SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Sustainability Criteria Options and Impacts for Irish Bioenergy Resources

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Disclaimer

Contents

Glossary of Terms

AD	Anaerobic Digestion
BEIS	UK Department for Business, Energy and Industrial Strategy (formerly the Department of Energy and Climate Change)
BOS	Biofuel Obligation Scheme
BSL	Biomass Suppliers List
CAP	Common Agricultural Policy
CHP	Combined Heat and Power
DAFM	Department of Agriculture, Food and the Marine
DCCAE	Department of Communications, Climate Action and Environment
Default values	Conservative GHG emissions intensity calculated by the Commission and contained in annexes to the RED and RED II
EC	European Commission
EIS	Environmental Impact Statement
FIT	UK Feed-In Tariff
FQD	Fuel Quality Directive (2009/30/EC)
FSC	Forest Stewardship Council
GAEC	Good Agricultural and Environmental Condition
GHG	Greenhouse Gas
IEA	International Energy Agency
ILUC	Indirect Land Use Change
IPCC	Intergovernmental Panel on Climate Change
LUC	Land Use Change
LULUCF	Land Use, Land Use Change and Forestry
NHA	Natural Heritage Area
NOx	Oxides of Nitrogen
NPWS	National Parks and Wildlife Service
Ofgem	UK Office of Gas and Electricity Markets
PM	Particulate Matter
RED	Renewable Energy Directive (2009/28/EC)
RED II	Revised Renewable Energy Directive, as agreed between the Council, Parliament and Commission in June, 2018
RHI	UK Renewable Heat Incentive
RO	UK Renewables Obligation
ROCs	Renewables Obligation Certificates
SAC	Special Areas of Conservation
SFR	Sustainable Fuel Register
SOx	Oxides of Sulphur
SPA	Special Protection Areas
SRC	Short Rotation Coppice

1 INTRODUCTION

SEAI appointed Byrne Ó Cléirigh (BÓC) and Navigant to propose an appropriate approach to solid and gaseous bioenergy sustainability for Ireland that will support the goal of promoting sustainable low carbon bioenergy feedstocks. The study was carried out in three phases; this report covers the activities carried out in Phases I & II. Phase III examines options for implementing a sustainability system and how such a system could be administered.

The objective of Phase I was to collate knowledge on what constitutes sustainable biomass, whilst Phase II looks in more detail at likely biomass supply chains in the Irish context. While there have been sustainability requirements for biofuels (fuel used in transport) and bioliquids (used to produce electricity and heat) for several years in the EU, the schemes that govern biofuel sustainably can differ – it is still an area that is being developed and there are often different views and opinions on what factors need to be considered when determining if a biofuel or bioliquid is sustainable.

Bioenergy can play an important part in a future energy system, but it must be done sustainably. The Intergovernmental Panel on Climate Change (IPCC) fifth assessment report (2014)[1] states that *bioenergy can play a critical role for mitigation, but there are issues to consider, such as the sustainability of practices and the efficiency of bioenergy systems.* The report states that *barriers to large-scale deployment of bioenergy include concerns about GHG emissions from land, food security, water resources, biodiversity conservation and livelihoods. The scientific debate about the overall climate impact related to land-use competition effects of specific bioenergy pathways remains unresolved… Bioenergy technologies are diverse and span a wide range of options and technology pathways. Evidence suggests that options with low lifecycle emissions (e.g. sugar cane, Miscanthus, fast-growing tree species, and sustainable use of biomass residues), some already available, can reduce GHG emissions; outcomes are site-specific and rely on efficient integrated 'biomass-to-bioenergy systems', and sustainable land-use management and governance.*

In Phase I, we examined the biomass sustainability criteria that could be applied, the legislative regime in Ireland and the approach other Member States have taken to implementing sustainability criteria for solid and gaseous biomass. We also examined the approaches to calculating GHG emissions from biomass and recommended an approach that provides SEAI with sufficient information to understand what represents robust sustainability criteria and how compliance could be demonstrated. In Phase II we examined in greater detail the specific GHG savings from potential Irish bioenergy supply chains and developed a framework to assess the level of sustainability of those supply chains, taking into account the criteria set out in the recast Renewable Energy Directive (RED II) and other environmental, economic and social indicators.

Section 2 of this report describes the EU legislation, covering the RED and RED II. Section 3 covers relevant Irish regulations and guidelines. Section 4 describes the system in place in the UK to demonstrate the sustainability of solid and gaseous biomass, while Section 5 gives an overview of examples in other Member States. Section 6 describes the approach to calculating and reporting GHG emissions in the RED II, examines GHG emissions for typical bioenergy supply chains in the Irish context, and also describes indirect effects and the concept of carbon debt. Section 7 describes a framework that could be used for assessing the sustainability risk of different biomass fuel chains. The framework is intended to be informative and to identify where sustainability risks may arise. Finally, in Section 8, we summarise the main conclusions arising from this study.

Given the range of topics covered in this report, we provide a short summary of the key information at the start of each section.

[1] http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf

2 EU Legislation

This section examines the EU legislation, as it pertains to sustainability criteria for bioenergy, and the obligations on Member States.

The Renewable Energy Directive (RED 2009/28/EC) has governed the sustainability of biofuels and bioliquids in the EU since 2009 – for a biofuel or bioliquid to be classified as sustainable in the EU, it must meet the sustainability criteria set out in the RED and comply with the verification requirements. The RED does not contain mandatory sustainability requirements for solid and gaseous biomass; only the accompanying Communications include a recommended approach that Member States might implement.

RED II is an extension of the RED for the period 2021 to 2030 and it will introduce mandatory criteria for solid and gaseous biomass. RED II will be at the core of defining sustainability for solid and gaseous biomass for the coming years; it includes three overarching sustainability criteria which relate to land for agricultural biomass, management of forest biomass, and GHG emission savings for all biomass fuels. In the context of installations producing electricity, heating and cooling or fuels, those with a fuel capacity >=20 MW in the case of solid biomass, and 2 MW in the case of gaseous biomass, will be required to comply and Member States will need to put in place biomass sustainably requirements that will need to be independently verified if the biomass is to count towards national and/or fuel supplier obligations. (All biofuels are already required to comply with the sustainability requirements of the RED and this will remain the case from 2021.)

We recommend that SEAI remain up-to-date with the RED II sustainability regime and explore the potential impacts on biomass supply chains relevant for Irish installations, in preparation for the mandatory RED II requirements from 2021 onwards.

2.1 Renewable Energy Directive (RED)

In 2009, the EU Renewable Energy Directive (RED 2009/28/EC) came into force. The RED includes comprehensive and binding sustainability criteria for biofuels (used in transport) and bioliquids (used to generate electricity or heat). Operators using biofuels or bioliquids need to meet specific sustainability criteria to be eligible for support under national incentive schemes and for Member States to count those fuels towards national renewable energy targets.

In Ireland, for a biofuel or bioliquid to be eligible to count towards the national 2020 renewable energy target, they must meet the sustainability criteria, as defined in the RED Articles 17(2)-(6). In summary, a biofuel or bioliquid must meet a minimum life-cycle greenhouse gas (GHG) saving and the feedstocks cannot be grown on peatlands, on land with a high biodiversity value (e.g. primary forests, special areas of conservation or highly biodiverse grasslands) or on land with a high carbon stock (e.g. wetlands, continually forested areas).

The RED requires that a mass balance chain of custody system[2] is used to pass sustainability information through the supply chain and establishes an EU framework for determining and verifying sustainability. There are three main options when demonstrating compliance with the sustainability criteria:

1. Use a national system (established by Member States);
2. Use a bilateral or multilateral agreement concluded by the EU with countries outside the EU that guarantees the sustainability of feedstocks from those countries (none have been established to date);
3. Use a voluntary (certification) scheme that has been recognised by the EC.[3]

The RED does not include mandatory sustainability criteria for solid and gaseous biomass, but the EC has published two papers with recommendations Member States could follow if they opt to implement sustainability criteria[4]:

- COM(2010)11[5] which proposes sustainability criteria, a GHG methodology and several GHG default values; and
- SWD(2014)259[6] which examines the state of play of biomass sustainability in the EU and proposes updates to the GHG methodology and default GHG emission values, including some for supply chains not covered in COM(2010)11.

These documents form the basis of the mandatory GHG methodology contained in the recast RED II and so will be superseded once it comes into force in 2021.

2.2 ILUC Directive

When bioenergy feedstocks are produced on land, there is a risk that the increased consumption of bioenergy requires agricultural expansion at a global scale, which could take place on land with high carbon stock and result in additional GHG emissions. This effect is called 'Indirect Land Use Change' (ILUC). The RED required the EC to develop a methodology to account for ILUC from biofuels. As the effect is indirect, global and cannot be measured directly, it can only be modelled using a complex set of assumptions. The most recent report commissioned by the EC used the GLOBIOM model to estimate land use change GHG emissions ('LUC factors') for various land-using feedstocks[7].

In September 2015, Directive (EU) 2015/1513 (the ILUC Directive) was published to amend the RED; it was required to be transposed into Irish law by 10 September 2017, but has not yet been completed[8]. The stated purpose of the ILUC Directive is to reduce the risk of ILUC and to prepare for transitioning towards advanced biofuels. To achieve this, the Directive provides for, amongst other things, limiting the share of biofuels from food crops produced as the main crop (e.g. cereals, sugars and oil crops) to 7% of the 2020 renewable energy target. The Directive also sets an *indicative* 0.5% target for advanced biofuels, i.e. biofuels produced from a pre-defined list of (mainly) waste and residue feedstocks. Ireland has set an advanced biofuel target of 0.25%[9]. In addition, the Directive amends the GHG threshold that must be met by economic operators, but it does not incorporate ILUC factors into the GHG calculation methodology. Member States should take into account the ILUC factors when reporting to the EC.

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[2] A mass balance system ensures that the quantity of compliant biomass taken from a mixture is not higher than the quantity of compliant biomass that was added to the mixture. The mass balance chain of custody provides assurance that claims of compliance with sustainability requirements can be tracked along the supply chain.
[3] A list of all EC-recognised voluntary schemes is published here: http://ec.europa.eu/energy/en/topics/renewable-energy/biofuels/voluntary-schemes
[4] http://ec.europa.eu/energy/en/topics/renewable-energy/biomass
[5] Communication on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling COM(2010)11. http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1410874845626&uri=CELEX:52010DC0011
[6] State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU SWD(2014)259. http://ec.europa.eu/energy/sites/ener/files/2014_biomass_state_of_play_.pdf
[7] Ecofys, IIASA and E4tech (2015). *The land use change impact of biofuels consumed in the EU: Quantification of area and GHG impacts* https://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report_GLOBIOM_publication.pdf
[8] At the time of completing this report, the DCCAE was working on transposing this Directive.
[9] The Directive permits Member States to set a lower national target where, inter alia, there is limited potential for the sustainable production of biofuels produced from feedstocks and of other fuels, listed in part A of Annex IX, or the limited availability of such biofuels at costefficient prices on the market.

While the ILUC debate is often framed as 'food versus fuel', what is important is the area of land used to produce the feedstock rather than whether the feedstock is edible per se. Feedstocks typically used for solid and gaseous biomass include forestry feedstocks, agricultural and forestry residues and, so far, a small quantity of energy crops and wastes. To date, the ILUC Directive only includes ILUC factors for cereals and oil seeds. In relation to solid and gaseous biomass, the GLOBIOM study modelled ILUC impacts for maize silage, straw, perennial energy crops, short rotation plantations and forestry residues. The ILUC impact for these crops was found to be small, and in the case of short rotation plantations and perennial energy crops the GHG effect was even found to be positive (this is described further in Section 6.8).

2.3 Recast RED II

In November 2016, the EC published a proposal for a follow-on RED covering the period 2021 to 2030. The so called RED II will extend the scope of the sustainability requirements to include solid and gaseous biomass used for heating, cooling and electricity generation; it was agreed by the European Council, Parliament and Commission in June 2018[10].

Given the fundamental role played by the RED in defining the sustainability of biofuels and bioliquids, we envisage that RED II will determine the sustainability criteria that will be applicable to portions of the solid and gaseous biomass markets. The Directive includes the sustainability criteria, the verification requirements, the reporting requirements and the methodology for calculating GHG emissions from biomass fuels. As well as continuing with the sustainability requirements for biofuels and bioliquids, the RED II applies the sustainability and GHG emission savings criteria to biomass fuels if they are used in installations producing electricity, heating and cooling or fuels with a fuel capacity >= 20 MW in the case of solid biomass, and 2 MW in the case of gaseous biomass, i.e. in 'large installations'. The key elements of RED II are described in the following sub-sections.

The Directive states that for measuring compliance with EU renewable energy targets / obligations and eligibility for financial support, Member States may not apply additional sustainability requirements to biomass fuels, as is currently the case for biofuels (under a previous draft of the Directive, it had been permitted). Thus, we expect that for biomass used to produce electricity, heating and cooling, the RED II sustainability criteria will be the only applicable criteria. The RED II does, however, explicitly allow Member States to apply the sustainability criteria to installations below the size thresholds (Article 26).

2.3.1 Sustainability Criteria

Article 26 of the RED II (formerly Article 17 of the RED), which is summarised below, sets out the sustainability criteria that will need to be applied for biomass fuels from 2021.

1. Biomass fuels produced from agricultural biomass shall not be made from raw material obtained from land:
    a. with high biodiversity value, i.e. primary forests (those with no clearly visible human activity), specially protected areas, special areas of conservation and highly biodiverse grasslands;
    b. with high carbon stock, i.e. wetlands, continuously forested areas;
    c. that was peatland.

[10] The text of the Directive will have to be formally approved by the European Parliament and Council. Once endorsed by both co-legislators (expected in the second half of 2018), the updated RED will be published in the Official Journal of the Union and will enter into force 20 days after publication. Member States are required to transpose the new elements of the Directive into national law 18 months after its entry into force.

2. Biomass fuels produced from forest biomass shall meet the following requirements:
   a. The country of origin of the biomass has harvesting laws, and monitoring and enforcement systems (or where not available in the country of origin, if management systems are in place at *forest sourcing area level*) to ensure:
      i. it is carried out in accordance with a harvesting permit;
      ii. forest regeneration is in place;
      iii. nature protection areas, including peatlands and wetlands, are protected;
      iv. its impacts on soil quality and biodiversity are minimised;
      v. it does not exceed the long-term production capacity of the forest.
   b. The country (or regional economic integration organisation) meets the following LULUCF[11] requirements:
      i. is party to or has ratified the Paris agreement [12];
      ii. has submitted a Nationally Determined Contribution (NDC) to the UNFCCC or there are laws in place (in accordance with the Paris Agreement) to conserve and enhance carbon stocks and sinks;
      iii. has a national system for reporting GHG emissions and removals from land use including forestry and agriculture.

      If the above are not available, management systems at the *forest sourcing area level* will need to be in place to ensure that the carbon stocks and sinks levels in the forest are maintained for the long term.

All biomass fuels used for electricity, heating and cooling shall achieve at least a 70% GHG emission saving, increasing to 80% for installations that start operating from 2026. We have used the 70% GHG threshold as the basis for the GHG analysis in Chapter 6 of this report.

2.3.2 GHG Calculations

The RED II methodology for calculating life cycle GHG emissions is contained in Annex VI: *Rules for calculating greenhouse gas impact of biomass fuels and their fossil fuel comparators*.

Part A of Annex VI sets out the 'default' GHG emission savings values for selected biomass and biogas production pathways that the Commission considers to be the more common biomass production pathways. The combinations of biomass and biogas fuel production systems, transport distances, technological options and end uses gives rise to over one hundred default value options. Nevertheless, default values are not available for all possible supply chain options. The default values range from -33% saving (i.e. an increase in emissions compared to the fossil equivalent) for *palm kernel meal* transported more than 10,000 km and used for electricity generation to 240% saving from *wet manure* (with closed system digestate storage) used to produce biogas for electricity[13]. The default values are calculated by the Joint Research Centre (JRC) on behalf of the EC and use conservative assumptions so that, in theory, if an operator reports GHG savings using actual values from their supply chain, they should be able to report a higher GHG saving than the default.

Operators can always choose to report 'actual' values if they wish. If there is no appropriate default value available, an operator must report actual values. Part B of Annex VI sets out the methodology for calculating actual GHG emission savings values. Carrying out an actual value calculation requires a detailed understanding of the entire biomass supply chain and, depending on the type of biomass, experience in agronomy, transport, process engineering, data management and statistics. Apart from some very simple biomass fuel chains, calculating actual values for the entire biomass fuel chain is a complex task.

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[11] Land Use, Land Use Change and Forestry.

[12] Note that this would mean that US-sourced material would not be compliant if the US withdraws from the Paris Agreement, as is the current stated intention.

[13] The very high savings primarily result from a credit for manure management of 45 gCO_{2eq}/MJ due to the avoided methane and nitrous oxide emissions of treating manure via AD.

Alternatively, actual value calculations can be combined with disaggregated default values for specific parts of the fuel chain, which would allow an operator to report actual values for parts of the fuel chain for which it has data, without having to report actual data for every step. For example, actual value calculations for cultivation can be combined with disaggregated default values for processing and transport.

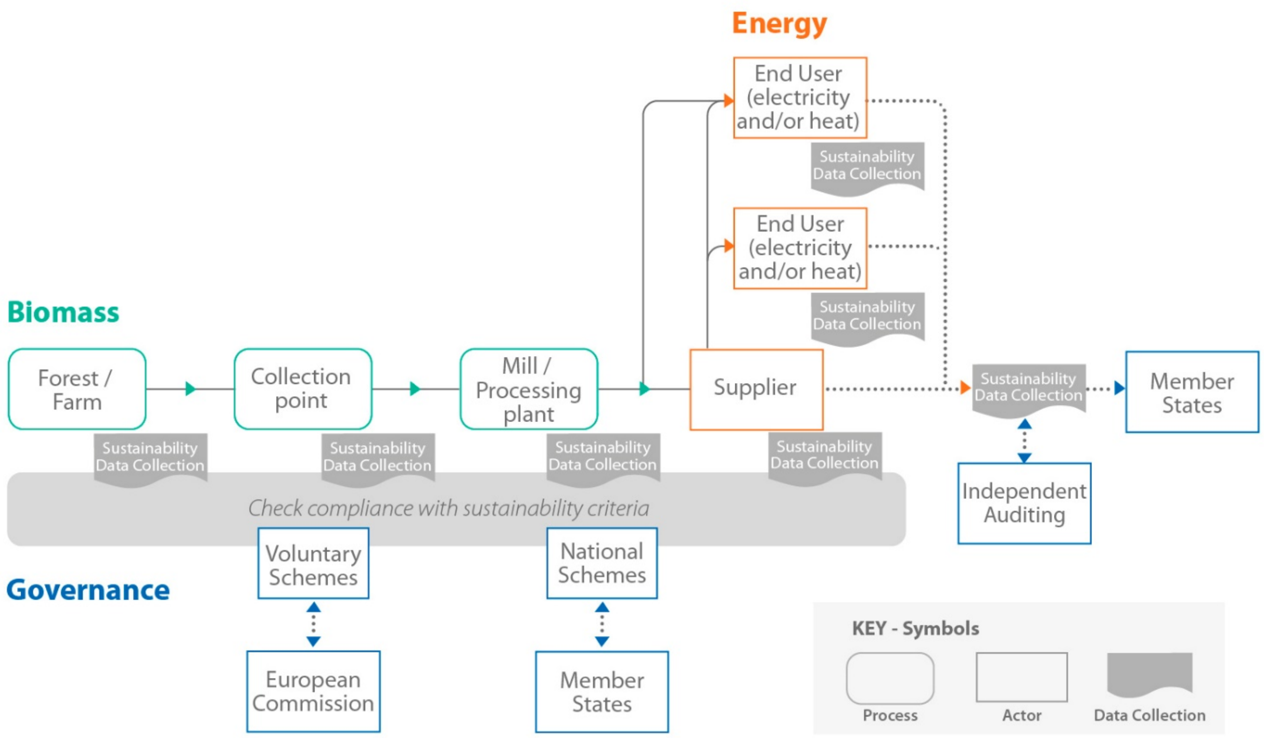
The RED II approach to GHG calculations is further explained in Section 6, including how the calculations are performed and the tools available for performing the calculations.

2.3.3 Verification Requirements

Article 27 of RED II (formerly Article 18 of the RED) sets out the verification requirements, i.e. how do economic operators demonstrate to Member States that the sustainability and GHG emission saving criteria have been met. It describes the information that needs to be passed along the fuel supply chain and requires economic operators to use a mass balance system. It also requires independent auditing of sustainability information submitted to Member States and establishes an option for the EC to recognise voluntary schemes as a means for economic operators to demonstrate to Member States that a biomass fuel is compliant with the sustainability and GHG emissions savings criteria. Member States may also establish national systems for allowing economic operators to demonstrate compliance (note that this could include Member States recognising voluntary schemes for the purpose). This is similar to the approach already adopted in Ireland for verifying the sustainability and GHG emission savings for biofuels.

These requirements will need to be met if the biomass is to be counted towards the renewable energy target in Ireland.

Figure 2-1: Verification of sustainability



Member States will be required to report to the EC aggregated information about the economic operators' compliance with the sustainability and GHG emissions savings criteria and the independent auditing carried out on the information submitted by the operators.

2.3.4 Other Responsibilities on Member States

In addition to existing administrative procedures, regulations and codes for authorising, certifying and licencing the process of transforming biomass into biofuels or other energy products, and using renewable energy in buildings, Member States shall:

1. Endeavour to increase the penetration of renewable energy in the heating and cooling sector by an indicative 1.3 % as a yearly average, calculated for the periods of 2021-2025 and 2026-2030, starting from the level achieved in 2020 (Article 23).
2. Carry out an assessment of their potential renewable energy sources and the use of waste heat and cold for heating and cooling (Article 15).
3. Report to the EC under various articles and produce an Integrated National Energy and Climate Plan (the Plan is a requirement of the Energy Union Governance Regulations, which was also agreed, along with RED II, in June 2018).

The next section examines how existing legislation in Ireland overlaps with the requirements of RED II.

3 Irish Regulations and Guidelines

This section examines existing Irish legislation and its coverage of the RED II sustainability criteria for agricultural and forestry biomass.

There are many Acts, Regulations, guidelines and standards that indirectly address sustainability as a consequence of addressing related matters, such as land use and good agricultural practices.
While there is no existing legislation requiring GHG emission savings for solid and gaseous biomass produced from agricultural crops and forestry, the Forestry Act 2014, Forestry Regulations 2017, Birds and Natural Habitats Regulations 2011, Wildlife Act 1976, and the Planning and Development Regulations 2001 to 2015 indirectly cater for the land use and carbon stock sustainability criteria of RED II.

There are clear monitoring and enforcement systems in place for the existing legislation that are the responsibility of the Forestry Service, the Local Authorities and the NPWS. In addition, the DAFM is responsible for ensuring Cross Compliance requirements are satisfied – this requires farmers to satisfy thirteen Statutory Management Requirements (SMRs) and seven Good Agricultural and Environmental Condition (GAEC) standards to ensure CAP funding. The SMRs and GAEC standards include for compliance with some of the existing legislation that indirectly caters for the sustainability criteria of RED II. There may be 'exceptional circumstances' where agricultural biomass could be grown on land of high carbon stock or high biodiversity; however, this is unlikely and, if it did occur, there would be records (e.g. EIAs or screening assessments) that could be used to identify where it occurred and thus assist with determining if a biomass was produced in accordance with the RED II sustainability criteria.

Given the extent of the Irish legislation and the monitoring and enforcement systems in place, we consider that Irish forestry and agriculture biomass, once it meets the GHG savings criteria of RED II, should satisfy the remaining RED II sustainability criteria. Other than for biofuels and bioliquids, there is no existing Irish legislation that includes requirements for GHG emissions savings.

3.1 Overview

Currently, there is no Irish legislation setting criteria for determining the sustainability of solid or gaseous biomass. There are, however, numerous items of legislation and guidelines that cover environmental protection, forest management, agricultural practices and the broad concept of sustainable production. As the RED, and its successor RED II, have the most developed set of sustainability criteria, we have focused our review on Irish legislation that relates to the sustainability characteristics set out in RED II.

The sustainability criteria set out in RED II for solid and gaseous biomass distinguishes between agricultural biomass and forest biomass. For agricultural biomass, the raw material cannot be made from land with high biodiverse value (primary forest, nature protection areas or highly biodiverse grassland), land with a high carbon stock (wetlands, forested areas) and peatland. For forest biomass, there are requirements for harvesting permits, forest regeneration, protection of nature areas, minimising the impact on soil quality and biodiversity, and conservation of forest production capacity – there are also land use, land use change and forestry (LULUCF) requirements.

While there is generally separate legislation for agriculture and for forestry, some of it covers both sectors. Implementing this legislation is the responsibility of various government departments and agencies.
In the following sub-sections, we present a summary of our findings. The particular clauses and how they relate to the sustainability criteria are presented in Appendix 2.

3.2 Agricultural Biomass

There are many Acts, Regulations and guidelines that address the concept of sustainability. In RED II, in addition to the GHG emissions savings criteria, there are the land criteria (see Section 2.3.1). In Table 1 we have identified the Irish legislation that is most relevant to each land criteria listed in RED II. These items of existing national legislation do not directly address GHG emissions for solid and gaseous biomass. While there are GHG emission saving requirements for biofuels used in transport and bioliquids used in electricity generation and heating and cooling (covered in BOS Act[14], the Sustainability Regulations[15] and the Renewable Energy Regulations[16]), these GHG emission savings criteria do not apply to solid and gaseous biomass fuel, except in the case of biomethane used for transport.

Table 1: Relevant Legislation for Agricultural Biomass

Land Criteria	Forestry Act 2014 & Forestry Regulations 2017	Birds and Natural Habitats Regulations 2011	Planning and Development Regulations 2001 to 2015	Wildlife Act 1976 (as amended)
High biodiverse value				
Primary forest Note 1	-	-	-	-
Nature protection area	×	✓	×	✓
Highly biodiverse grassland	×	✓ Note 3	×	✓ Note 4
High carbon stock				
Wetland	×	✓ Note 2	✓ Note 2, Note 4	✓ Note 4
Forested area	✓	✓ Note 2	×	✓ Note 4
Peatland	×	✓ Note 2	✓ Note 2, Note 4	✓ Note 4
Note 1: There is no primary forestry in Ireland. Note 2: Areas designated as European Sites are afforded protection. Note 3: Grasslands in areas designated as European Sites are afforded protection in accordance with Regulation 1307/2014[17]. Highly biodiverse grasslands are afforded protection by the Renewable Energy Regulations, but this protection only extends to lands used to produce biomass for biofuels and bioliquids. Note 4: Areas designated as Natural Heritage Area (NHA) / proposed NHA are afforded protection.				

The following sub-sections provide a summary of each item of legislation and describe how they relate to the RED II sustainability criteria.

3.2.1 The Forestry Act and Forestry Regulations

Although primarily concerned with forestry, the Forestry Act 2014 and the Forestry Regulations 2017 place restrictions on felling trees and converting forest land to other uses. The legislation requires a person to apply to the Minister for Agriculture, Food and the Marine for a licence to fell trees, unless the trees are exempt. There are fifteen categories of exempt trees; some examples include trees in urban areas, trees within 30 m of a building and trees within 10 m of a public road (which are dangerous to road users). The Forest Service[18] (part of the Department of Agriculture, Food and the Marine (DAFM) is the competent authority responsible for assessing applications for felling licences.

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[14] Energy (Biofuel Obligation and Miscellaneous Provisions) Act 2010

[15] SI 33 of 2012 European Union (Biofuel Sustainability Criteria) Regulations 2012

[16] SI 483 of 2014 European Union (Renewable Energy) Regulations 2014

[17] EC Regulation on defining the criteria and geographic ranges of highly biodiverse grassland for the purposes of Article 7b(3)(c) of Directive 98/70/EC of petrol and diesel fuels and Article 17(3)(c) of Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources.

[18] The Forest Service is Ireland's national forest authority and is responsible for, among other things, national forest policy, the promotion of forestry, the administration of the forest consent system and forestry support schemes, forest health and protection, and the control of felling.

It is Forest Service policy that, where a felling licence is required, the permanent removal of trees is only considered in *exceptional circumstances*, namely: overriding environmental concerns, supporting renewable energy and energy security, commercial development, conversion to agricultural land, public utilities and other land use change (assessed on a case-by-case basis). In the case of renewable energy and energy security projects, the Forest Service may require the applicant for the felling licence to report in an Environmental Impact Statement (EIS) on the potential loss of soil and biomass carbon dioxide (CO_2) and the reduction in productivity of the forest area. In the case of conversion to agricultural land, if the area to be deforested is greater than 10 ha of natural woodlands or 70 ha of conifer forest, and Environmental Impact Assessment (EIA) must be carried out and an EIS must be prepared.

In addition, there is a portion of Ireland's forestry that is of high biodiversity value and is designated by law for nature protection purposes or for the protection of rare, threatened or endangered ecosystems or species, i.e. European Site[19] or a Natural Heritage Areas (NHA) [20]. In these cases, the Forest Service can only approve applications for felling licences after it has ascertained that the project will not significantly affect the integrity of European Sites or NHA. Therefore, for forestry of high biodiverse value, it is very unlikely that a consent to fell would be granted.

In summary, there are measures in place to preserve forested areas and even if there exists *'exceptional circumstances'* and forested land is converted to agricultural land, there would be a requirement for an EIS and a record of this change in land use would exist. Thus, if such converted land was used to produce solid or gaseous biomass feedstock, its compliance with the land criteria could be assessed by determining if an EIS was previously carried out and establishing the status of the land prior to conversion.

3.2.2 The Birds and Natural Habitats Regulations

In accordance with the Birds and Natural Habitats Regulations 2011, any activity with the potential for adverse or significant effects on a European Site (this includes SACs and SPAs), such as the production of agricultural biomass, cannot be carried out unless consent has been given by the Minister for Arts, Heritage and the Gaeltacht. Where consent is requested, it will only be given where it can be demonstrated that the activity will not interfere with the protection of the environment (termed *nature protection purposes* in the Regulations). The National Parks and Wildlife Service (NPWS) is the competent authority for enforcement of the Regulations. Sites designated as European Sites cover, *inter alia*, wetlands and peatlands. While it is not clear if all of Ireland's wetlands and peatlands are European Sites, the area of land in Ireland designated as an SAC and / or SPA is substantial: 0.71 M hectares and 0.57[21] M hectares, respectively (Ireland's total land area is approximately 6.9 M hectares). Given that growing agricultural biomass on a European Site would have an adverse environmental impact on the site, it is very unlikely that consent would be given for such an activity. Therefore, implementing this legislation in Ireland should preclude growing agricultural biomass for energy purposes on a European Site and should ensure that the carbon stock criteria of RED II are not breached.

EC Regulation 1307/2014 requires that any grassland within an SAC or SPA be designated as highly biodiverse grassland. For grasslands outside of these areas the criteria in Regulation 1307/2014 should be applied to determine if the grassland is highly biodiverse. The CORINE[22] database for Ireland shows approximately 45,000 hectares of 'natural grassland'[23] could potentially be classified as highly biodiverse grassland. Of this, approximately 23,000 hectares is located within an SAC and/or SPA, and accordingly must be classified as highly biodiverse grassland under Regulation 1307/2014. The remaining 22,000 hectares is not located within SAC or SPA and is currently not afforded protection under Irish legislation; however, because this grassland is low productivity, it is unlikely that it would be suitable for cultivating agricultural biomass.

[19] 'European Sites' are Special Areas of Conservation (SAC), Special Protection Areas (SPA) and sites of community importance, all of which are important from a nature protection perspective.

[20] NHAs are areas that are considered important for the habitats present or which hold species of plants and animals whose habitat needs protection.

[21] Includes land and water.

[22] The CORINE (Co-ordinated Information on the Environment) data series was established by the EC as a means of compiling geo-spatial environmental information in a standardised and comparable manner across Europe).

[23] Low productivity grassland with at least 75% of the surface covered by vegetation which developed under minimum human interference (not mowed, fertilized or stimulated by chemicals which might influence production of biomass).

3.2.3 Planning and Development Regulations 2001 to 2015

The Planning and Development Regulations require that an application for planning permission be made for proposals to drain or reclaim wetland (including peatlands) where the area impacted by the works exceed 0.1 ha.

An EIS is mandatory for wetlands that are larger than 2 ha and where an area to be deforested is greater than 10 ha of natural woodlands or 70 ha of conifer forest. The competent authority for assessing applications is the Local Authority (i.e. the City or County Council).

Where the proposed development is below the threshold for a planning application, it is a matter for the person who proposes to carry out the development to make an assessment as to whether it is likely to have a significant effect on the environment. If it may have a significant adverse effect on the environment, it is not exempt from the requirement to obtain planning permission and an EIS will be required.

Following receipt of an application, the Local Authority will screen the project and decide whether the applicant can proceed with the intended work or if an application for consent is required (e.g. if the proposed project impacts on a European Site or NHA). Where an application for consent is required, the Local Authority will refuse consent if the proposed activity fails to meet, among other things:

- any relevant environmental guidelines made by a Minister of the Government;
- any relevant policy of a Minister of the Government;
- any acts of the institutions of the European Union;
- the requirements of these Regulations;
- any other legal requirements; or
- is likely to have an adverse impact on human health or a significant adverse impact on animal health, plant health or water quality.

As growing agricultural biomass on peatland is likely to have an adverse impact on a European Site or a NHA, unless exceptional circumstances occur, it is very unlikely that consent for this activity would be given. Therefore, implementing this legislation in Ireland should preclude growing agricultural biomass for energy purposes on peatland designated as a European Site or a NHA and should ensure that the carbon stock criteria of RED II are not breached.

3.2.4 Wildlife Act

The Wildlife Act 1976 (as amended) prohibits any works that are liable to destroy or to significantly alter, damage or interfere with a NHA, such as the production of agricultural biomass, being carried out unless the Minister for Arts, Heritage and the Gaeltacht gives consent. NHAs contain habitats that are considered important: either important in their own right or important for particular plants and animals. NHAs include wetlands and peatlands. While the extent to which these areas are covered by NHAs is not clear, almost 60,000 ha of bog has been given protection to date. A further 65,000 ha of land is designated as a proposed NHA (pNHA) and is afforded limited protection in the form of:

- agri-environmental farm planning schemes;
- requiring NPWS approval before the Forest Service for will pay afforestation grants on pNHA lands; and
- recognition of the ecological value of pNHAs by Planning and Licencing Authorities.

As with the Birds and Habitats Regulations, the NPWS is the competent authority for the Wildlife Act. Given that growing agricultural biomass in an area of high biodiverse value or peatland is likely to have a significant environmental impact on the site, it is very unlikely that consent would be given and, therefore, implementing this legislation in Ireland should preclude growing agricultural biomass for energy purposes on peatland designated a NHA or pNHA and should ensure that the carbon stock criteria of RED II are not breached.

3.2.5 Other Guidelines and Schemes

In addition to the legislation, there are other relevant guidelines and schemes. As part of the Common Agricultural Policy (2015 to 2019), there are thirteen different payment schemes for farmers. To avail of funding under the Basic Payments Scheme (the most common) and other area based schemes[24], farmers must satisfy the requirements of Cross Compliance as a condition of payment. Cross compliance consists of thirteen Statutory Management Requirements (SMRs) and seven Good Agricultural and Environmental Condition (GAEC) standards. The DAFM, as the EU Accredited Paying Agency for the CAP, carries out inspections annually to ensure the Cross Compliance requirements are satisfied.

Two of the SMRs relevant to the RED II sustainability criteria are:

- SMR 2 Conservation of Wild Birds; and
- SMR 3 Conservation of Natural and of Wild Flora and Fauna.

These are also covered by the provisions of the Birds and Natural Habitats Regulations (see sub-Section 3.2.2). The remaining SMRs are not relevant to the RED II sustainability criteria (they deal with public health, plant health, animal health and animal welfare).

The GAECs deal with water protection, water irrigation, groundwater protection, minimum soil cover, soil erosion, organic soil matter, and retention of landscape features. Under GAEC designated NHAs, SACs, SPAs and other habitats protected under EU or national legislation may not be damaged or removed. The GAECs are also relevant for reporting on measures taken for soil, water and air protection and the avoidance of excessive water consumption in areas where water is scarce. All these indicators could be relevant if other sustainability characteristics need to be considered.

One percent of all beneficiaries of CAP payment schemes are selected for full Cross Compliance inspections. Where non-compliances are determined, penalties may be applied to an applicant's payments. In 2015, approximately 130,000 farmers received funding as part of the CAP.

3.3 Summary – Agricultural Biomass

In general, the RED II sustainability criteria for agricultural biomass are provided for in existing legislation.

- The Forestry Act and Forestry Regulations control the felling of forestry and converting the land from forestry to other uses. The controls ensure that land used for forestry (i.e. high carbon stock land) is unlikely to be adopted for agriculture.
- The Birds and Natural Habitats Regulations provide for the control of activities with the potential for adverse or significant effects on European Sites, which include areas of high biodiverse value or peatland.
- The Planning and Development Regulations require an application for planning permission and screening for an EIS to take place for proposals to drain or reclaim wetlands (including peatlands).
- The Wildlife Act provides protection for areas that are considered important for habitats or certain species of plants or animals whose habitat needs protection, which include areas of high biodiverse value or peatland.

Clear monitoring and enforcement systems exist for the above legislation. The Forestry Service is the competent authority for the Forestry Act and the Forestry Regulations, the Local Authorities for the Planning and Development Regulations, and the NPWS for the Birds and Natural Habitats Regulations and Wildlife Act. Furthermore, farmers in receipt of CAP-related funding must satisfy the requirements of Cross Compliance as a condition for payment; certain elements of Cross Compliance (the conservation of wild birds and the conservation of natural and of wild flora and fauna) cover elements of the sustainability criteria.

[24] Including the Greening Payment, the Young Farmers Scheme, the Areas of Natural Constraints Scheme (ANC) including Islands, the Green, Low Carbon, Agri-Environment Scheme (GLAS), the Agri-Environment Options Scheme (AEOS), the Organic Farming Scheme and the Beef Data and Genomics Programme.

While these elements of Cross Compliance are provided for by the Birds and Natural Habitats Regulations, their inclusion in Cross Compliance means that they are subject to an additional layer of monitoring and enforcement to that provided by the NPWS.

While the land related sustainability criteria for agricultural biomass contained in RED II are generally catered for in existing legislation, in exceptional circumstances, it may be possible for agricultural biomass to be produced from high biodiverse, high carbon stock areas or peatlands that are *not* designated under the Birds and Natural Habitat Regulations or the Wildlife Act; however, it is important to note that given the vast areas covered by the legislation, we anticipate that the area not covered is relatively small.

Even if agricultural biomass was produced from an area that was previously of high biodiversity, high carbon stock or peatland designated under the Birds and Natural Habitats Regulations or the Wildlife Act, and it was used for energy purposes, it is important to note the following.

- Agricultural biomass may only be grown after it has been established that its production does not have a significant environmental impact on the area.
- A record of the assessment that was undertaken will exist and it could be used to determine if the biomass was produced in accordance with the sustainability criteria. This would not stop it from being grown, but the records could be used as a means of assessing compliance with the sustainability criteria.

3.4 Forest Biomass

In the following table we have identified the Irish legislation that is most relevant to the sustainability criteria set out in RED II for forest biomass. As is the case with agricultural biomass, none of the existing forestry legislation directly addresses GHG emissions. Sub-section 3.4.1 provides a summary of this legislation. The clauses and how they relate to the sustainability criteria are presented in Appendix 2.

Table 2: Relevant Legislation for Forest Biomass

Requirement	Forestry Act 2014 & Forestry Regulations 2017
Legal permit	√
Forest regeneration	√
Protection of areas designated for nature purposes	√ Note 1
Soil quality and biodiversity	√
Unsustainable production	√
Note 1: Areas designated as European Sites in accordance with the Birds and Natural Habitats Regulations, and areas designated as Natural Heritage Areas (NHA) / proposed NHAs in accordance with the Wildlife Act, are protected.	

In addition to the requirements to minimise the risk of unsustainable forest biomass, certain LULUCF requirements must also be addressed at a country level. If the LULUCF requirements are not addressed, management systems must be in place at the forest sourcing area to ensure that carbon stock and sink levels in the forest are maintained over the long term. The LULUCF requirement are shown in Table 3, along with the measures Ireland has in place for each.

Table 3: LULUCF Requirements for Forest Biomass

Requirement	Status
Country of origin is party to, or has ratified the Paris Agreement.	Ireland has ratified the Paris Agreement.
Country of origin has submitted and Nationally Determined Contribution to the UNFCCC or there are laws in place (in accordance with the Paris Agreement) to conserve and enhance carbon stocks and sinks.	The EU submitted its Intended Nationally Determined Contribution (INDC) in March 2015 which commits the EU and its 28 Member States to a binding target of at least 40% domestic reduction in GHG emissions by 2030, when compared to 1990.
Country of origin has a national system for reporting GHG emissions and removals from land use including forestry and agriculture.	The EPA compiles Ireland's national greenhouse gas emission inventory on an annual basis. This inventory is submitted to the European Commission and UNFCCC each year by 15 January and 15 April respectively.

3.4.1 The Forestry Act and Forestry Regulations

In the following paragraphs we have set out how the existing regulations satisfy the RED II forest biomass criteria listed in Table 2.

Legal Permit
As discussed in sub-section 3.2.1, the Forestry Act 2014 and the Forestry Regulations 2017 require a person to apply to the Forest Service for a licence to fell trees, unless the trees are exempt.

Regeneration
The Forestry Act allows the Minister to require the replanting of trees. According to the Felling and Reforestation Policy[25], permanent removal of trees where a felling licence is required may only be considered under exceptional circumstances (i.e. typically forest regeneration must occur). Even where permanent removal of a forest is permitted, it may be necessary to afforest an equivalent area elsewhere.

Protection of Nature Protection Areas
The Forestry Act requires that, in carrying out his functions (e.g. granting licences for felling or afforestation), the Minister considers whether one or more of the following is being carried out:

- screening for an EIA;
- submission of an EIS;
- an EIA;
- screening for an appropriate assessment;
- a Natura Impact Statement;
- an appropriate assessment.

The measures listed above are primarily concerned with the protection of the environment and the protection of European Sites (i.e. nature protection areas). The Forestry Regulations set out, in more detail, the measures to be taken for EIAs and Appropriate Assessments (for European Sites).

Soil quality and biodiversity
Under the conditions of a felling licence, the licensee is required to satisfy a range of good forest practise standards published by the Forest Service. These include the following that are related to minimising the impact on soil quality and biodiversity.

1. Forest Harvesting and the Environment Guidelines which address, *inter alia*:
   - soil conservation;
   - the protection of water quality, archaeological sites, biodiversity and the visual landscape; and
   - the maintenance of forest health and productivity.

[25] DAFM (2017). *Felling and Reforestation Policy.* https://www.agriculture.gov.ie/media/migration/forestry/treefelling/FellingReforestationPolicy240517.pdf

2. Forest Biodiversity Guidelines which set out measures based on the principles of sustainable forest management and best available scientific information.

Unsustainable production
The Forest Service ensures compatibility with the principals of sustainable forest management by setting felling, preservation and reforestation conditions and carrying out compliance checks to ensure compatibility with the principles of sustainable forest management and the protection of the environment.

DAFM policy is to expand forest cover in Ireland to 18% by 2046 (current level is approximately 10.5%). The DAFM and Forest Service has published a range of documents outlining this: *Growing for the Future*[26], *Forests, products and people*, *Ireland's forest policy – a renewed vision*[27] and the *Felling & Reforestation Policy*.

3.4.2 Other Guidelines and Schemes

There are numerous schemes designed to promote the development of forestry in Ireland in line with Ireland's Forest Policy. The Forestry Programme 2014 to 2020 sets out the funding to be provided for forestry projects including afforestation, road construction, woodland improvement, woodland reconstitution and native woodland conservation.

Numerous standards and guidelines have been published by the Forest Service covering all aspects of forestry; examples of these include the following.

- The Irish National Forestry Standard (INFS)
- The Code of Best Forest Practice
- The Suite of Environmental Guidelines:
  - Forestry and water quality guidelines;
  - Forestry and the landscape guidelines; Forestry and archaeology guidelines;
  - Forest biodiversity guidelines;
  - Forest harvesting and environmental guidelines; and
  - Forest protection guidelines.
- Forestry and Aerial Fertilisation

It is a standard condition in all felling licences that felling and planting operations be carried out in accordance with the above standards and guidelines. Adherence to the measures set out in the above is required to receive funding for forestry projects. A full list of the standards and guidelines, including descriptions, is provided in Appendix 2.

In summary, with the exception of the GHG savings criteria, the RED II sustainability criteria for forest biomass are already provided for in the Forestry Act and Forestry Regulations which include provisions for permits, forest regeneration, nature protection areas, soil quality and biodiversity, and unsustainable production.

Work is also being carried out by the DAFM to encourage and assist private forest owners with becoming certified[28]. The objective of forest certification systems, such as FSC and PEFC, is to verify that forests are managed in accordance with a defined best practice and sustainable standard. Certification works throughout the forest supply chain with the aim of promoting good practice in the forest and to ensure and verify that timber and non-timber forest products are produced with respect to ecological, social and ethical standards. A chain of custody system further ensures traceability of certified materials from the forest to the processors and ultimately to the end user.

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[26] DAFM (1996). *Growing for the Future.* https://www.agriculture.gov.ie/forestservice/publications/growingforthefuture/
[27] DAFM (2014). *Ireland's Forests, products and people. Ireland's forest policy – a renewed vision.* https://www.agriculture.gov.ie/media/migration/forestry/forestpolicyreviewforestsproductsandpeople/00487%20Forestry%20Review%20-%20web%2022.7.14.pdf
[28] www.groupcertification.ie/

4 UK Approach

The UK has implemented a comprehensive sustainability regime for solid and gaseous biomass. The UK has incentive schemes in place for large and small scale renewable electricity and renewable heat that all incorporate sustainability requirements, based on the EC's current recommended criteria (section 2.1). The exact reporting obligations and compliance options for suppliers and end-users vary, depending on the renewable energy support scheme (RO, CfD, FIT, RHI), the fuel type and the installed capacity, to balance a robust scheme with the level of sustainability risk and the practicalities of reporting for different scales of operation. For small generators under the RHI, the UK has set up two lists of sustainable biomass suppliers to transfer the responsibility of demonstrating compliance from the (small) biomass user to the company who places the biomass on the market.

The underlying sustainability criteria are the same across all schemes. The sustainability criteria include biodiversity and carbon stock (i.e. the land criteria) and achieving GHG emissions savings targets (66% savings for electricity used for RO and FIT, and 60% saving for heat for the RHI).

Ireland can draw on the experience and lessons learned from the different designs of the compliance options for different scales of biomass operations.

4.1 Overview of UK policies on biomass sustainability

The UK imposes mandatory sustainability criteria on the solid and gaseous biomass consumed in the UK electricity and heat market. Sustainability criteria for electricity are set under the Renewables Obligation (RO) for largescale electricity and the feed-in-tariff (FIT) scheme for small-scale electricity. (The RO is to be replaced by the Contracts for Difference (CFD) support scheme, which will follow the same sustainability approach[29]).

Sustainability criteria for the biomass consumed in the UK heat market are set under the Renewable Heat Incentive (RHI). The UK Office of Gas and Electricity Markets (Ofgem) runs all the UK support schemes for small and largescale biomass heat and electricity (RO, FIT, CFD and the RHI).

4.1.1 The Renewables Obligation (RO)[30]

The UK government transposed the mandatory bioliquid sustainability requirements of the RED as well as the voluntary solid biomass and biogas recommendations from the 2010 EC Communication into the RO on 1 April 2011. In 2015, meeting the sustainability criteria was made mandatory for solid biomass and biogas stations to receive support under the RO.

The RO requires that all bioliquid stations, and solid biomass and/or biogas stations ≥1 MW must report against and meet sustainability criteria to be eligible for Renewables Obligation Certificates (ROCs). Solid biomass and/or biogas stations <1 MW are required to report against the same sustainability criteria, but receiving ROCs does not depend on meeting the criteria. As is the case with the RED, the RO sustainabilty criteria cover both land criteria and GHG criteria.

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[29] DECC (2014). *Government Response to the consultation on adjustments to sustainability and reporting provisions for biomass.* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/343005/Response_to_Biomass_Consultation.pdf

[30] Ofgem (2016). *Renewables Obligation: Sustainability. Guidance.* https://www.ofgem.gov.uk/system/files/docs/2016/03/ofgem_ro_sustainability_criteria_guidance_march_16.pdf

4.1.2 The Feed-in tariff (FIT)[31]

On 1 April 2010, the Feed-in Tariff (FIT) scheme was introduced, aimed at encouraging the uptake of small-scale renewable and low-carbon technologies. The scheme requires licensed electricity suppliers to pay eligible installations for generating and exporting renewable and low carbon electricity.

Installations using solar photovoltaic (PV), wind, hydro and Anaerobic Digestion (AD) technologies up to 5 MW can receive FIT payments, if all eligibility requirements are met.

The FIT scheme, introduced by the Department of Energy and Climate Change (DECC) (now the Department for Business, Energy and Industrial Strategy (BEIS)), is administered by Ofgem. FIT support is payable for 20 years (10 years for CHP) and it works through one of two routes, depending on the size and type of installation:

- For small installations (home-scale or small business solar PV, wind or CHP), applications are made to an energy supplier (MCS-FIT accreditation[32])
- For large installations (commercial wind and solar PV and all hydro and AD), applications are made directly to Ofgem (ROO-FIT accreditation[33])

Since 1 May 2017, there are sustainability requirements and feedstock restrictions on all AD installations that make a new application for ROO-FIT.

Overall, the FIT scheme requires that all AD installations <5 MW[34] must report against and meet sustainability criteria (land and GHG criteria) to be eligible for payments.

4.1.3 The Renewable Heat Incentive (RHI) (Non-Domestic)[35]

The RHI has two schemes: Non-Domestic and Domestic. They have separate tariffs, but the same conditions, rules and application process. For renewable heating systems in commercial, public or industrial premises, the Non-Domestic RHI applies. If the renewable heating system heats a single property which is capable of getting a domestic Energy Performance Certificate (EPC), then the Domestic RHI applies.

The Non-Domestic RHI provides financial incentives to increase the uptake of renewable heat by businesses, the public sector and non-profit organisations. Eligible installations receive quarterly payments over 20 years based on the amount of heat generated. Similar to the RO and FIT, biomass installations must demonstrate that they meet sustainability requirements.

In 2017, new sustainability requirements for participants that use biomass or biogas, or produce biomethane for injection, were introduced.

Under the RHI, solid biomass, biogas, CHP and biomethane stations must report against and meet sustainability criteria (land and GHG criteria) to be eligible for RHI payments. For smaller solid biomass installations <1 MW, purchasing biomass from the Biomass Suppliers List (BSL) or Sustainable Fuel Register (SFR) is sufficient to demonstrate sustainability compliance. These lists have been set up to place the responsibility to demonstrate compliance with the sustainability criteria on the fuel supplier, rather than the small RHI participant (see Section 4.3.3 for further information).

[31] Ofgem (2017). *Feed-in Tariffs: Guidance on sustainability criteria and feedstock restrictions.* https://www.ofgem.gov.uk/system/files/docs/2017/05/feed-in_tariffs_guidance_on_sustainability_criteria_and_feedstock_restrictions.pdf

[32] Microgeneration Certification Scheme. http://www.microgenerationcertification.org/

[33] Ofgem. ROO-FIT: Large installations. https://www.ofgem.gov.uk/environmental-programmes/fit/applicants/roo-fit-large-installations

[34] If >5MW, the installation is not eligible for FIT payments.

[35] Ofgem (2016). *Non-Domestic RHI. Sustainability Self-Reporting Guidance.* https://www.ofgem.gov.uk/system/files/docs/2017/01/sustainability_self-reporting_guidance_jan_2017.pdf

4.2 Sustainability criteria

The underlying sustainability criteria are the same under the RO, FIT and RHI. The criteria are based on the EC's 2010 Communication, which includes criteria that Member States could put in place for solid and gaseous biomass. (Note that the UK has not implemented the EC recommendations from the 2014 report on the state of play of biomass, which relate to certain details of the GHG methodology, and there are no plans to revise the sustainability criteria.)

The sustainability criteria for solid and gaseous biomass used for heat and power in the UK consider the land from which the biomass is sourced and the life-cycle GHG emissions associated with the biomass[36]:

- Land criteria focuses on the land from which the biomass is sourced;
- GHG criteria account for the lifecycle GHG emissions of the biomass.

The exact criteria that need to be complied with depend on the classification of the biomass (e.g. woody product, non-woody product, waste or residue). The criteria are explained in further detail below. A summary of the feedstock classification reporting requirements is shown in Appendix 3.

4.2.1 Land criteria

The land criteria refer specifically to the production of the raw material, e.g. at the farm, forest or plantation. They do not apply to any other steps further down the supply chain. There are two types of land criteria: (a) for woody biomass; and (b) for non-woody biomass. The type of fuel used will affect which land criteria to report against. For non-woody biomass, the RED land criteria apply. Whereas for woody biomass, the criteria focus on ensuring ongoing sustainable forest management, rather than preventing land conversion.
A fuel that is classified as a waste or a residue (and that is not derived from wood) meets the land criteria automatically.

4.2.1.1 Woody biomass land criteria

If the biomass used to generate electricity was wood or derived from wood, the generator is required to report against the land criteria for woody biomass. The Woodfuel Advice Note[37], based on the UK Timber Standard for Heat and Electricity[38] and published by BEIS, provides advice and guidance on the requirements and how to demonstrate compliance. The UK Timber Standard specifies the minimum legal and sustainable requirements for the use of woodfuel in the UK. These requirements draw upon the principles set under the UK Government Timber Procurement Policy (UK-TPP).

There is a '70:30 threshold' that applies when demonstrating that woodfuel meets the land criteria:

- at least 70% of each consignment must meet the sustainability requirements in the Woodfuel Advice Note; or
- at least 70% of all the woodfuel used in a quarterly period must meet the sustainability requirements outlined in the legislative framework.

Note this is in contrast to the sustainability criteria in the RED that require that 100% of raw materials used to produce biofuels or bioliquids meet the sustainability criteria. The 70% sustainability threshold is permitted in the UK for woody biomass as this is common practice in existing forestry certification schemes.
Chain of custody evidence that traces the biomass from the source to the end user is required to demonstrate compliance with the land criteria for woody biomass.

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[36] The Orders specify that the sustainability information must be gathered for each consignment of biomass.

[37] BEIS (2017). *Woodfuel Advice Note Version 2.* https://www.gov.uk/government/publications/woodfuel-guidance-version-2

[38] DECC (2014). *Timber Standard for Heat & Electricity. Woodfuel used under the Renewable Heat Incentive and Renewables Obligation* https://www.gov.uk/government/publications/timber-standard-for-heat-electricity

There are two routes to demonstrate compliance outlined in the Woodfuel Advice Note:

- Category A evidence: use of the Forest Stewardship Council (FSC) or the Programme for the Endorsement of Forest Certification (PEFC) certification schemes.
- Category B evidence: collection of bespoke evidence from the specific supply chain that demonstrates compliance with the criteria. A 'risk-based regional approach' can be used with this method.

In addition, in 2016, Ofgem assessed a number of forestry certifications schemes against the land criteria of the RO[39]. Of those schemes assessed, the Sustainable Biomass Partnership (SBP) was also deemed to fully meet the requirements (i.e. equivalent to Category A evidence).

4.2.1.2 Non-woody biomass land criteria

For non-woody biomass (that is not exempt on the basis of being a waste or residue), the generator must demonstrate compliance with the RED land criteria. This means that, for biomass to meet the sustainability requirements, it must be demonstrated that it was not obtained from any of the following:

- land which at any time during or after January 2008 was primary forest;
- land which at any time during or after January 2008 was land designated for nature protection purposes;
- highly biodiverse grassland;
- land which at any time during January 2008 was peatland;
- a former continuously forested area; or
- a former wetland area.

If a land-use change is permitted under the criteria (e.g. non-highly biodiverse grasslands to cropland, or lightly forested area to cropland), then a carbon stock calculation resulting from the land-use change needs to be performed and included in the GHG intensity of the consignment.

To demonstrate compliance with the land criteria, the generator can use voluntary schemes recognised by the European Commission under the RED and/or collect evidence to support the land use from where the biomass was sourced. Ofgem benchmarked a number of voluntary schemes against the land criteria in 2012[40], but no additional schemes were recognised on the basis of this assessment. The assessment results can be used as information to see where the gaps are between an existing scheme and the RO (RED) land criteria.

Energy crops, as defined in Article 2 of the Orders[41], are automatically deemed to meet the land criteria if they received financial assistance under the Energy Crop Scheme.[42]

If the operator seeks to collect evidence to demonstrate compliance with the criteria, they need to collect information on the land use of the farm/plantation in January 2008 (and after this date, where applicable). The types of evidence that could be useful in demonstrating compliance include aerial photographs, satellite images, maps, land register entries/databases and site surveys.

4.2.2 GHG criteria

For each consignment of biomass or biogas, Generators must report GHG emissions in grams of CO_2 equivalent per MJ (gCO_{2eq}/MJ) of electricity or heat. Where the biomass used has any exemptions from the GHG emission criteria or parts of the methodology, generators need to gather evidence to demonstrate the correct fuel classification.

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[39] Ofgem (2016). *Renewables Obligation: Sustainability Criteria.* See Appendix 2. https://www.ofgem.gov.uk/system/files/docs/2016/03/ofgem_ro_sustainability_criteria_guidance_march_16.pdf

[40] See Appendix 2 of Ofgem (2016). *Renewables Obligation: Sustainability Criteria.*

[41] The energy crops definition includes 15 species of crop. A list of energy crops can be found under Ofgem (2016): Renewables Obligation: Fuel Measurement and Sampling.

[42] The Energy Crop Scheme is managed by Natural England and offered grants to farmers in England for establishing Miscanthus and short rotation coppice. A sustainability check was part of the application process.

For example, for waste materials, operators are only required to calculate the GHG emissions from the 'process of collection', i.e. including the emissions from the collection of waste, but not for the production of the material in the first place.

Generators can demonstrate compliance with the GHG criteria by determining the GHG emissions of the biomass fuel (using actual or default values, or a combination of the two).

The GHG thresholds differ depending on whether the end use is electricity or heat production. For electricity (see the RO and the FIT), generating stations using solid biomass or biogas must produce electricity with lifecycle GHG emissions of less than or equal to 66.7 gCO_{2eq}/MJ of electricity generated[43,44]. This equates to a minimum 66% GHG saving compared to the fossil fuel comparator for electricity of 198 gCO_{2eq}/MJ.

For heat (see RHI), participants must produce heat with lifecycle GHG emissions of less than or equal to 34.8 gCO_{2eq}/MJ[45] of heat generated. This equates to a minimum 60% GHG saving compared to the fossil fuel comparator for heating of 87 gCO_{2eq}/MJ. For biomethane injected into the grid, the biomethane (i.e. not the final heat) must have lifecycle GHG emissions of less than or equal to the same 34.8 gCO_{2eq}/MJ of biomethane (measured as the net calorific value).

The fossil fuel comparator, maximum GHG thresholds and GHG savings for solid biomass and biogas installations for electricity and heat are summarised in Table 4.

Table 4: Fossil Fuel Comparators

	Electricity	Heat
Fossil fuel comparator[46]	198 gCO_{2eq}/MJ	87 gCO_{2eq}/MJ
GHG threshold	66.7 gCO_{2eq}/MJ	34.8 gCO_{2eq}/MJ
Min. GHG saving	131.3 gCO_{2eq}/MJ (66%)	52.2 gCO_{2eq}/MJ (60%)

4.3 Sustainability reporting requirements

The sustainability reporting requirements under the RO, FIT and RHI are very similar with only minor differences. Therefore, in the following we first explain the reporting requirements for each of the three schemes and then provide a summary of the UK's sustainability reporting requirements.

4.3.1 The Renewables Obligation (RO)[47]

The sustainability reporting requirements differ depending on the type of generating station. For stations with a declared net capacity >50 kW and total installed capacity of <1 MW using solid biomass or biogas, operators must report annually to Ofgem against the sustainability criteria; however, this is not linked to a station's eligibility for support under the scheme.

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[43] Ofgem (2017). *Feed-in Tariffs: Guidance on sustainability criteria and feedstock restrictions.* https://www.ofgem.gov.uk/system/files/docs/2017/05/feed-in_tariffs_guidance_on_sustainability_criteria_and_feedstock_restrictions.pdf

[44] From 1 April 2020 to 31 March 2025 the value will be 55.6 gCO_{2eq}/MJ electricity and from 1 April 2025 onwards the value will be 50.0 gCO_{2eq}/MJ electricity.

[45] Ofgem (2011). *Renewable Heat Incentive Guidance Volume Two: Ongoing obligations, payments.* https://www.ofgem.gov.uk/system/files/docs/2016/11/guidance_volume_2_v9_sep_16.pdf

[46] The UK applies the EU fossil fuel comparators. These are based on: https://publications.europa.eu/en/publication-detail/-/publication/6e598e2a-2655-4ae2-8c20-ef617d5bf3fd/language-en

[47] Ofgem (2016). *Renewables Obligation: Sustainability Criteria.* https://www.ofgem.gov.uk/system/files/docs/2016/03/ofgem_ro_sustainability_criteria_guidance_march_16.pdf

Operators of all generating stations using bioliquids, and operators of generating stations with a total installed capacity ≥1 MW using solid biomass and biogas, must report against, and meet, the sustainability criteria to get support under the scheme. Such operators report monthly against the sustainability criteria, as part of each ROC claim. These operators also must provide further information at the end of each obligation year. This includes an annual sustainability audit report[48] to verify the sustainability information already reported by the operator.

The RO also requires all generators with >50 kW to submit annual profiling information[49] which contains information on the sustainability characteristics of their fuel. This includes information such as the type of biomass, the form of biomass (e.g. chips or pellets), the country of origin and whether the biomass was wood or derived from wood.

4.3.2 The Feed-in tariff (FIT)[50]

Similar to the RO, the sustainability reporting requirements differ depending on generating capacity. For AD installations with a declared net capacity <1 MW, operators must report annually against the sustainability criteria; operators of AD installations with a total installed capacity ≥1 MW are required to report against, and meet, the sustainability criteria to get support under the scheme.

Operators of AD installations ≥1 MW are required to report each month against the sustainability criteria and to provide further information to verify the sustainability data provided at the end of each obligation year; this is done by submitting an annual sustainability audit report[51].

There are feedstock restrictions that place an annual limit on the FIT generation payments an AD installation is entitled to. The restrictions depend on the classification of the feedstocks[52] used to produce the biogas. When more than 50% of the feedstock used to produce biogas in an AD installation is from feedstocks that are not waste or residues (in terms of energy content of the biogas yield) in a given year, the installation is not entitled to FIT payments for the proportion in excess of 50%.

4.3.3 The Renewable Heat Incentive (RHI) (Non-Domestic)

The sustainability reporting requirements for the RHI depend on the type of installation.

Solid biomass (including solid biomass contained in waste)[53]
For solid biomass (including solid biomass contained in waste) with a total installed capacity <1 MW, a Biomass Suppliers List (BSL) and Sustainable Fuel register (SFR) has been established. The BSL[54] is a list of wood fuel suppliers (e.g. briquettes, chips, pellets) and the SFR[55] is a list of non-woody biomass suppliers (e.g. Miscanthus, straw etc.). For a supplier to be on either list, they first must demonstrate that they meet the sustainability criteria. If a small biomass user buys biomass from a company on the BSL or SFR, then no further action is required by the user (apart from keeping receipts or records of invoices) because the responsibility for demonstrating the sustainability of the biomass is transferred to those who put the biomass on the market.

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[48] The Annual Sustainability Audit Report is an independent audit report commissioned by generating stations.

[49] Ofgem (2016). *Renewables Obligation: Sustainability Criteria*. https://www.ofgem.gov.uk/system/files/docs/2016/03/ofgem_ro_sustainability_reporting_guidance_march_16_0.pdf

[50] Ofgem (2017). *Feed-in Tariffs: Guidance on sustainability criteria and feedstock restrictions.* https://www.ofgem.gov.uk/system/files/docs/2017/05/feed-in_tariffs_guidance_on_sustainability_criteria_and_feedstock_restrictions.pdf

[51] The Annual Sustainability Audit Report is an independent audit report commissioned by generating stations.

[52] Feedstocks are as (1) Products, (2) Residues from agriculture, aquaculture, forestry and fisheries, (3) Processing Residues and (4) Wastes.

[53] Comprises wood logs, chips and pellets straw and agricultural residues, food waste, paper/pulp residues from the paper manufacturing process, biomass residues from the food processing industry, sewage sludge.

[54] https://biomass-suppliers-list.service.gov.uk/

[55] https://www.sfregister.org/

If the installation has a capacity of 1 MW or above, an annual independent sustainability audit report needs to be submitted to Ofgem, irrespective of whether the fuel consignments have been sourced from either the BSL or SFR.

For solid biomass (including solid biomass contained in waste) with a total installed capacity ≥1 MW, participants that do not purchase from an authorised suppliers list must self-report on the sustainability requirements for the fuels they use. Self-reporters need to collate evidence that demonstrates the consignments of fuels consumed each quarter meet the land and GHG emission criteria (as set out in Sustainability Self-Reporting Guidance[56]). Users need to fill out a Fuel Measurement and Sampling (FMS) questionnaire, which provides a template for agreeing fuel measurement processes and classifications with Ofgem. If the installation has a capacity of 1 MW or above, an annual independent sustainability audit report needs to be submitted to Ofgem.

Biogas combustion for heat[57]
Biogas systems of any size are eligible for RHI support. Biogas installations must self-report against the requirements quarterly using the FMS questionnaire. If the installation has a capacity of 1MW or above, an annual independent sustainability audit report needs to be submitted to Ofgem.

CHP (for solid biomass, solid biomass contained in waste, biogas)
If a solid biomass or biogas CHP installation with a capacity of 1 MW_{el} or above receives ROCs under the RO for its electricity output, then separate sustainability information (including an annual sustainability audit report) does not need to be provided to Ofgem under the RHI.

For CHP not covered by the RO, installations must self-report against the requirements (as per Table 1 in the Sustainability Self-Reporting Guidance). The guidance gives further information on the GHG and land criteria, and what additional responsibilities are applicable. CHP installations cannot use the BSL or the SFR to demonstrate compliance.

Biomethane producers
All biomethane producers[58] must self-report to Ofgem and meet the sustainability requirements.

[56] Ofgem (2016). *Non-Domestic RHI Sustainability Self-Reporting Guidance*. https://www.ofgem.gov.uk/publications-and-updates/non-domestic-rhi-main-guidance

[57] Comprises AD, gasification and pyrolysis.

[58] Biomethane refers here to biogas that has been upgraded (CO_2 removed to leave methane of a higher purity) and injected into the gas grid.

5 Examples from other Member States

This section gives an overview of the sustainability requirements in place for solid and gaseous biomass in other Member States.

The UK, Belgium, Denmark, and the Netherlands have implemented sustainability requirements for solid and gaseous biomass for heat and electricity production. No other Member States have a comprehensive sustainability scheme in place. In Germany, requirements have been implemented for gaseous biomass only, while in France the sustainability criteria are specific to each 'call for tender' subsidy allocation. In general, the sustainability criteria have two components: requirements for minimum levels of GHG savings compared to fossil fuels; and requirements relating to the legality and sustainability of forest management (i.e. land criteria). Sometimes other conditions, such as restrictions on types of feedstock or on minimum plant energy efficiency levels, are also included. For example, in Belgium, there are restrictions on certain types of wood that could be used by the pulp and paper or wood-processing industries.

5.1 Overview

Several EU Member States have developed their own sustainability requirements for solid and gaseous biomass for heat and electricity production.

Other than the UK, to date, the most detailed sets of criteria have been developed in Belgium, Denmark and the Netherlands. In general, they have two components: requirements for minimum levels of GHG savings compared to fossil fuels; and requirements relating to the legality and sustainability of forest management (i.e. land criteria).

No other Member States have a comprehensive sustainability scheme in place, but some have individual rules or incentives. The following is a list of other noteworthy requirements or features of the biomass support schemes in Member States that aim to ensure efficient and sustainable use of biomass for heat or electricity, as identified in the 2017 Chatham House report[59] (this report is also discussed in Section 6.9).

- Minimum levels of efficiency. France, for example, requires a minimum conversion efficiency of at least 75%, which rules out anything other than CHP plants, whereas Spain gives higher levels of support to biomass plants achieving higher energy efficiency through cogeneration.
- The provision of greater levels of support for small-scale plants; examples include Finland and Germany.
- Forestry feedstocks must be sourced from sustainably managed forests; examples include France, Germany, Hungary and Slovenia.
- Support for domestically sourced feedstock instead of imports; examples include Austria, the Czech Republic and Italy.
- Restrictions on certain types of feedstock. For example, France does not allow stemwood; in Hungary feedstock cannot be of higher quality than firewood and no subsidies are provided for bioenergy produced from stemwood of a diameter above 10 cm; Poland only allows the use of forestry residues and requires a minimum share of agricultural biomass.

In the following sections, we provide a summary of the sustainability requirements placed on solid and gaseous biomass for heat and electricity production in selected Member States. The information has been gathered from, amongst others, Chatham House (2017)[60], country-specific government websites and phone calls with Member State representatives.

[59] Chatham House (2017). *Woody Biomass for Power and Heat. Impacts on the Global Climate.* https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2017-02-23-woody-biomass-global-climate-brack-final2.pdf

[60] Chatham House (2017). *Woody Biomass for Power and Heat. Impacts on the Global Climate.*

5.2 Belgium

Energy policy in Belgium is the responsibility of the country's three regions: Brussels, Flanders and Wallonia. All three require electricity suppliers to supply a prescribed proportion of renewable energy, underpinned by a system of tradable green certificates (although the three systems are not fully compatible with each other). All three have GHG requirements for biomass and Flanders and Wallonia have sustainability requirements, although none of the systems are based exactly on the EC Communications.

In Flanders, the value of a certificate for bioenergy is determined by the life-cycle energy balance, whereas in Brussels and Wallonia, eligibility for green certificates depends on the GHG saving compared to the best available natural gas system. GHG emissions from production, processing and transport of the feedstock are taken into account.

Furthermore, in Flanders biomass streams suitable for other uses, e.g. some types of wood that could be used by the pulp and paper or wood-processing industries[61], are not entitled to receive green certificates. The respective wood types are decided in collaboration with the Public Waste Agency and the paper and wood-using industry. In Wallonia, feedstocks are required to be 'sustainable', i.e. the use of the resource must not compromise its use by future generations, which is subject to an audit.

5.3 Denmark

In Denmark, woody biomass used for energy is included in the government's timber-procurement policy (revised in 2014), although its application to bioenergy is voluntary throughout the public sector. Products certified under FSC or PEFC satisfy the criteria. These certification schemes cover criteria for legality and sustainability, but they do not include GHG criteria.

In 2015, the Danish District Heating Association and the Danish Energy Association introduced a voluntary sustainability standard for biomass. This voluntary standard requires that between 2016 and 2019, CHP installations gradually work towards compliance of their biomass fuel input with the requirements (from 40% in 2016 to 100% in 2019). Apart from legality and sustainability requirements that are similar to FSC and PEFC requirements, the standard also requires GHG reductions of 70% by 2015, 72% by 2020 and 75% by 2025, compared to the fossil fuel comparator of the RED. Note that this excludes emissions from changes in forest carbon stock or ILUC, though the industry is working to develop further criteria to cover these. The standard also aims not to use biomass where there is regionally competing demand for high-value wood resources or if the supply of those resources derives from deforestation or inappropriate conversion of forest to agriculture.

The standard is voluntary and only applies to stations with a capacity above 20 MW.

5.4 Netherlands

A working group composed of energy companies, environmental organisations and the government developed sustainability requirements for biomass energy production under the so-called Energy Agreement for Sustainable Growth. The agreement also included an upper limit of 25 PJ of renewable energy per year from co-gasification and co-firing of biomass in coal-fired power stations.

The sustainability criteria were officially published in April 2017[62] and have been formulated for the co-firing and co-gasification of biomass in coal-fired power plants (≥ 100 MW) and large-scale heat projects where steam is generated from burning wood pellets (≥ 5 MW). Five categories of requirement are defined, which comprise a total of 15 'principles'.

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[61] This excludes bark, sawdust, fine pruning wood with a diameter less than 4 cm, twigs of tree crowns with a diameter less than 4 cm, and stumps up to 30 cm above the ground.

[62] Netherlands Enterprise Agency (2017). *Verification Protocol for Sustainable Solid Biomass.* https://english.rvo.nl/sites/default/files/2017/06/Verification%20Protocol%20for%20Sustainable%20Solid%20Biomass%20SDE.pdf

The most relevant requirements and corresponding principles are as follows.

- **Requirements for GHG emissions saving:** The reduction in GHG emissions needs to be at least 70% compared to the fossil fuel comparator of the RED. Therefore, the average emissions must be a maximum of 56 gCO_{2eq}/MJ for electricity and 24 gCO_{2eq}/MJ for heat. This does not account for any changes in forest carbon stock.
- **Requirements for soil management when using residues from nature and landscape management and agriculture:** Best practice shall be applied for the maintenance or improvement of the soil and soil quality in relation to production, or the management objectives as these have been included in a management plan.
- **Carbon and Land Use Change requirements**:
    - Biomass sourced from high conservation value or converted forest land or peatland or where soil and water quality have not been maintained is not allowed.
    - The use of biomass may not result in long-term carbon debt meaning that the biomass shall be sourced with the aim of retaining or increasing carbon stocks in the medium or long term and with a low risk of ILUC.
    - Biomass shall not be sourced from stumps, but tops, branches, residues and roundwood are permitted, as long as, on average, less than half the volume of the annual roundwood harvest from the forest is processed as biomass for energy.
    - Wastes, such as mill residues or post-consumer wood waste, are permitted.
- **Sustainable Forest Management (SFM) requirements:** These are mainly taken from the country's timber procurement policy, including the maintenance and enhancement of biodiversity and the health and production capacity of the forest and its contribution to the local economy.

A detailed system for the verification of compliance with these criteria, including elements that must be included in the sustainable forest management system and a chain of custody system is in place. The Dutch system has the most detailed of all the national sustainability criteria, and some doubt has been expressed that the requirements can be satisfied in practice.

5.5 France

In France, bioenergy is subsidised through a 'call for tender' system. Companies bid for contracts to supply energy at a set price, above market rates. The sustainability criteria are specific to each call.

The following criteria were, for example, specified in the 2016 call for tender:

- Use of roundwood excluded;
- Strict limits for particulate and NOx emissions;
- A minimum conversion efficiency of at least 75%, ruling out anything other than CHP;
- Depending on regional rules, between 8 and 22% of the feedstock that was domestically sourced to be certified (FSC or PEFC). All imported wood for bioenergy use to be FSC or PEFC certified.

Exceptions are allowed in case there is a shortfall of (renewable) energy in a certain region.

5.6 Germany[63]

The German Renewable Energy Law provides different levels of subsidies for different types of bioenergy production. For example, biogas from waste and manure are treated preferentially over the use of crops. Small-scale bioenergy installations are also treated preferentially. The *increase* of total electricity production from biomass per year in Germany should not exceed 100 MW installed capacity. Additional subsidies for biomass are set to decrease continuously.

In Germany, the federal office for agriculture and nutrition (BLE) is the competent authority for the implementation of the RED sustainability criteria. By adopting the RED[64], Germany has sustainability requirements in place for liquid and gaseous biomass, therefore also including biomethane.

There are no sustainability criteria in place for solid biomass use for heat or electricity so far but this has been discussed for several years. Currently, Germany sources most of its biomass for heat and electricity generation domestically and has stringent national forestry rules in place, so the introduction of sustainability criteria for solid biomass is not a pressing topic within German bioenergy policies.

Nonetheless, there are some initiatives/agreements at the federal state level. For example, the energy company Vattenfall and the state of Berlin have come to a voluntary agreement on biomass sustainability for Vattenfall's biomass power station, which includes a 50% GHG reduction compared to coal, following the EC-recommended accounting methodology.

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[63] http://www.ble.de/EN/Topics/Climate-Energy/Sustainable-Biomass-Production/sustainable-biomass-production_node.html;jsessionid=5BDDB3EA678AB8B1E01351071CDC9C90.1_cid325

[64] The requirements of the RED are transposed into national legislation by the biofuel sustainability ordinance (Biokraftstoff-Nachhaltigkeitsverordnung -Biokraft-NachV-) and the biomass-electricity-sustainability ordinance (Biomassestrom-Nachhaltigkeitsverordnung -BioSt-NachV-).

6 GHG Calculations

This section explains the EC's approach to calculating GHG emissions. It also presents the EC default values for a selection of key biomass supply chains relevant to Ireland and compares these to typical Irish GHG emission values. It also gives an overview of publicly available GHG calculators designed for solid and gaseous bioenergy and describes the latest status of work to estimate indirect GHG impacts.

A method for calculating the GHG emissions from the production and use of biomass fuels is included in Annex VI of the RED II. Largely it formalises the EC's previous guidance, but it includes some important changes relating to biogas fuel chains in particular.

Annex VI includes conservative 'default' GHG intensities for a selection of biomass and biogas fuels, as well as a breakdown of those emissions into the different supply chain stages.

In general, a GHG emission savings threshold of at least 70% can be met for biomass fuels relevant for the Irish context using the default values, provided that the transport distance is <10,000 km and, in the case of wood pellets, that process heat and power is provided by a CHP fed by woodchips.

For biogas fuels, the GHG emission savings for wet manure can far exceed this threshold (i.e. up to 240%) depending on the technology option deployed, whereas no defaults for maize meet the threshold. For biomethane, key considerations are whether digestate is stored in a closed-system and off gases are combusted.

Operators can always choose to report 'actual' values if they wish. Typical GHG values have been calculated for a representative range of supply chains in the Irish context, including a value for perennial energy crops (Miscanthus and SRC willow) and grass silage for biogas, neither of which have default values in the RED II. This study found that in most cases, reporting typical emissions for Irish supply chains should achieve better GHG savings than the RED II default values. Anaerobic digestion of 100% grass silage or co-digestion with high shares of grass silage, however, is only likely to meet the GHG threshold under certain conditions.
This section also examines the potential for indirect effects from solid and gaseous biomass feedstocks.

These feedstocks generally have a low risk of negative indirect effects, as long as existing uses are respected and agricultural and forestry residues are harvested up to a 'sustainable' removal rate. Increasing perennial energy crop and short rotation forestry feedstocks can even lead to positive indirect impacts.

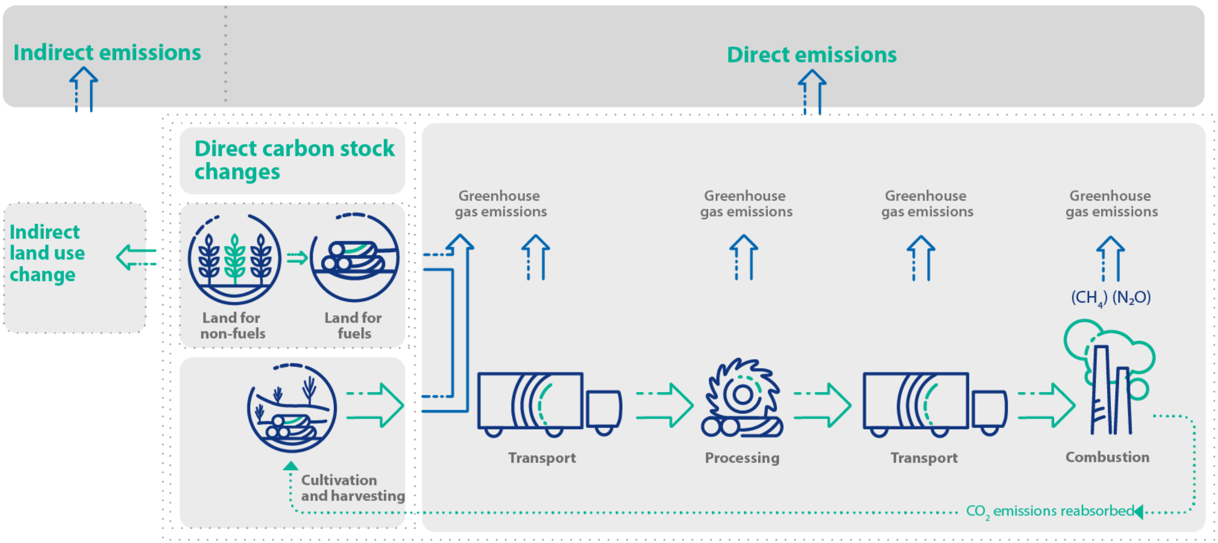
The debate surrounding 'carbon debt' (which can be described as the loss of sequestered biogenic carbon per land area due to the initial harvest for bioenergy), is also briefly described in this section. For annual biomass crops, this debate is less relevant as the carbon cycle acts over a short period of time. For forestry biomass, the key is to ensure that forests are sustainably managed over a large area so that overall carbon stock levels are neutral or increasing.

6.1 Sources of GHG emissions

The GHG emissions generated from biomass used for energy generation can arise at four distinct stages, as illustrated in Figure 6-1 (numbers 1 to 3 are commonly referred to as 'direct emissions'):

1. **Supply chain emissions** from cultivating, harvesting, processing and transporting the biomass. These emissions differ significantly depending on the type of biomass used and the specific supply chain. For example, in the case of woody biomass fuels, the emissions will vary according to whether the fuel is derived from a dedicated forest plantation, a forestry residue or a waste, and whether the wood is in chip or pellet form. These are the main source of emissions typically accounted and reported by operators, for example under the RED and RED II.
2. **Combustion emissions**, i.e. tailpipe emissions, are counted as zero because it is assumed that the CO_2 arising from combustion is cancelled out by the CO_2 absorbed by the material as it grows. This is the approach taken in the RED and RED II (see 6.2 below), although it should be noted that combustion emissions of biomass can be higher per unit of energy produced than fossil fuels because biomass is less energy dense than fossil fuels, has a higher moisture content and a lower hydrogen content.
3. **Direct carbon stock change emissions** from a change in the carbon stock resulting from land use changes (e.g. grassland to agricultural land) or a change in the standing forest carbon stock.[65] Operators are required to account and report direct land use change emissions under the RED and RED II.
4. **Indirect emissions** from indirect effects, such as substitution effects and indirect land use change (ILUC), are discussed in detail in Sections 2.2 and 6.8. Currently operators are not required to account for ILUC emissions under the RED, but Member States are asked to monitor and account for ILUC emissions in their reporting to the EC.

Figure 6-1: Illustration of different sources of GHG emissions



[65] A related concept is 'carbon debt'. See section 6.8 for further details.

6.2 RED II GHG emission calculation methodology

RED II sets out the greenhouse gas emission calculation methodology for solid and gaseous biomass fuels and implements the EC's recommended methodology, as published in SEC (2010) 65 final and SWD (2014)259. RED II takes an attributional life-cycle assessment approach to calculating GHG emissions, which is an estimate of the 'direct' GHG emissions associated with different bioenergy supply chains (items 1 and 3 as described in Section 6.1)[66]. 'Indirect effects' (item 4) are not included; in Section 6.8 we discuss this in greater detail.

All direct GHG emissions from the whole fuel chain must be included in the calculation, from cultivating or producing the feedstock, through any processing and transport steps to the use of the fuel. GHG emissions from the production of solid and gaseous biomass fuels, before conversion into heating or electricity, are calculated according to the following formula:

$$E = e_{ec} + e_{l} + e_{p} + e_{td} + e_{u} - e_{sca} - e_{ccs} - e_{ccr}$$

- E = total emissions from the production of the fuel before energy conversion
- e_{ec} = emissions from the extraction or cultivation of raw materials
- e_{l} = annualised emissions from carbon stock changes caused by land use change
- e_{p} = emissions from processing
- e_{td} = emissions from transport and distribution
- e_{u} = emissions from the fuel in use
- e_{sca} = emission savings from soil carbon accumulation via improved agricultural management
- e_{ccs}/e_{ccr} = emission savings from carbon capture and geological storage/replacement
- Emissions from the manufacture of machinery and equipment are <u>not</u> included

A key point to note is that wastes and residues (e.g. tree tops and branches, straw, husks, cobs and nut shells) are considered to have zero life-cycle GHG emissions up to the process of collection. The rationale behind this is that the production of these materials is incidental to the primary aim of the production process. For example, in the case of forestry residues, the primary aim is the production of timber, while in the case of agricultural residues the primary aim is the production of crops. This means that emissions from collecting the waste need to be included, but emissions from producing the material in the first place are excluded.

The RED II methodology includes some significant changes compared to the EC's previous recommendations. These include:

- e_{sca}: A bonus of 45 gCO_{2eq}/MJ manure can be applied for improved agricultural and manure management, if animal manure is used as a feedstock to produce biogas and biomethane. The bonus can be applied because the methane (CH_4) and nitrous oxide (N_2O) emissions from treating manure via AD are avoided.
- e_{ee}: The credit for exporting excess electricity (e.g. in a CHP) is no longer applicable. GHG emissions are now allocated between the electricity and the useful heat according to the temperature of the heat (which reflects the usefulness (utility) of the heat).
- e_{u}: Non-CO_2 GHG emissions (CH_4 and N_2O) arising from the combustion of biomass fuels are now included. CO_2 emissions from combustion remain at zero because biomass is considered carbon neutral.
- Emissions are now allocated based on the exergy content of the respective outputs.
- For biogas and biomethane, the methodology has been updated to include rules for calculating GHG emissions for the co-digestion of multiple feedstocks (i.e. mixtures of different feedstocks going into an AD plant), which is common practice but was difficult to calculate. Previously, emissions were calculated for each individual feedstock. There are different co-

[66] In contrast, in a consequential life-cycle assessment approach the indirect GHG impacts on the whole system are also considered. [67] The 'outermost regions' include: Guadeloupe, French Guiana, Martinique, Réunion, Saint-Barthélemy, Saint-Martin, the Azores, Madeira and the Canary Islands, as defined by Article 349 of the Treaty on the Functioning of the European Union.

digestion calculation approaches for actual values and default values (see Appendix 4). Note that these two approaches may lead to different results, even if the input values are the same.

The RED (Part A of Annex VI) includes 'default' and 'typical' GHG values for a selection of common biomass fuel pathways. Operators can use the default values to report to Member State authorities, or alternatively can calculate 'actual' values based on their own supply chain data (e.g. transport distances, processing energy intensity and fuel type). The default values are designed to be conservative to encourage operators to report actual GHG values, so calculating actual GHG values should result in lower GHG emissions compared to the default values.

The EC set the disaggregated default values for each step in the chain at a conservative level, unless the contribution to overall emissions is small, or there is limited variation in the values, or the cost or difficulty of establishing actual values is high, in which case values are set at a level that is typical of normal production (see Table 5).

Table 5: Overview of the basis for calculating the RED II default values

	Cultivation	Transport	Processing	Fuel in use
Solid biomass	Typical values	Typical values +40%	Typical values +40%	Typical values +40%
Gaseous biomass	Typical values	Typical values	Typical values +40%	Typical values +40%

The final GHG value takes into account the end use of the biomass fuel, i.e. the biomass fuel emissions are divided by the conversion efficiency, depending on whether the fuel is used to produce electricity, heat (or cooling). Importantly, for CHP systems, the GHG emissions are calculated based on the 'exergy' content and conversion efficiencies of the heat and electricity outputs. This results in separate GHG emission intensities for the heat and the electricity, which the operator would use in their reporting. The respective calculation formulae are included in Appendix 4: GHG calculations.

The fossil fuel comparators used to calculate the GHG emission savings are 183 gCO_{2eq}/MJ electricity (or 212 gCO_{2eq}/MJ electricity for the 'outermost regions'[67]) and 80 gCO_{2eq}/MJ heat (or 124 gCO_{2eq}/MJ heat if a direct physical substitution of coal can be demonstrated). These are lower than the fossil fuel comparators published in the previous communication by the European Commission, SEC (2010) 65 final, which were 198 gCO_{2eq}/MJ electricity and 87 gCO_{2eq}/MJ heat, implying that it will be harder to meet the GHG emission saving threshold under the RED II.

The default GHG emission savings in the RED II are based on end-use conversion efficiencies of 85% for heat and 25% for electricity. The SWD (2014) 259 final report published by the EC acknowledges that 25% is conservative, and that in reality the average efficiency in bioelectricity plants is likely to be around 30-35% and up to 40% with co-firing, so again using actual values should achieve a better GHG saving value.

6.3 GHG calculators

Two key publicly available GHG calculators have been developed which can be used to calculate the GHG emissions for solid and gaseous biomass: BioGrace II[68] and the UK Biomass & Biogas Carbon Calculator (UK B2C2)[69].

The project BioGrace II aims to harmonise calculations of GHG emissions for electricity, heat and cooling from biomass throughout the EU. BioGrace is a project funded within the Intelligent Energy Europe Programme. The BioGrace I tool was designed for biofuels and bioliquids. The BioGrace II GHG calculation tool for electricity, heating and cooling follows the methodology laid down in the European reports of 2010 and 2014 (as implemented in RED II).

[67] The 'outermost regions' include: Guadeloupe, French Guiana, Martinique, Réunion, Saint-Barthélemy, Saint-Martin, the Azores, Madeira and the Canary Islands, as defined by Article 349 of the Treaty on the Functioning of the European Union.

[68] http://www.biograce.net/biograce2/

[69] https://www.ofgem.gov.uk/publications-and-updates/uk-solid-and-gaseous-biomass-carbon-calculator

The UK Biomass & Biogas Carbon Calculator (UK B2C2) is made freely available by Ofgem (the UK gas and electricity markets regulator) to facilitate RHI and RO scheme participants in calculating their GHG emissions for solid biomass, biogas and biomethane fuel chains. User manuals are available on how to use the calculator. The UK B2C2 applies the GHG emission methodology as laid down in SEC (2010) 65 final. The B2C2 calculator includes seven biogas fuel chains based on default values for AD,[70] as well as an additional 13 fuel chains based on the gasification of forestry feedstocks. The default values are UK-specific and were developed in consultation with UK stakeholders.

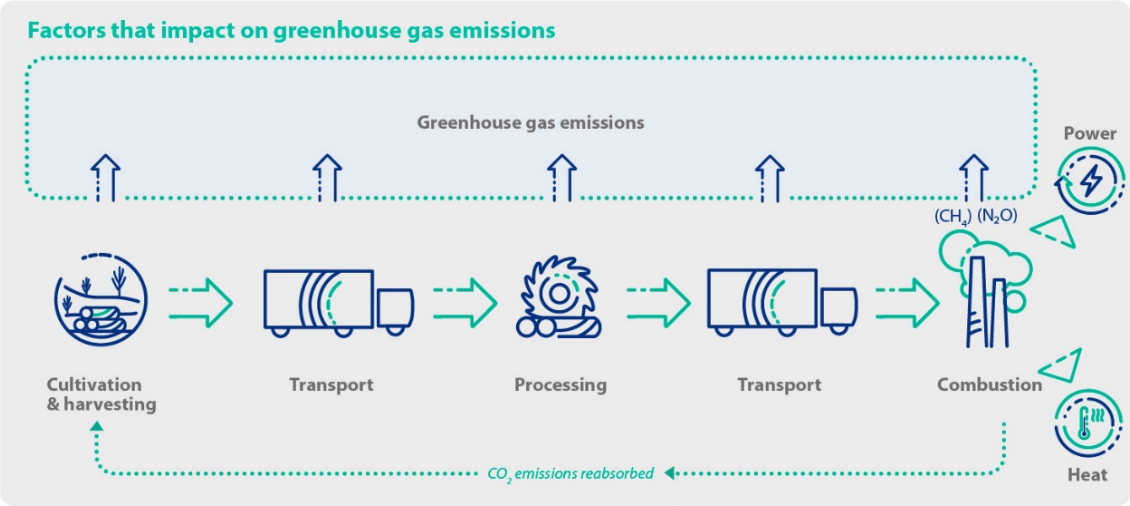
6.4 Key sources of GHG emissions for biomass supply chains

The following two illustrations show the key sources of GHG emissions in a solid and gaseous biomass pathway.

- Cultivation and harvesting GHG emissions can be significant, especially if large volumes of synthetic fertilisers are used (and in particular nitrogen fertilisers since their application results in N_2O emissions from soil). GHG accounting starts only at the process of collection for feedstocks that are wastes and residues and therefore these supply chains can have very low emissions as there are no associated cultivation emissions.
- The further the biomass is transported, the greater the GHG emissions. Road transport typically has a higher GHG intensity than sea transport on a per km basis. The GHG intensity of rail transport is largely dependent on whether the fuel type is diesel or electricity (and the applicable electricity grid factor).
- Processing emissions are negligible for chipping biomass. Pelleting emissions vary across a wide range depending on the fuel type used for drying the biomass and whether a boiler or CHP system is deployed in the pelleting plant. For example, emissions are low for a biomass CHP, but are significant for a natural gas boiler. The electricity usage and the applicable electricity grid factor also have an impact on the emissions. For biogas, a key consideration is whether the digestate is stored in an open or closed (gas tight) system, since the digestion process actually continues during the storage period.
- The processing emissions for upgrading biogas to biomethane relate to electricity usage and are not significant. A key factor that impacts the GHG emissions is whether the off-gases are vented to atmosphere, or oxidised (flared). If the off-gases are oxidised with a high efficiency of CH_4 conversion, then no CH_4 is released to the atmosphere.
- CO_2 combustion emissions from biomass are considered to be zero. However, non-CO_2 combustion emissions, specifically CH_4 and N_2O are taken into account. The non-CO_2 emissions for solid fuels are negligible (<1 gCO_{2eq}/MJ), but they are significant for biogas (12.5 gCO_{2eq}/MJ) as a consequence of the incomplete combustion of biogas in the CHP.

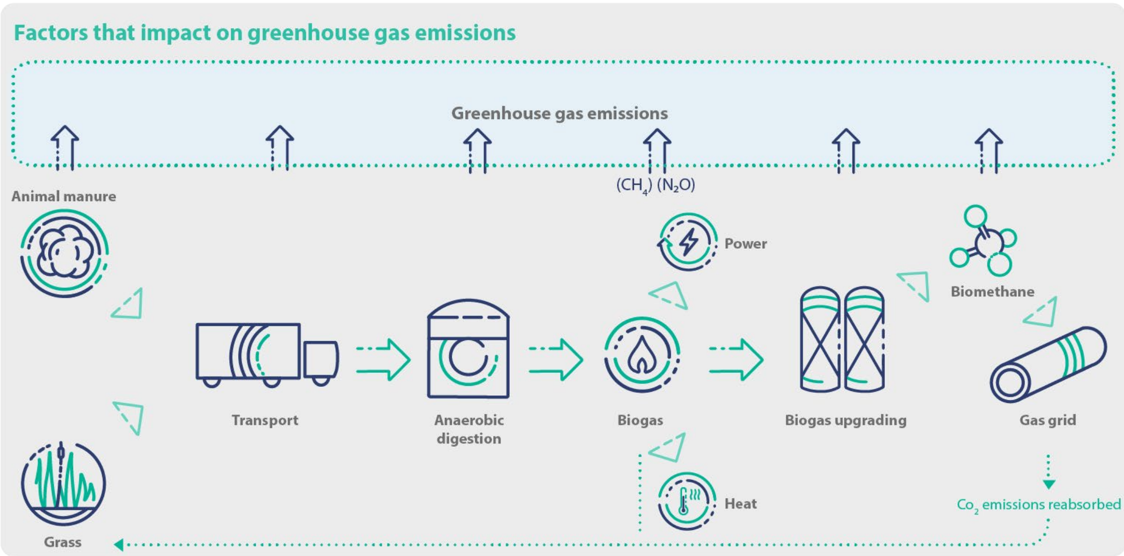
[70] Dry and wet manure, Silage grass, Sugar beet, Whole crop maize, wheat and rye.

Figure 6-2: Key sources of GHG emissions for an illustrative solid biomass pathway



Cultivation & harvesting	Transport	Processing	Transport	Combustion
• No upstream emissions for wastes and residues • Agro-chemical inputs • Fuel consumption for machinery • Carbon stock changes	• Transport mode • Transport distance • Fuel consumption • Fuel type	• Seasoning • Chipping • Pelleting • Losses during processing • Fuel consumption • Fuel type (biomass, natural gas) • Electricity consumption • [CHP or boiler]	• Transport mode • Transport distance • Fuel consumption • Fuel type	• CO_2 emissions from combustion of biogas are zero • CH_4 and N_20 emissions [Conversion efficiency]

Figure 6-3: Key sources of GHG emissions for an illustrative gaseous biomass pathway



Cultivation and harvesting	Transport	Processing	Combustion	Upgrading	Injection to grid
• No upstream emissions for wastes and residues • Agro-chemical inputs • Fuel consumption for machinery • Carbon stock changes	• Transport mode • Transport distance • Fuel consumption • Fuel type	• Methane loss • Fuel consumption • Fuel type (biogas) • Electricity consumption • Digestate storage (open or closed) • [CHP or boiler]	• Methane loss • CO_2 emissions from combustion of biogas are zero • CH_4 and N_20 emissions [Conversion efficiency]	• Methane loss • Electricity Consumption • Off-gas combustion	• Methane loss • Electricity consumption

6.5 Default values applicable for the Irish context

Table 6 provides a summary of the default values provided in Annex VI of RED II for a selection of fuel chains that are likely to be applicable in the Irish context. Also indicated is whether the defaults comply with the RED II minimum GHG saving threshold of 70%. Note that plants which start operating from 2026 will have to meet an 80% GHG saving threshold (see section 2.3). Green shading in the right-hand column indicates that the pathway will always meet the 70% GHG threshold, if default values are reported, amber shading indicates that the default value meets the GHG threshold under certain conditions (e.g. limits on the transport distance) and red shading indicates that the pathway does not meet the GHG threshold, if default values are reported. As indicated in Section 6.2, the default values have been calculated conservatively, so operators should in theory be able to report better GHG savings if actual values are reported. In some cases, this could mean that pathways marked amber or red *could* meet a 70% GHG threshold.

Table 6: RED II default value ranges and GHG emission savings for selected fuel chains

Feedstock	Form	Default value range (gCO_{2eq}/MJ)	GHG emission saving range (heat and electricity)*	Compliance with a 70% GHG saving threshold
Biomass				
Forest residues	Chips	6-27	91/60% - heat 87/41% - electricity	If transport distance is <10,000 km for heat, or <2,500 km for electricity.
Sawmill residues	Chips	5-25	93/63% - heat 90/44% - electricity	If transport distance is <10,000 km for heat, or <2,500 km for electricity.
SRC poplar (Fertilised)	Chips	9-30	87/57% - heat 81/35% - electricity	If transport distance is <10,000 km for heat, or <2,500 km for electricity.
Forest residues	Pellets	7-41	90/40% - heat 85/11% - electricity	If process heat and power is provided by a CHP fed on woodchips, or If process heat is provided by woodchip boiler and power is supplied via grid, and transport distance is <10,000 km (heat only).
Sawmill residues	Pellets	4-27	94/61% - heat 91/42% - electricity	If process heat and power is provided by a CHP fed on woodchips, or If process heat is provided by woodchip boiler and power is supplied via grid, and transport distance is <10,000 km for electricity.
SRC poplar (Fertilised)	Pellets	9-43	87/37% - heat 81/7% - electricity	If process heat and power is provided by a CHP fed on woodchips, and transport distance is <10,000 km.
Straw	Pellets	10-16	85/76% - heat 78/64% - electricity	All fuel chains, except if transport distance is <10,000 km for electricity.

Feedstock	Form	Default value range (gCO_{2eq}/MJ)	GHG emission saving range (heat and electricity)*	Compliance with a 70% GHG saving threshold
Biogas				
Wet manure	Biogas	(-89)-10	85/240% - electricity	All fuel chains.
Maize	Biogas	28-59	10/53% - electricity	No fuel chains.
Manure/ Maize (80%:20%)	Biogas	(-9)-43	35/114% - electricity	If closed digestate system is applied.
Wet manure	Biomethane (used in transport)	(-100)-22	72/202%	All fuel chains.
* Note that the assumed conversion efficiencies are 85% for heat and 25% for electricity. ** The fossil fuel comparators used to calculate the GHG emission savings are 80 gCO2eq/MJ heat, 183 gCO2eq/MJ electricity and 94 gCO2eq/MJ for biomethane used in transport.				

6.6 GHG emissions in the Irish context

The GHG emissions for a selection of biomass fuel chains that are considered relevant to the Irish market have been calculated using typical 'input data' in the Irish context (see Table 7). These included biomass fuel chains for which no default value exists (namely SRC willow, Miscanthus and grass silage for AD), as well as updated calculations for several of the RED II defaults included in Table 6. Wood pellet imports were assumed to be sourced from the US South East as this region is a key global producer and currently exports significant volumes to Europe, including the UK. The input data for the relevant parameters used in the calculations were gathered primarily from a literature review and from discussions with stakeholders[71].

Table 7: GHG emissions for selected fuel chains in the Irish context

Feedstock	Form	Value (gCO_{2eq}/MJ)	GHG emission saving (heat and electricity)	Key assumptions ('Central' scenario)
Biomass				
Forest residues	Chips	3.2	95/95%	50% moisture content at collection. Natural drying to 30% moisture content. 150 km transport by road.
Sawmill residues	Chips	1.7	98/97%	30% moisture content at collection. 150 km transport by road.
Miscanthus	Bales	7.4	89/88%	Yield of 18 t/ha (30% moisture content). Natural drying to 15% moisture content. 100 km transport by road.
SRC willow	Chips	12.7	81/79%	Yield of 14 t/ha (50% moisture content). Natural drying to 25% moisture content. 100 km transport by road.
Forest residues	Pellets	9.9	85/83%	50% moisture content at collection. Wood chip boiler for process heat, electricity import at pellet plant. 10% moisture content for pellets. 150 km transport by road.

[71] Including the Irish Bioenergy Association, Teagasc and University College Cork.

Feedstock	Form	Value (gCO_{2eq}/MJ)	GHG emission saving (heat and electricity)	Key assumptions ('Central' scenario)
Forest residues (imported from USA South East)	Pellets	18.6	73/69%	50% moisture content at collection. Wood chip boiler for process heat, electricity import at pellet plant. 10% moisture content for pellets. 100 km transport to pellet plant by road. 500 km transport to coast by freight train. 6,310km sea transport by bulk carrier (Savannah to Foynes). 150 km transport to end-user by road.
Miscanthus	Pellets	10.5	85/82%	Yield of 18 t/ha (30% moisture content). Natural drying. 150 km transport by road.
SRC willow	Pellets	17.0	75/71%	Yield of 14 t/ha (50% moisture content). Wood chip boiler for drying at pellet plant. 150km transport by road.
Straw	Pellets	5.2	92/91%	13.5% moisture content at collection. 10% moisture content for pellets. 150km transport by road.
Biogas and biomethane				
Grass silage	Biogas	60.5	43/30%	Yield of 89 t/ha (82% moisture content). 10 km transport from farm to digester. 8,129 MJ biogas/ t dry input. 0.2 gCH_4/MJ biogas losses. Closed digestate system.
Wet manure	Biogas	-63.1	159/173%	90% moisture content. 10 km transport from farm to digester. 6,477 MJ biogas/ t dry input. 0.2 gCH_4/MJ biogas losses. Closed digestate system.
Grass silage / Wet manure	Biogas	25.4	76/71%	40:60 split (by weight). Closed digestate system.
Grass silage / Wet manure	Biomethane	19.2	71.8% - heat	40:60 split (by weight). Closed digestate system. Off-gas combustion (no methane emitted from upgrading).

* Note that the assumed conversion efficiencies are 85% for heat and 32.5% for electricity, and 40% for heat and 33% for electricity in the case of the Biogas supply chains (assuming application in a CHP system). The actual conversion efficiencies will be plant specific.
** The applied electricity grid factors for Ireland (EU mix-MV) and the USA are 128 and 180 gCO_{2eq}/MJ respectively (as published by the European Commission – Standard Values v1.0).
*** Grass is cultivated as an energy crop.

The GHG emissions were calculated for 3 scenarios: 'Central' (most representative), 'Low' (best case) and 'High' (worst case), based on the estimates for input values found in literature. For energy crops and imported wood pellets, a sensitivity analysis was undertaken to identify the most influential input parameters.

Section 6.6.1 provides the results for the solid biomass fuel chains, Section 6.6.2 for the gaseous biomass fuel chains and in Section 6.7 we report the findings from the sensitivity analysis.

6.6.1 Solid biomass fuel chains

In this section we provide an overview of the GHG emissions for the key solid biomass supply chains, broken down by supply chain step. Separate plots are provided for the GHG emissions of the biomass fuel (i.e. prior to conversion to heat or electricity) (Figure 6-4), and the GHG emissions following conversion to heat (Figure 6-5) or electricity (Figure 6-6). The maximum GHG emissions permitted under the RED II in 2021 and for new plants from 2026 are indicated (blue lines in the figures) to illustrate the extent to which the supply chains meet the expected 70% and 80% GHG savings targets. These correspond to 24/16 gCO_{2eq}/MJ heat and 54.9/36.6 gCO_{2eq}/MJ electricity respectively in 2021 and for new plants from 2026 (equivalent to GHG savings of 70%/80%).

Figure 6-4: GHG emissions for solid biomass pathways (per MJ fuel)

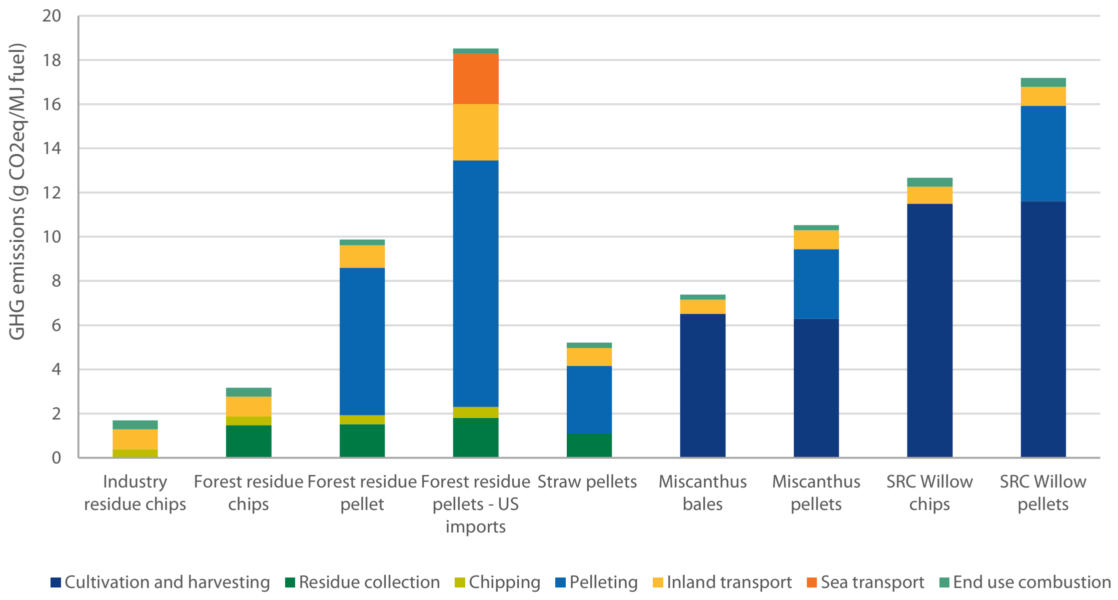


Figure 6-5: GHG emissions for solid biomass pathways per MJ heat (assuming 85% conversion efficiency to heat)

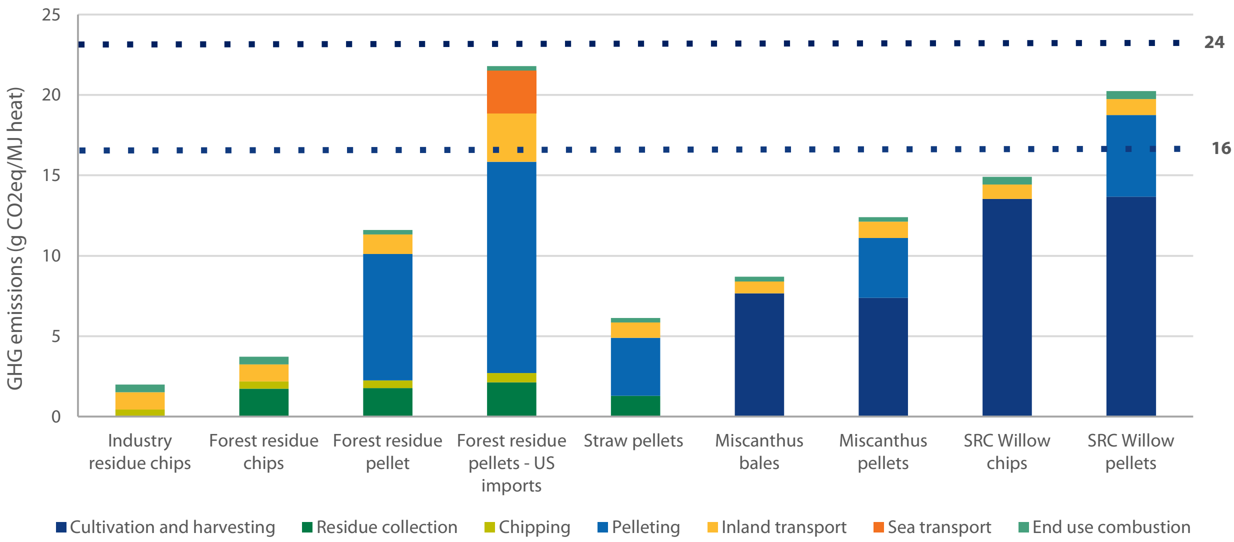
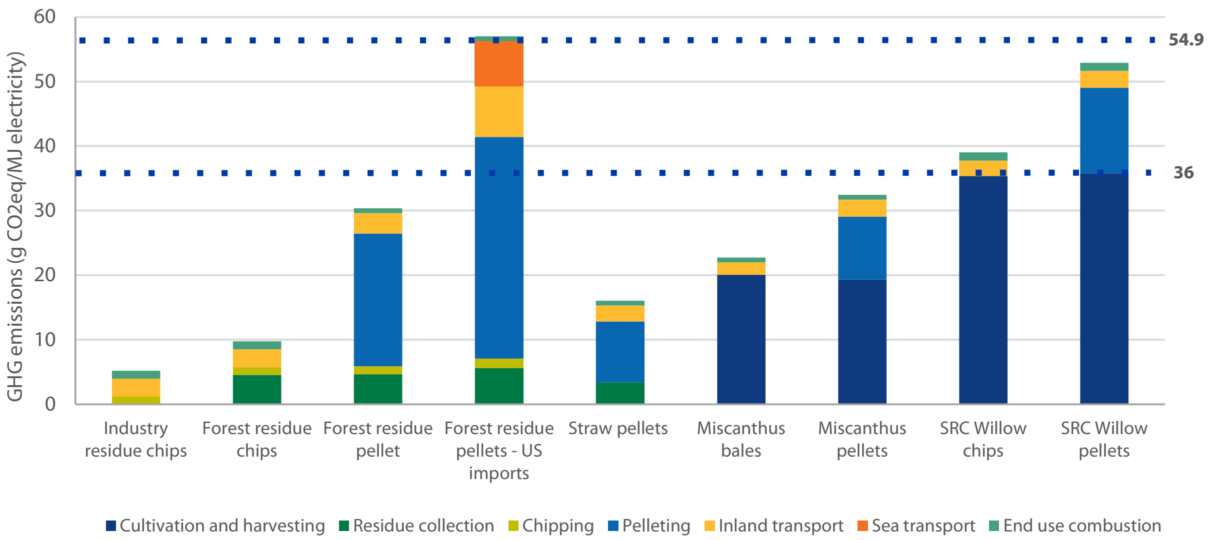


Figure 6-6: GHG emissions for solid biomass per MJ electricity (assuming 32.5% conversion efficiency to electricity)



Emissions from cultivating and harvesting the biomass are only relevant for the energy crop supply chains (represented by Miscanthus and SRC willow), and are highest for SRC willow. Emissions from residue collection and chipping are negligible, whereas emissions from pelleting can have a considerable impact.[72] Key considerations that can impact the GHG intensity are the fuel type used to dry the biomass prior to pelleting and the electricity grid factor for the pelleting process. The GHG emissions from sea transport have a relatively low impact compared to those from road transport, resulting from the higher fuel efficiency for sea transport[73]. Long-distance road transport therefore quickly adds to the GHG intensity of a fuel; this is an important consideration for biomass supply chains to ensure that the GHG intensity limits are met. Emissions from end-use combustion are negligible (< 1 gCO_{2eq}/MJ).

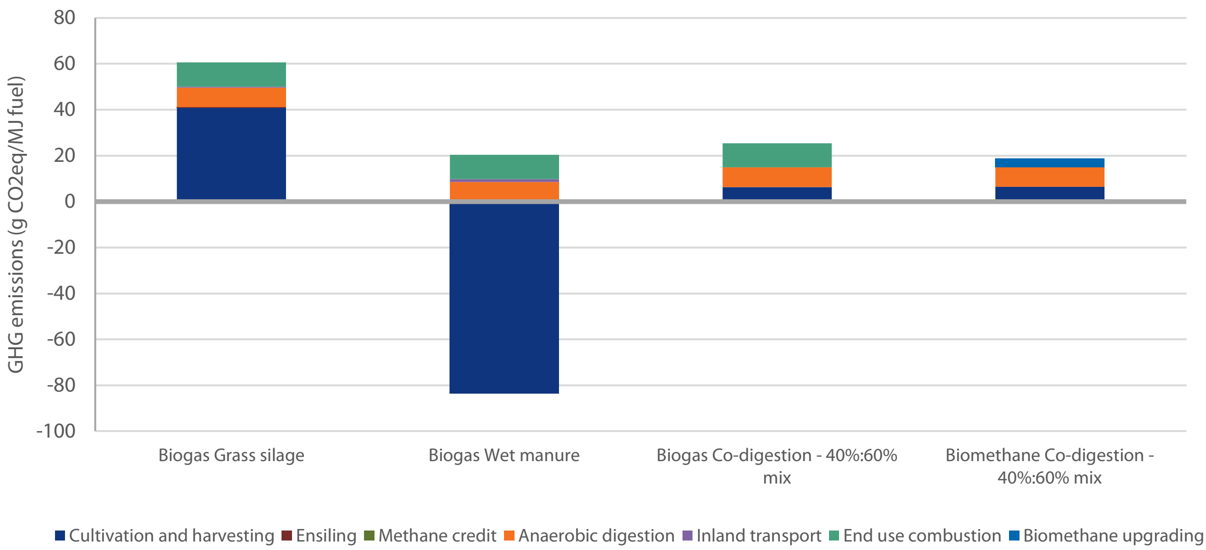
The majority of the supply chains assessed comfortably meet a 70% GHG emission savings target (the bars are below the blue lines in the above figures), with the exception of forestry residue imports and SRC Willow pellets. A sensitivity analysis of selected key parameters is provided in section 6.7.

6.6.2 Gaseous biomass fuel chains

In this section we provide an overview of the GHG emissions for the key gaseous biomass supply chains, broken down by supply chain step. Separate plots are provided for the GHG emissions of the biomass fuel (i.e. prior to conversion to heat or electricity) (Figure 6-7) and the GHG emissions following conversion to heat (Figure 6-8) or electricity (Figure 6-9). The supply chains assume that the biogas is combusted in a CHP system, which produces both heat and electricity outputs. Biomethane is considered differently to biogas since it is the final fuel.

The maximum GHG emissions permitted under the RED II in 2021 and for new plants from 2026 are indicated (blue lines in the figures) to illustrate the extent to which the supply chains meet the expected GHG savings targets. These correspond to 24/16 gCO_{2eq}/MJ heat and 54.9/36 gCO_{2eq}/MJ electricity in 2021 and for new plants from 2026 (equivalent to GHG savings of 70%/80%).

Figure 6-7: GHG emissions for gaseous biomass per MJ fuel/MJ biomethane (upstream emissions are included in the 'Cultivation and harvesting' category for co-digestion – similarly in Figure 6-8 and Figure 6-9)



[72] The calculations assume that a wood chip boiler is used in the drying process prior to pelleting.

[73] The fuel efficiency kilometre for a 'Supramax' bulk carrier running on fuel oil transporting pellets is 0.07 MJ/t.km. This compares to 0.88 MJ/t.km for a 40tonne truck running on diesel transporting pellets.

Figure 6-8: GHG emissions for gaseous biomass per MJ heat (assuming 40% conversion efficiency to heat in a CHP)

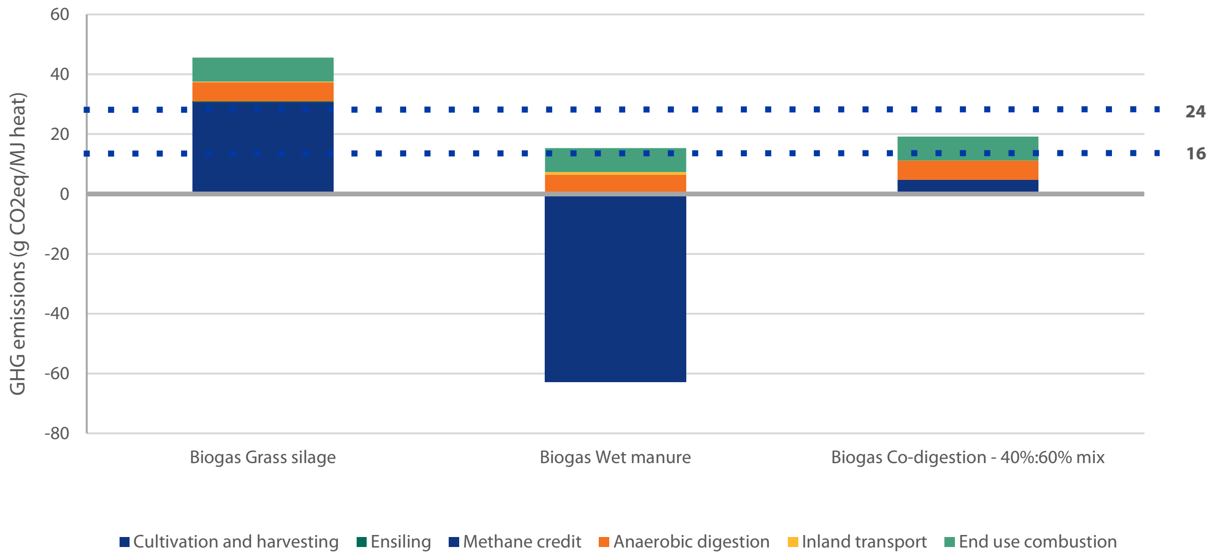
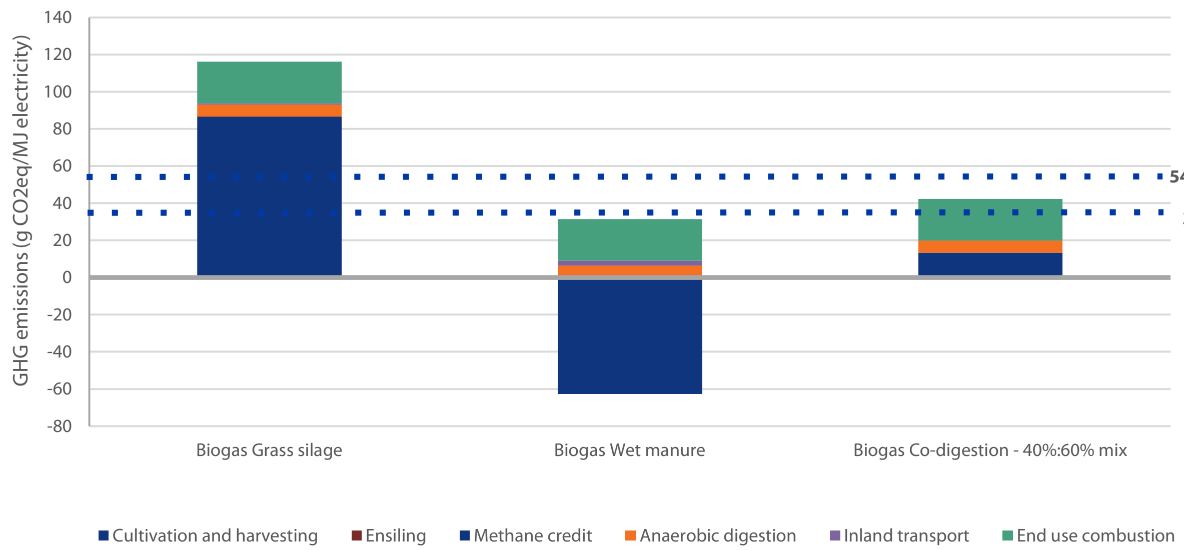


Figure 6-9: GHG emissions for gaseous biomass per MJ electricity (assuming 33% conversion efficiency to electricity in a CHP)



Emissions from cultivating and harvesting of biomass are only relevant for the grass silage supply chain (since wet manure is considered a waste). Cultivation emissions are significant for grass silage cultivated as an energy crop. Wet manure benefits from a significant GHG credit (i.e. negative emissions), as discussed in Section 6.2. Transport emissions are negligible since the assumed distances are small (it is not economical to transport wet feedstocks over large distances). There will be additional transport emissions for biomethane in a setup in which a mobile upgrader is used to upgrade and compress biogas to biomethane onsite and then transport the biomethane to a grid injection point (these emissions are not included in the above figures).

Emissions for the AD process relate to the import of grid electricity and methane leakage[74]. All gaseous biomass pathways assume that the digestate is stored in a gas-tight 'closed system', in which any biogas released during storage is recovered. In an 'open system' the biogas is released to the atmosphere with subsequent impact on the GHG emission intensity. End-use combustion emissions are significantly higher compared to the solid biomass supply chains (around 9 gCO_{2eq}/MJ). This is a consequence of the incomplete combustion of biogas in the CHP.

A consequence of the very high cultivation emissions is that grass silage, if processed on its own, would not meet the expected GHG saving target, using the input values from the literature assessed in this study. In contrast, wet manure achieves a very high emission saving. Grass silage would need to be co-digested with wet manure in a maximum proportion of approximately 40:60 (by weight) to meet the 70% target (for both biogas and biomethane).

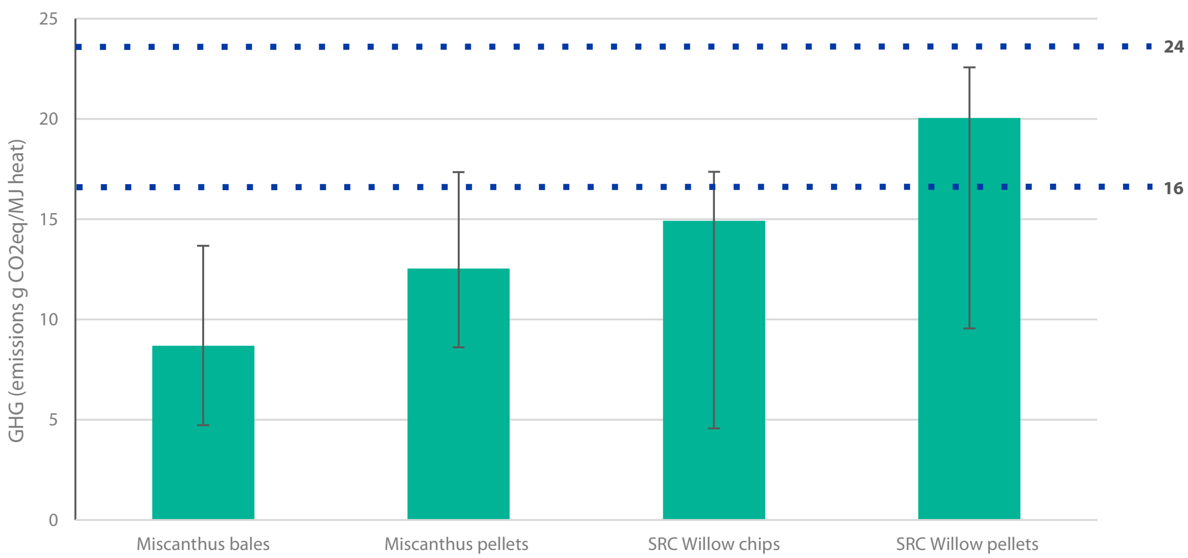
Note that it is permitted to calculate a single GHG value for a mixture of feedstocks for AD systems, whereas this approach is not permitted for solid biomass or biofuels, for which the RED requires separate GHG values to be calculated *per feedstock*.

6.7 Sensitivity analysis

6.7.1 Perennial energy crops (cultivated in Ireland)

Figure 6-10 overleaf illustrates the potential variation in the calculated GHG emissions for Miscanthus and SRC Willow fuel chains when selected input parameters are varied. The green bar is the 'Central' scenario, while the 'Low' (best) and 'High' (worst) scenarios are represented by the lowest/highest points in the vertical lines respectively. The parameter that has the most impact on the variability is fertiliser use in cultivation. Nevertheless, domestic Miscanthus and SRC pathways meet the required GHG thresholds.

Figure 6-10: Range of calculated GHG emissions for perennial energy crops (cultivated in Ireland) per MJ heat



[74] Methane has a global warming potential of around 25 times that of carbon dioxide. Therefore, even small leaks of methane can have a material impact on the GHG emission intensity.

6.7.2 Grass silage for AD

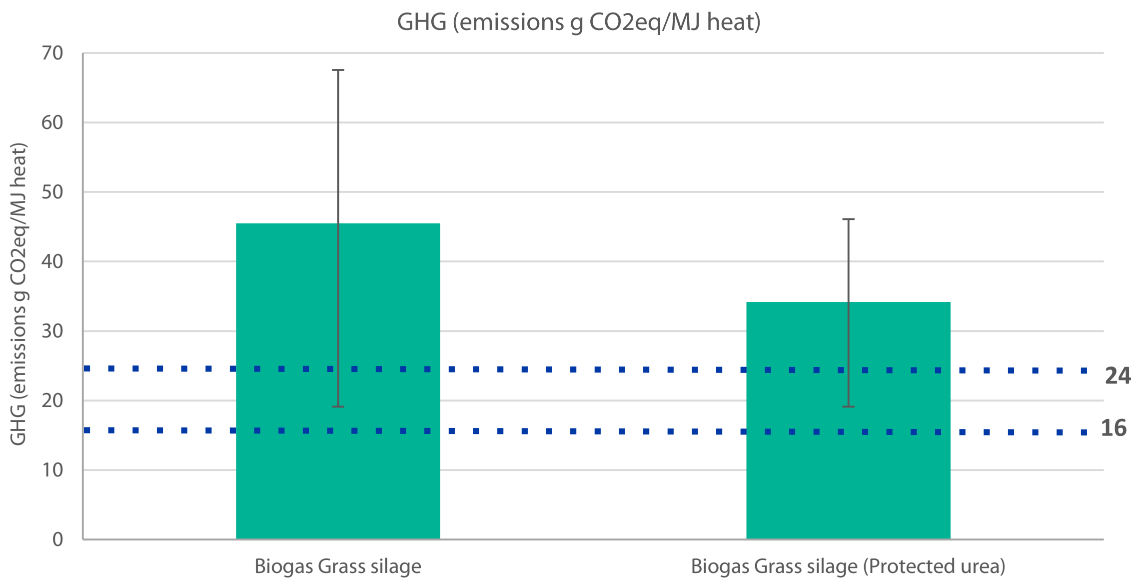
Figure 6-11 overleaf illustrates the potential variation in the calculated GHG emissions for grass silage. The green bar is the 'Central' scenario, while the 'Low' (best) and 'High' (worst) scenarios are represented by the lowest/highest points in the vertical lines respectively. The assumptions applied in developing these scenarios are detailed in Table 8. The scenarios assume that grass grown for energy would be cut (harvested) four times per year.

Table 8: Grass cultivation assumptions applied in the Low, Central and High scenarios (as provided by Teagasc)

Parameter	Low	Central	High
Yield (odt/ha/yr)	13 (4 cuts/yr – 3, 4, 3, 3)	16 (4 cuts/yr – 6, 4, 3, 3)	9 (4 cuts/yr – 2, 3, 2, 2)
Synthetic Nitrogen (N) fertiliser application	None Red clover system assumed	400 kg N /ha	285 kg N /ha
Digestate application	100% of the digestate from AD process is applied to land 85% recovery assumed	100% of the digestate from AD process is applied to land 85% recovery assumed	None

The parameters that have the most impact on the variability are synthetic fertiliser use in cultivation, along with the associated soil N_2O emissions, as well as methane leakage in the AD system (including the operation of the CHP).

Figure 6-11: Range of calculated GHG emissions for grass silage (cultivated in Ireland) per MJ heat



Two pathways are presented with respect to the type of synthetic fertiliser used (in addition to the scenarios in Table 8), one which assumes the application of a mixture of 92% calcium ammonium nitrate (CAN)/ 8% urea synthetic fertiliser and one which assumes the application of 100% 'protected NBPT urea[75]. Note that the change in synthetic fertiliser type to protected urea impacts the central and high scenarios only as the low scenario assumes no synthetic fertiliser application. According to Harty et al. (2016)[76], by switching from 92% CAN/ 8% urea to 100% 'protected NBPT urea' the direct emission factor associated with the application of synthetic fertiliser from soils reduces from 1.49% to 0.4%. (N_2O emissions tend to be higher from nitrate-containing fertilisers, such as CAN in comparison to urea, particularly in regions that have mild, wet climates and high organic matter soils such as Ireland. Urea can be an inefficient nitrogen source due to ammonia (NH_3) volatilisation, but nitrogen stabilisers (urease and nitrification inhibitors) can improve its efficacy.)

A recent study published by the IEA Task 37 (2017) on 'Methane emissions from biogas plants' cited a number of factors that can have a significant impact on the GHG emission balance[77]. These are characterised by structural (the technologies deployed) and operational (plant management) factors. The most relevant ones include: open storage or composting of the digestate; the CHP engine; leaks; and the pressure release valve. The report indicates that the results available show a large variability in the level of emissions and that it is very difficult to give typical numbers for emissions from components or complete biogas plants. There is insufficient data for a general assessment of the sector, but trends indicate which components should be monitored and which measures are useful to minimise the amount of released methane. GHG emissions in biogas operation can be significantly reduced by taking measures such as the application of a gas-tight cover of digestate tank, frequent maintenance of the gas engine and monitoring of methane concentrations in the exhaust. The calculations in this study assume a methane loss during AD of 0.1, 0.2 and 0.3 gCH_4/MJ biogas for the Low, Central and High scenarios respectively. In addition, non-CO_2 emissions resulting from the incomplete combustion of biogas in the CHP are assumed to be 8.9 gCO_{2eq}/MJ biogas for all 3 scenarios.

6.7.3 Co-digestion of feedstocks in AD

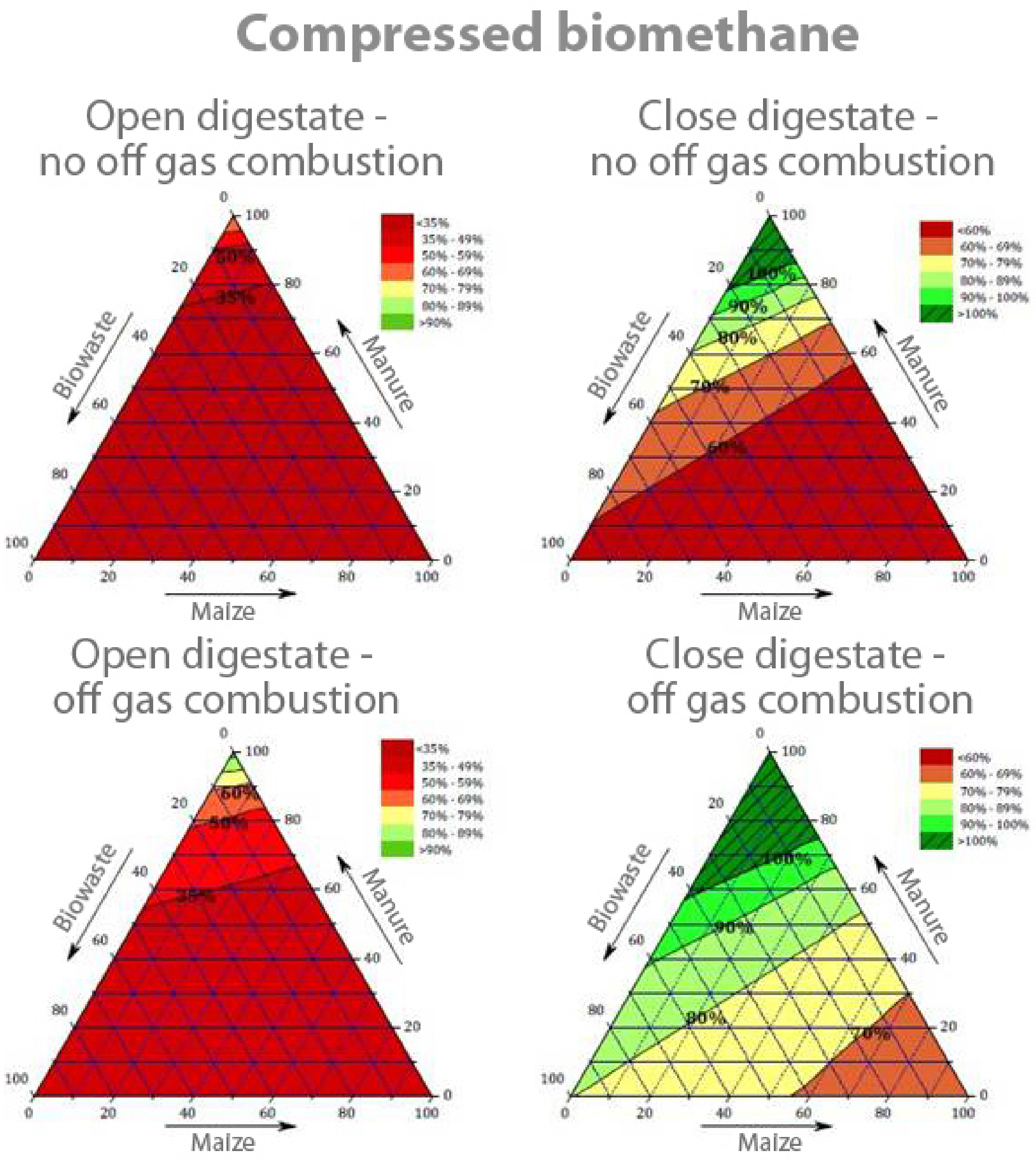
Figure 6-12 provides an illustration of the GHG emission savings for the co-digestion of manure, biowaste and maize feedstock mixes to produce biomethane. The underlying GHG emission data are the RED II default values for the individual feedstocks. (Note that it is assumed that electricity required in the AD process is imported and heat is applied by the CHP itself – i.e. the 'Case 2' scenario in the RED II defaults). The colour coding indicates the level of GHG savings (see legend for details).

[75] Specifically, Urease inhibitor N-(n-butyl) thiophosphoric triamide (NBPT) and/or the nitrification inhibitor dicyandiamide (DCD).

[76] Harty et. al. (2016). Reducing nitrous oxide emissions by changing N fertiliser use from calcium ammonium nitrate (CAN) to urea-based formulations, Science of the Total Environment, 563–564 (2016) 576–586, 2016

[77] IEA (2017). *Methane emissions from biogas plants.* http://task37.ieabioenergy.com/files/daten-redaktion/download/Technical%20Brochures/IEABioenergy_Task%2037_methane_emissions_2Psummary.pdf

Figure 6-12: Sensitivity of GHG emission savings for various co-digestion mixtures of manure, biowaste and maize to produce biomethane. Source: JRC (2017), Solid and gaseous bioenergy pathways: input values and GHG emissions, Figure 13



The figure highlights how sensitive the results are to whether digestate is stored in an 'open' or 'closed' system, and whether 'off gases' are combusted during biomethane upgrading. In an open system a minimum 70% threshold can only be met if off gases are combusted and a very high percentage (around 95%) of the feedstock mixture is manure. This contrasts with the closed digestate system where a 70% threshold can be met more flexibly, particularly when combined with offgas combustion.

6.7.4 Forestry residue imports

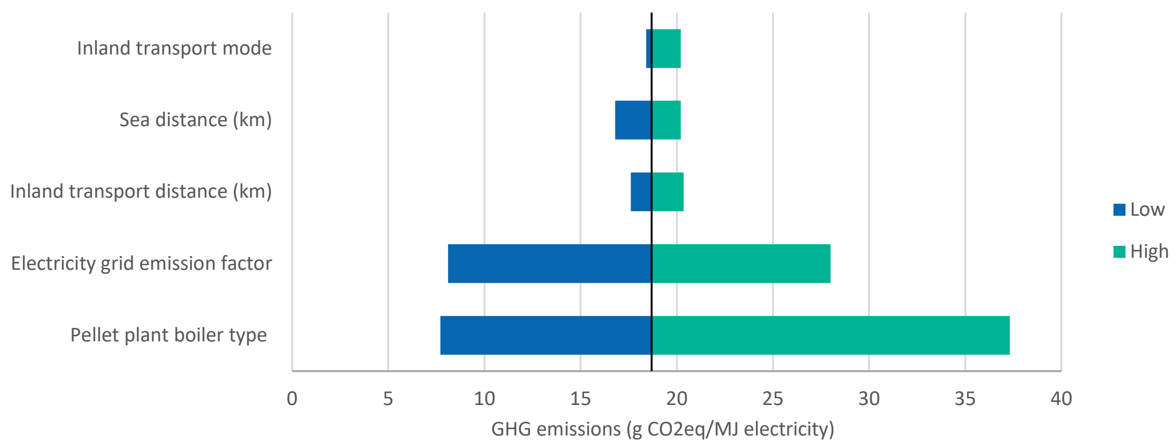
A sensitivity analysis for forestry imports was undertaken using the 'Forestry residue pellets – imported from USA South East' supply chain as the 'Central' scenario. We varied the assumptions for a number of the parameters in this scenario to assess the impact on the calculated results (see Table 9). Each parameter was assessed independently (i.e. all other Central scenario parameters were unchanged). The low and high assumptions for 'Sea distance' and 'Electricity grid emission factor' are based on Sweden and South Africa respectively, two potential biomass export countries. These countries are selected as they have very different characteristics to the USA and therefore illustrate the sensitivity of these two parameters. With respect to the Electricity grid emission factor it should be noted that individual countries within a region can have very different characteristics. For example, the grid emission factor for Canada (55 gCO_{2eq}/MJ), another potential export country, is significantly lower than the USA (180 gCO_{2eq}/MJ).

Table 9: Assumptions used in sensitivity analysis of Forestry residue pellets - imported from US South East

Parameter	Central scenario	Low scenario	High scenario
Inland transport distance (forest to sea port)	600 km (100 km forest to pellet plant and 500 km from pellet plant to sea port)	600 km (50 km forest to pellet plant and 250 km from pellet plant to sea port)	1,200 km (200 km forest to pellet plant and 1,000 km from pellet plant to sea port)
Inland transport mode (of pellet transport)	Diesel train	Electric train	40 tonne truck
Electrical conversion efficiency (%)	30%	32.5%	35%
Sea distance	USA (6,300 km)	Sweden (1,484 km)	South Africa (11,000 km)
Electricity grid emission factor for pellet production	USA (180 gCO_{2eq}/MJ)	Sweden (6.1 gCO_{2eq}/MJ)	South Africa (338 gCO_{2eq}/MJ)
Pellet plant process heat	Wood chip boiler	Wood chip CHP	Natural gas boiler

Figure 6-13 that the 'Pellet plant boiler type' has the greatest impact on the overall results, followed by the 'Electricity grid emission factor'. The 'Inland transport mode', 'Inland transport distance (forest to sea port)', 'Sea distance' and 'Electrical conversion efficiency' all have relatively modest impacts in comparison.

Figure 6-13: Sensitivity analysis for Forestry residue pellets – imported from USA South East (per MJ electricity)



6.8 Indirect effects

An issue that has been debated at length for bioenergy policy is that of indirect effects. This refers to the effect that diverting materials to bioenergy consumption can mean the original biomass demand has to be met through new or alternative materials, so-called 'substitution effects'. If this means that new materials have to be produced, this can lead to increased land use globally. This leads to an increased risk of land use changes such as deforestation, thereby increasing GHG emissions. This specific effect is referred to as indirect land -use change (ILUC) (see also Sections 2.2 and 6.1), although substitution effects can be broader, for example if an existing use of a material is replaced by a fossil alternative.

Many of the feedstocks that are interesting for solid and gaseous bioenergy are wastes or residues. Wastes have no (or very limited) existing uses, therefore negative indirect effects are not expected from diverting wastes to bioenergy. Residues (e.g. straw or sawmill residues) are not the primary product that the process aims to produce, but they do often have existing uses. It is important to understand these existing uses, to assess whether there is a risk of a negative impact from increasing the use of these materials for bioenergy. For energy crops, the relevant discussion is on competition with alternative uses for land. Crops like perennial energy crops or forestry, if appropriately grown and harvested, have the potential to increase carbon stock levels. In the Irish context, existing grassland is a significant carbon store and ploughing grasslands to convert to alternative agricultural crops (e.g. maize) could lead to significant GHG emissions (note this would be counted as a direct land use change and would have to be included in any GHG calculation in the context of the RED or RED II – see sections 6.1and 6.2).

Section 6.8.1 looks at the existing uses for the feedstocks in question and qualitatively describes the indirect effects for each feedstock. In Section 6.8.2, we summarise the results of a study by Ricardo-Energy & Environment for SEAI (2017)[78] which estimates the potential availability of domestic feedstocks for bioenergy in Ireland, once demand from existing uses has been met. Demand for feedstocks *above* this potential could lead to risks of negative indirect effects, unless measures are taken by operators to ensure that additional demand can be met in a way that does not cause negative indirect effects.

In Section 6.8.3 we discuss the GHG factors modelled in the most recent GLOBIOM study for the EC on indirect land -use change, and their relevance in this context.

6.8.1 Existing uses of feedstocks

Forestry residues include both residues collected from the forest when the forest is cut (e.g. tops, branches, bark and leaves) and 'thinnings' which are whole trees harvested part way through a forest's growing cycle to give space for the remaining trees to grow and thereby increase the productivity of the forest.
Forest residues left on the forest floor decompose, providing nutrients back to the soil, maintaining soil quality and also providing an important habitat to maintain biodiversity. Higher quality thinnings can be used for sawlog production – they would command too high a price to be used for bioenergy at current market prices. Lower quality thinnings can be used for pulpwood[79].

The SEAI (2017) report indicates that there is a lack of experience in the Irish forestry sector in the removal of forest residues for biomass and therefore, typically, forestry residues are left on the forest floor. This suggests that there is potential to increase the collection and use of this feedstock for bioenergy. However, we would first recommend that guidelines on an appropriate "sustainable removal rate" for forestry residues are developed, to ensure that residues are removed at a rate that does not impact on biodiversity or soil quality (note that this is a direct impact).

[78] SEAI (2017). *Bioenergy Supply in Ireland 2015-2035.* https://www.seai.ie/resources/publications/Bioenergy-Supply-in-Ireland-2015-2035.pdf

[79] 'Pulpwood' refers to timber with the principal use of making wood pulp for paper production.

SEAI (2017) also indicates that harvesting of thinnings in Ireland is currently low. As current harvesting is low, we consider that there is scope for increasing these feedstocks without a significant risk of negative indirect effects. Increased harvesting of thinnings could increase the productivity of forests, and have a positive impact on carbon stock levels by increasing overall productivity.

Sawmill residues include residues from processing in a sawmill or panel board mill and can take the form of woodchips, saw dust or bark. Sawmill residues are an important resource to the wood panel industry. According to SEAI (2017), in 2014, 40% of sawmill residues were used to make panel boards, 3% for other non-energy uses (including bark mulch and animal bedding), 2% were exported. The remaining 55% was used for energy (also directly within the panel board industry),[80] of which 50% as woodchips and 5% as pellets.

The main substitute for the wood panel industry is pulpwood, which could also be used for bioenergy. Currently, good quality residues used in pulpwood and wood panel production are priced at a premium, making their use uneconomic in the bioenergy industry. This could change, for example if high energy prices or subsidies for biomass increase the sector's ability to pay and should therefore be monitored.

Perennial energy crops (Miscanthus and SRC willow or poplar) and grass would be specifically grown for energy. Therefore, the most relevant discussion is on competition with alternative uses for land (rather than the feedstock, although grass is also used as feed/fodder for animals).

Analysis published by Teagasc (Irish Agriculture and Food Development Authority)[81] assumes that existing grassland in Ireland can be used more intensively, freeing up some grassland used for animal grazing for conversion to energy crops.[82] The Teagasc estimate of land that could be available for energy crops assumes a limit on the amount of land that can be converted from grassland under the current CAP regime, which leaves a significant area that must remain grassland and could therefore be used to grow grass for grass silage.

Teagasc argue that Irish agricultural GHG emissions are dominated by methane (CH_4) emissions from cattle, which accounts for over 15% of national emissions. Providing farmers with an option to remove animals from their land and still receive an income by growing grass under contract for AD biogas production would assist in reducing agricultural GHG emissions. This is a significant GHG reduction opportunity for Ireland, but note that it only reduces emissions in the overall context if the reduction in Irish cattle production is matched by an overall reduction in beef consumption. Without this, production of Irish beef would be replaced by production of beef in other countries, which would still contribute to global emissions. Changes in diet to reduce meat consumption is often quoted as a key emission reduction measure in the context of overall global emission reduction.

Straw is classed as an agricultural residue. Straw is currently used as animal feed (barley), for animal bedding (all types) and/or can be ploughed into the ground to maintain soil quality and nutrient levels (all types). Wheat straw is also currently used in mushroom cultivation.

Diverting straw from animal feed would require substitution with other animal feed types. There are very few good alternatives to straw for animal bedding or mushroom compost. If no straw is ploughed back into the land, this can impact soil quality and nutrient levels and could lead to either soil degradation or a need to increase fertiliser use (see Section 6.8.3). Guidelines on an appropriate "sustainable removal rate" for straw would be beneficial, to ensure that it is removed at a rate that does not impact on biodiversity or soil quality (note that this is a direct impact).

Straw has important existing uses, which are not high value so could be displaced if bioenergy is supported; however, there is an excess potential once non-energy uses are taken into account that could be available for bioenergy. SEAI (2017) estimates non-energy uses for straw to be 86% of the straw resource in 2015, decreasing to 78% in 2020 and 67% in 2035.

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[80] COFORD Connect (2014). *Woodflow and forest-based biomass energy use on the island of Ireland.* Gordon Knaggs and Eoin O'Driscoll as quoted in SEAI (2017).

[81] https://www.teagasc.ie/

[82] McEniry et al. (2013). *How much grassland biomass is available in Ireland in excess of livestock requirements?* Irish Journal of Agricultural and Food Research 52, 2013.

Animal manure is a waste and so does not have many existing uses. It does contain nutrients and can be used on the land as fertiliser (although there are restrictions on spreading on land because of the risk of disease).

If manure is not spread on land, it could lead to an increased need to use fertiliser. The nutrients are retained in the digestate produced by the AD plant, so there is no loss if the digestate is spread on land. Note there are restrictions on digestate spreading to avoid disease. Farms can spread their own digestate. Farms importing manure can only spread digestate locally unless all feedstocks are pasteurised before AD. Pasteurisation of all feedstocks is required for all AD plants that import more than 5,000 tonnes of feedstock.

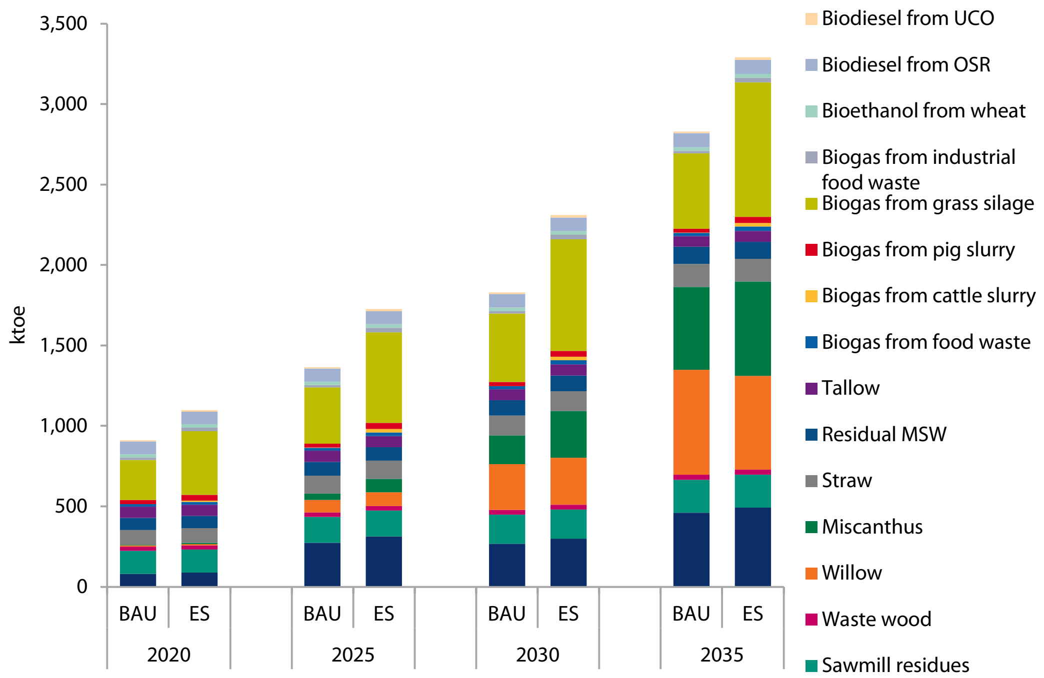
For imported biomass, the indirect effects depend – in the same way as for domestic feedstocks – on the type of feedstock, e.g. whether it is a waste, residue or energy crop. Energy crops experience competition for land, agricultural and forestry residues have competing uses and wastes should have no or few alternative uses beyond energy.

6.8.2 Estimated domestic feedstock potential (based on Ricardo, 2016 for SEAI)

In 2016, SEAI published supply curves for bioenergy in Ireland to 2035[83] that were developed by Ricardo Energy & Environment. The SEAI report estimates the availability of a range of feedstocks under a business as usual (BAU) scenario and enhanced supply (ES) scenario to 2035. Figure 6-14 shows the estimated annual potential to 2035 of individual feedstocks under 'favourable' conditions (high market prices and mitigation of market barriers).

The estimates of feedstock available for bioenergy take into account existing non-energy uses. This can therefore be considered to be the estimated amount of feedstock that could be used for bioenergy with low risk of indirect effects. Use of these feedstocks *above* this potential could lead to risks of negative indirect effects, unless measures are taken by operators to ensure that additional demand can be met in a way that does not cause negative indirect effects.

Figure 6-14: Estimated bioenergy resource potential for individual feedstocks (ktoe). Source: SEAI (2017), Bioenergy Supply in Ireland 2015-2035, Figure 1.6



[83] Ricardo (2017). *Bioenergy Supply in Ireland 2015-2035*. https://www.seai.ie/resources/publications/Bioenergy-Supply-in-Ireland-2015-2035.pdf

The largest potentials in 2035 are estimated to be from SRC willow, Miscanthus and grass silage, although achieving this potential will require policy efforts to stimulate planting of especially SRC willow and Miscanthus, and higher market prices for biomass feedstocks than seen today.[84] These are all land-using and could therefore be realised through appropriate land-use planning and incentives, accompanied by a strong domestic environmental legislation. Sawmill residues are significant, but not estimated to increase significantly to 2035. Forest thinnings are estimated to be a resource that could increase significantly and are also estimated to be available at a lower cost.

The following are some specific points to note in relation to Ricardo's estimates.

- For forest residues, the BAU scenario assumes no forestry residues are extracted and only some thinning operations. The enhanced supply scenario assumes supply-side barriers are overcome, all thinning operations assumed in the COFORD forecast are carried out by 2030, and all the residues identified as available are extracted. Thinnings that can be used for sawlogs or pulpwood are subtracted from the potential estimate (based on COFORD[85]).
- The sawmill residues potential depends on the throughput at sawmills and pulpwood debarking. COFORD estimate this is likely to rise by 27% and 20% respectively between 2014 and 2020 due to economic recovery. Post-2020, growth is assumed to continue, but at half the rate. No enhanced scenario was estimated (because the potential depends on the throughput of other industries).
- For perennial energy crops, the difference between the BAU and enhanced scenarios is that planting expands at a faster rate under in the enhanced scenario. The maximum land availability in both scenarios is the same. SEAI (2017) assumes that perennial energy crops would be grown on medium quality land, as high productivity land would be used to meet increased demand for annual crops. The additional land availability for perennial energy crops is estimated to be 203,000 ha (under the current CAP regime), which could produce 1,167 ktoe of SRC and Miscanthus in 2035. For comparison, current planting of perennial energy crops stands at 939 ha SRC and 2,414 ha Miscanthus, which could produce around 15 ktoe annually. The estimated land that could be made available for grass silage production in 2035 is 305,000 ha land (under the current CAP regime).
- Straw estimates are based on projections of cereal crop production. Similar to sawmill residues, no enhanced scenario was estimated because the potential depends on the throughput of other industries.
- Use of animal manure for bioenergy is only assumed to be suitable for larger farms (~6,000 pigs or ~1,000 cattle) because of the necessity to collect sufficient quantities of waste to provide a consistent source of feedstock for the AD plant.

6.8.3 Results from the GLOBIOM study

Indirect land -use change (ILUC) has been found to be a risk in particular for some biofuel feedstocks, such as oil crops. ILUC cannot be observed or measured because it is indirect. It can only be modelled using complex global equilibrium models. This modelling shows that most ILUC risks are associated with the use of vegetable oils for biofuels. Using starch or sugar crops leads to much lower risks. The main reason for this difference is that ultimately, most land use change related emissions are caused by deforestation of (peatland) rainforest in Indonesia driven by palm oil expansion. Palm oil is the cheapest vegetable oil commodity and has a relatively high substitutability with other vegetable oils, whereas substitutability with starch and sugar crops is limited. This means that when for example rapeseed oil previously used for food is used for biodiesel, the loss of oil to the food sector can be compensated for by an increase of palm oil.

[84] SEAI (2017) report that the profitability of perennial crops is around €4/GJ, when an establishment grant of €1300/ha is included. However, prices would reportedly need to reach at least €130/t at 20% moisture (about €9/GJ) before farmers would consider switching land from cereals to biomass. At €6/GJ, biomass returns are comparable to those from winter wheat, and at €10/GJ, returns are comparable to the most profitable enterprise dairy production.

[85] COFORD Wood Mobilisation Group (2015). *Mobilising Ireland's forest resource.*

The ILUC Directive (see Section 2.2) includes ILUC factors for cereals and oil seeds. The GLOBIOM study[86] published by the EC was used as the basis for the factors in the ILUC Directive. The study modelled ILUC impacts for a range of biofuels feedstocks, including also feedstocks that are typically used for solid and gaseous biomass (maize silage, straw, perennial energy crops, short rotation plantations and forestry residues). These feedstocks were included in the study as they are of interest for advanced biofuel production.

The study compares a 'world with additional biofuels' (the policy scenario, based on the RED) to the 'world as it would have developed without the additional biofuels' (the baseline scenario). The ILUC impact is the difference between emissions in the policy scenario and those in the baseline. The emission sources included in the study – and shown in Figure 6-15 – are described in the box.

GLOBIOM Emissions Sources

Peatland oxidation
Emissions caused by peatland drainage due to oil palm plantation expansion.

Soil organic carbon
Changes in carbon stored in soils.

Forest reversion (foregone sequestration)
Avoided emission savings due to less afforestation or returning less cropland to other natural land because the land is being used for cropland. This effect takes place in particular in Europe where a trend exists of cropland abandonment.

Natural vegetation conversion
Release of carbon stored in forest biomass or natural biomass at the moment the land use change occurs.

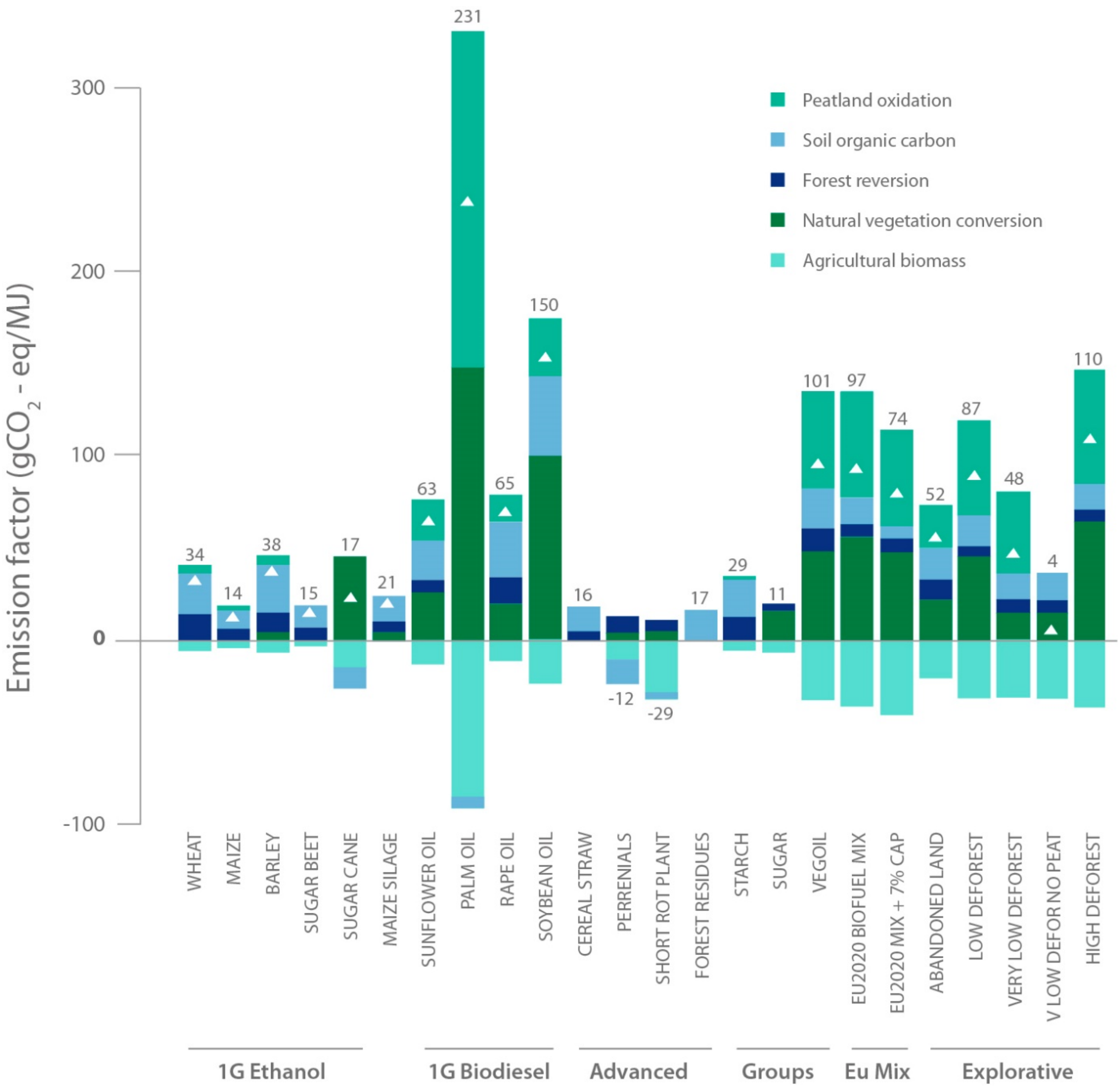
Agricultural biomass
Changes in carbon stored in agricultural crops can be biofuel feedstocks cultivated as a direct consequence of increased biofuel demand, or other crop cultivation triggered indirectly by increased biofuel demand.

Some of these emission sources can be both positive, i.e. generate emissions, and negative, i.e. take more CO_2 out of the atmosphere than emitted, even within the same scenario. Soil organic carbon emissions, for example, are positive when the carbon stored in the soil is released, e.g. when forests or other natural biomass are converted and tilled for farming. The emissions are also positive when the build-up of soil organic carbon is avoided (relative to the baseline), e.g. when the collection of forest residues is increased. These emissions can result directly from increased cultivation of specific biofuel feedstocks, or from the increased cultivation of other crops triggered by increased biofuel demand. At the same time, soil organic carbon emissions can be negative when carbon is stored in soils or crops, due to, for example, changing crop cultivation methods.

[86] Ecofys, IIASA and E4tech (2015). *The land use change impact of biofuels consumed in the EU: Quantification of area and GHG impacts.* https://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report_GLOBIOM_publication.pdf

Figure 6-15 shows the LUC emission values for each feedstock and the breakdown between various emission sources. Positive emissions are above the x-axis and negative emissions below. The resulting net LUC emission value is represented by the small triangle in each bar and by the number on top of each bar.

Figure 6-15 Overview of modelling results: LUC emissions per scenario. Source: Ecofys et al. (2015)[87]



The modelled LUC emissions for the feedstocks relevant to solid and gaseous biomass are those in the 'advanced' category, and maize silage, which is the closest analogy to grass silage (although note that the agricultural systems are quite different). The findings show that for all advanced feedstocks, and maize silage, the ILUC impact is either very small or negative, i.e. increasing their use could increase carbon stocks overall.

[87] Ecofys, IIASA and E4tech (2015). *The land use change impact of biofuels consumed in the EU: Quantification of area and GHG impacts.* https://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report_GLOBIOM_publication.pdf

The key insights are:

- Perennial energy crops and short rotation forestry can have negative LUC emissions (-12 or -29 gCO_{2eq}/MJ biofuel respectively), mainly because of an increase in the carbon stock of the land that is converted to produce these high carbon stock crops;
- Forestry residues have estimated LUC emissions of 17 gCO_{2eq}/MJ biofuel, even though no land use change takes place *per se* when harvesting forestry residues. The emissions result from a lower build-up of soil organic carbon in the ground when forest residues are harvested for bioenergy compared to the situation when they are left in the forest. It is therefore more appropriate to speak about a 'soil organic carbon (SOC) emission value' for forestry residues, instead of a 'LUC emission value'
- Cereal straw has estimated LUC value of 16 gCO_{2eq}/MJ biofuel, caused by a slight reduction in yield of the main commodity (i.e. the cereal). This would be the case if overharvesting of straw occurs, for example, if high volumes of straw are already harvested for purposes such as animal feed and bedding. Overharvesting of straw leads to soil carbon depletion, and a small yield loss. However, if straw harvesting is limited to a 'sustainable' removal rate,[88] the GLOBIOM study demonstrates that no yield effect occurs and therefore no land use change effect is observed. The LUC value would reduce to zero if a sustainable straw removal rate is introduced to limit straw removal. The straw market is relatively local, with typical transportation distances of up to 300 km. the GLOBIOM study found large regional differences in supply and demand, and significant price differences across the EU. The study looked at Hungary, France and the UK in detail and found different results because of different straw market situations. It would be valuable to examine the Irish straw market in further detail from the perspective of indirect effects and an appropriate local sustainable removal rate.

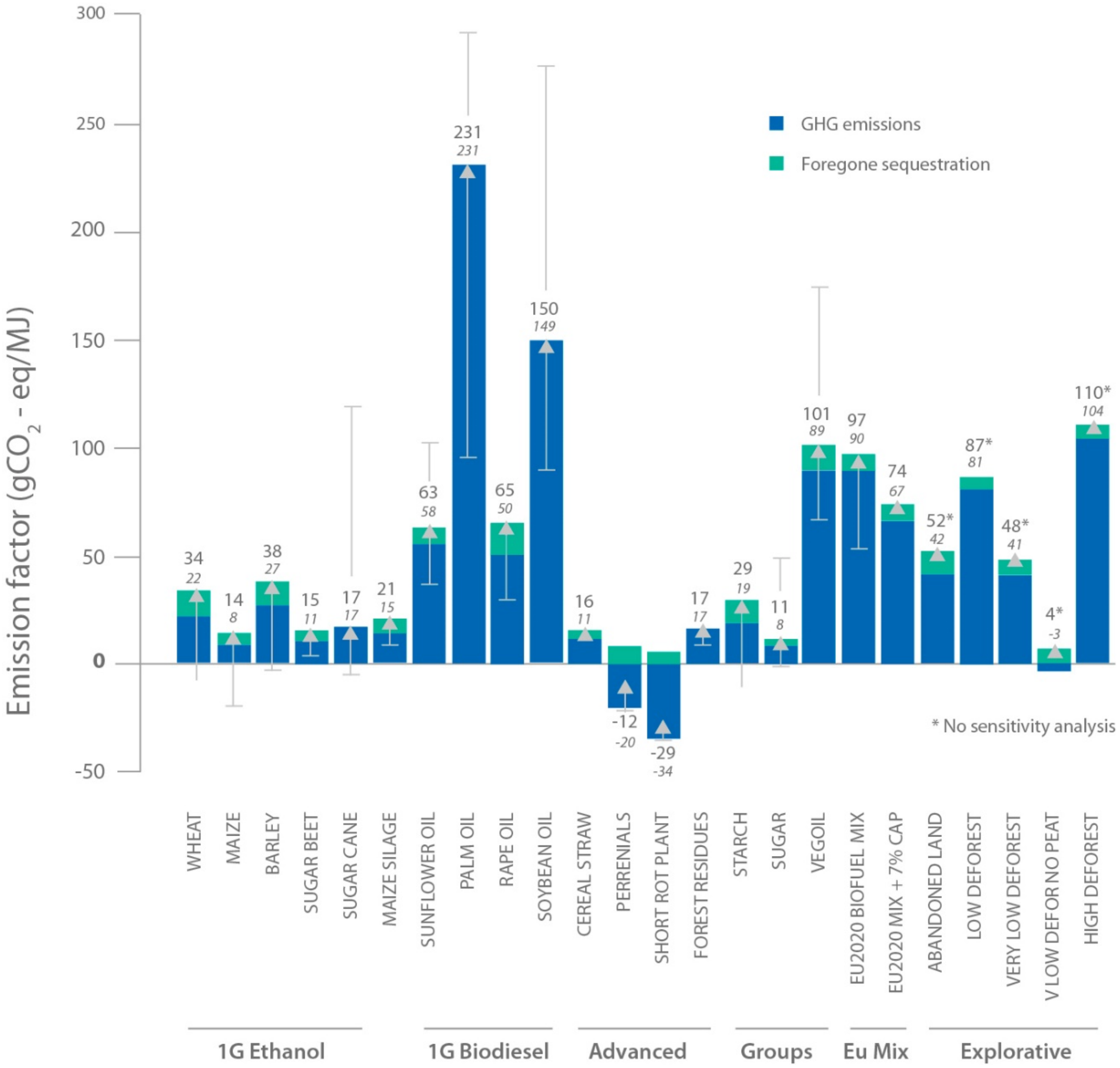
It should be noted that the GLOBIOM modelling was conducted in the context of the EU as a whole and is not specific to Ireland. Uncertainties are large. Although the modelling was conducted in the context of biofuels for transport and so the ILUC value in grams per MJ is specific to the energy density of the fuel, the relative 'land converted' and overall GHG emissions results for each feedstock remains the same in the context of feedstocks for heat and power. It is still considered valid to conclude that there is a relatively low ILUC risk for the feedstocks under consideration for solid and gaseous biomass.

Figure 6-16 shows the results for each feedstock with the error bars included. It also shows the results with and without foregone sequestration (called 'forest reversion' in Figure 6-15) as this discussion did not reach the core of the EU policy debate.

[88] Ecofys (2013): *Low ILUC potential of wastes and residues for biofuels.*

The report estimated a sustainable removal rate across the EU as a whole of 33-50%, or once every 2-3 years.

Figure 6-16 Overview of modelling results: LUC emissions with and without foregone sequestration and with uncertainty ranges (bars indicate the range within the first and the last decile). Source: Ecofys et al. (2015)



6.9 Carbon debt

A fundamental assumption of bioenergy policy is that burning biomass is carbon neutral. In reality, burning biomass emits carbon dioxide (CO_2) at the point of combustion, but this is considered to be cancelled out by the CO_2 that was absorbed from the atmosphere when the biomass was grown. However, when forestry feedstocks are used, the volume of CO_2 emitted when the wood is burned can take several years to be reabsorbed in new forestry growth. This lag between the emission and reabsorption of the CO_2 is referred to as '*carbon debt*'.

Initially, the term carbon debt was defined by Fargione et al. (2008) as the "*above-and below-ground carbon loss from the conversion of land to liquid biofuel production systems*". Later, it was described as the "*additional emissions from forest biomass as compared to fossil fuels per unit of energy generated*" (Manomet (2010)). In the scientific literature, it has generally been established as the loss of sequestered biogenic carbon per land area due to the initial harvest for bioenergy[89].

[89] https://www.researchgate.net/publication/259576449

A Chatham House report,[90] published in February 2017, was critical on the use of woody biomass for power and heat, stating that, with respect to trees, "*it is not valid to claim that because trees absorb carbon as they grow, the emissions from burning them can be ignored.* It also states that *the methodology specified in the 2009 EU Renewable Energy Directive and many national policy frameworks for calculating emissions from biomass only considers supply-chain emissions, counting combustion emissions as zero. These arguments are not credible."*

In the recommendations, the report states that "*the provision of financial or regulatory support to biomass energy on the grounds of its contribution to mitigating climate change should be limited only to those feedstocks that reduce carbon emissions over the short term. In practice, this means that support should be restricted to sawmill residues, together with post-consumer waste. Burning slower-decaying forest residues or whole trees means that carbon emissions stay higher for decades than if fossil fuels had been used."*

In March 2017, IEA Bioenergy issued a response to these claims[91] disagreeing with many of the report's conclusions and recommendations. The response states, "*The Chatham House report is comprehensive and includes many references to the scientific literature. However, it fails to present an accurate description of the current state of understanding informed by climate science, integrated modelling and forestry disciplines. Instead it presents a misleading description of bioenergy, and refers to extreme cases that do not represent current practice and that provide the worst climate outcomes. It fails to acknowledge the benefits bioenergy can provide in supporting urgently-needed energy system transition to reduce reliance on fossil fuels in order to meet climate targets."*

IEA Bioenergy followed up in January 2018 with a paper titled, "*Is energy from woody biomass positive for the climate?".*[92] The paper asserts that, *"Energy from woody biomass can be very positive for the climate, particularly when applying sustainable forest management practices, and when the biomass is used efficiently (such as in combined heat and power plants and biorefineries)." And "[…] Using by-products and residues for energy has typically been found to achieve climate change mitigation benefits in the short term. It is not recommended to use long-rotation high quality stemwood for energy, or cutting entire forests to generate bioenergy. Nevertheless, lower-value roundwood from short rotation forestry, thinnings, diseased or low quality trees should not be excluded."*

The concept of carbon debt is debated in part because of a difference in perspective in the way bioenergy can be perceived. If you take the example of a plantation, the CO_2 is absorbed as the tree grows, reducing atmospheric CO_2 and then released when the tree is burned, bringing the CO_2 balance back to zero. However, if you assume the counterfactual is that the tree already exists and CO_2 is released when it is burned, then you have a CO_2 'debt' that takes several years to repay. For annual biomass crops, this debate is less relevant as the carbon cycle acts over a shorter period of time (typically one year). For forestry biomass, the key is to ensure that forests are sustainably managed *at the landscape scale* so that overall carbon stock is neutral or increasing.

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[90] https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2017-02-23-woody-biomass-global-climate-brack-final2.pdf

[91] http://www.ieabioenergy.com/wp-content/uploads/2017/03/Chatham_House_response_supporting-doc.pdf

[92] http://www.ieabioenergy.com/wp-content/uploads/2018/01/FAQ_WoodyBiomass-Climate_final-1.pdf

7 Sustainability Framework

In this section we examine additional indicators of sustainability and describe a framework that could be used for assessing the sustainability risk of a biomass fuel.

RED II will set definitive sustainability requirements for solid and gaseous biomass used in installations above certain capacity thresholds. However, biomass will be used as an energy source below the RED II thresholds and there are other indicators of sustainability that extend beyond the RED II sustainability criteria, which are primarily concerned with the environmental impacts on GHG emissions, land use and carbon stocks.

IEA Bioenergy has reviewed several sustainability initiatives and identified a set of **environmental, economic** and **social** sustainability indicators. Using these indicators, in combination with the RED II requirements, we have developed a framework for examining the sustainability risk. The framework is built upon a 'decision tree' approach whereby answering a set of specific questions enables the user to determine the sustainability risks.

To assist with developing the framework and identifying the sustainability risks, we have applied the framework to the chosen supply chains. The framework is intended to inform SEAI on areas of potential sustainability risk. It could be refined further and used by a wider audience.

7.1 Introduction

RED II will set the sustainability requirements for solid and gaseous biomass when it comes into force in 2021, but there are other factors that could be considered when assessing the sustainability of a biomass fuel that go beyond the environmental criteria set out in RED II, and include economic and social criteria.

In this context, we have established a framework for assessing sustainability risk. The framework is built on the 'decision tree' approach[93], whereby answering specific questions determines where the risks may lie; it is designed to:

1. examine biomass sustainability under the RED II criteria;
2. identify other potential sustainability risks.

In addition, the process of applying the framework is a useful way of developing a wider understanding of sustainability and how a biomass fuel may impact on the environment, the economy and socially.
A flowchart illustrating the entire framework is provided in Appendix 6. In Section 7.2 we examine the IEA's research into additional sustainability indicators and, thereafter, in Section 7.3 we describe the additional sustainability indicators we have identified for inclusion in the framework.

7.2 IEA Bioenergy

IEA Bioenergy was established with the aim of improving cooperation and information exchange between countries that have national programmes for bioenergy research, development and deployment. It has several ongoing 'tasks', two of which are particularly relevant to this study:

- Task 38 – Climate Change Effect for Biomass and Bioenergy Systems
- Task 43 – Biomass Feedstocks for Energy Markets

[93] We include a synopsis of work carried out by Forest Research in Appendix 5; it describes and advocates using decision trees for conducting assessments of biomass sustainability.

There is some overlap between the tasks and both address biomass sustainability. In 2017, IEA Bioenergy published a report[94] that reviewed, *inter alia*, several sustainability initiatives, including: Global Bioenergy Partnership (GBEP) framework; ISO 13065 (Sustainability Criteria for Bioenergy); PROSUITE (Prospective Sustainability Assessment of Technologies); LEEAFF (Land use, Environment, Employment, Acceptability, Financial, Feedstock & Inputs); and an approach developed for the US Department of Energy. Typically, these sustainability frameworks apply to the whole supply chain and some can also be applied to products other than biomass.

The different sustainability frameworks have elements in common. All consider environmental, economic and social sustainability. There is a common core set of environmental indicators, similar economic indicators, but differing social indicators. The frameworks also differ in the intended end user and application, and the time and effort needed to complete. It was noted in the IEA report that *while the frameworks reviewed propose how sustainability should be described, none of the frameworks bring the user to the point where it can be said that biomass to bio-product pathway X is more sustainable than pathway Y. They enable the comparison of how X and Y rate with respect to defined sustainability indicators, or can track progression of a pathway over time if time series data are available. This outcome might not be adequate for some who search for a more definitive result.*

Table 10 is a listing of all the sustainability indicators that are contained in the sustainability schemes reviewed by the IEA (some of the indicators straddle two or more of the three categories).

The environmental indicators cater for the ecological properties, e.g. GHG emissions, air quality, surface and groundwater quality, soil conditions and land productivity. The economic indicators compare the cost of cultivating, processing, distributing and using the biomass fuel with other energy sources and capture other valuable economic contributions such as energy security and stability. The social indicators cover, *inter alia*, the price and supply of food, access to land, water and other natural resources, labour conditions, rural and social development, access to energy, and human health and safety.

Table 10: Sustainability indicators

Environmental	Economic	Social
GHG emissions	Energy diversity	Acceptability
Air quality	Gross value added	Labour rights
Water quality	Economic sustainability	Food security
Water use	Macroeconomic impact	Unpaid labour
Soil quality	Market demand	Access to bioenergy
Biodiversity	Change in consumption of fossil fuels	Mortality and disease attributed to indoor smoke
Biomass use	Infrastructure and logistics for distribution of bioenergy	Occupational injury, illness and fatality
Non-renewable resource use	Capacity and flexibility if use of bioenergy	Employment in bioenergy
Land use and land use change	Training and requalification of workforce	

We have developed a framework for qualitatively examining the sustainably risks using the above indicators, in combination with the RED II requirements.

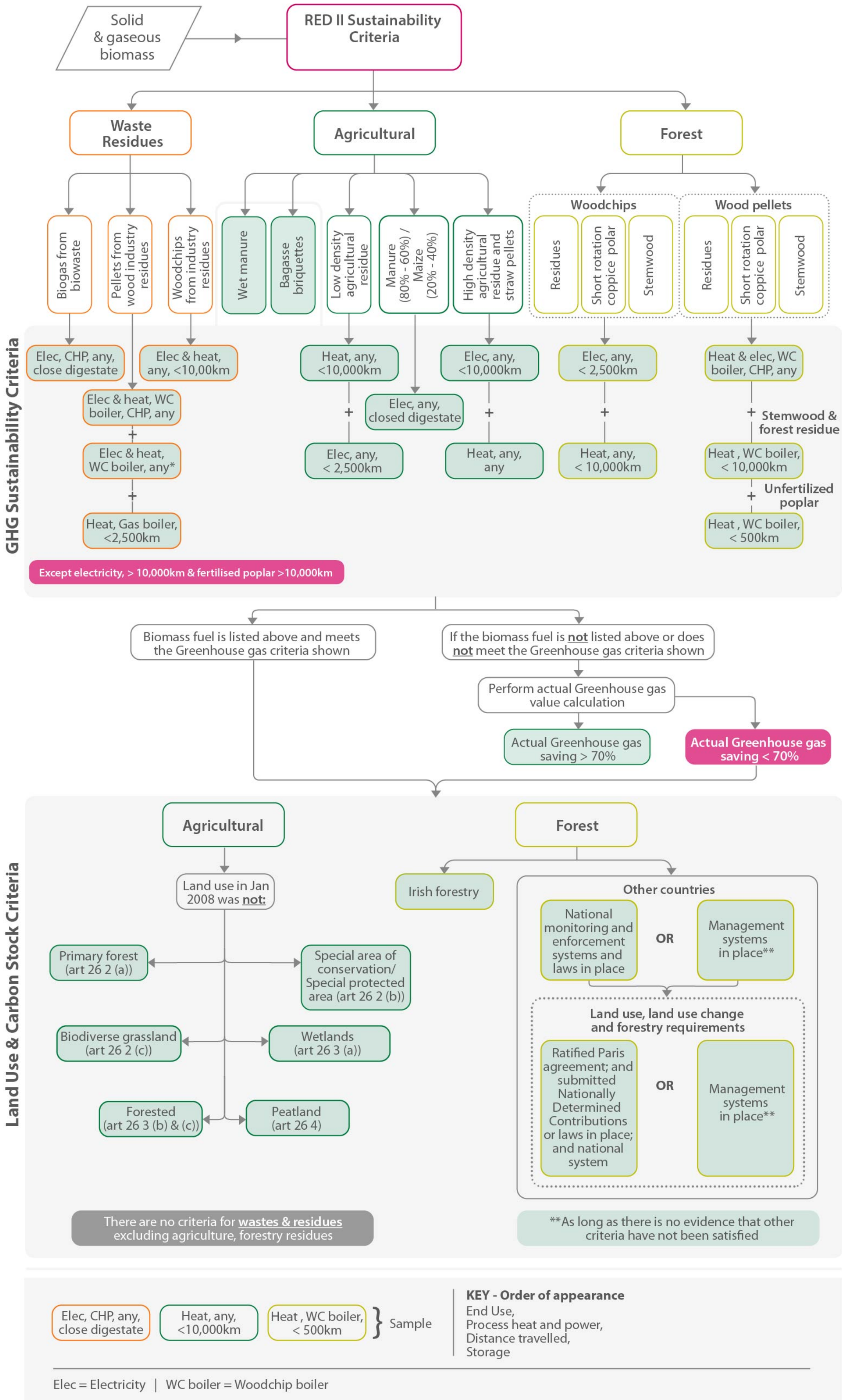
[94] http://www.ieabioenergytask43.org/wp-content/uploads/2017/03/TR2017-01-F.pdf

7.3 Sustainability under RED II

The first step in the framework is to examine the RED II sustainability requirements. Using the findings from our analysis of RED II and our examination of Irish legislation, we have identified the biomass fuels that meet the RED II GHG criteria and under what conditions the biomass fuels would satisfy the land use and carbon stock requirements. We have codified this in the flowchart overleaf. (The green nodes indicate that the applicable criteria are satisfied under the conditions specified.)

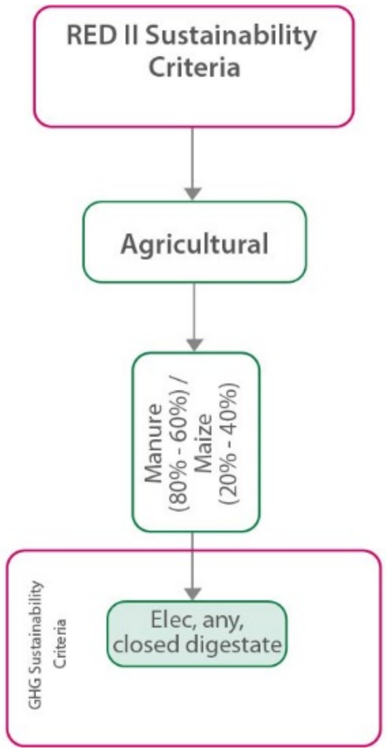
We have also incorporated the flowchart logic into a decision tree spreadsheet which assists in the process of examining sustainability. (Unless otherwise stated 'wastes & residues' means all wastes and residues, other than agricultural, aquaculture, fisheries and forestry residues.)

Figure 7-1: RED II logic, sustainability framework



We describe how to apply the flowchart logic in several steps.

1. The top half of the flowchart identifies the biomass fuels for which default values are provided in RED II. For example, 'Manure/maize', which is an agricultural biomass, satisfies the GHG savings requirements for mixes between 80:20 and 60:40, where the biogas is used for electricity production and the digestate is stored in a closed tank, i.e. a gas-tight tank.



For 'Wood pellets' made from stemwood (or SCR poplar or forest residues), the GHG savings requirements are satisfied where:

Heat or electricity, Woodchip CHP, All distances*

- the biomass is used for heat or electricity production;
- the power and heat required in the pellet mill are supplied by a CHP fired with pre-dried woodchips;
- the biomass is transported any distance.

For 'Wood pellets' made from stemwood & forest residues:

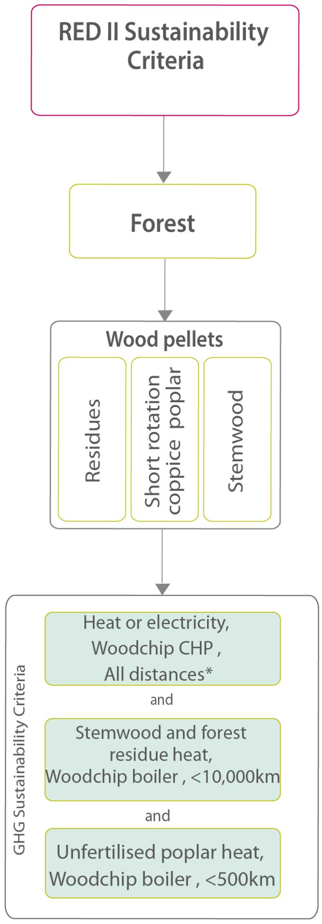
Stemwood and forest residue heat, Woodchip boiler, <10,000km

- the biomass fuel is used for heat production;
- process heat is supplied by a boiler fired with pre-dried woodchips and power for the pellet mill is supplied from the grid;
- the biomass is transported less than 10,000 km.

For 'Wood pellets' made from unfertilized poplar:

Unfertilised poplar heat, Woodchip boiler, <500km

- the biomass fuel is used for heat production;
- process heat is supplied by a boiler fired with pre-dried woodchips and power for the pellet mill is supplied from the grid;
- the biomass is transported less than 500 km.



2. If none of the biomass fuels are listed or if the conditions identified in the flowchart do not apply, then an actual GHG value calculation would be required to determine the GHG savings. If the savings are less than 70%, then the biomass would not meet the expected GHG savings requirements of RED II.
3. Upon determining the GHG savings, the land use and carbon stock requirements are examined. We determined in Section 3 that forest biomass produced in Ireland meets the land use and carbon stock criteria of RED II[95]. Because we have not assessed which other countries fulfil these criteria, there are some conditions to be met for forest biomass imports.
   For agricultural biomass, if the land is not categorised in January 2008 as one of those identified in Figure 7-1, then the land use and carbon stock requirements will be satisfied. As discussed in Section 3, each of the land types specified in Figure 7-1 are generally protected under Irish law, therefore almost all agricultural feedstocks from Ireland meet the land use, carbon stock and biodiversity criteria of RED II.
   The land use and carbon stock requirements do not apply to biomass fuels produced from wastes and residues (other than agricultural, aquaculture, fisheries and forestry residues).

Once the GHG savings and land use and carbon stock requirements have been examined, the RED section of the framework is complete and, in the context of RED II, it will be determined whether a biomass fuel may be deemed to be sustainable or not. The RED criteria are definitive – biomass has to comply with all the sustainability and GHG criteria. There is no scope to classify biomass fuels as anything other than sustainable or not sustainable in the context of the RED.

[95] Once RED II is implemented, economic operators will still have to demonstrate that they comply with the requirements, whether the forest biomass is grow in Ireland or outside.

7.4 Additional Sustainability Indicators

The next step is to examine the additional sustainability indicators and identify where the sustainability risks *may* exist, which is more subjective than examining the RED II requirements and the findings are not definitive. We have used the sustainability indicators listed in Table 10.

In each of the following sub-sections, we explain the indicators and the questions that need to be answered to identify where sustainability risks may exist. Based on the answers to these questions, a score is assigned under each indicator. The questions are answered sequentially, beginning at question 1, for each indicator. Some questions contain a qualifier (e.g. 'for forestry biomass') and should only be answered when applicable. Table 11 sets out the three outputs that can be assigned to each indicator depending on its score.

Table 11: Risk categories

Risk descriptor	Score	Note
Low / negligible	< 0.33	Risk is not considered to be significant.
Moderate	≥ 0.33, <0.67	Potential risk exists.
Investigate	≥ 0.67	A more detailed examination of how the risk arises is advisable.

The environmental indicators are more well defined in legislation, and so there are more of them and the questions posed are more specific. The economic and social indicators are more subjective and the questions are more general. This is because the concept of economic and social sustainability, and what determines a biomass fuel to be economically and socially sustainable, is not definitive; there isn't a single set of sustainability rules. In addition, the relationship between cultivating, processing and using biomass and economic and social activity is complex, and thus examining these indicators can be complex. We have attempted to negate this complexity by using questions that give some level of insight while not placing a large burden on the user of the framework.

The questions and scores can be modified and refined as more data is collected.

7.4.1 Environmental

The environmental indicators are listed in Table 12 and each is described in the following sub-sections.

Table 12: Environmental Indicators

Indicator		
GHG emissions	Soil quality	Water use
Carbon debt*	Biodiversity	Non-renewable resource change
Air quality	Biomass use	Land use and land use change
Water quality		
* Carbon debt does not appear as a separate indicator in the Task 43 framework. It has been added here to specifically address the issue of carbon debt in forestry.		

7.4.1.1 GHG Emissions

This indicator builds upon the findings from the RED II GHG emission assessment carried out in the first step of the framework. The scoring considers the level of GHG savings above the expected threshold value of 70%. In the case of sawmill residues, scores are deducted if the raw material itself, i.e. the material from which residue was produced, is not sourced from sustainable forestry.

No.	Question / Means of assessment	Assessment	Score	Note
1	What is the GHG saving, as calculated using the RED II methodology? (Where the fuel is used for heat and electricity, use the average heat and electricity savings value.)	< 70%	1	If GHG saving is less than 70%, the biomass fuel is not sustainable under RED II.
		≥ 70%, < 80%	0.67	-
		≥ 80%, < 90%	0.33	-
		≥ 90%	0	-
2	Sawmill residue Was the raw material harvested in accordance with the requirements for sustainable forest biomass production (para 5 sub-para 6) of RED II?	Yes	-	Answer is 'Yes' where the saw mill is certified to FSC/PEFC.
		No	Increase score to 1	Where the raw material used in the sawmill does not meet the requirements, it should be assigned the highest risk score for this indicator.

7.4.1.2 Carbon Debt

The concept of carbon debt is covered in Section 6.9 and concerns the time lag between when CO_2 is emitted, i.e. when the biomass fuel is burned, and when it is reabsorbed as new biomass grows.

No.	Question / Means of assessment	Assessment	Score	Note
1	Is the biomass from forestry?	Yes	1	Carbon debt is primarily a concern for forest biomass. For annual biomass crops, this debate is less relevant as the carbon cycle is a lot shorter.
		No	0	
2	Forestry biomass Is the harvest period of the forest ≥ 40 years and is ≥ 50% of the annual production of round wood used for biomass?	Yes	-	This is a requirement of sustainability criteria set out by the Netherlands Enterprise Agency.
		No	-0.5	
3	Forestry biomass Does the biomass contain stumps, where the stumps were removed for no other reason than the production of wood or biomass?	Yes	-	Forest Research (2016) identified the harvesting of stumps as 'high risk' for negatively impacting soil carbon stock and biodiversity. The harvesting of stumps is prohibited under the Netherland's Verification Protocol for Sustainable Biomass, unless for reasons other than wood or fuel production. In addition, the harvesting of stumps was excluded in the scenarios modelled under the GLOBIOM study.
		No	-0.5	

For the purposes of avoiding long-term carbon debt, the Netherlands Enterprise Agency's Verification Protocol for Sustainable Biomass (discussed in Section 5.4) requires that less than 50% of the annual round wood harvest from forests with rotations of 40 years or more be processed as biomass for energy generation, i.e. all the wood cannot be used for energy generation, which is permitted under RED II. It also prohibits biomass sourced from production forests that were created by means of conversion of natural or semi-natural forest after 31 December 1997. (See Section 6.9 for further discussion of carbon debt.)

7.4.1.3 Air quality

This indicator covers emissions that impact on human health as well as the environment. Air quality is a significant problem for many countries, and is of particular concern in urban areas. Biomass production, as well as consumption, may pose a risk to air quality.

The score is assigned based on the type of biomass (i.e. solid or gaseous) and whether the country in which the biomass was extracted/cultivated and processed has laws in place relating to the monitoring and enforcement of air quality

No.	Question / Means of assessment	Assessment	Score	Note
1	Cultivation / extraction and processing Does the area(s) in which the biomass was extracted/cultivated and processed have laws in place relating to the monitoring and enforcement of air quality?	Yes	0	This is taken to be the case for biomass sourced from EU Member States. For biomass sourced from countries outside the EU, the laws must be comparable to those enforce within the EU: • Directive 2008/50/EC on ambient air quality and cleaner air for Europe; • Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air; • Industrial Emissions Directive (2010/75/EU); • National Emissions Ceiling (NEC) Directive (2016/2284/EU).
		No	0.5	
2	Consumption Is the fuel a solid biomass or biogas/ biomethane?	Solid	+0.5	These scores reflect the higher PM emission factors for wood (including pellets) compared to those for biogas / biomethane.
		Biogas/ biomethane	-	

This indicator could be further developed to reflect the growing concern about pollutants such as NOx, SOx and PM. It could also be refined to consider biogas, biomethane and solid biomass emission factors for such pollutants and take account of the expected combustion technology. The EMEP/EEA air pollutant emission inventory guidebook[96] and database contains emission factors for wood, waste wood and methane, and takes account of the combustion technology (e.g. pellet stove / boiler, gas turbine, natural gas boiler).

7.4.1.4 Water quality

Cultivating and processing biomass can impact on water quality, by polluting surface and ground waters via application of fertilizers and pesticides, for example. In Ireland and the EU, water quality is protected by law.

[96] EEA (2016). *EMEP/EEA air pollutant emission inventory guidebook 2016*. https://www.eea.europa.eu/publications/emep-eea-guidebook-2016

No.	Question / Means of assessment	Assessment	Score	Notes
1	Does the area(s) in which the biomass was extracted/cultivated and processed have laws in place relating to monitoring and enforcement of water quality?	Yes	0	This is taken to be the case for biomass sourced from the EU. Outside the EU, laws must be comparable to those enforce within the EU: • Water Framework Directive (200/60/EC) covering rivers, lakes, groundwater, estuarine and coastal water; • Industrial Emissions Directive (2010/75/EU); • Groundwater Directive 2006/118/EC.
		No	1	

7.4.1.5 Water use

Water is a resource that has been a source of debate in Ireland in recent years. While the energy used to pump water in cultivating, extracting and processing biomass[97] is captured in the GHG methodology of RED II, the energy used to produce (i.e. treat) the water and the amount of water consumed is not captured. Likewise, the RED II sustainability requirements do not address the environmental effects of excessive water consumption in the source area.

	Question / Means of assessment	Assessment	Score	Notes
1	Where biomass cultivation occurs on irrigated lands, what is the baseline water stress indicator in the country (or region, if data is available) of origin?	> 3	0.5	The baseline water stress[98] score, used by the World Resource Institute (WRI), measures the ratio of total water withdrawals (by industry, agriculture, and domestic users) to the available supply, taking into account upstream uses and depletion of water. The indicator ranges from 0 (low stress) to 5 (extremely high stress). Ireland has a score of 2.92 (medium-high stress) – although this varies significant depending upon the location within the country.
		≤ 3	0	
2	Is water use in processing the biomass in excess of industrial norms?	Yes	+0.5	Data would need to be gathered on what is a ‘normal' quantity of water.
		No	-	

As was the case for air quality, this indicator could be further developed, if it was found that large volumes of water were being used in any of the biomass production steps.

[97] In the context of solid and gaseous biomass, water use is most relevant for cultivating biomass, specifically if artificial irrigation systems are used.

[98] An interactive map can be used to find the baseline water stress score (http://www.wri.org/our-work/project/aqueduct/). The following report explains the basis for the scores: *Aqueduct country and river basins rankings: A weighted aggregation of spatially distinct hydrological indicators*, World Resources Institute, working paper, December 2013.

7.4.1.6 Soil quality

Under RED II, biofuels, bioliquids and biomass fuels from forestry must be subject to monitoring and enforcement systems to ensure that, inter alia, 'the impacts of forest harvesting on soil quality and biodiversity are minimised.' There is no such requirement for agricultural biomass. While there are three Good Agricultural and Environmental Conditions (GAECs) in the EU's common agricultural policy (CAP) relating to soil and carbon stock (listed below), there is no EU or Irish legislation that sets specific soil quality parameters, similar to those for air and water quality.

1. GAEC 4, minimum soil cover
2. GAEC 5, minimum land management reflecting site specific conditions to limit erosion
3. GAEC 6, maintenance of soil organic matter level through appropriate practices including ban on burning arable stubble, except for plant health reasons.

No	Question / Means of assessment	Assessment	Score	Notes
1	Is the biomass sourced from forestry or wastes & residues?	Yes	0	All forestry must meet the RED II criteria for soil quality. It is assumed that biomass from wastes & residues do not impact on soil quality.
		No	1	
2	Is biomass from agriculture sourced from an EU Member State?	Yes	-1	EU CAP provides for the protection of soil quality.
		No	-	
3	Where biomass from agriculture is not sourced from the EU, is there a soil management plan in place in the source area?	Yes	-1	
		No	-	

This indicator could be further developed by examining whether a soil management plan provides for a *sustainable removal rate* for agricultural and forestry residues, as discussed in Section 6.8.

7.4.1.7 Biodiversity

The impact of biomass cultivation on biodiversity is addressed in Article 26 (2) of RED II for agriculture and Article 26 (5) for forestry. Agricultural and forestry biomass that complies with the RED II criteria are deemed to be of low risk of causing damage to biodiversity. This indicator builds upon the RED II approach by including for wastes and residues, in general, and sawmill residue specifically.

No.	Question / Means of assessment	Assessment	Score	Notes
1	Is the biomass from forestry or agriculture (including forestry or agriculture residues)?	Yes	0	If it meets the RED II criteria, this is sufficient.
		No	1	
2	In the case of sawmill residues, is the wood harvested in accordance with the biodiversity criteria (para 5 sub-para 5) of RED II?	Yes	-1	Under RED II, wastes & residues* are exempt from complying with the biodiversity criteria under RED II.
		No	-	
3	Where the biomass is derived from a waste & residue* (other than sawmill residue), was the material from which the waste or residue was generated cultivated in accordance with the biodiversity requirements of RED II?	Yes	-1	
		No	-	
* Wastes & residues means all wastes and residues, other than agricultural, aquaculture, fisheries and forestry residues.				

7.4.1.8 Biomass use

This indicator aims to capture the benefits of using less carbon intensive fuels to produce the biomass fuel. While the carbon intensity of the biomass is calculated and included in the RED II assessment, this indicator provides explicit recognition for using renewable fuels in the biomass production process.

	Question / Means of assessment	Assessment	Score	Note
1	Which of the following energy types provide the largest share of the energy input to processing the biomass?	Biomass fuel	0	-
		On-site renewables	0	-
		Grid electricity	0.5	Electricity is generated using fossil fuels and renewable fuels.
		Fossil fuel	1	-

7.4.1.9 Non-renewable resource use

While we have not identified any non-renewable resources of concern (other than fossil fuels) that may be consumed in biomass production and use, as technologies are developed and brought to market, it may be that, akin to cobalt and lithium for EV batteries, non-renewable resources are used.

No.	Question / Means of assessment	Assessment	Score	Note
1	Are non-renewable resources used in extracting/cultivating or processing the biomass (e.g. catalysts)?	Yes	0.5	-
		No	0	-
2	Are non-renewable resources used in the process of combusting the biomass fuel?	Yes	+0.5	-
		No	-	-

Land use and land use change

As discussed in Section 2.2, the ILUC debate is often framed as 'food versus fuel'. The most recent report commissioned by the EC used the GLOBIOM model to estimate indirect land -use change GHG emissions ('ILUC factors') for various feedstocks[99] (see Section 6.8.3). Thus, by reference to this report, it can be established what the current position is with respect to indirect emissions that may arise from land use change. The LUC factors presented in the GLOBIOM study were calculated as gCO_{2eq} per MJ of biofuel (i.e. liquid) and not per MJ of biomass; notwithstanding this, these values can be used to assess the LUC risk associated with a feedstock.

ILUC emissions are not included in the RED II GHG emission calculation methodology for operators.

No.	Question / Means of assessment	Assessment	Score	Note
1	What is the risk that cultivating the biomass could result in significant Land-Use Change (LUC) emissions?	Low	0	Corresponding to a LUC emission ≤ 0 gCO_{2eq}/MJ using the GLOBIOM model (e.g. perennials – Miscanthus and SRC, wastes & residues).
		Medium	0.33	Corresponding to a LUC emission of 0 – 20 gCO_{2eq}/MJ using the GLOBIOM model (e.g. forest residues, forest stemwood*, straw**).
		High	0.67	Corresponding to a LUC emission > 20 gCO_{2eq}/MJ using the GLOBIOM model (e.g. maize)
2	Does the country of origin of the feedstock meet the LULUCF requirements in Article 26 (6) of RED II?	Yes	-	-
		No	+0.33	-
* For forest stands planted after January 2008, apply the decision tree in the Netherland's Verification Protocol for Sustainable Biomass to determine that there is no elevated risk of ILUC. ** For straw harvesting, a removal rate of 40% is considered to be sustainable[100], i.e. 40% of straw is harvested every year, or all straw is harvested on average once every 2.5 years.				

7.4.2 Economic

The economic indicators are listed in Table 13 and each is described in the following sub-sections.

Table 13: Economic Indicators

Indicator	
Energy diversity	Change in consumption of fossil fuels
Gross value added	Infrastructure and logistics for distribution of bioenergy
Economic sustainability	Capacity and flexibility of use of bioenergy
Market demand	Training and requalification of workforce

There are two economic indicators listed in the IEA Bioenergy study that are not examined in the framework: macro-economic impact and training and requalification of workforce. The macro-economic factor is accounted for in three other indicators (gross value added, economic sustainability and market demand) and thus it is not included as a stand-alone indicator.

[99] Ecofys, IIASA and E4tech (2015). *The land use change impact of biofuels consumed in the EU: Quantification of area and GHG impacts* https://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report_GLOBIOM_publication.pdf

[100] Ecofys (2013). *Low ILUC potential of wastes and residues for biofuels.* https://www.ecofys.com/files/files/ecofys-2013-low-iluc-potential-of-wastes-and-residues.pdf

In relation to the workforce, a lack of expertise or the requirement for extensive retraining of the workforce could act as an economic barrier to bringing a biomass fuel to the market. Conversely, there may be an opportunity for the Irish workforce to develop specialist expertise in a bioenergy technology or capitalise on existing expertise in cultivation. Because a need to retrain or requalify could be considered to be both a positive and a negative, we have not attributed a risk score under this indicator. However, it is important to know if the workforce does require training, for planning purposes, and we do include a question to capture this.

7.4.2.1 Energy security & diversity

Approximately 3.2% of Ireland's primary energy requirement was met by bioenergy (biomass and renewable waste, biogas and liquid biofuel) in 2016, according to SEAI's Energy in Ireland Report[101]. An increase in bioenergy's contribution to Ireland's energy requirement would increase energy diversity by displacing fossil fuel imports. Energy security also needs to be considered. For example, relying on a single supplier or single country of origin could mean that supplies could be reduced or stopped completely by a single disruption in the supply chain.

No.	Question / Means of assessment	Assessment	Score	Notes
1	Is the biomass extracted / cultivated and processed in Ireland?	Yes	0	We consider that biomass extracted / cultivated and processed within Ireland improves energy diversity and security.
		No	1	
2	Is the biomass extracted / cultivated and processed in another Member State?	Yes	-0.25	Laws and regulations in other Member States are likely to remain aligned with those in Ireland and, thus, there is a low risk of regulatory change that would impact supply to Ireland.
		No	-	
3	Where biomass is **not** extracted / cultivated and processed in Ireland, what proportion of Ireland's biomass consumption is provided by the country of origin?	≤ 10%	-0.5	This is to reflect the risk to Ireland's biomass supply from a disruption to a supply chain. The more reliant Ireland is on a single supplier, the greater the risk to energy security.
		> 10%, <= 50%	-0.25	
		> 50%	-	

7.4.2.2 Gross value added

Rather than delving into a detailed economic assessment of the biomass fuels, the questions are aimed at getting a broad indication of the contribution that bioenergy production could have on the Irish economy.

No.	Question / Means of assessment	Assessment	Score	Notes
1	Is the biomass extracted / cultivated and processed in Ireland?	Yes	0	-
		No	0.75	
2	At current and foreseeable production levels, is there a potential for Ireland to become a net exporter of the biomass or biomass fuel?	Yes	-	-
		No	+0.25	

7.4.2.3 Economic sustainability

It may be necessary to support both the production and supply of the biomass fuels, and to promote its consumption, rather than leave it to the market to dictate. For example, biofuels are supported by an exemption from carbon tax and oil companies are required to meet a blending obligation; renewable electricity is supported by REFIT (Renewable Energy Feed-In Tariff). To assess the economic sustainability of a biomass, the country of origin and the presence of state support (either by financial subsidies or obligation) are assessed.

[101] http://www.seai.ie/resources/publications/Energy-in-Ireland-1990-2015.pdf

Question / Means of assessment	Assessment	Score	Note
Which of the following apply?	Ireland does not provide state support to biomass production, supply, or consumption.	0	This is the most economically sustainable case; the production and consumption of the biomass is not reliant on any state support.
	Biomass is extracted/cultivated and processed in Ireland and is supported by the state (on supply and/or demand side).	+0.5	The use of the biomass is dependent on Irish state support. A change of policy, e.g. removal of state support, would pose a risk to the economic viability of the biomass
	Biomass is extracted / cultivated and processed in another country, but is not supported by that state. Biomass consumption is provided with state support in Ireland.	+0.5	
	Biomass is extracted / cultivated and processed in another country and the production is supported by that state (e.g. subsidies or mandates).	1	Biomass production is subject to support from another state; changes in that support pose a risk to the supply of the biomass to the Irish market.

7.4.2.4 Market demand

Market demand will depend on several factors – cost is typically the most important. The most appropriate means of comparing the cost of different fuels and technologies is to use the levelised cost of energy (LCOE). The LCOE represents the total cost per unit of energy produced from a plant (e.g. heat from a boiler) over its lifetime; it includes the capital investment, operational and fuel costs. This indicator measures the relative cost of fossil fuel and biomass fuel. Where the LCOE is available, this should be used.

No.	Question / Means of assessment	Assessment	Score	Note
1	Rate the economic competitiveness of the biomass fuel with its fossil fuel equivalent.	Low	+1	The cost of biomass fuel is significantly higher than fossil fuel.
		Medium	+0.5	The cost of biomass fuel is broadly similar to fossil fuel.
		High	0	The cost of biomass fuel is significantly lower than fossil fuel.

There is some level of overlap between some of the economic indicators. In the case of this indicator, market demand may be dependent on state support and, therefore, the more state support provided, the more competitive a fuel may become. The impact of state support should be excluded when assessing the score.

7.4.2.5 Change in consumption of fossil fuels

If a biomass fuel is to be considered for support, the characteristics of the fuel being replaced are important. A biomass fuel that replaces oil would be more beneficial than replacing grid electricity, for example. This indicator measures the reduction in CO_{2eq} emissions relative to the fossil fuel it is replacing. While the assessment is based on GHG emissions, and it could be included in the environmental indicators, it is listed as an economic indicator by the IEA.

No.	Question / Means of assessment	Assessment	Score	Note
1	What fuel is being replaced by the biomass or biogas (in the majority of cases)?	Fossil fuel	0	-
		Grid electricity	+0.5	The emission factor for grid electricity is 126.8 gCO_{2eq}/MJ[102], corresponding to a 31% saving in GHG compared to the fossil fuel comparator for electricity that is provided in RED II (183 gCO_{2eq}/MJ).
		Other renewables	+1	-

In 2016, 27.2% of Ireland's gross electricity consumption came from renewable electricity (source: Eurostat). We have conservatively assumed that displacing grid electricity poses a moderate risk to change in the consumption of fossil, i.e. it has the potential to displace other renewables rather than fossil fuel.

7.4.2.6 Infrastructure and logistics for distribution of bioenergy

A biomass fuel may meet all the sustainability criteria, but the supply chain may need to be significantly altered to provide a route to market. This would require investment and it would take time. In this context, we consider it more sustainable where a biomass fuel requires less supply chain change. This indicator covers the infrastructure and logistics required to distribute the bioenergy, e.g. extension of the natural gas grid to allow for injection of methane or redevelopment of port facilities for importing solid biomass. This indicator does not include the development of infrastructure required for cultivating, extracting or processing the biomass, which is covered in section 7.4.2.7, e.g. construction of forestry roads for extraction of forest thinning or construction of wood-pelleting plants.

No.	Question / Means of assessment	Assessment	Score	Note
1	Required level of development or modification of existing distribution infrastructure.	High	1	Requires extensive development of new infrastructure
		Medium	0.5	Requires significant modification of existing infrastructure
		Low	0	Minor or no modification of existing infrastructure

[102] CO_2 intensity of electricity in 2015, as reported in SEAI's 2016 report: *Energy-Related Emissions in Ireland*.

7.4.2.7 Capacity and flexibility of use of bioenergy

There are two aspects considered in this indicator: the impact on the supply chain and the impact on the end user. Like the previous indicator, we consider it more sustainable where there is existing capacity in place to bring the fuel to market and the end user has the means to use the fuel.

No.	Question / Means of assessment	Assessment	Score	Note
1	Cultivated / extracted in Ireland What is the current availability and short-term capacity to cultivate / extract the feedstock in Ireland?	High	0	This reflects the availability of the feedstock in the short term.
		Medium	0.17	
		Low	0.33	
2	Cultivated / extracted in Ireland (excludes wastes and residues) What is the growth period of the feedstock?	≤ 2 years	-	This reflects the lead-in time for increasing production of the feedstock.
		> 2 years	+0.17	
3	Processed in Ireland What is the current and short-term capacity to process the feedstock in Ireland?	High	-	If processing capacity is currently low and the lead-in time for increasing capacity is greater than one year, then the biofuel should be assigned a 'low' status.
		Medium	+0.17	
		Low	+0.33	
4	Cultivated / extracted and processed in another country Globally, what is the current availability and short-term capacity to cultivate / extract and process the biomass fuel?	High	-	-
		Medium	0.33	
		Low	0.67	
5	Consumption To change from the fossil fuel equivalent, the final energy consumer will require:	Significant capital investment (e.g. new plant / equipment)	+0.33	The assessment will depend on the size and consumption of the end-user.
		Moderate capital investment (e.g. modification of existing plant)	+0.17	
		Minor or no capital investment	-	

7.4.3 Social

The breakdown of the social indicators is provided in Table 14 and each one is described in the following sub-sections.

Table 14: Social Indicators

Indicator
Acceptability
Labour rights
Food security
Employment in bioenergy

There are four indicators listed in the IEA Bioenergy study that are not covered in the framework: access to bioenergy (as a means to improve access to energy); change in unpaid labour; mortality and disease attributed to indoor smoke; and occupational injury, illness and fatality. In a developed country, such as Ireland, the potential for biomass to improve the population's access to energy or decrease time spent in unpaid labour (e.g. collecting fuel) is negligible. Likewise, it has been assumed that the consumption of biomass in Ireland will not have any effect on mortality or disease rates attributed to indoor smoke from solid fuel.

The risk of occupational injury in the production or processing of biomass in Ireland is addressed by extensive health and safety legislation (mostly under the Safety, Health and Welfare at Work 2005) and various initiatives and programmes run by the Health and Safety Authority (e.g. the Farm Safety Action Plan). We consider the impact of increased biomass fuel production on the rates of occupational injury within the state to be beyond the scope of this assessment.

Occupational injury, illness and fatality in other countries of origin are reflected in the labour rights indicator detailed in Section 7.4.3.2.

7.4.3.1 Acceptability

This indicator reflects the broad opinion towards extracting / cultivating, processing and using the biomass. Gauging stakeholder and public opinions towards the production and use of a particular biomass fuel can help in assessing its potential viability on the Irish market. Stakeholders include, for example, farmers, forestry owners, processing plant operators, importers, distributers and industrial/commercial end users. Policy makers could assess stakeholder and public opinion as a first step towards addressing any concerns that stakeholders or the public may have towards a particular biomass.

No.	Question / Means of assessment	Assessment	Score	Notes
1	What is stakeholder opinion towards extracting / cultivating, processing and using the biomass?	Favourable	0	Almost all stakeholders have a favourable or neutral opinion.
		Neutral	0.25	Opinion is broadly neutral or significantly divided between favourable and unfavourable.
		Unfavourable	0.5	Opinion is broadly unfavourable towards the production and/or use of the biomass.

No.	Question / Means of assessment	Assessment	Score	Notes
2	What is public opinion towards the use (consumption) of the biomass?	Favourable	-	-
		Neutral	+0.25	
		Unfavourable	+0.5	
3	Are additional measures required to raise awareness of the biomass as an alternative to non-renewable energy consumption through the provision of information or advice to end users?	-	-	No score assigned for this question. This is included as an aid to prompt policy makers to identify where measures may be required to address concerns or lack of information on the part of end users or the public.

7.4.3.2 Labour rights (and Unpaid labour)

This indicator assesses the current status of labour rights within the country of origin of the feedstock. EU Member States and other countries that have ratified and implement each of the conventions of the International Labour Organisation are considered to have met the requisite standards for labour rights. This may be updated in the future as the Commission publish additional guidance.

No.	Question / Means of assessment	Assessment	Score	Notes
1	Is the cultivation / extraction and processing carried out within the EU?	Yes	0	-
		No	1	
2	If cultivated / extracted outside the EU, has the country of origin ratified and implemented each of the Conventions of the International Labour Organisation?	Yes	-1	Under RED, the Commission reports every two years on whether a country that is a significant source of raw material for biofuel has ratified each of the conventions of the International Labour Organisation. This can be used to determine the answer to this question.
		No	-	

7.4.3.3 Food security

This indicator assesses the impact of biomass production on food security in the country of origin. Potentially, cultivating biomass could displace the cultivation of crops for food, particularly in developing counties.

As Ireland is a net exporter of food, it is unlikely that producing biomass in Ireland would negatively impact Ireland's food security.

No.	Question / Means of assessment	Assessment	Score	Notes
1	Is cultivation / extraction carried out within the EU?	Yes	0	-
		No	1	-
2	If cultivated / extracted outside the EU, has the production of biomass diverted feedstock from the food chain and impaired food security (e.g. price volatility)?	No	-1	Under RED, the Commission reports every two years on the impact of EU biofuel policy on the availability of foodstuffs at affordable prices, in particular for people living in developing countries.
		Yes	-	

7.4.3.4 Employment in bioenergy

This indicator reflects employment directly supported by the production of the biomass fuel within Ireland; it does not address the numbers of people employed. The assessment excludes people employed in Ireland in the distribution of the biomass fuel as it is assumed that they would otherwise be employed in the distribution of a fossil fuel equivalent.

No.	Question / Means of assessment	Assessment	Score	Notes
1	Are people in Ireland directly employed in cultivating / extracting or processing the biomass?	Yes	0	'Yes' where the biomass is cultivated / extracted and processed in Ireland, otherwise 'No'.
		No	1	

7.5 Framework Tool

We developed a spreadsheet tool (Ref. 533-18P0098) to assist with examining biomass supply chains under the sustainability framework. The spreadsheet contains the questions set out in Sections 7.4.1, 7.4.2 and 7.4.3 and relies on the relationships between answers to reduce the number of questions to be answered. For example, if a biomass is grown in Ireland, the scores for questions such as: '*Is the cultivation/extraction carried out within the EU?*' and *'Is biomass from agriculture sourced from an EU Member State?',* are automatically allocated. This reduces the number of questions to be answered and simplifies the framework. The spreadsheet displays the category of risk (low / negligible, moderate or investigate) for each of the sustainability indicators.

7.6 Application of Framework

We have applied the sustainability framework to the biomass fuels of interest to assist with developing the framework and understanding how the findings can be interpreted and presented. It should be noted that members of the study team answered the questions, rather than SEAI or other stakeholders, using typical input value for each biomass fuel. In this instance, the purpose of applying the framework to the biomass fuels is to identify the indicators to which sustainability risks may apply and to present how the results could be interpreted, using what we consider to be reasonable inputs values. The results should not be interpreted to be SEAI's position on the sustainability of each biomass fuel – it is an illustration of how the results of the framework could be presented and how useful the results could be when comparing different biomass fuels. There are limitations to this approach and the results should be interpreted with caution; the risks under different indicators are not comparable.

The first step in the application of the framework is the assessment of the biomass fuels under RED II. A summary of each fuel's compliance with the Directive is provided in Table 15.
For the purposes of this study, it is assumed that each fuel meets the land and carbon stock criteria of the RED II. As discussed in Section 3, agricultural and forestry biomass from Ireland is, in most cases, likely to meet the criteria; however, for RED II compliance, this would need to be demonstrated. The GHG savings can vary, depending on the input parameters (see Section 6.6 and 6.7).

Table 15: Summary of RED II compliance - sample biomass fuels

Biomass fuels	GHG Savings Note 1		Land & carbon stock	RED II Sustainability
	Electricity	Heat		
Sawmill residue chip (IE)	97%	98%	N/A	Yes
Forest residue chip (IE)	95%	95%	Compliant	Yes
Forest residue pellet (IE)	83%	85%	Compliant	Yes
Forest residue pellet (USA)	69%	73%	Compliant	No / Yes Note 2
Straw pellet (IE)	91%	92%	Compliant	Yes
Miscanthus bale (IE)	88%	89%	Compliant	Yes
Miscanthus pellet (IE)	82%	85%	Compliant	Yes
SRC Willow chip (IE)	79%	81%	Compliant	Yes
SRC Willow pellet (IE)	71%	75%	Compliant	Yes
Grass silage biogas (IE)	30%	43%	Compliant	No
Wet manure biogas (IE)	173%	159%	Compliant	Yes
Grass silage – wet manure biogas (IE)	71%	76%	Compliant	Yes

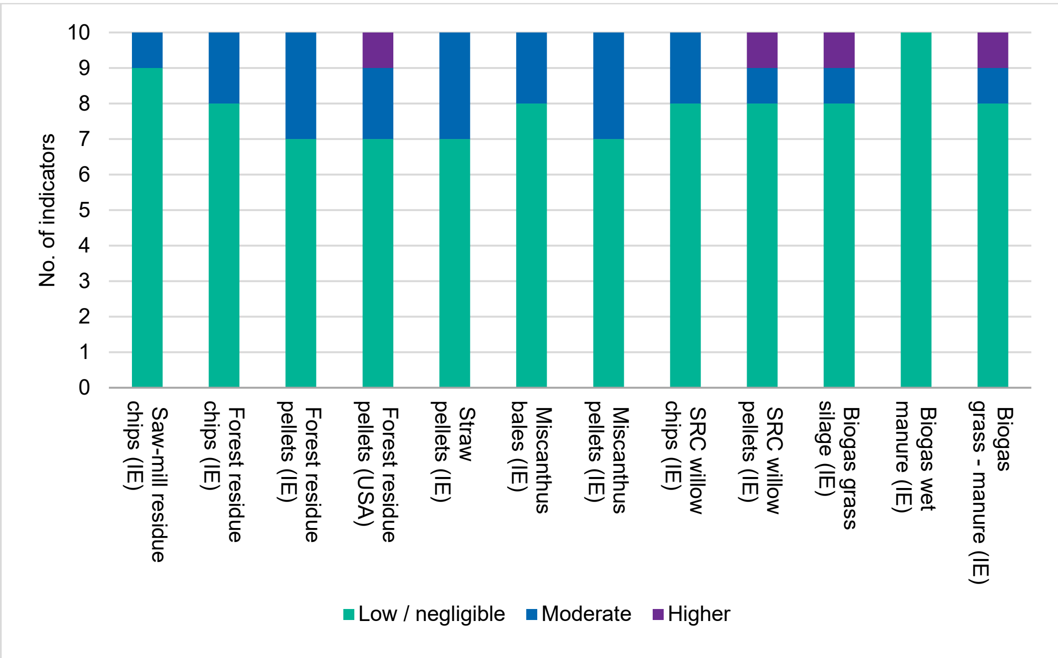
Note 1: GHG savings are those calculated by Navigant using values typical in Ireland (see Section 6.6). For solid biomass, electrical and heat efficiencies were taken to be 32.5% and 85%, respectively. It is assumed that the biogas is used in CHP plant with electrical and heat efficiencies of 33% and 40%, respectively.
Note 2: Electricity generated from forest residue pellets (USA) does not meet the GHG saving criterion; however, the heat generated does meet the criterion.

The next step in the framework is to apply the additional sustainability indicators. The results are summarised in Figure 7-2 for the environmental indicators, Figure 7-3 for the economic indicators and Figure 7-4 for the social indicators. The risks associated with each indicator are set out in more detail in Table 17. Each indicator was assigned one of three risk categories (shown in Table 16) for each biomass fuel.

Table 16: Risk categories with colour code

Risk descriptor	Score	Note
Low / negligible	< 0.33	Risk is not considered to be significant.
Moderate	≥ 0.33, <0.67	Potential risk exists.
Investigate	≥ 0.67	A more detailed examination of how the risk arises is advisable.

Figure 7-2: Qualitative risk - environmental indicators

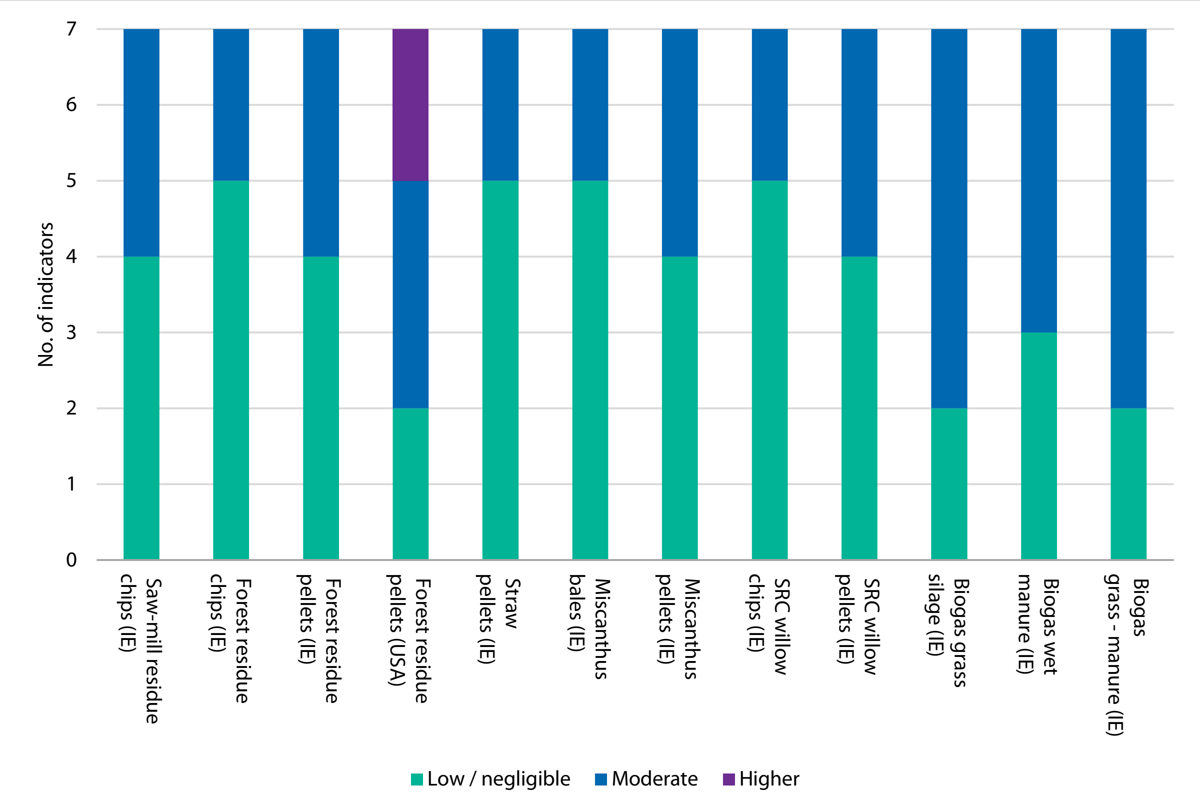


The results shown in Figure 7-2 and Table 17 for the environmental indicators should be interpreted as follows.

- The biomass fuels have a low or negligible environmental risk for the majority of the environmental indicators.
- The red bars indicate where there is an environmental risk that should be investigated further. These risks are associated with forest residue pellets (USA), SRC willow woodchips, SRC willow pellets, biogas from grass silage and biogas from a grass-manure mix (50% grass, 50% manure). Table 17 shows that each of these fuels has a higher risk associated with the *GHG emissions* indicator.
- Biogas from grass silage may not meet the expected RED II GHG saving threshold of 70% for electricity and heat. As discussed in Section 6.6, we estimate biogas from grass silage to have a GHG saving of 30%/43% (electricity/heat).
- Biogas from grass-manure (40%:60%) mix will meet the RED II GHG saving threshold for both heat and electricity; however, its GHG saving is below 80%.
- Heat generated from forest residue pellets (USA) should meet the RED II GHG saving threshold; however, electricity generated from the fuel may not.
- Heat and electricity generated from SRC willow pellets both meet the RED II GHG saving threshold; however, its GHG savings are estimated to be below 80%.
- Forest residue pellets (IE), Miscanthus bales and Miscanthus pellets and SRC willow woodchip present moderate GHG emissions risks because their estimated GHG savings fall in the 80%-90% range.
- All the solid biomass fuels present moderate air quality risks: sawmill residue woodchips; forest residue chips and pellets (IE); forest residue pellets (USA); straw pellets; Miscanthus bales and pellets; and SRC willow chips and pellets. The actual risk will depend on the combustion and abatement technology.
- Straw pellets and Miscanthus pellets present moderate biomass use risks, assuming electricity is used as the energy input in the pellet processing stage.
- Six of the biomass fuels present moderate ILUC and LUC risks: forest residue woodchips & pellets (IE); forest residue pellets (USA); straw pellets; biogas from grass silage[103]; and biogas from a grass-manure mix. These qualitative risks were assigned based upon the results of GLOBIOM (discussed in Section 6.8 and 7.4.1.10).

[103] It is assumed that there is a small positive LUC emission (0 – 20 gCO_{2eq}/MJ) associated with grass as a feedstock similar to maize silage feedstock evaluated in the GLOBIOM study, see section 6.8.3.

Figure 7-3: Qualitative risk - economic indicators



The results shown in Figure 7-3 and Table 17 for the economic indicators should be interpreted as follows.

- All the biomass fuels present a low / negligible *energy security & diversity* risk, except for forest residue pellets (USA), which presents a moderate risk.
- All of the biomass fuels present a low / negligible *gross value-added* risk. The exception is forest residue pellets (USA), which have a higher risk as a result of being cultivated and processed outside Ireland.
- All the biomass fuels, except for forest residue pellets (USA), present a moderate risk to *economic sustainability* – it is assumed that all these fuels are in receipt of financial support from the state. It is also assumed that cultivating forestry in the USA is supported by the state; therefore, the risk to *economic sustainability* associated with forest residue pellets (USA) is higher than the other fuels.
- All the fuels present a moderate *market demand* risk because it was assumed that their market price is similar to their fossil fuel equivalent. The price of woodchips and pellets from domestic sources is broadly similar to industrial rates for natural gas (see Ricardo Energy & Environment 2017[104] report and SEAI's October 2017 data[105]). Another report prepared for SEAI in 2017 by Ricardo Energy & Environment[106] shows that the levelised cost of energy (LCOE) for heat and electricity produced from biogas CHP plants can vary widely depending on the cost of feedstock (manure, grass or waste), the electricity tariff, the capacity of the plant and the assumed discount rate. The report concluded that AD and biogas CHP plants may require financial support to encourage their development.
- All the solid fuels present a low risk under *fossil fuel consumption* because we assumed that they replace fossil fuels directly. Biogas fuels present a moderate risk because they are consumed in CHP plants and could replace some grid electricity.

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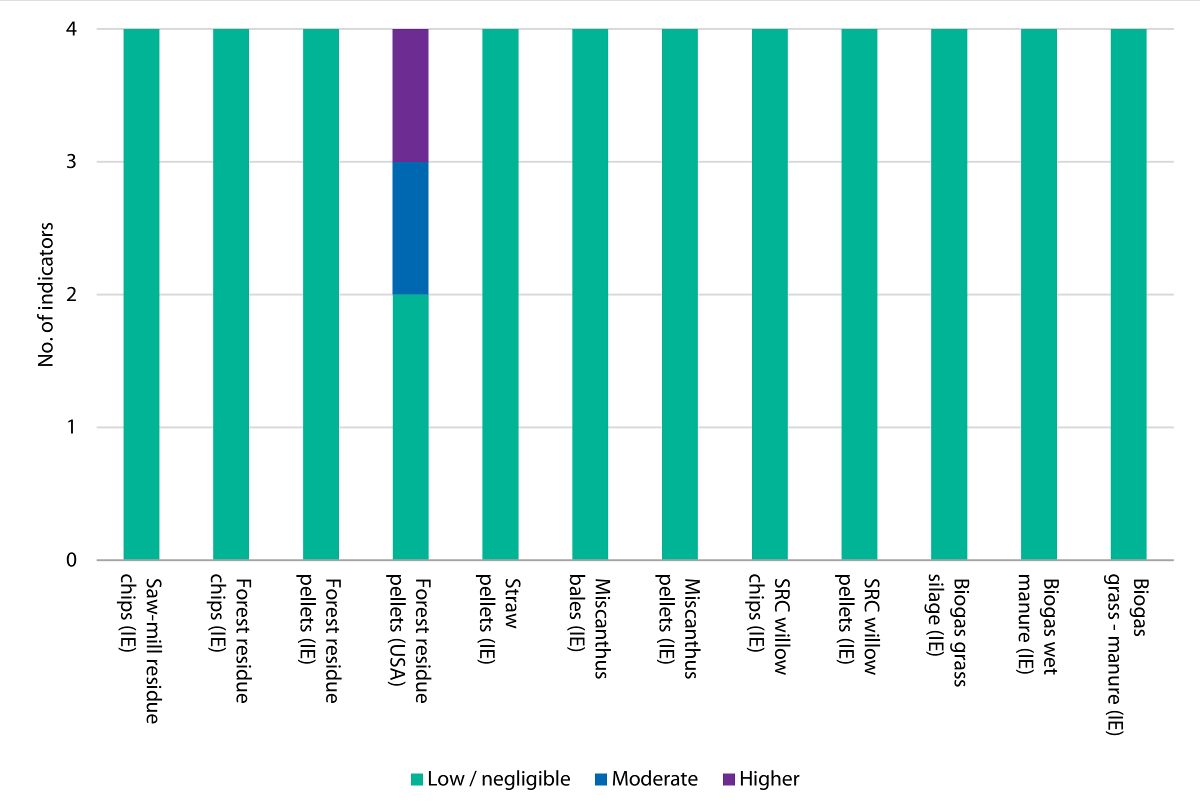
[104] Potential Biomass Prices in Ireland, Ricardo Energy & Environment, 2017, https://www.seai.ie/resources/publications/Advice-on-biomass-price-Final-Issue-5-25-Oct-20-2017.pdf

[105] Commercial / Industrial Fuels, Comparison of Energy Costs, SEAI, 1st October 2017, https://www.seai.ie/resources/publications/Commercial-Fuel-Cost-Comparison-October-2017.pdf

[106] Assessment of Costs and Benefits of Biogas and Biomethane, prepared by Ricardo Energy & Environment for SEAI, June 2017, https://www.seai.ie/resources/publications/Assessment-of-Cost-and-Benefits-of-Biogas-and-Biomethane-in-Ireland.pdf

- All the solid fuels produced in Ireland have a low / negligible risk under *infrastructure and logistics* because we assumed that distributing solid fuels would not require a significant modification of existing infrastructure. Forest residue pellets (USA) have a moderate risk as importing solid fuel may require upgrade to port facilities. The biogas[107] fuels present a moderate risk because it was conservatively assumed that distributing the final energy (electricity) would require the existing infrastructure (i.e. grid connections) to be modified.
- All the biomass fuels pose either low / negligible or moderate risks under *capacity and flexibility,* depending on the availability of the feedstock, the growth period of the biomass and the current processing capacity

Figure 7.4: Qualitative risk – social indicators



The results shown in Figure 7-4 and Table 17 for the social indicators should be interpreted as follows.

- All biomass fuels cultivated / extracted and processed in Ireland present a low / negligible risk under the four social indicators.
- Forest residue pellets from USA have a higher risk associated with employment because we assumed that cultivating and processing the biomass would not provide employment in Ireland.
- Forest residue pellets from USA have a moderate risk associated with acceptability because we assumed that stakeholder (within Ireland) and public opinion would be neutral towards importing biomass.

The framework provides a structured way of examining the sustainability of biomass fuels and identifying where sustainability risks may exist. It goes beyond the RED II environmental requirements and incorporates economic and social considerations. While there are weakness and limitations to the framework, it is a useful way to examine biomass fuels and identify where there may be risks to their sustainability.

[107] This is assuming biogas is not upgraded to biomethane.

Table 17: Qualitative risk - all indicators

	Feedstock	Sawmill residue	Forest residue	Forest residue	Forest residue	Straw	Miscanthus	Miscanthus	SRC Willow	SRC Willow	Grass silage	Wet manure	Grass - manure
	Type	Chip	Chip	Pellet	Pellet	Pellet	Bale	Pellet	WC	Pellet	Biogas	Biogas	Biogas
Section	Country of Origin	IE	IE	IE	USA	IE	IE	IE	IE	IE	IE	IE	IE
	Environmental												
7.4.1.1	GHG emissions												
7.4.1.2	Carbon debt / carbon stock												
7.4.1.3	Air quality												
7.4.1.4	Water quality												
7.4.1.5	Water use												
7.4.1.6	Soil quality												
7.4.1.7	Biodiversity												
7.4.1.8	Biomass use												
7.4.1.9	Non-renewable resources												
7.4.1.10	ILUC and LUC												
	Economic												
7.4.2.1	Security & diversity												
7.4.2.2	Gross value added												
7.4.2.3	Economic sustainability												
7.4.2.4	Market demand												
7.4.2.5	Fossil fuels consumption												
7.4.2.6	Infrastructure and logistics												
7.4.2.7	Capacity and flexibility												
	Social												
7.4.3.1	Acceptability												
7.4.3.2	Labour rights												
7.4.3.3	Food security												
7.4.3.4	Employment												

8 SUMMARY OF CONCLUSIONS

The RED II sustainability criteria will be at the core of defining sustainability for solid and gaseous biomass for the coming years. According to RED II, installations producing electricity, heating and cooling or fuels with a fuel capacity >=20 MW in the case of solid biomass, and 2 MW in the case of gaseous biomass, will be required to comply and Member States will need to put in place biomass sustainably requirements that will need to be independently verified if the biomass is to count towards national and/or fuel supplier obligations.

We have examined and described the Irish Regulations and associated guidelines, and how they pertain to the RED II sustainability criteria for agriculture and forestry biomass. Given the extent of the Irish legislation and the monitoring and enforcement systems in place, we consider that Irish forestry and agricultural biomass, once they meet the GHG savings criteria of RED II, will satisfy the RED II sustainability criteria, except in circumstances where the land use has changed. Notwithstanding this, operators will still need to *demonstrate* that the requirements of the RED II are satisfied, once it has been transposed into Irish law.

The UK has taken a proactive approach to implementing comprehensive sustainability requirements for solid and gaseous biomass across the different renewable energy incentive schemes in place. The criteria are based on the European Commission's current recommended criteria. Ireland can draw on the UK's experience with different compliance options for different scales of biomass operation. In addition to the UK, Belgium, Denmark, and the Netherlands have implemented sustainability requirements for solid and gaseous biomass for heat and electricity production. In general, the national systems have two components: requirements for minimum levels of GHG savings compared to fossil fuels; and requirements relating to the legality and sustainability of forest management (i.e. land criteria). Sometimes other conditions, such as restrictions on types of feedstock or on minimum plant energy efficiency levels, are also included.

We examined the RED II default values for a range of biomass supply chains that will be relevant in the Irish context. In general, the expected GHG emission savings threshold of 70% can be met for biomass fuels expected to be used in Ireland when using the RED II default values, provided that the transport distance is <10,000 km and, in the case of wood pellets, that process heat and power is provided by a CHP fed by woodchips. For biogas fuels, the default GHG emission savings for wet manure can far exceed the threshold (i.e. up to a 240% saving) depending on the technology option deployed, whereas no defaults for maize meet the threshold. For biomethane, the key considerations are whether digestate is stored in a closed -system and whether off gases are combusted.

Typical GHG values have been calculated for a representative range of supply chains in the Irish context, including a value for perennial energy crops (Miscanthus and SRC willow) and grass silage for biogas, none of which have default values in RED II. Our study found that, in most cases, reporting typical emissions for Irish supply chains should achieve better GHG savings than the RED II default values. Anaerobic digestion of 100% grass silage or co-digestion with high shares of grass silage, however, is only likely to meet the GHG threshold under certain conditions.

We also examined the potential for indirect effects from solid and gaseous biomass feedstocks. These feedstocks generally have a low risk of negative indirect effects, as long as existing uses are not compromised and agricultural and forestry residues are harvested up to a "sustainable" removal rate, which is a rate that does not impact on biodiversity or soil quality. Increasing perennial energy crop and short rotation forestry feedstocks could even lead to positive indirect impacts.

RED II will set definitive sustainability requirements for solid and gaseous biomass used in installations above certain capacity thresholds. However, biomass will be used as an energy source below the RED II thresholds and there are other indicators of sustainability that extend beyond the RED II sustainability criteria. The IEA has reviewed several sustainability initiatives and identified a set of sustainability indicators, and categorised them under three headings: environmental, economic and social. Using these indicators, in combination with the RED II requirements, we have developed a framework for examining sustainability and identifying risks to sustainability.

We applied the framework to the selected biomass supply chains to assist with developing the framework and understanding how the findings can be interpreted and presented. Two of the supply chains examined did not meet the GHG savings requirements of RED II (forest residue pellets imported from the USA when used for electricity generation and biogas produced from grass silage). Grass silage is likely to need to be co-digested with wet manure in a maximum proportion of approximately 40% grass silage: 60% wet manure (by weight) to meet the GHG target (for both biogas and biomethane). This does not mean that these supply chains will not meet the GHG savings requirements in all cases. It may be that by using different input values, other than those assumed by the study team, a GHG emission saving of greater than 70% could be achieved. However, it informs the level of GHG risk and identifies where operators may have to report actual GHG emission values in order to fulfil the RED II GHG requirements.

In addition to the risks of not meeting the RED II GHG savings threshold, the framework also assessed the biomass fuels against the additional sustainability indicators and identified several moderate risks and three risks that warrant further investigation. As above, this does not mean that those supply chains will be *unsustainable.* The framework is intended to identify where sustainability risks may arise and to assist in developing appropriate biomass policy.

APPENDIX 1: LIST OF REFERENCES

No.	Reference
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3	State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU SWD(2014)259, http://ec.europa.eu/energy/sites/ener/files/2014_biomass_state_of_play_.pdf
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Appendix 2: Legislative Sources

Forest Biomass

Requirement	Forestry Act 2014 & Forestry Regulations 2017
Legal permit	Section 17 (1) of the Forestry Act requires a person to apply to the Minister to fell trees, unless the trees are exempt under Section 19.
Forest regeneration	Section 17 (4) (b) of the Forestry Act allows the Minister to require the replanting of trees. According to the Forest Service's *Felling and Reforestation Policy*, permanent removal of trees where a felling licence is required may only be considered under exceptional circumstances which are set out in detail in Section 5 of the policy. These circumstances include: overriding environmental concerns, supporting renewable energy and energy security, commercial development, conversion to agricultural land, public utilities and other land use change (assessed on a case-by-case basis). Where permanent forest removal is permitted, it may be necessary to afforest an equivalent area elsewhere.
Protection of areas designated for nature purposes	Section 11 (d) of the Forestry Act requires that, in carrying out his functions, the Minister shall consider whether the one or more of the following be carried out. - A screening for an EIA. - The submission of an EIS. - An EIA. - A screening for an appropriate assessment. - The submission of a Natura Impact Statement. - The carrying out of an appropriate assessment. Part 7 of the Forestry Regulations set out, in more detail, the requirements that applications for afforestation or forest road works must meet in respect of Environmental Impact Assessment. An EIA must be carried out in respect of applications for: - afforestation which involve an area of 50 hectares or more, - forest road works which involve a length of 2000 meters or more, or - any afforestation or road works which the Minister considers likely to have significant effects on the environment. Part 8 of the Forestry Regulations set out, in more detail, the measures to be taken for Appropriate Assessment (for European Sites) in assessing applications for the following licences: - felling, - afforestation, - forest road works, and - certain other activities.
Soil quality and biodiversity	Section 11 of the Forestry Act requires that the Minister shall: a) have regard to the social, economic and environmental functions of forestry, b) follow good forest practice, c) take particular account of: i) the different habitats and species in forests, and ii) natural and semi-natural woodland.
Unsustainable production	Section 17 (1) of the Forestry Act requires a person to apply to the Minister to fell trees, unless the trees are exempted under Section 19. Section 17 (4) (b) of allows the Minister to require the replanting of trees. According to the Forest Service's *Felling and Reforestation Policy* permanent removal of trees where a felling licence is required may only be considered under exceptional circumstances which are set out in detail in Section 5 of the policy. These circumstances include: overriding environmental concerns, supporting renewable energy and energy security, commercial development, conversion to agricultural land, public utilities and other land use change (assessed on a case-by-case basis). Where permanent forest removal is permitted, it may be necessary to afforest an equivalent area elsewhere.

Agricultural Biomass

Requirement	Forestry Act 2014 & Forestry Regulations 2017	Birds and Natural Habitats Regulations 2011	Planning and Development Regulations 2011	Wildlife Act 1976
Primary forest	Section 17 (1) of the Forestry Act 2014 requires an application to be made to the Minister to fell trees, unless the trees are exempted under section 19. According to the Forest Service's Felling and Reforestation Policy permanent removal of trees where a felling licence is required may only be considered under exceptional circumstances which are set out in detail in Section 5 of the policy. These circumstances include: overriding environmental concerns, supporting renewable energy and energy security, commercial development, conversion to agricultural land, public utilities and other land use change (assessed on a case-by-case basis). Where permanent forest removal is permitted, it may be necessary to afforest an equivalent area elsewhere.	Regulation 28(1) of the European Communities (Birds and Natural Habitats) Regulations, 2011 (SI 477 of 2011) requires the Minister to direct that activities shall not be carried out by any person in the European Site except with, and in accordance with, consent given by the Minister under Regulation 30, where the activities are a type that may — (a) have a significant effect on a European Site, (b) have an adverse effect on the integrity of a European Site, or (c) cause the deterioration of natural habitats or the habitats of species or the disturbance of the species for which the European Site may be or has been designated pursuant to the Habitats Directive or has been classified pursuant to the Birds Directive, in so far as such disturbance could be significant in relation to the objectives of the Habitats Directive.	N/A	Section 19 of the Wildlife Act 1976 (as amended) prohibits the carrying out of any works on a Natural Heritage Area (NHA) which are liable to destroy or to significantly alter, damage or interfere with the features unless the Minister has been informed of the works and has given his consent.
Nature protection areas	N/A	See above	N/A	See above
High biodiverse grassland	N/A	See above	N/A	See above

Requirement	Forestry Act 2014 & Forestry Regulations 2017	Birds and Natural Habitats Regulations 2011	Planning and Development Regulations 2011	Wildlife Act 1976
Wetland	N/A	See above	Part 3 of Schedule 2 exempts drainage and / or reclamation of wetlands below 0.1 hectare, unless it would be likely to have an adverse impact on an area designated as an NHA. Article 93 requires an EIS to be prepared for the classes of activity set out in Schedule 5 of the Regulations. Part 2 of Schedule 5 sets out that the drainage and/or reclamation of wetlands where more than 2 hectares of wetlands would be affected is the subject of an EIA. Article 103 requires that where a development is below the threshold for an EIA but the likelihood of significant effects on the environment cannot be excluded by the planning authority, the planning authority shall make a determination as to whether the development would be likely to have significant effects on the environment. Where the planning authority determines that the development would be likely to have significant effects it must require the applicant to submit an EIS.	See above

Requirement	Forestry Act 2014 & Forestry Regulations 2017	Birds and Natural Habitats Regulations 2011	Planning and Development Regulations 2011	Wildlife Act 1976
Forested Area	Section 17 (1) of the Forestry Act 2014 requires a person to apply to the Minister to fell trees, unless the trees are exempted under section 19. According to the Forest Service's Felling and Reforestation Policy permanent removal of trees where a felling licence is required may only be considered under exceptional circumstances which are set out in detail in Section 5 of the policy. These circumstances include: overriding environmental concerns, supporting renewable energy and energy security, commercial development, conversion to agricultural land, public utilities and other land use change (assessed on a case-by-case basis). Where permanent forest removal is permitted, it may be necessary to afforest an equivalent area elsewhere.	See above	N/A	See above
Peatland	N/A	See above	N/A	See above

APPENDIX 3: UK SUSTAINABILITY CRITERIA PER FEEDSTOCK CLASSIFICATION

Fuel category	Solid biomass		Biogas/biomethane	
	Land criteria	**GHG criteria**	**Land criteria**	**GHG criteria**
Waste	Deemed to be met	Deemed to be met	Deemed to be met	Deemed to be met
Biomass wholly derived from waste	Deemed to be met	Deemed to be met	Deemed to be met	Deemed to be met
Processing residues	If not wood, meets land criteria If wood, must report against land criteria	Emissions during and from the process of collection only	If not wood, meets land criteria If wood, must report against land criteria	Emissions during and from the process of collection only
Residues from agriculture	Reporting required	Emissions during and from the process of collection only	Reporting required	Emissions during and from the process of collection only
Residues from forestry	Reporting required	Emissions during and from the process of collection only	Reporting required	Emissions during and from the process of collection only
Residues from arboriculture	If not wood, meets land criteria If wood, must report against land criteria	Emissions during and from the process of collection only	If not wood, meets land criteria If wood, must report against land criteria	Emissions during and from the process of collection only
Residues from aquaculture and fisheries	Reporting required	Emissions during and from the process of collection only	Reporting required	Emissions during and from the process of collection only
Products, co-products	Reporting required	Full life-cycle emissions	Reporting required	Full life-cycle emissions

APPENDIX 4: GHG CALCULATIONS

Calculating GHG emissions for heating, cooling and electricity

Greenhouse gas emissions from the use of solid and gaseous biomass in producing electricity, heating or cooling including the energy conversion to electricity and/or heat or cooling produced shall be calculated as follows:

For energy installations delivering only useful heat:

$$EC_h = \frac{E}{\eta_h}$$

For energy installations delivering only electricity:

$$EC_h = \frac{E}{\eta_h}$$

F or energy installations delivering only useful cooling:

$$EC_c = \frac{E}{\eta_c}$$

Where:

EC_h = Total greenhouse gas emissions from the final energy commodity, that is heating
EC_{el} = Total greenhouse gas emissions from the final energy commodity, that is electricity
EC_c = Total greenhouse gas emissions from the final energy commodity, that is cooling
η_{el} = The electrical efficiency, defined as the annual electricity produced divided by the annual fuel input.
η_h = The thermal efficiency, defined as the annual useful heat output, that is heat generated to satisfy an economically justifiable demand for heat, divided by the annual fuel input
η_c = The thermal efficiency, defined as the annual useful cooling output, that cooling generated to satisfy an economically justifiable demand for cooling, divided by the annual fuel input.

Calculating GHG emissions for CHP systems

For the electricity coming from energy installations delivering useful heat:

$$EC_{el} = \frac{E}{\eta_{el}} \left(\frac{C_{el} \cdot \eta_{el}}{C_{el} \cdot \eta_{el} + C_h \cdot \eta_h} \right)$$

For the useful heat coming from energy installations delivering electricity:

$$EC_h = \frac{E}{\eta_h} \left(\frac{C_h \cdot \eta_h}{C_{el} \cdot \eta_{el} + C_h \cdot \eta_h} \right)$$

Where:

C_{el} = Fraction of exergy in the electricity, or any other energy carrier other than heat, set to 100 % (C_{el} = 1)
C_h = Carnot efficiency (fraction of exergy in the useful heat)
Carnot efficiency, C_h, for useful heat at different temperatures:

$$C_h = \frac{T_h - T_0}{T_h}$$

Where:

T_h = Temperature, measured in absolute temperature (kelvin) of the useful heat at point of delivery as final energy
T_0 = Temperature of surroundings, set at 273 kelvin (equal to 0 °C)
For T_h < 150 °C (423 kelvin), C_h is defined as follows:
C_h = Carnot efficiency in heat at 150 °C (423 kelvin), which is: 0.3546

Calculating Biogas Co-digestion emissions – actual values

In the case of co-digestion of n substrates in a biogas plant for the production of electricity or biomethane, actual greenhouse gas emissions of biogas and biomethane are calculated as follows:

$$E = \sum_{1}^{n} S_n \cdot (e_{ec,n} + e_{td,feedstock\ ,n} + e_{l,n} - e_{sca,n}) + e_p + e_{td,product} + e_u - e_{ccs} - e_{ccr}$$

where

E = total emissions from the production of the biogas or biomethane before energy conversion

S_n = Share of feedstock n, in fraction of input to the digester

$e_{ec,n}$ = emissions from the extraction or cultivation of feedstock n

$e_{td,feedstock,n}$ = emissions from transport of feedstock n to the digester

$e_{l,n}$ = annualised emissions from carbon stock changes caused by land use change, for feedstock n

e_{sca} = emission savings from improved agricultural management of feedstock n*

e_p = emissions from processing

$e_{td,product}$ = emissions from transport and distribution of biogas and/or biomethane

e_u = emissions from the fuel in use, that is greenhouse gases emitted during combustion

e_{ccs} = emission savings from carbon capture and geological storage

e_{ccr} = emission savings from carbon capture and replacement

* For e_{sca} a bonus of 45 gCO_{2eq}/ MJ manure shall be attributed for improved agricultural and manure management in case animal manure is used as a substrate for the production of biogas and biomethane.

Calculating Biogas Co-digestion emissions – default values

In the case of co-digestion of different substrates in a biogas plant for the production of biogas or biomethane, the typical and default values of greenhouse gas emissions shall be calculated as:

$$\mathrm{E} = \sum_{1}^{n} S_n \cdot E_n$$

where

E = GHG emissions per MJ biogas or biomethane produced from co-digestion of the defined mixture of substrates

S_n = Share of feedstock n in energy content

E_n = Emission in gCO_2/MJ for pathway n

$$S_n = \frac{P_n \cdot W_n}{\sum_{1}^{n} P_n \cdot W_n}$$

where

P_n = energy yield [MJ] per kilogram of wet input of feedstock n**

W_n = weighting factor of substrate n defined as:

$$W_n = \frac{I_n}{\sum_{1}^{n} I_n} \cdot \left(\frac{1 - AM_n}{1 - SM_n}\right)$$

where:

I_n = Annual input to digester of substrate n [tonne of fresh matter]

A_{Mn} = Average annual moisture of substrate n [kg water / kg fresh matter]

S_{Mn} = Standard moisture for substrate n***

* For animal manure used as substrate, a bonus of 45 gCO_{2eq}/MJ manure (-54 kg CO_{2eq} / t fresh matter) is added for improved agricultural and manure management.

** The following values of P_n shall be used for calculating typical and default values:

P(Maize): 4.16 [MJ_{biogas}/kg $_{wet\ maize\ @\ 65\ \%\ moisture}$]

P(Manure): 0.50 [$MJ_{biogas}/kg_{wet\ manure\ @\ 90\ \%\ moisture}$]

P(Biowaste) 3.41 [$MJ_{biogas}/kg_{wet\ biowaste\ @\ 76\ \%\ moisture}$]

*** The following values of the standard moisture for substrate SM_n shall be used:

SM(Maize): 0.65 [kg water/kg fresh matter]

SM(Manure): 0.90 [kg water/kg fresh matter]

SM(Biowaste): 0.76 [kg water/kg fresh matter]

Appendix 5: Forest Biomass Research

Overview

In 2015, Forest Research, the research agency of the UK Forestry Commission, completed a report entitled *Carbon impacts of biomass consumed in the EU: quantitative assessment*[108] for the European Commission. The study focused on agricultural and forest biomass and provided a qualitative and quantitative assessment of the direct and indirect GHG emissions associated with different types of solid and gaseous biomass used in electricity and heating/cooling. It is worth noting that the report adopted a **consequential** approach to calculating GHG emissions.

Sustainability Assessment

Following a comprehensive literature review, the authors of the report advocated the use of decision trees to conduct systematic qualitative assessment of the sustainability of biomass sources. The report provides a sample decision tree for assessing forest biomass. The decision tree could be used to categorise sources of forest biomass as high, moderate or low risk of significant GHG emissions. The decisions, or questions, included in the proposed decision trees form the methodology to assess the consequential life-cycle emissions associated with the biomass produced or consumed by a particular initiative or project. Examples of the questions included in the decision tree proposed by Forest Research are:

1. "Is this recycled or waste wood?"
2. "Have the forest areas been established by active afforestation since 2000?"
3. "Is there evidence that this wood has been diverted from the use as a feedstock for materials production?"
4. "In the case of harvest residues, is there evidence to support the case that the extraction of harvest residues will not lead to significant depletion of the nutrient status of the soil or other deleterious effects on quality of the site?"

Some of the questions included in the proposed decision tree could be answered in a relatively straightforward manner (e.g. questions 1 and 2 above). However, it would require significant analysis to answer other questions (e.g. questions 3 and 4 above), particularly when applying the decision tree to an initiative with a wide scope (e.g. policy support for woodchips sourced from forest residue in Ireland). In general, the more straightforward questions relate to attributional emissions associated with the biomass, whereas the more involved questions relate to consequential emissions. The authors of the Forest Research report propose that decision trees could be developed to permit the '*systematic qualitative assessment of initiatives involving increased consumption and supply of forest biofuels*'.

Quantitative modelling of biomass consumption

The study also included a quantitative assessment of possible EU polices regarding biomass on total GHG emissions in the EU between 2010 and 2050. The study examined five scenarios:

- Scenario A – existing 2020 policy targets for renewable energy consumption and reductions in GHG emission are met, but no further policies or measures are taken.
- Scenario B ('carry on/unconstrained use') – same as scenario A up to 2020, more ambitious targets are set for 2030 and there are limited constraints on the sources of biomass consumed.
- Scenario C1 ('carry on/imported wood') – same as scenario A up to 2020, more ambitious targets are set for 2030 and an emphasis is placed on the consumption of imported forest bioenergy.
- Scenario C2 ('carry on/domestic crops') – same as scenario A up to 2020, more ambitious targets are set for 2030 and an emphasis is placed on the consumption of bioenergy from energy crop and agricultural biomass grown within the EU.
- Scenario C3 ('carry on/domestic wood') – same as scenario A up to 2020, more ambitious targets are set for 2030 and an emphasis is placed on the consumption of bioenergy from forests within the EU.

[108] https://ec.europa.eu/energy/sites/ener/files/documents/EU%20Carbon%20Impacts%20of%20Biomass%20Consumed%20in%20the%20EU%20final.pdf

- Scenario D ('back off') – same targets as in the carry-on scenarios; however, the consumption of bioenergy for meeting these targets is de-prioritised post 2020.

There were three key findings of the quantitative assessment of the above scenarios:

1. All scenarios achieve significant reductions in total annual GHG emission; scenario A produced the smallest reduction while scenario D produced the largest.
2. "*De-prioritising bioenergy* [as in scenario D] *could lead to significantly higher overall energy system cost.*"
3. Placing emphasis on particular bioenergy sources could have a significant impact on overall GHG emissions.

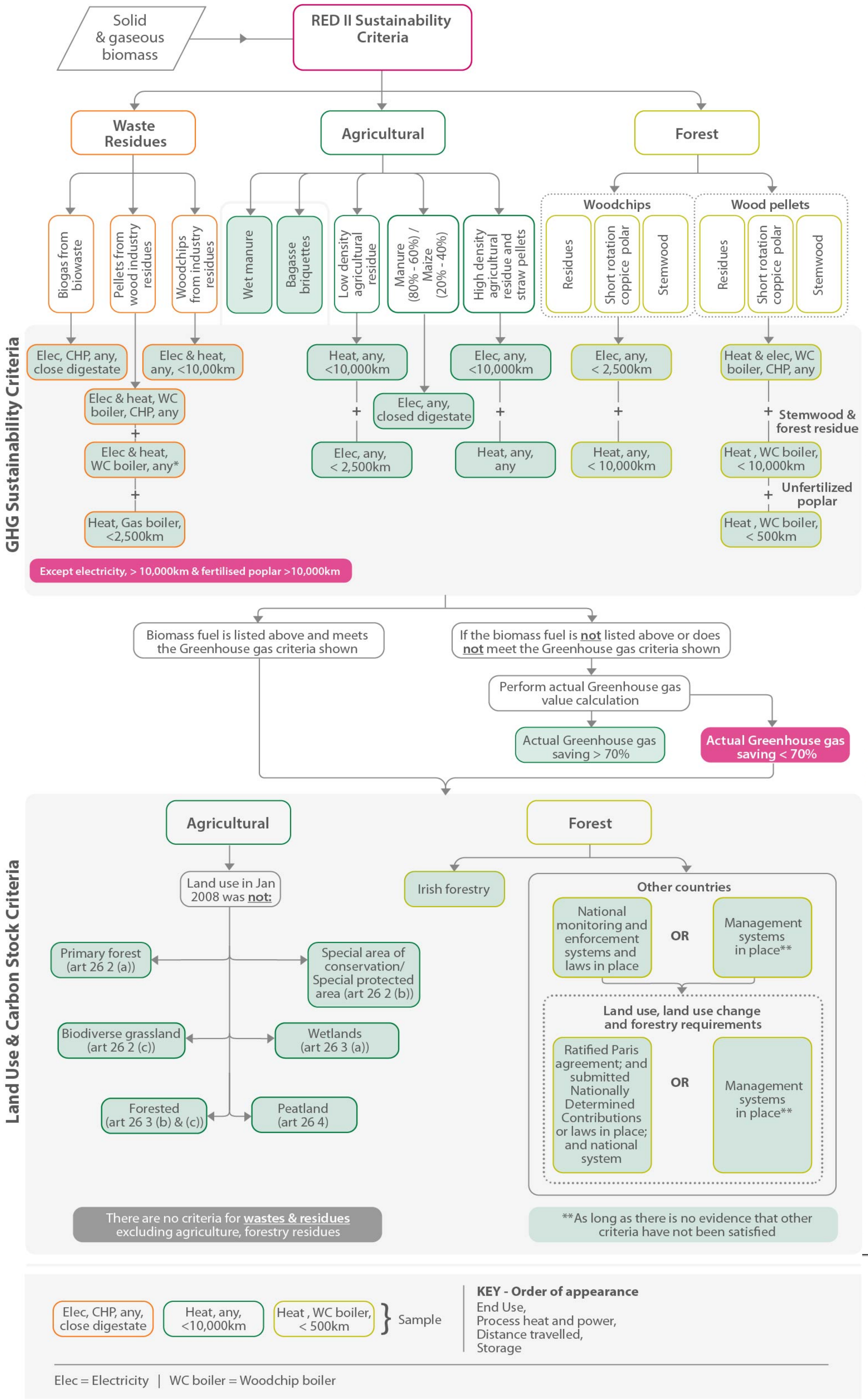
Scenario D ('back off') produced the largest savings in GHG emissions, but the highest cost per unit of GHG emissions saved. Scenario C2 ('carry on/domestic crops') produced the second largest savings in GHG emissions and the lowest cost per unit of GHG emissions saved.

Results of Forest Research report – comparison of GHG emission savings and cost of savings

Scenario	Average GHG reduction cost 2010 – 2050 (€/tCO_2)	2030 GHG emission savings compared to scenario A ($MtCO_2eq/yr$)
Scenario B ('carry on/unconstrained use')	122	378
Scenario C1 ('carry on/imported wood')	125	360
Scenario C2 ('carry on/domestic crops')	96	478
Scenario C3 ('carry on/domestic wood')	100	415
Scenario D ('back off')	183	508

The results of the study indicate that a policy of de-prioritising the consumption of biomass post 2020 would lead to a higher reduction in GHG emissions than one that prioritises it. However, to reach targets for the renewable energy consumption and reductions in GHG emissions that are likely to be set for 2030, de-prioritising the use of biomass would place a larger burden on the use of other renewable energy sources and would require the use of some higher-cost renewable sources (the authors cite the example of placing wind farms in non-optimal locations).

Appendix 6: Sustainability Framework



Sustainable under RED II, plus: Environmental risk; Economic risk; Social risk.

Additional Sustainability Indicators

Environmental

- GHG emissions
- Carbon debt
- Air quality
- Water quality
- Soil quality
- Biodiversity
- Biomass use
- Water use
- Non-renewable resource use
- Land use and change

GHG Emissions

1. What is the GHG savings as calculated using the RED II methodology: <70%; ≥ 70%, < 80%; ≥ 80%, < 90%; ≥ 90%?
2. Was the raw material harvested in accordance with the requirements for sustainable forest biomass production (para 5 sub-para 6) of RED II? ('Yes' where the saw mill is certified to FSC/PEFC.)

Carbon Debt / reduction in carbon stock

1. Is the biomass from forestry?
2. Is the harvest period of the forest ≥ 40 years and ≥ 50% of the annual production of round wood used for biomass?
3. Does the biomass contain stumps, where the stumps were removed for no other reason than production of wood or biomass?

Air Quality

1. Does the area(s) in which the biomass was extracted/cultivated and processed have laws in place relating to the monitoring and enforcement of air quality?
2. Is the fuel a solid biomass or biogas / biomethane?

Water Quality

Does the area(s) in which the biomass was extracted/cultivated and processed have laws in place relating to the monitoring and enforcement of water quality?

Water Use

1. Where biomass cultivation occurs on irrigated lands, what is the *baseline water stress* indicator in the country of origin?
2. Is the use of water in the processing of the biomass in excess of industrial norms?

Soil Quality

1. Is the biomass sourced from forestry or wastes & residues?
2. Is biomass from agriculture sourced from an EU Member State?
3. Where biomass from agriculture is not sourced from the EU, is there a soil management plan in place in the source area?

Biodiversity (Mostly covered by the RED II criteria)

1. Is the biomass from forestry or agriculture (including forestry or agriculture residues)?
2. In the case of saw-mill residue, is the wood harvested according to the biodiversity criteria (para 5 sub-para 5) of RED II?
3. Where the biomass is derived from a waste & residue (other than saw-mill residue), was the material from which the waste or residue was generated cultivated in accordance with the biodiversity requirements of RED II?

Biomass Use

Which of the following energy types provide the largest share of the energy input to processing the biomass? (biomass fuel, on-site renewables, grid electricity, fossil fuel)

Non-renewable resource use

1. Are non-renewable resources used in the extraction/cultivation/processing of the biomass (e.g. catalysts)?
2. Are non-renewable resources consumed in the process of combusting of the biomass fuel?

Land use and land use change

1. What is risk that cultivating the biomass could result in significant Land-Use Change (LUC) emissions? (low, medium, high)
2. Does the country of origin meet the LULUCF requirements in Article 26 (6) of RED II?

Economic

- Energy diversity & security
- Gross value add
- Economic sustainability
- Macroeconomic impact
- Market demand
- Change in consumption of FFs
- Infrastructure & logistics for distribution
- Capacity & flexibility
- Training & requal' of workforce

Energy Diversity & Security

1. Is the biomass is extracted / cultivated and processed in Ireland?
2. Is the biomass is extracted / cultivated and processed in another Member State?
3. Where biomass is **not** extracted / cultivated and processed in Ireland, what proportion of Ireland's biomass consumption is provided by the country of origin: ≤ 10%, < 10% & <= 50%, > 50%?

Gross Value Add

1. Is the biomass extracted / cultivated and processed in Ireland?
2. At current and foreseeable production levels, is there a potential for Ireland to become a net exporter of the biomass or biomass fuel?

Economic Sustainability

Choose: Ireland does not provide state support to biomass production, supply or consumption; or Biomass is extracted / cultivated & processed in Ireland and is supported by the state (on supply and/or demand side); or Biomass is extracted / cultivated & processed in another country, but is not supported by that state. Biomass consumption is provided with state support in Ireland; or Biomass is extracted / cultivated & processed in another country and the production is supported by that state (e.g. subsidies or mandates).

Market Demand

Rate the economic competitiveness of the biomass fuel with its fossil fuel equivalent (low, medium or high).

Change in Consumption of Fossil Fuels

What form of final energy consumption will be displaced by the biomass or biogas (in the majority of cases)? (fossil, grid electricity or other renewables)

Infrastructure and logistics for distribution of bioenergy

Required level of development or modification of existing distribution infrastructure: low, medium or high?

Capacity and Flexibility of use of bioenergy

Cultivated / extracted in Ireland: What is the current availability and short-term capacity to cultivate / extract the feedstock in Ireland (low/medium/high)? What is the growth period of the feedstock (≤ 2 years or > 2 years)? **Processed in Ireland:** What is the current capacity to process the feedstock in Ireland (low/medium/high)? **Cultivated / extracted and processed in another country:** Globally, what is the current availability and short-term capacity to cultivate/extract and process the biomass fuel (low/medium/high)? **Consumption:** To change from the fossil fuel equivalent, the final energy consumer will require: significant capital investment (new plant/equipment); moderate capital investment (modification of existing plant); minor or no capital investment?

Social

- Acceptability
- Labour rights
- Food security
- Employment in bioenergy

Acceptability

1. What is stakeholder opinion towards extraction/cultivation, processing and use of the biomass (favourable/neutral/unfavourable)?
2. What is public opinion towards the use (consumption) of the biomass (favourable/neutral/unfavourable)?
3. Are additional measures required to raise awareness of the biomass as an alternative to non-renewable energy consumption through the provision of information or advice to end users?

Labour Rights

1. Is the cultivation / extraction and processing carried out within the EU?
2. If cultivated / extracted outside the EU, has the country of origin ratified and implemented each of the Conventions of the International Labour Organisation?

Food Security

1. Is cultivation / extraction carried out within the EU?
2. If cultivated / extracted outside the EU, has the production of biomass diverted feedstock from the food chain and impaired food security (e.g. price volatility)?

Employment in Bioenergy

Are people in Ireland directly employed in the cultivation / extraction or processing of the biomass?

APPENDIX 7: ASSUMPTIONS FOR SAMPLE SUPPLY CHAINS

			Sawmill residue	Forest residue	Forest residue	Forest residue	Straw	Miscanthus	Miscanthus	SRC Willow	SRC Willow	Grass silage	Wet manure	Grass - manure
			Chip	Chip	Pellet	Pellet	Pellet	Bale	Pellet	Chip	Pellet	Biogas	Biogas	Biogas
Section	Indicator	Assessment	IE	IE	IE	USA	IE	IE	IE	IE	IE	IE	IE	IE
	Environmental													
7.4.1.1	GHG Emissions	Sawmill raw material harvested in accordance with the requirements for sustainable forest biomass production	Yes	-	-	-	-	-	-	-	-	-	-	-
7.4.1.2	Carbon debt / carbon stock	Is the harvest period of the forest ≥ 40 years and is ≥ 50% of the annual production of round wood used for biomass?	-	No	No	No	-	-	-	-	-	-	-	-
7.4.1.2	Carbon debt / carbon stock	Are stumps removed for no other reason than the production of wood / biomass?	-	No	No	No	-	-	-	-	-	-	-	-
7.4.1.3	Air quality	Are laws comparable to those in the EU?	-	-	-	Yes	-	-	-	-	-	-	-	-
7.4.1.4	Water quality	Are laws comparable to those in the EU?	-	-	-	Yes	-	-	-	-	-	-	-	-
7.4.1.5	Water use	Is the biomass cultivated on irrigated lands?	No	No	No	No	No	No	No	No	No	No	No	No
7.4.1.5	Water use	Is water use in processing in excess of industrial norms?	No	No	No	No	No	No	No	No	No	No	No	No
7.4.1.7	Biodiversity	In the case of sawmill residues, is the wood harvested in accordance with the biodiversity criteria of RED II?	Yes	-	-	-	-	-	-	-	-	-	-	-
7.4.1.8	Biomass use	Largest share of energy input to processing	Biomass	Biomass	Biomass	Biomass	Grid electricity	Biomass	Grid electricity	Biomass	Biomass	Biomass	Biomass	Biomass
7.4.1.9	Non-renewable resources	Are non-renewable resources used in production or consumption?	No	No	No	No	No	No	No	No	No	No	No	No
7.4.1.10	Land Use and Land Use Change	What is the risk of significant LUC emissions?	Low	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Medium	Low	Medium
	Economic													
7.4.2.1	Security & diversity	For imported biomass, what proportion of Ireland's biomass consumption is from the country of origin?	-	-	-	≤ 10%	-	-	-	-	-	-	-	-
7.4.2.2	Gross value added	Is there the potential to export the biomass or biogas?	No	No	No	-	No	No	No	No	No	No	No	No

			Sawmill residue	Forest residue	Forest residue	Forest residue	Straw	Miscanthus	Miscanthus	SRC Willow	SRC Willow	Grass silage	Wet manure	Grass - manure
			Chip	Chip	Pellet	Pellet	Pellet	Bale	Pellet	Chip	Pellet	Biogas	Biogas	Biogas
Section	**Indicator**	**Assessment**	IE	IE	IE	USA	IE	IE	IE	IE	IE	IE	IE	IE
7.4.2.3	Economic sustainability	Does production receive state support abroad?	-	-	-	Yes	-	-	-	-	-	-	-	-
7.4.2.3	Economic sustainability	Does production or consumption receive state support in Ireland?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7.4.2.4	Market demand	Rate economic competitiveness with fossil fuel equivalent.	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
7.4.2.5	Fossil fuels consumption	What form of final energy is displaced?	Fossil fuel	Fossil fuel	Fossil fuel	Fossil fuel	Fossil fuel	Fossil fuel	Fossil fuel	Fossil fuel	Fossil fuel	Grid electricity	Grid electricity	Grid electricity
7.4.2.6	Infrastructure and logistics	Required level of development or modification?	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Medium	Medium
7.4.2.7	Capacity and flexibility	Capacity to cultivate/ extract the feedstock in Ireland:	Medium	Medium	Low	-	Low	Medium	Low	Low	Low	Medium	High	Medium
7.4.2.7	Capacity and flexibility	Growth period	-	> 2 years	> 2 years	-	≤ 2 years	≤ 2 years	≤ 2 years	≤ 2 years	≤ 2 years	≤ 2 years	≤ 2 years	≤ 2 years
7.4.2.7	Capacity and flexibility	Capacity to process the feedstock in Ireland:	Medium	High	Medium	-	Medium	High	Medium	High	Medium	Low	Low	Low
7.4.2.7	Capacity and flexibility	Current global capacity to cultivate and process the biomass:	-	-	-	Medium	-	-	-	-	-	-	-	-
7.4.2.7	Capacity and flexibility	Capital investment by final energy consumer to change from fossil fuel equivalent	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Low	Low	Low
	Social													
7.4.3.1	Acceptability	Stakeholder opinion	Favourable	Favourable	Favourable	Neutral	Favourable	Favourable	Favourable	Favourable	Favourable	Favourable	Favourable	Favourable
7.4.3.1	Acceptability	Public opinion	Favourable	Favourable	Favourable	Neutral	Favourable	Favourable	Favourable	Favourable	Favourable	Favourable	Favourable	Favourable
7.4.3.2	Labour rights	Ratified and implemented Conventions of the ILO?	-	-	-	Yes	-	-	-	-	-	-	-	-
7.4.3.3	Food security	Impaired food security?	-	-	-	No	-	-	-	-	-	-	-	-
7.4.3.4	Employment	Employ people in Ireland?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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