Paper Tiger

Why the EU's RED II biomass sustainability criteria fail forests and the climate

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Background of this paper

This whitepaper arose out of a case that was brought against the European Commission and Parliament in the European Court of Justice on March 4, 2019. The case seeks to annul provisions of the EU's Renewable Energy Directive (RED II) that allow burning forest biomass to qualify as renewable energy. Applicants in the case were individuals and non-governmental organizations that had been harmed by harvesting and burning forest biomass. The case was rejected by the court on May 6, 2020 on the grounds that the applicants did not have standing. The decision on standing was appealed on July 2, 2020.

This paper is based on some of the arguments made in the legal case, and is being released contemporaneously with filing the appeal. In the interest of not making the report longer, it does not include arguments about why the RED II biomass provisions violate provisions in the Treaty for the Functioning of the EU concerning environmental policy, and violate the applicants' rights. For readers who are interested, the full case is available at http://eubiomasscase.org/the-case.

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Executive Summary

The EU has embarked on an ambitious program of new legislation and overhaul of existing legislation to tackle the intertwined crises of climate change and biodiversity. This document is a scientific and legal analysis that shows it is essential to overhaul the forest biomass[1] provisions in the recast Renewable Energy Directive (RED II) to avoid further undermining the EU's flagship goals of climate neutrality by 2050 and forest restoration under the Biodiversity Strategy. The RED II contains supposedly protective criteria that govern eligibility of forest biomass as renewable energy, and the EU is creating implementation guidance intended to assure the criteria are met. Nonetheless, far from ensuring greenhouse gas savings and forest protections as claimed, the criteria simply provide cover for continued forest exploitation and unchecked greenhouse gas (GHG) emissions from burning forest wood. Accordingly, the EU's entire approach on use of forest biomass needs top-to-bottom reform.

Biomass energy was not always so controversial, but its use has tripled in the EU since 1990, and the most intensive form of forest biomass harvesting, for wood pellets, is accelerating. Increased reliance on wood energy appears to be partially responsible for a shocking expansion of forest harvesting in Europe that is described in a study by the EU's Joint Research Centre. As reported by the Guardian:

> "Many of the EU's forests – which account for about 38% of its land surface area – are managed for timber production, and thus harvested regularly. But the loss of biomass increased by 69% in the period from 2016 to 2018, compared with the period from 2011 to 2015, according to satellite data. The area of forest harvested increased by 49% in the same comparison." ("Europe losing forest to harvesting at alarming rate, data suggests." The Guardian, July 1, 2020).

This kind of intensified harvesting is the hallmark of biomass extraction, because creating markets for so-called "low value" wood means literally every stick can be chipped up and sold as fuel. Despite the ongoing loss of forests, the RED II calls for even more exploitation of the EU's forest resources for energy, under the claim that it will be done "sustainably." This profoundly and tragically counterproductive strategy costs EU citizens billions of euros each year in renewable energy subsidies and other supports for bioenergy, payments that turn the concept of "polluter pays," which is enshrined as a central environmental principle in the Treaty of the Functioning of the EU, on its head.

The RED II promotes use of forest biomass as a "zero emissions" fuel, even though burning biomass emits more CO_2 per unit energy than coal, justifying this defiance of physical reality with the claim that if biomass is harvested "sustainably," so that harvesting levels do not exceed forest growth levels on the landscape, then there are no net emissions. In contradiction of this, multiple scientific studies show that far from being instantaneously carbon neutral, burning forest biomass has net CO_2 emissions that require decades to centuries to offset with forest regrowth.

[1] For the purposes of this discussion, "forest biomass" means biomass sourced directly from forests. Accordingly the definition does not include mill residues.

Nonetheless, policymakers who drafted the RED II ignored this science and doubled down on the discredited sustainability approach when they crafted requirements governing whether biomass counts toward renewable energy targets. The RED II claims these "Union-wide sustainability and greenhouse gas emissions saving criteria for biomass fuels used in the electricity sector and in the heating and cooling sector" will "continue to ensure high greenhouse gas emissions savings compared to fossil fuel alternatives, to avoid unintended sustainability impacts, and to promote the internal market."

These Potemkin-style protections cannot deliver on either reducing greenhouse gases or avoiding forest impacts for two major reasons. First, the criteria are ineffective, and will do little to nothing to reduce the ecosystem-destroying and forest carbon-hemorrhaging impacts of biomass harvesting. Second, even if the criteria were effective, the criteria apply solely to fuels burned in large power plants built from 2021 onward, and thus will only apply to a tiny fraction of the biomass burned in the EU in coming years.

Biomass use in the EU

Total bioenergy generation has tripled since 1990 and currently provides about 60% of renewable energy in the EU, while combustion of wood for heat and power provides about 35%. The EU produced woody biomass fuels that were equivalent to about 320 million tonnes (Mt) of green wood in 2018, and imported pellets that represented another 18 Mt. As burning one tonne of green wood emits about one tonne of CO_2, the approximately 340 Mt of CO_2 emitted by biomass combustion (which significantly underestimates of the full emissions impact of harvesting and manufacturing biomass fuels), is greater than 2017 CO_2 uptake in the land sector of 258 Mt.

About 60% of wood burned in the EU is for residential heating, which counts toward renewable energy targets. Some member states have seen large increases in wood heating, like Italy, where residential wood use rose 500% from 2000 to 2016.

The EU has thousands of wood boilers that generate heat, combined heat and power, or electricity only. Most plants are less than 5 MW, but plants greater than 20 MW consume 70% of the wood.

Actual forest harvesting levels may exceed official data by an estimated 20 percent or more. Millions of tonnes of unreported wood are used for energy in Germany, Slovakia, Romania, and other member states each year, some of it sourced from illegal logging. Some of the wood being counted toward renewable energy targets appears to be illegally sourced.

Wood pellet use increased from 17 Mt in 2013 to 26 Mt in 2018, a 50% jump in five years. Residential heating accounts for 40% of pellet consumption and power generation for 36%, with the balance going to commercial heating and combined heat and power. On a green wood basis, wood pellets and other compressed wood fuels currently constitute upwards of 15% of wood burned for energy in the EU. A significant percentage of the wood pellets used for bioenergy in the UK and EU are imported from North America.

Reform is possible, but it will require policymakers show wisdom and courage to admit the obvious: the EU cannot both restore its forests, and continue to log them for fuel. The EU must admit its mistake and stop relying on burning wood to meet renewable energy targets. The EU needs a climate policy that puts forests first.

The RED II forest biomass criteria and their implementation

The RED II contains four sets of criteria that apply to forest biomass, each containing several provisions. The "efficiency" and "greenhouse gas" (GHG) criteria concern manufacturing and use of biomass, and the "land use, land use change and forestry" (LULUCF) and "sustainability" criteria concern the conditions under which biomass is grown and harvested. Draft implementation guidance for the LULUCF and sustainability criteria, known as the "REDIIBIO" project, has been published. Once finalized, the guidance is overseen by the European Commission (EC) but administered by the member states. The EC may also approve existing sustainability certification schemes (such as the Sustainable Biomass Program) for administering the guidance.

Efficiency criteria – Art. 29(11)

Overview of efficiency criteria: The efficiency criteria set efficiency standards for power plants. They apply to new biomass plants or fossil fuel plants that have partially or fully converted to burning biomass (such plants qualify under the REDII as long as they do not use fossil fuels as the main input). The main provisions (Article 29(11)) are:

1. No efficiency requirement for new plants less than 50 MW energy input (however, member states are allowed to apply more stringent energy efficiency standards than those referred to in the criteria to plants smaller than 50 MW).
2. For new plants 50 – 100 MW, high-efficiency cogeneration, or electric-only (at 33.5% - 38% efficiency) if cogeneration not cost-effective
3. For new plants >100 MW, cogeneration or efficiency of at least 36%
4. Plants that use Biomass CO_2 Capture and Storage (BECCS) are exempt from efficiency requirements
5. By implication, no efficiency requirement for existing plants

Commentary on efficiency criteria: The lack of any efficiency standard for existing plants and new plants smaller than 50 MW leaves the plants most prone to inefficiency completely uncovered by the criteria. Further, the requirements are extremely weak in that co-generation is not required, meaning large-scale and highly inefficient plants continue to qualify as renewable energy generators. Overall, the efficiency standards are extremely unlikely to restrict further proliferation of the largest, most inefficient wood-burning power plants, and will likely allow further conversions of coal plants to burning wood, ensuring these large, inefficient and polluting facilities continue to operate.

In contrast to the EU standards, the UK enacted a standard in 2018 requiring all new bioenergy facilities to achieve at least 70% efficiency to qualify for subsidies. As this standard can only be met by cogeneration or heat-only facilities, it is likely to significantly restrict the size of facilities, and has the potential to displace more fossil fuels.

GHG criteria – Art. 29(10)

Overview of GHG criteria: The GHG criteria require accounting of partial lifecycle GHG emissions from biomass, including CO_2 from fossil fuels burned during biomass harvesting, manufacturing, and transport, and non-CO_2 GHG emissions from biomass combustion (minimal

compared to the fossil fuel CO_2.) The calculation does not include CO_2 from burning the biomass itself, which is treated as zero in the RED. Partial lifecycle emissions are most of concern for wood pellets, because pellet manufacturing and long-distance transport can result in significant fossil fuel emissions.

1. The GHG requirements apply solely to fuels burned in new biomass installations that are 20 MW (energy input basis) or greater.
2. Calculated emissions are compared to a standard value. The comparator values are expressed on an energy output basis, so they take facility efficiency into account. The standard comparators are 80 g CO_2eq MJ^{-1} for heat and 183 g CO_2eq MJ^{-1} for electricity. For heating where a direct physical substitution of coal can be demonstrated, the comparator is 124 g CO_2eq MJ^{-1} heat.
3. To qualify under the RED, biomass lifecycle emissions must show a savings of "at least" 70% for fuels burned in installations starting operation from 2021, and 80% for installations starting operation in 2026.

Commentary on GHG criteria: As the GHG criteria do not count emissions from burning the biomass itself, they are of no utility in determining the actual atmospheric CO_2 impact of burning forest biomass. Combustion emissions from biomass range from around 115 g CO_2eq MJ^{-1} for high-efficiency heat plants to around 400 g CO_2eq MJ^{-1} for inefficient electricity-only plants, thus combustion emissions alone exceed the comparators in most cases. Thus the RED II's statement that the GHG criteria help "ensure" biomass carbon savings compared to fossil fuels is ironically true in this sense, as excluding CO_2 from biomass combustion in the GHG criteria does indeed "ensure" that biomass *appears* to reduce emissions.

The GHG criteria are also of little utility in what they do assess. The electricity-only savings requirement of 70% progressing to 80% relative to the 183 g CO_2 MJ^{-1} comparator for electricity translates to emission rates of 54.9 and 36.6 g CO_2 MJ^{-1} respectively. Even the lower standard is already met by the wood pellets imported into the EU from North America. In comparison, the UK recently adopted a standard comparator value of 8.1 g CO_2 MJ^{-1} for biomass plants starting operation in 2021 – 2026, which is just 22% of the lower of the two RED II standards.

Further, even if the GHG criteria were made more rigorous, the criteria only apply at new plants of at least 20 MW energy input (corresponding to around 4 – 7 MW output at an electricity-only plant, depending on conversion efficiency). This means the major uses of pellets are left uncovered by the criteria, i.e., pellets burned in new plants less than 20 MW, pellets burned in all existing plants, and pellets burned for residential heating.

The RED II allows member states to apply the sustainability and GHG emissions saving criteria to installations with lower total rated thermal input than 20 MW. By stating that savings must be "at least" 70%, this Article implies that member states are allowed to increase the rigor of the standard. However, even if member states do implement stricter standards, this will not drive meaningful change unless the standard applies more broadly.

Land Use, Land Use Change, and Forestry (LULUCF) criteria – Art. 29(7)

Overview of LULUCF criteria: The LULUCF criteria are where the RED II "sustainable harvesting" provisions reside, rather than in the sustainability criteria as might be expected, and are thus the main locus for considerations of landscape carbon balance. To qualify under the RED II,

7. Biofuels, bioliquids and biomass fuels produced from forest biomass shall meet the following criteria:

(a) the country or region of origin of the forest biomass

(i) is a Party to the Paris Agreement;

(ii) has submitted a nationally determined contribution (NDC) covering carbon emissions and removals in the land sector that "ensures changes in carbon stock associated with biomass harvest are accounted towards the country's commitment to reduce or limit greenhouse gas emissions as specified in the NDC"; or

(iii) "has national or sub-national laws in place that apply in the area of harvest, to conserve and enhance carbon stocks and sinks, and providing evidence that reported LULUCF-sector emissions do not exceed removals";

(b) for countries where points a(i)-a(iii) do not apply, biomass is eligible "if management systems are in place at forest sourcing area level to ensure that carbon stocks and sinks levels in the forest are maintained, or strengthened over the long term."

Commentary on LULUCF criteria: The LULUCF criteria seek to equate "sustainability" with carbon neutrality – an approach specifically rejected as unscientific by the EC staff scientists who authored a 2016 biomass sustainability assessment:

> "Certain forest management practices can enhance the carbon sink, but ensuring that the harvest level stays below the growth rate of the forest is not sufficient to ensure climate change mitigation. Sustainable forest management practices… cannot guarantee that an increase in forest biomass for energy will deliver greenhouse gas savings."

Accordingly, despite the Directive's claim that the forest biomass criteria "ensure" GHG savings compared to fossil fuels, the LULUCF criteria utilize an approach that EC scientists have admitted is not capable of ensuring GHG savings. The criteria also fail to protect carbon stocks in any given area of forest because they do not prohibit intensive harvesting or clearcutting.

The provisions of Article 29(7)(b) were likely crafted to apply to the United States, one of the EU's main pellet suppliers, because the US government had promised to exit the Paris Agreement when the RED II was being drafted. The draft REDIIBIO guidance for ensuring maintenance of forest carbon stocks and sinks calls for comparing historical and future (at least 30 years hence) forest carbon in the biomass sourcing area, with the biomass producer responsible for projecting the future forest condition using modeling. The goal of maintaining or increasing forest carbon stocks will often be impossible to achieve if carbon accounting is confined to the actual area from which biomass is sourced, since biomass and wood pellet producers routinely cut trees much older than 30 years. The only way to achieve the goal is if the model counts carbon sequestration occurring in a larger area than just the area harvested (see box on "sustainability," especially Figure S-2),

demonstrating that the supposed equivalence of sustainability and carbon neutrality depends on arbitrary factors.

Biomass "sustainability" is not equivalent to carbon neutrality

The IPCC warns,

"The combustion of biomass generates gross GHG emissions roughly equivalent to the combustion of fossil fuels. If bioenergy production is to generate a net reduction in emissions, it must do so by offsetting those emissions through increased net carbon uptake of biota and soils."

Treating sustainable harvesting as equivalent to carbon neutrality identifies ongoing forest growth on the landscape and "assigns" it to offset bioenergy emissions. Growth of trees over *there* is suddenly expected to compensate for emissions from cutting and burning trees over *here*. However, the trees over "there" were already growing and taking CO_2 out of the atmosphere. Thus, their carbon sequestration does not constitute "increased" carbon uptake per the IPCC warning, and treating it as an offset for trees being cut and burned actually double-counts the forest carbon sink.

A symptom of the error of the "landscape" approach to bioenergy carbon accounting is that estimates of carbon balance are extremely susceptible to the size of the area assessed (Figure S-1).

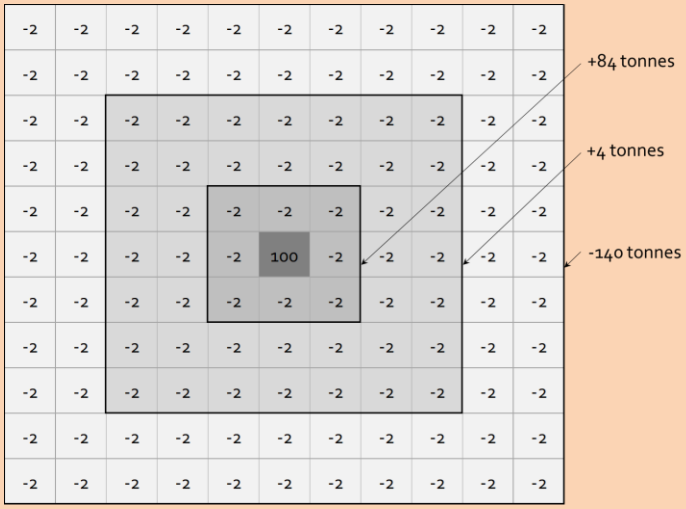

Figure S-1. The scale-dependency of the "sustainability" approach. The center plot represents one forest plot harvested and burned in an otherwise undisturbed landscape of plots, emitting +100 tonnes of CO_2. If plots grow at 2% per year, re-growing this plot to offset that emission will take 50 years. However, when sustainability is equated with carbon neutrality, ongoing carbon uptake in other plots is claimed as offsetting emissions from the center plot. Summing the 100 tonnes of emissions from the center plot with the 2 tonnes of annual CO_2 uptake in each of the 8 surrounding unharvested plots produces a landscape balance of +84 tonnes CO_2 emitted. Summing it with CO_2 uptake in the larger area with 48 surrounding plots, the landscape balance is +4 tonnes emitted. Summing with all 120 surrounding plots, the landscape balance is -140 tonnes CO_2 sequestered. In each case, the objective physical reality is that the atmosphere experienced a new addition of 100 tonnes of CO_2, but under the landscape approach to carbon accounting, the biomass producer can claim that emissions are instantaneously neutralized to some degree depending on the size of the surrounding area claimed as an offset, offset, even to the point of achieving "negative emissions" in at large landscape scales.

Sustainability criteria – Art. 29(6)

Overview of sustainability criteria: The sustainability criteria are intended to "minimise the risk of using forest biomass derived from unsustainable production." They require the country in which forest biomass is harvested to have national or sub-national laws applicable in the area of harvest, as well as monitoring and enforcement systems, ensuring harvesting legality, forest regeneration, protection of areas designated by international or national law for nature conservation, that harvesting attempts to minimize impacts on soil quality and biodiversity, and that harvesting "maintains or improves the long-term production capacity of the forest."

If such laws do not exist, or are inadequate, then "management systems" are sufficient to meet the objectives. In this case, however, the last clause is amended to allow harvesting in protected areas if "evidence is provided that the harvesting of that raw material does not interfere with those nature protection purposes." As with the GHG criteria, the sustainability criteria only apply to fuels burned in installations 20 MW energy input or greater. However, member states are permitted to apply the criteria to smaller installations, and Article 29(14) provides that member states "may establish additional sustainability criteria" for biomass fuels.

Commentary on sustainability criteria: As the sustainability criteria only apply to biomass burned in new facilities 20 MW or greater, they do not apply to biomass burned in new facilities smaller than 20 MW and all existing facilities, as well as biomass burned for residential heating. Thus, the criteria will only apply to a small fraction of the biomass burned in the EU in coming years.

As with the LULUCF criteria, the REDIIBIO implementation guidance will apply to the sustainability criteria. However, neither the criteria nor the guidance as drafted would prevent continuing damage from biomass harvesting, because the criteria are concerned with the existence of laws and regulations concerning damaging practices, rather than setting actual standards that restrict such practices. Because damaging practices are legal in source countries, they will be allowed under the sustainability criteria. For instance, in Estonia it is legal to remove stumps after logging, which tears up organic soils and leads to soil carbon loss (Figure S-2).

Figure S-2. Forest after clearcutting and stump removal, near Imavere, Estonia. Photo: Almuth Ernsting, Biofuelwatch

In Canada, some of the wood used in pellets exported to Europe and Asia comes from logging ancient cedars in British Columbia's inland rainforest (Figure S-3). This has been approved by local authorities.

Figure S-3. Truck bringing logs to be made into pellets at Pacific Bioenergy, a pellet plant in British Columbia, Canada. Ancient cedars from the region's rare inland rainforest ecosystem are being made into wood pellets that are burned in Europe and Asia. The trees were deemed low-value and thus acceptable for pellet feedstock. Photo James Steidel for Conservation North.

In the Southeastern US, the source of much of the wood pellet fuel burned in the EU, it is not only commonplace to harvest wetland forests for pellet feedstock, but also to replace biodiverse natural forests with monoculture pine plantations. Figure S-4 (next page) shows a clearcut in North Carolina natural riverine hardwood forest that was replanted to commercial pine.

The RED II forest biomass criteria do not prohibit intensive forestry practices or clearcutting, or require retention of any amount of forest following harvesting. There is also almost no consideration in the sustainability criteria on how biomass harvesting impacts biodiversity. The implementation guidance of the REDIIBIO project envisions all such matters being taken care of by provisions in contracts between biomass producers and land-owners.

Additionally, protected areas are not really off-limits from biomass harvesting in the Directive, as some provisions of the sustainability criteria allow harvesting in protected areas, and large areas of the EU's Natura 2000 network of protected areas are open to harvesting, including for biomass. Legality of wood sourcing is also given little consideration in the RED II. The EU Timber Regulation requires legal sourcing of all wood used in the EU, but it is common knowledge that some of the biomass currently qualifying toward renewable energy targets, particularly for residential heating, is of unknown and possibly illegal origin. The RED II does not contain any blanket statement requiring legality, and the sustainability criteria, where legality is mentioned, only cover new facilities 20 MW or larger.

Figure S-4. Area of about 27 ha in riverine hardwood forest in North Carolina USA (at 36.164990°, -77.284164°) before, just after, and five years after logging. The hardwood forest was replaced by a commercial pine plantation. The amount of wood harvested would be sufficient to run the Drax power station in the UK (last panel) for 3 hours and 24 minutes (see Appendix III in main text for calculations).

Carbon sink impacts of bioenergy and the LULUCF Regulation

As of 2017, the reported land sector carbon sink for the EU was equivalent to less than 6% of reported emissions, and instead of increasing, as is necessary to help mitigate climate change, the land sink has been decreasing in recent years, with some member states experiencing dramatic reductions (Figure S-5, next page).

This terrible trend, which spells disaster for climate mitigation, is projected to get even worse. The foreboding projections arise due to the EU's new LULUCF Regulation, which requires EU member states to establish a forest reference level (FRL), which is a baseline for assessing whether the forest carbon sink is increasing, decreasing, or holding steady over time compared to the reference period. This baseline is calculated by projecting forward in time what the forest carbon sink would be, based on forest harvesting intensity and practices in the reference period 2000 – 2009. Member state FRL projections for the 2021-2026 period show that collectively, the EU's forest sink is projected to decline by 11% compared to the average forest sink from 2016 to 2018. The degradation of the EU's forest carbon sink, which as recently reported is even more extreme than had been realized, is an alarming indictment of how forests have been managed in recent decades and a flashing red warning light that forest management needs to drastically change.

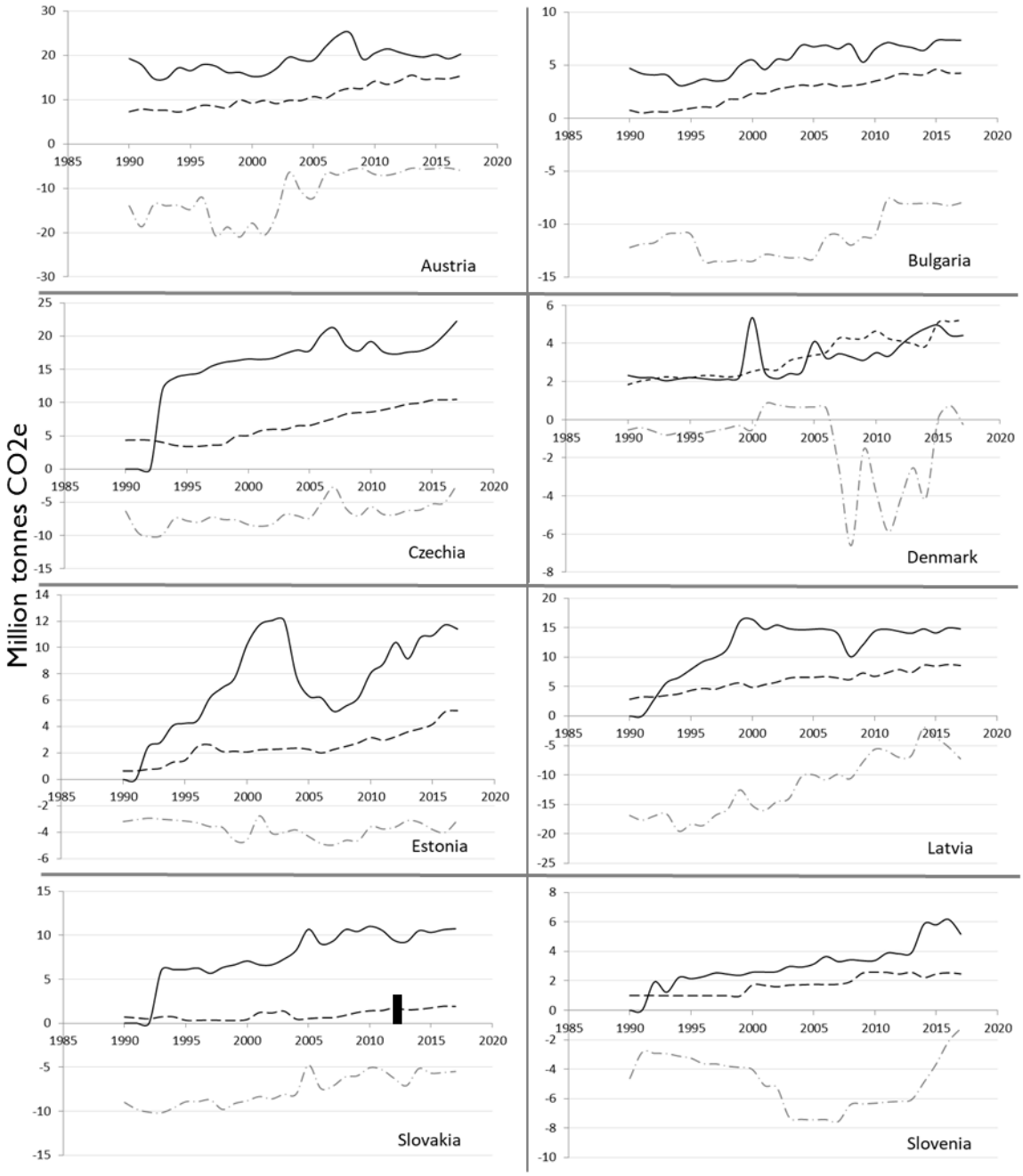

Figure S-5. Trends (as CO_2 equivalents) in total roundwood harvested (solid line), wood biomass fuels manufactured and burned in-country (dark dashed line), and the forest carbon sink (light dashed line) in eight countries that have experienced a significant decline in forest carbon uptake since 1990. The bar at 2012 in the Slovakia graph represents the higher estimate of biomass use (from researchers) than what was reported officially. Of the countries shown, Austria, Czechia, Estonia, and Latvia are important wood pellet producers in Europe.

What can the EU do to minimize harm from use of forest biomass?

Top recommendation: remove eligibility for forest biomass under the RED

The EU needs a climate policy that puts forests first. Accordingly, the most effective course of action for forests and the climate is to remove eligibility of forest biomass for renewable energy targets and subsidies altogether. This is fast climate mitigation. Ending supports would reduce forest carbon loss, protect habitats, and free up billions of euro in subsidies annually to then allocate to efficiency and true zero-emissions renewable energy, or, to forest owners to compensate for financial impacts associated with prioritizing growing forests instead of cutting them. Removing eligibility of forest biomass in the RED II would likely have no effect on wood availability for people who depend on burning wood for residential heating.

However, if the EU falls short of genuine reform, it must at a minimum drastically improve the forest biomass criteria and expand their applicability to all biomass burned in the EU, including wood for residential heating. Currently, the criteria are not capable of delivering on the RED's claim that they ensure GHG savings and avoid forest impacts. The following steps would improve the forest biomass criteria:

Implement full life-cycle GHG accounting: Full accounting for forest biomass includes all the GHG emitted by growing, harvesting, processing, transporting, and **burning** the fuel. Precedent exists within the RED II for assessing carbon loss from forests: the RED II protocol for assessing carbon loss from land use change when energy crops replace forest assigns the net carbon loss over a 20 year period to the energy crop. This protocol could be adapted for assessing carbon loss from use of forest biomass. No biomass fuel should qualify toward renewable energy targets in the RED II unless it has an unambiguously strong carbon benefit within ten years or less. Even this time-frame is probably too long. If there is one thing that seems universally true regarding forest biomass, it is that carbon emissions are usually worse than they appear on paper.

Put natural forests off-limits to biomass harvesting: Short of eliminating subsidies for forest biomass altogether, disqualifying biomass from natural forests in the RED, including for categories of wood currently not covered under the criteria such as wood burned for residential heating, would do more to reduce logging pressure on forests than any other measure. For the sake of biodiversity protections *solely* (as this solution would not address concerns about GHG emissions), biomass could in this case be sourced from existing monoculture plantations, as a means of effectuating their transition to more diverse, natural forest ecosystems that are envisioned in the Biodiversity Strategy. This would need to be accompanied by a strict cap on use of forest biomass in the RED overall, to avoid pressure on remaining allowable resources and associated leakage.

Designate more forests as protected and make such "protection" meaningful: The Directive should consider more classes of forests as protected and/or biodiverse and accordingly designate them genuinely off-limits to biomass harvesting. At a minimum, the definition of "biodiverse" should be extended to forests that are reported to the Convention on Biological Diversity as protected, and biomass from "biodiverse" forests should be excluded from eligibility in the RED II with no exceptions. It is wildly inappropriate to *encourage* biomass harvesting in protected areas by allowing the wood to qualify toward renewable energy targets and to receive subsidies.

Explicitly disqualify illegally sourced wood: The RED II should be amended to explicitly state that no illegally sourced wood should qualify toward renewable energy targets, and more enforcement measures added where relevant.

Enact recommendations in the Biodiversity Strategy: Policymakers should take seriously the exhortation of the Biodiversity Strategy that all forms of bioenergy rely on "residues and non-reusable and non-recyclable waste" and that "The use of whole trees and food and feed crops for energy production – whether produced in the EU or imported – should be minimised."[1]

Do not pretend burning forestry residues is the answer: Restricting eligible forest biomass to just forestry residues has been suggested as an option for reducing damage from biomass. However, even if such a policy were enforceable, harvesting and burning forestry residues depletes soil carbon, degrades biodiversity, and increases net emissions over decades, and thus does not deliver true climate and forest protections.

Options for member states to minimize damage to forests and climate

If the EU does not meaningfully reform its treatment of forest biomass, member states have several options for reducing harm from its use.

Reduce or eliminate subsidies for forest biomass

Article 4(1) of the RED II states that member states "may" apply support schemes to achieve renewable energy targets, meaning the Directive does not *require* member states to provide subsidies or other financial supports to any form of renewable energy, including bioenergy. Accordingly, other countries can follow the example of Slovakia, which in 2018 amended their renewable energy law to limit subsidies for biomass energy to mill residues and energy crops, thereby eliminating subsidies for forest biomass. The EU definition of biomass still appears in the law, but the definition of what sources of renewable energy receive support includes "biomass, including all products of its processing, except wood that does not come from energy crops and except wood that is not waste from the wood processing industry."

Exclude forest biomass from tendering procedures

The RED grants flexibility to member states to "meet their greenhouse gas reduction targets in the most cost-effective manner in accordance with their specific circumstances, energy mix and capacity to produce renewable energy." Member states are allowed by Article 4(5) of the RED II to "limit tendering procedures to specific technologies where opening support schemes to all producers of electricity from renewable sources would lead to a suboptimal result, including for biomass, "the need to avoid distortions of raw materials markets." The approach of eliminating forest biomass projects from tendering would be rendered more effective if accompanied by elimination of subsidies.

Establish additional sustainability criteria

Article 29(14) provides that member states may establish additional sustainability criteria for forest biomass. However, it is an open question whether sustainability criteria could be crafted that are genuinely protective, because no set of criteria will redress the net GHG impacts of burning forest

wood. Additionally, member states may face challenges if they adopt criteria that undermine the purposes of the RED II, which include the promotion and mobilization of forest biomass. However, sustainability criteria could potentially be crafted to provide greater protections for forests, for instance by adapting the criteria for agricultural biomass in Article 29(2) – 29(5). These cover soil carbon, biodiversity, and protection of ecosystem carbon stocks in wetlands and forests.

Expand applicability and rigor of GHG criteria

The Directive's instruction that fuels must show "at least" a 70% reduction in emissions appears to mean that more rigorous standards are allowed. To effect meaningful protection, member states should consider adopting a stringent GHG standard such as the UK's limit of 8.1 g CO_2 MJ^{-1}, which represents a 95.5% reduction relative to the 183 g CO_2 MJ^{-1} comparator, as this will restrict use of imported wood pellets.

Expand applicability rigor of efficiency criteria

The criteria allow member states to apply an efficiency threshold to plants smaller than 50 MW, and even increase the efficiency requirement relative to the standard set in the criteria. Member states should consider adopting the UK policy requiring facilities to achieve a minimum of 70% efficiency or an even higher standard. Such a standard cannot be achieved by electricity-only plants but only by combined heat and power or thermal-only plants, and could thus help limit facility size, fuel consumption, and some associated impacts.

Full report: Forest Biomass in the EU's Renewable Energy Directive

To increase the share of energy generated from renewable sources, and thus reduce greenhouse gas emissions, the EU has adopted the Renewable Energy Directive (RED), which mandates renewable energy and greenhouse gas (GHG) reduction goals for EU member states and sets criteria for which renewable energy technologies are eligible to meet those goals. The objectives of the most recent RED ("RED II," enacted in 2018 and covering the years 2021 to 2030[2]) are for the EU to reach a collective target of 32% energy from renewable sources and cut GHG emissions by at least 40 % below 1990 levels by 2030.[3] As part of the European Green Deal, the European Commission (EC) is considering increasing these targets and has carried out a number of consultations to solicit input.[4] However, if targets are increased without reforming the treatment of forest biomass[5] in the RED II, the results could be profoundly counterproductive, due to the GHG and ecosystem impacts of harvesting and burning forest wood for energy.

The RED's goal of reducing GHG emissions made its inclusion of forest biomass as a source of renewable energy controversial from the start. Biomass generally emits more CO_2 per unit of final energy than fossil fuels, and a variety of scientific studies conclude that cumulative net CO_2 emissions from burning forest biomass can exceed emissions from fossil fuels for decades to more than a century, even when forests cut for fuel are presumed to regrow and offset emissions. For instance, a study of Norwegian forests found that increasing the use of wood from a boreal forest to replace coal in power plants will create a carbon debt that will only be repaid after almost two centuries of regrowth[6] (see Appendix I for a few of the many papers highlighting net GHG impacts of burning forest biomass). Despite general acceptance of this science, including by the European Commission's own science staff, the RED treats burning biomass as having zero CO_2 emissions, the same as wind and solar energy, though the Directive does require accounting of CO_2 emitted from fossil fuels burned during biomass harvesting, processing, and transport, as well as non-CO_2 greenhouse gases (GHG) from biomass combustion. Eligibility in the RED as a zero-emissions energy source makes biomass use eligible at the member state level for subsidies, which for the top 15 biomass-using member states were over €6 billion in 2017.[7] Such subsidies turn the concept of "polluter pays," which is enshrined as a central principle governing environmental policy in the Treaty on the Functioning of the EU,[8] on its head.

the RED II treats forest biomass as "zero emissions," even though burning wood emits more CO_2 than coal and net impacts can last centuries

The controversy around forest biomass is particularly heated because as biomass use has increased, so have reports of forests devastated by biomass harvesting, particularly by the wood pellet industry, which supplies a growing portion of the wood burned in the EU. Much of the wood being manufactured into pellets comes from areas with little oversight or accountability, where the forest industry sets its own rules – the boreal forests of Estonia, Russia, and Canada, the wetland hardwood forests of the U.S. Southeast, and even the ancient wilderness forests of the Carpathian Mountains.[9]

Rapid growth in use of forest biomass has alarmed many scientists and environmental organizations, who fear growing emissions from biomass energy are undermining climate mitigation, even as the EU takes credit for increasing "zero emission" renewable energy. Forest protection, clean energy, health, climate, and social justice groups have made common cause on this issue as hundreds of

millions of tonnes of wood are burned each year, destroying forests and increasing air pollution and climate pollution. During the drafting process for the RED II, various groups petitioned policymakers to restrict biomass logging in natural forests and to require full lifecycle accounting that would reflect the carbon emissions impact of burning forest wood. Despite these concerns, the RED II as published continued to promote use of forest biomass[10] as a zero emissions fuel.[11] However, for the first time, it justified this treatment of biomass by including "Union-wide sustainability and greenhouse gas emissions saving criteria for biomass fuels used in the electricity sector and in the heating and cooling sector" that it claims will "continue to ensure high greenhouse gas emissions savings compared to fossil fuel alternatives, to avoid unintended sustainability impacts, and to promote the internal market."[12]

The efficacy of these criteria, and their ability to deliver on these claims, is the subject of this paper.

Current use of wood for energy in the EU

Currently, about half the reported uses of wood in the EU-28 are for energy, but the Joint Research Centre (JRC), a research and advisory group that serves the European Commission, reports that energy uses are underreported and thus the energy share of wood biomass should reasonably be even higher.[13] While production of traditional wood products for material use has mostly held steady,[14] bioenergy generation has tripled since 1990[15] and currently constitutes the EU's largest source of renewable energy, with the category of biomass and renewable wastes as a whole (including liquid biofuels) comprising about 60% of renewable energy in 2018[16] and combustion of wood for heat and power comprising about 35%.[17] The JRC attributes the surge in biomass use in recent years to EU targets for renewable energy.[18]

even wood burned in household fireplaces counts toward the EU's renewable energy targets

Eurostat data on fuel energy content indicate that the EU produced biomass fuels equivalent to about 320 million tonnes (Mt) of green (freshly harvested) wood in 2018, although this is certainly an underestimate, as discussed below. This estimate includes around 35 Mt of green wood required to produce more than 16 Mt of EU-sourced wood pellets and "other agglomerates" (compressed wood fuels other than wood pellets). Another 8.3 Mt of wood pellets and other agglomerated fuels imported from countries outside the EU, mostly the US and Canada, represented about 18 Mt green wood in 2018.[19] Accordingly on a green wood basis, wood pellets and like fuels appear to constitute somewhere upwards of 15% of wood burned for energy in the EU, though to the extent that actual wood burning is underestimated (see below) the percentage could be smaller. Burning one green tonne of forest wood emits around one tonne of CO_2, assuming a standard moisture content of 45 – 50%. For context, the approximately 340 Mt of CO_2 directly emitted from biomass combustion in the EU (which considerably underestimates the full emissions impact of forest biomass harvesting) is similar in magnitude to CO_2 uptake in the land sector in 2017 of 258 Mt[20].

GHG emissions from burning wood exceed CO_2 uptake in the EU's land sector

Under both RED I[21] and RED II,[22] nearly all wood and other biomass burned for energy, including in households, counts toward renewable energy targets. Eurostat data indicate about 60% of wood

burned in the EU (~190 Mt) is for residential heating, which accordingly plays a central role in meeting renewable energy targets. As wood heating tends to be lightly subsidized, it helps member states meet the renewable energy targets at a low cost. Some member states do provide financial supports for residential heating, including subsidizing purchase of wood-burning appliances.[23] Partly as a result of these incentives, some member states have experienced a large increase in residential wood-burning, for example Italy, where official statistics show residential wood use increasing more than 500 percent from 2000 to 2016.[24]

some of the wood counted toward renewable energy targets is illegally harvested

Even with residential wood-burning already dominating renewable energy generation, indications are that actual use of wood is even greater than official data suggest. Logging is significantly underreported by some member states due to landowners that use wood directly from the land, rather than selling it,[25] and because illegally sourced wood is generally not reported.

The discrepancies between actual and reported logging can be significant.

- Eurostat data for Slovakia recorded just 0.155 Mt of green wood equivalent burned for residential heating and around 1.7 Mt total wood burned for energy in 2012, but data collected by the Slovak Hydrometeorological Institute concluded wood use for heating was 11 times higher, at 1.8 Mt, and total wood use for energy was 2.9 Mt.[26]
- In Romania, data collected via a special survey estimates total wood removals of 38.5 million cubic meters (Mm^3) in 2017, 265% the 14.5 Mm^3 reported by Eurostat. At least some of the discrepancy is due to illegal logging,[27] although methodological issues of reporting could also account for some of the difference. A report on the fate of illegally logged wood in Romania determined that some was being made into wood pellets that are bagged and sold for home heating in Europe.[28]
- In Italy, the JRC study showed that wood use for energy was 4 – 5 times greater than use for materials. A large proportion of wood use is for residential heating, and the JRC concluded that about 40% of wood was of unknown, possibly illegal, origin.[29]
- Even member states with well-regulated forestry industries can show large discrepancies. The JRC's tally in Germany of recorded uses of wood compared to known sources found that about 45 million green tonnes of wood used is "unaccounted," with no known origin. This was second only to Romania with 58 million green tonnes of unaccounted wood.[30]

actual logging can exceed official estimates by tens of millions of tonnes

- In some cases, illegally harvested wood may be rolled into official statistics on wood use. In Hungary, a 2009 wood market analysis[31] found residential wood use based on household surveys exceeded official reports that were based on harvesting data by 3 – 3.5 Mm^3. Much of this wood may be illegally harvested. In 2015, Hungary officially revised its methodology for assessing residential wood use, basing the new numbers on household surveys rather than harvesting reports, and applying the new methodology retroactively to 2010. The result was a 250% increase overnight in reported residential wood consumption, which then allowed Hungary to claim it had exceeded its EU-mandated renewable energy target at that time. It is

an open secret[32] that much of the wood use reported by Hungary – and counted toward its renewable energy targets – may be harvested illegally. The market analysis[33] observed that other member states had apparently also seen a large overnight increase in estimates of residential wood use, including Belgium, Croatia, Czechia, Italy, the Netherlands, the UK, and Sweden. Regarding additional impacts of burning wood for energy, the study pointed out that in 2012, Hungary was third in the EU after Bulgaria and Romania for the death rate from air pollution, for which residential wood smoke is a primary contributor. Those rankings still held in 2016, though overall death rates have fallen.[34]

Reporting data on wood burning for commercial, industrial, and utility heat and power may be somewhat more accurate than for residential heating. A 2013 survey coordinated by the European Biomass Association[35] identified 4,079 biomass plants greater than 1 MW energy input in the EU burning wood to generate heat, electricity, and combined heat and power, consuming around 129 Mt of green wood fuel. The large majority of plants were less than 5 MW in capacity on an energy input basis, but plants greater than 20 MW energy input were responsible for about 73% of fuel consumption (95 Mt). Data from the European Large Combustion Plant database[36] indicate wood use by plants greater than 50 MW was about 61 Mt (47% of the survey total) at that time.

Health impacts from residential wood-burning in Europe

The issue of air pollution from residential wood-burning has been brought more into focus by the COVID-19 pandemic. Air pollution in the EU currently kills around 500,000 people in the EU each year.[37] Particulate matter in the 2.5 micrometre size class ($PM_{2.5}$) is the pollutant with the highest impact in terms of premature deaths. The most recent EU report on air quality in Europe finds that $PM_{2.5}$ pollution alone was responsible for about 374,000 premature deaths in the EU-28 in 2016, and that particulate matter from households, commercial establishments and institutions, which is mostly from burning solid fuels (including wood) for heat, is responsible for 39% of total PM.[38] Emissions of mercury and some other toxic pollutants are actually increasing, partly due to "re-emissions"; such re-mobilization is responsible for 60% of mercury emissions in the EU,[39] with domestic wood burning likely a significant source.[40] Residential wood-burning poses a particular danger because emission sources are located in homes and close to the ground. Achieving the WHO air quality standard for $PM_{2.5}$ in the EU-28 would decrease premature mortality by 27%.[41] Unfortunately, because death rates from the virus are higher in polluted areas,[42] death rates connected to air pollution can reasonably be expected to increase in the future.

Use of wood pellets for heating and power generation in the EU has increased sharply. Data from Bioenergy Europe show wood pellet consumption in the EU-28 increasing from around 17 Mt in 2013 to over 26 Mt in 2018, a 50% increase in five years (the 26 Mt figure is slightly higher than calculated based on Eurostat data, above). In 2018, residential heating accounted for 40% and power generation for 36% of pellet consumption, with the balance going to commercial heating and combined heat and power.[43]

Biomass harvesting impacts on the EU's carbon sink

Achieving the Paris Agreement's goal of balancing emissions sources and sinks by midcentury,[44] expressed in the EU goal of net zero emissions by 2050,[45] will require both drastic reductions in emissions and a transformative increase in the EU's forest carbon sink. However, as of 2017, the reported land sector carbon sink for the EU was equivalent to less than 6% of reported emissions,[46] and instead of increasing, the land sink has been decreasing (becoming less negative) in recent years. New research[47] indicates a shocking expansion of forest harvesting in Europe, partly driven by biomass harvesting. As reported by the Guardian[48]:

> "Many of the EU's forests – which account for about 38% of its land surface area – are managed for timber production, and thus harvested regularly. But the loss of biomass increased by 69% in the period from 2016 to 2018, compared with the period from 2011 to 2015, according to satellite data. The area of forest harvested increased by 49% in the same comparison."

Despite the urgency of prioritizing carbon storage and sequestration, the EU has not historically included increased carbon sequestration in the land-sector as part of its climate mitigation goals, in part due to uncertainties in measurement and reporting of carbon stocks and sinks. Meanwhile, however, the EU has continued to promote logging and burning forest wood as fuel, with little consideration of how this may be undermining the forest carbon sink.

There has been surprisingly little discussion of tradeoffs between biomass harvesting and increasing net forest carbon uptake. However, there are occasional instances when policymakers seem to register concerns. For instance, the European Environment Agency's website states:

> "Further continued expansion of forest fellings may result in unsustainable production. For instance, an increase in the demand for bioenergy would require an increase in the import of wood from outside Europe in order to allow forest biomass resources to be rebuilt to a sustainable level. However, such displacement of land use is very likely to lead to the collapse of forest resources, in the form of deforestation, in other parts of the world."[49]

Given the major role that biomass plays in the EU's renewable energy portfolio, acknowledgements of its potential for damage are sometimes surprisingly minimal. For instance, EU legislation on Governance of the Energy Union and Climate Action (2018),[50] which among other things sets out requirements for member states to report on national energy and climate progress, requires inclusion of information on biomass use, including "an assessment of its source and impact on the LULUCF[51] sink." Even with this acknowledgement, however, subsidies for harvesting forest biomass have largely gone unquestioned.

biomass demand creates a strong market for so-called "low value" wood, sucking carbon out of the forest

As many forests have been hollowed out by harvesting,[52] reducing logging to increase the carbon density of existing forests offers potentially significant gains in carbon storage,[53] and is a cost-effective mechanism in the EU's climate mitigation efforts.[54] Yet the forestry sector seems to proceed with business as usual, partly because the demand for biomass has created a strong market

for "low value" wood that might otherwise have been left in the forest.[55] The Joint Research Centre estimates that official harvest levels currently consume about 63% of the forest growth increment, but that as removals are underestimated by up to 20%, the harvest-to-increment ratio is likely about 12% higher.[56]

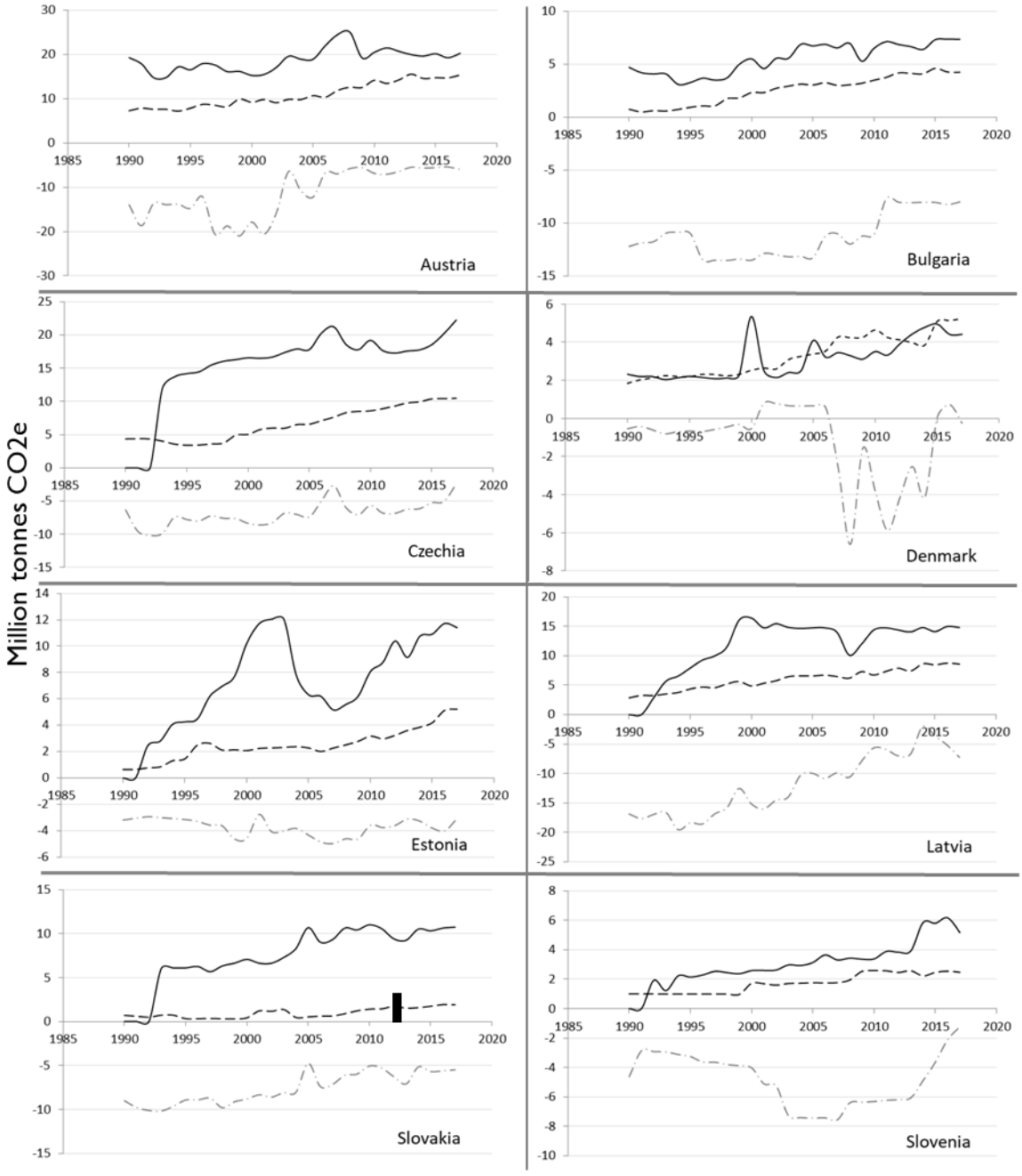

Figure 1. Comparison (as CO_2 equivalents) of total roundwood harvested (solid line),[57] wood biomass fuels manufactured and burned in-country (dark dashed line),[58] and the forest carbon sink (light dashed line).[59]

In part due to logging, the EU's forest carbon sink is declining, with some member states experiencing dramatic reductions. Figure 1 shows trends in total roundwood harvesting, manufacturing and use of biomass harvested in-country (a subset of roundwood harvesting), and the forest carbon sink in six countries that have experienced a significant decline in forest carbon uptake since 1990. While correlation does not imply causation, the trends in the lines reinforce reports that wood use for energy constitutes around half of total harvesting,[60] and that increased logging, including for biomass energy, is degrading the forest sink. In some cases, for instance Denmark, the calculated amount of wood burned (which is estimated from energy accounts) actually exceeds the amount reported as harvested. Denmark's forests now appear to be a source of carbon, rather than a sink. It is almost certainly the case that both total logging and biomass use in some cases are underreported; the bar at 2012 in the chart for Slovakia represents the amount of wood that was calculated for energy use (as described above), which exceeded the amount calculated as burned using Eurostat data. Slovakia has lost half its carbon sink since the early 1990s (and is the one country that has taken significant action to constrain use of forest biomass as fuel, as discussed in the last section of this paper). The data show Latvia going from a reported forest sink of around 20 million tonnes in the early 1990's to a small fraction of that currently. Of the countries shown in Figure 1, Austria, Czechia, Estonia, and Latvia are important wood pellet producers in Europe.[61]

the outlook for the EU's forests is that carbon sequestration will continue to decline

Although EU policy now supports increased forest carbon sequestration (for example, the EU's new Biodiversity Strategy commits the EU to planting at least 3 billion trees by 2030 "in full respect of ecological principles"[62]), the current outlook for the EU's forests is that carbon sequestration will continue to decline. The trend is particularly stark in member state projections that are about to be finalized as part of EU climate policy. The EU's new Land Use, Land Use Change and Forestry (LULUCF) Regulation requires EU member states to establish a forest reference level (FRL), essentially an extrapolation of the forest sink based on forest harvesting intensity and practices from the reference period of 2000 – 2009. The FRL serves as a baseline against which to assess whether the forest carbon sink is increasing, decreasing, or holding steady over time. These new land sector targets are intended to help achieve economy wide net emissions reductions while attempting to avoid the policy assumptions that made forest baseline setting so variable and controversial under the Kyoto Protocol,[63] although the process of establishing the FRL's is also turning out to be more complicated and more influenced by policy than had perhaps been anticipated.

Overall, the news is not good. Member state projections for the 2021-2026 period[64] show that collectively, the EU's forest sink is projected to decline by 11% compared to the average forest sink from 2016 to 2018.[65] Half of member states project that management will reduce their forest sink relative to the 2016-2018 average, and the majority of these plan to reduce their sink by 20% or more. This loss in the sink is partially a function of harvesting, partially a function of the EU's heavily managed forests aging and slowing their carbon sequestration, and partially a function of climate, pest, and pathogen stress, all of which are common in low biodiversity forests managed for wood products. In contrast, natural and biodiverse forests can continue as carbon sinks for decades to centuries longer, [66] and show greater resistance to stressors. The degradation of the EU's forest carbon sink just when it is most needed for climate mitigation is an alarming indictment of how forests have been managed in recent decades, and a flashing red warning light that forests need to be restored and re-naturalized to both store more carbon and help restore biodiversity.

The changing cast of reasons for counting biomass as emitting "zero" CO_2

Given the EU's recent and ambitious goal of net zero emissions by 2050, the tradeoff between biomass harvesting and forest carbon uptake may now receive more attention. However, if logging is known to degrade the EU's forest carbon sink and accordingly increase atmospheric CO_2 concentration, a fundamental issue requiring clarification is how the RED, as well as the EU's emissions trading scheme (ETS), justifies incentivizing biomass as a "zero emissions" fuel.

The answer to this question is not straightforward. While an obvious response might be that biomass is considered to be "renewable" and to have zero net emissions because new biomass growth offsets emissions from fuel combustion over time, few EU regulations or their supporting documents directly refer to this argument, probably because the length of time required for forest regrowth (decades to centuries) is simply unacceptable in light of the urgency of the climate crisis. Biomass apologists thus had to come up with other arguments for why cutting and burning forests does not add net CO_2 to the atmosphere. Currently, there appear to be three interlinking concepts used to justify treating forest biomass as having zero CO_2 emissions: that emissions are counted in the land sector; that biomass is sourced from forestry and mill residues; and that forest biomass is "sustainably harvested." These concepts are examined below.

The "biomass emissions are counted in the land sector" argument

Under IPCC GHG reporting rules, emissions from forest harvesting are attributed to the land use sector and can show up as impacts on the forest carbon sink, thus to avoid double-counting, emissions from burning the fuel are not included in energy sector emissions totals.[67] Though the IPCC warns that "the approach of not including bioenergy emissions in the Energy Sector total should not be interpreted as a conclusion about the sustainability or carbon neutrality of bioenergy,"[68] the "count in the land sector/avoid double-counting" argument is sometimes invoked as a rationale for treating biomass as "carbon neutral." For instance, a 2009 report from European Commission staff on sustainability criteria for forest biomass invokes this argument, entangled with other rationalizations:

> the RED is an incentive scheme, not a carbon inventory, so concerns with double-counting biomass emissions are misplaced

> "The combustion of biomass involves GHG emissions, but it is considered carbon-neutral following the practice of the IPCC national inventory guidelines, where emissions from biomass are included in the energy sector for information only, and not added to the total. The reason for this is that emissions from combustion are offset against CO_2 absorbed from the atmosphere during the growing phase. In addition, any changes in the carbon stock on land are reported under the land use, land-use change and forestry category, therefore counting them under energy would constitute double counting."[69]

Counting biomass as "zero" to avoid double-counting is simply an accounting convention, and does not justify treating burning forest wood in an incentive scheme such as the RED II as if it *actually* has zero emissions. Yet EU policy continues to treat the two concepts as if they are interchangeable. As the EU is instituting improved carbon accounting for the land sector under the 2018 Land Use, Land Use Change and Forestry (LULUCF) Regulation, there is now a new version of the "counted

in the land sector" argument, although EC science staff appear to be somewhat more careful now about claiming bioenergy is carbon neutral. Pronouncements from some EU staff and policymakers indicate they believe that because land sector carbon will now be *better* accounted under the LULUCF Regulation, this is sufficient justification for treating biomass as having zero emissions in the RED. For instance, an EU webpage on the Regulation states,

> "Emissions of biomass used in energy will be recorded and accounted towards each Member State's 2030 climate commitments, through the correct application of accounting in LULUCF. This breakthrough addresses the earlier broad criticism that emissions from biomass in energy production were not accounted for under previous EU law. As forest management is the main source of biomass for energy and wood production, more robust accounting rules and governance for forest management will provide a solid basis for Europe's future renewables policy after 2020.[70]"

This seems to be an indirect justification for treating forest biomass as zero emissions, if not "carbon neutral."

The argument that biogenic emissions should not be counted in the RED in order to avoid double-counting is actually undercut by the RED's *own* approach to lifecycle emissions for biomass. In counting CO_2 emissions from fossil fuels burned during biomass harvesting, manufacturing, and transport, the RED is already engaging in "double-counting," because these emissions have been counted in the fossil fuel sectors of country-level GHG inventories.

Nonetheless, because the purpose of the RED is to define renewable energy and determine which technologies are eligible for incentives, not to serve as a duplicate carbon inventory, the concern with double-counting biomass emissions is misplaced.

The "biomass is sourced from residues and wastes" argument

Forestry and mill residues are widely treated as having negligible or even zero net emissions when burned for energy, since it is assumed that alternative fates of these materials - decomposition, or burning for disposal without energy recovery - would emit CO_2 in any case. The assumption that most biomass is derived from residues appears to inform the RED I definition of biomass as "the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste." Notably, the 2009 RED defined wood pellets as "generally consisting of processing residues from forest based industries"[71] which even if it was true in the mid-2000's, is certainly no longer the case, given the important role whole tree logging plays in providing pellet feedstock.[72]

even burning forestry residues increases CO_2 emissions and undermines climate mitigation

In reality, residues and the carbon benefits they promise are limited. For the statement that residues would have emissions "anyway" to be true, materials must be products of some process unrelated to biomass production; as the RED II puts it: "a substance that is not the end product(s) that a production process directly seeks to produce; it is not a primary aim of the production

process and the process has not been deliberately modified to produce it."[73] This description matches sawdust and offcuts from sawmills, much of which are already claimed as fuel and for other purposes such as particleboard, animal bedding, or mulch. The definition also applies to tops and limbs from trees harvested for sawtimber that would otherwise be left in the field or burned for disposal, but does not apply if logging is conducted specifically for pellet feedstock and other woody biomass.

Even where the definition of true forestry residues is met, cumulative emissions from burning these materials for energy will always exceed emissions in a counterfactual situation where residues are left at the logging site to decompose. The cumulative net emissions, i.e., the additional CO_2 added to the atmosphere due to burning residues for energy, is the difference between smokestack emissions and decomposition emissions over time. This cumulative net impact is eventually less than direct smokestack emissions over time, but is still substantial. For instance, cumulative net emissions from burning forest residues for fuel over the period 2020 – 2030 would still be 50 – 80% of smokestack emissions over the period, and would thus be comparable to or greater than cumulative emissions from burning fossil fuels[74] during the period when the EU needs to most aggressively reduce emissions. Use of forestry residues is often portrayed as a "best case" scenario for carbon impacts, but it is clear that impacts are incompatible with aggressive EU targets to reduce emissions over the next decade.

The "biomass is sustainably harvested" argument

The third and most important rationale underpinning the treatment of biomass as having zero CO_2 emissions is the idea that if logging is "sustainable," then biomass emissions are instantaneously offset. At its most basic, the concept of sustainable harvesting entails that logging not exceed forest growth, meaning that the forest area under consideration can as a whole sequester at least as much carbon in biomass each year as was removed by logging. The concept of sustainable forest management is a valid approach for maintaining and even expanding carbon stocks when it is properly implemented. However, it is not a proxy for instantaneous biomass carbon neutrality. Treating the concepts as interchangeable essentially attempts to substitute space (assigning forest carbon uptake that is occurring elsewhere in the forest to instantaneously offset emissions from logging and burning forest wood) for time (the multiple decades required for forests to regrow after logging in order to offset emissions – see references in Appendix I). The concept is also fundamentally incompatible with the above justification for counting biomass as zero emissions, that "emissions are counted in the land sector." Both cannot be true – either there are emissions and they are counted in the land sector, or the biomass is "sustainably harvested" and thus instantaneously has zero net emissions.

either there are emissions and they are counted in the land sector, or biomass is "sustainably harvested" and has net zero emissions – both cannot be true

The supposed equivalence of sustainability and carbon neutrality is the conceptual basis of all existing biomass "sustainability certification" schemes (see Appendix II) and also partially underpins the treatment of forest biomass as zero emissions in the RED II.

Sustainability is not equivalent to carbon neutrality, however, because as the IPCC warns,

> "The combustion of biomass generates gross GHG emissions roughly equivalent to the combustion of fossil fuels. If bioenergy production is to generate a net reduction in emissions, it must do so by offsetting those emissions through increased net carbon uptake of biota and soils."[75]

Treating sustainable harvesting as a proxy for carbon neutrality assigns *ongoing* forest growth to offset emissions, and thus does not constitute "increased" carbon uptake per the IPCC warning, as shown by the following example. Considering a 100k hectare forest managed to produce on average 4 tonnes of green wood per hectare per year, this growth would sequester about 400k tonnes of CO_2 from the atmosphere into new growth annually. In this case, it would be possible to initiate logging for biomass fuel and "sustainably" harvest close to 400k tonnes of biomass from part of the forest, as long as other parts of the forest continued growing and sequestering carbon. However, the atmosphere no longer "sees" a yearly net removal of 400k tonnes of CO_2 by that forest, because the CO_2 uptake by the forest is now negated by the CO_2 from burning the wood that was harvested. The decrease in CO_2 removal by the forest is registered by the atmosphere as an increase in CO_2 concentration, and there is no additional, increased carbon uptake to offset the emissions as the IPCC warning requires. Thus, even though the harvesting was "sustainable," the biomass is not "zero emissions" or "carbon neutral."

A symptom of this error is that estimates of landscape carbon balance are extremely susceptible to the size of the area assessed (Figure 2). Biomass producers need to define large sourcing areas, even if they only actually harvest a small proportion, as this allows them to claim carbon sequestration over the entire area as offsetting carbon loss in the logged area.

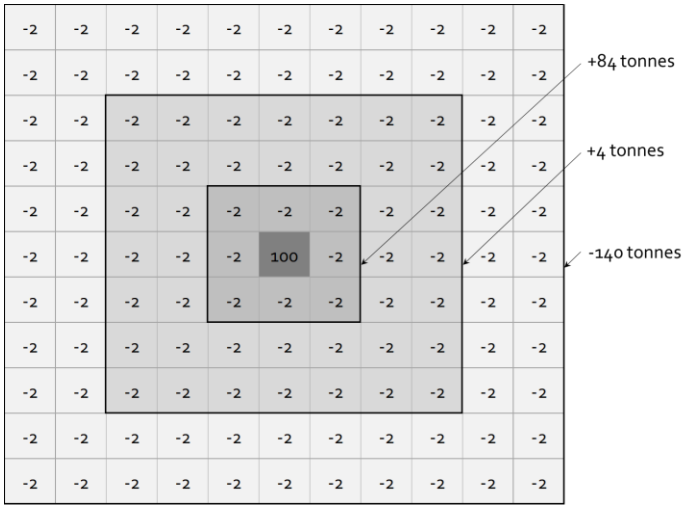

Figure 2. The scale-dependency of the "sustainability" approach. The center plot represents one forest plot harvested and burned in an otherwise undisturbed landscape of plots, emitting +100 tonnes of CO_2. If plots grow at 2% per year, re-growing this plot to offset that emission will take 50 years. However, when sustainability is equated with carbon neutrality, ongoing carbon uptake in other plots is claimed as offsetting emissions from the center plot. Summing the 100 tonnes of emissions from the center plot with the 2 tonnes of annual CO_2 uptake in each of the 8 surrounding unharvested plots produces a landscape balance of +84 tonnes CO_2 emitted. Summing it with CO_2 uptake in the larger area with 48 surrounding plots, the landscape balance is +4 tonnes emitted. Summing with all 120 surrounding plots, the landscape balance is -140 tonnes CO_2 sequestered. In

each case, the objective physical reality is that the atmosphere experienced a new addition of 100 tonnes of CO_2, but under the landscape approach to carbon accounting, the biomass producer can claim that emissions are instantaneously neutralized to some degree depending on the size of the surrounding area claimed as an offset, offset, even to the point of achieving "negative emissions" in at large landscape scales.

Current assessments by the Sustainable Biomass Program (SBP) tend to define very large sourcing areas, which they call "supply bases." For instance, the SBP assessment for pellet manufacturer Granuul defines the supply base as including the entire country of Estonia[76], and two SBP assessments conducted in the Southeastern US for pellet company Enviva define the supply base as 14.4 million hectares for the Ahoskie plant,[77] and 52.5 million hectares for the Amory plant[78] (the SBP has performed assessments for 8 Enviva plants and more for many other companies).

treating sustainability as a proxy for biomass carbon neutrality is a classic error of double-counting

The assumption that biomass has zero net emissions as long as growth exceeds harvest is essentially a "double-counting" error, not of emissions, as discussed above, but of the forest carbon sink and forest growth that was already ongoing. The net land carbon sink is counted in the UNFCCC GHG inventory as "reducing" total GHG emissions. For instance, the UNFCCC[79] reports total EU emissions in 2017 "with" and "without" the land sector sink (4,065,088.75 kilotonnes CO2e and 4,323,163.15 kilotonnes CO2e respectively). Uptake in the land sector translates to about a 6% reduction in net emissions, with forests doing most of the heavy lifting, as the rest of the EU land sector is a net source of emissions. Calling that net sink into service *again*, as an instantaneous offset for emissions from burning forest biomass, constitutes a far worse double-counting error than counting bioenergy emissions in the energy sector and the land sector.

Although the assumption of carbon neutrality for "sustainably sourced" biomass falsely counts emissions as zero, the assumed equivalence of sustainability and carbon neutrality nonetheless underpins biomass sustainability schemes developed in the UK, the Netherlands, Denmark, and by the corporate group the Biomass Sustainability Program (see Appendix II for more information). It is also one of the main justifications for treating biomass as zero emissions in the RED II, as laid out in the Directive's sustainability and LULUCF criteria. Nonetheless, publications from science staff at the EC show that thinking has evolved on the equivalence of sustainability and carbon neutrality. A 2010 report by EC staff exploring potential biomass sustainability criteria,[80] along with a supporting study,[81] never questioned the centrality of sustainable harvesting for delivering carbon benefits. However, a 2016 impact assessment on bioenergy sustainability[82] acknowledged the obvious problem:

EC science staff admit that burning forest biomass can increase GHG emissions for decades to centuries

> "compared to crops which regrow over short periods, forest biomass is part of a much longer carbon cycle. A forest stand typically takes between decades and a century to reach maturity. Recent studies have found that when greenhouse gas emissions and removals from combustion, decay and plant growth (so-called biogenic emissions from various biological pools) are also taken into account, the

> use of certain forest biomass feedstocks for energy purposes can lead to substantially reduced or even negative greenhouse gas savings compared to the use of fossil fuels in a given time period (e.g. 20 to 50 years or even up to centuries)."

The 2016 assessment specifically rejected the equivalence of "sustainability" and carbon neutrality:

> "Certain forest management practices can enhance the carbon sink, but ensuring that the harvest level stays below the growth rate of the forest is not sufficient to ensure climate change mitigation."

And (emphasis added),

> "Sustainable forest management practices (e.g. implemented through national legislation or in the context of certification schemes) play a role in mitigating the risk of overharvesting of forests. As such, **they cannot guarantee that an increase in forest biomass for energy will deliver greenhouse gas savings**, but they can avoid excessive wood removals which would result in a decrease in carbon sinks."[83]

The 2016 assessment determined that a central objective of any sustainability policy adopted by the EU should be to "Ensure that bioenergy use in the EU delivers a significant contribution to climate change mitigation, taking into account the full lifecycle emissions including biogenic carbon." It went on to summarize a study by Forest Research commissioned by the EC that found high risk of forest carbon loss and increased emissions from burning forest wood.

How to ensure that biomass would deliver carbon savings? The sustainability impact assessment spoke favorably of doing full GHG accounting:

> "This option would ensure that biogenic CO_2 emissions are included in the lifecycle greenhouse gas performance of forest biomass, on top of supply-chain emissions. This would allow for a full picture of climate impacts from these feedstocks. This is in line with the agreement in the scientific community that adequate account of biogenic CO_2 emissions is needed."

However, the option of conducting full GHG accounting using a counterfactual approach, as supported by current science (see Appendix 1) was immediately discarded at this stage with no further study or follow-up to determine actual feasibility:

> "Studies stress that it is very difficult to attribute a greenhouse gas performance to a specific consignment of forest biomass. While the combustion emissions are easy to calculate, the benefits accruing to biomass production are difficult and uncertain to estimate, and certain feedstocks can have positive or negative impacts, depending in particular on the counterfactual scenario (i.e. what would otherwise have happened with the wood and with the land)… Hence, while an assessment of the overall greenhouse gas impact of an increase of demand in forest biomass is possible and has been modelled (with the inherent limitations to any prospective modelling exercise), a reliable assessment of lifecycle biogenic emissions of specific consignments or pathways of forest biomass would be extremely difficult, notably

> because it would have to be based on subjective choices. In addition, it would pose difficulties linked to verification. Therefore, this option is discarded."

and just like that, the science-based approach on biomass carbon accounting was abandoned

And just like that, the decision was made to abandon a science-based approach. Despite damning conclusions by the EC's own science staff that burning forest biomass would likely increase emissions, and that only full GHG accounting could reveal the true emissions impact of burning forest biomass, the RED II continues to treat biomass as "zero" emissions and claims that GHG and sustainability criteria – a discredited approach – "ensure" biomass delivers carbon savings compared to fossil fuels.

The Forest Biomass Criteria

The RED II biomass criteria determine which biomass fuels, liquid biofuels, and biogases are eligible to contribute toward renewable energy targets and receive financial support from member states.[84] The RED II distinguishes between agricultural biomass, which is mostly used as feedstock for liquid biofuels and biogas, and forest biomass, which is mostly burned for heat and electricity generation, but may also serve as feedstock for liquid biofuels and biogases. Key provisions for agricultural biomass are found in Article 29(2) – 29(5) of the Directive, while key provisions for forest biomass are the sustainability criteria in Article 29(6); the land-use, land-use change and forestry criteria ("LULUCF criteria") in Article 29(7); the greenhouse gas emission savings criteria ("GHG criteria") in Article 29(10); and the efficiency criteria in Article 29(11).

Requirements relating to the procurement of biomass are set out in the LULUCF and sustainability criteria.[85] The European Commission set up the "REDIIBIO" project[86] to develop guidance for implementing the LULUCF and sustainability criteria; once finalized, the guidance will be incorporated into an Implementing Act. Operators of power plants will demonstrate compliance with the criteria by adhering to national schemes set up by member states in concordance with the Implementing Act, or by obtaining biomass that has been certified under voluntary schemes that have been recognized as meeting the implementation guidance by the European Commission.

The four types of criteria and other relevant provisions concerning forest biomass are laid out in the following sections and in Table 1. In some cases, the text has been summarized for brevity and clarity.

Efficiency criteria – Art. 29(11)

These criteria set efficiency standards for large power plants burning biomass, and apply to new or converted plants starting operation after 2021.

The efficiency criteria (Article 29(11)) allow electricity from biomass fuels to count toward renewable energy targets under the RED II under the following conditions:

(a) it is produced in installations with a total rated thermal input below 50 MW;

(b) for installations with a total rated thermal input from 50 to 100 MW, it is produced applying high-efficiency cogeneration technology, or, for electricity-only installations, meeting an energy

efficiency level associated with the best available techniques (BAT-AEELs) as defined in Commission Implementing Decision (EU) 2017/1442 (1);

(c) for installations with a total rated thermal input above 100 MW, it is produced applying high-efficiency cogeneration technology, or, for electricity-only installations, achieving a net-electrical efficiency of at least 36 %;

(d) it is produced applying Biomass CO_2 Capture and Storage (BECCS).
Power plants that convert from burning fossil fuels to biomass can qualify under these criteria. For the purposes of points (a), (b), and (c), electricity-only installations only qualify if they do not use fossil fuels as the main fuel, and if there is not cost-effective potential for the application of high-efficiency cogeneration technology, based on assessments that member states were required to perform under a previous Directive.[87]

The efficiency criteria do not apply to existing plants, but only to new or converted facilities. Parts (a) and (b) apply to plants "starting operation or converted to the use of biomass fuels after 25 December 2021," while part (c) applies to support granted "in accordance with Article 4 approved by 25 December 2021" (Article 4 sets general conditions for support schemes). The criteria also exempt many facilities even if they are new. Provision (a) exempts plants less than 50 MW thermal input from any efficiency requirement, which for an electricity-only facility corresponds to about 10 – 15 MW of electricity output for plants burning green or partially dried woodchips (due to the impacts of fuel moisture on facility efficiency), while plants burning dried chips or wood pellets could generate more.

For plants 50 – 100 MW energy input, plants must use cogeneration of heat and power, or, they can generate electricity if they use the "best available technology-associated energy efficiency levels," which are 33.5 – 38% net electrical efficiency for new solid biomass boilers.[88] These efficiency levels are calculated using the European method, as energy output divided by the lower heating value of energy input, meaning they are around 10% higher than efficiency values calculated using the US approach, which uses the higher heating value as the denominator.

Part (d), which grants eligibility to plants using BECCS, does not set any conditions regarding efficiency or a minimum level of net carbon storage.

The RED II permits member states to apply higher energy efficiency requirements than those referred to in the criteria to plants lower in capacity than 50 MW as specified in (a), but can also appeal requirements of (a) to the Commission "based on the duly substantiated existence of risks for the security of supply of electricity."

GHG criteria – Art. 29(10)

These criteria set standards for the allowable amount of CO_2 from fossil fuels burned during biomass harvesting, fuel manufacture, and transport. Carbon dioxide from biomass combustion is excluded.

The Directive requires partial life-cycle accounting for biomass under the GHG criteria, counting CO_2 emissions from fossil fuels burned during harvesting, processing, and transporting biomass fuels, plus any non-CO_2 GHG emitted by burning biomass. The GHG criteria do not include CO_2

from biomass combustion, as the RED II states that for all biomass and biomass-derived fuels, "emissions from the fuel in use shall be taken to be zero"[89] (unless biomass production causes land-use change). These partial life-cycle emissions are of most concern for wood pellets, which can have associated fossil-fuel lifecycle emissions equivalent to at least 14 – 15%[90] of the biogenic CO_2 released by burning the pellets.

The RED assesses fossil fuel life-cycle emissions for forest biomass in units of grams CO_2 per megajoule (g CO_2 MJ^{-1}) of final energy, which requires taking the efficiency of fuel conversion to final energy into account. Article 29(10)(d) requires a savings relative to an emissions comparator of "at least 70% for electricity, heating and cooling production from biomass fuels used in installations starting operation from 1 January 2021 until 31 December 2025, and 80% for installations starting operation from 1 January 2026." The standard comparator values are 80 g CO_2eq MJ^{-1} for heat and 183 g CO_2eq MJ^{-1} for electricity. For biomass heating where a direct physical substitution of coal can be demonstrated, the comparator is 124 g CO_2eq MJ^{-1} heat.[91]

The GHG criteria apply to solid biomass used in installations equal to or greater than 20 MW capacity on an energy input basis, [92] which corresponds to about 4 – 7 MW output at an electricity-only plant, depending on conversion efficiency. The facility in-operation dates for the GHG criteria mean the criteria do not apply to existing facilities.

Under Article 29(1)(c), member states may apply the sustainability and GHG emissions saving criteria to installations with lower total rated thermal input than 20 MW. It also appears that member states may have the discretion to impose more rigorous lifecycle standards; the phrase that savings must be "at least" 70% in Article 29(10)(d) implies this discretion exists.

Land Use, Land Use Change, and Forestry (LULUCF) Criteria – Art. 29(7)

These criteria pertain to the land carbon balance in the country or region from which biomass is sourced, and are where the concept of "sustainable harvesting" resides.

The "Land Use, Land Use Change, and Forestry" (LULUCF) criteria for forest biomass are set out in Article 29(7). [93] The LULUCF criteria are where the "sustainable harvesting" provisions reside, rather than in the sustainability criteria as might be expected, and are thus the main locus for considerations of carbon balance. To qualify under the RED II,

> 7. Biofuels, bioliquids and biomass fuels produced from forest biomass shall meet the following land-use, land-use change and forestry (LULUCF) criteria:
>
> (a) the country or region of origin of the forest biomass
>
> (i) is a Party to the Paris Agreement;
>
> (ii) has submitted a nationally determined contribution (NDC) covering carbon emissions and removals in the land sector that "ensures changes in carbon stock associated with biomass harvest are accounted towards the country's commitment to reduce or limit greenhouse gas emissions as specified in the NDC"; or
>
> (iii) "has national or sub-national laws in place that apply in the area of harvest, to conserve and enhance carbon stocks and sinks, and providing evidence that reported LULUCF-sector emissions do not exceed removals";

(b) for countries where points a(i)-a(iii) do not apply, biomass is eligible "if management systems are in place at forest sourcing area level to ensure that carbon stocks and sinks levels in the forest are maintained, or strengthened over the long term."

"Removals" in this context refers to removal of CO_2 from the atmosphere by forests and the rest of the land sink.

"Sourcing area" is defined as "the geographically defined area from which the forest biomass feedstock is sourced, from which reliable and independent information is available and where conditions are sufficiently homogeneous to evaluate the risk of the sustainability and legality characteristics of the forest biomass." [94]

The RED II does not discuss any means for member states to strengthen the LULUCF criteria.

Sustainability criteria – Art. 29(6)

These criteria require the country or region of origin of the biomass to have laws and monitoring concerning forest harvesting

Article 29 sets out the sustainability criteria for biofuels, bioliquids and biomass fuels. Subparagraphs (2)-(5) are concerned with agricultural biomass and preventing impacts to carbon-rich or biodiverse lands (including forests) by their conversion to energy crops. Agricultural biomass is disqualified if it is sourced from land that prior to January 2008 had a high carbon stock, including wetlands and continually forested areas meeting certain criteria, and also if it is sourced from land that was peatland prior to January 2008, unless producing the material does not involve drainage of previously undrained soil. The criteria provide that biomass from wastes and residues from agricultural land only qualifies under the RED II where systems are in place to address impacts on soil quality and carbon, and that qualifying biomass from agricultural sources cannot be sourced from land that was primary forest, highly biodiverse forest, or land that was designated for nature protection or species protection.

Separate from these requirements, Article 29(6) sets out the sustainability criteria for biofuels, bioliquids and biomass fuels produced from forest biomass. These criteria differ notably from the criteria for agricultural biomass in having fewer protections or consideration of carbon stocks.

6. Biofuels, bioliquids and biomass fuels produced from forest biomass shall meet the following criteria to minimise the risk of using forest biomass derived from unsustainable production:

(a) the country in which forest biomass was harvested has national or sub-national laws applicable in the area of harvest as well as monitoring and enforcement systems in place ensuring:

i. the legality of harvesting operations;

ii. forest regeneration of harvested areas;

iii. that areas designated by international or national law or by the relevant competent authority for nature protection purposes, including in wetlands and peatlands, are protected;

iv. that harvesting is carried out considering maintenance of soil quality and biodiversity with the aim of minimising negative impacts; and

v. that harvesting maintains or improves the long-term production capacity of the forest;

(b) when evidence referred to in point (a) of this paragraph is not available, the biofuels, bioliquids and biomass fuels produced from forest biomass shall be taken into account for the purposes referred to in points (a), (b) and (c) of the first subparagraph of paragraph 1 if management systems are in place at forest sourcing area level ensuring the same matters listed in (6)(a)(i)-(v), except that element (iii) in this case reads, "that areas designated by international or national law or by the relevant competent authority for nature protection purposes, including in wetlands and peatlands, are protected unless evidence is provided that the harvesting of that raw material does not interfere with those nature protection purposes."

The Commission may decide that voluntary national or international schemes setting standards for the production of biomass provide accurate data sufficient to meet the criteria laid down in Article 29(6), the sustainability criteria, and Article 29(7), the LULUCF criteria, and operators can provide data directly at the sourcing area level.[95]

Regarding biodiversity, the RED II considers forests as biodiverse in accordance with the sustainability criteria if they are protected by national nature protection law, or where they are "primary" forests under the FAO definition, which requires there be "no known significant human intervention or the last significant human intervention was long enough ago to have allowed the natural species composition and processes to have become re-established."[96] Other types of forest defined by the FAO, such as modified natural forests, semi-natural forests and plantations, are not considered to be primary forests.[97]

As is the case for the GHG criteria, the forest biomass sustainability criteria are limited in the size of facilities they cover. Article 29(1)(c) restricts their applicability to fuel used in installations with a total rated thermal input equal to or exceeding 20 MW in the case of solid biomass fuels. Member states are permitted to apply the criteria to smaller installations, and Article 29(14) provides that member states "may establish additional sustainability criteria" for biomass fuels. However, Article 29(12) prohibits member states from imposing more protective sustainability criteria on biofuels or bioliquids obtained in compliance with the Directive, meaning the criteria provide a 'ceiling' of regulation if such fuels are sourced from forest biomass.

Evaluation of the RED II forest biomass criteria

The RED II criteria for forest biomass are complex and intricate, making them difficult to interpret, yet policymakers have not hesitated to claim that they will widely protect forests and the climate. In reality, however, the criteria fall far short of the Directive's claim to "ensure" emissions savings and avoid unintended sustainability impacts. First, the criteria apply to only a portion of the biomass that will be burned in the EU in coming years. Second, the criteria in many respects replicate the assumptions and conditions under which biomass is currently sourced, assuring that the damage being observed currently will continue. The exception to this would be if the EU elects to create extremely rigorous implementation guidance for the LULCF and sustainability criteria under the REDIIBIO program, as discussed below, and member states actually enforce it. This might have the effect of limiting some harvesting in the EU and possibly also imports of wood pellets from non-EU countries. However, even the most rigorous implementation guidance will not ensure that burning biomass has a lower net carbon impact than burning fossil fuels.

Policymakers are unlikely to understand the degree to which the RED fails to deliver meaningful protections, but there are indications that unease is growing. The EU's proposed Sustainable Finance Taxonomy,[98] which provides an imprimatur of "greenness" for projects financed in the EU, does not overtly allow unfettered use of forest biomass in its criteria for sustainable energy projects, but instead limits allowable biomass fuels to a list[99] of mostly wastes and residues approved in the RED II as feedstocks for advanced liquid biofuels. The intention was clearly to reduce use of trees as fuel; unfortunately, however, some elements on this list are still likely to be interpreted as sanctioning the continued unrestricted use of forest biomass as fuel. The EU's new Biodiversity Strategy suggests that the RED II sustainability criteria may not be protective enough by exhorting that biomass should be sourced from wastes and residues, and use of whole trees should be avoided.[100] Additionally, the Biodiversity Strategy hints that additional protections may be needed, and that existing regulations may need to be revisited, including the RED II.

Can the RED II forest biomass criteria be improved? Are there measures that would ensure biomass actually delivers GHG savings and does not harm forests? Most importantly, failing meaningful improvements and additional protections being enacted at the EU level, what can member states do now to ensure that use of forest biomass does not damage forests and undermine their climate mitigation efforts?

Answering these questions requires evaluating the strength and enforceability of the RED II's forest biomass criteria, as well as their applicability – that is, the degree to which they will actually apply at facilities burning biomass in the EU.

Applicability is limited to a fraction of the biomass burned in the EU

Considering applicability first, the RED II criteria are only going to cover a small percentage of the EU's biomass facilities and the fuels they burn, exempting the majority of biomass now burned in the EU (Table 1).

Applicability of efficiency criteria

There are no facility efficiency criteria for existing facilities or for new facilities of less than 50 MW energy input. Thus, the efficiency requirements will only apply to a small fraction of the facilities burning biomass in the EU, i.e., new facilities greater than 50 MW. Since the RED II allows member states to extend the criteria to facilities with lower capacity, there is potential for covering a greater share of *new* facilities. However, as the criteria now stand, they will do nothing to increase efficiency across the whole EU fleet of biomass burning units.

Applicability of GHG criteria

the criteria will only apply to a tiny fraction of the biomass burned in coming years

While the GHG criteria for transport fuels and bioliquids apply to the sector as a whole, Recital 104 states that "in order to minimize the administrative burden," sustainability and GHG savings criteria for electricity and heating from biomass apply only at installations equal or greater than 20 MW energy input, which corresponds to about 4 – 7 MW output at an electricity-only plant depending on conversion efficiency. Accordingly, the GHG criteria do not apply to the majority of future uses of wood pellets: residential heating (which currently accounts for 40% of wood pellet use in the EU[101]), existing facilities of any size, and

future facilities smaller than 20 MW, which if the existing population of facilities is a guide, is the size of facility most likely to be built. Thus the GHG criteria are ineffectual as a way to induce improvements in resource use in the wood pellet industry, or as a way of limiting the import of wood pellets. This is particularly the case because most imported pellets apparently already meet the criteria, as discussed below.

Applicability of LULUCF criteria

The LULUCF criteria have wide applicability to forest biomass seeking to qualify under the RED II, with provisions that apply to the country, region, or "forest sourcing area" from which forest biomass is sourced. However, as explained below (in section "The LULUCF criteria do not protect forests or the climate"), the criteria are irrelevant to the issue they are intended address, GHG emissions from bioenergy.

	Where found	Units/fuels affected	Units/fuels exempted	Discretion for Member States
Efficiency criteria	Article 29(11)	New installations >= 50 MW thermal input; different requirements for increasing plant capacity (1)	New installations < 50 MW thermal input; installations using BECCS (1); all existing installations	MS can apply higher efficiency requirement to plants with lower rated thermal input than 50 MW (1)
GHG criteria	Article 29(1); Article 29(10)(d)	New(2) installations>= 20 MW thermal input (3)	New installations < 20 MW thermal input (3); all existing installations; all residential use	MS can apply GHG requirements to plants with lower rated thermal input than 20 MW (4); MS appear to be allowed to institute lower limits (2)
Sustainability criteria	Article 29(1); Article 29(6)	Installations >= 20 MW thermal input (3)	Installations < 20 MW thermal input (2), all residential use	MS can apply sustainability requirements to plants with lower rated thermal input than 20 MW (4); MS may establish additional sustainability criteria for biomass fuels (5)
LULUCF criteria	Article 29(7)	Biofuels, bioliquids, and biomass fuels prodcued from foresty biomass seeking to qualify under the RED (6)		No discretion granted to MS to expand or contract applicability (6)

Notes

(1) Article 29(11); Applies to installations starting operation or converted to the use of biomass fuels after 25 December 2021.

(2) Article 29(10)(d); 70% GHG savings for installations starting operation from 1 January 2021 until 31 December 2025; 80% GHG savings for installations starting operation 1 January 2026.

(3) Article 29(1); Recital 104

(4) Article 29(1)

(5) Article 29(14)

(6) Article 29(7)

Table 1. Summary of forest biomass criteria and their applicability.

Applicability of sustainability criteria

The sustainability criteria apply at facilities of at least 20 MW energy input and appear to apply at both new and existing facilities, as there is no "in operation by" date for the plants to which the criteria apply. Importantly, however, the provisions will not apply to wood pellets or other wood burned for residential heating, which is the main use of wood for energy in the EU. The RED allows member states to extend coverage of the sustainability criteria to new plants with a lower rated thermal input than 20 MW, and they can establish new sustainability criteria for biomass

fuels, which might afford some protections if member states devise criteria that are actually meaningful.

Overall, the limited applicability of the efficiency and GHG criteria to a narrow subset of new facilities and conversions mean that even if the criteria were effective, they would likely not bring about any meaningful reduction in the damage done by the biomass industry. The wider applicability of the sustainability and LULUCF criteria mean that these criteria might have the potential to elicit changes in the biomass industry, but as discussed below, the criteria contain multiple loopholes and are generally weak and ineffective, and thus are unlikely to restrict use or imports of biomass compared to the situation under the 2009 RED. This could change if the EU elects to implement rigorous and enforceable standards under the REDIIBIO program.

The efficiency criteria set a low standard

The lack of any efficiency standard for existing plants and new plants smaller than 50 MW leaves the plants most prone to inefficiency completely uncovered by the criteria. However, even for those new plants that will be covered, the requirements are weak. The requirement that facilities between 50 – 100 MW thermal input employ high-efficiency cogeneration could be minimally impactful if it were broadly applied, as this could help slightly reduce the amount of fuel burned to generate a given amount of energy, and might stop development of plants in locations that could not find a "heat customer" that ensures both heat and power are utilized. However, the efficiency criteria contain a large loophole, allowing electricity-only plants in this size-class if cogeneration is deemed not cost-effective. This would likely apply to a situation where a nearby heat customer cannot be found, and is particularly likely to be the case for large plants, as they generate enormous amounts of waste heat.

the efficiency criteria won't stop coal-to-biomass conversions and may even increase use of the most carbon-intensive biomass

Further, the "best available techniques" efficiency range for electricity-only plants is already established in EU law; it is not an exceptional or exemplary standard as might be expected for plants that are going to receive millions of euros in subsidies each year. Ironically, the efficiency standard may have the additional negative impact of increasing the resource-intensity of the biomass burned, as achieving slightly elevated efficiency levels in electricity-only plants may require use of dried wood chips or imported wood pellets, which represent more embodied carbon than locally sourced green woodchips. The same observations apply to facilities greater than 100 MW, which the criteria allow to be electricity-only as long as they achieve an efficiency level of 36%. Overall, the efficiency standards are unlikely to restrict proliferation of the largest, most inefficient wood-burning power plants, and will likely allow further conversions of coal plants to burning wood, ensuring these inefficient and polluting facilities continue to operate.

The provision allowing plants using BECCS to qualify under the efficiency standard is problematic, as well. In theory, BECCS should reduce emissions of CO_2, but the additional power required to pump and store CO_2 belowground increases fuel consumption at a plant using BECCS for a given amount of power generation.[102] The criteria do not contain any requirement for a minimum net

carbon storage, meaning the entire process could be a net source of CO_2 to the atmosphere, and it would still qualify under the criteria.

In contrast to the EU standards, the UK enacted a standard in 2018 requiring all new bioenergy facilities to achieve at least 70% efficiency to qualify for subsidies.[103] As this standard can only be met by cogeneration or heat-only facilities, it is likely to significantly restrict the size of facilities, and has the potential to displace more fossil fuels. Under the UK's new, more stringent standard, the Drax power plant coal-to-biomass conversions would not have received the hefty renewable energy subsidies they currently enjoy. In 2019, Drax collected about €2.4 million per day in subsidies for its wood-burning operations in the UK.[104]

The GHG criteria are already out of date

The GHG criteria are of little utility, *per se*, as they do not count emissions from burning the biomass itself. Since combustion emissions from biomass on an energy output basis range from around 115 g CO_2eq MJ^{-1} for high-efficiency heat plants to around 400 g CO_2eq MJ^{-1} for inefficient electricity-only plants, including CO_2 emissions from biomass combustion in lifecycle accounting would usually cause total emissions to exceed the RED II comparators for heat (80 g CO_2eq MJ^{-1} or 124 g CO_2eq MJ^{-1} heat if coal is substituted) and electricity (183 g CO_2eq MJ^{-1}). The RED II's statement that the GHG criteria help "ensure" biomass carbon savings compared to fossil fuels is thus true in this one sense, as the exclusion of biomass combustion CO_2 from the GHG account does indeed "ensure" that biomass appears to reduce emissions. In reality, biomass power plants generally emit more CO_2 per unit of energy generated than the fossil fuels they replace.

the greenhouse gas criteria are so weak, wood pellets imported in 2014 already exceeded the standard

Even beyond the failure to count full lifecycle emissions, however, the GHG criteria are weak even regarding what is regulated, i.e., CO_2 from fossil fuels that are burned in the course of harvesting, manufacturing, and transporting biomass, and non-CO_2 GHG's from biomass combustion (the latter contributing a small proportion).

For instance, the RED II electricity-only savings requirement of 70% progressing to 80% relative to the 183 g CO_2 MJ^{-1} comparator for electricity translates to emission rates of 54.9 and 36.6 g CO_2 MJ^{-1} respectively. At Drax, the UK coal electricity plant that has converted to biomass and currently burns more than twice as many wood pellets than any other *country* in the EU-28,[105] average fossil lifecycle emissions of wood pellets imported in 2014 were already lower (at 122.4 kg CO_2 MWh, converting to 34 g CO_2 MJ^{-1}) than the RED II low-end standard of 36.6 g CO_2 MJ^{-1}.[106]

Thus, the new EU standard will do nothing to constrain wood pellet imports, even those from North America with maximal transport emissions. In contrast, a new UK GHG standard of 8.1 g CO_2 MJ^{-1} for biomass plants starting operation in 2021 – 2026[107] will likely rule out the use of imported wood pellets for new facilities that wish to receive subsidies.[108] This standard represents a 95.5% reduction relative to the 183 g CO_2 MJ^{-1} standard.

To remedy the utter lack of utility of the GHG criteria, the RED II should be reformed to require full lifecycle accounting for bioenergy that includes emissions from burning the fuel. In fact, the

RED II appears to contain a minor admission that its GHG accounting is not adequate, mildly exhorting member states that when developing support schemes for renewable energy, they "should consider the available sustainable supply of biomass"[109] and "avoid distortive situations resulting in the extensive importation of resources from third countries. A life-cycle approach should be considered and promoted in that respect."[110]

To create a GHG standard that at a minimum constrains imports of wood pellets, the manufacture of which is demonstrably obliterating forests in Europe and North America, the EU should adopt a similarly low GHG standard as in the UK, and make the criteria apply to wood pellets burned in the EU. The "administrative burden" claim used to exempt existing facilities does not seem valid, considering the responsibility for complying with GHG criteria ultimately falls on pellet producers, and there are far fewer of them than there are consumers of pellets.

The LULUCF criteria do not protect forests or the climate

As the LULUCF Regulation only applies to EU member states, the LULUCF criteria in the RED II are intended to cover member states but also extend concerns about forest carbon stocks and sinks to non-EU regions that provide forest biomass to the EU. As the provisions broadly seek to ensure that forest harvesting does not exceed growth, the criteria are the locus for one of the main justifications for treating biomass as having zero carbon emissions. Yet as explained above, and observed by EU science staff, "ensuring that the harvest level stays below the growth rate of the forest is not sufficient to ensure climate change mitigation."[111]

legalistic language in the criteria does not translate to genuine protections

The LULUCF criteria do not deliver carbon savings and they do not deliver protection for carbon stocks on any given area of land. Alternative (a)(i) combined with (a)(ii) will allow biomass to comply with the LULUCF criteria by coming from any of the 189 countries[112] that have so far ratified the Paris Agreement as long as the country's Nationally Determined Contribution (NDC) plan tracks changes in the land carbon sink from biomass harvesting and counts these toward GHG commitments. If the country of origin has ratified the Paris Agreement but its NDC falls short of this standard, alternative (a)(iii) stipulates that laws be in place in the area of harvest that value the land carbon sink, and that there be evidence that land-sector emissions do not exceed the carbon sink.[113] These legalistic level "a" provisions do not protect any given forest and its carbon stocks because they do not prohibit intensive harvesting and clearcutting of forests.

Given that the United States is the biggest supplier of wood pellets outside the EU, and the U.S. government had initiated the process of leaving the Paris Agreement as the RED II was being drafted, policymakers were aware that none of the alternatives laid out in (7)(a) may apply in the U.S. in the future. Accordingly, option (7)(b) provides another way for biomass to qualify under the LULUCF criteria with no mention of the Paris Agreement, requiring that "management systems be in place" in the "forest sourcing area" to ensure forest carbon stocks and sinks are maintained.

Unfortunately it appears to be impossible for the draft REDIIBIO implementation guidance[114] to assure that carbon stocks and sinks are maintained. The level "b" guidance recommends that biomass producers quantify forest carbon stocks and sinks in the sourcing area for a historical reference period (recommended: 2000 – 2009) taking into account the carbon pools from the

IPCC GHG protocol (which include soil carbon and deadwood). Then producers are supposed to describe development of forest carbon stocks and sinks over a "future long-term period" (recommended as 30 years) using modeling. The final step is to compare "future carbon stocks and sinks with the historical reference period" to ensure that "Mean carbon stocks and sinks of the long-term period are higher or equal to mean carbon stocks and sinks of the reference period."[115]

The goal of maintaining or increasing forest carbon stocks will often be impossible to achieve if carbon accounting is confined to the actual area from which biomass is sourced, since biomass and wood pellet producers routinely cut trees much older than 30 years. In such cases, even assuming the forest is allowed to fully regrow after harvest, the only way to achieve the goal is if the model counts carbon sequestration occurring in a larger area than just the area harvested (see Figure 2). However, even if the producer's contract with the land owner specifies that regrowth must occur, and the landowner adheres to the contract, the contract only covers the forest land that was harvested. There is no contract with the owners of the unharvested lands that the model counts as providing the extra "offsetting" capacity. Even for the owners with contracts – and for a wood pellet manufacturer like US-based Enviva, there are thousands – who will stay in touch with them to ensure regrowth occurs over the next 30 years? The time-period might even be longer; as with characterization of sourcing areas,[116] the time-period for assessing regrowth is left up to biomass producers. During the REDIIBIO workshop[117] it was suggested that producers working in smaller sourcing areas would want to pick timeframes *longer* than 30 years as their definition of "long-term," since the smaller the sourcing area, the more difficult it is to demonstrate carbon stocks will recover in a few decades. The entire concept of "sustainability" turns out to be booby-trapped when it comes to practical implementation, laying bare the failure of the RED II to acknowledge the long time-frames required for forest regrowth.

"sustainability" turns out to be booby-trapped when it comes to practical implementation.

In fact the entire approach of claiming forest growth occurring elsewhere on the landscape as an offset for emissions from forest biomass is a departure from carbon accounting done elsewhere in the RED II. Leaving aside the issue of indirect land use change, biomass from agricultural crops is treated as carbon neutral because it is commonly assumed that crops can grow back within a short period of time and thus sequester carbon equivalent to that released by burning the fuel. However, if planting the crop results in direct land-use change and loss of carbon stocks on that piece of land – for instance if the crop replaces a forest – the agricultural biomass either does not qualify as renewable, or is assigned a carbon emissions value equivalent to the net carbon loss from the land amortized over 20 years (note, not 30 years). Accordingly, the question of carbon balance through time is adjudicated on the *plot of land on which the crop is grown* - agricultural biomass is not treated as carbon neutral because crops are growing somewhere else, or because the total amount of agricultural biomass in the region or country is determined to be constant or growing; and it is not exempted from the penalty of having replaced forest because trees are growing somewhere else. Yet these are the very arguments invoked to justify the treatment of forest biomass as having zero emissions: that despite a forest stand having been obliterated by logging for fuel, forests *somewhere else* in the "sourcing area" are still growing and sequestering carbon, and this carbon uptake is assumed to instantaneously offset emissions from burning the biomass. It would make just as much sense to argue that forests are growing on the other side of the world.

The EU's LULUCF Regulation is not a panacea because it will not reflect carbon loss

The EU's 2018 LULUCF Regulation, which the LULUCF criteria mirror, cannot remedy these problems. At best, an accounting system to track land sector carbon would show that burning biomass to "reduce" emissions in the energy sector is simply robbing Peter to pay Paul. However, the forest reference level (FRL) approach used under the Regulation does not fully value forest carbon loss due to logging for biomass, and thus will continue to incentivize harvesting forests for fuel, for three main reasons.

First, forest biomass use in the EU increased more than 70 percent[118] from 2000 – 2009, and member state FRL baselines, which are an extrapolation of the forest sink based on forestry practices in this period, "bake in" this harvesting and do not register it as an emission. Accordingly, even if it is working optimally, the FRL approach is only capable of revealing impacts of *additional* logging above what is already accounted for in the baseline.

member state forest baselines "bake in" current biomass demand

Second, the Regulation differentially values forest carbon loss depending on the strength of the forest carbon sink relative to the baseline. A forest carbon sink that is stronger than the baseline (meaning more negative) can be reduced through harvesting to generate "zero emissions" biomass without generating a penalty (whereas if the harvested wood were converted to wood products, that portion of the carbon would continue to be counted as contributing to the carbon sink). Only if harvesting is so intense that a member state's net forest carbon sink fails to meet the FRL baseline will this loss in the forest carbon sink generate a debit under the Regulation, requiring member states to compensate by reducing emissions elsewhere. This penalty at the member state level will be imposed long after governments have paid out potentially billions in renewable energy subsidies that support companies logging and burning forest wood.

This problem of dueling incentives was noted in the European Commission's 2016 sustainability impact study, which observed,

> "Accounting for biogenic emissions in the LULUCF sector could reduce the incentives for harvesting certain types of forest biomass for energy that would reduce the forest sink. This phenomenon is difficult to assess, as it will largely depend on the degree to which the negative impact of the harvest on national greenhouse gas inventories will be passed on to operators, and how these would counterbalance positive incentives (e.g. the additional income from the sale of biomass for energy)."[119]

Third, member state FRL baselines, even after adjustments by EU officials as of June 2020, project significant losses of the forest carbon sink that amount to a more than 10% loss in forest carbon uptake at the EU level compared to the 2016-2018 average, and some states will lose much more. Because member states are managing toward such weak targets, this will increase the amount of biomass available for harvest without creating a debit.

The sustainability criteria focus on legal regimes, not outcomes

The sustainability criteria are the provisions in the RED II that should deliver on the Directive's claim to "avoid unintended sustainability impacts." Given how destructive logging can be to forest ecosystems, especially the forest clearcutting that is observed with the wood pellet industry,[120] a wide range of extreme impacts already occurring under existing "sustainability" schemes could reasonably be said to be "intended." Accordingly, the EU sustainability criteria at Article 29(6)(a) appear to be mostly a box-checking exercise to ensure that the country of origin has laws and monitoring pertaining to forestry. These laws are required to be concerned with legality of harvesting, regeneration, protection of conserved areas, consideration of soil quality, and "long-term productivity" of the forest.[121] As for the LULUCF criteria, the draft REDIIBIO implementation guidance includes a list of requirements and types of proof that are acceptable.

If the required laws are not in place, then Article 29(6)(b) applies, requiring a "management system" to meet the requirements at the "forest sourcing area level." In this case, there is additional latitude granted; harvesting in wetlands and peatlands is specifically allowed if "evidence is provided that the harvesting of that raw material does not interfere with those nature protection purposes," a provision likely added to accommodate wood pellet producers in the United States who frequently log mature hardwoods in wetland and riverine forests.[122]

Article 29(6)(a) appears to assume that the existence of regulatory or management systems ensures sustainability, and that such sustainability ensures carbon benefits and protects forests. However, as laws and regulations governing forest harvesting and their enforcement can vary greatly across jurisdictions, in practice the sustainability criteria are likely to tolerate highly damaging actions that are currently allowed under forestry laws in a number of countries. For instance, in Estonia, the mills of one of the world's largest pellet companies, Graanul Invest, have been certified by the Sustainable Biomass Partnership, yet comments submitted by the Estonian Fund for Nature[123] noted significant and ongoing damage to forests by the wood pellet industry, including logging in wetlands and habitat of threatened and endangered species. Particularly notable in Estonia is the practice of removing stumps after logging, which tears up organic soils and leads to soil carbon loss (Figure 3). This practice is legal under Estonian forestry laws[124] and would apparently be permissible under the new REDIIBIO guidance.

Figure 3. Forest after clearcutting and stump removal, near Imavere, Estonia. Photo: Almuth Ernsting, Biofuelwatch

In Canada, some of the wood used in pellets exported to Europe and Asia comes from logging ancient cedars in British Columbia's inland rainforest (Figure 4), these trees having been classified by local authorities as eligible to be used for pellet feedstock if they are not sawtimber quality.[125] There is nothing in the REDIIBIO guidance that will prohibit use of such trees as pellet feedstock.

Figure 4. Truck bringing logs to be made into pellets at Pacific Bioenergy, a pellet plant in British Columbia, Canada. Ancient cedars from the region's rare inland rainforest ecosystem are being made into wood pellets that are burned in Europe and Asia. The trees were deemed by authorities as low-value and thus acceptable for pellet feedstock. Photo James Steidel for Conservation North.

In the Southeastern US, where much of the wood pellets for EU biomass plants are currently sourced, it is legal to clear-cut biodiverse natural forests then replant with monoculture pine, eliminating the hardwood ecosystem and associated biodiversity[126] and causing permanent carbon loss, including loss of soil carbon.[127] Figure 5 (next page) shows replacement of a North Carolina riverine hardwood forest about double the size of Parc de Bruxelles, which would provide wood pellets sufficient to power the UK Drax power station for 3 hours and 24 minutes, if all the wood harvested went for pellet feedstock (see Appendix III for calculations). There is nothing in the REDIIBIO guidance that would prohibit this practice.

As with the LULUCF criteria, the draft REDIIBIO implementation criteria for sustainable biomass sourcing at the "b" level require a degree of accountability for biomass producers, but none of the suggested guidance would actually prohibit the widespread continuation of the practices shown in Figures 3 – 5. For instance, the REDIIBIO guidance suggests that if harvesting for stumps and residues is conducted as shown in Figure 3, which is widely acknowledged as a damaging and carbon-intensive process,[128] supplier contracts should require suppliers to provide evidence that the material has not been "harvested inappropriately from poor or vulnerable soils." Likewise, the sustainability criteria's provision regarding forest regeneration is supposed to be ensured by supplier contracts that "require that forest area is regenerated before or after final felling or harvest… and done in a matter that ensures quantity and quality of next generation forest resources." This is practically unenforceable, as is the similar provision concerning maintenance of forest carbon stocks and sinks in the LULUCF criteria.

Figure 5. Area of about 27 ha in riverine hardwood forest in North Carolina USA (at 36.164990°, -77.284164°) before, just after, and five years after logging. The hardwood forest was replaced by a commercial pine plantation, as is common in southeastern USA. The amount of wood harvested would be sufficient to run the Drax power station in the UK (last panel) for 3 hours 24 minutes.

The forest biomass criteria themselves could have been hardened to align better with the agricultural biomass criteria. The RED II demonstrates considerable awareness of the issue of carbon loss from land-use change for agricultural biomass. To discourage permanent conversion of high-carbon stock lands to agriculture, the Directive disqualifies agricultural biomass that is sourced from land with a high carbon stocks, including wetlands, continually forested areas, and other treed land meeting minimum criteria.[129] It warns of the potential for carbon loss with agricultural land conversion:

> "If land with high stocks of carbon in its soil or in its vegetation is converted for the cultivation of raw materials for biofuels, bioliquids and biomass fuels, some of the stored carbon will generally be released into the atmosphere, leading to the formation of carbon dioxide. The resulting negative greenhouse gas impact can offset the positive greenhouse gas impact of the biofuels, bioliquids or biomass fuels, in some cases by a wide margin. The full carbon effects of such conversion should therefore be taken into account in calculating the greenhouse gas emissions savings of particular biofuels, bioliquids and biomass fuels. This is necessary to ensure that the greenhouse gas emissions saving calculation takes into account the totality of the carbon effects of the use of biofuels, bioliquids and biomass fuels."[130]

In contrast, the forest biomass criteria do not contain any discussion of forest carbon loss, do not prohibit sourcing biomass from lands with high carbon stock, and do not put any types of forests off-limits for harvesting, unless such lands are set aside under national law as nature reserves. The forest biomass criteria do not contain any mention let alone prohibition on clearcutting, or any requirement that some amount of forest be left following harvesting.

while the agricultural biomass criteria count forest carbon loss, the forest biomass provisions actively encourage logging

Similarly, whereas the criteria for agricultural biomass specify other minimum requirements for feedstock provision (including monitoring and managing soil fertility and carbon[131] and protecting high biodiversity areas), the forest biomass criteria do not set any conditions concerning the actual physical condition of forests from which wood is harvested, focusing instead on the regulatory regime that covers the source of the wood. Even though biomass harvesting has been shown to significantly deplete soil carbon in forest soils,[132] residues from forestry are actively *excluded* from a provision requiring monitoring or management plans on agricultural lands to address impacts on soil quality and soil carbon from removal of wastes and residues.[133]

The criteria do not protect biodiversity and areas of conservation concern

Whereas the agricultural biomass criteria contain some provisions concerned with protecting biodiversity,[134] the forest biomass criteria barely touch the issue. A discussion of what forests should be classified as "biodiverse" and therefore essentially off-limits at Recital 97 restricts the definition to areas protected by national nature protection law and to "primary" (essentially undisturbed) forests, thereby excluding by definition nearly all forests where harvesting for biomass occurs.

the EEA predicts biomass harvesting will "substantially affect" biodiversity and ecosystem function in European forests

Protected areas are given little consideration. Although Article 29(6)(a) seeks protection for areas "designated by international or national law or by the relevant competent authority for nature protection purposes," this definition excludes Natura 2000 areas in Europe, which constitute a large area of ostensibly protected lands and yet which permit harvesting in some areas, including for biomass.[135] Further, Article 29(6)(b) allows harvesting for biomass in protected areas if evidence is provided that "does not interfere with those nature protection purposes." Again, the implementation guidance turns to "supplier contracts" to ensure the correct permissions for such harvesting are granted.

There is no discussion of direct biomass harvesting impacts on biodiversity, which is especially significant given that the removal of residues is one of the factors that degrades biodiversity,[136] along with the removal of standing and downed deadwood. As the European Environment Agency states:

> "The increased use of woody biomass is likely to substantially affect forest biodiversity and forest ecosystem services. A study of 24 European countries indicates that an increase in wood and residue removal to their maximum potentials would reduce the average amount of deadwood by 5.5 % by 2030, compared with 2005. Consequently, adverse effects are expected on deadwood-

> dependent species, which constitute an important component of biodiversity in European forests."[137]

There is no requirement for retention of residues and deadwood. Instead, the REDIIBIO guidance for level "b" implementation requires supplier contracts to "take biodiversity attributes into consideration and mimimize the impacts on such features."

It is interesting to note that the EU's new Biodiversity Strategy refers to the "strengthened sustainability criteria" in the RED, as if they will be effective, yet also calls for minimizing the use of whole trees for fuel and promoting use of residues and wastes for energy – two things the RED II criteria cannot currently deliver. In fact, it would take significant revisions to the criteria to effect any such protections, and it is important to remember that even if the criteria were revised, unless they were extended to wood burned for residential heating, new facilities smaller than 20 MW, and all existing facilities, they would still only apply to a tiny fraction of the wood burned for energy in the EU.

the Biodiversity Strategy calls for minimizing use of whole trees for fuel and promoting use of residues and wastes

The criteria ignore the known issue of illegal sourcing

Last but far from least, the sustainability criteria refer to laws or policies pertaining to legality of wood sourcing, but nowhere does the RED II itself actually state that forest biomass must be legally sourced to qualify as "renewable energy." Legality of forest biomass is of course governed by the EU Timber Regulation,[138] which covers all forms of wood, including that burned for energy. However, the lack of any blanket requirement within the RED itself that forest biomass be legally sourced is notable, given that the sustainability criteria only apply to wood burned in power plants, and given that it is common knowledge that some of the wood currently qualifying toward renewable energy targets, particularly for residential heating, is of unknown and possibly illegal origin.

What can the EU do to minimize harm from use of forest biomass?

Top recommendation: remove eligibility for forest biomass under the RED

The EU needs a climate policy that puts forests first. Accordingly, the most effective course of action for forests and the climate is to remove eligibility of forest biomass for renewable energy targets and subsidies altogether. This is fast climate mitigation. Ending supports would reduce forest carbon loss, protect habitats, and free up billions of euro in subsidies annually to then allocate to efficiency and true zero-emissions renewable energy, or, to forest owners to compensate for financial impacts associated with prioritizing growing forests instead of cutting them. Removing eligibility of forest biomass in the RED II would likely have no effect on wood availability for people who depend on burning wood for residential heating.

Improve the biomass criteria

The increased use of biomass is undermining climate mitigation, biodiversity conservation, air quality, and other environmental and health goals. It is profoundly and tragically counterproductive to be pouring billions of euros each year into cutting and burning forests when the EU goals on

climate and biodiversity favor protecting and expanding natural forests. The EU must seriously reconsider its priorities and ensure member state renewable energy subsidies are aligned with the urgent need to protect and restore forests and invest in technologies that truly reduce emissions.

However, if the EU falls short of genuine reform, it must at a minimum drastically improve the forest biomass criteria. Currently, the criteria are by design not capable of delivering on the RED's claim that they ensure greenhouse reductions and avoid forest impacts. Thus, any meaningful reform to the criteria would include two fundamental elements that are currently missing: full greenhouse gas accounting using a counterfactual approach, and genuine forest protections. The improved criteria must then applied to all the forest biomass qualifying under the RED II, including wood for residential heating.

Institute full life-cycle GHG accounting: Full accounting for forest biomass includes all the greenhouse gases emitted by growing, harvesting, processing, transporting, and **burning** the fuel. It implies consideration of a timeframe, as it is not a simple matter of calculating how long is required for one cohort of trees to regrow, but requires calculating the cumulative impact of multiple years of power plant operation.

The RED II already contains a basic protocol that could be adapted for valuing carbon loss from burning forest biomass, i.e., the current approach for counting carbon loss from land use change, in which carbon stock change is assessed as the difference between the reference land use (for instance forest) and the actual land use (crops), annualized over 20 years.[139] The annualized carbon impact of the loss in carbon is assigned to the energy crop's calculated GHG emissions, which may disqualify the fuel from being classified as "renewable." Applying a similar approach to assessing net emissions from burning forest biomass – that is, treating forest harvesting and carbon loss as effectively the same as land-use change over the coming decades when mitigation is so essential – could provide one criterion to determine whether biomass is eligible in the RED II. However, as pointed out by the European Academies Science Advisory Council (EASAC) in a letter to the President of the EU and a subsequent journal article,[140] the urgency of reducing emissions immediately should disqualify any fuel with significant net emissions persisting more than a decade, meaning most biomass sourced directly from forests, including harvesting residues, would likely be disqualified. Given the urgency of the climate crisis, however, even 10 years is probably too long, supporting the elimination of forest biomass as counting toward the EU's renewable energy targets.

at a minimum, policymakers must add full greenhouse gas accounting and actual forest protections to the RED II

Put natural forests off-limits to biomass harvesting: Biomass harvesting is devastating for forest ecosystems and carbon stocks because biomass demand drives up the value so-called "low-value" wood, creating a market for literally anything that can be gleaned or fed into a chipper. Consequently, logging for biomass tends to be much more destructive than other forest harvesting practices. A climate policy that put forests and biodiversity first would remove or reduce that demand to give space for natural forests to recover. Short of eliminating subsidies for forest biomass altogether, disqualifying biomass from natural forests in the RED, including for categories of wood currently not covered under the criteria such as wood burned for residential heating, would do more to reduce logging pressure on forests than any other measure (again, this does not

meant that people would not continue to harvest firewood – it simply means that use of firewood would not qualify toward renewable energy targets under the RED). For the sake of biodiversity protections *solely* (as this solution would not address concerns about GHG emissions from biomass), biomass could in this case be sourced from existing monoculture plantations, as a means of effectuating their transition to more diverse, natural forest ecosystems that are envisioned in the Biodiversity Strategy. However, any restriction on eligible feedstocks would need to be accompanied by a strict cap on use of forest biomass in the RED overall, to avoid pressure on remaining allowable resources and associated leakage due to multiple demands on plantation forests.

putting natural forests off limits for biomass harvesting would promote the goals of the Biodiversity Strategy

Designate more forests as protected and make "protection" meaningful: The Directive's treatment of biodiverse and protected areas is inadequate. More classes of forests should be considered as protected and/or biodiverse and accordingly designate them genuinely off-limits to biomass harvesting. At a minimum, the definition of "biodiverse" should be extended to forests that are reported to the Convention on Biological Diversity as protected, and biomass from "biodiverse" forests should be excluded from eligibility in the RED with no exceptions. Natura 2000 areas that are currently open to other harvesting should be put off limits for harvesting biomass that is eligible under the Directive. The Natura 2000 network is based in the EU's Habitats Directive,[141] whose "main aim" is "being to promote the maintenance of biodiversity." It was envisioned as a means to designate "special areas of conservation in order to create a coherent European ecological network." Described on the EC Environment webpage as "a network of sites selected to ensure the long-term survival of Europe's most valuable and threatened species and habitats,"[142] the network is the crown jewel of the European reserve system. Accordingly, while some logging inevitably occurs within the network's boundaries, it is wildly inappropriate to *encourage* biomass harvesting, which is known to be highly damaging to biodiversity and ecosystem function, by allowing the wood to qualify toward renewable energy targets and to receive subsidies.

it is wildly inappropriate to encourage biomass harvesting in the Natura 2000 network

Explicitly disqualify illegally sourced wood: The RED II should be amended to explicitly state that no illegally sourced wood should qualify toward renewable energy targets, and more enforcement measures should be added to promote compliance.

Enact recommendations in the Biodiversity Strategy: Policymakers should consider implementing the advice in the Biodiversity Strategy that all forms of bioenergy rely on "residues and non-reusable and non-recyclable waste" and that "use of whole trees and food and feed crops for energy production – whether produced in the EU or imported – should be minimised."[143] Restricting eligibility to industrial mill residues and non-recyclable waste would be a step in the right direction. [144]

Do not pretend burning forestry residues is the answer: Restricting eligible forest biomass to just forestry residues has been suggested as an option for reducing damage from biomass, but this policy is unenforceable (as once wood is in the chipper, its provenance cannot be determined) and

is predicated on unrealistic assumptions of fuel supply. In reality, it serves as an inducement for *all* forest wood to be defined as "residues," which is already often what the biomass and wood pellet industries claim.[145] Most importantly, even if such a policy were enforceable, supplies were adequate, and only true forestry residues were utilized, harvesting and burning forestry residues depletes soil carbon,[146] degrades biodiversity,[147] and increases net emissions over decades,[148] and thus does not deliver true climate and forest protections.

Options for member states to minimize damage to forests and climate

If the EU fails to meaningfully reform its treatment of forest biomass, member states have several options under the RED II that could help reduce harm from its use.

Eliminate subsidies for forest biomass

Article 4(1) of the RED II states that member states "may" apply support schemes to achieve renewable energy targets, meaning the Directive does not require member states to provide subsidies or other financial supports to any form of renewable energy, including bioenergy. Accordingly, other countries can follow the example of Slovakia, which in 2018 amended its renewable energy law to limit subsidies for biomass energy to mill residues and energy crops, thereby eliminating subsidies for forest biomass.[149] The EU definition of biomass still appears in the law, but the definition of what sources of renewable energy receive support includes "biomass, including all products of its processing, except wood that does not come from energy crops and except wood that is not waste from the wood processing industry." The elimination of supports for forest biomass can discourage continued operation of the large-scale facilities, but is unlikely to affect other uses of wood such as for residential heating, which generally does not receive subsidies.

Slovakia responded to excessive forest harvesting by eliminating subsidies for forest biomass

Exclude forest biomass from tendering procedures

The RED grants flexibility to member states to "meet their greenhouse gas reduction targets in the most cost-effective manner in accordance with their specific circumstances, energy mix and capacity to produce renewable energy."[150] Member states are allowed by Article 4(5) of the RED II to

> "limit tendering procedures to specific technologies where opening support schemes to all producers of electricity from renewable sources would lead to a suboptimal result, in view of:
>
> (a) the long-term potential of a particular technology;
>
> (b) the need to achieve diversification;
>
> (c) grid integration costs;
>
> (d) network constraints and grid stability;
>
> (e) for biomass, the need to avoid distortions of raw materials markets."

The approach of eliminating forest biomass projects from tendering would be rendered more effective if accompanied by elimination of subsidies.

Establish additional sustainability criteria

Article 29(14) provides that member states may establish additional sustainability criteria for forest biomass, though Article 29(12) prohibits member states from imposing more protective sustainability criteria on biofuels or bioliquids obtained in compliance with the Directive, meaning that for forest biomass used as feedstock for these fuels, the Directive provides a 'ceiling' of regulation. It is unlikely that sustainability criteria could ever be crafted that redress the problem of net GHG emissions from biomass. This is in part due to the simple physics that burning wood emits CO_2 faster than trees can grow to sequester it, but also because member states' discretion to adopt stricter criteria is limited by the overarching legal authority of the RED II. Accordingly, member states may face challenges if they adopt criteria that undermine the purposes of the RED II, which include the promotion and mobilization of forest biomass (Recital 93) and the inclusion of biodegradable "products … from forestry" within the definition of renewable, supposedly low carbon form of energy (Article 2(24)). Nevertheless, sustainability criteria could potentially be crafted to provide greater protections for forests, for instance by adapting the criteria for agricultural biomass in Article 29(2) – (5). These cover soil carbon, biodiversity, and protection of ecosystem carbon stocks in wetlands and forests.

it is unlikely new sustainability criteria could address the problem of biomass GHG emissions

Expand applicability and rigor of GHG criteria

The EU's GHG criteria are too weak to effectively limit use of imported wood pellets, thus the discretion explicitly granted by the RED II to apply the criteria to new facilities smaller than 20 MW thermal input[151] would not limit import or use of wood pellets in a meaningful way. However, the Directive's instruction that fuels must show "at least" a 70% reduction in emissions appears to mean that more rigorous standards are allowed. Member states should consider adopting a stringent GHG standard such as the UK's limit of 8.1 g CO_2 MJ^{-1}, which represents a 95.5% reduction relative to the 183 g CO_2 MJ^{-1} comparator, as this will restrict use of imported wood pellets.

wood pellet imports and the damage they cause can be ended with the simplest change of all

Expand applicability and rigor of efficiency criteria

Currently, the RED II criteria contain no efficiency requirement for plants less than 50 MW energy input. The criteria allow member states to apply an efficiency threshold to smaller plants, and even increase the efficiency requirement relative to the standard set in the criteria.[152] The UK policy requiring facilities to achieve a minimum of 70% efficiency[153] should be considered, or an even higher standard. Such a standard cannot be achieved by electricity-only plants but only by combined heat and power or thermal-only plants, and could thus help limit facility size, fuel consumption, and some associated impacts.

Appendix I: Journal articles on GHG impacts from burning forest biomass

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Appendix II: Overview of biomass sustainability schemes

Some of the voluntary sustainability schemes for biomass contain more detailed criteria than those of the RED II, but all treat biogenic emissions as zero, none acknowledge the duration of carbon debt, and none provide any means for actually ensuring that forests cut for bioenergy regrow and resequester carbon.

The provisions concerning forest carbon tend to be quite vague.

The UK program requires that "Management of the forest must ensure that productivity of the forest is maintained," including "harvest levels that do not exceed the long-term production capacity of the forest based on adequate inventory and growth and yield data," but does not define what constitutes "long-term production capacity." Nothing in the scheme prohibits clearcutting forests.[154]

Denmark's scheme requires that "The forests' productivity and ability to contribute to the global carbon cycle must be maintained. Management of forests must ensure the least negative impact on the forest's productivity and carbon sequestration through maintaining the forest's ability to produce wood for future generations; Balancing logging and growth rates; Establishing a system for measuring the forest's productivity; Education and training of producers and subcontractors; Refraining from using wood from forests which cannot be replanted/rejuvenated; Refraining from converting land with forest status; [and], Refraining from converting forests with high carbon content"[155] (meaning forests in wetlands and undrained peatlands). Nothing prohibits intensive logging and nothing ensures that forests grow back.

The Dutch system[156] has relatively stringent requirements for biomass sourced directly from forests. Principle 4 of the scheme requires that "the use of biomass does not result in long-term carbon debt," which is operationalized by requiring that "The forest management unit where the wood is sourced is managed with the aim of retaining or increasing carbon stocks in the medium or long term." How this is ensured and enforced over time is not specified; nor is "medium to long term" defined. Nothing in the scheme prevents clearcutting of forests, but provision C4.3 requires that "On average, less than half the volume of the annual round wood harvest from forests is processed as biomass for energy generation," though round wood from thinnings or from production forests with a rotation period of 40 years or less is exempt from this requirement.

The Sustainable Biomass Program[157] likewise requires in criterion 2.9 that "regional carbon stocks are maintained or increased over the medium to long term." Criterion 2.9.2 states, "Analysis demonstrates that feedstock harvesting does not diminish the capability of the forest to act as an effective sink or store of carbon over the long term. Examples of means of verification: results of analysis of carbon stocks, analysis of historic and present carbon uptake rates, regional, publicly available data from a credible third party, and the existence of a strong legal framework in the region."[158] Nothing prevents forest clearcutting for bioenergy; indeed, much of the wood processed into pellets at facilities owned by Enviva, whose pellet manufacturing facilities are certified by the Sustainable Biomass Program,[159] is harvested by clearcutting ecologically sensitive and carbon-rich swamp hardwood forest in the Southeastern US.

Appendix III: Calculation of Drax pellets example

The analysis associated with Figure 5 was performed by PFPI using the following methodology: Size of clearcut was measured using "ruler" on Google Earth. Data on standing green aboveground biomass for lowland hardwood forests in North Carolina is taken as an average of 150 tons per acre.[160] The 27 ha area would therefore contain about 9,079 metric tonnes of biomass. Assuming 2/3 of this is roundwood that is useable for pellets, and pellet manufacturing requires 2.2 tonnes of roundwood per tonne of pellets,[161] this would produce 2,751 tonnes of pellets. The 2018 Drax annual report states Drax burned 7,171,074 tonnes pellets in 2018,[162] which on average is 819 tonnes per hour. Accordingly, the 2,751 tonnes of pellets would power the plant for 3.4 hours.

Endnotes

[1] Page 10 at https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF
[2] At https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN
[3] Recital 2
[4] E.g., https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12265-2030-Climate-Target-Plan
[5] For the purposes of this discussion, "forest biomass" means biomass sourced directly from forests. Accordingly the definition does not include mill residues.
[6] Holtsmark, Bjart. 2012. "Harvesting in boreal forests and the biofuel carbon debt." Climatic Change 112:415-428. https://www.researchgate.net/publication/227584033_Harvesting_in_boreal_forests_and_the_biofuel_carbon_debt
[7] Stashwick, S. (2019). Burnout: E.U. clean energy subsidies lead to forest destruction, Natural Resources Defense Council, Washington DC. At https://www.nrdc.org/resources/burnout-eu-clean-energy-policies-lead-forest-destruction
[8] Article 191(2), Treaty on the Functioning of the EU. At https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT&from=EN
[9] E.g., repeated investigations of Enviva, the world's largest wood pellet company, have revealed damaging logging practices in the Southeastern United States (see https://www.dogwoodalliance.org/2019/06/caught-in-the-act/). In Estonia, clearcutting for fuel is leveling forests (see Danish TV2. 9 Sept 2019. Når Danmark brænder træer af, bliver der ikke altid plantet nye :"When Denmark burns trees, new ones are not always planted" at https://nyheder.tv2.dk/2019-09-09-naar-danmark-braender-traeer-af-bliver-der-ikke-altid-plantet-nye?fbclid=IwAR1gVoIIhHjTblMA1Hr_C_I8j7RN4y07Itr2d-OQiGP5cYhv-XAyRzp1_Uc). In Canada, the wood pellet industry is increasingly sourcing wood pellet feedstock directly from British Columbia's inland rainforest (see Canada's National Observer. B.C. says firms can chip down whole trees for pellet fuel if they are 'inferior.' At https://www.nationalobserver.com/2020/04/30/news/bc-says-firms-can-chop-down-whole-trees-pellet-fuel-if-they-are-inferior).
[10] E.g, Recital 93, regarding biomass, "the Union and the Member States should promote greater sustainable mobilisation of existing timber and agricultural resources and the development of new forestry and agriculture production systems, provided that sustainability and greenhouse gas emissions saving criteria are met."
[11] The RED II does require that lifecycle fossil fuel CO_2 emissions from bioenergy are assessed
[12] Recital 101
[13] Camia, A., et al. 2018. Biomass production, supply, uses and flows in the European Union Ispra, Italy: Joint Research Centre. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC109869/jrc109869_biomass_report_final2pdf2.pdf
[14] Ibid.
[15] Calculated using Eurostat data on indigenous production of fuelwood, wood residues and byproducts (units terajoules; dataset "Supply, transformation and consumption of renewables and wastes [nrg_cb_rw]"
[16] Proportion of renewable energy that is total bioenergy was calculated using Eurostat data on gross inland consumption of bioenergy as proportion of renewables and biofuels (dataset "Complete energy balances [nrg_bal_c]").
[17] Proportion of renewable energy from wood was calculated using data on indigenous production of fuelwood, wood residues and byproducts (units terajoules; dataset "Supply, transformation and consumption of renewables and wastes [nrg_cb_rw]"), as a proportion of gross inland consumption of renewables and biofuels (dataset "Complete energy balances [nrg_bal_c]").
[18] Ibid.
[19] Data on indigenous production of wood fuels is converted to green tonnes assuming 99.98 tonnes of green wood per terajoule of energy from Eurostat data on "Supply, transformation and consumption of renewables and wastes [nrg_cb_rw]." Estimate of wood use for pellets and other agglomerated fuels is calculated separately using Eurostat data on "Roundwood, fuelwood and other basic products [for_basic]." Use of wood for pellets is calculated assuming about 2.2 tonnes of green roundwood per tonne of finished pellets, per Forisk Consulting

LLC. 2014. Revisiting Wood-Use Conversions and Projections For Bioenergy Projects. At https://forisk.com/blog/2014/08/12/revisiting-wood-use-conversions-projections-bioenergy-projects/

[20] https://di.unfccc.int/detailed_data_by_party

[21] Article 2(f) of 2009 RED, at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN

[22] Article 2(4) of RED II

[23] Banja, Manjola, et al. 2019. "Biomass for energy in the EU – The support framework." Energy Policy 131:215-228. At https://www.sciencedirect.com/science/article/pii/S0301421519302873

[24] Eurostat "Supply, transformation and consumption of renewable energies - annual data: nrg_107a." This dataset covers residential solid biofuel use (which is assumed to be mostly wood) for the period 1990 – 2016. Eurostat now reports residential biomass use in a different dataset.

[25] Camia et al 2018.

[26] Data provided by Peter Sabo, WOLF Forest Protection Movement, Slovakia.

[27] Romania Insider. Romania's environment minister confirms massive illegal logging figures. Nov. 25, 2019. At https://www.romania-insider.com/minister-confirms-illegal-logging-report

[28] Environmental Investigation Agency. 2015. Stealing the last forest: Austria's largest timber company, land rights, and corruption in Romania. Washington, DC. At https://content.eia-global.org/assets/2015/10/Stealing_the_Last_Forest/EIA_2015_Report_Stealing_the_Last_Forest.pdf

[29] Pilli, R., and A. Camia. 2019. "Wood Resource Balances of EU-28 and Member States, year 2015." Joint Research Centre, Ispra, Italy. At https://ec.europa.eu/knowledge4policy/publication/wood-resource-balances

[30] Camia et al 2018.

[31] REKK (Foundation for Regional Energy and Infrastructure Policy Cooperation). Renewables Statistics. Policy Brief 01, 2017. At https://rekk.hu/downloads/academic_publications/rekk_policybrief_hu_2017_01.pdf

[32] It is also an open secret, as admitted by the Hungarian Energy Authority and probably known at the EU Commission, that Hungary counts garbage-burning by households as "solid biomass," so this is contributing to renewable energy targets.

[33] REKK, 2017

[34] World Health Organization. Deaths By Country, 2016. Global Health Observatory data repository. Accessed June 14, 2020. At https://apps.who.int/gho/data/node.main.BODAMBIENTAIRDTHS?lang=en

[35] BASIS Bioenergy. Project results (updated 17.03.2016) At http://web.archive.org/web/20160427212553/http://www.basisbioenergy.eu/fileadmin/user_upload/Project_Results_BASIS.pdf

[36] EU Large Combustion Plant data available at https://www.eea.europa.eu/data-and-maps/data/lcp-9

[37] Carvalho, H. 2019. Air pollution-related deaths in Europe - time for action. Journal of Global Health 9(2):020308. At https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6858990/

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[39] Ibid.

[40] Huang, Jiaoyan, et al. 2011. "Mercury (Hg) emissions from domestic biomass combustion for space heating." Chemosphere 84 (11):1694-1699. At http://www.sciencedirect.com/science/article/pii/S0045653511005091

[41] European Environment Agency. 2019. Air quality in Europe - 2019 report.

[42] See https://projects.iq.harvard.edu/covid-pm

[43] Bioenergy Europe. Pellet statistical report 2019. Brussels. At http://bit.ly/Pellet_report_SR19. Data from Tables 4&5.

[44] Article 4 Paris Agreement

[45] EU Climate Strategy at https://ec.europa.eu/clima/policies/strategies/2050_en

[46] Total GHG emissions for the EU as reported under the Convention. At https://di.unfccc.int/detailed_data_by_party

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[48] Fiona Harvey. "Europe losing forest to harvesting at alarming rate, data suggests." The Guardian, July 1, 2020. At https://www.theguardian.com/environment/2020/jul/01/europe-losing-forest-to-harvesting-at-alarming-rate-data-suggests

[49] https://www.eea.europa.eu/data-and-maps/indicators/forest-growing-stock-increment-and-fellings-3/assessment
[50] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999
[51] "Land Use, Land Use Change, and Forestry," "Lucifer" for short.
[52] Jacob, Mascha, et al. 2013. "Significance of Over-Mature and Decaying Trees for Carbon Stocks in a Central European Natural Spruce Forest." Ecosystems 16. At https://www.researchgate.net/publication/257469643_Significance_of_Over-Mature_and_Decaying_Trees_for_Carbon_Stocks_in_a_Central_European_Natural_Spruce_Forest
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Pilli, Roberto, et al. 2017. "The European forest sector: Past and future carbon budget and fluxes under different management scenarios." 14:2387-2405. At https://www.biogeosciences.net/14/2387/2017/bg-14-2387-2017.pdf
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[54] Vass, Miriam Münnich, and Katarina Elofsson. 2016. "Is forest carbon sequestration at the expense of bioenergy and forest products cost-efficient in EU climate policy to 2050?" Journal of Forest Economics 24:82-105. At https://www.sciencedirect.com/science/article/pii/S1104689916300071
[55] Comment from Fanny-Pomme Langue, Sec.General of The Confederation of European Forest Owners, during webinar on June 29, 2020: "Future Prospects of Sustainable Biomass in the Context of the European Green Deal."
[56] Camia et al 2018.
[57] FAOSTAT data on roundwood harvesting (at http://www.fao.org/faostat/en/#search/roundwood). Wood underbark data converted to overbark values using average conversion factor from Forest Research of 1.13 (at https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2016-introduction/sources/timber/conversion-factors/). Conversion from volume to energy content uses conversion factor of 10.06 GJ per cubic meter, assuming 45% moisture content.
[58] Data on CO_2 emissions from burning wood is calculated from data on indigenous production of wood fuels (as terajoule) which is converted to emissions assuming 91.6 tonnes of CO_2 per terajoule. Indigenous production data are from Eurostat ("Supply, transformation and consumption of renewables and wastes [nrg_cb_rw]")
[59] UNFCCC data on "forest land remaining forest land," "land converted to forest land," and "harvested wood products." At https://di.unfccc.int/detailed_data_by_party
[60] Ibid.
[61] Eurostat data on wood pellet production from "Roundwood, fuelwood and other basic products [for_basic]."
[62] Biodiversity Strategy at https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF
[63] Brack, Duncan. 2017. Woody biomass for power and heat: Impacts on the global climate. London: Chatham House. At https://www.chathamhouse.org/sites/default/files/publications/research/2017-02-23-woody-biomass-global-climate-brack-final2.pdf
[64] https://ec.europa.eu/clima/sites/clima/files/forests/lulucf/docs/frl_proposed_by_ms_en.pdf
[65] Member state forest carbon targets were published at https://ec.europa.eu/clima/sites/clima/files/forests/lulucf/docs/frl_proposed_by_ms_en.pdf. For this analysis, however, we used as yet unpublished estimates (as of June 29, 2020) that are going to be published in the Draft Delegated Act. These estimates show somewhat *less* of a decline in the sink overall than the publicly available estimates published at the link above. Data on the 2016-2018 forest sink was obtained at https://unfccc.int/ghg-inventories-annex-i-parties/2020, using common reporting format for the UNFCCC to obtain data on the categories of "forest land remaining forest land" and "harvested wood products" but not "land converted to forest land."
[66] Lutz, James A., et al. 2018. "Global importance of large-diameter trees." Global Ecology and Biogeography 0 (0):1 - 16. At https://www.fs.fed.us/rm/pubs_journals/2018/rmrs_2018_lutz_j001.pdf. Luyssaert, Sebastiaan, et al. 2008. "Old-growth forests as global carbon sinks." Nature 455:213. At https://www.researchgate.net/publication/42089659_Old-growth_forests_as_global_carbon_sinks_Nature; https://www.nature.com/articles/nature07276#supplementary-information.

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[68] At http://www.ipcc-nggip.iges.or.jp/faq/faq.html

[69] European Commission. 2010. Impact assessment: Accompanying document to the Report from the Commission to the Council and the European Parliament on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling. Brussels. At https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52010SC0065&from=EN

[70] From https://ec.europa.eu/clima/policies/forests/lulucf_en

[71] Report from the Commission to the Council and the European Parliament on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling SEC(2010) 65 final SEC(2010) 66 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1410874845626&uri=CELEX:52010DC0011

[72] Booth, Mary S. 2016. Carbon Emissions and Climate Change Disclosure by the Wood Pellet Industry – A Report to the SEC on Enviva Partners LP. Pelham, MA: Partnership for Policy Integrity. At http://www.pfpi.net/wp-content/uploads/2016/03/Report-to-SEC-on-Enviva-March-14-2016.pdf

[73] Recital 43

[74] Booth, Mary S. 2018. "Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy." Environmental Research Letters 13 (3):035001. At http://iopscience.iop.org/article/10.1088/1748-9326/aaac88/meta. Also Laganière, Jérôme, et al. 2017. "Range and uncertainties in estimating delays in greenhouse gas mitigation potential of forest bioenergy sourced from Canadian forests." GCB Bioenergy 9 (2):358-369. Interactive model at https://apps-scf-cfs.rncan.gc.ca/calc/en/bioenergy-calculator

[75] IPCC, 2014: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Eds Edenhofer, O., et al). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Page 877 at https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_full.pdf

[76] The definition of "supply base" for the four Granuul plants refers variously to national level forest growth and harvest statistics at the country level for Estonia and other countries from which the company sources wood. Reports at https://sbp-cert.org/accreditations-and-certifications/certificate-holders/

[77] At https://sbp-cert.org/wp-content/uploads/2019/04/Supply-Base-Report-v1-1-Enviva-Pellets-Ahoskie.pdf

[78] At https://sbp-cert.org/wp-content/uploads/2019/05/Supply-Base-Report-v1.2_Enviva-Pellets-Amory-FINAL.pdf

[79] https://di.unfccc.int/detailed_data_by_party

[80] European Commission, 2010.

[81] Vis, M.W., et al. 2008. Sustainability Criteria & Certification Systems for Biomass Production. Enschede, The Netherlands: BTG Biomass Technology Group. At https://www.compete-bioafrica.net/sustainability/sustainability_criteria_and_certification_systems.pdf

[82] European Commission. 2016. Impact Assessment: Sustainability of Bioenergy. Accompanying the document Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (recast). Brussels. At https://eur-lex.europa.eu/resource.html?uri=cellar:1bdc63bd-b7e9-11e6-9e3c-01aa75ed71a1.0001.02/DOC_1&format=PDF

[83] Ibid, p.107

[84] Article 4(1); Article 7(1); Article 29(1)

[85] The LULUCF criteria should not be confused with the LULUCF Regulation.

[86] The objective of the REDIIBIO project is to provide technical assistance to the European Commission on the harmonised and correct implementation of the new EU sustainability criteria for forest and agricultural biomass used for energy generation, as set out in Article 29 of the REDII. At https://www.efi.int/projects/rediibio-red-ii-sustainability-criteria

[87] In accordance with Article 14 of Directive 2012/27/EU on energy efficiency, at https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:en:PDF

[88] Table 2.2.1 at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D1442&from=EN

[89] Annex VI(B)(13): "Emissions of CO_2 from fuel in use, eu, shall be taken to be zero for biomass fuels. Emissions of non-CO_2 greenhouse gases (CH_4 and N_2O) from the fuel in use shall be included in the eu factor."

[90] The UK power plant Drax reports emissions of around 250 g CO_2/MJ final energy from burning wood pellets (calculated from annual reports). Their average lifecycle emissions for pellets burned in 2018 was 34 g/MJ, thus representing 13.6% increase over direct emissions from burning the fuel.
[91] Annex VI (B)(19)
[92] Article 29(1)(c)
[93] The LULUCF criteria are not expressly linked to the new LULUCF rules to come into effect in 2021, though the concern (the forest carbon sink) is the same.
[94] Recital 30
[95] Article 30(4)
[96] FAO. 2012. FRA 2015 Terms and Definitions. Rome. At http://www.fao.org/3/ap862e/ap862e00.pdf
[97] Recital 97
[98] Technical annex with criteria available at https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:en:PDF
[99] At Annex IX.
[100] Page 10, at https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF
[101] Bioenergy Europe. Pellet statistical report 2019. Brussels. At http://bit.ly/Pellet_report_SR19. Data from Tables 4&5.
[102] Pehl, Michaja, et al. 2017. "Understanding future emissions from low-carbon power systems by integration of life-cycle assessment and integrated energy modelling." Nature Energy 2: 939–945. At https://www.researchgate.net/publication/321683340_Understanding_future_emissions_from_low-carbon_power_systems_by_integration_of_life-cycle_assessment_and_integrated_energy_modelling
[103] UK BEIS. 2018. Contracts for difference scheme for renewable electricity generation, Part A. London: Department for Business, Energy & Industrial Strategy. At https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/714067/contracts-for-difference-renewable-energy-consultation-response-part-a.pdf
[104] Calculated from Drax 2019 annual report, at https://www.drax.com/wp-content/uploads/2020/03/Drax_AR2019_Web.pdf
[105] Drax reports burning 7.2 Mt wood pellets in 2018 (p. 25 Drax 2018 annual report at https://www.drax.com/wp-content/uploads/2019/03/Drax-Annual-report-accounts-2018.pdf). The 2019 Bioenergy Europe pellet statistical report (at http://bit.ly/Pellet_report_SR19 table 6) reports that the UK as a whole consumed 8.5 MT pellets in 2018. The country with the next greatest consumption was Italy, at 3.3 Mt.
[106] See 2018 Drax Annual report, page 25, at https://www.drax.com/wp-content/uploads/2019/03/Drax-Annual-report-accounts-2018.pdf. For detailed data, see Partnership for Policy Integrity. "New UK biomass policy removes subsidies for high-carbon wood pellets." Sept 3, 2018. At http://www.pfpi.net/new-uk-biomass-policy-removes-subsidies-for-high-carbon-wood-pellets
[107] UK BEIS. 2018. Contracts for difference scheme for renewable electricity generation, part B. . London: UK Department for Business, Energy & Industrial Strategy. At https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/736640/Consultation_document.pdf
[108] See http://www.pfpi.net/new-uk-biomass-policy-removes-subsidies-for-high-carbon-wood-pellets. Unfortunately, because the UK's major coal-to-biomass conversions and recently built biomass plants qualified under an older UK emissions threshold that is similar to the higher RED II standard, they will not be subject to the 8.1 g CO_2 MJ^{-1} standard.
[109] Recital 21
[110] Recital 25
[111] Ibid, p.107
[112] Apparicio, S. and N. Sauer. "Which countries have not ratified the Paris climate agreement?" Climate Home News, Mar 1 2020. At https://www.climatechangenews.com/2020/03/01/countries-yet-ratify-paris-agreement/
[113] This interpretation of the text, which treats (a)(i) – (a)(iii) not as three distinct alternatives, but instead as requiring (a)(i), the country being a party to the Paris Agreement, as a precondition for both (a)(ii) and (a)(iii), is based on information presented at the European Commission's "REDIIBIO" presentation on implementation guidelines development for the biomass criteria, held June 25, 2020.

[114] Navigant Consulting. 2020. REDIIBIO project: Technical Assistance to develop guidance for the implementation of the new bioenergy sustainability criteria set out in the revised Renewable Energy Directive. 3rd Progress Report - for stakeholder consultation. Permalink at http://www.pfpi.net/wp-content/uploads/2020/06/REDIIBIO_Draft-Report_for-consultation.pdf

[115] The "b" level standard is at least theoretically more rigorous than the "a" level standard in one regard. The guidance recommends comparing current and projected forest stocks and sinks to a historical level in the 2000 –2009 period. Under the LULUCF Regulation, which will govern how EU member states assess biomass harvesting impacts on the land carbon sink, countries will compare their forest carbon stocks and sinks not directly to those of that 2000 – 2009 time-period, but instead to a target baseline that projects forest carbon sinks based on management during that period. Many EU countries project on significant and continuing carbon sink loss compared to current (2016 – 2018) levels (see Figure 1 and section "Biomass harvesting impacts on the EU's carbon sink"). If member states had to compare against actual stocks and sinks in the 2000 – 2009 period as the "b" level guidance suggests, the recorded carbon loss would be even more dramatic.

[116] Article 2(30)

[117] Workshop was held online June 25, 2020

[118] Eurostat data on indigenous production of fuelwood, wood residues and byproducts (units terajoules; dataset "Supply, transformation and consumption of renewables and wastes [nrg_cb_rw]")

[119] European Commission. 2016. Impact Assessment: Sustainability of Bioenergy. Accompanying the document Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (recast). Brussels. At https://eur-lex.europa.eu/resource.html?uri=cellar:1bdc63bd-b7e9-11e6-9e3c-01aa75ed71a1.0001.02/DOC_1&format=PDF

[120] See e.g. https://www.dogwoodalliance.org/wp-content/uploads/2019/07/Biomass-Investigation-Booklet-2019.pdf

[121] Navigant Consulting. 2020. REDIIBIO project: Technical Assistance to develop guidance for the implementation of the new bioenergy sustainabilty criteria set out in the revised Renewable Energy Directive. 3rd Progress Report - for stakeholder consultation. Permalink at http://www.pfpi.net/wp-content/uploads/2020/06/REDIIBIO_Draft-Report_for-consultation.pdf

[122] See https://www.dogwoodalliance.org/wp-content/uploads/2019/07/Biomass-Investigation-Booklet-2019.pdf

[123] At https://media.voog.com/0000/0037/1265/files/230-1_ELF_Verification%20Protocol%20for%20Sustainable%20Forest%20Biomass.pdf

[124] Ibid.

[125] Canada's National Observer. B.C. says firms can chip down whole trees for pellet fuel if they are 'inferior.' At https://www.nationalobserver.com/2020/04/30/news/bc-says-firms-can-chop-down-whole-trees-pellet-fuel-if-they-are-inferior

[126] Seddon, Nathalie, et al. 2019. "Grounding nature-based climate solutions in sound biodiversity science." Nature Climate Change 9 (2):84-87. At https://www.researchgate.net/publication/330691577_Grounding_nature-based_climate_solutions_in_sound_biodiversity_science

[127] Sohngen, Brent, and Sandra Brown. 2006. "The influence of conversion of forest types on carbon sequestration and other ecosystem services in the South Central United States." Ecological Economics 57:698-708. At https://www.sciencedirect.com/science/article/abs/pii/S0921800905002685; full pre-print at https://bit.ly/2Y3177h

[128] Repo, Anna, et al. 2011. "Indirect carbon dioxide emissions from producing bioenergy from forest harvest residues." GCB Bioenergy 3 (2):107-115. At https://onlinelibrary.wiley.com/doi/full/10.1111/j.1757-1707.2010.01065.x

[129] Article 29(4)

[130] Recital 114

[131] Article 29(2)

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[134] Article 29(3)
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