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Report

Quantifying the loophole and sustainability impacts of bioenergy being rated zero emissions in the EU Emissions Trading System and Effort Sharing Regulation

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1 Introduction: greenhouse gas emissions from biomass

The European Union, through the European Green Deal proposed in 2019, is aiming to become the first carbon-neutral continent by 2050. This includes increasing the EU's greenhouse gas emissions reduction target for 2030 from 40 per cent to at least 55 per cent (compared to 1990 levels). In turn, this requires the revision of a wide range of EU climate and energy laws and targets, including three of the key climate policy frameworks:

- The Emissions Trading System (ETS) Directive, which regulates the EU ETS, the system of allowances and trading for major emitters of greenhouse gas emissions, including power stations, large industrial installations and aviation.
- The Effort Sharing Regulation, which sets targets for the reduction of greenhouse gas emissions from power, heat and industrial installations too small to qualify for the ETS, together with emitting sectors not included in the ETS: transport, buildings, agriculture and waste (it does not include emissions from the land use, land-use change and forest (LULUCF) sector).
- The recast Renewable Energy Directive, which sets the framework for EU renewable energy policy after 2020.

In July 2021 the European Commission published its proposals for the revision of these policy frameworks, and many others, in the 'Fit for 55' package of interconnected measures.[1]

All these three key policy frameworks treat biomass as zero-carbon at the point of combustion, so emissions from bioenergy are omitted from the ETS and the effort-sharing framework. The Renewable Energy Directives (the original directive, covering the period before 2020, and the recast version) permit member states to count biomass towards their renewable energy targets, and to provide financial and regulatory support to applications that use biomass feedstocks, alongside other forms of renewable energy, under conditions set out in the Directives' sustainability criteria.

This paper examines the implications of the treatment of biomass as carbon-neutral for these three key EU policy instruments: the EU Emissions Trading System (Chapter 2), the Effort-Sharing Framework (Chapter 3) and the Renewable Energy Directives (Chapter 4). Each of these chapters estimates what EU carbon dioxide emissions would have been if emissions from biomass had been included in the greenhouse gas emissions totals covered by these frameworks. Chapter 1 provides background on the treatment of biomass as carbon-neutral, together with an overview of the use of biomass for energy in the EU.

(Various bioenergy-related terms are not always used consistently in studies and data sources; in particular, the terms 'biomass' and 'biofuels' are sometimes used interchangeably. This paper uses the term 'biomass' to refer to all bioenergy feedstocks, whether these are in solid, liquid or gaseous form. 'Solid biomass', 'bioliquid' and 'biogas' are used to refer specifically to those three categories of feedstock, and 'biofuels' (or 'transport biofuels') refers specifically to liquid biomass feedstock used for transport.)

[1] For a summary, see https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541.

1.1 Treatment of biomass as carbon-neutral

The classification of biomass as zero-carbon at the point of combustion derives from either or both of two assumptions. First, that biomass emissions are part of a natural cycle in which forest or plant growth absorbs the carbon emitted by burning biomass for energy. The problems with this assumption are examined at length in reports from a wide range of individuals and organisations.[2] To summarise, harvesting and burning trees (the main form of solid biomass) for power or heat results in a large initial increase in carbon emissions, creating a 'carbon debt'. While regrowing trees and the displacement of the fossil fuels that would have been used instead will eventually pay off this carbon debt, this regrowth takes time; as studies have shown, this burning of wood will increase global warming for decades to centuries – the 'carbon payback period'.

Where residues or wastes are used instead of whole trees, the impact on carbon levels in the atmosphere is lower, though it can still be significant, depending partly on what would have happened to these wastes and residues if they had not been burnt for energy. However, current policy frameworks do not generally distinguish between different categories of feedstock in allocating financial and regulatory support, and feedstock category definitions for reporting purposes are often not tightly drawn enough to permit accurate distinctions between whole trees and residues.

Crops used for liquid biofuels, and dedicated energy crops, grow more rapidly than trees, and harvesting therefore has a smaller impact on carbon sequestration rates; the main impact on the carbon payback period derives from the nature of the land-use conversion to establish the crop in the first place. If crops are planted on lands with a high carbon stock (e.g. if established forests are converted to crops), then it can take from decades to over a century to compensate for the carbon losses from the initial land-use change.

The same considerations apply to anaerobic digestion plants. Where genuine farm wastes are used, the carbon payback can be very low, depending partly on how the methane generated by the process is used. Where food crops or energy crops are used instead of wastes, however, the impact will depend on the extent of direct or indirect land use change.

The first EU Renewable Energy Directive, agreed in 2009 to cover the period until 2020, put in place sustainability criteria designed to minimise these impacts. These required biofuels counting towards the Directive's target of a 10 per cent share of biofuels in energy for transport not to be obtained from highly biodiverse land, land with high carbon stock, or peatland that was classified as such in 2008, and also to meet greenhouse gas emission savings thresholds compared to fossil fuels. While addressing the problem of direct land-use change in sourcing the feedstock, these criteria failed to take into account the impacts of indirect land-use change (ILUC) – such as sourcing feedstock from land previously used for food crops, and forest elsewhere being cleared to replace the lost food production. Attempts were subsequently made, first to measure the ILUC impacts of the feedstock used in the EU, and then to include them in the recast Renewable Energy Directive for the post-2020 period (see further in Chapter 4).

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[2] See, e.g., Helmut Haberl et al, 'Correcting a fundamental error in greenhouse gas accounting related to bioenergy', *Energy Policy* Vol. 45, 2012; Duncan Brack, *Woody Biomass for Power and Heat: Impacts on the Global Climate* (Royal Institute of International Affairs, 2017); *Multi-functionality and sustainability in the European Union's forests* (EASAC, 2017); *Commentary by the European Academies' Science Advisory Council (EASAC) on Forest Bioenergy and Carbon Neutrality* (EASAC, 2018).

Similar sustainability criteria for solid biomass were not included in the 2009 Directive, though several member states introduced their own; in general, these featured criteria relating to legal and sustainable sourcing (sometimes borrowed from timber procurement policies). Sometimes they also included greenhouse gas saving thresholds compared to fossil fuels, but only emissions from the supply chain (harvesting, processing and transport) were included in these calculations, not emissions from combustion. A few member states placed restrictions on the types of feedstocks eligible for support, reflecting concerns over carbon payback periods. New criteria for solid biomass were introduced in the new Renewable Energy Directive, and in July 2021 the Commission published proposals for further modifications for the use of forest biomass; these are discussed further in Chapter 4.

The second assumption underlying the treatment of biomass as zero-carbon stems from the international greenhouse gas reporting and accounting frameworks established under the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. To avoid double-counting emissions from biomass within the energy sector (when the biomass is burned) and the land-use sector (when the biomass is harvested), the rules provide that emissions should be reported within the land-use sector only.[3] While this approach make sense in the context of global *reporting* of emissions, it can result in significant gaps in the context of national *accounting* – measuring emissions levels against countries' targets under the Kyoto Protocol or the Paris Agreement or under domestic legislation setting national targets for reducing emissions. This is particularly true where the biomass feedstock is produced in one country and exported for use for energy in another.

This problem has been recognised by the Intergovernmental Panel on Climate Change (IPCC), which observed in its Special Report on Climate Change and Land that: 'One of the complications in assessing the total GHG flux associated with bioenergy under UNFCCC reporting protocols is that fluxes from different aspects of bioenergy lifecycle are reported in different sectors and are not linked. … Thus, the whole lifecycle GHG effects of bioenergy systems are not readily observed in national GHG inventories or modelled emissions estimates.'[4] Similarly, a report from the EU Joint Research Centre in 2021 drew attention to the same problem existing even within countries, as well between them, given the potential mismatch between policy signals for the energy and land use sectors, and their associated policy-makers, and the need for national policies to be guided by a full awareness of bioenergy-land-use links and trade-offs.[5]

The problem is unlikely to be resolved under the Paris Agreement. Most Nationally Determined Contributions (NDCs) submitted so far under the agreement do not contain any separate targets for the land-use sector; relatively few anticipate the use of any kind of accounting rules, and where accounting for land-use sector emissions and removals is mentioned, the submitting countries have chosen a variety of accounting methods. As a result, it is not possible to assess the net climate effects of bioenergy simply by comparing the emissions from combustion with those associated with the bioenergy feedstock in the land-use category and the supply chain, and therefore there is no

[3] Non-CO2 greenhouse gas emissions from burning biomass (e.g. methane) for energy *are* reported in the energy sector, as they do not exist in the land-use sector.

[4] *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* (IPCC, 2019), p. 583.

[5] A. Camia et al, *The use of woody biomass for energy purposes in the EU* (EU Joint Research Centre, 2021), p. 164.

automatic link between apparently falling emissions in countries using bioenergy and the need for corresponding action in the countries supplying the feedstock.[6]

Existing policy frameworks, under which almost all EU member states provide financial and regulatory support to biomass alongside other renewable technologies, are in effect subsidising the growth of carbon emissions in the atmosphere. Per unit of energy, biomass-burning installations emit more carbon dioxide from their smokestacks than their fossil fuel equivalents, and, depending on the feedstock used these emissions will not be recaptured for years at best and centuries at worst, even if biomass emissions are accurately reported in the land-use sector of the producing country. In the case of liquid biofuels, when direct and indirect emissions are added together, some biofuel feedstocks result in emissions of more carbon dioxide than their fossil counterparts; this is particularly true of biodiesel produced from vegetable oils.

1.2 Biomass use and emissions in the EU

For the last ten years the EU has been the main global source of demand for modern (non-traditional) uses of biomass: a result largely of the policy support frameworks put in place by EU member states following the 2009 Renewable Energy Directive, which set targets for the proportion of energy supplied by renewables to be achieved by each member state by 2020. This framework has led to the EU's share of final energy consumption from renewables more than doubling from 2004 (8.6 per cent) to 2019 (18.9 per cent).[7] All sources of renewable energy in the EU have grown, including biomass, which is the largest single source, accounting for 60 per cent of gross consumption of renewable energy in total in 2018.[8]

Solid biomass accounted for 68.4 per cent of that figure, the remainder being liquid biofuels (12.6 per cent), biogas (11.6 per cent), renewable municipal waste (7.2 per cent) and charcoal (2 per cent). Various types of wood (including wood fuel, wood residues and by-products and wood pellets) accounted for 77 per cent of the solid biomass burnt for energy, and black liquor (a waste product from the kraft pulping process used to make paper – categorised as solid biomass even though it is a liquid) for a further 14 per cent; the remaining 9 per cent were agricultural crop and animal residues and wastes.[9] Across the EU, solid biomass supplied 3 per cent of generation of electricity (9 per cent of electricity from renewable sources) and 15 per cent of energy used in heating and cooling (76 per cent of heating and cooling from renewable sources).

In the transport sector, in 2018 biomass accounted for 8 per cent of energy used, almost entirely for road transport, though small volumes were used in maritime transport and aviation. The biomass was mainly in the form of bioliquids, or liquid biofuels, for which the main feedstocks are oil crops such as oil palm, soybean, rapeseed and sunflower (for biodiesel), and starch crops such as wheat, maize (called 'corn' in North America), sugar beet and sugar cane (for bioethanol). A range of other

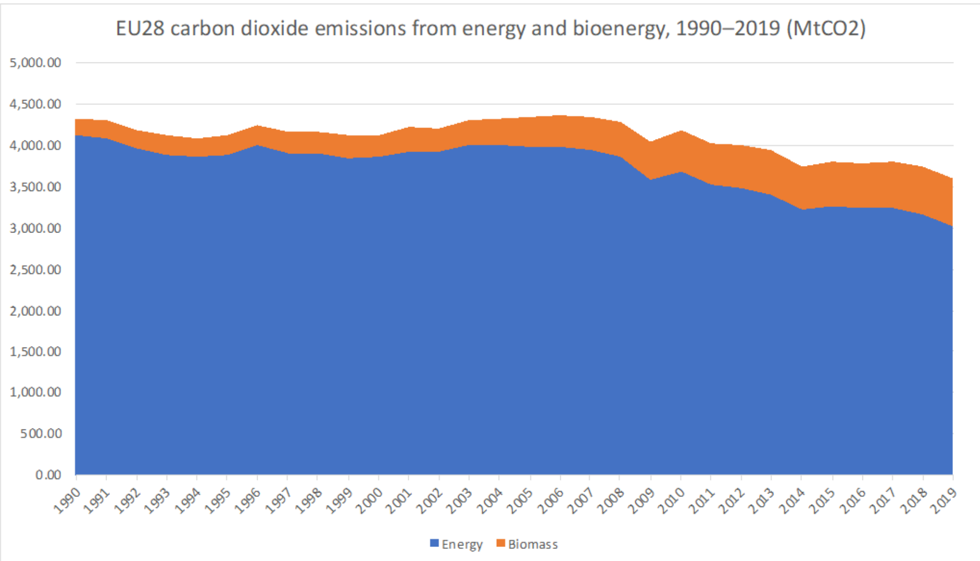
[6] Fyson, C. L., & Jeffery, M. L. (2019), 'Ambiguity in the land use component of mitigation contributions toward the Paris Agreement goals'. *Earth's Future*, 7, 873–891. https://doi.org/10.1029/2019EF001190.
[7] Eurostat SHARES database, https://ec.europa.eu/eurostat/web/energy/data/shares. Figures relate to the EU28; for the EU27 the figures are 9.6 per cent (2004) and 19.7 per cent (2019).
[8] *Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Renewable Energy Progress Report* (European Commission, COM(2020) 952 final, 14 October 2020).
[9] Navigant Consulting, *Technical assistance in realisation of the 5th report on progress of renewable energy in the EU: Analysis of bioenergy supply and demand in the EU (Task 3)* (European Commission, 2020).

feedstocks, including wastes, agricultural residues and algae, are under development or beginning to enter commercial production. Bioliquids, particularly palm oil, are also sometimes used for heat and power generation.

Even though emissions from the combustion of biomass are not included in emissions from energy for the purposes of accounting against EU and member states' targets, it is possible to calculate their volume. This is because under the UNFCCC, Annex I parties (essentially, developed countries) report carbon dioxide emissions from biomass used for energy as a separate line item (referred to as a 'memo item') in their greenhouse gas inventories.[10]

Between 1990 and 2019, EU emissions from biomass used for energy increased from 204 MtCO_2 to 585 MtCO_2, an average growth rate of 3.7 per cent a year. If biomass emissions had been included in emissions from other energy use, in 1990 they would have added another 4.8 per cent to total EU energy-related emissions; by 2019 this had grown to 16.3 per cent, as biomass use rose and emissions from other sources of energy fell. See Figure 1.1.

Fig. 1.1 EU28 carbon dioxide emissions from energy and biomass, 1990–2019



Source: EU National Inventory Report to UNFCCC, at https://unfccc.int/ghg-inventories-annex-i-parties/2021.

To look at it another way, energy-related emissions excluding biomass across the EU28 fell by 26 per cent between 1990 and 2019; if emissions from biomass are included, the reduction is 15 per cent.

Note that these figures do not indicate the real impact on the climate. As discussed in Section 1.1, this depends critically on the carbon payback period, the period of time during which carbon levels in the atmosphere are higher than they would have been if biomass had not been used for energy. This in turn depends on the type of feedstock, the counterfactual, i.e. what would have happened to

[10] Available at https://unfccc.int/ghg-inventories-annex-i-parties/2020. Total reported carbon dioxide emissions from biomass energy in greenhouse gas inventories are calculated, and reported, in two different ways, using a bottom-up 'sectoral approach' and a top-down 'reference approach'. The estimates resulting from these two approaches are very rarely, if ever, equivalent; it is not possible to compare these values directly. All calculations in this paper uses the sectoral approach. In general, the biomass figures in the reference approach are slightly higher (by about 5–6 per cent) than in the sectoral approach.

the feedstock if it had not been used for energy and also on what fossil fuels are substituted by the biomass. Calculating carbon payback periods for the biomass feedstocks used in the EU is virtually impossible, partly because regulatory frameworks usually do not require biomass users to differentiate the feedstock they use by data which would allow the calculation of carbon payback periods. It should also be remembered that some of these emissions will already be reported, as removals of biomass, in the land-use section of the EU's national inventory reports to the UNFCCC, and adding emissions from combustion would represent double-counting. The figures used above represent gross single-year emissions from biomass use, rather than a comprehensive analysis of the impact on the climate.

The national inventory reports for the UNFCCC contain a breakdown of energy use and emissions by sector. Table 1.1 sets out the energy-related emissions from biomass use in the EU included in these reports for the period 2013–19, broken down by the four main emitting sectors (green rows), and including the key biomass-using sub-sectors within each sector (indicated in italics). As can be seen, the main biomass-using sectors are public electricity and heat production, and residential; together, these sectors accounted for roughly two-thirds of biomass-related emissions in each year in the table. The pulp, paper and print sector and road transport together account for a further sixth of emissions.

Table 1.1 EU28 emissions from energy (total), biomass (total and selected sectors)

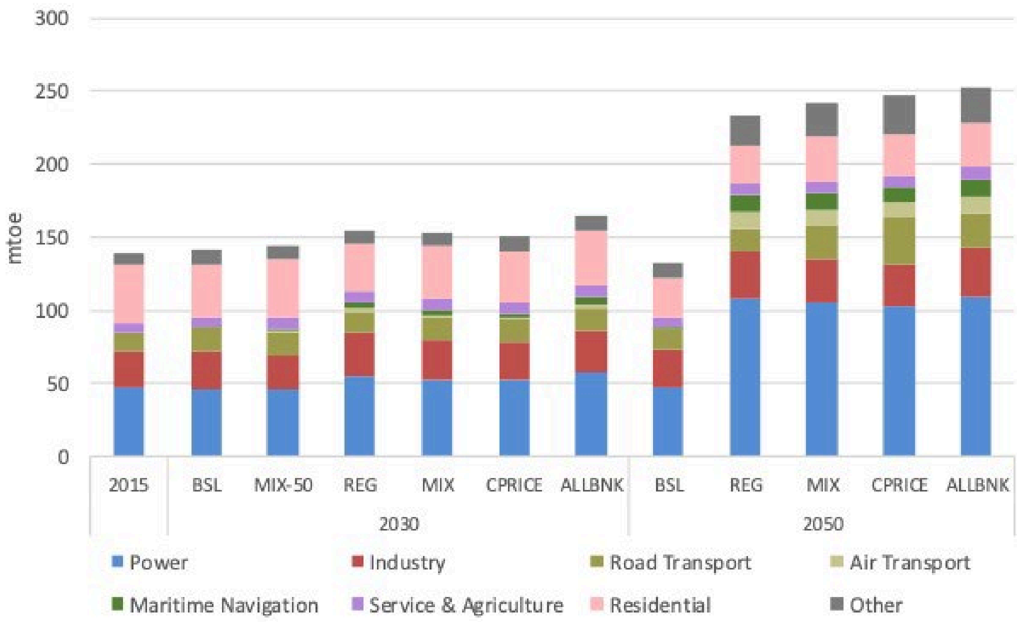
Emissions (MtCO2)	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Energy (not including biomass), total	**3,402.43**	**3,222.99**	**3,262.15**	**3,243.81**	**3,249.13**	**3,170.08**	**3,023.98**
Biomass, total	**539.99**	**525.85**	**545.61**	**553.76**	**565.14**	**568.68**	**584.52**
Energy industries, total	162.75	168.25	175.67	179.20	181.95	184.23	189.50
Public electricity and heat production	*158.54*	*164.20*	*171.75*	*175.41*	*178.08*	*180.64*	*185.92*
Other	*4.21*	*4.05*	*3.92*	*3.79*	*3.88*	*3.59*	*3.58*
Manufacturing and construction, total	102.52	104.76	108.87	111.38	113.70	115.85	121.33
Pulp, paper and print	*51.69*	*52.85*	*52.25*	*53.42*	*54.33*	*55.16*	*56.31*
Other	*50.84*	*51.91*	*56.62*	*57.95*	*59.37*	*60.69*	*65.02*
Transport, total	37.94	40.83	40.28	40.43	44.17	49.74	52.01
Road transport	*37.69*	*40.56*	*39.99*	*40.15*	*43.88*	*49.43*	*51.76*
Other	*0.25*	*0.27*	*0.28*	*0.27*	*0.29*	*0.30*	*0.26*
Other sectors, total	236.41	211.69	220.20	222.08	224.71	218.74	221.56
Residential	*209.08*	*185.29*	*192.33*	*193.46*	*194.82*	*188.42*	*190.73*
Other	*27.33*	*26.40*	*27.87*	*28.62*	*29.90*	*30.32*	*30.83*

Source: EU National Inventory Reports to UNFCCC

Emissions from biomass use have climbed steadily in recent years, by about 8 per cent in total from 2013 to 2019. EU consumption of biomass for energy is projected to continue to grow in most applications in the future, as efforts to phase out fossil fuels accelerate. The EU's 2030 Climate

Target Plan, which set out the ambition of raising the emissions target from 40 per cent to 55 per cent by 2030, on the road to zero net emissions by 2050, was based on a comprehensive impact assessment which includes projections for biomass consumption in 2030 and 2050, across a range of different scenarios; see Figure 1.2.

Fig. 1.2 Projected consumption of biomass by sector and scenario in EU27, in 2030 and 2050 (mtoe)



Scenarios – BSL: based on pre-2020 2030 targets; REG: regulatory-based measures achieving 55 per cent GHG reductions; CPRICE, a carbon-pricing based scenario achieving 55 per cent GHG reductions; MIX: combined approach of REG and CPRICE achieving 55 per cent GHG reductions; MIX-50, combined approach achieving 50 per cent GHG reductions; ALLBNK: based on MIX and further intensifying fuel mandates for aviation and maritime sectors.

Source: *Commission Staff Working Document Impact Assessment accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Stepping up Europe's 2030 climate ambition – Investing in a climate-neutral future for the benefit of our people* (SWD(2020) 176 final, 17 September 2020), Part 2, p. 95.

Table 1.2 contains the data represented in Figure 1.2 for three of the six scenarios, seen as the most likely paths forward:[11]

- REG, a regulatory-based measures scenario which assumes a high increase in the ambition of energy efficiency, renewables and transport policies, while keeping the EU ETS scope unchanged. This scenario does not expand carbon pricing and relies mostly on other policies.
- CPRICE, a carbon-pricing based scenario which assumes strengthening and further expanding of carbon pricing, via the EU ETS or other instruments, to the transport and buildings sectors, combined with low intensification of transport policies while not intensifying energy efficiency or renewables policies.
- MIX, a combined approach of the REG and CPRICE scenarios, both expanding carbon pricing and moderately increasing the ambition of regulatory policies, but to a lesser extent than in the REG scenario.

[11] Descriptions: *Impact Assessment*, Part 1, p. 43.

Table 1.2 Projected consumption of biomass by sector (three main scenarios only) in EU27, in 2030 and 2050 (mtoe)

	2015	2030			2050		
		REG	*MIX*	*CPRICE*	*REG*	*MIX*	*CPRICE*
Power	47.57	55.63	52.75	52.02	107.59	105.76	103.03
Industry	23.94	28.49	26.50	25.81	32.21	29.21	28.45
Road transport	12.70	14.59	15.16	15.85	15.96	22.86	31.55
Air transport	0.00	2.96	1.98	1.48	11.15	11.09	11.00
Service & agriculture	6.42	7.18	7.82	7.15	8.62	8.82	7.76
Residential	40.61	32.22	36.04	35.87	25.41	30.29	29.13
Maritime navigation	0.00	3.71	3.20	2.47	11.51	10.76	9.77
Other	7.53	9.29	9.88	9.97	20.59	23.26	26.65
Total	138.77	154.08	153.31	150.62	233.04	242.05	247.34

Source: as Fig. 1.2 (online supplement at https://ec.europa.eu/clima/sites/default/files/eu-climate-action/docs/2030_climate_target_plan_figures_en.xlsx)

As can be seen, all the scenarios for the more ambitious targets foresee roughly a doubling in biomass energy (of all kinds) by 2050 (compared to a seven-fold increase in other renewables).[12] This includes a fall in use in the residential sector, but a doubling in the use of biomass for electricity production, including through bioenergy with carbon capture and storage (BECCS). The other major growth sector is transport, where large increases are projected from biomass consumption for aviation and maritime transport, and slightly slower growth (though large in some scenarios) in consumption in road transport.

[12] *Commission Staff Working Document Impact Assessment accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Stepping up Europe's 2030 climate ambition – Investing in a climate-neutral future for the benefit of our people* (SWD(2020) 176 final, 17 September 2020), Part 1, p. 55.

2 Emissions Trading System

Established in 2005, the EU ETS is the world's first international emissions trading system. It covers all member countries of the European Economic Area (EEA) – i.e. all EU member states plus Iceland, Liechtenstein and Norway.[13] It uses a cap-and-trade system to limit emissions from about 11,000 heavy energy-using installations – power stations and industrial plants – and airlines operating within those countries; this covers around 38 per cent of total greenhouse gas emissions in its member countries.

An overall cap is set on the total amount of greenhouse gases that can be emitted by installations covered by the ETS; the cap is reduced over time. Within the cap, companies are given, or buy, emission allowances, which they can trade with one another as needed. After each year each company must surrender enough allowances to cover all its emissions within that period, or face fines (which are more costly than buying the necessary allowances). If a company reduces its emissions, it can keep the spare allowances to cover its future needs, or sell them to another company that is short of allowances. Thus the system should work both to deliver cuts in emissions where it is most cost-effective to do so, and, as the cap is steadily reduced over time, to increase the cost of emitting greenhouse gases and thus encourage further efforts at reductions.

2.1 Biomass for stationary installations in the ETS to date

In common with the other policy instruments discussed in this paper, emissions from biomass are not included in the ETS. Installations exclusively using biomass are not covered by the ETS at all.[14] For installations using biomass alongside fossil fuels, emissions from biomass are 'zero-rated' as long as they meet the sustainability criteria included in the Renewable Energy Directive.[15] As discussed in Section 1.1, prior to 2020, no such criteria existed for solid biomass, but they did apply to bioliquids.

Biomass emissions from installations using biomass alongside fossil fuels – for example, coal stations partly converted to using biomass, or pulp mills using biomass and other fossil fuels – should be included in the national reports submitted under Article 21(1) of the ETS Directive, which requires each member state to submit an annual report to the European Commission on ow the Directive is applied in their country. Under Article 21(2), the Commission is required to publish an annual analysis of the national Article 21 reports,[16] and it also publishes an annual report on the functioning of the European carbon market.

Installations are divided into three categories: Category A installations, with annual emissions equal to or less than 50,000 tonnes of carbon dioxide equivalent (CO_2e); Category B, with annual emissions between 50,000 and 500,000 tonnes CO_2e; and Category C, with annual emissions greater than 500,000 tonnes CO_2e (in all cases, excluding emissions from biomass). Figure 2.1 shows the total number of installations, and those using biomass, in each category in 2019 (the latest year for which

[13] The UK is now outside the EEA, and EU ETS – it has established its own ETS – but was inside for the period covered by this paper. All figures for the EU relate to the EU28. The projections in Section 2.2 are adjusted to exclude the UK.

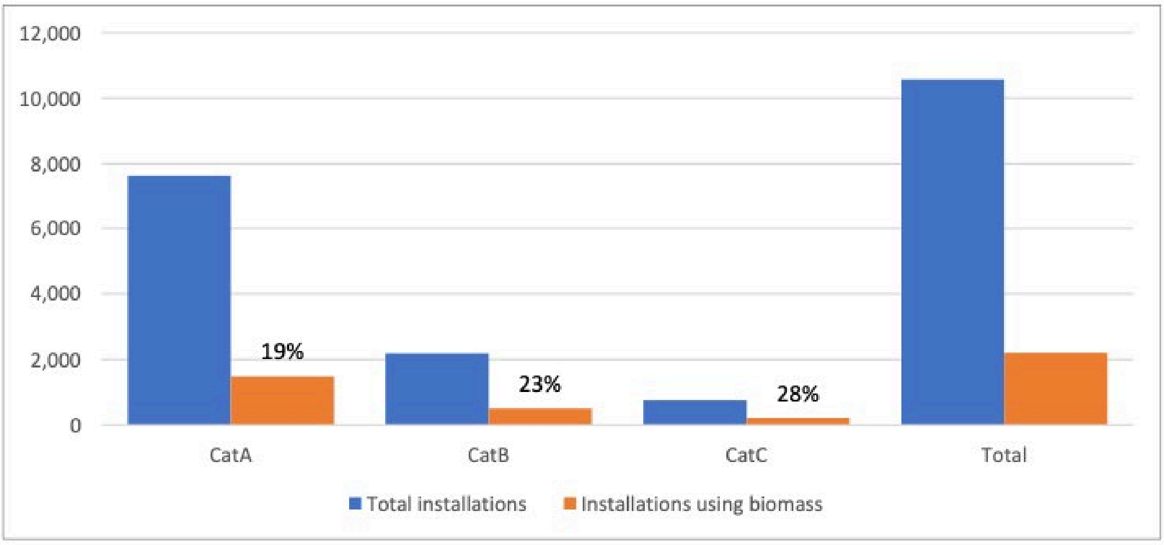
[14] *Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Union and amending Council Directive 96/61/EC*, Annex I, para 1.

[15] *Guidance Document: Biomass issues in the EU ETS* (European Commission, November 2017).

[16] The national Article 21 reports are available at http://rod.eionet.europa.eu/obligations/556/deliveries.

the analysis is available). In that year a total of 10,569 installations were included in the ETS, of which 2,197 reported the use of biomass for energy.

Fig. 2.1 Number of ETS category A, B and C installations and those using biomass, EU28, 2019 (percentages indicate the proportion of installations in each category that burn biomass)

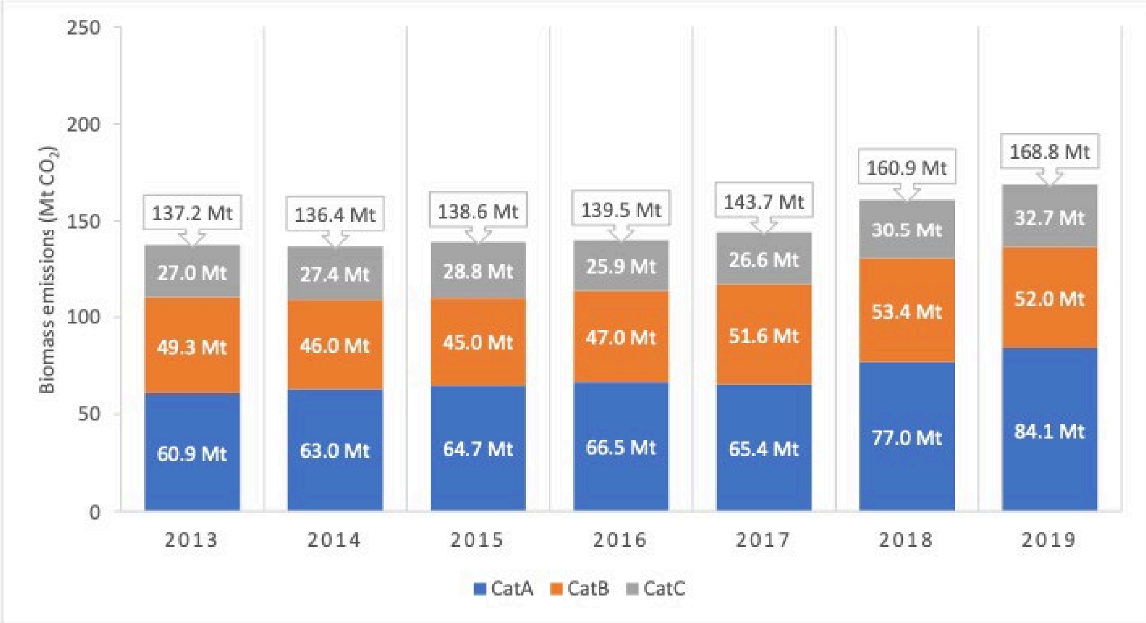


Source: *Application of the European Union Emissions Trading Directive: Analysis of national responses under Article 21 of the EU ETS Directive in 2020* (European Commission, 2021)

Figure 2.2 shows emissions from each category of installations reporting biomass use, from 2013 to 2019.[17] (The analyses also report a small volume – about 1.2–1.4 Mt CO_2 – of non-zero-rated biomass emissions each year, presumably from the use of bioliquids not compliant with the sustainability criteria in power and heat generation. Since these are included in the ETS emissions figures, they are ignored in this analysis.)

[17] Analyses for earlier years do not appear to be available, perhaps partly because an older reporting format was in use.

Fig. 2.2 EU28 emissions in $MtCO_2e$ originating from biomass between 2013 and 2019, by ETS installation category



Source: *Application of the European Union Emissions Trading Directive: Analysis of national responses under Article 21 of the EU ETS Directive in 2020* (European Commission, 2021)

It should be noted that there are doubts over the accuracy of these figures. Member states have not always reported complete ETS data, especially in the earlier years; this is particularly true of data on biomass emissions, which, since they are zero-rated, have no impact on the functioning of the system. The 2020 analysis of national responses (covering data up to 2018) included a note about the use of proxy data to compensate for gaps in data submitted by Italy for 2014 and France for 2015 (two very large users of biomass for energy), and the 2021 report incorporated quite substantial changes to the data reported for 2013 and 2014. Earlier analyses contain comments about member states not submitting biomass data at all, or reporting biomass energy use without reporting associated emissions; the 2021 report commented approvingly on the 'significant improvement in the quality of the information reported by the EU ETS countries'.[18]

As noted in Chapter 1, biomass is used for energy both in generating electricity and heat and in industrial applications, of which the largest single category is pulp, paper and print. The analyses of ETS national reports provide figures for the breakdown of biomass emissions from these named sectors; over the period 2013–19, this varied from 47 to 56 per cent for combustion (with the exception of 2014), 20 to 22 per cent for pulp and 17 to 20 per cent for paper and cardboard (figures for these two sectors were not included in the reports for 2013–14). The report for 2014 stated that emissions from biomass used for combustion accounted for 79 per cent of the total; this is so significantly different from all the other years' data that it is assumed to be an outcome of incomplete data reporting, and in Table 2.1 the figure of 52 per cent (the average of the other years' data) has been used.

[18] *Application of the European Union Emissions Trading Directive: Analysis of national responses under Article 21 of the EU ETS Directive in 2020* (European Commission, 2021), p. 60.

Table 2.1 accordingly includes non-biomass and biomass emissions reported in the ETS for electricity and heat production and for industrial processes. The figures have been corrected to deduct estimated emissions from the ETS's three non-EU members, Iceland, Lichtenstein and Norway, to enable comparisons with the data reported by the EU28 to the UNFCCC (see Table 1.1).[19] The percentage figures show biomass emissions as a proportion of the total of non-biomass emissions included in the ETS.

Table 2.1 EU28 ETS emissions with and without biomass (MtCO_2e), 2013–19

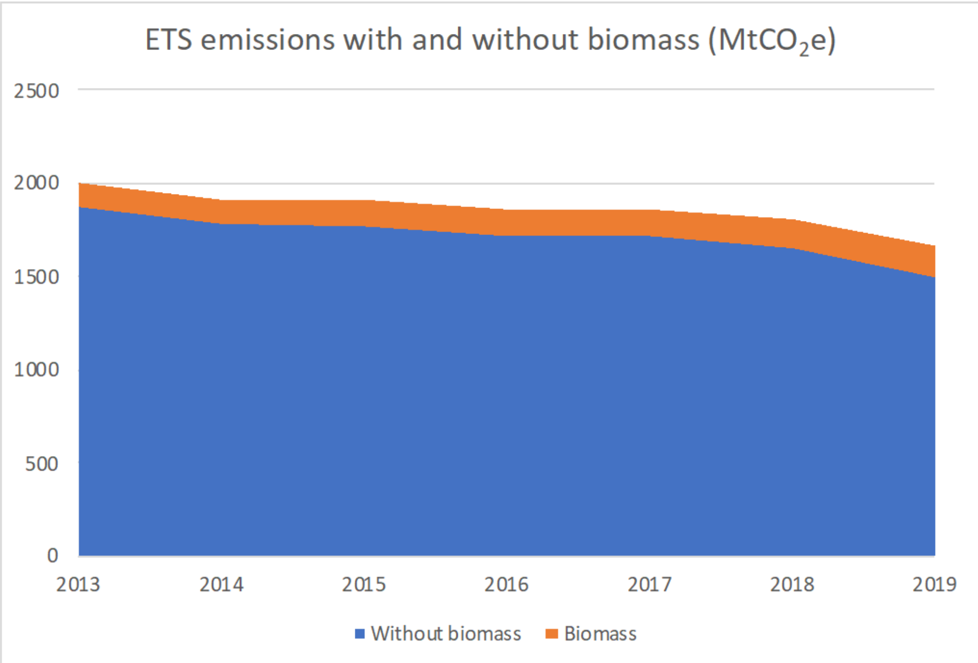
	2013	2014	2015	2016	2017	2018	2019
Total ETS							
Without biomass	1,875	1,783	1,772	1,720	1,725	1,653	1,504
Biomass	135	134	136	137	141	158	166
Total including biomass	2,010	1,917	1,908	1,857	1,866	1,811	1,669
Biomass as %	*7.2%*	*7.5%*	*7.7%*	*8.0%*	*8.2%*	*9.6%*	*11.0%*
Power and heat							
Without biomass	1,118	1,031	1,025	984	979	914	778
Biomass	77	71	73	71	68	82	93
Total including biomass	1,195	1,102	1,098	1,055	1,046	996	871
Biomass as %	*6.9%*	*6.9%*	*7.2%*	*7.2%*	*6.9%*	*9.0%*	*11.9%*
Industrial							
Without biomass	757	752	747	737	746	740	725
Biomass	60	65	65	68	76	79	76
Total including biomass	817	817	812	805	822	819	801
Biomass as %	*8.0%*	*8.7%*	*8.7%*	*9.3%*	*10.2%*	*10.7%*	*10.5%*

Sources: Total ETS figures from: *Report from the Commission to the European Parliament and the Council: Report on the functioning of the European carbon market* (European Commission, COM(2020)740, 18 October 2020). Biomass figures from: *Application of the European Union Emissions Trading Directive: Analysis of national responses under Article 21 of the EU ETS Directive in 2013/2014/2015/2016/2017/2018/2019* (European Commission).

Figure 2.3 shows the trajectory of total ETS and biomass emissions from Table 2.1. **As can be seen, emissions from biomass (which are not included in the ETS) were equivalent to 7 cent of non-biomass ETS emissions in 2013; by 2019 this had risen to 11 per cent. The reduction in total ETS emissions not including biomass for the EU28 from 2013 to 2019 was 20 per cent; if biomass is included, the fall is 17 per cent.**

[19] Based on comparing reported ETS emissions from these three countries with the whole of the ETS in 2019, the three together accounted for 1.7 per cent of all emissions and 1.8 per cent of biomass emissions.

Fig. 2.3 Total EU28 ETS emissions with and without biomass ($MtCO_2e$), 2013–19



Source: as Table 2.1.

As would be expected – since they exclude biomass-only installations – these figures are very different from those included in Table 1.1, which is based on the EU's greenhouse gas emissions reports to the UNFCCC, which should therefore capture all biomass emissions. In 2019, biomass emissions from public electricity and heat production in the UNFCCC report (186 $MtCO_2$) were double the figure here (93 $MtCO_2$). The figure for emissions from biomass use in industry in 2019 (121 $MtCO_2$) was 60 per cent higher than the figure here (76 $MtCO_2$). About four-fifths of industrial biomass emissions reported in the ETS should be from pulp, paper and print (i.e. 61 $MtCO_2$); the UNFCCC report shows 56 $MtCO_2$ for that sector, which is much closer.

Calculating the volume of biomass emissions that would be included in the ETS if the system were to be extended to cover biomass, whether or not burnt in installations also burning fossil fuels, is complicated, as many such installations would in any case be too small to be included – i.e. those with less than 20 MW thermal rated input, which roughly equates to about 7 MW electricity output capacity (energy in the fuel adjusted for conversion efficiency).

Information on the numbers and sizes of biomass power and heat plants in individual countries is difficult to find and is collected and reported in different ways. In the UK, of approximately 200 installations producing power from biomass, about 40 are rated higher than 7 MW electricity capacity; most of those below this level generate power from anaerobic digestion, using farm and other organic waste.[20] Only one of the 200 or so stations – Drax – burns biomass and fossil fuels (coal), but by itself it accounts for about 60 per cent of total biomass power capacity (2.64 GW). The total capacity of dedicated biomass stations is about 1.9 GW (about 40 per cent of the total), of which plants below 7 MW account for 0.36 GW (about 8 per cent). So if the ETS coverage in the UK was extended to include dedicated biomass stations above 7 MW, the total of biomass emissions

[20] Sources: *Power Stations in the UK* (UK Department for Business, Energy and Industrial Strategy, May 2020), https://www.gov.uk/government/statistics/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes, and UK Electricity Production website (June 2019), https://electricityproduction.uk.

covered by the ETS would rise by almost 60 per cent (assuming emissions are proportional to capacity, which may not be accurate).

In Germany, in December 2019 the Bundesnetzagentur (Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railways) identified a total of 15,122 biomass plants in operation, with a total capacity of 8.33 GW.[21] Another part of the agency's database listing power plants for the purpose of network planning included 75 biomass plants with a net rated capacity of 10 MW or more in operation in June 2020, with a total capacity of 8.61 GW.[22] (The latter list included plants which used other fuels as well, helping to explain the difference between the two figures.) It is probably safe to assume that the vast majority of the 15,122 plants are very small (Germany is unusual, within the EU, in possessing a very high number of biogas / anaerobic digestion plants), but it is impossible to calculate their capacity or emissions from the available data.

Figures used by the European Commission in the impact assessment of its July 2021 proposals for changes in the forest biomass sustainability criteria suggested that a total of 3,490 plants used woody biomass in the EU in 2016; plants of 20 MW thermal rated input or above accounted for 75 per cent of consumption of biomass, those between 10–20 MW for 10 per cent and those below 10 MW for 15 per cent.[23] This data presumably excludes plants burning agricultural biomass or waste, most of which will probably be too small to be covered by the ETS.

Acquiring information on the range of industrial (non-power) installations using biomass is even more difficult. As discussed above, the UNFCCC figures suggest that ETS were extended to such installations burning only biomass, its emissions might increase, but the size of the installations is not known, and it is possible that many of them would be too small to qualify anyway.

For the purposes of this analysis, we assume that if the ETS were to be extended to biomass, power-sector biomass emissions would increase by about 70 per cent. (As noted, the UNFCCC figures suggest total biomass emissions roughly 100 per cent higher than current ETS coverage, but the Commission data cited above shows 25 per cent of woody biomass consumption from stations below the ETS threshold, plus an estimated 5 per cent from small plants burning agricultural biomass.) Industrial-sector biomass emissions are assumed to remain the same.

Table 2.2 includes the ETS figures from Table 2.1, increased by 70 per cent for the electricity and heat sector. As before, the percentage figures show biomass emissions as a proportion of the total of non-biomass emissions included in the ETS.

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[21] 'Figures, data and information concerning the EEG', https://www.bundesnetzagentur.de/EN/Areas/Energy/Companies/RenewableEnergy/Facts_Figures_EEG/FactsFiguresEEG_node.html

[22] 'Power plant list', https://www.bundesnetzagentur.de/EN/Areas/Energy/Companies/SecurityOfSupply/GeneratingCapacity/PowerPlantList/PubliPowerPlantList_node.html

[23] European Commission, *Commission Staff Working Document Impact Assessment Report Accompanying the Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652* (SWD(2021) 621 final), Part 1, p. 153.

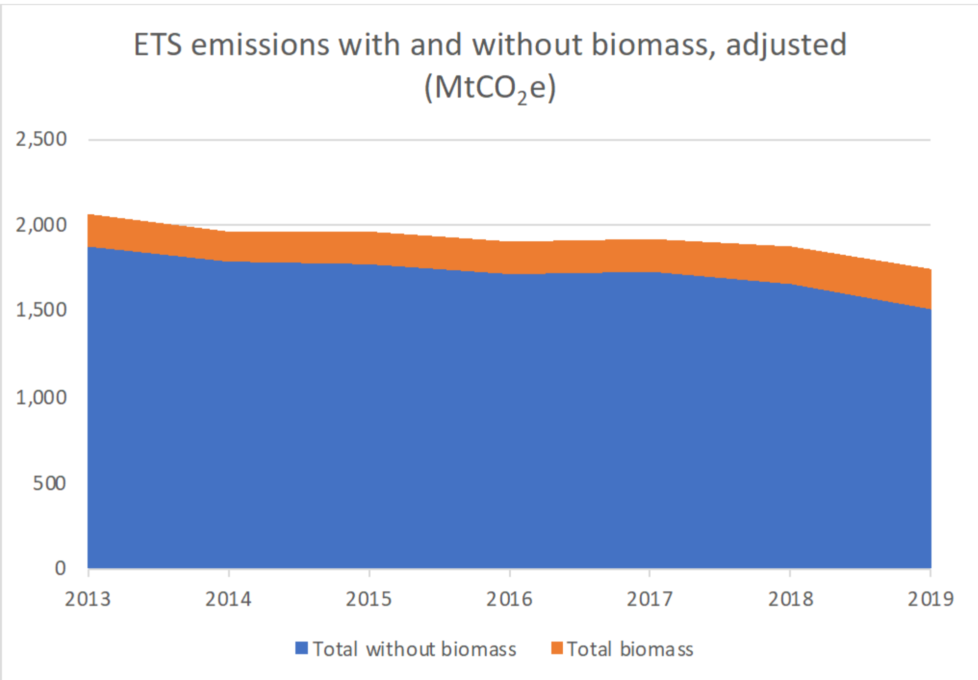
Table 2.2 EU28 ETS emissions with and without biomass, power sector adjusted ($MtCO_2e$), 2013–19

	2013	2014	2015	2016	2017	2018	2019
Power and heat adjusted							
Without biomass	1,118	1,031	1,025	984	979	914	778
Biomass adjusted	131	121	125	121	115	140	158
Total including biomass	1,249	1,151	1,150	1,105	1,094	1,053	936
Biomass as %	*11.7%*	*11.7%*	*12.2%*	*12.3%*	*11.7%*	*15.3%*	*20.3%*
Total ETS adjusted							
Without biomass	1,875	1,783	1,772	1,720	1,725	1,653	1,504
Biomass adjusted	191	186	190	189	191	218	234
Total including biomass	2,066	1,969	1,962	1,909	1,916	1,871	1,737
Biomass as %	*10.2%*	*10.4%*	*10.7%*	*11.0%*	*11.1%*	*13.2%*	*15.5%*

Source: as Table 2.1, power and heat biomass figures increased by 70 per cent.

Figure 2.4 shows the trajectory of total ETS and biomass emissions from Table 2.2. **Under these adjusted figures, emissions from biomass (which are not included in the ETS) were equivalent to 10 cent of non-biomass ETS emissions in 2013; by 2019 this had risen to 16 per cent. The reduction in total ETS emissions not including biomass for the EU28 from 2013 to 2019 was 20 per cent; if biomass is included on these adjusted figures, the fall is 16 per cent.**

Fig. 2.4 Total EU28 ETS emissions with and without biomass, adjusted figures ($MtCO_2e$), 2013–19



Source: as Table 2.1, power and heat biomass figures increased by 70 per cent.

2.2 Biomass for stationary installations in the ETS: projections to 2030 and 2050

This section discusses potential future growth in the use of biomass for energy in installations included in the ETS. Section 1.2 included the projections for the future consumption of biomass for energy set out in the impact assessment accompanying the EU's 2030 Climate Target Plan.

Table 2.3 includes the percentage increases in consumption projected from the baseline year of 2015 in each of these three scenarios for 2030 and 2050 for the power and heat and industry sectors (from Table 1.2 in Chapter 1). It applies these increases to the biomass emissions recorded in the ETS national reports in 2015 to calculate biomass emissions in 2030 and 2050 under these projections. (As noted, the ETS figures are adjusted to subtract emissions reported by the UK in 2015.[24]) An additional row is added to indicate what ETS power emissions would be if all biomass-using installations were included (the additional 70 per cent increase discussed above). The table also includes, for the sake of comparison, the projections in the impact assessment for the falls in ETS emissions not including bioenergy. As before, the 'biomass as percentage' figures show biomass emissions as a proportion of the total non-zero-rated emissions included in the ETS – i.e. the proportion of unaccounted-for emissions.

Table 2.3 EU 27 ETS emissions with and without biomass (MtCO_2e), 2015 and projected to 2030 and 2050

	2015	2030			2050		
Scenario		***REG***	***CPRICE***	***MIX***	***REG***	***CPRICE***	***MIX***
Biomass power and heat							
% change from 2015		*16.9%*	*9.3%*	*10.9%*	*126.2%*	*116.6%*	*122.3%*
ETS biomass power and heat	59	69	65	65	134	128	131
ETS biomass power and heat adjusted	100	117	110	111	227	217	223
Biomass industry							
% change from 2015		*19.0%*	*7.8%*	*10.7%*	*34.6%*	*18.9%*	*22.0%*
ETS biomass industry	63	76	68	70	85	75	77
Total biomass							
Total biomass	122	145	133	136	219	203	209
Total biomass adjusted	164	193	178	182	312	293	301
Total ETS stationary installations							
% change from 2015		*-54.5%*	*-54.9%*	*-53.5%*			
ETS excluding biomass	1,598	727	721	743			
ETS including biomass	1,720	872	854	878			
Biomass as %		*19.9%*	*18.4%*	*18.3%*			

[24] UK emissions reported under the ETS in 2015 came to 174 MtCO_2, and ETS biomass emissions to 16.11 MtCO_2 (14.41 MtCO_2 from combustion, 1.70 MtCO_2 from industry); http://cdr.eionet.europa.eu/Converters/run_conversion?file=gb/eu/emt/envvynqyw/UK%20Article%2021%20report%20for%202015.xml&conv=527&source=remote

	2015	2030			2050		
Scenario		***REG***	***CPRICE***	***MIX***	***REG***	***CPRICE***	***MIX***
ETS including biomass adjusted	1,761	920	899	924			
Biomass adjusted as %		*26.5%*	*24.7%*	*24.4%*			

Sources: biomass – Table 2.1; projected changes in non-biomass ETS emissions: *Impact Assessment*, Part 2, p. 48 (Table 39).[25]

Overall, biomass emissions in the ETS stationary installations sector grow by 9–19 per cent by 2030, depending on the scenario, and by 66–80 per cent by 2050. Biomass emissions are equivalent to an additional 18–20 per cent on top of the total of ETS emissions in 2030, or as estimated 24–26 per cent if the ETS is extended to all biomass use for power and heat.

It is possible that the new sustainability criteria introduced in the 2018 Renewable Energy Directive might limit the feedstock available for zero-rated biomass for the ETS for the period 2020–30 and thus constrain biomass use; this issue is discussed further in Chapter 4. It is also possible that *emissions* from biomass use may not increase at the same rate as *consumption* (which is what the projections here are based on), particularly if biomass in the future projections is used more heavily in large (more efficient) or CHP stations and less in smaller (less efficient) or power-only stations; in this case the projections above will over-estimate biomass emissions.

This table assumes that the scope of the ETS remains at its current coverage. One of the options included in the Climate Target Plan, however, was the expansion of the ETS to include road transport and buildings; this is a particular feature of the CPRICE scenario and, to a lesser extent, the MIX scenario. In fact, in its 'Fit for 55' proposals, the Commission has proposed to introduce a separate emissions trading system for fuel suppliers for road transport and buildings – both sectors in which biomass is used extensively.

The impact assessment does not contain any estimates for ETS emissions in 2050, but the projections for energy consumption suggest that coal and gas use are reduced to almost (though not quite) zero. If included in the ETS, emissions from biomass would therefore account for the vast bulk of it.

2.3 Biomass for aviation in the ETS

Since 2012, the ETS has also included carbon dioxide emissions from aviation. All airlines operating in the EEA, European and non-European alike, are required to monitor, report and verify their emissions, and to surrender allowances against those emissions. As with stationary installations, they receive tradeable allowances covering a certain level of emissions from their flights per year.

The original intention was to cover emissions from all flights from, to and within the EEA, but in the wake of opposition from non-EEA countries and because of progress by the International Civil

[25] The 2015 figure for emissions for ETS stationary installations in the Impact Assessment is given as 1,601 $MtCO_2$, rather than the 1,803 $MtCO_2$ included in the Commission's reports on the ETS (corrected to 1,598 $MtCO_2$ to exclude non-EU countries; see Table 2.2). It is not known why this is the case. The figures above in Table 2.3 for projected ETS emissions are based on the percentage changes shown in the Impact Assessment applied to the 1,598 $MtCO_2$ starting figure.

Aviation Organisation (ICAO) in developing a global framework for addressing aircraft emissions, the EU decided to limit the scope of the ETS only to flights within the EEA. In the absence of any new amendment, the EU ETS was to revert back to its original full scope from 2024, but in July 2021 the Commission proposed instead to apply the ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) scheme to EU-based airlines' emissions from flights to and from countries outside the EEA. This means that when emissions from flights outside the EEA reach levels above 2019, they will have to be offset with corresponding carbon credits.

Biofuels used for aviation are subject to the sustainability criteria in the successive Renewable Energy Directives; if their use meets the criteria, they are zero-rated for the purposes of the ETS, like stationary installations using biomass. In fact, no biofuel use in aviation was reported under the ETS before 2019. In that year, two operators, one in Denmark and one in Sweden, reported, covering 0.01 per cent of the 2019 ETS aviation emissions – i.e. about 7 ktCO_2.[26]

The impact assessment accompanying the Climate Target Plan includes projections for the use of biofuel in aviation in 2030 and 2050: see Table 2.4, which includes the consumption figures for the three scenarios focused on earlier. The impact assessment suggests that about 1–1.5 per cent of bioenergy demand will be contributed by aviation biofuel in 2030 and about 4–4.5 per cent in 2050.

Table 2.4 Projected use of bioenergy in aviation by selected scenario, EU27 (mtoe)

	2015	2030			2050		
		REG	*CPRICE*	*MIX*	*REG*	*CPRICE*	*MIX*
Air transport	0.00	2.96	1.48	1.98	11.15	11.00	11.09

Sources: as Table 1.2.

This may prove to be an over-estimate, thanks to another part of the 'Fit for 55' package published in July 2021: a new proposal to promote the uptake of sustainable aviation fuels.[27] The proposed ReFuelEU regulation would oblige fuel suppliers to blend sustainable aviation fuels – advanced biofuels based on waste and residues without negative direct or indirect land use impacts, and synthetic fuels (e-fuels, or e-kerosene) – into existing jet fuel uploaded at EU airports, rising from a minimum of 2 per cent in 2025 to 5 per cent in 2030 and to 63 per cent in 2050 (within this figure, the share of synthetic fuels is to rise from 0.7 per cent in 2030 to 28 per cent in 2050). The regulation explicitly excludes the use of crop-based biofuels. It also requires airlines to uplift from EU airports at least 90 per cent of the jet fuel they require to perform flights within and from the EU, in order to prevent airlines avoiding the mandate by purchasing extra fuel outside the EU.

The proposed ReFuelEU regulation would, if adopted unamended, significantly limit emissions from biomass used for aviation. It would not completely eliminate them because a portion of the advanced biofuels will be produced from agricultural and forestry wastes. Calculations for the impact assessment accompanying the regulation suggest that this contribution could be quite high – by 2030, an estimated 2.7 per cent of the EU's total available potential of agricultural and wood waste, and by 2050, about 11 per cent of the available potential of agricultural residues and wood

[26] *Report from the Commission to the European Parliament and the Council: Report on the functioning of the European carbon market* (European Commission, COM(2020)740, 18 October 2020), p. 7.
[27] European Commission, *Proposal for a Regulation of the European Parliament and of the Council on ensuring a level playing field for sustainable air transport* (COM(2021) 561 final, July 2021).

waste, 3 per cent of the available potential of forestry products and residues, and 9 per cent of the available potential of energy crops.[28] There seems likely to be demand for such feedstocks for other uses, and there is of course the danger of land-use change deriving from the need to generate agricultural residues and energy crops.

2.4 Biomass for maritime transport

Maritime transport is not currently included in the ETS, but the Commission's 'Fit for 55' package proposed a gradual extension of the ETS to the maritime sector over the period 2023–25. Shipping companies are to pay for emissions allowances for voyages between EU ports, and for half of emissions from voyages to or from non-EU ports.

The proposed FuelEU Maritime regulation specifies the types of fuels that may be used.[29] Ship operators will be required to monitor and report on the greenhouse gas intensity of the energy used onboard a ship, and limits on the yearly average greenhouse gas intensity of the energy used will become increasingly stringent, falling from a reduction of 2 per cent by 2025 (from the fleet average in 2020) to a reduction of 75 per cent by 2050. The regulation does not include, however, any further restriction on biofuels used for maritime transport other than the application of the sustainability criteria in the Renewable Energy Directive. As discussed in Chapter 4, this is of limited value.

Biofuels used in maritime transport will be zero-rated for the purposes of the ETS. The impact assessment accompanying the FuelEU Maritime regulation suggests that biofuels could account for about 6 per cent of maritime energy use by 2030 and 39–48 per cent by 2050.[30] The majority of this is assumed to be advanced biofuels produced from agricultural and forestry wastes and residues, though by 2050 about a third is assumed to be supplied by energy crops.[31]

[28] European Commission, *Commission Staff Working Document Impact Assessment Report Accompanying the Proposal for a Regulation of the European Parliament and of the Council on ensuring a level playing field for sustainable air transport* (SWD(2021) 633 final, July 2021), p. 41.
[29] European Commission, *Proposal for a Regulation of the European Parliament and of the Council on the use of renewable and low-carbon fuels in maritime transport and amending Directive 2009/16/EC* (COM(2021) 562 final, July 2021).
[30] European Commission, *Commission Staff Working Document Impact Assessment Report Accompanying the Proposal for a Regulation of the European Parliament and of the Council on the use of renewable and low-carbon fuels in maritime transport* (SWD(2021) 635 final, July 2021), pp. 52–53.
[31] Ibid., p. 57.

3 Effort-Sharing Framework

The EU's effort-sharing climate framework covers emissions from power, heat and industrial installations too small to qualify for the ETS, together with emitting sectors not included in the ETS: road transport, domestic shipping, buildings, agriculture and waste. It does not include LULUCF emissions. It establishes binding annual greenhouse gas emission targets for member states for the periods 2013–20 (set out in a Decision of 2009) and 2021–30 (included in Regulation 2018/842, agreed in 2018).

Collectively the national targets aim to deliver a reduction of 10 per cent in total EU emissions from the sources and sectors covered by 2020, and 30 per cent by 2030, compared with 2005 levels; the 'Fit for 55' package proposes increasing the 2030 target to 40 per cent. To date the effort-sharing framework has delivered its targets, though progress has slowed in recent years; in 2018 ESR emissions were actually higher than in 2014. (For convenience, the framework is abbreviated as ESR (effort-sharing regulation) in the rest of this chapter.)

3.1 Effort-sharing framework and biomass

Biomass emissions are not included in the effort-sharing framework; all biomass use is in effect zero-rated whether or not it meets the sustainability criteria in the Renewable Energy Directive. The only means of estimating their volume, therefore, is to use the EU's National Inventory Reports to the UNFCCC to obtain figures for total biomass emissions (see Table 1.1 in Chapter 1) and deduct the biomass emissions included in the ETS, as calculated in Chapter 2.

However, the UNFCCC figures are for combustion (tailpipe) emissions only, and adjustments therefore need to be made for those categories of fast-growing biomass which sequester carbon over a short period – mostly liquid biofuels used in road transport (see Section 1.2). A more accurate estimate of the impact of using this feedstock on the atmosphere can be obtained by using a life-cycle analysis including, importantly, the emissions impact of indirect land-use change (ILUC) arising from the production of the feedstock. (In an ideal world, the same approach would be used for the use of energy crops and agricultural residues in installations covered by the ETS, and other users of these types of biomass feedstock in the ESR, but as discussed in Chapter 1, there is insufficient reliable and comprehensive data on which to base these calculations.)

Table 3.1 includes emissions figures for the main crop-based feedstocks used for transport biofuels, calculated as the sum of direct emissions from cultivation, processing, transport, etc. (using the default values included in the Renewable Energy Directive), plus land-use change impacts (as calculated in the Globiom report published in 2016, commissioned by the European Commission but not used for the purposes of legislation).[32] The totals are notably higher than the default values used by the Commission in calculating ILUC impacts; they are based on a more detailed and more sophisticated analysis (see further in Chapter 4).[33]

(Note that this analysis of emissions will lead to some double-counting in emissions totals in the ESR, for example from emissions within the EU from processing and transport used in producing and

[32] *The land use change impact of biofuels consumed in the EU: Quantification of area and greenhouse gas impacts* (IIASA, Ecofys and E4tech, 2016).
[33] See the discussion in *Globiom: the basis for biofuel policy post-2020* (Transport & Environment, April 2016).

moving the biofuel feedstock, which will also be included separately. In the Globiom analysis, these direct emissions account for 28 per cent of biodiesel emissions and 68 per cent of bioethanol emissions (on average), though of course for imported biofuels or feedstock, some of these emissions will be outside the EU.)

Table 3.1 Emissions from main crop-based biofuel feedstocks, composed of direct emissions (from Renewable Energy Directive) and land-use change emissions (from Globiom study)

	Emissions (g CO_2eq/MJ)			
	Direct emissions	*Land use change emissions*	*Total emissions*	*% of fossil diesel or petrol*
1G biodiesel				
Rapeseed	46	65	111	118%
Palm	54	231	285	303%
Soy	50	150	200	213%
Sunflower	35	63	98	104%
1G biodiesel average	48	122	171	181%
1G bioethanol				
Maize	37	14	51	54%
Wheat	57	34	91	97%
Sugar beet	33	15	48	51%
Barley	76	38	114	121%
Sugar cane	24	17	41	44%
1G bioethanol average	43	21	63	67%

Source: *Globiom: the basis for biofuel policy post-2020* (Transport & Environment, April 2016).

These emission figures are then used together with data on the mix of biofuel feedstock consumed in the EU to calculate total emissions from road transport. Data on the biofuel feedstock mix is not published regularly by the EU but is available for biodiesel from industry sources. Table 3.2 includes data on consumption of the main biodiesel feedstock and the energy this generates. (‘Wastes’ include used cooking oil, tallow and grease, where the direct and indirect land-use change impacts are of course zero.)

Data is even less easily available on bioethanol feedstock consumption. The Commission’s most recent two Renewable Energy Progress Reports, containing data for 2016 and 2018, include a breakdown (earlier reports do not): feedstocks are roughly a third wheat, a third maize and a third everything else (mainly sugar beet, sugar cane and triticale, a hybrid of wheat and rye). The figures for energy output from the Renewable Energy Progress Reports are included below in Table 3.2, together with the associated emissions calculated from the Globiom study. Bioethanol emissions came to an average of 10.5 per cent of biodiesel emissions in each of 2016 and 2018, so that percentage has been used to calculate estimated emissions from bioethanol use (in italics) in the other years in the table; clearly, this will not be precise but bioethanol emissions are much lower per unit of fuel than biodiesel emissions, so the inaccuracy in terms of emissions is not likely to be large.

Table 3.2 Biofuels used for transport in the EU28: consumption and greenhouse gas emissions

	2013	2014	2015	2016	2017	2018	2019
Biodiesel – palm oil							
Consumption (MT)	2.76	3.27	3.34	3.60	4.22	4.24	4.49
Energy (PJ)	96.85	114.91	117.26	126.54	148.29	149.03	157.81
Emissions ($MtCO_2$)	27.60	32.75	33.42	36.06	42.26	42.47	44.98
Biodiesel – soybean oil							
Consumption (MT)	0.29	0.49	0.44	0.69	0.68	0.71	0.91
Energy (PJ)	10.12	17.11	15.53	24.18	23.79	25.02	32.12
Emissions ($MtCO_2$)	2.02	3.42	3.11	4.84	4.76	5.00	6.42
Biodiesel – rapeseed oil							
Consumption (MT)	5.66	6.21	6.27	5.90	5.91	5.78	5.64
Energy (PJ)	198.75	218.22	220.22	207.33	207.68	203.21	198.08
Emissions ($MtCO_2$)	22.06	24.22	24.44	23.01	23.05	22.56	21.99
Biodiesel – sunflower oil							
Consumption (MT)	0.09	0.19	0.11	0.23	0.45	0.49	0.63
Energy (PJ)	3.13	6.54	3.72	8.19	15.85	17.36	22.14
Emissions ($MtCO_2$)	0.31	0.64	0.37	0.80	1.55	1.70	2.17
Biodiesel – wastes							
Consumption (MT)	1.89	2.13	2.28	2.56	2.89	3.24	3.40
Energy (PJ)	66.41	74.81	80.15	90.06	101.38	113.99	119.41
Emissions ($MtCO_2$)	3.19	3.59	3.85	4.32	4.87	5.47	5.73
Biodiesel – other							
Consumption (MT)	0.02	0.02	0.02	0.02	0.02	0.02	0.01
Energy (PJ)	0.63	0.74	0.77	0.77	0.56	0.60	0.49
Emissions ($MtCO_2$)	0.11	0.13	0.13	0.13	0.10	0.10	0.08
Bioethanol – wheat							
Energy (PJ)				30.60		46.10	
Emissions ($MtCO_2$)				2.79		4.19	
Bioethanol – maize							
Energy (PJ)				42.12		42.54	
Emissions ($MtCO_2$)				2.15		2.17	
Bioethanol – other							
Energy (PJ)				36.97		37.18	
Emissions ($MtCO_2$)				1.99		2.13	
Emissions totals							

Biodiesel ($MtCO_2$)	55.29	64.75	65.32	69.17	76.59	77.31	81.37
Bioethanol ($MtCO_2$)	*5.81*	*6.80*	*6.86*	6.93	*8.04*	8.49	*8.54*
Total ($MtCO_2$)	61.09	71.55	72.17	76.10	84.63	85.80	89.92

Sources: Consumption figures from T&E database. Emissions calculated from *Globiom: the basis for biofuel policy post-2020* (Transport & Environment, April 2016).[34]

As would be expected, these totals are higher than the data included in the analysis of transport biofuel use in the summary of member states' reports under the Fuel Quality Directive, which use the older values for ILUC impact. The latest (2019) of these reports gives totals of 20.05 $MtCO_2$ for 2017 and 38.70 $MtCO_2$ for 2018.[35] The sharp rise between the two dates is due largely to an almost doubling in consumption of biodiesel, which is not in line with the data used above or that included in the Renewable Energy Progress Reports or other sources, such as US Department for Agriculture data on biofuel consumption.[36] **As with other biomass data, these figures seem unlikely to be precise.**

The emissions estimates from Table 3.2 are included in Table 3.3 below, alongside non-transport emissions from the UNFCCC reports for the other sectors in the ESR (see Table 1.1.). Biomass emissions from installations in the ETS are then deducted to reach an estimate of total biomass emissions in the ESR sectors. A line is also included for the adjusted total of ETS emissions, as calculated – of course, if the ETS is extended to include all biomass-using installations (apart from those beneath the 20 MW threshold), that means that the total of biomass emissions in the ESR falls correspondingly.

Table 3.3 EU28 emissions from biomass: total, in ETS and in ESR ($MtCO_2$), 2013–19

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Biomass excluding transport	502	485	505	513	520	519	532
Biomass transport	61	72	72	76	85	86	90
Biomass total	563	556	577	589	605	605	622
Biomass in ETS	135	134	136	137	141	158	166
Biomass in ETS adjusted	191	186	190	189	191	218	234
Biomass in ESR	428	422	441	452	464	447	457
Biomass in ESR adjusted	372	370	387	399	414	386	389

Source: EU National Inventory Reports to UNFCCC; transport data from Table 3.1; ETS calculations as in Chapter 2.

Eurostat publishes data on the total emissions reported under the ESR, so we can compare the biomass emissions calculated above to the non-biomass emissions in the framework; see Table 3.4 and Figure 3.1 (unadjusted) and Figure 3.2 (adjusted).

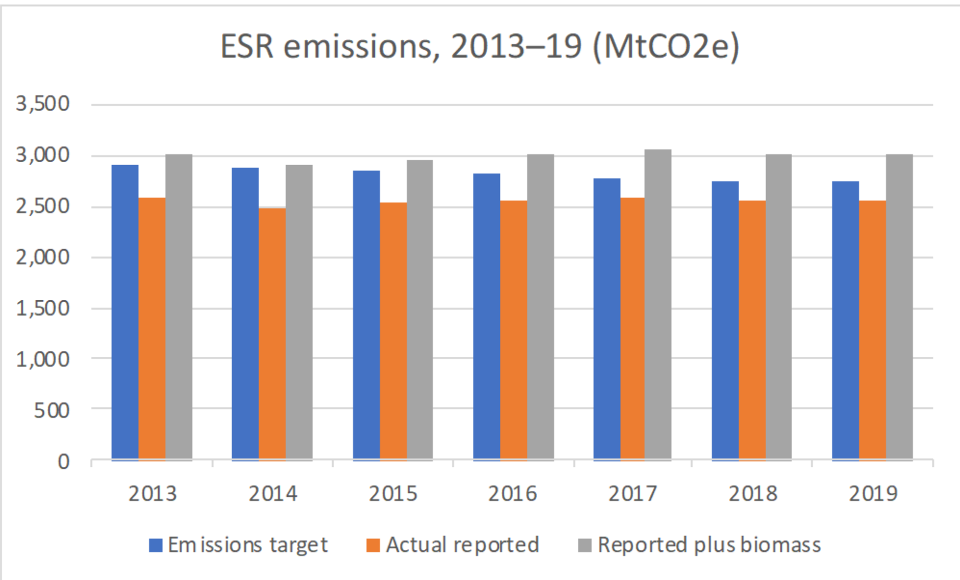
[34] Average biodiesel or bioethanol values have been used for 'wastes' and 'other' categories, except that the land-use change impact of wastes is assumed to be zero.
[35] Giorgos Mellios and Evi Gouliarou, *Greenhouse gas intensities of road transport fuels in the EU in 2018: Monitoring under the Fuel Quality Directive* (Eionet Report for European Environment Agency, November 2020), p. 15.
[36] See, e.g., *EU Biofuels Annual 2019* (USDA Foreign Agricultural Service, July 2019).

Table 3.4 EU28 emissions in ESR, with and without biomass (MtCO$_2$e), and percentage variation from target, 2013–19

	2013	2014	2015	2016	2017	2018	2019
Emissions target	2,892	2,870	2,847	2,824	2,773	2,751	2,729
Actual reported	2,567	2,478	2,519	2,555	2,584	2,551	2,544
% compared to target	*-11.2%*	*-13.6%*	*-11.5%*	*-9.5%*	*-6.8%*	*-7.3%*	*-6.8%*
Biomass	428	422	441	452	464	447	457
Reported plus biomass	2,995	2,900	2,960	3,007	3,048	2,997	3,000
% compared to target	*3.6%*	*1.1%*	*4.0%*	*6.5%*	*9.9%*	*8.9%*	*9.9%*
Biomass adjusted	372	370	387	399	414	386	389
Reported plus biomass adjusted	2,939	2,848	2,906	2,954	2,998	2,937	2,932
% compared to target	*1.6%*	*-0.7%*	*2.1%*	*4.6%*	*8.1%*	*6.8%*	*7.4%*

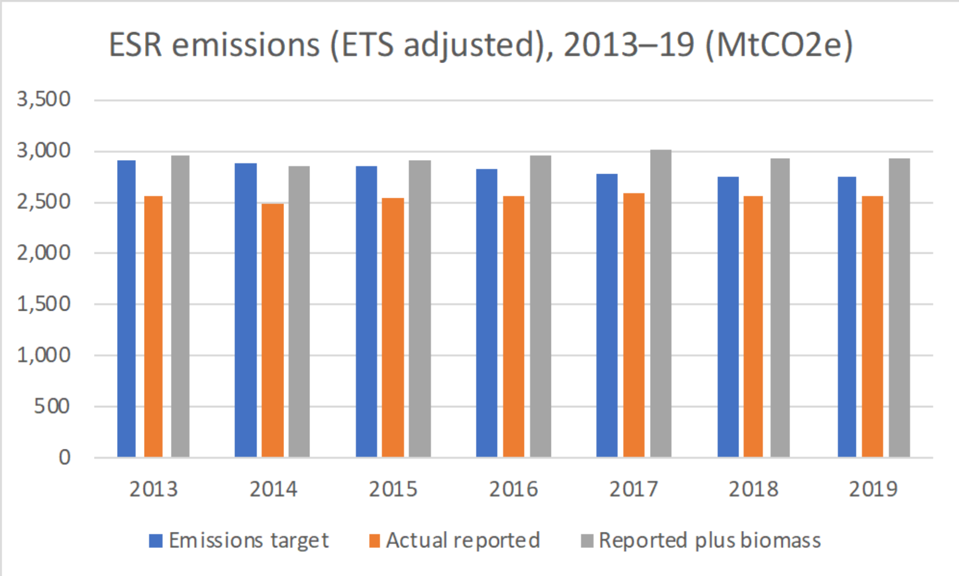
Source: ESR target figures: *Commission Decision (EU) 2017/1471 of 10 August 2017 amending Decision 2013/162/EU to revise Member States' annual emission allocations for the period from 2017 to 2020* (L209/53, 12 August 2017); Reported figures: Eurostat, 'Greenhouse gas emissions in ESD sectors'; Biomass figures: Table 3.3.

Figure 3.1 EU28 ESR emissions, 2013–19: target, actual reported and reported plus biomass (MtCO$_2$e)



Source: Table 3.4.

Figure 3.2 EU28 ESR emissions, 2013–19: target, actual reported and reported plus biomass (ETS adjusted) ($MtCO_2e$)



Source: Table 3.3.

As can be seen, without bioenergy emissions, the EU undershot its effort-sharing framework targets in every year in the table, though the gap has become narrower in more recent years. **If biomass emissions are included, however, only in 2014 on the adjusted biomass figures (where more biomass emissions are in the ETS and less in the ESR) was the target achieved; in every other year, the cap was exceeded by between 1 per cent and 10 per cent for the unadjusted figures, or 2 per cent and 8 per cent if using adjusted figures.**

3.2 Biomass in the effort-sharing framework: projections to 2030 and 2050

Figure 1.2 and Table 1.2 in Chapter 1 reproduce the projections for biomass use in 2030 and 2050 contained in the impact assessment accompanying the European Commission's Climate Target Plan published in September 2020. Section 2.2 estimated the potential growth of biomass emissions in the ETS the scenarios included there might represent.

This section uses the same approach for biomass use outside the ETS, in those sectors covered by the effort-sharing framework. The growth rates used are those projected in the three chosen scenarios in the impact assessment for the 'energy industries', 'manufacturing and construction', 'transport' and 'residential' sectors; the 'other' category is a combination of the 'agriculture and services' and 'other' growth rates. The total emissions in the ESR framework and for road transport are taken from Table 3.3 above; the figures for the other sectors are taken from the UNFCCC figures in Table 1.2, adjusted to delete the proportion covered by the ETS, both unadjusted and adjusted (from Tables 2.1 and 2.2, respectively), and also adjusted to delete the UK volumes of biomass emissions (taken from the UK reports to the UNFCCC and the Eurostat data for ESR emissions). Table 3.5 shows the results.

Table 3.5 EU27 ESR biomass emissions ($MtCO_2e$), 2015 and projected to 2030 and 2050

	2015	2030			2050		
		REG	*CPRICE*	*MIX*	*REG*	*CPRICE*	*MIX*
Biomass power outside ETS							
% change from 2015		*16.9%*	*9.3%*	*10.9%*	*126.2%*	*116.6%*	*122.3%*
Biomass power outside ETS	93	109	102	103	211	202	207
Biomass power outside ETS adjusted	52	61	57	58	117	112	115
Biomass industry outside ETS							
% change from 2015		*19.0%*	*7.8%*	*10.7%*	*34.6%*	*18.9%*	*22.0%*
Biomass industry outside ETS	38	45	41	42	51	45	46
Biomass road transport							
% change from 2015		*14.9%*	*24.9%*	*19.4%*	*25.7%*	*148.5%*	*80.0%*
Biomass road transport	67	77	84	80	84	167	121
Biomass residential							
% change from 2015		*-20.7%*	*-11.7%*	*-11.3%*	*-37.4%*	*-28.3%*	*-25.4%*
Biomass residential	185	146	163	164	116	132	138
Biomass other							
% change from 2015		*18.0%*	*26.8%*	*22.7%*	*109.4%*	*130.0%*	*146.6%*
Biomass other	32	38	41	39	67	74	79
Biomass totals in the ESR							
Total unadjusted	415	415	430	428	529	620	591
Total adjusted	373	367	385	383	435	530	499
Total ESR							
% change from 2015		*-32.0%*	*-31.6%*	*-31.6%*			
ESR excluding biomass	2,193	1,492	1,500	1,499			
ESR including biomass	2,608	1,908	1,930	1,928			
Biomass as %	*18.9%*	*27.8%*	*28.7%*	*28.6%*			
ESR including biomass adjusted	2,567	1,859	1,885	1,882			
Biomass adjusted as %	*17.0%*	*24.6%*	*25.7%*	*25.5%*			

Sources: projected growth rates from Table 1.2; 2015 emissions totals from Table 1.1 and Table 3.3; ETS emissions (deducted) from Table 2.1. Projected changes in ESR emissions: *Impact Assessment*, Part 2, p. 48 (Table 39).[37]

Overall, biomass emissions in the ESR sectors grow by 0–4 per cent by 2030, depending on the scenario, and by 17–49 per cent by 2050. This is a markedly slower growth than in the projections

[37] The 2015 figure for ESR emissions in the Impact Assessment is given as 2,236 $MtCO_2$, rather than the 2,519 $MtCO_2$ included in the Eurostat data (see Table 3.4). It is not known why this is the case. The figures above in Table 3.5 for projected ESR emissions are based on the percentage changes shown in the Impact Assessment applied to the 2,519 $MtCO_2$ starting figure. This is a similar adjustment to that made for the ETS figures.

for the use of biomass in the ETS; the significant fall in the use of biomass in the residential sector (presumably because of increased penetration of electric heating and a fall in households using wood fuel) offsets increases elsewhere. **Biomass emissions in the ESR sectors, but not recorded there, are equivalent to 19–29 per cent of total ESR emissions in these three scenarios for 2030, or 17–28 per cent if the ETS is extended to cover all biomass use** (above the 20 MW threshold). The impact assessment does not contain any estimates for ESR emissions in 2050; as with the ETS, they are presumably close to zero.

As with the ETS projections, it is possible that *emissions* from biomass use may not increase at the same rate as *consumption*, if the technology the biomass is used in increases in efficiency; this is probably less of an issue for the ESR sectors than the ETS, as the users will tend to be much smaller and therefore less efficient. This table also assumes that the scope of the ETS remains at its current coverage, whereas, as noted in Chapter 2, the European Commission's 'Fit for 55' package proposes to establish a new ETS for suppliers of energy for road transport and buildings. The impact of the application of the sustainability criteria included in the Renewable Energy Directive to these sectors is not yet clear, but underlines the need for better data on biomass use.

4 Renewable Energy Directive

The other key EU policy frameworks affecting the consumption of biomass for energy are the successive Renewable Energy Directives: 2009/28/EC, covering the period to 2020, and (EU)2018/2001, covering the period after 2020. Both Directives include sustainability criteria for biomass, designed to ensure that its use delivers greenhouse gas savings compared to the fossil fuels it replaces, and to limit the environmental impacts of its production. The sustainability criteria in the 2009 Directive applied only to biofuels and bioliquids; criteria for solid biomass were added in the 2018 Directive. The ‘Fit for 55’ package published in July 2021 includes proposals to modify the criteria for solid biomass.

This chapter reviews these sustainability criteria, and discusses the impact of consumption of biomass in the EU if the criteria introduced in the 2018 Directive had been in force before 2020.

4.1 Solid biomass

Sustainability criteria for solid biomass, constraining the feedstock that is to be eligible for financial and regulatory support from EU member states, were introduced for the first time in the 2018 Renewable Energy Directive, though some member states had used nationally developed criteria before that.

The criteria include requirements for minimum greenhouse gas savings compared to fossil fuels of 70 per cent for installations starting operation after 2020 or 80 per cent for installations starting after 2025 (this relates only to supply-chain emissions, not to combustion emissions or changes in forest carbon stocks – i.e. the impact on carbon debt and carbon payback periods (see Chapter 1) is ignored). In addition, new biomass stations (starting operation from 2022) producing electricity with above 100 MW total rated thermal input (which roughly equates to about 30 MW electricity output capacity – energy in the fuel adjusted for conversion efficiency) must either use CHP technology or achieve a net-electrical efficiency of at least 36 per cent (stations between 50–100 MW have more relaxed efficiency rules and below 50 MW no rules at all, though member states can decide to apply them), or be a BECCS plant.

The sustainability criteria also include requirements on the sourcing of feedstock. Feedstock produced from agricultural biomass is not eligible for support if it has been produced from land that was, at any time after 2008, classified as highly biodiverse grasslands, primary forest, highly biodiverse forest, or protected areas or from wetlands or (with some exceptions) peatlands.

For forest biomass, the sustainability criteria aim to constrain the sourcing of feedstock from countries with less strict forest protection laws than the EU. These include ensuring either that the country of origin has laws in place or that forest management systems are in place, in either case to ensure that forest biomass is legally harvested and sustainably sourced, including ensuring that the harvested forest is regenerated, protected areas remain protected, the impacts of harvesting on soil quality and biodiversity are minimised, and harvesting is limited to the long-term production capacity of the forest. The country from which the forest biomass is sourced must also be a party to the Paris Agreement which has submitted a Nationally Determined Contribution (NDC) covering emissions and removals from agriculture, forestry and land use ensuring either that changes in carbon stock associated with biomass harvests are accounted towards the country’s climate commitments or that there are laws in place to conserve and enhance carbon stocks and sinks. If evidence for these requirements is not available, forest management systems must be 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.

None of these criteria apply at all to stations below 20 MW thermal rated input (about 7 MW electricity output capacity), though member states may choose to apply them, and may also choose to apply additional criteria more broadly.

The new proposals published in July 2021 introduce a number of changes, including:[38]

- The extension of the provision to forest biomass (currently applicable only to agricultural biomass) that the feedstock must not be produced from land that was, at any time after 2008, classified as highly biodiverse grasslands, primary forest, highly biodiverse forest, or protected areas, or from wetlands or (with some exceptions) peatlands.
- No support to be given to the use of saw logs, veneer logs, stumps or roots for feedstock.
- National legislation (or, where this is not available, forest management systems) should avoid harvesting of stumps or roots, the degradation of primary forests or their conversion into plantation forests, and harvesting on vulnerable soils.
- The extension of the minimum greenhouse gas saving figure of 70 per cent to stations starting operation before 2021 as well as later.
- The ending of support for the use of forest biomass in electricity-only installations after 2026, unless they are BECCS plants or are situated in a 'region identified in a territorial just transition plan … due to its reliance on solid fossil fuels' (i.e. a coal-dependent region).
- The extension of the sustainability criteria to stations equal to or above 5 MW total rated thermal input (from 20 MW in the current criteria).

It is not possible to determine what volume of feedstock consumed during the 2010–20 period would not have qualified under the existing criteria. Whether the greenhouse gas saving threshold would have been met would depend on the feedstock sourced, which would require a detailed examination of each individual station's supply chain. Data for the Drax power station in the UK, however, is readily available from the company's annual reports; they show an average supply-chain emissions level of 124 kg CO_2/MWh over the period 2014–19. This represents approximately a 70 per cent saving compared to the life-cycle emissions of hard coal (414 CO_2/MWh), but only about 45 per cent compared to gas (227 CO_2/MWh).[39] Drax burns wood pellets mainly sourced from the US and Canada; in 2019, an estimated 50 per cent of its supply-chain emissions derived from the pelletising process, 20 per cent from shipping, 19 per cent from other transport, 8 per cent from drying the wood and about 4 per cent from cultivation, harvesting and chipping.[40] So if Drax were to source its pellets from the UK rather than abroad, it would probably achieve an 80 per cent savings level; of course this is not feasible for Drax, as the UK is only a very small producer of wood pellets,

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[38] European Commission, *Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652* (COM(2021) 557 final, 14 July 2021).
[39] Drax figures: Annual Reports, 2013–19. Fossil fuel comparisons: https://www.forestresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-biomass/facts-figures/carbon-emissions-of-different-fuels/.
[40] Drax Annual Report 2019, p. 43.

but more feasible for most EU member states. In recent years, as well as the UK, Belgium, Denmark and the Netherlands have been the main importers of biomass for energy from outside the EU, Belgium and the Netherlands mainly from the US and Denmark mainly from Russia.

The minimum electrical efficiency level of 36 per cent would probably have excluded many older plants. In 2017 the European Commission's Joint Research Centre reported average electrical efficiencies of existing biomass plants of 28–38 per cent and of new plants of 33.5 to higher than 38 per cent.[41] However, many new biomass stations are likely to be CHP or BECCS plants, which satisfy the criteria. Much of the increase in biomass consumption for power in the Commission scenarios for 2050 is assumed to be for BECCS plants.

The criteria seem unlikely to do much in practice to constrain the use of feedstocks, even if amended as the Commission proposed in July 2021.[42] None of the criteria currently apply to the smallest stations, below 20 MW thermal rated input, which represents the majority of biomass plants in the EU and perhaps about 25 per cent of total feedstock consumption, though the proposed lowering of the threshold to 5 MW would capture many of these. The efficiency criteria apply only to larger new plants, thus excluding the older and smaller plants that are more likely to have low efficiencies. The greenhouse gas saving criteria currently apply only to new plants, though the July 2021 proposals will extend them to existing plants too; however, they are not particularly stringent. The proposal to extend support after 2026 for the use of forest biomass in electricity-only installations in coal-dependent regions is an open invitation to coal-to-biomass conversions.

The sourcing criteria relate mainly to the existence of regulatory frameworks rather than their implementation or effectiveness, and many of the conditions, such as the limitation of extraction to the 'long-term production capacity of the forest', are fairly loose. The July 2021 proposals help to tighten them somewhat, through banning sourcing from primary forests or plantations converted from primary forests, but there is very little primary forest left in the areas of the EU or major overseas producers, such as the US, from which biomass is sourced, and the requirements are only retrospective to 2008; sourcing from plantations that were converted from primary forest before 2008 would still be permitted. The proposed ban on feedstock from saw logs, veneer logs, stumps or roots is welcome insofar as it introduces to the criteria the principle of limiting feedstock by category, but in reality specifying those particular categories will have very little effect: saw logs and veneer logs are generally too valuable to use for energy, and stumps and roots are difficult and costly to extract.

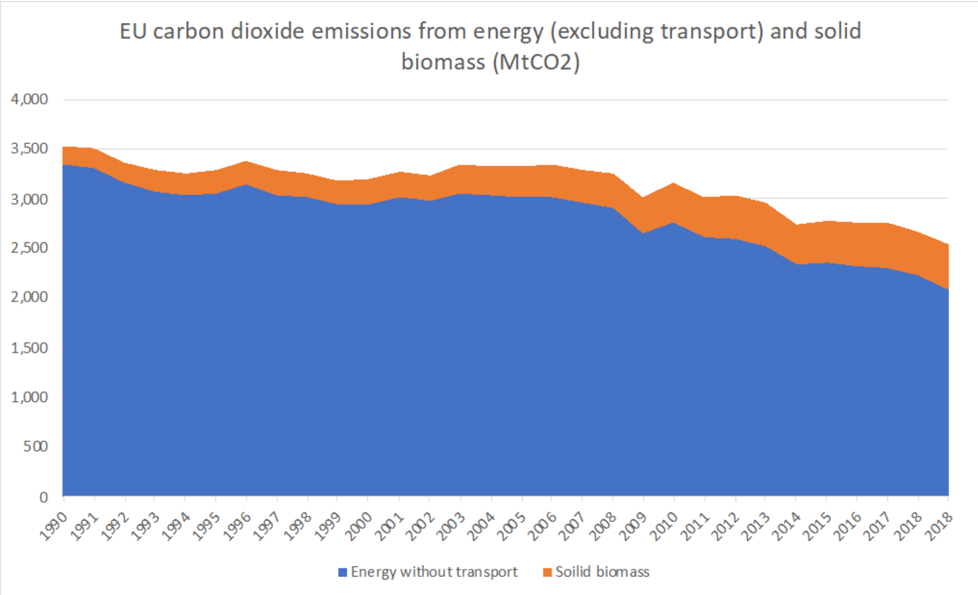
It is possible to calculate the total volume of emissions from the use of solid biomass for energy from the EU's National Inventory Reports to the UNFCCC, as discussed in Chapter 1. Between 1990 and 2019, EU emissions from solid biomass used for energy increased from 192 $MtCO_2$ to 482 $MtCO_2$, at an average growth rate of 3.2 per cent a year. In 1990, solid biomass emissions were equivalent to an additional 5.8 per cent of emissions from energy use excluding transport (where solid biomass is

[41] Thierry Lecomte et al, *Best Available Techniques (BAT) Reference Document for Large Combustion Plants: Industrial Emissions Directive 2010/75/EU Integrated Pollution Prevention and Control* (EU Joint Research Centre, 2017), p. 763.

[42] For a longer exploration of this issue, see Tim Searchinger et al, 'Europe's renewable energy directive poised to harm global forests' (*Nature Communications* 2018, 9:3741); Mary S. Booth and Ben Mitchell, *Paper Tiger: Why the EU's RED II biomass sustainability criteria fail forests and the climate* (PFPI, July 2020); and *Unsustainable and Ineffective: Why EU Forest Biomass Standards won't stop destruction* (Fern, Canopée, Biofuelwatch, Zero, Estonian Fund for Nature and Client Earth, May 20201).

not used); by 2019 this had grown to 21.8 per cent, as biomass use rose and emissions from other sources of energy fell. See Figure 4.1.

Fig. 4.1 EU28 carbon dioxide emissions from energy (excluding transport) and solid biomass, 1990–2019



Source: EU National Inventory Reports to UNFCCC.

EU28 emissions from energy excluding transport fell by 37 per cent between 1990 and 2019; if emissions from solid biomass are included, the reduction is only 28 per cent. (As before, it should be noted that a proportion of the emissions from using biomass will be reflected in the land-use section of the national inventory reports to the UNFCCC, though it is impossible to determine the end use of biomass extracted from forests and other sources.)

4.2 Liquid biofuels

The 2009 Renewable Energy Directive contained sustainability criteria for liquid biofuels designed to ensure that they achieved minimum greenhouse gas savings levels compared to fossil fuels, and to limit the negative impacts of their production. Biofuels were only to be counted towards the overall target in the Directive of a 10 per cent share of energy for transport by 2020, and would only be eligible for financial and regulatory support, if they met greenhouse gas saving criteria compared to fossil fuels of at least 35 per cent across their life cycle, rising to 50 per cent from 2017 and 60 per cent from 2018 for installations starting operation in 2017 or later. The Directive set out the methodology for calculating the saving figures, and also included default values to be used if operators did not conduct their own calculations. In addition, for biofuels produced from feedstock other than waste or residues, the feedstock was required not to have been obtained from highly biodiverse land, land with high carbon stock, or peatland, that was classified as such in 2008.

The criteria did not relate to the impacts of biofuel consumption on indirect land-use change (ILUC), but as the evidence strengthened for these negative impacts, additional requirements were introduced through the ILUC Directive ((EU) 2015/1513) in 2015. This amended the Renewable

Energy Directive to introduce, among other things, a 7 per cent cap on the contribution of food-based biofuels to the 10 per cent target; an indicative sub-target of a 0.5 per cent contribution from advanced (non-food-based) biofuels; and an obligation on fuel suppliers to report annually the provisional mean values of the estimated ILUC emissions from their biofuels.

The 2018 Renewable Energy Directive raised the overall target for non-fossil energy for transport to 14 per cent, but capped the contribution of first-generation, food-crop-based, biofuels to 1 per cent above the member state's consumption level in 2020; if consumption was reduced below the maximum 7 per cent level set in the 2009 Directive, the 14 per cent target figure could be reduced correspondingly. Higher targets were set for advanced biofuels, and biofuels derived from specified wastes were allowed to count double towards the target (up to a ceiling). The contribution of high-ILUC-risk biofuels to national targets was limited to a freeze at 2019 levels for the period 2021–23, and a gradual fall thereafter, reaching zero by 2030. Biofuels certified as low ILUC risk were exempt from these limits. The other sustainability criteria were retained, with some modifications.

In 2019 the Commission adopted a further regulation ((EU) 2019/807) setting out specific criteria to determine high-ILUC-risk feedstock, and low-ILUC-risk biofuels. The only feedstock it specifically identified as being of high ILUC risk was palm oil; its use for biofuel qualifying under the Renewable Energy Directive must therefore be phased out by 2030. Member states are allowed to phase out particular feedstocks faster if they wish; to date, Denmark, France, Germany and Italy have all announced earlier phase-out dates for palm oil, and France and Italy have discussed phasing out soybean-oil-based biofuels.[43]

If these criteria had been in place for the 2010–20 period, they would have disallowed the use of palm oil in biodiesel, which accounted for 30 per cent of biodiesel consumption (by volume) in the EU in 2019 (see Table 3.1 in Chapter 3). As discussed in Section 3.1, however, the Commission's calculations of ILUC impacts rest on estimates that are too low.

If ILUC criteria based on the Globiom calculations had been in place during 2010–20, no biodiesel at all would have satisfied the greenhouse gas saving criteria, and neither would bioethanol from wheat or barley (wheat accounted for 28 per cent of bioethanol consumption in the EU in 2016 and 37 per cent in 2018, and barley for 0 and 2 per cent respectively, according to the Commission's Renewable Energy Progress Reports (see Table 3.2)). **In total, more than 85 per cent of the feedstocks used during this period would not have qualified under sustainability criteria based on the Globiom calculations**.

The 'Fit for 55' proposals to modify the Renewable Energy Directive make relatively little difference to transport biofuels. The proposal increases the 2030 target for advanced biofuels (from 1.75 per cent to 2.2 per cent) without changing the relevant sustainability criteria; introduces a target for the supply of green electrofuels (hydrogen and e-fuels) in transport; and changes the overall fuel target from requiring a specified share of renewable energy in transport fuels to a specified reduction in the carbon footprint of the fuels.

[43] 'Palm, soy under further pressure in EU biofuels mix', Argus Media, 20 November 2020; https://www.argusmedia.com/en/news/2155904-palm-soy-under-further-pressure-in-eu-biofuels-mix.

5 Conclusions

To summarise the findings in Chapters 2, 3 and 4:

- EU28 emissions from biomass reported under the ETS (i.e. burnt in installations burning biomass and fossil fuels) but not accounted for against emissions totals (since biomass is zero-rated for the purposes of the ETS) grew from 135 $MtCO_2$ (equivalent to 7 per cent of accounted-for emissions) in 2013 to 166 $MtCO_2$ (11 per cent) in 2019. The reduction in total ETS emissions not including biomass for the EU28 from 2013 to 2019 was 20 per cent; if biomass is included, the fall is 17 per cent.
- Installations only burning biomass are not covered by the ETS at all. If the ETS were to be extended to cover all biomass stations above the 20 MW threshold, power-sector biomass emissions would increase by an estimated 70 per cent over those currently reported. Under these adjusted figures, biomass used in ETS installations grew from 191 $MtCO_2$ (equivalent to 10 per cent of accounted-for emissions) in 2013 to 234 $MtCO_2$ (16 per cent) in 2019. The reduction in total ETS emissions not including biomass for the EU28 from 2013 to 2019 was 20 per cent; if biomass is included on these adjusted figures, the fall is 16 per cent.
- Biomass use in the ETS in the EU27 is projected to rise under all of the scenarios considered under the European Commission's Climate Target Plan, by 9–19 per cent by 2030, and by 66–80 per cent by 2050. Biomass emissions are equivalent to an additional 18–20 per cent on top of the total of ETS emissions in these three scenarios for 2030, or as estimated 24–26 per cent if the ETS is extended to all biomass use.
- Biomass emissions are also zero-rated in the sectors covered by the effort-sharing framework, i.e. those sectors outside the ETS (apart from the LULUCF sector). Without biomass emissions, the EU achieved its effort-sharing framework targets in every year between 2013 and 2019. If biomass emissions are included, however, only in 2014 on the adjusted biomass figures (where more biomass emissions are in the ETS and less in the ESR) was the target achieved; in every other year, the cap was exceeded by between 1 per cent and 10 per cent for the unadjusted figures, or 2 per cent and 8 per cent if using adjusted figures.
- (These calculations include transport biomass emissions adjusted for land-use change impacts according to the Globiom study analysis. They will include some double-counting of emissions from energy used in processing and moving biofuels and feedstock for road transport.)
- As with the ETS, biomass use in the ESR sectors in the EU27 is projected to rise under all of the scenarios considered under the Climate Target Plan, but by less: by 0–4 per cent by 2030, and by 17–49 per cent by 2050. A significant fall in the use of biomass in the residential sector offsets increases elsewhere. Biomass emissions in the ESR sectors but not recorded there are equivalent to 19–29 per cent of total ESR emissions in the three key scenarios for 2030, or 17–28 per cent if the ETS is extended to cover all biomass use.
- The new sustainability criteria for solid biomass in the Renewable Energy Directive seem unlikely to make much difference, in practice, to the mix of solid biomass feedstocks currently used, even if amended as the Commission proposed in July 2021.
- The sustainability criteria for liquid biofuels do not incorporate the direct and indirect land-use change impacts of feedstock use calculated in the Globiom study. Roughly 85 per cent of

the feedstock used in the EU28 over the 2010–20 period would not have satisfied criteria based on this approach.

Calculating the real impact on the climate of using biomass for power, heat and transport is a difficult exercise, for two main reasons. First, the unreliability of the data, as commented on throughout this paper. The ETS data reports have been subject to significant adjustments in the light of incomplete data, and it seems unlikely that even the most up-to-date data are wholly accurate. Similarly, data on transport biofuel use included in the European Commission's Renewable Energy Progress Reports differ widely from data on the same subject from other sources. Calculating the volume of biomass emissions that would be covered by the ETS if it were extended to cover installations burning only biomass (as well as those burning biomass alongside fossil fuels) is a difficult exercise because of a lack of data on the size and number of installations that would fall under the 20 MW threshold.

Second, and more fundamentally, as discussed in Chapter 1, the real impact on the climate depends critically on the carbon payback period, the period of time during which carbon levels in the atmosphere are higher than they would have been if biomass had not been used for energy. This in turn depends on the type of feedstock (wastes, residues and energy crops have short carbon payback periods, whole trees have the longest); the counterfactual, i.e. what would have happened to the feedstock if it had not been used for energy (would wastes have been disposed of by burning, or left to decay; would the trees have been left to grow; would food crops have been cultivated on the land instead of energy crops? etc. etc.); and also on what fossil fuels are substituted by the biomass (replacing coal will have a more positive impact on the climate than replacing gas).

Calculating carbon payback periods for biomass feedstocks is a complex and contested topic. In general, regulatory frameworks do not require biomass users to differentiate the feedstock they use by data which would allow the calculation of carbon payback periods in any case.

The biomass emissions estimates included in this report do not take account of carbon payback periods. They therefore over-estimate the net emissions from biomass use, though the extent of the over-estimation depends on the time period chosen. For fast-growing feedstocks, for example, a time horizon of a year or a few years would see biomass growth absorb some or all of the emissions from combustion for energy (though this also depends on the direct and indirect land-use change impacts). For slow-growing feedstocks (e.g. trees), a time horizon of decades to centuries would be required to see the same outcome.

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