <https://www.iso.org/standard/38498.html>. A more recent standard (ISO/TS 14067:2013) builds on this framework and establishes guidelines for the quantification and communication of the carbon footprint of a product. ISO/TS 14067:2013: Greenhouse gases – Carbon footprint of products – Requirements and Guidelines for quantification and communication [online]. Available at: <https://www.iso.org/standard/59521.html>



Box 1: Defining the goal and scope of an LCA

Each LCA will set out to answer a specific question. To provide a meaningful answer to this question, it is important to clearly define what elements of a system or supply chain the LCA will consider and how it will be undertaken. This activity is called the goal and scope definition and should at least include<sup>7</sup>:

- The intended application and audience e.g. is this an LCA for monitoring emissions directly associated with a current supply chain, or is it assessing the potential emissions resulting from a change in government policy?
- The composition of the system being considered e.g. a bioenergy value chain taking feedstock X from location Y and using it in application Z.
- The system boundary. This is effectively an imaginary line drawn around a part or whole of the system being examined by the LCA, so that all inputs and outputs which cross this line can be quantified by the LCA. The system boundary needs to be defined both spatially and temporally and should be defined systematically to include all key effects resulting from the system. The spatial boundary identifies (for example) whether the analysis includes global emissions or only those emitted in a specific region. The temporal system boundary defines the period of time over which the environmental impact will be quantified, and will define, for example, whether emissions associated with the manufacturing and/or decommissioning of any machinery used in the system will be included. Ideally, the system should be considered from a point

7 Further information on defining a bioenergy LCA, including a template for goal and scope definition (Appendix A), can be found in NEA (2017), *Bioenergy Life Cycle Assessment Review Report* [online]. Available on the ETI's Knowledge Zone: [http://www.eti.co.uk/programmes/bioenergy?size=10&from=0&\\_type=eti-document&publicOnly=false&query=programmeName%5B0%5D=Bioenergy&projectName%5B0%5D=Carbon+Accounting+Evidence+Collation](http://www.eti.co.uk/programmes/bioenergy?size=10&from=0&_type=eti-document&publicOnly=false&query=programmeName%5B0%5D=Bioenergy&projectName%5B0%5D=Carbon+Accounting+Evidence+Collation); and in Thornley, P. and Adams, P. (2017) *Greenhouse Gas Balances of Bioenergy Systems*. ISBN: 978-0-08-101036-5



of pseudo-equilibrium to another point of pseudo-equilibrium. Where this is not possible it should be made clear why this is not the case and the impact this has on the overall result considered.

- The environmental impact(s) under consideration. An LCA can be used to quantify many different impacts on the environment, but LCA studies which examine different energy sources typically concentrate on estimating GHG emissions. The scope must specify which GHGs are being measured. It is common for this to include carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O). Other greenhouse gases, such as fluorinated gases (F-gases) can also be included if relevant to the system being examined. These are often reported in terms of “CO<sub>2</sub> equivalent” (CO<sub>2</sub>e), which is why these studies are often referred to as “Carbon LCAs”.
- The impact time horizon. For LCAs examining GHGs, this relates to the selection of time horizon used to assess the global warming potential (GWP) of the different GHGs quantified in the LCA. This is important because the relative warming impact of CH<sub>4</sub> and N<sub>2</sub>O relative to CO<sub>2</sub> is different over different time horizons (20 or 100 years are typically used).
- Functional Unit and Reporting Metric. These are the units used to describe the outputs of the system, and how the environmental impact per ‘functional unit’ is reported. For example, an LCA examining water use in wheat farming, may report its findings in ‘litres of water per tonne of grain.’

# WHAT QUESTIONS CAN LCA HELP TO ANSWER?



Broadly speaking, LCAs are useful in helping to answer two types of questions:

- 1. What is the impact on X directly associated with producing Product Y? For example, what are the GHG emissions directly associated with current levels of production of bioethanol from UK-grown wheat?
- 2. What is the impact on X directly and indirectly associated with a change in the level of production of Product Y? For example, what would be the GHG emissions directly and indirectly associated with doubling production of bioethanol from UK-grown wheat?

While an LCA can be used to answer both questions, they each require a different methodological approach.

An Attributional LCA (ALCA) approach can answer the first question. ALCA has been defined as an LCA which “provides information about the impacts of the processes used to produce (and consume and dispose of) a product, but does not consider indirect effects arising from the changes in the

output of a product<sup>8</sup>.” For example, an ALCA considering the GHG emissions associated with producing and distributing wood pellets would include emissions directly associated with transporting and pelletising the biomass, but would not include indirect emissions associated with a change in levels of production of other forestry products indirectly caused by a change in the level of wood pellet production.

In practice, an ALCA approach is most commonly applied in compliance and monitoring of existing systems. It can identify the main sources of emissions within a supply chain to help target emissions reductions efforts at those activities where the greatest impact is likely to be achieved. If carried out using a consistent methodology and system boundary, ALCAs can be used to compare emissions directly associated with the production of different products.

A Consequential LCA (CLCA) can answer the second question. A CLCA “provides information about the consequences of changes in the level of output (and

8 Brander, M., Tipper, R., Hutchinson, C., Davis, G. (2009). Consequential and Attributional Approaches to LCA: a guide to policy makers with specific reference to greenhouse gas LCA of biofuels. [online]. Available at: <https://ecometrica.com/white-papers/consequential-and-attributional-approaches-to-lca-a-guide-to-policy-makers-with-specific-reference-to-greenhouse-gas-lca-of-biofuels>



consumption and disposal) of a product, including effects both inside and outside the life cycle of the product”<sup>9</sup>. CLCAs are often used to inform policy makers about the potential environmental impacts of a policy which will lead to an increase or decrease in the production of a product. Therefore, typically, a CLCA would compare significantly different production systems on a large scale, not on small, marginal increases in production.

In a CLCA, the system boundary is expanded (‘system expansion’) to include emissions indirectly caused by a change in the level of production of a product. This scenario is compared with a ‘reference system’ or ‘counterfactual’ (see Box 2) which describes what would have happened to the system if the change in production of Product Y had not occurred. The system boundary of the bioenergy scenario and its counterfactual must be consistent and determined systematically to ensure it includes activities associated with significant emissions. To use the wood pellet example, a CLCA would consider the impact that an

increase in wood pellet production would be likely to have on forest management practices (and consequently) on carbon stock levels and compare that to carbon stock levels in a counterfactual scenario where there was no change in wood pellet output. To give another example, if doubling the production of bioethanol from UK-grown wheat also increased the production of the by-product Distillers Dried Grains and Solubles (DDGS), an animal feed, the counterfactual must account for the emissions associated with producing an equivalent amount of animal feed from another source.

9 ibid., p.12



### Box 2: Counterfactual scenarios in bioenergy LCAs

A counterfactual to a bioenergy value chain LCA describes what would have otherwise happened within the system if the required outcome (e.g. heat or power) was produced by a means other than bioenergy. The counterfactual needs to define:

- What would otherwise have happened to the biomass and the land it was grown on? If the counterfactual assumes that the biomass would have been used to produce another product, the bioenergy scenario should account for where that product would now be sourced from (or what alternative product would be used). Equally, if the production of bioenergy results in by-products (e.g. DDGS), the counterfactual must include an alternative source of the same or similar product.

- What alternative method is used to deliver the required outcome?

The choice of counterfactual scenario, and the scale and time horizon over which the bioenergy scenario and its counterfactual are assessed can have a significant impact on the results of an LCA.

GHG emissions will be emitted and sequestered at different points in time in the bioenergy scenario and in its counterfactual. Therefore, the bioenergy scenario may result in higher atmospheric GHG emissions than the counterfactual for a period immediately following the combustion of the biomass for bioenergy (unless generated in a CCS plant), but as CO<sub>2</sub> is then (re) sequestered through new biomass growth this balance switches and the bioenergy scenario delivers lower



emissions than the counterfactual. Where the bioenergy scenario has higher emissions than the counterfactual, this is often referred to as a 'carbon debt'. A 'carbon debt' could be the result of:

- A permanent reduction in forest carbon stock levels resulting from changes in management practice to meet demand for biomass for bioenergy; and/or
- Forgone carbon sequestration. This is applicable if the counterfactual assumes that forest carbon stocks would increase if biomass were not removed for bioenergy purposes. This can result in a 'carbon debt' being calculated for a new bioenergy value chain even if it maintains forest carbon stocks at current levels.

An area of growing research interest is in modelling the timing of GHG emissions in bioenergy systems to understand the climate implications of those systems

which result in a temporary increase in atmospheric emissions in the short term but which will lead to significantly lower emissions in the long term<sup>10</sup>.

It is important to note that using forest biomass for bioenergy does not have to result in a carbon debt. Where the forest management methods mean that removing biomass for bioenergy has no impact on carbon stock levels (when compared to the counterfactual scenario), there will be no carbon debt. Using biomass for bioenergy can also increase forest carbon relative to the counterfactual, if using some biomass for bioenergy improves the economic viability of a forest leading to afforestation, more intensive areas of planting, or avoids deforestation for housing or farming.

The scale at which a bioenergy value chain and its counterfactual are modelled can make a significant difference to the assessment of the level of 'carbon

<sup>10</sup> Thornley, P. and Röder, M. (2016). Bioenergy as climate change mitigation option within a 2°C target – uncertainties and temporal challenges of bioenergy systems. *Energy, Sustainability and Society*, 6, 6. Available at: <https://doi.org/10.1186/s13705-016-0070-3>



debt’ between a bioenergy scenario and its counterfactual. For example, where a bioenergy scenario using forest-derived biomass and its counterfactual are modelled at the level of an individual tree or small stand of trees, a ‘carbon debt’ could appear to take decades to repay. But given that the strategic objective is always to minimise the overall GHG emissions across a whole land area, it is much more meaningful to perform broader forest-wide analysis, as this provides a better understanding of the impact of forest management practice changes on carbon stocks across an entire forest. At this scale, what appeared to be a ‘carbon debt’ at a local level may no longer exist as removals in one part of the forest are compensated for by growth elsewhere.

Overall, it is important to consider a range of realistic counterfactuals as part of the sensitivity analysis of an LCA as this can highlight the conditions where

bioenergy can deliver the greatest emissions benefits. To draw meaningful insights and recommendations from an LCA for a specific bioenergy source, it is important that the counterfactuals are modelled for the specific environment in which the biomass is grown and that the assessment of the results considers the likelihood of alternative counterfactuals. This requires an understanding of the local environment, management practices, economic drivers, policy and regulation<sup>11</sup>.

11 An example of an assessment of the likelihood of different counterfactuals is, Ricardo-AEA (2017). Use of high carbon North American woody biomass in UK electricity generation [online]. Available at: <https://www.gov.uk/government/publications/use-of-high-carbon-north-american-woody-biomass-in-uk-electricity-generation>



## HOW HAVE LCAs BEEN USED TO ASSESS OPTIONS FOR BIOENERGY?



Since the mid-1990s, as the use of bioenergy for power, heat and transport fuels has grown, particularly in the western world, there has been rapid growth in the number of LCA studies seeking to quantify the GHG emissions impacts of different bioenergy value chains<sup>12</sup>. Similar bioenergy value chains can produce very different LCA results depending on the data and assumptions used, methodological approach taken and the system boundary of the LCA. This has led to confusion where supposedly similar bioenergy value chains have produced very different results in separate LCA studies. For example, during the 1990s and early 2000s, several conflicting results were published on the production of biodiesel from oilseed rape (OSR). The Department for the Environment, Food and Rural Affairs (Defra) commissioned a comparative assessment of these studies to determine the causes of differences in results. In some instances, it was possible to identify differences in assumptions and data, but it was not possible to resolve all variation in the results due to the lack of transparency of approach and calculations in most studies<sup>13</sup>. This highlights

the importance of transparency in setting out the goal and scope of LCAs as well as the actual calculation details in publications.

As interest in biofuels and bioenergy grew during the 1990s and 2000s, CLCA studies were increasingly used to examine concerns being raised over the potential impact biofuel crops were having (or could have) on wider land and resource availability, and the GHG emissions implications of these. Concern centred around the impact of Land Use Change (LUC); both direct (dLUC) where transitioning from a land use with a high carbon stock to arable crops could result in a loss of carbon stored in plant matter and in the soil, which could take a significant amount of time to ‘payback’ through offsetting the use of fossil transport fuels, and indirect (iLUC) where concern centred on whether biofuel crops grown on existing arable land were causing non-arable land (grass or forest land) in other locations to be converted to arable land in order to continue to meet food and feed demand.

12 McManus, M.C., Taylor, C.M. (2015). The changing nature of life cycle assessment. *Biomass and Bioenergy*, 82, p13-26. Available at: <https://doi.org/10.1016/j.biombioe.2015.04.024>

13 Mortimer, N.D. et al (2003). Evaluation of the Comparative Energy, Global Warming and Socio-Economic Costs and Benefits of Biodiesel. [online]. Available at: [http://sciencesearch.defra.gov.uk/Document.aspx?Document=NF0422\\_488\\_FRP.pdf](http://sciencesearch.defra.gov.uk/Document.aspx?Document=NF0422_488_FRP.pdf)



Policy makers responded to concerns about dLUC by introducing land use criteria, preventing the conversion of land with a high carbon stock (such as forestry or wetlands) to crops for bioenergy as these conversions would be more likely than other land use changes to result in higher GHG emissions, by reducing the carbon stock stored in the biomass and soil.

Recent research projects, including the ETI funded ELUM and MAGLUE<sup>14</sup>, have substantially increased our understanding of dLUC emissions resulting from energy crop transitions in the UK, helping to identify transitions which could increase soil carbon stocks, as well as identifying those with a detrimental GHG impact. A considerable amount of research has also been carried out to try and quantify iLUC factors (both in terms of land area affected, and the emissions associated with the land use change) for different bioenergy systems<sup>15</sup>, while others have

highlighted circumstances under which bioenergy and food production can be complementary and need not compete for land use<sup>16</sup>.

In the 2010s there has been an increased focus on the impacts of using forest biomass in power and heat generation, as the use of wood pellets and chips has increased. A requirement to meet GHG criteria was included in the Renewables Obligation in 2015, with emissions calculated following the methodology set out in the Renewable Energy Directive (RED)<sup>17</sup>. This accounts for emissions directly attributable to current production of bioenergy, but does not provide information on the indirect emissions associated with an increase or decrease in production of forest-derived feedstocks, such as those resulting from a change in forest management practices or displacement of other forestry products.

14 For further information visit: ELUM ([www.elum.ac.uk](http://www.elum.ac.uk)) and MAGLUE (<http://www.maglue.ac.uk/>)

15 Including: Ecofys, IIASA and E4tech (2015). The land use change impact of biofuels consumed in the EU [online]. Available at: [https://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report\\_GLOBIOM\\_publication.pdf](https://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report_GLOBIOM_publication.pdf)

16 Kline, K.L. et al (2017). Reconciling food security and bioenergy: priorities for action. *Global Change Biology Bioenergy*, 9 (3), p.557-576. Available at: <https://doi.org/10.1111/gcbb.12366>

17 Further information on the development of sustainability criteria in the Renewables Obligation can be found in: Ofgem (2016). Renewables Obligation: Sustainability Criteria [online]. Available at: <https://www.ofgem.gov.uk/publications-and-updates/renewables-obligation-sustainability-criteria>

## HOW HAVE LCAs BEEN USED TO ASSESS OPTIONS FOR BIOENERGY? Continued »



As set out earlier, it is vital for policy makers to consider the causes of indirect emissions when analysing the impacts of an increase (or decrease) in bioenergy use. Indirect emissions, such as those resulting from a change in forest carbon stock, often have a large impact on overall LCA results, and can vary significantly depending on the counterfactual assumptions (see Box 2). This shows that ensuring bioenergy delivers emissions savings at a global scale cannot be achieved through monitoring direct emissions alone. Additional measures are needed to encourage good land and forest management practices and prohibit high-risk practice. This should not only apply in relation to bioenergy feedstocks, but should take a holistic view across the production of all bio-based products.

For a more detailed background to Life Cycle Assessments and the key aspects of calculating bioenergy LCAs, please see Chapter 2 of Deliverable 2 – Bioenergy Life Cycle Assessment Review Report from the Carbon Life Cycle Assessment Evidence Analysis project<sup>18</sup>.



<sup>18</sup> Available from the ETI's Knowledge Zone: [http://www.eti.co.uk/programmes/bioenergy?size=10&from=0&\\_type=eti-document&publicOnly=false&query=&programmeName%5B0%5D=Carbon+Accounting+Evidence+Collation](http://www.eti.co.uk/programmes/bioenergy?size=10&from=0&_type=eti-document&publicOnly=false&query=&programmeName%5B0%5D=Carbon+Accounting+Evidence+Collation)

## WHAT ARE THE MAIN AREAS OF UNCERTAINTY IN BIOENERGY LCAs?



An LCA should include a sensitivity analysis to identify impacts on the overall result. In interpreting the results of the sensitivity analysis, it is important to distinguish between uncertainty in the results caused by a gap in the knowledge base or modelling capability, and natural variability within environmental and climatic systems<sup>19</sup>. The Carbon Life Cycle Assessment Evidence Analysis project identified key areas where knowledge and/or modelling uncertainty can result in significant differences in results, which can make it difficult to draw meaningful conclusions and recommendations.

Three key areas identified by the project team were:

- Forest management scenarios and practices in both the bioenergy scenario and its counterfactual. As mentioned earlier, this needs to be location-specific and requires an understanding of the local environment, management practices, economic drivers, policy and regulation.

- Production of wood products, their counterfactuals and waste management routes for both. Reducing uncertainty in this area would require extensive economic modelling of relevant wood products and their possible counterfactuals to assess trade-offs between sectors at different market prices.
- GHG emissions from storage. Some research has been carried out into emissions associated with different wood chip storage techniques<sup>20</sup>, but overall sufficient data are not available. More comprehensive field sampling across common storage types would develop the knowledge base, informing updates to best practice guidelines regarding wood and energy crop storage.

<sup>19</sup> Thornley, P. and Röder, M. (2016). Bioenergy as climate change mitigation option within a 2°C target – uncertainties and temporal challenges of bioenergy systems. *Energy, Sustainability and Society*, 6, 6. Available at: <https://doi.org/10.1186/s13705-016-0070-3>

<sup>20</sup> Including: Whittaker, C. et al (2016). Dry matter losses and methane emissions during wood chip storage: the impact of full life cycle greenhouse gas savings of short rotation coppice willow for heat, *Bioenergy Research*, 9 (3), 820-835 [online]. Available at: <https://doi.org/10.1007/s12155-016-9728-0>; and Whittaker, C. et al (2015). Dry matter losses and greenhouse gas emissions from outside storage of short rotation coppice willow chip, *Bioenergy Research*, 9 (1), 288-302 [online]. Available at: <https://doi.org/10.1007/s12155-015-9686-y>

# SUMMARY

The LCA technique can quantify the emissions associated with a current bioenergy production practice or with a change in the level of bioenergy production. Where these systems are well understood, an LCA can provide useful insights about the dominant sources of emissions within the supply chain which could be targeted for reduction through efficiency improvement or technological change.

For LCAs which compare a bioenergy system to several alternative scenarios (counterfactuals), it can highlight the circumstances under which an increase in bioenergy production could deliver genuine emissions reductions. However, translating this into meaningful recommendations and policy decisions requires the modelling of both the bioenergy scenario and its counterfactual to be specific to the local environment, and for the likelihood of different counterfactuals to be understood, taking into account local

management practices, economic drivers behind forestry and farm management, policy and regulation.

Translating these recommendations into practice requires more than just monitoring of emissions directly associated with bioenergy production. Land criteria currently require woody biomass to be sourced from sustainably managed forests<sup>21</sup>. For non-woody biomass, such as energy crops, the land criteria prevent land use transitions which have a high risk of releasing a significant quantity of GHG emissions and/or being detrimental to other ecosystem services<sup>22</sup>. These criteria should continue to develop as the bioenergy sector evolves, and must also balance the need to reduce GHG emissions with wider sustainability issues, such as biodiversity, water and air quality.

21 The biomass must be certified under the Forest Stewardship Council (FSC) or Programme for the Endorsement of Forest Certification (PEFC), or bespoke evidence must be provided that demonstrates compliance with the criteria.

22 Prohibited land use transitions include producing energy crops on land which was previously forested, peatland, highly biodiverse grassland or wetland.



# FURTHER INFORMATION

**The role of the ETI**

The Energy Technologies Institute (ETI) was established in 2007 to identify and accelerate the development of low carbon technologies to help the UK address its long-term GHG emissions reduction targets, as well as delivering nearer term benefits. The ETI's bioenergy programme was established to deliver research, technology development and deployment projects which would fill knowledge gaps within the sector and assess and understand the potential for different bioenergy value chains in the UK.

The ETI was established as a 10-year partnership between the UK government and industry and will cease to operate at the end of 2019.

**The role of the ESC**

The Energy Systems Catapult (ESC) was established by the UK government in 2015 as part of a network of world-leading centres to transform the UK's capability for innovation. The ESC has a mission to unleash innovation and open new markets that help transform the energy system and capture the growth opportunity recognised in the UK Industrial Strategy. Working with government, industry, academia and consumers, the ESC vision for the UK energy sector will see it overcoming systemic barriers

and delivering the innovation, products, services and value chains required to accelerate the decarbonisation of the energy system at least cost and deliver the UK's economic ambitions.

The ETI's Whole System Analysis Function transferred to the ESC in September 2017 it continues to disseminate and build on findings from the ETI's research programmes.

- Further Reading**
- The following ETI publications are available to download from: <http://www.eti.co.uk/library>
- Delivering GHG savings through UK bioenergy value chains
  - Insights into the future UK bioenergy sector, gained using the ETI's BVCM
  - Increasing UK biomass production through more productive use of land

**Acknowledgements**

The Carbon Life Cycle Assessment Evidence Analysis project was commissioned and funded by the ETI. The project was led by North Energy Associates Ltd (NEA) working with Forest Research and the NNFCC.





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01509 202020



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