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COMMISSION STAFF WORKING DOCUMENT

State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU

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CONTENT

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1. INTRODUCTION

Solid and gaseous biomass –particularly wood and wood waste[1]– used for electricity, heating and cooling production is the biggest source of renewable energy in the EU and is expected to make a key contribution to the 20% EU renewable energy target by 2020. Sustainable biomass can play an important role in helping to address concerns about climate change and security of energy supply, while contributing to economic growth and employment, particularly in rural areas. According to the Impact Assessment to the 2030 Climate and Energy Framework[2], biomass use in the heat and power sectors is expected to further increase in the medium term, in the context of the EU effort to move to a low-carbon economy by the middle of the century.

The EU Renewable Energy Directive[3] (RED) lays down sustainability criteria for biofuels for transport and bioliquids used in other sectors but not for solid and gaseous biomass used for electricity, heating and cooling[4]. In February 2010, as required by Article 17(9) of the RED, the Commission published a Report[5] on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling (the Biomass Report). The Commission decided not to introduce EU binding criteria but to adopt non-binding recommendations to Member States that had already introduced or planned to introduce national biomass sustainability requirements.

The Commission undertook to report by 31 December 2011 on whether national schemes have been sufficient to address sustainability issues related to the use of biomass from inside and outside the EU and whether the absence of EU criteria has led to barriers to biomass trade, potentially limiting bioenergy development. In addition, the report would assess how international developments regarding LULUCF accounting (Land Use, Land Use Change and Forestry) relate to sustainable production of biomass, whether used for energy, food, feed or fibre.

1 In 2010 wood and wood waste supplied 49% of the share of energy from renewable sources in the EU gross final energy consumption. See: Eurostat (2012), Statistics in focus, renewable energy. http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-SF-12-044/EN/KS-SF-12-044-EN.PDF

2 SWD(2014)15, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014SC0015&from=EN.

3 Directive 2009/28/EC, http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0028.

4 For ease of reference, it is recalled that the sustainability criteria for biofuels and bioliquids of the RED are as follows: Article 17(2) establishes minimum greenhouse gas saving values of 35%, rising to 50% on 1 January 2017 and to 60% from 1 January 2018 for biofuels and bioliquids produced in installations in which production started on or after 1 January 2017. According to Article 17(1) wastes and residues only need to fulfil the minimum greenhouse gas requirements, not the other criteria. Article 17(3), 17(4) and 17(5) require that raw material should not come from high biodiversity value areas, from the conversion of high-carbon stock areas, or from undrained peatland, respectively. Article 17(6) requires that agricultural raw materials cultivated in the Community are obtained in accordance with specific agricultural regulations of the EU. Article 18(1) requires that economic operators show compliance with the criteria using the 'mass balance' method for verifying the chain of custody. Biofuels and bioliquids which do not meet the sustainability criteria cannot be counted towards the EU's renewable energy targets or the targets of the Fuel Quality Directive (Directive 2009/30/EC) and national renewable energy obligations or benefit from financial support.

5 COM/2010/11, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0011:FIN:EN:PDF

In February-March 2011, the Commission carried out a public consultation which showed that a number of stakeholders are concerned that large-scale biomass use in the heat and power sectors may lead to negative sustainability impacts not just in third countries, but also in the Union[6]. In this context, the majority of respondents asked for some kind of additional EU action on biomass sustainability. There was, however, a divergent spectrum of views on the need for energy-related binding sustainability criteria at EU level. This was further confirmed by the large number of meetings with Member States and stakeholders held between 2011 and 2014, following which a significant amount of evidence has been provided and considered by the Commission services.

In December 2012, in its conclusions on the 2012 Commission's Communication on renewable energy[7], the Council acknowledged the need to consider the sustainability dimensions of the use of sensitive biomass resources[8]. In January 2014, in its Communication 'A policy framework for climate and energy in the period from 2020 to 2030'[9], the Commission stated that "[a]n improved biomass policy will also be necessary to maximise the resource efficient use of biomass in order to deliver robust and verifiable greenhouse gas savings and to allow for fair competition between the various uses of biomass resources in the construction sector, paper and pulp industries and biochemical and energy production. This should also encompass the sustainable use of land, the sustainable management of forests in line with the EU's forest strategy and address indirect land use effects as with biofuels".

In February 2014, in its resolution[10] on the 2030 climate and energy framework, the European Parliament asked the Commission to propose sustainability criteria for solid and gaseous biomass, taking into account lifecycle greenhouse gas emissions in order to limit the inefficient use of biomass resources. Furthermore, in March 2014 the Council[11] highlighted that future climate and energy policies should aim for the right balance between the various policy objectives of sustainability, energy security and competitiveness, and recognized the role of renewable energy sources for more sustainable and competitive energy systems.

Against this policy background, the Commission's services have produced this Staff Working Document to review the state of play of the sustainability of solid and gaseous biomass for electricity, heating and cooling production in the EU. This document is structured as follows. Section 2 (supported by further information in the Annex) gives an overview on EU solid and gaseous biomass use for electricity, heating and cooling up to 2020 and beyond, based on information from the National Renewable Energy Action Plans (NREAPs)[12], the 2013 Member States' Progress Reports[13] and the modelling used for the Impact Assessment to the 2030 Framework on climate and energy[14]. Section 3 considers whether existing national biomass sustainability regulations are an obstacle to the internal market. Section 4 analyses the key sustainability risks of large-scale biomass production and use for energy and discusses how they are currently being addressed at EU level. Section 5 presents the conclusions of this analysis.

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6 http://ec.europa.eu/energy/renewables/consultations/doc/20110329_biomass_consultation_report.pdf. The Commission consulted again on bioenergy sustainability in early 2012, see SWD (2012) 149. http://ec.europa.eu/energy/renewables/doc/communication/2012/staff_working.pdf

7 COM (2012)0271. http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52012DC0271

8 www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/trans/133950.pdf

9 COM (2014)15. http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52014DC0015

10 EP 2013/2135(INI). http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P7-TA-2014-0094&language=EN

11 http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/trans/141312.pdf.

12 http://ec.europa.eu/energy/renewables/action_plan_en.htm

13 http://ec.europa.eu/energy/renewables/reports/2011_en.htm

14 SWD (2014)015. http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52014SC0015

2. THE ROLE OF BIOMASS IN ACHIEVING THE EU RENEWABLE ENERGY TARGETS

2.1. The benefits of biomass use for energy production

Sustainable biomass use for heating/cooling and electricity production can result in a number of energy, economic, employment and environmental benefits. Biomass can be stored at times of low demand and provides dispatchable energy when needed. Depending on the type of conversion plant, biomass can thus play a role in balancing the rising share of variable renewable electricity from wind and solar in the electricity system. The possibility to store biomass allows for generation of heat to meet seasonal demand. In addition, biomass allows the generation of high-temperature heat that cannot be easily produced through other low carbon sources (see Box 1 for details).

Biomass can also contribute to the EU energy security, in so far as the majority of biomass demand is met through domestically produced raw material and imports are supplied by diversified sources (see more details in section 2). In the case of additionally mobilised biomass, there is also a potential for new sources of income along the whole biomass value chain, from cultivation to harvest, processing and conversion into electricity, heating and cooling. This can benefit farmers and forest owners and support rural development. In 2012, the European bioheat and bioelectricity sectors generated a total turnover of at least EUR 33 billion and employed over 374,800 people[15].

Furthermore, greater awareness of the value of biomass can help motivate small forest owners to consider carrying out active and sustainable management of their forests. By incentivising forest management, biomass markets can also contribute to reducing fire risks, particularly in the EU's Mediterranean countries. When waste is used as a bioenergy feedstock, this helps to reduce the amount of waste being landfilled with positive environmental and economic impacts.

Furthermore, when sustainably produced and used efficiently, biomass can lead to significant greenhouse gas savings compared to the use of fossil fuels. This said, bioenergy systems involve a chain of activities from production of feedstocks to final energy conversion that can pose different sustainability challenges, which are analysed in detail in section 4 of this document.

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[15] The sectorial turnover and employment contribution were respectively: 27,679 €M and 282,095 jobs in the solid biomass; 5,698 €M and 68,895 jobs in biogas; and 23,935 jobs in wastes (turnover N/A). Source: Eurobserver (2013), The state of renewable energies in Europe. http://www.energies-renouvelables.org/observ-er/stat_baro/barobilan/barobilan13-gb.pdf

Box 1: Biomass heating and electricity systems[16]

Technologies for producing heat and electricity from biomass are well developed in many applications. Biomass heating systems range from small-scale stoves for households with capacities ranging between 5 kilowatts (kW) and 100 kW (often run on wood logs and wood pellets), to larger-scale boilers for farms, commercial buildings, or in industry, reaching capacities of 100 kW to 500 kW (running on a variety of feedstocks such as wood chips and miscanthus). Large heating plants for district heating or industrial use have capacities in the range of 1 MW to up to 500 MW and are capable of using various biomass feedstock, including wood chips, straw and miscanthus.

Biomass can also be converted in cogeneration plants that produce both electricity and heat (CHP) at a typical ratio of 1:2 to 1:3, with possible overall efficiency of 70-90%. CHP plants have a substantially higher capital costs than heat-only installations of the same scale, and at smaller scales (below 10 MW) the electric efficiency of the plant is typically lower. It is therefore important to find a steady heat demand to ensure the economic viability of the investment. In industrial operations, such as pulp and paper production, biomass-based CHP are common, as the heat is used in the production processes. Biomass CHP plants for district heating are widespread in Northern and Eastern Member States, thanks to an extensive district heating network combined with relatively high heat demand during winter season and an established resource supply (see the Annex for more details).

Co-firing in fossil-fired power plants is the most cost-effective option for electricity production. Direct co-firing with up to 10 % biomass (measured on an energy basis) in pulverised-fuel and fluidised-bed boilers is successfully demonstrated and commercially available. This approach makes use of the existing infrastructure of the coal plant and thus requires only relatively minor investment in biomass pre-treatment and feed-in systems. It also profits from the comparatively higher conversion efficiencies of these large-scale coal plants. A complementary approach is the conversion of coal-fired power plants nearing the end of their lifetime to operate entirely on biomass. This involves some down-rating of capacity, but indications are that this can be achieved at low costs, with generation costs similar to those achieved through co-firing.

Anaerobic digestion – the conversion of organic material to biogas in the absence of air – is a commercial technology for several agricultural feedstocks. This technology produces methane-rich biogas from wet agricultural biomass such as manure, crops, and crop residues, typically at decentralised sites but close to the resources. Biogas can be used for local heating, district heating or CHP in small boilers, internal combustion engines and gas turbines. Biogas can also be upgraded in quality for injection into the natural gas network as biomethane.

Electricity generation can in some cases be competitive today where low cost fuels such as wastes or process residues are used, the scale of generation is high or there is also a good heat load enabling effective CHP operation. However, in most cases generation currently requires some level of financial support, particularly where the external costs of fossil fuel-based generation are not fully taken into account. Heat generated from biomass can also be a cost competitive option today, again depending on feedstock and scale of operation, and on the fuel source being replaced.

The different physical and chemical characteristics of bioenergy feedstocks can be a development challenge, since they can pose difficulties in handling, transport and final conversion. To make handling, transport and energy conversion more efficient and reduce the associated costs, biomass can be pre-treated. The most common forms of pre-treatment include drying, pelleting and briquetting. More advanced thermo-chemical pre-treatment technologies such as torrefaction and pyrolysis are at the verge of commercialization. These technologies increase the energy density of biomass feedstocks, benefiting both transport and final conversion.

[16] IEA (2012), Technology roadmap: bioenergy for heat and power. http://www.iea.org/publications/freepublications/publication/bioenergy.pdf

2.2. Outlook on biomass for electricity, heating and cooling

As shown in Figure 1, the consumption of biomass for heating and electricity in the EU has already significantly grown since 2005 and, according to estimates from the National Renewable Energy Action Plans (NREAPs), it is expected to further increase from 86.5 million tonnes of oil equivalent (Mtoe) in 2012 up to 110.5 Mtoe in 2020, although its share of total final renewable energy consumption will decrease from 54% to 45% due to the faster deployment of other renewables. By the end of the decade, on the basis of current trend, biomass for energy is expected to be used mainly for heating (90.4 Mtoe), followed by electricity (20 Mtoe).

In 2012, the total EU27 biomass supply for electricity, heating and cooling amounted to 103.3 Mtoe in 2012, chiefly domestically produced (95.7 Mtoe). According to the NREAPs estimates, biomass supply is projected to increase by nearly 37% to 132 Mtoe by 2020 (see Figure 2). The same plans project forest biomass to grow from 71 Mtoe in 2012 to 73.6 Mtoe in 2020, although its relative share of overall biomass supply will decline from 74.4% to 55.7%.

More specifically, in the NREAPs, Member States foresee an important mobilization of an additional 95 million cubic meters (Mm^3) of wood for energy use by 2020 (compared to 2006[17]), which is equal to the total wood mobilized in Finland and Sweden for energy uses in 2010. Secondly, the NREAPs also estimates a growth in agriculture biomass for energy, (mainly in the form of residues and agricultural by-products), which is projected to grow significantly from 13.2 Mtoe in 2012 to 41.7 Mtoe in 2020, equal to a share increase from 14% to 31.6%. Thirdly, the relative contribution of biodegradable waste is projected by the NREAPs to increase in absolute terms from 10.8 Mtoe in 2012 to 16.7 Mtoe in 2020. The above-mentioned projections imply a significant concerted effort both at EU and national level, in terms of technical, institutional and financial support in order to mobilize additional forest and agricultural biomass in the coming years.

While the vast majority of the EU's solid biomass consumption will still be met through domestic supplies by 2020, imports from third countries are projected to grow by the end of the decade. Table 1 compares domestic biomass supply with final energy consumption in 2020. A gap is projected of about 21.4 Mtoe, equal to over 15% of EU primary bioenergy supply in 2020[18]. This is likely to be met by imports from mainly the US and Canada, followed by Russia, Ukraine and Belarus, and largely in the form of wood chips and densified biomass, e.g. wood pellets (including torrefied pellets after 2020).

The EU imports of wood pellets have risen from 2.7 million tonnes in 2010 up to 4.3 million tonnes in 2013. By 2020, EU wood pellet imports from third countries are expected to be in the range of 15-30 million tonnes (equal to about 6-12 Mtoe)[19]. The predominant EU market for these wood pellet imports is the industrial sector, i.e. large-scale co-firing and dedicated

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[17] NREAPs project forest biomass to increase from 336 M m3 to 431 M m3. Additional mobilization includes: direct wood supplies (e.g. wood thinning and felling): +83 Mm3; residues of the wood-based industries (eg. sawdust and sawchips: +12 Mm3). Source: NREAPs.

[18] Biomass imports may be even large depending on whether EU production of biomass grows in line with the NREAPs projections. The biomass supply gap could reach 38 Mtoe according to Pöyry Energy Consulting (2011), Biomass imports to Europe and global availability, research for Euroelectric/VGB. http://www.eurelectric.org/media/26720/resap_biomass_2020_8-11-11_prefinal-2011-113-0004-01-e.pdf

[19] Pelkmans *et al.* (2012), Benchmarking biomass sustainability criteria for energy purposes, VITO Consortium. http://ec.europa.eu/energy/renewables/studies/doc/2014_05_biobench_report.pdf

combined heat and power (CHP) installations, although in recent years pellet demand from the household heating sector has also grown significantly[20].

According to the Impact Assessment to the Communication on the 2030 climate and energy Framework, biomass demand for electricity and heating is projected to further increase in the post-2020 period, including biomass imports from third countries. This raises the question of the availability of sufficient supply of sustainable and cost-effective biomass feedstock for all uses, which requires further research and analysis at EU and national level.

For instance, the EUwood study[21] has investigated the feasibility of meeting increasing EU wood demand for energy and material use through domestic supply. By comparing the potential demand for wood for all uses with the 'realistic' potential supply in 2020 and 2030, they found that under a medium biomass mobilisation scenario**,** the expected demand is likely to exceed the potential before 2020 and therefore imports from third countries will be needed. This applies to Europe as a whole although the situation may differ at national and local level.

Under a high biomass mobilisation scenario they estimate possible yet challenging to supply enough wood to satisfy domestically both the energy and material demand in 2020 but not in 2030. The high mobilization scenario is based on a number of assumptions, including that: the share of wood employed to produce renewable energy in 2005 would be constant till 2020; and an exceptional wood mobilisation strategy, with long-term commitment and investment, a comprehensive approach, numerous specific policy measures and favourable framework conditions. Follow-up studies[22] have noted that the EU wood study projections should be updated with the impact of the financial crisis and the current decline in the pulp industry in Europe.

The Commission's services are undertaking a number of research studies to assess future biomass availability, in order to inform the development of the post-2020 biomass policy.

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20 AEBIOM (2013), European bioenergy outlook, statistical report, European biomass association. http://www.aebiom.org/blog/aebiom-statistical-report-2013

21 See: Mantau *et al.* (2011), Real potential for changes in growth and use of EU forests, EUwood Study. http://ec.europa.eu/energy/renewables/bioenergy/bioenergy_en.htm.

22 Pelkonen *et al.* (2014), Forest bioenergy for Europe: what science can tell us. http://www.efi.int/files/attachments/publications/efi_wsctu_4_net.pdf

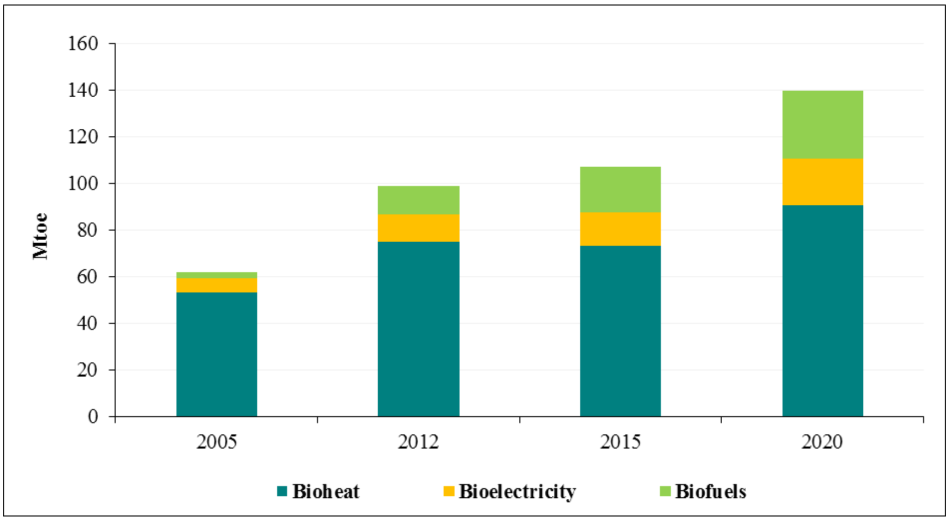

Figure 1: EU biomass consumption in electricity, heating, and transport (Mtoe, 2005-2020).
Source: National renewable energy action plans (NREAPs) and 2011 progress reports[23].

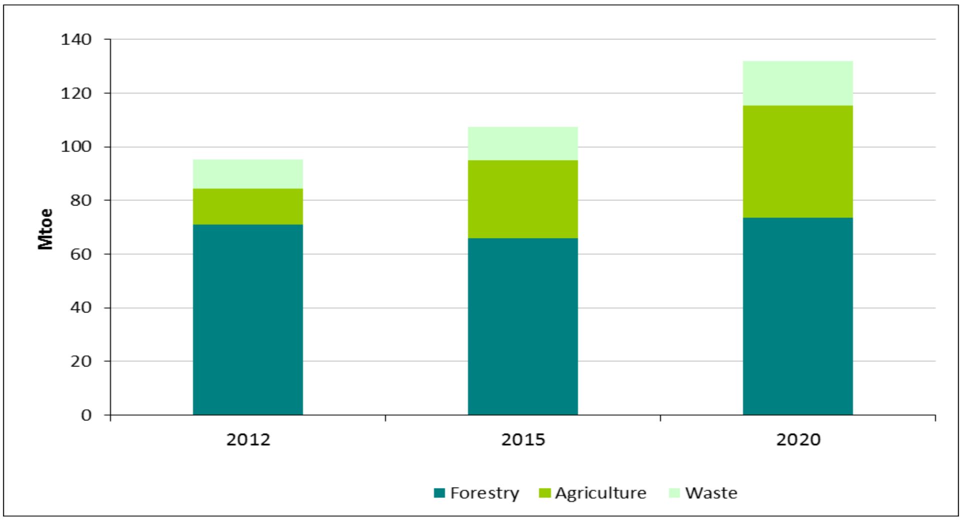

Figure 2: EU biomass supply for electricity, heating and cooling (Mtoe, 2012-2020).
Source: National renewable energy action plans (NREAPs) and 2011 progress reports[24].

Domestic biomass in 2012	Total final consumption of biomass in electricity, heating and cooling in 2020	Estimated primary energy from biomass in electricity, heating and cooling in 2020	Estimated primary energy from domestic biomass supply for electricity, heating and cooling in 2020	Gap between primary energy from domestic biomass supply and total supply needs
95.7 Mtoe	110.5 Mtoe	140 Mtoe	118.6 Mtoe	21.4 Mtoe

Table 1: Estimated gap between domestic biomass supply and final biomass consumption (Mtoe).
Source: National renewable energy action plans (NREAPs), Eurostat.

[23] For DE and PT 2010 data was used.
[24] See note 17.

3. PROMOTING THE SMOOTH FUNCTIONING OF THE INTERNAL MARKET

3.1. National biomass sustainability criteria

In its 2010 Biomass Report, the Commission recommended sustainability criteria similar to those applying to biofuels and bioliquids, for biomass installations of a minimum 1 MW electric or thermal capacity. National authorities were also recommended to design national support schemes with the objective of stimulating higher efficiency of bioenergy plants. Furthermore, Member States were invited to keep records of the origin of primary biomass used in electricity and heating/cooling installations of 1 MW or above, in order to improve the biomass statistics and allow for a better monitoring of market trends. These recommendations were aimed at preventing both the risk of trade barriers stemming from the development of (potentially conflicting) national sustainability regulations and addressing potential sustainability issues.

A review[25] of Member States' implementation of the 2010 recommendations found that:

- While about half of the Member States have adopted regulations promoting higher efficiency of bioenergy production (i.e. efficient CHP), only few Member States (Belgium, Italy, UK) have adopted greenhouse gas (GHG) saving criteria for biomass used in electricity/heating, which appear broadly in line the Commission recommendations (see Table 2).
- Other Member States (Belgium, Hungary, UK) have introduced specific sustainable forest management (SFM) criteria for forest biomass and land criteria for agricultural biomass (UK). More recently, the Netherlands has announced plans to adopt by the end of 2014 a comprehensive set of sustainability criteria addressing, amongst others, impacts on forest carbon stocks and on indirect land use change (ILUC).
- A number of countries have introduced regulations aimed at addressing potential competition with existing biomass uses. In Belgium, for example, woody feedstocks suitable for the wood-processing industry are not eligible for the Flemish Green Power Certificates. Moreover, Poland has adopted a policy increasingly excluding the use of stem wood (with a diameter above a certain size) from being eligible for national financial incentives for renewables.

Country	Status	Energy specific sustainability criteria
BE	Adopted in 2007	Financial incentives linked to GHG savings, SFM requirements for forest biomass
HU	Adopted in 2010	SFM requirements for forest biomass
IT	Adopted in 2012	Minimum GHG saving threshold for forest biomass
UK	Adopted in 2013	Minimum GHG saving threshold for solid and gaseous biomass, land use criteria for agricultural biomass, timber standard for woodfuel for heat and electricity
NL	Planned for end of 2014	GHG saving performance, forest carbon stock and ILUC impacts

Table 2: Selected national sustainability criteria for biomass used in heat and electricity.
Source: Pelkmans et al. 2012, 2011 Member States' Progress Reports on renewable energy.

25 Pelkmans *et al.* 2012.

3.2. Potential impacts on the internal market

During the Commission's public consultation on biomass sustainability, a number of Member States, utilities, and biomass traders raised concerns that divergent national sustainability rules may become a barrier to international and intra-EU trade in solid biomass fuels such as wood chips or pellets, and therefore make more difficult or costly to meet increasing demand for biomass use in electricity and heating/cooling.

Such stakeholders have argued that trade is essential to secure the reliability as well as the flexibility of biomass supplies, thus facilitating bioenergy production. For instance, large biomass installations may have unplanned maintenance periods, suppliers of pellets may have technical problems, investors may want to hedge price risk, ships transporting biomass may be delayed etc. In all these cases, incompatibilities between national biomass sustainability schemes may hinder biomass trading across plants and countries, making biomass supply chains less efficient and reducing flexibility for economic operators. Furthermore, in theory the existence of different criteria across the EU may also promote arbitrage business, whereby biomass which does not meet the sustainability criteria of country A may be moved to a country B where sustainability criteria do not apply, thus limiting the overall environmental effectiveness of the sustainability policy in country A.

In this respect, it should be noted the emergence of a number of industry-led sustainability initiatives addressing biomass used for heating and power generation. In addition, there are several well established schemes that certify forestry and agricultural products, and these could provide a basis for certification schemes for bioenergy for heat and power[26].

For instance, in 2013 a number of major European utilities that use biomass, mostly in the form of wood pellets, in large thermal power plants have funded the Sustainable Biomass Partnership[27] (SBP) with the aim to develop sustainability standards & processes. The SBP has elaborated a harmonized sustainability standard and plans to test it on the ground through pilot projects during the second half of 2014, with the view to make the scheme fully operation by early 2015. If successful, such initiative could provide useful experience to stakeholders and regulators on possible approaches to ensuring sustainability, while facilitating pellet trading across European markets.

Significant amounts of biomass for material use are already traded within the EU without apparent internal market barriers, with energy representing only a by-product in the overall production chain. Most such biomass is consumed within its country of origin, given that such bulky and low value materials are inefficient to transport very far on surface. For example, wood raw materials for the wood-based panel industry typically travel 150 km and a maximum of 300 km to mills. This means that little of the wood raw material overall crosses an internal EU border and only mills in proximity to borders may have to deal with nuances between national sustainability criteria. Even in regions where small Member States are concentrated, any given mill would logically only have to deal with a maximum of between two and four sets of criteria.

To promote the smooth functioning of the internal market and to minimise administrative costs for economic operators, the 2010 Biomass report recommended interested Member States to align as much as possible their existing and planned national sustainability schemes, including through mutual recognition when appropriate. As noted in section 3.1, sustainability requirements of those Member States with significant trade in biomass for heat and power production (both international and intra EU) are not considered to diverge significantly. In

[26] http://www.solidstandards.eu/sustainabilty/result-documents.html
[27] http://www.sustainablebiomasspartnership.org

any case, under the Technical Standards Directive (TSD)[28], national authorities are required to notify to the Commission and to other Member States their draft sustainability schemes applying to biomass. This will help ensuring that national regulations do not constitute an unjustified barrier to international and intra-EU biomass trade.

4. PROMOTING SUSTAINABLE BIOMASS PRODUCTION AND USE

A wide range of biomass feedstocks can be used for heat and/or electricity production (which can be also used for producing transport biofuels)[29]. These include direct supplies from forestry and agriculture (i.e. thinnings, branches, straw, purpose-grown energy crops, including short-rotation coppice); processing residues (i.e. saw dust, black liquor soap); and, dry or wet organic wastes (i.e. sewage sludge, manure, the organic fraction of municipal solid waste).

Despite the many benefits associated with biomass use in electricity, heating and cooling (see section 2.1), there are a number of sustainability risks that need to be properly managed by both economic operators and Member States. These risks include: unsustainable feedstock production; emissions from land use, land use change and forestry (LULUCF); lifecycle GHG emission performance; indirect impacts; inefficient bioenergy generation; and air emissions. The following sub-sections briefly present these risks and analyse how they are being addressed at EU-level.

4.1. Ensuring sustainable feedstock production

Forest biomass

Biomass for bioenergy production can negatively affect forest biodiversity and carbon stocks through direct land use change (deforestation) and unsustainable forest management (e.g. forest degradation due to excessive removal of raw material).

In Europe, forest biomass for energy is currently largely produced as a complementary co-product of wood material/fibre products. Therefore it is unlikely that bioenergy demand is associated to direct deforestation in Europe. As a result of afforestation programmes, natural succession of vegetation and abandonment of farming, EU forest area has increased and, over the last decade, have grown by around 2% in area[30], while the use of bioenergy has been increasing at the same time. It is expected that forest expansion will continue, although the process is slowing down due to agriculture maintenance and urbanization[31]. In addition to growth in area, as only 60-70% of the annual increment is being cut, the growing stock of wood is also rising significantly[32]. Furthermore, according to the current knowledge[33], there is

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28 Directive 98/34/EC. http://ec.europa.eu/enterprise/tris/consolidated/index_en.pdf

29 Under the RED, biomass is defined as 'the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste'.

30 Forest Europe/UNECE/FAO (2011), State of Europe's Forests: Status and Trends in Sustainable Forest Management in Europe, Ministerial Conference on the Protection of Forests in Europe. http://www.foresteurope.org/documentos/State_of_Europes_Forests_2011_Report_Revised_November_2011.pdf

31 SWD (2013) 342. http://ec.europa.eu/agriculture/forest/strategy/staff-working-doc_en.pdf

32 The growing stock in forests available for wood supply (commercial wood volume) in the EU was estimated at about 22 000 m^3 in 2010. The increment was 700 million m^3 and the volume of fellings was 484 million m^3. This means that, while the EU is using its forests in a sustainable manner at least from a wood production point of view, the forests could – at least theoretically – be used much more

no evidence of systematic imbalance between forest functions at the European level –such as systematically prioritizing production over biodiversity or vice versa, although there may be some localised problems at national level.

Globally, the conversion of natural forests to agricultural land remains at high levels but there is no evidence that it is driven by demand for forest biomass for heat and power in the EU. Around 7.6 million hectares of natural forest were converted to other uses or lost through natural causes each year in the 2000s compared to 8 million hectares per year in the 1990s with no statistically significant difference. The contribution of humid forests to the net forest loss decreased from 65% to 54% from the 1990s to the 2000s[34].

More than half of the wood harvested globally is used to produce energy[35], making up around one-tenth of the global energy supply. Most of this is used for domestic cooking and heating in wood or charcoal stoves, chiefly in the developing world. Furthermore, the direct loss of natural forests in tropical countries is typically driven by a range of other drivers, including illegal logging, agriculture expansion (including cattle ranching, food and energy crops), mining and urbanization[36].

At EU level, the EU Timber Regulation[37], which entered into force in March 2013, addresses the risk that forest biomass (for all uses, not just energy) has been harvested in contravention of the legislation applicable in the country of harvest. This measure prohibits the placing on the EU market of illegally harvested timber or timber products, including wood fuels such fuel wood, wood chips and pellets, and lays down mandatory obligations on suppliers to exercise due diligence when placing domestic or imported timber or timber products produced on the EU market.

Accordingly, economic operators are expected to have a system in place that provides information about the wood and wood-based products that are supplied for the first time on the internal market for distribution or use in the course of a commercial activity[38]. The implementation of the EU Timber Regulation should contribute to ensuring sustainable production of biomass used in the EU heat and power sector, as long as sustainability requirements are part of the legislation of biomass producing country. The effectiveness of this legislative measure could be further improved in the context of the review foreseen for 2015.

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efficiently. However, this does not mean that all the uncut growth may be available for use from the point of view of bio-diversity. In any case, increasing the forest harvest would mean an increase in marginal harvesting costs since smaller, steeper, rougher and less accessible parts of forest would have to be worked.

33 Forest Europe/UNECE/FAO, (2011).

34 Losses of forest cover and other wooded land cover resulted in estimates of annual carbon losses which are similar for 1990s and 2000s at 887 and 880 Million tons of carbon respectively, with humid regions contributing two-thirds. See: Achard *et al.* (2014), Determination of tropical deforestation rates and related carbon losses from 1990 to 2010, Global Change Biology. http://onlinelibrary.wiley.com/doi/10.1111/gcb.12605/abstract

35 FAO (2007) FAOSTAT database – forestry. http://faostat.fao.org/site/626/default.aspx#ancor

36 Cuypers *et al.* (2013), The impact of EU consumption on deforestation: comprehensive analysis of the impact of EU consumption on deforestation, EC Technical Report, 2013-063. http://ec.europa.eu/environment/forests/impact_deforestation.htm

37 Regulation (EU) No 995/2010 of the European Parliament and of the Council of 20 October.

38 According to the Regulation, the operator must have access to the following information: trade name of the product and species name of the timber used (where available), the country of harvest (including the sub national region of harvest and the concession of harvest), the quantity of product (volumes, weight and number of items), and the name and address of the supplier and of the customer.

In order to meet growing forest biomass demand for energy and other uses, forest production will need to be intensified across the EU. If done unsustainably, this could lead to forest degradation, with consequent negative impacts on biodiversity and ecosystem services, including on the carbon pool. For instance, the 2011 European Forest Sector Outlook Study II (EFSOS II)[39] analysed the possible impacts of four different scenarios of wood mobilisation in Europe over the next 15 years. It found that overly increased wood extraction for bioenergy production up to 2030 could result in a deterioration of forest resources and ecosystems. This research highlighted that, in certain regions, specific attention would be required to preserve the forest health and vitality and its overall biodiversity status. Similar concerns have been raised concerning the production of forest biomass in third countries, where little environmental safeguards exist or where forest law enforcement is weak.

A number of EU policy measures have been put in place in order to address the above-mentioned risks. In September 2013, the Commission adopted a new EU Forest Strategy[40] with the view to address in a holistic way the overall increasing demands put on forests by many end-uses, including bioenergy. The 2020 objective of this strategy is to ensure and demonstrate by 2020 that all EU forests are managed according to the principle of sustainable forest management (SFM) and that the EU's contribution to promoting sustainable forest management and reducing deforestation at global level is strengthened. These objectives were further confirmed by Member States and the European Parliament in the Seventh EU Environmental Action Programme[41].

With respect to the issue of forest biomass sustainability, it should be recognized that the development of SFM criteria measurable is not yet sufficiently advanced for use throughout all life-cycle phases at EU-level. To this end, the Commission is currently working to develop 'objective, ambitious and demonstrable' SFM criteria that can be applied in different policy contexts regardless of the end use of forest biomass. Such exercise will be carried out in close consultation with Member States and stakeholders and building on internationally agreed criteria[42].

Once developed, the EU-wide SFM criteria could be used to demonstrate the first life-cycle phase of sustainability of forest biomass for energy and other uses. Furthermore, under the 'Forest Europe' process, the EU is supporting the implementation of sustainable forest management, thus contributing to strengthen forest protection and management in the wider European region (including in biomass trading partners such as Russia).

Agricultural biomass

In the agricultural sector, additional biomass supply is likely to come from dedicated crops (such as maize), residues (such as straw) and to a less extent from energy plantations[43].

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39 UN Economic Commission for Europe (2001), European Forest Sector Outlook Study II. http://www.unece.org/efsos2.html

40 COM (2013) 659. http://ec.europa.eu/agriculture/forest/strategy/communication_en.pdf

41 Decision No 1386/2013/EU, point 28, (g). http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:354:0171:0200:EN:PDF

42 http://www.foresteurope.org/sfm_criteria/criteria

43 This include plantings established and managed under short rotation intensive culture practices, including fast growing tree species (like poplar, willow, black locust and eucalyptus) and a coppice systems. According to Regulation (EU) No 1307/2013: 'short rotation coppice' means areas planted with tree species of CN code 06029041 to be defined by Member States, that consist of woody, perennial crops, the rootstock or stools remaining in the ground after harvesting, with new shoots emerging in the following season and with a maximum harvest cycle to be determined by the Member States. As regards the difference to fast-growing species under short rotation forestry, the Delegated Act C (2014) 1460 explains that for 'fast-growing species': Member States shall define the minimum

Regarding straw, negative environmental impacts may be associated when large scale use of residues enters into competition with the biological role that straw plays (i.e. the recycling of organic matter into soil, protection of the soil surface and structure, nitrogen retention in soils and limitation of nitrates release during the autumn period), potentially causing damages to soil fertility and deterioration of biodiversity.

Environmental impacts of energy crop plantations depend on several factors. In some cases, plantations of short rotation coppice may require high fertilisation, with negative impacts on soils and water, and may lead to compaction of soils. It should be noted, however, that plantations of short rotation forestry, with longer rotation periods, are not or little fertilised in the EU. If located on degraded land or poor arable land they could result into environmental improvements, although the location may affect their productivity.

The use of crops (such as maize for biogas) as a feedstock can have a number of direct and indirect negative environmental effects associated with intensive agricultural production (especially regarding biodiversity, soil and water resources). Rising demand for maize can also increase the pressure to convert grass- and peatlands for cultivation of maize (causing significant CO2 emissions form the soil). It should be noted, however, that under the CAP the conversion of permanent grass land is limited (the ratio of grassland to overall agricultural land cannot decrease by more than 5%, otherwise land has to be converted back to grassland). Increased use of manure can help mitigate the above-mentioned unwanted side effects[44].

On the other hand, the stabilisation of manure by anaerobic digestion provides an important contribution to the control of pathogens. GHG emissions from manure used for biogas are significantly lowered compared to the direct use of manure in crop production because open manure storage –a common practice in the EU– would otherwise emit substantial amounts of methane into the atmosphere. The waste treatment of manure depends on the availability and economic viability of biogas installations throughout areas of livestock production. Smaller installations that are more dispersed allow for a reduction of emissions that are associated with the transport of manure and with the digestate put back to the fields. Furthermore they are likely to better support local farmer's income.

In Europe, the Common Agriculture Policy (CAP)[45] and applicable environmental legislation are aimed to reduce the environmental impact of agricultural production. The CAP has been recently reformed for the period of 2014-2020 and substantial changes have been introduced concerning environmental protection. For example, 30% of direct payments to farmers will be subject to compliance with a new set of environmental "greening" measures. Furthermore, environmental protection, including climate change aspects and the production of renewable energy has been strengthened in the Rural Development Policy. In each Member State, 30% of rural development funds have to be spent on measures beneficial to the environment or climate change.

The Rural Development Policy now includes two specific priorities "restoring, preserving and enhancing ecosystems related to agriculture and forestry" and "promoting resource efficiency and supporting the shift towards a low-carbon and climate resilient economy in agriculture,

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and maximum time before felling. The minimum time shall not be less than 8 years and the maximum shall not exceed 20 years. This implies that "short rotation coppice" are expected to have a growing cycle between 2 and 7 years. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0608:0670:EN:PDF

44 Under the EU Waste Framework Directive, manure is considered waste when it is used for biogas production. In the present document, manure is considered as an agricultural waste.

45 Regulation (EU) No 1305/2013. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0487:0548:EN:PDF

food and forestry sectors". The CAP also enforces applicable environmental standards via the cross-compliance mechanism and sets up additional standards for ensuring that agricultural land is kept in good agricultural and environment condition. This entails requiring the maintenance of permanent grassland within strict limits and soil protection measures.

4.2. Addressing land use, land use change and forestry emissions (LULUCF)

Deforestation, forest degradation and a number of agriculture practices can also result in a significant loss of terrestrial, biogenic carbon. It has also been highlighted that there are possible loopholes in the international accounting system for carbon emissions, which may mean that the emissions accounted for underestimate their actual level[46].

Under the reporting rules of the United Nations Framework Convention on Climate Change (UNFCCC), direct carbon dioxide emissions associated with the combustion of bioenergy are not included in the national total in order to avoid double counting, as any resulting changes in carbon stocks is meant to be reflected in the land use, land-use change and forestry (LULUCF)[47] and reduced emissions from waste would be reflected in the waste sector. A similar approach is followed in the EU Emission Trading Scheme, which accounts biomass as having a zero emission combustion factor.

Furthermore, while the Kyoto Protocol adopted the same UNFCCC assumption, an important issue is that any biomass sourced from countries that are not Parties to the Kyoto Protocol or have not assumed GHG emission reduction/limitation commitments (such as the US, Canada, emerging economies and developing countries) will automatically be recorded as having a zero emission combustion factor. In addition, under the 1st commitment period of the Kyoto Protocol, the LULUCF accounting was only obligatory for afforestation, deforestation and reforestation, while accounting for forest management was voluntary. From 2013 onward, the accounting of forest management is mandatory for all Kyoto Parties.

The Commission will continue its work towards achieving more transparent international accounting systems at global level. In particular, the current international climate negotiations include discussion on future mandatory comprehensive accounting for all land use processes and extension of commitments to account for biomass in major exporting countries, thereby eventually covering all biomass for energy use imported into the EU.

Concerning the EU, in 2013 the Parliament and Council adopted a Decision on LULUCF emissions[48], as a first step towards the inclusion of the related sector in the EU's climate policy. This gradual approach consists firstly of establishing common and robust accounting, monitoring and reporting rules mandatory for forests, croplands and grazing land as well as a requirement for Member States to provide information on national LULUCF action to enhance mitigation in the sector. Some degree of the impact of forest biomass use is therefore now enacted, albeit only with respect to EU Member States; international commitments under

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Searchinger *et al.* (2009), Fixing a critical climate accounting error. Science, 326, pg. 527-528. http://www.sciencemag.org/content/326/5952/527

47 If energy use, or any other factor, is causing a long term decline in the total carbon embodied in standing biomass (e.g. forests), this net release of carbon should be evident in the calculation of CO2 emissions described in the Land Use Change and Forestry chapters. See 1996 IPPC guidelines for national greenhouse gas inventories, vol. 1, pg. 1.3. http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html

48 Decision No 529/2013/EU. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:165:0080:0097:EN:PDF

the Kyoto Protocol. Such accounting does not, however, address the issue of most imports from third countries.

4.3. Assessing the lifecycle GHG emission performance of biomass

The GHG balance of given biomass energy applications differs depending on the type of feedstock used, carbon stock changes due to land use, transport, processing and the efficiency of the conversion into electricity, heating and/or cooling. Conventionally, emissions from carbon stock change related to land use (positive or negative) have not been accounted in a standard approach to Life Cycle Analysis (LCA) because it is implicitly assumed that an almost immediate uptake via plant re-growth of the initially released biogenic carbon takes place[49].

However, while such an assumption may hold true for (multi) annual cropping systems with short carbon cycles, in the case of forest biomass, carbon release and sequestration may not be in temporal balance with each other. Depending on the rotation of the forest, a timing difference can be observed between the absorption of forest carbon during forest growth (which can take several decades) and release of carbon during combustion. This phenomenon has therefore caused a number of researchers to express concerns about the climate change mitigation potential of forest biomass and to call for proper accounting of the loss of the initially sequestered biogenic carbon (i.e. carbon in the form of biomass) due to biomass harvest (the so-called 'carbon debt')[50].

The studies[51] carried out for and by the Commission on this topic have found a large variability in the results of the published scientific literature. This can be explained by differences in: a) methodological choices, b) assumptions within the scenarios, c) site-specific characteristics of forests, and d) forest management practices. In particular, the design of the GHG accounting framework has a key influence on the calculated GHG saving performance of the bioenergy pathways analysed.

Furthermore, the outcomes of GHG assessment of forest bioenergy are very sensitive to the counterfactual scenario for land use (i.e. the definition of the "without bioenergy" reference scenario, against which the bioenergy scenario is evaluated). This reference scenario may include forest management for a different mix of products and services, or reserving the forest for conservation. It follows that counterfactual scenarios need to be developed carefully and

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49 According to the 2013 Commission's Recommendation on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations (2013/179/EU), biogenic carbon removals and emissions should be accounted but kept separate in the resource use and emissions profile of products/organizations. In addition, credits associated with temporary (carbon) storage or delayed emissions shall not be considered in the calculation of the default environmental footprint (EF) impact categories. However, these may be included as "additional environmental information". Moreover, these shall be included under "additional environmental information" if specified in a supporting rules (see para. 5.4.9, pg. 31-32). http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:124:0001:0210:EN:PDF

50 EEA Scientific Committee (2011), Opinion on greenhouse gas accounting in relation to bioenergy. http://www.eea.europa.eu/about-us/governance/scientific-committee/sc-opinions/opinions-on-scientific-issues/sc-opinion-on-greenhouse-gas/view

51 Matthews *et al.* (2014), Review of literature and key issues on biogenic carbon and life cycle assessment of forest bioenergy, Forest Research, Task 1 Report. http://ec.europa.eu/energy/renewables/studies/doc/2014_05_review_of_literature_on_biogenic_carbon_report.pdf
Agostini *et al.* (2013), Carbon accounting of forest bioenergy, JRC Report. http://iet.jrc.ec.europa.eu/bf-ca/sites/bf-ca/files/files/documents/eur25354en_online-final.pdf

robustly, and assumptions must be transparent to ensure they are clearly understood when results are interpreted.

In terms of their probable effect on emission reduction, the analysis of scientific literature suggests it is possible to identify 'low risk' and 'high risk' pathways of forest bioenergy. However, the same feedstock can be involved in 'low risk' and 'high risk' scenarios. As a consequence, it is not possible to limit or remove risk of adverse GHG emissions due to consumption of forest bioenergy by favouring particular feedstocks and discouraging the use of others, while not considering the wider production framework and context. This places a major obstacle to regulating the consumption of forest bioenergy based on individual consignments of forest bioenergy or based on specific types of forest bioenergy feedstock. Nevertheless, stumps extracted for energy or stem wood harvested only for bioenergy production (both expected to play a minor role in the achievement of the 20% EU renewable energy target) could lead to negligible GHG savings or even net emissions within policy relevant periods.

Forest biomass used in the EU heat and power sectors is currently based primarily on processing and harvesting residues while dedicated harvest of stem wood only for bioenergy markets still plays a marginal role. Therefore it would appear that the vast majority of the biomass pathways used today in the EU, whether domestic or imported, provides carbon emission reductions not only over the long term, but also over the medium- short term. These include forest thinnings, harvest residues, salvage loggings (under certain conditions), landscape care wood, industrial residues, and waste wood.

Forest biomass practices and pathways may evolve in the future in order to meet increased levels of bioenergy consumption. Therefore, as highlighted in the 2010 Report, there is a need to collect better information on the different types of management regimes for wood used as feedstock and the general forest management practices used in the region. To this end, the Commission will continue monitoring the relevant trends in biomass trade and imports and further analyse the climate performance of different biomass pathways for the period beyond 2020.

Besides impacts on forest carbon stocks, it is also important to minimize GHG emissions of biomass supply chains. In its 2010 Biomass Report, the Commission has developed a simplified methodology for the calculation of GHG performance of solid and gaseous biomass used for heating/cooling and electricity production. This methodology considers the GHG emissions from the cultivation, harvesting, processing and transport of the biomass feedstocks. It also includes direct land use change where the land use has changed category since 2008. It does not include land use emissions and emissions from biomass fuel combustion and indirect impacts such as displacement effects.

Differently from the method applying to biofuels and bioliquids under the RED, the GHG methodology for biomass and biogas covers also the final step of conversion of the biomass fuel into electricity, heating or cooling. To calculate the climate performance, the GHG emissions of different biomass pathways are compared against the EU average of fossil electricity, heating or cooling[52]. In the context of this SWD, the GHG default values were calculated by the Joint Research Centre[53] following broadly the 2010 GHG methodology, with some adaptations regarding the definition of the fossil fuel comparator (FFC) and the calculation of GHG emissions of biogas production (see Box 2 for further details).

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52 Annex 5 of SEC (2010)66. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52010SC0065&from=EN

53 For further details see JRC (2014) Solid and gaseous bioenergy pathways: input values and GHG emissions, EUR 26696, http://iet.jrc.ec.europa.eu/bf-ca/publications.

Box 2: Basis for assessing the GHG emission savings of solid and gaseous biomass

The assessment of GHG emission savings of biomass carried out by JRC for this Staff Working Document is based broadly on the simplified methodology contained in the Commission report on biomass sustainability published in 2010 (see Annex 1 of COM(2010)11), which is based on the following formula:

$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} – e_{ccs} - e_{ccr}$$

Where:
E = total emissions from the use of the fuel before energy conversion
e_{ec} = emissions from the extraction or cultivation of raw materials
e_l = annualised emissions from carbon stock changes caused by land use change
e_p = emissions from processing
e_{td} = emissions from transport and distribution
e_u = emissions from the fuel in use
e_{sca} = emission savings from soil carbon accumulation via improved agricultural management
e_{ccs} = emission savings from carbon capture and geological storage
e_{ccr} = emission savings from carbon capture and replacement

In order to integrate additional knowledge and information collected during the expert consultation process, for illustrative purpose for this SWD, the default values were calculated on the basis of the following alternative accounting rules compared to the ones used in the 2010 Biomass Report. It should be noted that the definition of the GHG methodology is a policy choice which goes beyond the scope of this document.

a) *Fossil fuel comparator (FFC)*. GHG performance can be expressed as "savings" relative to a fossil fuel comparator or in absolute terms[54]. Different methods exist for calculating the comparator. In the 2010 Report, the FFC was calculated as the EU average of fossil electricity, heating or cooling. However, a number of stakeholders have raised the question of the stability of the comparator given the progressive decarbonisation of the EU energy sector (e.g. the GHG emission average is expected to decrease in the coming years). Therefore in the context of this SWD, the FFC was calculated in a way that would take into account the future likely evolution of energy markets, with the view to ensuring a more stable comparator. Accordingly, for electricity the FFC was based on the following power mix: 50% natural gas fired CCGT plants (with gas sourced from a mixture of sources, from short/long distance as well as LNG), 25% coal fired IGCC plants, and 25% conventional coal. For heat, the FFC was based on natural gas, as this is likely to remain the dominant fossil source of heat in the EU up to 2020[55]. For biomethane (gas of biogenic origin with the characteristics of methane) injected into the grid, the FFC was based on the same mix of natural gas as for heat, as this is assumed to be the substituted energy source in the grid and it is likely to remain so up to 2020. For cooling, the FFC was based on a Seasonal Energy Efficiency Ratio (SEER) of air-conditioning units with inverters in Europe equal to 4[56]. Accordingly, the following values for the FFC were used in this document: electricity = 186 gCO_2 eq./ MJ; heat = 80 gCO_2 eq./ MJ; natural gas = 72 gCO_2 eq./ MJ; cooling = 47 gCO_2 eq./ MJ.

b) *Mass balance approach*. The GHG methodology set in the 2010 Biomass Report uses a mass balance approach, whereby physical mixing of certified and non-certified products is permitted but products are kept administratively segregated. The system ensures that for the volume of biomass for which sustainability claims are made at the end of the supply chain, sufficient certified material has been added to the supply chain, taking into account relevant conversion factors. However, a number of stakeholders have highlighted that this approach creates difficulties for the majority of existing biogas plants that typically use a mixture of locally-produced feedstock, ranging from animal manure, to

54 https://www.ofgem.gov.uk/ofgem-publications/87988/renewablesobligationsustainabilitycriteriaguidance.pdf
55 http://ec.europa.eu/energy/publications/statistics/doc/2011-2009-country-factsheets.pdf
56 SWD (2012) 35. http://ec.europa.eu/energy/efficiency/labelling/doc/en_impact_assesment.pdf

food/feed energy crops (such as silage maize) and to residues from the agro-food industry. They claim that given the operational characteristics of biogas plants, a mass balance approach results in lower GHG saving performances compared to an alternative approach whereby the GHG emission default values are calculated for the entire mixture within a given biogas plant.

c) *Improved manure management*. The GHG methodology set in the 2010 Biomass Report includes certain emission savings from carbon accumulation via improved agriculture management. For this SWD, JRC was asked to include in this category also the avoided methane and nitrous oxide emissions resulting from improved manure management via anaerobic digestion. Manure management contributes significantly to GHG emissions of the agricultural sector, mostly due to methane emissions during storage and field application. Biogas produced via anaerobic digestion of manures, thus, not only supplies substitute fossil sources, but it also generates an emission credit due to the avoidance of large part of the above mentioned emissions. It has been shown that, often, the emissions saved from manure management largely offset additional GHG emissions associated with the biogas supply chain, causing GHG savings higher than 100% even in less-than-optimal biogas production systems[57]. If such credits were not accounted for, most of the biogas pathways produced from manures would appear not leading to GHG savings and would thus be penalized**.**

Figures 3 and 4 show illustrative GHG saving performances calculated for this Staff Working Document by JRC for selected biomass pathways, on the basis of default values compared against a fossil fuel comparator (see Box 3 for details). For solid woody biomass, the long transport shipping distance was calculated with reference to distances to Rotterdam harbour.

It should be noted that in reality the GHG saving performances of the biomass in question can however be improved in a number of ways. For instance, emission savings may be achieved by transporting the biomass feedstock for shorter distances than to the assumed transport distance to Rotterdam (e.g.: from S.E. US to Portugal or from St. Petersburg to Stockholm). On the contrary, it is also possible that biomass imports are transported to a location in the EU hinterland, causing higher emissions. Furthermore, a conservative electrical efficiency of 25% was assumed in the calculations while in reality the average efficiency in bioelectricity plants is likely to be around 30-35% and up to 40% with co-firing[58]. Finally, emissions can be reduced by using more renewable energy in the production process (e.g. wood chips CHP to supply process heat and electricity to pellet mills). As for biofuels, actual values for GHG savings can always be calculated using the input values defined by the Joint Research Centre, regardless of whether there exist a default value for the biomass pathway in question. To facilitate such calculations, bioenergy operators and regulatory agencies can use the standardised GHG calculation tool developed by the EU-funded Biograce II project[59].

As shown in Figure 3, GHG emission savings can change significantly depending on: (i) the amount of fertiliser used, if any, (ii) the amount of energy used in processing and (iii) the transport mode and distance. Where forest or agriculture residues are used, the GHG emission savings are generally above 70% compared to fossil fuel alternatives. However, lower savings can occur for short-rotation coppices (e.g. eucalyptus in tropical countries) in cases of high fertiliser use in agriculture and when natural gas is used for drying pellets. Figure 4 indicates that default GHG emission performance of biogas and biomethane can vary significantly depending on the feedstock and the conversion technology used at plant level. In particular, GHG performance is sensitive to the amount of energy crops used and to the leakage of

[57] Boulamanti *et al.* (2013), Influence of different practices on biogas sustainability, Biomass and Bioenergy (53), 149-161. http://www.sciencedirect.com/science/article/pii/S0961953413000949

[58] Ecofys (2010), Evaluation of improvements in end-conversion efficiency for bioenergy production. http://ec.europa.eu/energy/renewables/bioenergy/doc/2010_02_25_report_conversion_efficiency.pdf

[59] http://biograce.net/biograce2

methane emissions during: biogas processing, biogas combustion, and storage of digestate. Therefore the GHG performance of biogas and biomethane plants can be improved by using higher shares of waste, animal manure and slurry as feedstock, while improving as much as possible the operational performance and efficiency of the installation itself (e.g. through closed digestate storage or by flaring the methane in the off-gases of upgrading plants).

Limiting the use of dedicated annual energy crops in the production of biogas/biomethane can also contribute to avoid direct and indirect negative impacts resulting from high monoculture production in certain areas (e.g. distortive effects on land prices). A number of Member States, such as Germany, are progressively limiting support for the use of annual energy crops for biogas production. In this respect, the revised CAP requires Member States to establish maximum thresholds for the use of cereals and other starch rich crops, sugars and oil crops (including silage maize), in order for biogas plants to receive financial support from the Rural Development programmes[60].

Given the above analysis, it is considered to be good practice for existing bioenergy installations to achieve GHG savings of at least 70% compared to the fossil fuels comparators. This equates to lifecycle emissions of less than or equal to 86 kg CO2 equivalent per MWh of biomass heat generated, to 201 kg CO2 equivalent per MWh of biomass electricity, and 78 kg CO2 equivalent per MWh of biomethane injected into the grid. As the energy carbon intensity is projected to decrease in the future, higher GHG emission savings thresholds could be set for post-2020 in order to promote higher carbon savings, technology innovation, and best practices in feedstock production.

Box 3: Basis for calculating the GHG emission default values

Following the same approach described in the Staff Working Document[61] accompanying the Renewable Energy Directive (2009/28/EC), default values were set: (a) at a level that is typical of normal production processes where the contribution to overall emissions is small, or where there is limited variation, or the cost or difficulty of establishing actual values is high; (b) at a conservative level in other cases.

In the case of solid biomass, emissions from transport fall into category (b) because their contribution is high and variability is also high. Emissions from cultivation fall into category (a) because the contribution they make to overall emissions is small (for dedicated non-food energy crops on agricultural land) or because the cost or difficulty of establishing actual values is high. Emissions from processing and from the fuel in use both fall into category (b) because their contribution to overall emissions can be high and variability is also high. In the calculation of default values, conservative values were used for emissions from processing and transport and from the fuel in use, while typical values were used for emissions from cultivation. In this context, emissions from processing and from transport and from the fuel in use were increased by 20%.

In the case of biogas, emissions from transport fall into category (a) because their contribution is very limited as the substrates are normally locally sourced. Emissions from cultivation fall into category (a) because the cost or difficulty of establishing actual values is relatively high given that normally plants are sized at farm scale. Emissions from processing and from the fuel in use both fall into category (b) because their contribution to overall emissions can be high and technological variability (including accidental leakages of methane) is also very high. Furthermore, biogas can be used in the three energy sectors (transport, heating and cooling and electricity), and the approach here presented would be

[60] Article 13 (e) of Commission Delegated Regulation of 11.3.2014 supplementing Regulation (EU) No 1305/2013 of the European Parliament and of the Council on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) and introducing transitional provisions. C(2014)1460. http://ec.europa.eu/transparency/regdoc/rep/3/2014/EN/3-2014-1460-EN-F1-1.Pdf

[61] SEC (2008) 85 v. II. http://ec.europa.eu/clima/policies/package/docs/climate_package_ia_annex_en.pdf

consistent with the one taken for biogas in transport in the Renewable Energy Directive. Therefore, conservative values were used for emissions from processing (including upgrading) applying an increment of 40%, while typical values were used for emissions from other parts of the production process.

For biogas, default and typical GHG emissions were calculated in combination for the entire mixture of substrates within one installation. Accordingly, the weighted average of the GHG savings from biogas produced from a combination of manure, biowaste and maize silage was then compared to the fossil fuel comparator. For co-digestion of substrate types, the different methane potentials per tonne were taken into account. In case of co-digestion of *n* different substrates in a biogas plant for the production of electricity or biomethane the typical and default values were calculated as follows[62]:

$$E = \sum_1^n S_n \cdot E_n$$

Where:
E = emissions per MJ electricity or biomethane from biogas
S_n = Share of feedstock n in energy content
E_n = Emission in gCO_2/MJ from substrate n, see (a) below

$$S_n = \frac{P_n \cdot W_n}{\sum_1^n P_n \cdot W_n}$$

Where:
P_n = energy yield [MJ] per kilogram of wet input of feedstock n, see (b) below
W_n = weighting factor of substrate n defined as:

$$W_n = \frac{I_n}{\sum_1^n I_n} \cdot \left(\frac{1 - AM_n}{1 - SM_n}\right)$$

Where:
I_n = Annual input to digester of substrate n [tonne of fresh matter]
AM_n = Average annual moisture of substrate n [kg water / kg fresh matter]
SM_n = Standard moisture for substrate n, see (c) below

When considering biogas consumption in CHP engines and production of electricity on-site, heat production is not included in the default values calculation because useful heat export is driven by demand and infrastructures and it varies largely between installations and geographic locations. When biogas is combusted in gas-engines for the production of electricity, waste heat can be recovered and exported to external users. In the default values calculations only the useful heat recovered for the heating of the digester is considered.

Additional useful heat production is not included because this export is driven by demand and infrastructures and it varies largely between installations and geographic locations. Operators exporting useful heat will be able to allocate part of the total emissions to the exported heat using the formula given in Annex 3 point 1b.

Notes:
(a) For manure as substrate a bonus of 45 gCO2 eq. / MJ manure is added for improved agricultural and manure management
(b) The Pn values were calculated as follows: Pn = Yn · VSn · LHV(n)biogas
Where:
Yn = yield of biogas [m3] per kg of volatile solids for feedstock n
VSn = volatile solids content in feedstock n
LHV biogas = 35.9 MJ/m3 * CH4 % vol.
P (maize) = 4.16
P (manure) = 0.50
P (biowastes) = 3.41
(c) The following moisture content was used: for manure 90%, for maize 65%, for biowaste 76%.

62 For further details see: JRC (2014).

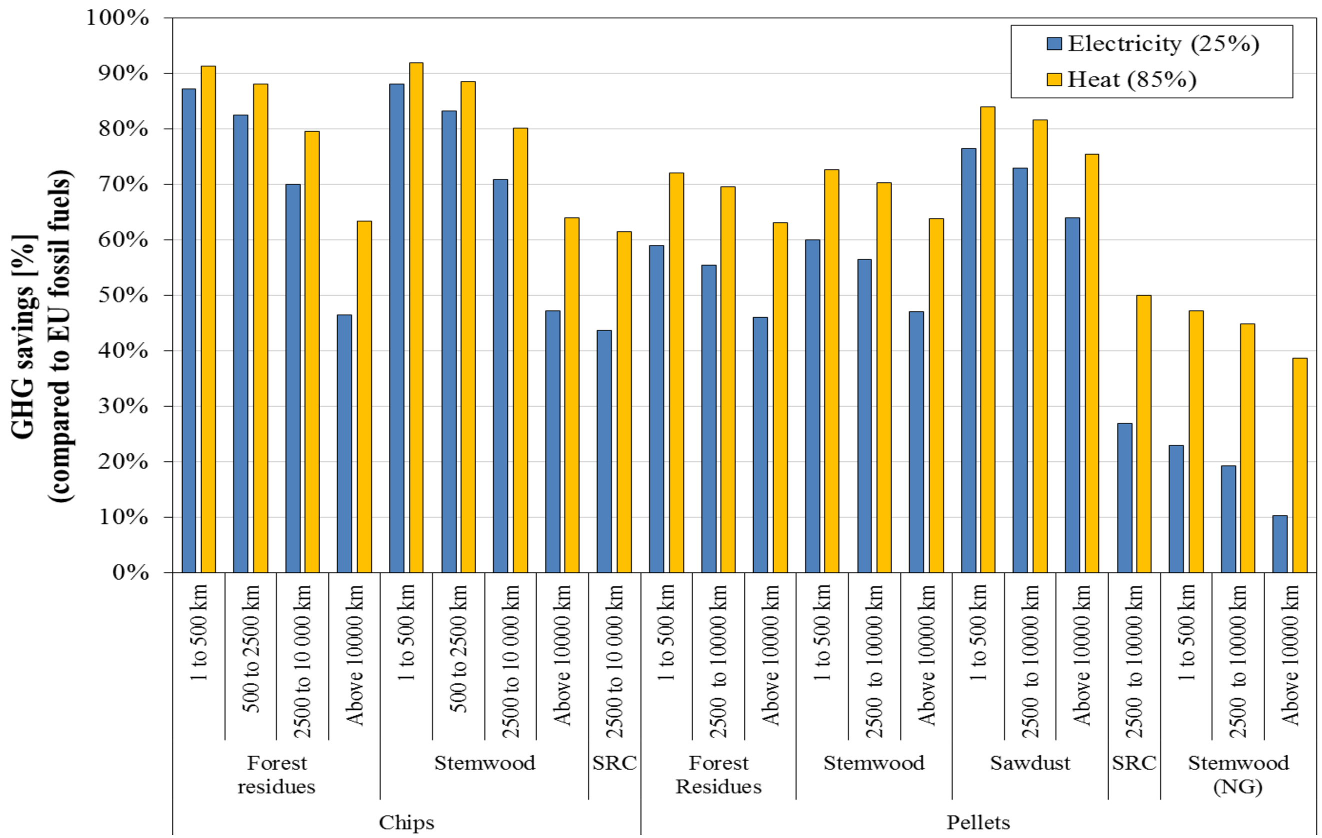

Figure 3: Default GHG saving performance of solid biomass

Source: Joint Research Centre 2014.

Notes:

- Default GHG values are obtained applying a standard electrical efficiency of 25% and a standard thermal efficiency of 85%.
- SRC = Short Rotation Coppice. The calculations are based on GHG data from eucalyptus cultivation in tropical areas.
- Stem wood (NG)= pellets produced using natural gas as process fuel, all the other pathways are based on wood as process fuel.
- Distances refer to the following regions: 1-500 km = intra-EU trade, 500-2500 km = imports from Russia and Baltic countries, 2500 – 10000 km = imports from South East USA and South America, >10000 km = imports from Western Canada.

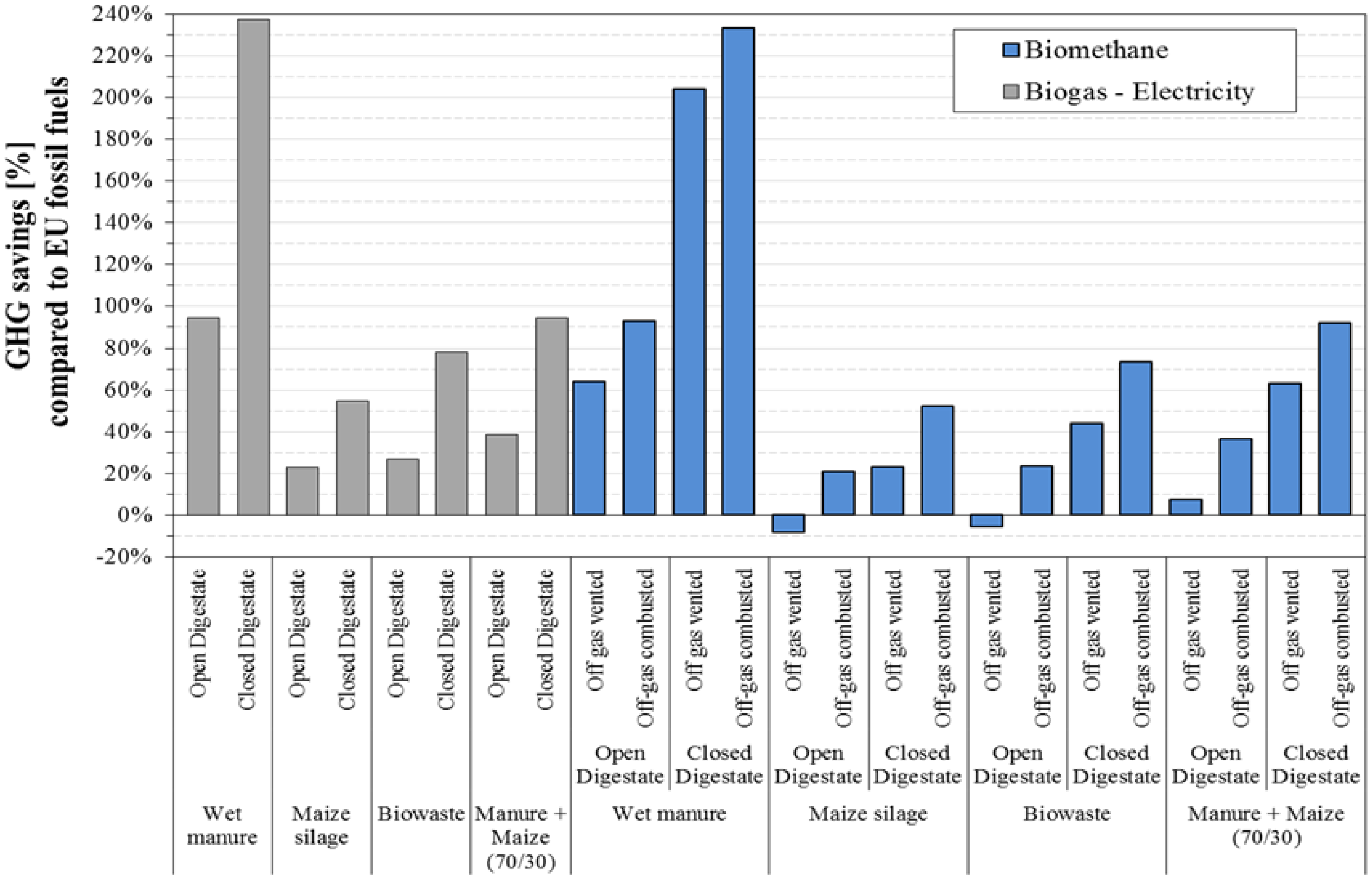

Figure 4: Default greenhouse gas saving performance of biogas and biomethane
Source: Joint Research Centre 2014.

Notes:

- Manure + maize (70/30) = illustrative example of co-digestion of a mixture composed of 70% manure and 30% maize silage (on a wet mass basis).
- Results obtained for different mixture compositions can be found in JRC 2014.

4.4. Preventing indirect impacts

The large-scale deployment of forest and agriculture bioenergy can result in a number of potential indirect impacts. Demand for biomass can create competition with existing uses in sectors such as construction, paper and pulp and biochemistry, or result in land use change. This could affect the GHG saving benefits that would be due to the use of the same biomass resource to make material products (which may stock carbon for longer or replace more GHG intensive materials).

Behaviour of markets for wood and wood-based products is complex, especially those operating internationally, but if energy prices were to rise, the effect would be unlikely to directly divert high-grade timber from the construction or furniture making sector. Even with the current financial incentives for bioenergy, the price currently paid for biomass fuels for electricity and heat generation is significantly lower than that for quality sawlogs.

Competition is rather likely to increase on the use of lower-grade wood that is commonly used for the production of pulp, paper and particle board, as well as for energy generation, which could lead to upward price pressure on wood markets in general, with possible displacement of intermediate grades[63]. More qualitative and quantitative information and analysis on the resource competition and overall availability of biomass is however needed in order to better understand the type and scale of the issue.

Possible indirect impacts of agriculture production for electricity, heating and cooling could include the displacement of agricultural production to previously uncultivated areas with potential effects on land use, GHG emissions and biodiversity. In order to reduce such risk, as well as other local environmental impacts stemming from intensive monoculture production, a number of Member States (such as Germany) increasingly promote the use of ILUC-free waste, animal manure and slurry in anaerobic digestion while progressively limiting support for the use of food-based energy crops.

While food crops for bioenergy may be grown on prime agricultural land, this is unlikely to be the case for short rotation tree plantations as it would rarely make economic sense to replace productive cropland with a plantation that will not bring in an income for several years. Indeed bioenergy plantations could reduce land competition pressures as planting trees on degraded land can increase ecosystem services (carbon sequestration, water retention etc.) while also providing commodities (bioenergy feedstocks, timber, fibre) more efficiently than natural forests[64].

It should be noted that, following a broad analysis and debate with stakeholders, in October 2012 the Commission adopted a proposal[65] establishing an approach to minimize possible ILUC impacts of biofuels consumed in the EU. This includes a cap on the contribution that first generation food crops-based biofuels can make towards the national target of 10% renewable energy target in transport by 2020. The Commission proposal does however not include feedstock-specific ILUC factors due to the uncertainties associated to the modelling[66]. Such uncertainties also apply to biomass used for heating and electricity.

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63 A Blueprint for the EU forest-based industries, SWD (2013) 343. http://ec.europa.eu/enterprise/newsroom/cf/_getdocument.cfm?doc_id=8128

64 See WWF (2011), New Generation Plantations. Bioenergy and carbon report 2011. www.panda.org

65 COM (2012)595. http://ec.europa.eu/energy/renewables/biofuels/doc/biofuels/com_2012_0595_en.pdf

66 Due to the lack of an agreed methodology, indirect land use change was also not included in the GHG calculation of the Product Environmental Footprint (PEF), under the Commission's Recommendation 2013/179/EU.

Increasing mobilisation of forest and agriculture feedstock in a sustainable way, while developing new, innovative ways to further optimise the added value from raw materials would help match wood supply and demand and mitigate the above-mentioned risks. To this end, progress is needed to increase forest and agriculture management efficiency as part of an overall EU policy framework supporting the sustainable supply and cascading use of forest and agriculture biomass, in addition to energy efficiency.

The idea of biomass cascading is that the same biomass should be used more than once, starting with material uses (e.g. high-grade wood for the construction sector), followed by the subsequent use of the recovered/recycled material in applications where lower grades are acceptable, such as particle board and other agglomerated materials. While in principle energy conversion would typically be the last step in this broad hierarchy, in reality in several markets energy conversion may result the only economically valuable or available option for the use of biomass resources.

Under the EU Forest Strategy and the EU Bio-economy Strategy and Action Plan[67], as well as under the European Innovation Partnership for Raw Materials[68], the Commission is conducting research and analysis to identify good practices on the cascading use of biomass and to gain a better understanding of future biomass availability.

4.5. Promoting efficient energy conversion

Given that the supply of biomass feedstock is constrained by the finite availability of land, it is important to ensure that it is used as efficiently as possible. To this end, the key is the conversion technology used to produce heat, CHP or electricity.

There are substantial benefits from the use of biomass for CHP rather than simply to provide power alone. For CHP, the overall energy efficiency is typically 60-90% compared to an average of 30-35% in dedicated biomass plants for power alone. This said, the heat produced does not always have a use. In addition, biomass power facilities, including co-firing, can have a transitional role in the decarbonisation of the power sector[69]. A review[70] of national sustainability regulations conducted for the Commission found that, in accordance with the recommendations contained in the 2010 Biomass report, many Member States have already introduced measures promoting higher end-use efficiency, including CHP plants.

The expansion of biomass CHP plants and district heating and cooling is further promoted by Energy Efficiency Directive (EED)[71], which requires Member States to develop national heating and cooling plans and set non-binding energy efficiency targets by May 2014. The Commission is currently reviewing Member States' progress towards the 2020 energy efficiency target and indicate how energy efficiency can contribute to the 2030 energy and climate policy framework.

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67 COM (2012) 60 final. http://ec.europa.eu/research/bioeconomy/pdf/201202_innovating_sustainable_growth_en.pdf

68 COM (2011) 25. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0025:FIN:en:PDF

69 IRENA (2013), Biomass co-firing, IEA-ETSAP and IRENA Technology Brief E21. http://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP%20Tech%20Brief%20E21%20Biomass%20Co-firing.pdf

70 Pelkmans *et al.* 2012.

71 Directive 2012/27/EU. http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1399375464230&uri=CELEX:32012L0027

Furthermore, through the implementation of Directive 2009/125/EC on eco-design[72] and Directive 2010/30/EU on energy labelling[73], the Commission is currently working to address the energy-efficiency (and other environmental aspects) of different types of small-scale biomass boilers, stoves and fire places.

4.6. Minimizing air quality impacts

Wood burning, especially in case of incomplete combustion, can be an important source of air pollutants harmful to human health and the environment, including particulate matter (PM_1, $PM_{2,5}$, PM_{10}, elemental and black carbon), and heavy metals, polycyclic aromatic hydrocarbons, non-methane volatile organic compounds, persistent organic compounds and carbon monoxide. In particular, household solid fuel combustion has traditionally been the major source of particulate emissions in the EU, accounting for about one third of all EU-27 PM emissions and linked to respiratory health problems.

At EU level, air pollution is addressed through a number of legal measures. These include: Directive 2004/107/EC aimed to reduce concentrations of pollutants (as fine particulates, heavy metals and PAH) in ambient air, and Directive 2008/50/EC on ambient air quality, which sets standards and target dates for reducing concentrations of fine particles. Furthermore, the Large Combustion Plants Directive (2001/80/EC) lays down measures to control emissions from large combustion plants - those whose rated thermal input is equal to or greater than 50 MW, in order to reduce emissions of acidifying pollutants, particles, and ozone precursors.

Furthermore, in order to complete the regulatory framework for the combustion sector, in December 2013 the Commission adopted a proposal for a new Directive[74] to control emissions of air polluting substances from combustion plants with a rated thermal input between 1 and 50 MW. With the latter, the Commission aims to avoid possible trade-offs between air quality and increased biomass use, which may otherwise result in increased air pollution.

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72 http://ec.europa.eu/enterprise/policies/sustainable-business/documents/eco-design/legislation/framework-directive/index_en.htm

73 http://ec.europa.eu/energy/efficiency/labelling/labelling_en.htm

74 COM(2013) 919: http://ec.europa.eu/environment/air/index_en.htm

5. CONCLUSIONS

Solid and gaseous biomass used for electricity, heating and cooling production is the biggest source of renewable energy in the EU and is key to achieving the 2020 renewable energy targets and the EU long-term decarbonisation goals by 2050.

Increasing concerns have been expressed by a number of stakeholders about the potential sustainability risks associated with such large-scale use of biomass for energy, including those stemming from imports from third countries. While biomass imports are estimated to triple between 2010 and 2020, the EU demand for solid and gaseous biomass for bioenergy production is likely to continue to be met largely through domestic raw material up to 2020. Biomass demand is projected to further increase up to 2030, including imports, which raises the question of sufficient supply of sustainable and cost-effective biomass for all uses in the EU.

Against this background, this Staff Working Document has analysed the key internal market and sustainability issues related to biomass for heat and power generation. As discussed in section 3, currently a limited number of Member States have adopted broadly consistent sustainability schemes and no apparent internal market barriers have been identified thus far. Therefore, at this stage, it is considered that the risk of market distortion caused by national sustainability regulations can be effectively managed through the existing EU tools on technical standards.

Section 4 has discussed the most important sustainability risks of large-scale biomass production and use for energy, and reviewed how they are currently being addressed at EU level. While a number of knowledge gaps still exist, the vast majority of the biomass used today in the EU for heat and power are considered to provide significant GHG savings compared to fossil fuels.

At the same time, a number of biomass pathways can lead to negligible or negative GHG savings or other sustainability impacts. Further research and analysis is therefore needed to assess the future role of such pathways in the EU energy sector and to gain better information on overall biomass availability for the EU in the period post-2020.

Through the reporting requirements under the Renewable Energy Directive, and other policy initiatives related to the bioeconomy, the Commission will closely monitor the origin and the end-use of biomass in the EU, with the view to take appropriate corrective action, if needed. In this way, the Union and its Member States can ensure a stable and predictable regulatory framework for meeting the 2020 energy and climate targets, while at the same time taking action to minimize the risks of unintended sustainability impacts.

For the post-2020 period, as announced in the Communication on a 2030 Framework on climate and energy, an improved biomass policy will be developed in order to maximise the climate and resource efficiency benefits of biomass in the wider bioeconomy, while delivering robust and verifiable GHG emission savings and minimising the risks of unintended environmental impacts.

Annex: Statistics on biomass use for electricity, heating and cooling in the EU

1. Bioenergy now and beyond 2020

This annex provides updated statistics on solid and gaseous biomass used in electricity, heating and cooling in the EU 28, based on the information contained in the 2nd national Progress Report[75] submitted by Member States at the end of 2013 and the estimates on deployment up to 2020 contained in the National Renewable Energy Action Plans[76].

According to the above reports, bioenergy (in the three markets of bioelectricity, bioheat and biofuels) is currently the major source of renewable energy in the EU 28. In 2012, bioenergy consumed in EU amounted to 99 Mtoe, representing 62% of renewable energy consumption (159.7 Mtoe) and 8.7% of EU 28 total final energy consumption. As shown in Figure 1, bioenergy consumption is projected to increase up to 139.5 Mtoe in 2020, although its share of renewables will decrease to 57% due to faster increase of other renewables. Biomass is and will continue to be used to provide heat (90.4 Mtoe in 2020), followed by transports (29.1 Mtoe in 2020), and bioelectricity (20 Mtoe).

Figure 2 shows that current role of bioenergy in final energy consumption varies significantly among Member States. In absolute terms, Germany[77], France and Sweden are the largest producers with 42 % of final bioenergy used in EU28 in 2012, followed by Finland and Italy. In relative terms, Finland, Sweden and Latvia have the highest shares of bioenergy in final energy consumption. Looking at 2020, the most important consumption of bioenergy will be in France (21.6 Mtoe), Germany (21.1 Mtoe), Sweden (11.7 Mtoe), UK (10.4 Mtoe) and Italy (9.8 Mtoe). In relative terms, the higher share of bioenergy will be in Latvia (32.8 %), Sweden (29.9 %), Finland (29.4 %) and Denmark (22.4 (%).

According to the Impact Assessment to the Commission Communication on the 2030 climate and energy targets, the share of renewable energy in gross final energy consumption is expected to continue its growth also in the decades beyond 2020. More specifically, under the "reference scenario" renewable energy share will increase from 12.6% in 2010 to reach 24.4% in 2030 and 28.7% in 2050. On the contrary, under the '30 RES decarbonisation scenario' the overall renewable share will increase to 30.3% in 2030 to almost further double in 2050 reaching 59.2%.

In this context, biomass will remain the biggest renewable energy source, although its relative share will decrease from 56% in 2030 to just below 50% in 2050. In absolute terms, biomass consumption is expected to increase to 178 Mtoe under the reference scenario and 192 Mtoe under the 30% RES decarbonisation scenario, and keep increasing slowly up to 2050.

Solid biomass consumption is expected to rise to 107.3 Mtoe in 2030 and 115 Mtoe in 2050 according to reference scenario while under the 30% RES decarbonisation scenario a higher increase in solid biomass consumption is expected with 125.6 Mtoe in 2030 and 134.4 Mtoe in 2050. Domestic solid biomass production in EU 28 is expected to reach 89.2 Mtoe in 2030 and 91 Mtoe in 2050 according to reference scenario while under the 30% RES decarbonisation scenario no further change is expected after reaching 102 Mtoe in 2030.

[75] http://ec.europa.eu/energy/renewables/reports/2013_en.htm

[76] http://ec.europa.eu/energy/renewables/action_plan_en.htm

[77] For Germany and Portugal data on gross final energy consumption, renewable energy consumption and bioenergy consumption refer to year 2010.

Biogas production will almost double in 2030 compared with 2012 rising from 5.5 Mtoe to 9.2 Mtoe in both scenarios.

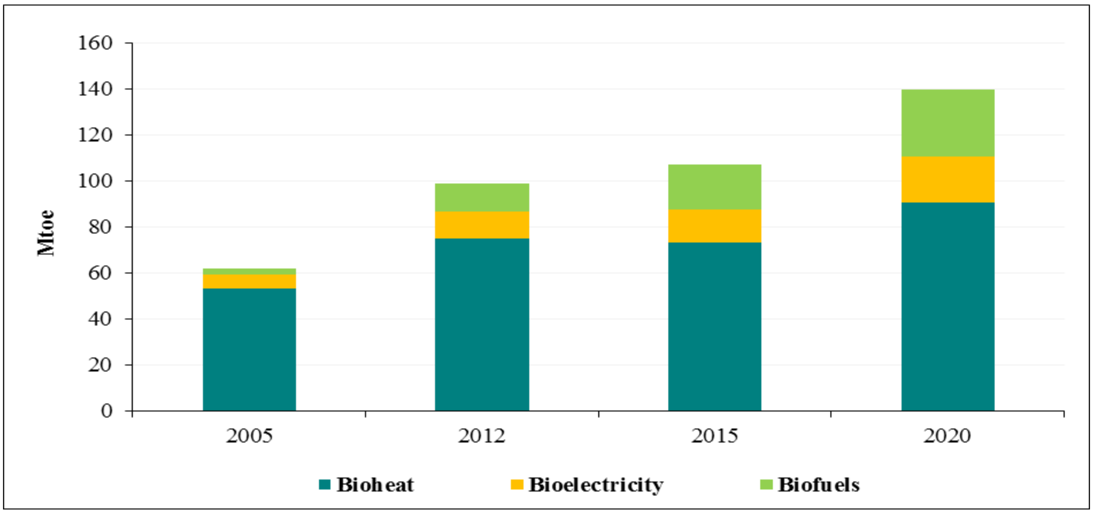

Figure 1: Outlook for EU final bioenergy demand (Mtoe, 2012-2020).
Source: Progress Reports and National Renewable Energy Action Plans.

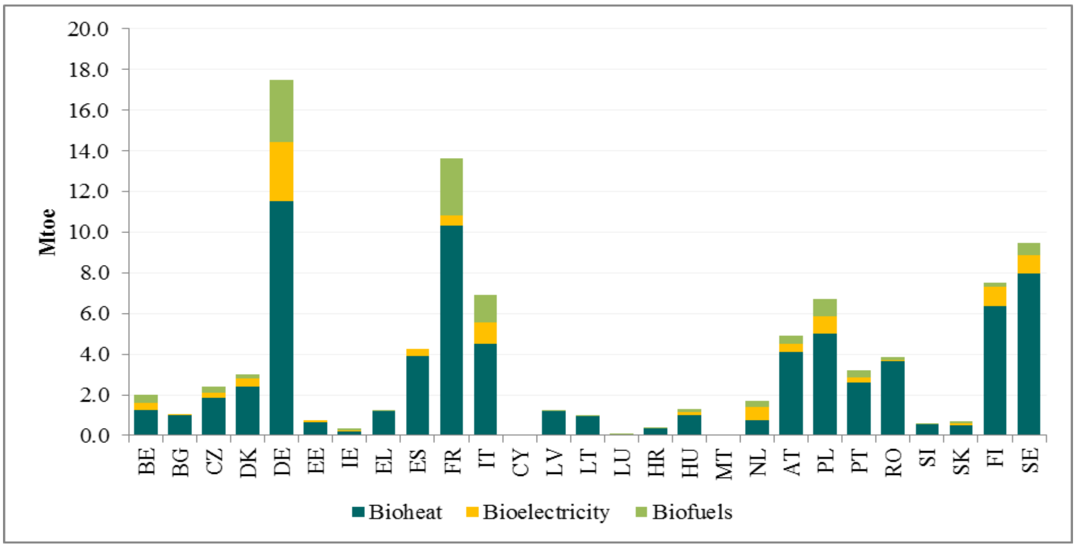

Figure 2: Final bioenergy demand by Member State (2012, Mtoe).
Source: Member States Progress Reports on Renewable Energy

2. Biomass in heat and cooling

The market for renewable heating (including biomass, solar thermal and geothermal) has a substantial potential for growth since the heating and cooling sector represent more than 46 % of the final energy consumption. Biomass consumption for heat generation increased from 40 Mtoe in 1997 to 51.2 Mtoe in 2002, 61.5 Mtoe in 2007 and 74.9 Mtoe in 2012. The biomass heat represented 14.2 % of 525.7 Mtoe of total heat generation in the EU in 2012.

Biomass heating is currently used mainly in households for heating space (over 50% of the overall bioheat) while a consistent biomass amount feeds small-scale heating plants and district heating systems. These kind of plants typically make use of modern wood log, pellet and chips burning stoves, municipal solid waste incineration or biogas installations and in cases where both power and heat are requested, cogeneration plants can also be established.

As shown in the Figure 3, bioenergy contribution to heating and cooling consumption from both solid biomass and biogas is projected to increase from 73.3 Mtoe in 2012 to 85.4 Mtoe in 2020, although bioenergy relative share in the final renewable heating and cooling consumption will decrease from over 85% to about 76% as other technologies such as thermal solar will growth faster. Solid biomass will continue to be the main source of heat from biomass in 2020, providing 80.9 Mtoe (89.5% share of total bioheat), followed by biogas with 4.5 Mtoe (4.9% share) and bioliquids with 5 Mtoe (5.5%).

The amount of biomass used in households heating is expected to slightly increase from 28.2 Mtoe in 2005 to 35.6 Mtoe in 2020, to represent 39.4% of the biomass used for heating in 2020, compared with 25.5% share of biomass used in households in 2005. In the same time period, the amount of biomass used in district heating plants is expected to have an increase more than three times from 5.8 Mtoe in 2005 to 17.7 Mtoe in 2020, accounting for a share of 19.6% of the overall bioheat produced.

As shown in Figure 4, in 2020, France is expected to be largest user of biomass for heating and cooling, with 16.5 Mtoe, accounting for a share of 18.3 % of the total bioheat in EU28, followed by Germany with 10.6 Mtoe (11.8%), Sweden with 9.4 Mtoe (10.5%), Italy with 5.5 Mtoe (6.1%) and Poland with 5.1 Mtoe (5.7%). These first five countries together will account for a 52.4% share of the overall biomass heating and cooling production in EU28.

As shown in Figure 5, in most EU-28 countries biomass consumption in the heating and cooling sector was above the 2012 indicative target from NREAPs, with a few countries some even exceeding their 2020 targets.

From the point of view of biomass-based district heating, France will also be the largest user in 2020, with 3.2 Mtoe, representing 18.1% of the district heating in EU 28. Other major users include Sweden with 3.1 Mtoe, Germany with 2.6 Mtoe, Denmark with 1.5 Mtoe, Romania with 1.3 Mtoe and Finland with 1.26 Mtoe. The first three countries (France, Sweden and Germany) will account for just more than 50% of district heating and cooling in EU28.

In 2020 France, with 7.4 Mtoe, will be the largest user of biomass in households too, accounting for 20.9% of the total biomass use in households in EU28. Other Member States with important household use of biomass will be Germany with 6 Mtoe, Italy with 3.6 Mtoe, Austria with 2.9 Mtoe and Romania with 2.7 Mtoe. The first three countries (France, Germany and Italy) will account for a share of 48.1% of use of biomass in household in EU 28.

Looking beyond 2020, under the reference scenario biomass & waste use in thermal power generation are expected to rise from 57.1 Mtoe in 2030 to 77.1 Mtoe in 2050 while the 30% renewables scenario estimates a higher penetration of biomass with 79.4 Mtoe in 2030 and 114.5 Mtoe. Biomass will reach a share in fuel input in thermal power plants of 16% in 2020, 19% in 2030 and 26% in 2050. In district heating, biomass is projected to be increasingly used as input fuel representing almost 50% of fuel input in 2020 and 57% in 2050 according to reference scenario.

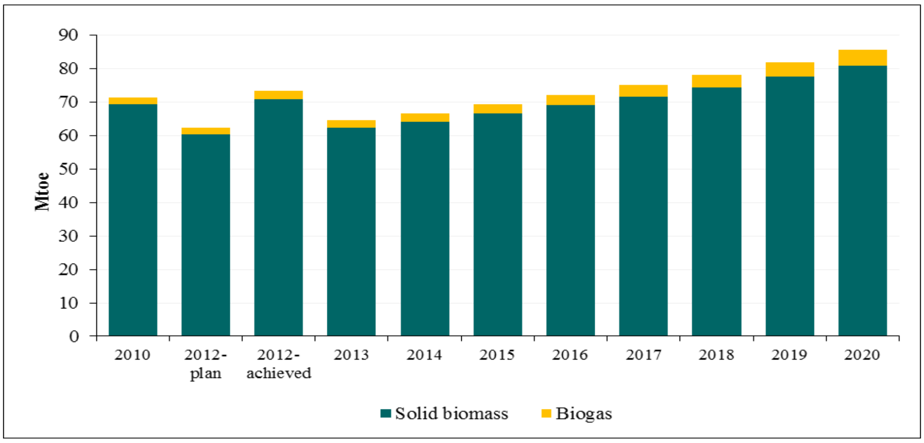

Figure 3: Outlook for total EU heat and cooling demand from solid and gaseous biomass (2012 -2020, Mtoe). Source: Progress Reports, National Renewable Energy Action Plans.

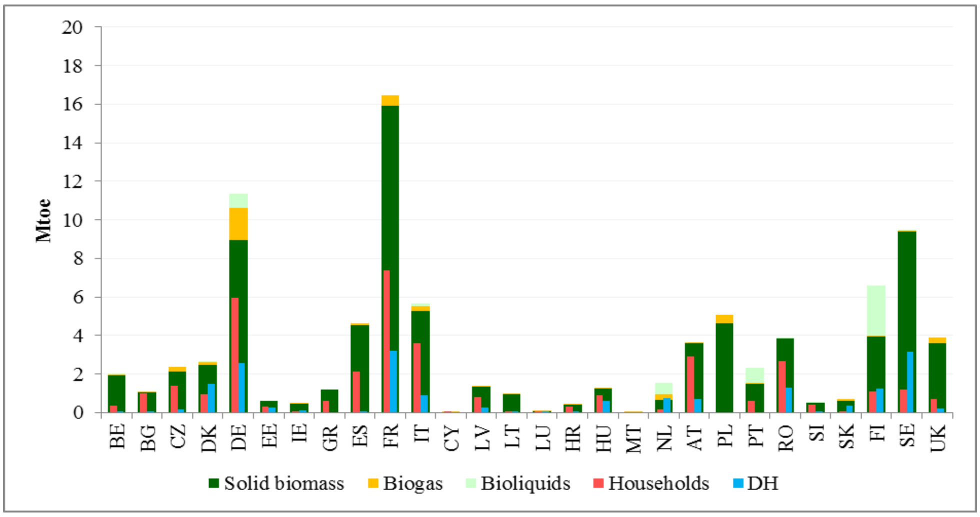

Figure 4: Heating and cooling demand from solid biomass and biogas in households and district heating (2020, Mtoe). Source: National Renewable Energy Action Plans.

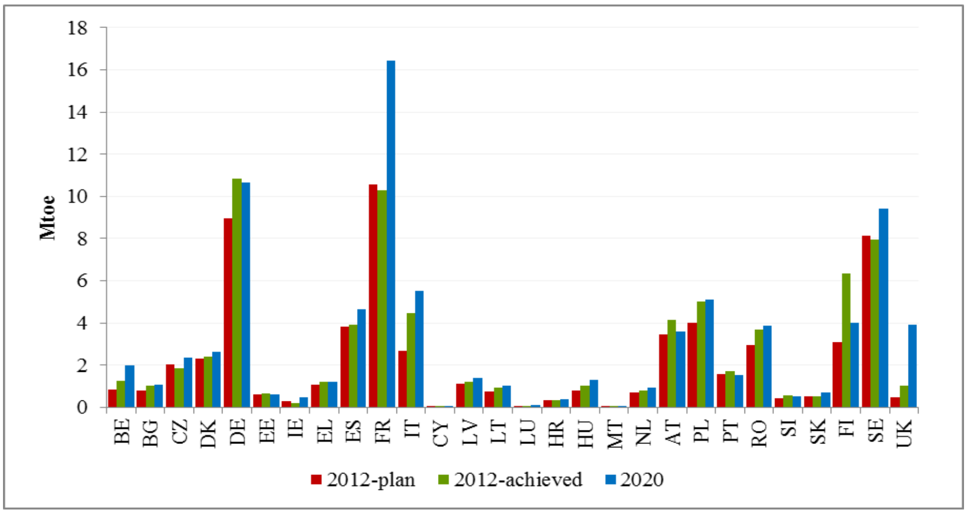

Figure 5: Heating and cooling demand from solid and gaseous biomass by Member State (2012-2020 Mtoe). Source: National Renewable Energy Action Plans, Progress Reports.

3. Electricity from biomass

In 2012 renewable electricity production amounted to 723.2 TWh (38.9% of the total renewable energy production), of which electricity from biomass (both solid biomass and biogas) amounted to 129.6 TWh (11 Mtoe), representing 17.9% of the overall renewable electricity in EU 27. Since 1999, bioelectricity has increased by 13.5%, mostly due to the development of CHP plants, large coal-biomass co-firing plants and, more recently, biogas production based on anaerobic digestion of agriculture waste and energy crops.

According to the NREAPs projections (see Figure 6), renewable electricity will reach 1210 TWh (104.1 Mtoe), representing about 34% of electricity production in 2020. The share of biomass (solid biomass and biogas) in renewable electricity is expected to remain constant around 18.3%, but to almost double in absolute terms to 220.4 TWh (19 Mtoe) in 2020. Solid biomass will remain the main source of bioelectricity generation, although its share will decrease slightly from over 72% in 2012 to about 71% in 2020, while biogas contribution will grow from 27% in 2010 to 29% in 2020.

Figure 7 shows how Germany will remain the largest producer of bioelectricity with 48 TWh accounting for 21.7% of the total EU bioelectricity in 2020, followed by UK with 26.2 TWh (2.2 Mtoe or 11.8 %), France with 17.1 TWh (7.8%), Sweden with 16.7 TWh or (7.5%), and the Netherlands with 16.6 TWh (7.5%). These first five countries will cover a share of 55.3% in bioelectricity production in EU27. Moreover, in 2020, the leading countries in electricity generation in CHP are expected to be Germany (20.8 TWh), France (17.2 TWh), Sweden (16.7 TWh), Finland (12.3 TWh), Denmark (8.8 TWh) and the Netherlands (8.3 TWh).

Beyond 2020, biomass-based electricity production is expected to grow to 335.7 TWh in 2050 under the reference scenario and to 520.6 TWh in 2050 under 30% RES decarbonisation scenario. The installed bioelectricity capacity in the EU according to reference scenario is expected to reach 39 GW in 2030 and 66 GW in 2050. The contribution of biomass in the overall electricity generation could rise from 2.6% share in 2005 and 4.3% in 2012 to 6% in 2030 and 8% in 2050 according to Reference Scenario and 10% in 2030 and 12% in 2050 according to 30% RES decarbonisation scenario. Biomass will become very significant in CHP, in which according to reference scenario reaches 35% in 2030 and 41% in 2050.

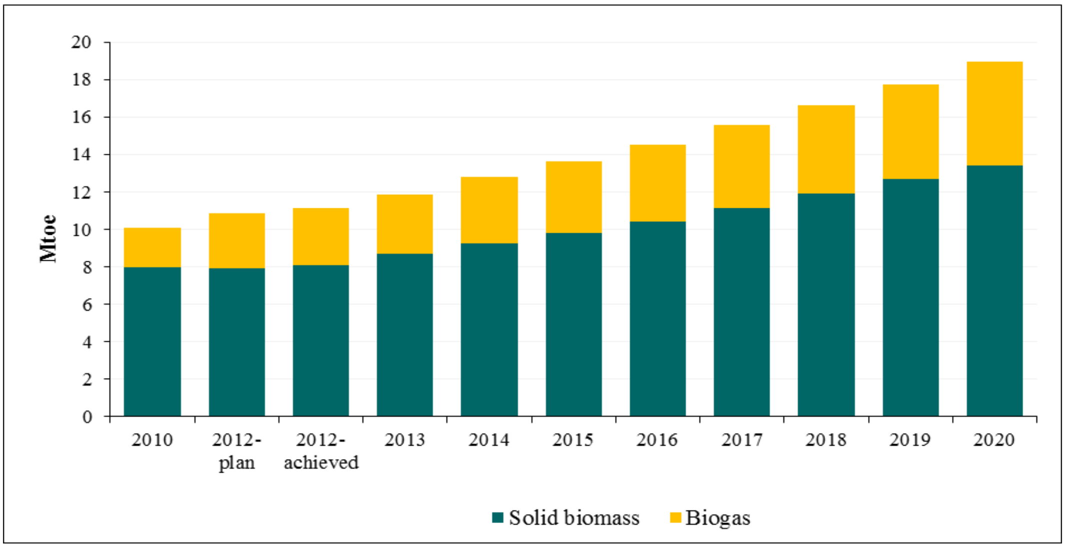

Figure 6: EU electricity demand from solid and gaseous biomass (2012-2020, Mtoe).
Source: Progress Reports, National Renewable Energy Action Plans**.**

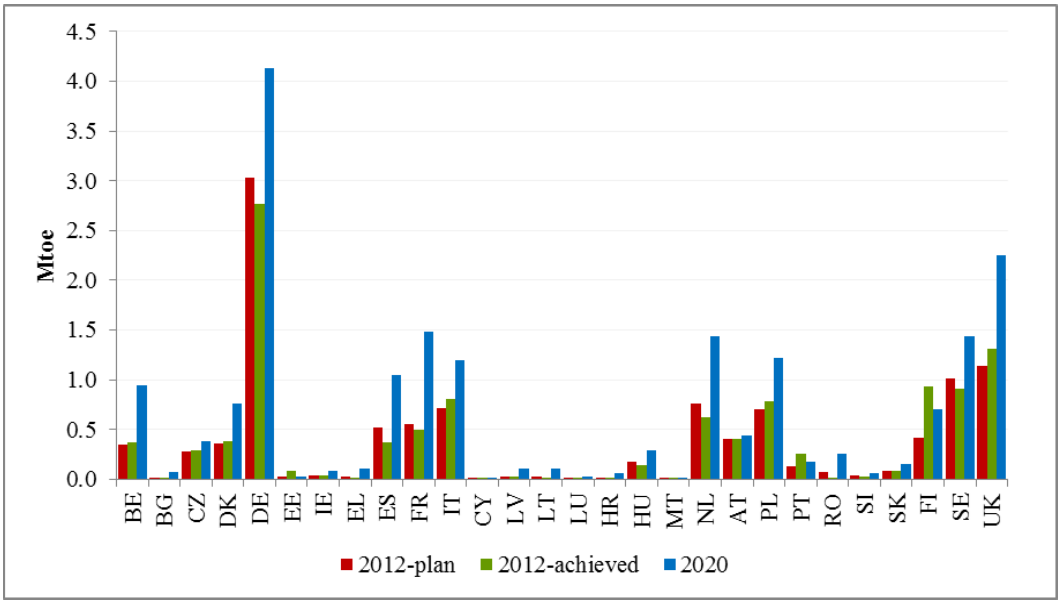

Figure 7: MS electricity demand from solid and gaseous biomass (2012-2020, Mtoe).
Source: Progress Reports, National Renewable Energy Action Plans.