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REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT

on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling

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1. Introduction

The Renewable Energy Directive[1] includes a sustainability scheme for (a) biofuels for transport and (b) bioliquids used in other sectors (electricity, heating and cooling). Article 17(9) of that Directive provides that the Commission should report by December 2009 on requirements for a sustainability scheme for energy uses of biomass other than biofuels and bioliquids (i.e. solid and gaseous fuels in electricity, heating and cooling). This report is intended to fulfil that obligation.

In the EU, around 5% of final energy consumption is from bio-energy. The projections made for the Renewable Energy Road Map[2] of January 2007 suggested that the use of biomass can be expected to double, to contribute around half of the total effort for reaching the 20% renewable energy target in 2020.

The growing production and use of biomass for energy purposes already gives rise to international trade, and this market is bound to expand in future. Most of the increased trade is expected to be in the form of pellets, a type of solid biomass, generally consisting of processing residues from forest based industries[3]. Several non-EU countries are producing wood pellets specifically for the European market. Member States that are dependent on biomass imports increasingly turn to sources in other Member States or outside the EU[4].

For biomass produced within the EU, the current legal framework (notably related to agriculture and forest management) gives certain assurances for the sustainable management of forest and agriculture[5]. The same is true for some third countries – but others lack such a framework. For this reason, concerns have been expressed that an expansion of international trade of biomass and increasing imports from third countries may lead to the unsustainable production of biomass. As a result, the main importing countries of biomass have started to develop national sustainability requirements for bio-energy. This has led to certification

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1 Directive 2009/28/EC

2 COM(2006)848

3 The European Biomass Association (AEBIOM) estimates that by 2020 up to 80 million tons of pellets could be used in the EU (33 Mtoe) http://www.aebiom.org/IMG/pdf/Pellet_Roadmap_final.pdf

4 The Netherlands for instance reported that approximately 30% of biomass consumed in the Netherlands originates from North America and 20% from Asia Source: Junginger, Sikkema, Faaij "International bioenergy trade in the Netherlands", Special IEA Bioenergy Task 40 Issue of Biomass and Bioenergy, 2008

5 Environmental rules in the Common Agriculture Policy, as well as common environmental rules on nitrates, pesticides, water quality and protected areas provide for a framework for sustainable agriculture in the EU. In forestry, the applicable forest laws of Member States include either specific regulation for obligatory reforestation after final cuttings or regulate the subject as part of sustainable forest management and forest management planning (source: UNECE European Forest Sector Outlook Studies)

schemes (voluntary and mandatory) in the agriculture, forestry and energy sectors which are not necessarily complementary or compatible[6]. This in turn has led to calls from utilities, environmental organisations and biomass importing countries for a common sustainability scheme for biomass in order to limit intra-EU cross-border barriers in setting up bio-energy projects.

In its analysis of requirements for extending the EU sustainability scheme, the Commission has considered three principles which a European-wide policy on biomass sustainability has to meet:

- effectiveness in dealing with problems of sustainable biomass use,
- cost-efficiency in meeting the objectives and
- consistency with existing policies.

The Commission has also further reflected on whether or not it is necessary to propose binding or voluntary policy measures at this stage, and this is outlined in this report.

Section 2 of the report will cover the main sustainability issues, and section 3 will make recommendations for actions to be taken. The accompanying impact assessment[7] assesses all the issues in more detail.

2. Sustainability issues for solid and gaseous biomass in electricity, heating and cooling

This section evaluates the main sustainability issues identified during the public consultation carried out in July-September 2008 and in the accompanying impact assessment, bearing in mind the need for consistency with the sustainability scheme adopted for biofuels and bioliquids under the Renewable Energy Directive.

Solid and gaseous biomass originates from agricultural crops and residues (e.g. maize, wheat, straw, animal manure), from forestry (e.g. logs, stumps, leaves and branches) wood-processing industries (bark, off-cuts, wood chips, sawdust) and from organic waste (e.g. municipal solid waste, post consumer recovered wood, refuse-derived fuels, sewage sludge). It can be virtually any organic material. Many of these feedstocks can also be used for producing transport biofuels or bioliquids used in electricity, and heating and cooling.

2.1. Sustainability in production (land management, cultivation and harvesting)

Sustainability related to biomass production concerns *inter alia* the protection of highly biodiverse ecosystems and of carbon stocks, such as those in forests. In Europe, sustainable agricultural production is regulated through the environmental cross-compliance requirements

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[6] In some Italian regions for instance, financial support is limited to power plants which use to a significant extent (50 to 70%) local biomass, defined as biomass produced within a radius of 50 km from the power generation site, whereas in the Flanders region in Belgium, power plants are not supported to use biomass coming from the region itself.

[7] The impact assessment considered the need for sustainability measures in biomass production, greenhouse gas performance and energy conversion efficiency. It did not consider whether a scheme should be binding or voluntary at EU level.

in the Common Agricultural Policy (CAP)[8]. Forest management is regulated at national level, with policy guidance through the EU Forestry Strategy and international processes such as the Ministerial Conference for the Protection of Forests in Europe (MCPFE).

It is difficult to say exactly how much primary biomass directly from forestry or agriculture is used for energy purposes. According to estimations of an ongoing study by the United Nations Economic Commission for Europe (UNECE)[9], around 24% of woody biomass for energy comes from direct removals from forests and agriculture in Europe and a large share of biomass comes from agricultural crop residues, forestry residues[10], processing residues and recovered wood[11].

Unlike some agricultural crops, including short-rotation coppice, biomass wastes and processing residues are not produced specifically for use in the energy sector, but result from other economic activity that would take place anyway. Saw mills sell on the sawdust to wood pellet manufacturers and manure is used to produce biogas through anaerobic digestion. This is one of the reasons why the use of biomass for energy purposes has been able to increase in the EU, at the same time as European forests increase in area, growing stock and standing volume.[12] There are also direct removals of forest and agricultural residues for energy purposes, such as the removal of stumps, branches and leaves or straw.

Increased demand for forestry or agricultural residues can lead to reduction of land carbon stock in the soil, for instance, if too few residues are left on the land. There are large quantities of carbon in soil organic matter, which can increase or decrease depending on the crops or trees planted and the management regime, such as the application of fertiliser.

At a global level, deforestation and forest degradation continue, whereas European and North American forests are increasing. Among the root causes for deforestation and forest degradation are weak governance structures for forest conservation and sustainable management of forest resources, in particular in developing countries[13]. A large number of countries are party to intergovernmental initiatives to put in place criteria and indicators to monitor sustainable forest management, but they are not entirely based on common principles and criteria and do not have a mechanism for verifying compliance with the agreed principles. Instead, voluntary certification schemes have been set up to verify sustainable forest

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8 The cross-compliance rules provide for *inter- alia* preservation of habitats, biodiversity, water management and use and mitigating climate change.

9 UNECE/FAO Timber Section "Joint Wood Energy Enquiry (JWEE)", Presentation at the Joint Working Party on Forest Economics and Statistics, Geneva, 31 March – 1 April 2009, http://timber.unece.org/fileadmin/DAM/meetings/03-wood-energy-steierer.pdf

10 Forest residues mean all raw materials collected directly from the forest whether or not as a result of thinning or logging activities, and they do not include residues from related industries or processing

11 Recovered wood is the source with the biggest growth rate in the past two years (UNECE, FAO JWEE)

12 However, this situation has changed somewhat during the economic recession, whereby a drop in demand for sawnwood has resulted in whole sawlogs being converted directly to wood pellets. FAO's Forest Resources Assessment (FRA) 2000 and 2005: http://w3.unece.org/pxweb/DATABASE/STAT/Timber.stat.asp

13 FAO (2009) "Small-scale bioenergy initiatives", ftp://ftp.fao.org/docrep/fao/011/aj991e/aj991e.pdf

management[14]. Only 8% of all forests are certified in the world today, compared to almost 45% in the EU[15].

In the EU, as most biomass comes from European forest residues and by-products of other industries (processing residues), and as forest management governance structures are strong, the current sustainability risks are considered to be low. However, the expected increase of demand for domestic and non-EU biomass feedstock warrants vigilance in how far and in what way the expected expansion will impact on carbon stocks in forests and agricultural land and soils.

2.2 Land use, land use change and forestry accounting

Deforestation, forest degradation and a number of other practices can result in a significant loss of terrestrial carbon and/or significant changes in productivity (e.g. harvesting practices that result in excessive removal of litter or stumps from the forests).

Emissions related to land use, land use change and forestry (LULUCF), are reported by all Annex 1 countries under the United Nations Framework Convention on Climate Change (UNFCCC), including EU Member States, Russia, Canada and the USA, but accounting methods as applied under the Kyoto Protocol need to be improved. International climate change negotiations are ongoing to decide accounting methods for LULUCF under a new international agreement. A UN programme for reducing emissions from deforestation and forest degradation in developing countries (REDD) is also being discussed under UNFCCC.

LULUCF emissions can best be addressed through a general framework that accounts for both removals and emissions of all land uses (production of food, feed, and fibre etc.). This would reward increasing carbon stocks, which is important to secure sufficient biomass resources over time. Proper global LULUCF accounting can make an important contribution in the context of the sustainable production of biomass.

2.3 Life cycle greenhouse gas (GHG) performance

The potential environmental benefits, including in terms of GHG savings that can be obtained from replacing fossil fuels with biomass sources, are one of the main driving forces for the promotion of bio-energy.

Life Cycle Assessment (LCA) is considered to be the appropriate method to evaluate the GHG performance of bio-energy compared to that of fossil alternatives. The GHG balance of bio-energy systems differs depending on the type of feedstock, carbon stock changes due to land use change, transport, processing of the feedstocks and the conversion technologies to produce heat or electricity.

There is no single LCA methodology. Methodological choices for LCA will have an effect on the measurement of the GHG performance of bio-energy. The LCA methodology for biofuels and bioliquids laid down in the Renewable Energy Directive was based on a careful analysis

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14 Such as the Programme for the Endorsement of Forest Certification (PEFC) or the Forest Stewardship Council (FSC)

15 COWI Consortium (2009) "Technical Assistance for an evaluation of international schemes to promote biomass sustainability"

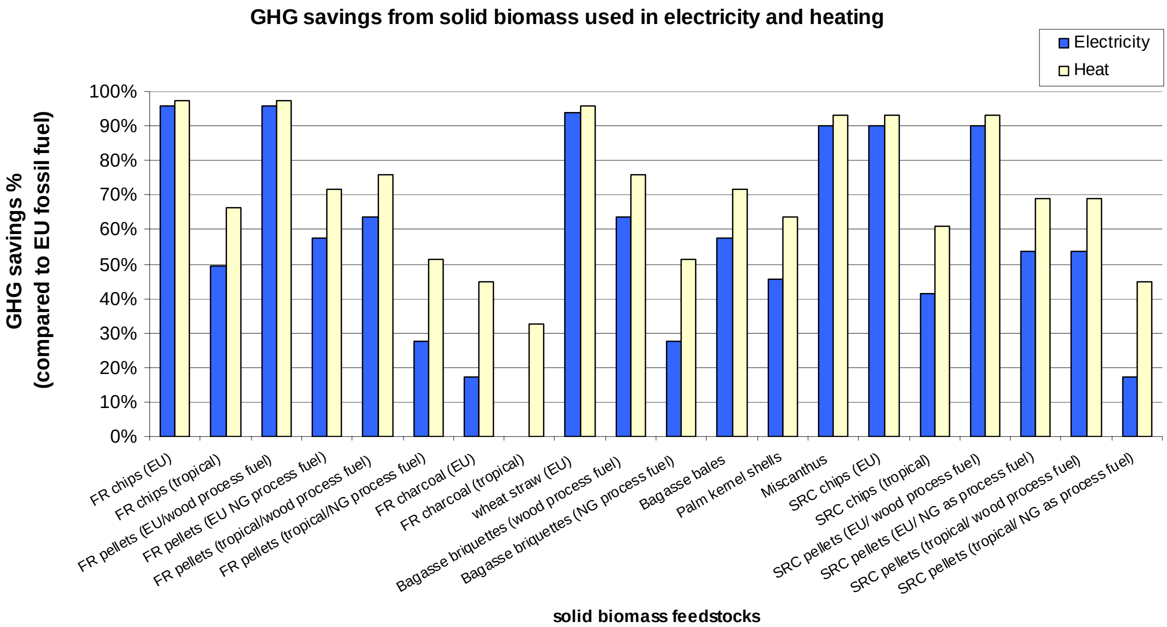
and has been endorsed by the legislator. For consistency, it would make sense to use the same methodology for all types of bio-energy.

The LCA method in the Renewable Energy Directive follows the energy chain from source to final energy, i.e. in the case of transport the final fuel. In the case of solid and gaseous biomass used for electricity, heating and cooling, the final energy is not the final fuel; it is electricity, heat and cooling. To assess the GHG performance of biomass, the LCA methodology should be extended so that conversion of the biomass fuel to electricity, heating or cooling is included in the GHG emissions calculations.

In addition, the methodology should be capable of allocating appropriate respective fractions of the GHG emissions coming from cogeneration of heat and electricity, to the amount of electricity and heat produced. Life cycle emissions for solid and gaseous biomass used in electricity, heating and cooling can then be compared to the average EU fossil electricity, heat and cooling.[16]

Taking these methodological points into account, figure 1 shows the typical greenhouse gas performance values of bio-energy produced from different solid biomass feedstocks. Losses for energy conversion are included, based on assumptions of 25% electrical conversion efficiency, and 85% thermal conversion efficiency.

Figure 1 – Typical greenhouse gas performance of solid biomass[17]



Source: JRC 2009[18]

[16] For consistency, it would be desirable for similar extensions to be made to the method for bioliquids, since these are also used for the production of electricity and heat/cooling. Such an extension would however require amendment to Annex V of the Renewable Energy Directive.

[17] FR means forest residues and SRC means short rotation coppicing

Where forest or agricultural residues are used, the greenhouse gas savings of European feedstocks are high, generally above 80% savings compared to the fossil alternative. The risk of not achieving high GHG savings is thus lower than the risks identified for biofuels used in transport, because the typical processing steps (e.g. pelletisation) generally consume less energy than the processes required to make transport biofuels. Higher emissions can occur for agricultural crops and to some extent for short-rotation coppice due to fertiliser use in agriculture, which is not normally used in forestry.

Where tropical or subtropical feedstocks are used, in particular for products which require more energy input (as in the case of charcoal), greenhouse gas emissions are typically higher because processing is often carried out using fossil energy input and (to a lesser extent) because of emissions from transport to the EU.

2.4 Energy conversion efficiency

Reducing energy consumption and increasing the efficiency of energy production are among the main energy goals of the Community. The energy conversion efficiencies of household biomass stoves and boilers vary from around 10-95%. Cogeneration (producing electricity and heat) and district heating plants can achieve between 80-90% efficiency, while large scale power and waste incineration with energy recovery achieve between 10-35% efficiency. There is therefore significant potential for reducing energy consumption through increasing efficiency.

Considerations for energy efficiency criteria for bio-energy installations have to take account of the wide range of energy conversion efficiencies which are significantly influenced by size, feedstocks, technology and end-use. For feedstock where different conversion processes are available, it is particularly important to encourage the more efficient conversion processes. For household boilers, policy development for common energy efficiency and environmental performance standards (including related to air quality) is under way under the eco-design for energy-using products directive[19]. Measures are also introduced in the energy labelling directive[20], and the recast of the energy performance of buildings directive[21].

These policy instruments cover the energy conversion of (mainly) household stoves and boilers whether they are using fossil or renewable energy feedstocks. In principle, a common energy efficiency policy approach for both fossil and biomass fuels is preferable, in order to avoid the risk of switching to fossil energy if the same standards do not also apply to fossil fuel applications. Minimum efficiency requirements solely for bio-energy installations may lead to disincentivising the energy use of biomass waste streams which have no other use (e.g. sewage sludge).

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18 The values in figure 1 do not take into account the positive or negative greenhouse gas effects of land use change, but these effects should be included in assessing biomass policies.

19 Directive 2005/32/EC

20 Directive 92/75/EEC

21 COM(2008)780, in particular Article 8 related to minimum energy performance requirements of technical building systems

3. Recommendations for appropriate action to address sustainability issues

The sustainability concerns identified in section 2 raise the issue of (1) at what level is it appropriate for action to be taken and (2) what should the content of the action be?

3.1. At what level should the action be taken?

The wide variety of biomass feedstocks make it difficult to put forward a harmonised scheme at this stage. Different feedstocks present different challenges to sustainable production, greenhouse gas performance or efficient energy conversion. It is also considered that the sustainability risks relating to domestic biomass production originating from wastes and agricultural and forestry residues, where no land use change occurs, are currently low.

For these reasons, the Commission does not at this stage propose binding criteria at EU level. However, to minimise the risk of the development of varied and possibly incompatible criteria at national level, leading to varying degrees of mitigation, barriers to trade and stifling the growth of the bio-energy sector (and imposing increased costs on Member States for meeting their national targets), the Commission hereby makes recommendations to Member States on the development of their sustainability schemes.

3.2 Recommended sustainability criteria

The Commission recommends that Member States that either have, or who introduce, national sustainability schemes for solid and gaseous biomass used in electricity, heating and cooling, ensure that these in almost all respects are the same as those laid down in the Renewable Energy Directive[22]. This would ensure greater consistency and avoid unwarranted discrimination in the use of raw materials.

Due to the characteristics of the production and use of solid and gaseous biomass used in electricity, heating and cooling, the following differences are appropriate:

1. According to Article 17(1) of the Renewable Energy Directive, wastes and certain residues should only be required to fulfil the requirements of Article 17(2), i.e. the greenhouse gas performance criteria. It is challenging to set greenhouse gas default

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22 For ease of reference, it is recalled that the sustainability criteria of the renewable Energy Directive 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. [Compliance with the criteria can be proven in one of three ways: (1) EU-level recognition of voluntary schemes which address one or more of the sustainability criteria (2) through bilateral or multilateral agreements with third countries and (3) by Member States' national verification methods.] The consequences of not meeting the requirements of the sustainability scheme are contained in Article 17(1), detailing that biofuels and bioliquids which do not meet the 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.

values for the wide range of possible feedstocks such as wastes, or common default values to cover a range of similar feedstocks or a mixture of feedstocks. It is also difficult to justify imposing obligations and additional costs for proving compliance with greenhouse gas performance criteria, for sectors which routinely achieve high greenhouse gas savings such as by using wastes. It is recommended that the greenhouse gas performance criterion is not applied to wastes, but to the products for which default greenhouse gas emission values have been calculated as listed in Annex II.

2. The methodology for the calculation of greenhouse gas emissions should be extended as described in section 2.2, resulting in the methodological rules described in Annex I. Default and typical greenhouse gas performance values calculated using this methodology are presented for primary solid and gaseous biomass fuels in Annex II. The recommended methodology in Annex I would require that the default value is divided by the actual energy conversion efficiency value of the electricity or heating/ cooling installation to obtain a value for total greenhouse gas emissions.

3. To stimulate higher energy conversion efficiency, Member States should in their support schemes for electricity, heating and cooling installations differentiate in favour of installations that achieve high energy conversion efficiencies, such as high-efficiency cogeneration plants as defined under the Cogeneration Directive[23]. For small-scale solid-fuel boilers[24], the Commission is expected to propose minimum efficiency and environmental requirements related to air quality in 2010.

LULUCF accounting and provisions related to REDD could help addressing land use related sustainability issues in third countries. As such rules are not yet in place at international level, and because of the relatively higher sustainability risks related to forestry, the Commission will closely monitor progress in this field and, by 31 December 2011, reassess the situation. In case LULUCF and REDD issues are insufficiently addressed at international level, or if countries are not engaging sufficiently to implement such rules, the Commission may consider to introduce a procedure to address potential sustainability problems.

3.3 Scope of application of the criteria

The biomass sector is fragmented and there are numerous small-scale users of biomass. It is recommended that sustainability schemes apply only to larger energy producers of 1 MW thermal or 1MW electrical capacity or above. Placing requirements on small-scale producers to prove sustainability would create undue administrative burden, although higher performance and efficiency should be encouraged.

3.4. Requirements for reporting and monitoring

Biomass trade in the EU plays an important role in the development of the bio-energy sector. National and European statistics have large knowledge gaps concerning the amount of biomass used for energy purposes. In order to improve data on biomass use, it is

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23 Directive 2004/08/EC

24 All solid fuels (e.g. coal, biomass) have to be covered by energy efficiency policy in order to ensure a level playing field.

recommended that Member States keep records of the origin of primary biomass used in electricity, heating and cooling installations of 1 MW or above, helping to improve statistics on biomass use and to monitor the effects of biomass use on the areas of origin. Member States are also encouraged to monitor small-scale (mainly household) biomass use through surveys and strive to improve the availability and quality of data.

It is recommended that the information collected by Member States is communicated to the Commission so that the Commission may take this into account in monitoring potentially vulnerable areas. Further development on the emergence of wider sustainability regimes affecting forests (e.g. sustainable forest management schemes) or other agricultural or forest products will be monitored, to assess whether sustainability requirements for only the energy uses of forest and agricultural biomass help to deliver on sustainable development for the forest and agricultural sectors. The Commission will also examine efforts to account for global emissions from land use, land use change and forests under the United Nations Framework Convention on Climate Change.

4. Conclusions

Member States are invited to take into account the above recommendations for sustainability criteria and for reporting and monitoring. These recommendations aim to promote the sustainable production and use of biomass, a well functioning internal market in biomass trade and to lift barriers to bio-energy development. It is therefore recommended in particular to those Member States that have already developed sustainability criteria which differ from the above recommendations, to duly integrate these recommendations. In any event, Member States must ensure that national sustainability schemes do not constitute a means of arbitrary discrimination or a disguised restriction on trade.

The Commission will report by 31 December 2011 on whether national schemes have sufficiently and appropriately addressed the sustainability related to the use of biomass from inside and outside the EU, whether these schemes have led to barriers to trade and barriers to the development of the bio-energy sector. It will, *inter alia*, consider if additional measures such as common sustainability criteria at EU level would be appropriate. The Commission will also report on how international climate change negotiations and other policy developments including LULUCF accounting and REDD relate to the sustainable production of biomass, whether used for energy, food, feed or fibre.

ANNEX I – Methodology for calculating greenhouse gas performance of solid and gaseous biomass used in electricity, heating and cooling

1a. Greenhouse gas emissions from the production of solid and gaseous biomass fuels, before conversion into electricity, heating and cooling, shall be calculated as:

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

where

E = total emissions from the production of the fuel before energy conversion;

e_{ec} = emissions from the extraction or cultivation of raw materials;

e_{l} = annualised emissions from carbon stock changes caused by land use change;

e_{p} = emissions from processing;

e_{td} = emissions from transport and distribution;

e_{u} = emissions from the fuel in use, that is greenhouse gases emitted during the combustion of solid and gaseous biomass;

e_{sca} = emission savings from soil carbon accumulation via improved agricultural management;

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

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

Emissions from the manufacture of machinery and equipment shall not be taken into account.

1b. Greenhouse gas emissions from the use of solid and gaseous biomass in producing electricity, heating or cooling including the energy conversion to electricity and/ or heat or cooling produced shall be calculated as follows:

For energy installations delivering only useful heat:

$$EC_{h} = \frac{E}{\eta_{h}}$$

For energy installations delivering only electricity:

$$EC_{el} = \frac{E}{\eta_{el}}$$

For energy installations delivering only useful cooling:

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

Where:

EC_h = Total greenhouse gas emissions from the final energy commodity, that is heating.

EC_{el} = Total greenhouse gas emissions from the final energy commodity, that is electricity.

EC_c = Total greenhouse gas emissions from the final energy commodity, that is cooling

η_{el} = The electrical efficiency, defined as the annual electricity produced divided by the annual fuel input.

η_h = The thermal efficiency, defined as the annual useful heat output, that is heat generated to satisfy an economically justifiable demand for heat, divided by the annual fuel input.

η_c = The thermal efficiency, defined as the annual useful cooling output, that cooling generated to satisfy an economically justifiable demand for cooling, divided by the annual fuel input.

Economically justifiable demand shall mean the demand that does not exceed the needs of heat or cooling and which would otherwise be satisfied at market conditions.

For the electricity coming from energy installations delivering useful heat:

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

For the useful heat coming from energy installations delivering electricity:

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

Where:

C_{el} = Fraction of exergy in the electricity, or any other energy carrier other than heat, set to 100 % (C_{el} = 1).

C_h = Carnot efficiency (fraction of exergy in the useful heat).

Carnot efficiency, C_h, for useful heat at different temperatures:

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

Where:

T_h = Temperature, measured in absolute temperature (kelvin) of the useful heat at point of delivery as final energy

T_0 = Temperature of surroundings, set at 273 kelvin (equal to 0 °C)

For T_h < 150 °C (423 kelvin), C_h is defined as follows:

C_h = Carnot efficiency in heat at 150 °C (423 kelvin), which is: 0.3546

2. Greenhouse gas emissions from solid and gaseous biomass fuels for electricity, heating and cooling purposes, EC, shall be expressed in terms of grams of CO_2 equivalent per MJ of final energy commodity (heat, cooling or electricity), gCO_{2eq}/MJ.

3. Greenhouse gas emission savings from heat, cold and electricity being generated from solid and gaseous biomass shall be calculated as:

SAVING = $(EC_{F\ (h,el,c)} - EC_{h,el,c})/EC_{F\ (h,el,c)}$,

where

$EC_{h,el\ ,c}$ = total emissions from the heat, cooling or the electricity; and

$EC_{F\ (h,el,c)}$ = total emissions from the fossil fuel comparator for heat, cooling or electricity.

4. The greenhouse gases taken into account for the purposes of point 1 shall be CO_2, N_2O and CH_4. For the purpose of calculating CO_2 equivalence, those gases shall be valued as follows:

CO_2: 1

N_2O: 296

CH_4: 23

5. Emissions from the extraction, harvesting or cultivation of raw materials, e_{ec}, shall include emissions from the extraction, harvesting or cultivation process itself; from the collection of raw materials; from waste and leakages; and from the production of chemicals or products used in extraction or cultivation. Capture of CO_2 in the cultivation of raw materials shall be excluded. Certified reductions of greenhouse gas emissions from flaring at oil production sites anywhere in the world shall be deducted. Estimates of emissions from cultivation or harvesting may be derived from the use of averages calculated for smaller geographical areas than those used in the calculation of the default values, as an alternative to using actual values.

6. Annualised emissions from carbon stock changes caused by land-use change, e_l, shall be calculated by dividing total emissions equally over 20 years. For the calculation of those emissions the following rule shall be applied:

$e_l = (CS_R - CS_A) \times 3{,}664 \times 1/20 \times 1/P - e_B$,

where

e_l = annualised greenhouse gas emissions from carbon stock change due to land-use change (measured as mass of CO_2-equivalent per unit solid and gaseous biomass energy);

CS_R = the carbon stock per unit area associated with the reference land use (measured as mass of carbon per unit area, including both soil and vegetation). The reference land use shall be the land use in January 2008 or 20 years before the raw material was obtained, whichever was the later;

CS_A = the carbon stock per unit area associated with the actual land use (measured as mass of carbon per unit area, including both soil and vegetation). In cases where the carbon stock accumulates over more than one year, the value attributed to CS_A shall be the estimated stock per unit area after 20 years or when the crop reaches maturity, whichever the earlier;

P = the productivity of the crop (measured as solid and gaseous biomass energy per unit area per year); and

e_B = bonus of 29 g CO_{2eq}/MJ solid and gaseous biomass if biomass is obtained from restored degraded land under the conditions provided for in point 7.

7. The bonus of 29 g CO_{2eq}/MJ shall be attributed if evidence is provided that the land:

(a) was not in use for agriculture or any other activity in January 2008; and

(b) falls into one of the following categories:

(i) severely degraded land, including such land that was formerly in agricultural use;

(ii) heavily contaminated land.

The bonus of 29 g CO_{2eq}/MJ shall apply for a period of up to 10 years from the date of conversion of the land to agricultural use, provided that a steady increase in carbon stocks as well as a sizable reduction in erosion phenomena for land falling under (i) are ensured and that soil contamination for land falling under (ii) is reduced.

8. The categories referred to in point 7(b) are defined as follows:

(a) "severely degraded land" means land that, for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded;

(b) "heavily contaminated land" means land that is unfit for the cultivation of food and feed due to soil contamination.

Such land shall include land that has been the subject of a Commission decision in accordance with the fourth subparagraph of Article 18(4) of Directive 2009/28/EC.

9. In accordance with Annex V.C point 10 of Directive 2009/28/EC, the Commission guidelines for the calculation of land carbon stocks adopted in relation to that Directive, drawing on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories — volume 4, shall serve as the basis for the calculation of land carbon stocks.

10. Emissions from processing, e_p, shall include emissions from the processing itself; from waste and leakages; and from the production of chemicals or products used in processing.

In accounting for the consumption of electricity not produced within the fuel production plant, the greenhouse gas emission intensity of the production and distribution of that electricity shall be assumed to be equal to the average emission intensity of the production and distribution of electricity in a defined region. By derogation from this rule, producers may use an average value for an individual electricity production plant for electricity produced by that plant, if that plant is not connected to the electricity grid.

11. Emissions from transport and distribution, e_{td}, shall include emissions from the transport and storage of raw and semi-finished materials and from the storage and distribution of finished materials. Emissions from transport and distribution to be taken into account under point 5 shall not be covered by this point.

12. Emissions from the fuel in use, e_u, shall be taken to be zero for solid and gaseous biomass.

13. Emission saving from carbon capture and sequestration, e_{ccs}, that have not already been accounted for in e_p, shall be limited to emissions avoided through the capture and sequestration of emitted CO_2 directly related to the extraction, transport, processing and distribution of fuel.

14. Emission saving from carbon capture and replacement, e_{ccr}, shall be limited to emissions avoided through the capture of CO_2 of which the carbon originates from biomass and which is used to replace fossil-derived CO_2 used in commercial products and services.

15. Where a fuel production process produces, in combination, the energy carrier for which emissions are being calculated and one or more other products ("co-products"), greenhouse gas emissions shall be divided between the energy carrier or its intermediate product and the co-products in proportion to their energy content. For the accounting of useful heat as co-product, the allocation between the useful heat and other co-products shall be made using the Carnot efficiency (C), where all other co-products than heat has a C equal to 1.

$$A_i = \frac{E}{\eta_i}\left(\frac{C_i \cdot \eta_i}{C_i \cdot \eta_i + C_h \cdot \eta_h}\right)$$

Where:

A_i = Allocated GHG emissions at allocation point to (co-)product i

E = Total GHG emissions up to allocation point

η_i = The fraction of co-product or product, measured in energy content, defined as the annual amount of co-product or product produced divided by the annual energy input.

η_h = The fraction of heat produced together with other co-products or products, defined as the annual useful heat output divided by the annual energy input.

C_i = Fraction of exergy in the energy carrier (else than heat), equal to 1

C_h = Carnot efficiency (fraction of exergy in the useful heat).

Carnot efficiency, C_h, for useful heat at different temperatures:

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

Where:

T_h = Temperature, measured in absolute temperature (kelvin) of the useful heat at point of delivery.

T_0 = Temperature of surroundings, set at 273 kelvin (equal to 0 °C)

For T_h < 150 °C (423 kelvin), C_h is defined as follows:

C_h = Carnot efficiency for heat at 150 °C (423 kelvin), which is: 0.3546

16. For the purposes of the calculation referred to in paragraph 15, the emissions to be divided shall be e_{ec} + e_l, + those fractions of e_p, e_{td} and e_{ee} that take place up to and including the process step at which a co-product is produced. If any allocation to co-products has taken place at an earlier process step in the life-cycle, the fraction of those emissions assigned in the last such process step to the intermediate fuel product shall be used for this purpose instead of the total of those emissions.

In the case of solid and gaseous biomass, all co-products, including electricity that does not fall under the scope of paragraph 14, shall be taken into account for the purposes of this calculation, except for agricultural crop residues, including straw, bagasse, husks, cobs and nut shells. Co-products that have negative energy content shall be considered to have an energy content of zero for the purpose of the calculation.

Wastes, secondary biomass and primary forest and agricultural crop residues, including tree tops and branches, straw, bagasse, husks, cobs and nut shells, and residues from processing, including crude glycerine (glycerine that is not refined), shall be considered to have zero life-cycle greenhouse gas emissions up to the process of collection of those materials.

In the case of fuels produced in refineries, the unit of analysis for the purposes of the calculation referred to in paragraph 15 shall be the refinery.

17. For solid and gaseous biomass, for electricity production, for the purposes of the calculation referred to in point 4, the fossil fuel comparator $EC_{F(el)}$ shall be 198 gCO_{2eq}/MJ electricity.

For solid and gaseous biomass used for heating production, for the purposes of the calculation referred to in point 4, the fossil fuel comparator $EC_{F(h)}$ shall be 87 gCO_{2eq}/MJ heat.

For solid and gaseous biomass used for cooling through absorption heat pumps, for the purposes of the calculation referred to in point 4, the fossil fuel comparator $EC_{F(c)}$ shall be 57 gCO2eq/MJ cooling.

ANNEX II – Typical and default values for solid and gaseous biomass if produced with no net carbon emissions from land use change

Primary solid and gaseous biomass pathways	Typical greenhouse gas emissions (gCO_{2eq}/MJ)	Default greenhouse gas emissions (gCO_{2eq}/MJ)
Wood chips from forest residues (European temperate continental forest)	1	1
Wood chips from forest residues (tropical and subtropical forest)	21	25
Wood chips from short rotation forestry (European temperate continental forest)	3	4
Wood chips short rotation forestry (tropical and sub-tropical e.g. eucalyptus)	24	28
Wood briquettes or pellets from forest residues (European temperate continental forest) – using wood as process fuel	2	2
Wood briquettes or pellets from forest residues (tropical or subtropical forest) – using natural gas as process fuel	17	20
Wood briquettes or pellets from forest residues (tropical or subtropical forest) – using wood as process fuel	15	17
Wood briquettes or pellets from forest residues (European temperate continental forest) – using natural gas as process fuel	30	35
Wood briquettes or pellets from short rotation forestry (European temperate continental forest) – using wood as process fuel	4	4
Wood briquettes or pellets from short rotation forestry (European temperate continental forest) – using natural gas as process fuel	19	22
Wood briquettes or pellets from short rotation forestry (tropical and sub-tropical e.g. eucalyptus) – wood as process fuel	18	22

Wood briquettes or pellets from short rotation forestry (tropical and sub-tropical e.g. eucalyptus) – natural gas as process fuel	33	40
Charcoal from forest residues (European temperate continental forest)	34	41
Charcoal from forest residues (tropical and sub-tropical forest)	41	50
Charcoal from short rotation forestry (European temperate continental forest)	38	46
Charcoal from short rotation forestry (tropical and sub-tropical e.g. eucalyptus)	47	57
Wheat straw	2	2
Bagasse briquettes – wood as process fuel	14	17
Bagasse briquettes – natural gas as process fuel	29	35
Bagasse bales	17	20
Palm kernel	22	27
Rice husk briquettes	24	28
Miscanthus bales	6	7
Biogas from wet manure	7	8
Biogas from dry manure	6	7
Biogas from wheat and straw (wheat whole plant)	18	21
Biogas from maize as whole plant (maize as main crop)	28	34
Biogas from maize as whole plant (maize as main crop) – organic agriculture	16	19