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IMPACT ASSESSMENT

Accompanying document to the

Report from the Commission to the Council and the European Parliament on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling

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Section 1: Procedural issues and consultation of interested parties

- Organisation and timing

Article 17(9) of the Renewable Energy Directive[1] (RES Directive) requires the Commission to report by 31 December 2009 on requirements for a sustainability scheme for energy uses of biomass (other than biofuels and bioliquids), where appropriate, accompanied by proposals for a sustainability scheme.

The report is in the Commission's Work Programme for December 2009/ January 2010 (TREN WP 2009 Item 37).

An inter-service steering group was established. The first meeting took place on 9th October 2008 to introduce the timetable for the report and the steps to be taken in elaborating an IA. Two external studies (see details below) were introduced (a third having being concluded in February 2008) and services were invited to participate throughout the timeframe of the studies. A second meeting took place on 19 March 2009 to debate the policy options and to update the services about the external studies and about expert group meetings. A third meeting took place on 19 May 2009 to finalise the policy options and to discuss the presentation of impacts. The last meeting took place on 5 August 2009 to discuss the final draft impact assessment.

The Impact Assessment Board issued its opinion on 28th September 2009, recommending clarification of the distinction between the effects of a sustainability scheme and the effects of increasing use of biomass. It also asked that the administrative impacts be assessed using the EU's Standard Cost Model and that the impact on third countries be made clearer. Finally the Board asked that the report explain the potential impacts of international negotiations with regard to accounting methods on land use land use change and forestry (LULUCF). These points have been addressed in this final version of the Impact Assessment.

- Consultation and expertise

A public consultation was carried out July-September 2008. 252 responses in total were received, of these, 243 have been taken into account, due to some replies being sent more than once and/or from the same business association and therefore have been taken into consideration only once.

The questions covered five areas:

– General questions about the appropriateness and scope of a biomass sustainability scheme

[1] Directive 2009/28/EC

– Consideration of the greenhouse gas methodology – based on the methodology proposed in Annex V of the RES Directive)

– Consideration of promoting end-conversion efficiency

– Consideration of other environmental sustainability criteria such as for sustainable forest management

– Verification of sustainability criteria

8% of the respondents were public authorities, 22% were citizens and the rest came from organisations, among which 58% were industry and business, and 7% non-governmental organisations and research institutions. The results are further elaborated in section 3, but overall there was a large consensus that sustainability requirements for biomass are necessary.

Many stakeholders called for consistency with the sustainability scheme for biofuels used for transport as laid down in the RES Directive, and claimed that the sustainability scheme should not have different treatment for other biomass used for energy purposes. Consistency is also important for the development of the internal market. 55% of respondents advocated a legally binding scheme, where only biomass which meets sustainability criteria would count towards the national renewable energy targets laid down in the RES Directive. 18% advocated a legally binding scheme where biomass producers (biomass from agriculture, forestry and waste) could only place sustainable biomass on the market, and 10% thought that legally binding requirements should be set for electricity and heat producers (excluding households) to procure only sustainable biomass. Those who advocated a type of legally binding scheme believed that voluntary schemes are not reliable and give too much leeway to individual interests.

17% of respondents thought that such criteria should be non-binding, as they considered that existing voluntary schemes, such as for sustainable forestry are sufficient. Most proponents of a voluntary scheme came from forest-based industry and argued that legally binding schemes are not practicable because they reduce flexibility for new biomass markets and could discriminate against small-scale producers, and that they are not justifiable without also having legally binding schemes for other biomass uses such as paper, furniture, etc.

On the question of minimum greenhouse gas (GHG) requirements for biomass, the majority of respondents (58%) were in favour of a minimum GHG saving of 35%, (i.e. the same threshold as for biofuels and bioliquids as the Commission proposed in the RES Directive[2]). 18% of the respondents (including some public authorities and environmental organisations) advocated a threshold figure which should be higher than for biofuels for transport, whereas 5% argued for a threshold figure lower than for biofuels (e.g. waste industry). 19% of the respondents objected to setting requirements for GHG savings for biomass in general (including forest-based industry).

On the question of promoting efficient energy conversion, there was wide support among respondents for using resources efficiently but some argued that energy-conversion efficiency should be treated separately because efficiency requirements might discourage biomass development and rather encourage fossil fuels for which criteria are not imposed.

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2 The RES-Directive in fact lays down 35% GHG saving increasing to 50% GHG saving in 2017 for established installations and 60% GHG savings from 2018 for new installation.

On sustainable production of biomass, 67% of respondents were in favour of sustainable forest management criteria for forest biomass, but the 33% of respondents who opposed sustainable forest management criteria considered that proper implementation of existing criteria defined by the Ministerial Conference on the Protection of Forests in Europe (MCPFE) and other voluntary schemes for forest, such as the Forest Stewardship Council (FSC), the Programme for the Enforcement of Certification Schemes (PEFC) etc., are sufficient. Most of those who opposed came from the forest sector.

Some stakeholders, including international organisations, said that experience with existing certification schemes can help to build on existing schemes so that costs can be kept to a minimum. It was stressed furthermore that specific guidance and regulation of biomass for energy purposes should be simple and should allow simple methods of production by small-scale producers.

The results of the public consultation can be found at:

http://ec.europa.eu/energy/renewables/consultations/2008_09_30_biomass_en.htm

Three external studies were commissioned:

1. Contract No TREN/D1/2008/FV489-1/SI2.512885 on "Technical assistance to implement the EU Biomass Action Plan: evaluation of options to promote biomass efficiency", carried out by ECORYS NL in cooperation with Ecofys NL. The contract started in December 2008 and final report was submitted in June 2009 (Ecorys, 2009).

2. Contract No TREN/D1/2008/FV-490-1/SI2.528333 on "Technical assistance for an overview of international trade opportunities for sustainable biomass and biofuels", carried out by the COWI Consortium consisting of ECN Energy Research Centre of the Netherlands, Copernicus Institute at Utrecht University, Forest and Landscape Denmark at the University of Copenhagen, COWI A/S and ControlUnion Certifications. The contract started in April 2009 and final report on tasks 1 and 2 (global availability and impacts of sustainability schemes) were submitted end July 2009. A final report on Task 4 on assessing options for certifying chain of custody for forest products and forest management was submitted at the end of October 2009 (The COWI Consortium 2009).

3. A study by the Biomass Technology Group BTG BV[3] on "Sustainability Criteria and certification systems on sustainable biomass production" was finalised in February 2008 and served as an input into the assessment (BTG, 2008). The study is available at: http://ec.europa.eu/energy/renewables/bioenergy/doc/sustainability_criteria_and_certification_systems.pdf.

The Commission organised and attended various conferences and stakeholder meetings, including: MCPFE ad-hoc working group on biomass sustainability on 12 January (Brussels) and 18-19 February (Lichtenstein) 2009, 11-12 June 2009 (Sweden), DG TREN workshop on biomass sustainability held on 18 March 2008 (Brussels), DG TREN and AEBIOM jointly organised conference "Sustainable Bio-energy Strategies" held on 9 February (Brussels), Dutch Ministry of Economy workshop on GHG pathways for biomass held on 7 April 2009.

3 BTG (2008) "Sustainability criteria and certification systems on sustainable biomass production", The Netherlands

The Commission's minimum standards for consultation were all met.

Section 2: Problem definition

- What are the underlying drivers of the problem? What is the issue or problem that may require action?

The EU needs to increase its use of biomass for energy purposes to reach the 2020 targets agreed under the RES Directive (in order to contribute to reduce overall greenhouse gas emissions, increase competitiveness and the security of energy supply).

Biomass is a renewable energy source. Where biomass is used, it is important to have measures in place to encourage regeneration (in forestry and agriculture). As biomass resources are not infinite, its efficient use should also be encouraged.

For the purposes of this IA, only solid and gaseous biomass used for electricity and heating are under consideration as transport biofuels and bioliquids are covered by a sustainability scheme under Articles 17-19 of the RES-Directive. BOX A below explains the different biomass sources and energy conversion routes.

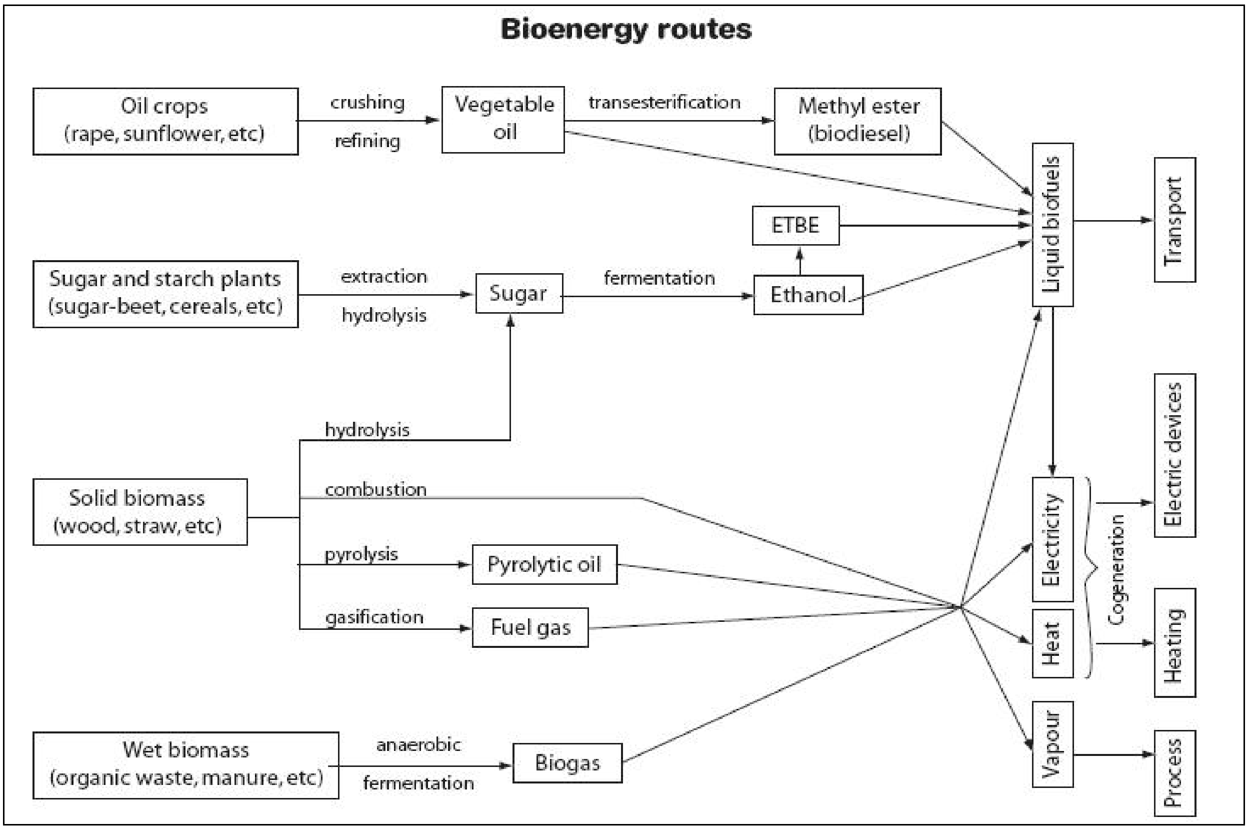
BOX A - Biomass sources and energy conversion routes

Biomass refers to "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"[4]. Using various transformation processes such as combustion, gasification, pyrolysis the biomass is either transformed into transport biofuels, bioheat or bioelectricity.

Biomass originates from forest (logs, bark, wood chips, sawdust, pellets etc) agriculture (rape, wheat, maize etc) and waste streams (municipal solid waste, post consumption wood waste, refuse-derived fuels, sewage sludge, etc.), but can be virtually any organic material.

Each biomass resource has different characteristics in terms of calorific value, moisture and ash content, etc. that require appropriate conversion technologies for bio-energy production. These conversion routes use chemical, thermal and/or biological processes, and can be used for transport, electricity or heating as follows:

4 As defined under Article 2(e) in Directive 2009/28/EC



The first issue to consider is biomass availability. There is a variety of literature on the future availability of biomass for energy purposes. In its proposal for a Renewable Energy Directive, the Commission based its assumptions on biomass availability on a study carried out by the European Environment Agency (EEA)[5], which estimated that around 235 Mtoe of EU-produced biomass will be available in 2020 for energy use.

The Commission asked the COWI Consortium to assess the wider literature on this issue for 2020-2050 (COWI Consortium 2009). The report finds that the largest difference between study results for the availability of biomass for energy production is due to the assumed availability of land, which, in turn, is heavily influenced by productivity development assumptions and development of technology. It was found that the EEA's assumptions are relatively conservative, as EEA considers lower productivity growth estimations due to environmentally sound farming (e.g. organic farming) for 2020 and does not cover Romania and Bulgaria.

The COWI Consortium (2009) report concludes that between 2020 and 2050 the availability of land for biomass energy and of also forest biomass will continue to increase, because the population in Europe is projected to decrease, the consumption of food is saturated, while the efficiency of agriculture is projected to increase. The biomass estimates of EEA and of the modelling scenarios by Green-X for 2020 [6] were compared with other available studies. It was concluded that most Green-X assumptions on costs and potentials are reasonable given the literature sources, but that the Green-X model may be optimistic on the availability and

5 EEA (2007): Environmentally compatible bio-energy potential from European forests. Copenhagen, European Environment Agency

6 As presented in the EMPLOY-RES study available at: http://ec.europa.eu/energy/renewables/studies/doc/renewables/2009_employ_res_report.pdf

(particularly) the low costs of forestry products and residues, which could be caused by the differences in oil price assumptions.

Even if adequate sustainable biomass availability is presumed to meet the EU's 2020 targets domestically, there is a risk of negative environmental impacts, linked to the increased use of the resource and increased imports.

Biomass is an easily tradable good and environmental protection or sustainable energy policies are not uniform across the EU or indeed outside the EU where biomass can be imported from. Public intervention is justified where an intensified use of biomass leads to environmental risks in the following five areas:

1) Production of biomass (land management, cultivation and harvesting)

- market failures leading to unsustainable production of resources (negative externality) e.g. emissions arising out of land use change, are not reflected in market prices, and potential negative impacts on biodiversity, water, soils and ecosystem services.

- regulatory failure: renewable energy policy encourages Member States to use more biomass to meet their targets, while rules or pricing mechanisms for biomass production do not always take into account negative externalities, such as deforestation.

In Europe, the risk of deforestation is very low, and in fact European forests have increased in area, growing stock and standing volume in recent years (Eurostat). Nevertheless, there are market failures in forestry at a global level, as the societal and environmental benefits of forests are not correctly priced. In developing countries in particular, there is a lack of coherent sustainability rules and regulations with regard to biomass (FAO, 2009[7]).One of the root causes behind deforestation in the developing world is the weak governance structure for forest conservation and sustainable management of forest resources.

At a global level, the United Nations Framework Convention on Climate Change (UNFCCC)[8] is currently discussing a new agreement including on how to account for emissions and removals from forests as well as how to reduce emissions from deforestation in developing countries. Should these processes fail to correct the market failures, there would be concerns, in particular for imported biomass, that increased demand may lead to loss of forest area, volume or quality, or wetlands being drained to increase productive land area, leading to a negative impact on natural biodiversity.

In Europe, environmental risks are more to do with new practices arising from the intensified use of forests. This includes practices such as stump extraction and the increased removal of other forest residues. There is relatively little known about the risks posed by stump harvesting, in particular because it is not common practice in the EU. Initial research suggests that if stumps are harvested in vulnerable areas, it may lead to soil damage, carbon loss, erosion and increased turbidity and siltation of local watercourses. The removal of essential nutrients (e.g. nitrogen, phosphorus, potassium and boron), could also lead to lower soil fertility, and potential loss of tree growth in subsequent rotations. Removal of base cations[9]

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

8 http://unfccc.int/2860.php

9 Base cations are the most prevalent, exchangeable and weak acid cations in the soil, including ions such as calcium (Ca2+), magnesium (Mg2+) potassium (K+) and sodium (Na+)

(calcium, magnesium, sodium and potassium) can also lead to reducing soil buffering capacity and lead to increased soil and stream water acidification (see Forest Research UK, 2009 interim guidance[10]). The total carbon emissions during harvesting and supply of stumps as well as utilisation of wood ash as a compensatory fertiliser corresponds to 5.6 % of carbon content in biomass, according to the Forest Research Institutes of Latvia and Sweden[11].

Similar uncertainties exist about removing branches and leaves (i.e. other forest residues), which are important sources of forest nutrients, necessary to maintain soil and ecosystem health (UN-Energy, 2007[12]). More research is necessary to determine how much forest residue can be removed safely to avoid degrading soil quality and reducing yields. These forest management practices can lead to overall carbon stock changes. Regulatory failures come from the lack of information on these practices.

In agriculture, there is a risk that intensive fertilisation of agricultural land to get better yields might lead to high nitrous oxide (N2O) emissions and risk of increased water consumption or pollution. The systematic removal of agricultural residues like straw for heating may deteriorate soil organic matter (and therefore carbon balance) and soil fertility, lead to intensified use of grasslands and more frequent cutting of hedges which may endanger biodiversity. Management practices (intercropping, crop rotation, double cropping and conservation tillage etc.), can overcome some problems. Although unsustainable practices are not usually in the interest of land users/owners, their interest for short-term profits can outweigh the importance of long-term productivity. However, in the EU, agriculture is subject to a set of environmental rules under the Common Agriculture Policy and under common environmental rules.

2) GHG performance throughout the whole chain (production (cultivation/harvesting) – transport - processing – transformation):

– regulatory failure if biomass used for energy purposes does not lead to GHG savings compared to fossil alternatives The risk of not achieving high GHG savings is lower than the risks identified for biofuels used in transport, because the processing steps (e.g. pelletisation) generally consume less energy than the processes required to make transport biofuels. It should be noted however, that while biogas from waste generally has a very favourable GHG profile, biogas production from agricultural crops can lead to more emissions due to emissions associated with the production phase.

3) Inefficient conversion of resource to useful energy - a lack of clear and/or common standards/ rules for using biomass feedstocks efficiently leads to processes which may lead to an overuse of resources.

– regulatory failure because sometimes the inefficient use of biomass is given state support

[10] http://www.forestry.gov.uk/fr/INFD-7RBJ23

[11] Andis et al (May 2009) "Productivity and cost of stump harvesting for bioenergy production in Latvian conditions", http://tf.llu.lv/conference/proceedings2009/Papers/33_Andis_Lazdins.pdf, LSFRI and SKOGFORS

[12] UN-Energy (2007) "Sustainable energy: a framework for decision makers" http://www.fao.org/docrep/010/a1094e/a1094e00.htm

– market failure also exists as imperfect information and lack of transparency in the market makes households unaware of the opportunities for energy savings in the long-term, by switching to more efficient heating technologies.

4) Local emissions - Traditional uses of bio-energy (open stoves for heating and cooking) can affect the health of people, causing respiratory diseases. However, the impact assessment will not deal with these risks because local emissions are also regulated by other European legislation, such as Directive 2008/50/EC which sets standards and target dates for reducing concentrations of fine particles, which together with coarser particles known as PM10 already subject to legislation, are among the more dangerous pollutants for human health. Local emissions from small-scale plants are regulated at national/regional level, and there are European standards developed by CEN (EN 303-5 for biomass boilers of below 50 kW, 50-150kW and 150-300 kW output), setting emissions limits for carbon monoxide (CO), unburned hydrocarbons or organically bound carbon (OGC)[13] and for particles. Labels have been developed in some Member States to certify low emissions, e.g. P-Mark (Sweden) and Swan Label (Nordic countries).

5) Risks associated with using biomass waste for energy purposes are also regulated by other policy measures[14] and biomass from non-agricultural and non-forest waste[15] will not be tackled by this impact assessment. The issue of using biomass waste (including municipal solid waste, biowaste, sewage sludge) for energy rather than for other purposes e.g. composting or fertilising, is an issue to be tackled under the implementation of the Waste Framework Directive. For instance, in case of municipal solid waste, waste incinerator operators have to meet a given energy efficiency threshold.

Positive effects of using biomass should not be forgotten: lower risk of forest fire from removing branches and leaves on ground, improved GHG performance in energy, benefits for stabilisation of forest stands and reduction of risk of insect infection, economic benefits like diversification of income possibilities for farmers and forest owners and rural areas as a whole. Positive impacts could arise from perennial grasses or short rotation coppicing grown on agricultural land, by increasing the soil carbon content as compared to annual agricultural crops (UN-Energy, 2007[12]). Possible indirect impacts on land use are therefore considered to be lower than for biofuels and bioliquids and may well be positive. The Commission has been asked to prepare a report on the effects on indirect land use change of increasing the

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13 The development of pellet burners (and stoves) has so far been focused on achieving low emissions of OGC, but as there is a trade off between CO/OGC and NOx emissions, this has resulted in combustion devices with relatively high emission of NO_x. (Eskilsson et al, 2002)

14 2001/80/EC or the Large Combustion Plants Directive aims toreduce emissions of acidifying pollutants, particles, and ozone precursors from large combustion plants greater than 50 MW; Directive 2001/81/EC of the European Parliament and the Council on National Emission Ceilings for certain pollutants (NEC Directive) sets upper limits for each Member State for the total emissions in 2010 of the four pollutants responsible for acidification, eutrophication and ground-level ozone pollution (sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia); Directive 2008/1/EC on Industrial Pollution Prevention and Control (IPPC) is about minimising pollution from various industrial sources and sets permit conditions including emission limit values based on Best Available Techniques (BAT), also for biomass plants above 50MW; The 2001/76/EC directive on waste incineration sets emission limit values and monitoring requirements for pollutants to air such as dust, nitrogen oxides (NOx), sulphur dioxide (SO2), hydrogen chloride (HCl), hydrogen fluoride (HF), heavy metals and dioxins and furans.

15 For the purpose of this impact assessment, waste from agriculture and forestry will be referred to as processed agricultural and forest residues

consumption of biofuels and bioliquids by 2010. The results of that work will give indications on whether or not the indirect land use change impacts of other commodities should be studied.

- Who is affected, in what ways, and to what extent?

Today the global trade in biomass is below 2% of the total biomass used for energy, but in the long term some projections expect global biomass trade to rise substantially[16]. If this contributes to forest areas decreasing globally (in particular in the highly bio-diverse tropical regions) or to degradation of the soil or water quality, entire ecosystems and species may be affected, including the long-term welfare of people who depend on the forest for income or for living. Some developing countries in particular depend on forest products for income. Nevertheless, it is to be noted that EU forests continue to increase their growing stock and the use of biomass in the EU has positive effects on job and income generation, diversification of enterprises and rural economies.

If biomass is used inefficiently, it may not contribute to mitigating climate change and scarce resources may be partly wasted. It is difficult to say however who will be affected if undesirable practices remain.

- How would the problem evolve, all things being equal?

It is important to recall here that this impact assessment does not look at the impact of the increased use of biomass. The impact assessment looks at the impacts of introducing sustainability criteria. The baseline scenario developed below does however take account of the projected increases in the use of biomass, as the baseline scenario includes the presumption that the 2020 renewable energy targets will be met.

To ensure maximum consistency with existing EU scenarios and projections, the baseline is derived from the EMPLOY-RES[17] study, 'advanced deployment policy' scenario, which uses the Green-X model and has used input parameters derived from PRIMES[18] modelling (efficiency case) and from recent assessments of the European renewable energy market (FORRES 2020[19], OPTRES[20], PROGRESS[21]).

The baseline scenario assumes that 177.5 Million tonnes of oil equivalent (Mtoe) biomass will be used for energy purposes in the EU in 2020 (the realisable potential is projected by Green-

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16 Umweltbundesamt, Ökoinstitut, IFEU (2009). Sustainable Bioenergy: Current Status and Outlook; March 2009

17 Ragwitz M, Schade W, Breitschop B, Walz L., Helfrich N, Rathmann, M, Resch G., Panzer C, Faber T.,., Held A., Haas R, Nathani C, Holzhey M, Konstantinavicitute I, Zagame M, Fougeyrollas A, Le Hir B, "The impact of renewable energy on growth and employment in the European Union" http://ec.europa.eu/energy/renewables/studies/doc/renewables/2009_employ_res_report.pdf

18 The European Energy and Transport Trends by 2030 /2007/ Efficiency case - http://ec.europa.eu/dgs/energy_transport/figures/trends_2030/index_en.htm

19 Ragwitz M, Schleick J, Huber C, Resch G., Faber T, Voogt M, Coenraads R, Cleijne H, Bodo, P (2005) "FORRES 2020: Analysis of the Renewable Energy Sources evolution until 2020", Karlsruhe, Germany

20 Ragwitz M, Held A, Resch G., Faber T, Haas R, Huber C, Coenraads R, Voogt M, Reece G, Morthorst P, Jensen-Risoe S, Konstantinavicitute I (2007) "Assessment and Optimisation of renewable energy support schemes in the European electricity market", Karlsruhe, Germany

21 Coenraads R, Reece G, Voogt M, Ragwitz M, Held A, Resch G., Faber T, Haas R, Konstantinavicitute I, Krivosik J, Chadim T (2008) "PROGRESS: Promotion and growth of renewable energy sources and systems", Utrecht

X to be 221.6 Mtoe in 2020, excluding imports) in primary energy. Annex I gives detailed information about the breakdown of realisable potentials for 2020 and the corresponding fuel costs for the considered biomass options.

On energy conversion efficiency, 16% energy demand reduction is assumed by 2020 in the baseline scenario, due to a stimulation of 'technological learning' and due to existing policies on energy efficiency[22]. Energy efficiency of renewable energy plants is also incentivised by the fact that the accounting for renewable energy target is in terms of final energy consumption, meaning that avoiding losses increases the renewable energy share counting towards the target. This especially incentivises biomass heating, where losses are low. Annex II shows the baseline efficiencies assumed for specific bio-energy technology combinations.

The baseline scenario for land use is more difficult to determine. Europe has seen increased afforestation, while globally gross deforestation is estimated at 13 million hectares a year (UNEP, 2008[23]). It is difficult to quantify what proportion of this was due to bio-energy demand (CIFOR, 2009)[24]. Currently, the amount of imported forest biomass for energy use in the EU is not significant (around 3 Mtoe mainly from Canada and Russia), but in the baseline it is assumed that imports could more than double in 2020[25].

Measures to address the issue of deforestation and encourage afforestation are being developed. In Europe, the Ministerial Conference on the Protection of Forests in Europe (MCPFE)[26] has produced detailed recommendations for forest management and protection. Community forest actions are based on the Forest Strategy for the EU[27] and the EU Forest Action Plan[28]. The EU has also engaged in fighting deforestation with its Action Plan for Forest Law Enforcement, Governance and Trade (FLEGT)[29] and the UNFCCC negotiations on reducing carbon emissions from deforestation and forest degradation in developing countries (REDD[30]) are ongoing.

International processes have also acknowledged the importance of forest protection and sustainable forest management and increasingly, voluntary sustainability schemes are provided by companies, independent organisations or through national or intergovernmental structures (see Annex III for an analysis of developments in the different sectors). The

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22 These include the Eco-Design Directive, the Energy Star Regulation, the Labelling Directive, the Energy Performance of Buildings Directive, the Cogeneration Directive and the Directive on Energy End-Conversion Efficiency and Energy Services. The latter Directive sets an indicative target for EU Member States to achieve a 9 % energy saving by 2016 from new energy services and other energy efficiency improvement measures. Moreover, to achieve the energy efficiency target (through implementing energy efficiency legislation), Member States have put in place energy efficiency obligation and White Certificates, end-conversion efficiency requirements for biomass in support schemes, household subsidy schemes for efficient pellet boilers and investment grants for small CHP.

23 UNEP, FAO, UNFF (2008) "Vital forest graphics: stopping the downswing?", UNEP/ Grid-Arendal, 2008, http://www.grida.no/publications/vg/forest/

24 Centre for International Forestry Research, CIFOR 2009 "A global analysis of tropical deforestation due to bioenergy development" Contract No. EuropeAid/DCI-ENV/2008/143936/TPS

25 Green-X projections

26 http://www.mcpfe.org/documents/r_2007/

27 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0084:FIN:EN:DOC

28 http://ec.europa.eu/agriculture/fore/action_plan/index_en.htm

29 COM(2003)251 final and COUNCIL REGULATION (EC) No 2173/2005

30 COM(2008)648/3 "Addressing the challenges of deforestation and forest degradation to tackle climate change and biodiversity loss"

UNFCCC[31] recognises the importance of forests in the global greenhouse gas balance. The Convention on Biological Diversity (CBD)[32] has addressed forest biodiversity through an expanded programme of work containing 11 forest specific goals. These initiatives could be a potentially promising approach in the battle to combat climate change, and to reduce the rate of forest and biodiversity loss. Voluntary and inter-governmental initiatives to fight deforestation and proposed requirements by the European Commission on economic operators to exercise due diligence to avoid illegal logging[33], will also ensure increased impetus for the use of sustainable forest biomass.

Carbon balances of forests are also difficult to estimate, due to uncertainties about the workings of the carbon cycle. The International Panel on Climate Change (IPCC) estimates that the amount of carbon absorbed in the soil and vegetation amounts to approximately 1.1 Gt/year. Due to inter-annual variability affecting both gains and losses, the net sink varies between approximately 0.9 and 4.3 Gt/year. Research is ongoing on how much carbon is emitted as a result of deforestation and forest degradation. In its 4th Assessment Report of 2007, the IPCC said carbon emissions as a result of land-use change – mainly due to deforestation in the tropics – were running at 1.6 Gt of carbon per year in the 1990s (central estimate), or around 20% of the world's total anthropogenic (manmade) emissions of greenhouse gases. According to the Effort Sharing Decision (ESD)[34] and Emissions Trading Directive (ETS)[35], the Commission will have to make a proposal related to Land Use and Land Use Change and Forestry (LULUCF[36]) in the Community GHG reduction commitment according to harmonised modalities as well as accurate monitoring and accounting. This suggests that forest carbon data should be better harmonised in the Community GHG inventory in future. However this is a general issue rather than one specifically in energy policy. The relevance of LULUCF accounting to energy policy and sustainability criteria for bio-energy in particular, is discussed in section 4.1.1.

The baseline scenario for employment is taken from a recent study for the Commission, which assessed the overall employment impacts of the renewable energy policy (EMPLOY-RES[37]). It was found that total gross employment is expected to increase to 2.5 million in the EU-27, the majority of which would be in biofuels and biomass production. From additional biomass provision alone (fuel use effects), around 1.2 million jobs are expected. There will be additional jobs associated with employment caused by producing the generation technology and plant (investment effects) and to run the generation facilities (operation and maintenance effects). The EMPLOY-RES study did not look at employment impacts of introducing sustainability criteria for biomass, but it can act as a benchmark for comparing impacts on employment due to the introduction of a sustainability scheme.

For households, the baseline scenario assumes moderate energy cost increases resulting from renewable energy policies. On local communities dependent on forests, a baseline scenario is

31 UNFCCC - United Nations Framework Convention on Climate Change Art 4 1. (d) – www.unfccc.int
32 https://www.cbd.int/forest/portal/home.shtml
33 COM(2008) 644
34 ESD : Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009
35 Directive 2009/29/EC of the European Parliament and of the Council of 23 April2009
36 UNFCCC OECD countries are required to make available national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, including inventories of GHG emissions and removals from the LULUCF sector.
37 http://ec.europa.eu/energy/renewables/studies/doc/renewables/2009_employ_res_report.pdf

difficult to construct, as it is related to wider economic and governance challenges, which cannot be addressed through renewable energy policy.[38]

- Does the EU have the right to act – Treaty base, 'necessity test' (subsidiarity) and fundamental rights limits?

EU has a right to act under Article 192 of the Treaty on the functioning of the European Union, to ensure the smooth functioning of the internal market and the protection of the environment.

If no action is taken at EU level, it is likely that there will be a complex set of sustainability requirements developing at national or regional level for biomass used for heating and electricity (Annex III describes some of the national developments), with a possibility of raw material producers having to prove several criteria depending on the end market and therefore creating market distortions between different sources of biomass. For this reason the legislator in the RES Directive specified that "*if the analysis done [...] demonstrates that it would be appropriate to introduce amendments, in relation to forest biomass, in the calculation methodology in Annex V or in the sustainability criteria relating to carbon stocks applied to biofuels and bioliquids, the Commission shall, where appropriate, make proposals to the European Parliament and Council at the same time in this regard*".

If Member States would act alone, the internal market may be disrupted for biomass traders, suppliers and producers. The added value of the Community therefore is that the same rules would apply throughout the Community. There are however differences in Member States' support for bio-energy and land-use policy, which need to be kept in mind.

Section 3: Objectives

- What are the general policy objectives? What are the more specific/operational objectives? Underline the consistency of these objectives with other EU policies

The general policy objective is to guarantee a sustainable use of biomass for energy purposes under the framework of the Renewable Energy Directive.

The specific objective of this are to ensure that heat and power uses of biomass leads to (1) sustainable production, (2) high GHG performance compared to fossil fuels and (3) efficient energy conversion of biomass into electricity and heating and cooling.

The operational objectives are to establish sustainability requirements for solid and gaseous forms of biomass used in electricity and heating, as long as they are:

- effective in dealing with problems of sustainable biomass use,
- cost-efficient in meeting the objectives and
- consistent with existing policies.

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38 World Bank (2004) estimates that 1.6 billion people around the world depend to some degree on forests for their livelihoods "Sustaining forests: a development strategy", http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2004/07/28/000009486_20040728090355/Rendered/PDF/297040v.1.pdf

These objectives are consistent with the EU's climate and energy policy objectives, including the RES-Directive and the EU's energy efficiency action plan which aims to achieve a 20% energy saving by 2020 compared to business as usual. The objectives are also consistent with the EU's policy on deforestation and forest degradation[39].

Section 4: Policy options

The policy options are presented under the three areas of possible actions:

– production of biomass

– GHG performance across the whole life cycle

– conversion of biomass to energy

There are synergies between the options identified under the Life Cycle Assessment (LCA) approach on GHG emissions, the production of biomass and the efficiency of energy-conversion. This is because life cycle GHG emissions take account of emissions along the whole chain (from production to end use, including emissions from land use change). However, high GHG performance cannot guarantee that land is managed sustainably, or that the efficiency of the chain improves, as inefficient processes can also lead to high GHG performance. Therefore, all three issues are studied separately and the options under the three areas are not mutually exclusive.

As far as the production phase of biomass in concerned, environmental effects of farming in the EU are mitigated through enforcing mandatory standards on "cross-compliance" through establishing a link between income payments to farmers and the respect of those standards. . Waste production and management is regulated by specific waste legislation in the EU. As a result, the policy options in the impact assessment focus on the sustainability of production of forest biomass. As far as agricultural production practices in third countries is concerned, the RES Directive settled that these would be tackled through appropriate reporting requirements. This question is not reconsidered in the impact assessment.

A summary table of the areas and options within are represented in Table 1 (the three issues are further explained following the summary):

Table 1: Summary table of options

ISSUES and Options		
A. Production of biomass	**Policy Scenario**	**Synergies with other options**
Option A1: no new EU action	Voluntary schemes continue to elaborate certification schemes for sustainable biomass production and land management.	B1 and C1 (business as usual)
Option A2: Guidance on intensification methods in forestry	Guidance on land use issues related to increased bio-energy production in forests e.g. increased use of stumps and branches	Partly A1, as voluntary processes are considering such guidance

[39] COM(2008)645/3

	and leaves.	
Option A3: minimum criteria on biodiversity and land use	Criteria on biodiversity and land use (as agreed under RES Directive) or so-called 'no-go' areas to apply to all biomass. Forest management issues are left out of the scope. (Section 5.1 elaborates the specific biodiversity and land use criteria)	Partly B3, and B4 , as GHG methodology will account for negative land use change (as it does in RES-Directive)
Option A4a: Option A3 + reporting on biomass origin	As Option A3, + reporting requirements on Member States on biomass origin. Commission (COM) to monitor if forests are regenerated by economic operators in areas of origin, if not, COM to propose corrective action.	As for A3
Option A4b: Option A3 + reporting on Sustainable Forest Management (SFM)	As Option A3, + mandatory reporting requirements on Member States on sustainable forest management. Commission (COM) to monitor (including third countries)	As for A3
Option A5: Option A3 + SFM minimum obligations	As Option A3, + obligations on Member States to count only forest biomass from SFM towards their renewable energy target. This requires a global definition of SFM and a verification mechanism and minimum requirements e.g. on carbon balances, nutrients or forest vitality.	As for A3
Option A6: Option A3 + LULUCF accounting	As Option A3, + evidence of good practice in case country of origin does not account LULUCF emissions	As for A3
B. GHG savings*:		
Option B1: no new EU action	GHG performance requirements are not necessary as most biomass used in heating and electricity contribute to an at least 50-60% saving in GHG emissions compared to the next best fossil alternatives.	A1 and C1 (business as usual)
Option B2: labelling of GHG performance	Label GHG performance to give information to the consumer (electricity or heat consumers) and in order to promote GHG life cycle thinking for production processes in a wider context. A common GHG methodology for labelling would be necessary to ensure consistency of claims. The obligation could be placed on electricity and heat providers, and the GHG performance could be made available on guarantees of origin, for disclosure purposes.	C4 (labelling requirements) – Guarantees of origin (GOs) for instance could be used to disclose the GHG performance as well as the efficiency of a plant
Option B3: Setting minimum GHG savings requirements for biomass from agriculture and	35% minimum GHG saving requirement for agricultural and forest biomass (compared to fossil alternative) - same minimum requirement as for biofuels and bioliquids in RES Directive for consistency	Partly A3 as GHG methodology account for negative land use change, but does not guarantee protection of biodiverse areas or high carbon stock areas.

forestry - 35% (increasing to 50-60% in 2017/2018)		Partly C3 if biomass pathways not able to meet minimum GHG threshold due to inefficient end-conversion technology.
Option B4: minimum GHG requirements for forest and agriculture biomass in accordance with GHG saving potential	Introduce minimum GHG requirement in accordance with the Best Available Technology (BAT) in each pathway to ensure that each sector and pathway achieves best practice results.	Partly A3 but does not guarantee protection of biodiverse areas and avoidance of negative land use change Partly C3 if biomass pathways not able to meet minimum GHG performance requirements due to inefficient end-conversion technology.
C. Conversion		
Option C1: No new EU action	Existing energy efficiency policy will yield results in making the use of all energy resources, including biomass, more efficient.	A1 and B1 (business as usual)
Option C2: Bonus for better end-conversion efficiency or penalty for lower end-conversion efficiency	Member States to give a bonus/penalty (i.e. financial incentive/disincentive) to improve efficiency through differentiating subsidy levels, or awarding additional green certificates.	None
Option C3: banning inefficient use or minimum efficiency standards (for large scale installations above 1 MW)	Banning certain inefficient biomass technology options or introducing minimum requirements. Small-scale (mainly residential) use is out of the scope as dealt with by other EU policy.	Partly B3, B4 and B5 if the inefficient technology is responsible for not meeting the minimum GHG threshold
Option C4: labelling efficiency	Labelling to create awareness of the (end conversion) efficiency of a biomass pathway or installation e.g. biomass boiler, by giving insight into its performance. This can be done for consumer goods or for larger applications (above 1MW capacity) through labelling energy savings on the guarantee of origin.	B2 (labelling criteria) - GOs for instance could be used to disclose the GHG savings as well as the efficiency of a plant
Option C5*: improve supply chain efficiency	A GHG life cycle methodology to include end-conversion efficiency.	Partly B2, B3, B4 – if the GHG methodology includes end-conversion efficiency

* On improvement of GHG emissions in the whole chain, methodological questions need to be addressed. The policy options under part B deal with the question of whether and to what extent there should be minimum requirements for GHG performance for the different biomass chains, but option C5 is asking a methodological question on how the GHG performance should be calculated. The methodological issues are separately discussed in Annex V.

4.1 Further explanations of the different options

4.1.1 Policy options on sustainable production and management of agricultural and forest land

Annex III outlines the voluntary actions already taken to ensure sustainable production of biomass in the forestry agriculture and waste sectors. It gives an indication of progress and developments in the absence of new policy initiatives in this area.

Option A1 would be no new EU action.

Option A2 (guidance) would have the effect of developing specific guidance at national or European level on dealing with the effects of intensified forest management, including harvesting of branches and leaves and stump harvesting. Today, these techniques are not common practice due to economic constraints and their impacts are not fully understood. Some Member States have issued preliminary guidance on the issue, (such as the UK's Forest Research Authority in April 2009[40]). Intensified harvesting of this kind could lead to lower amount of deadwood. The effects of a lower amount of deadwood depend on a number of factors, like the presence of saprophytic organisms[41] or the types of soils. The lack of empirical data makes it difficult to predict the impacts for different soil types. Intensified forest management can also have potential benefits, such as the need for less intensive ground preparation and improvement in tree stability, as well as improved disease and pest control. It should be noted that option A2 would not establish mandatory "no-go areas" to protect biodiversity or to prevent carbon-stock losses.

For option A3 (criteria for 'no-go' biodiverse areas and land use change), it must also be considered whether the close link with other policies, notably on sustainability criteria for biofuels and bioliquids would cause any inconsistencies for biomass producers. Extending the RES-Directive biodiversity and land-use criteria to all biomass would at least ensure that biomass for all energy purposes are treated in the same way (even though inconsistencies may remain for non-energy uses). However, these would need to be adapted, as the no-go areas were developed with the purpose of avoiding undesirable land conversion (usually to arable land).

Option A4a (A3 + reporting biomass origin) requires that Member States register the origin of biomass used in electricity and heating and report it to the Commission. This is so that the Commission can monitor the areas where biomass originates from to see if land use change has occurred in those areas. If problems are identified in certain areas, the Commission would propose appropriate corrective action. Two options for further action are possible: a legislative proposal could address the issue following monitoring of biomass origin, or appropriate corrective action could be included in the Directive covered by the present impact assessment.

Option A4b (A3 + reporting on SFM) would require mandatory reporting on sustainable forest management. At EU level, the Pan-European Operational Level Guidelines for Sustainable Forest Management could serve as a basis for the agreed principles and measures and reporting could be based on the criteria and indicators agreed by the Lisbon Ministerial Conference on the Protection of Forests in Europe (although MCPFE reporting has shown shortcomings on consistency and data adequacy)[42]. However, as third countries cannot be required to report to the Commission, the Commission itself would need to monitor developments in third countries.

Option A5 (A3 + SFM requirements) would require a common and precise definition of SFM. The definition used by the UN and MCPFE is: *"the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration*

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40 Forest Research (April 2009) Stump harvesting guidance, sited at: http://www.forestresearch.gov.uk

41 Organisms that feed on dead organic matter, especially fungus or bacterium

42 19 other non-EU states are members and report on this basis to MCPFE

capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems". This definition is globally accepted but the principles and measures to implement this definition vary from region to region and indicators and criteria are defined locally. It is therefore not easy to find common thresholds and criteria that can be applied globally. Moreover, it may be difficult to enforce this option all over the world, in particular given the weak inter-governmental responses identified in Annex IV.

Furthermore, studies suggest that setting common rules for minimum rules for SFM are difficult, given the climatic differences and the uncertainty about the impacts of harvesting intensity. Guidance has been issued by the IPCC for methods for estimating greenhouse gas emissions due to changes in biomass, dead organic matter and soil organic carbon on Forest Land and Land Converted to Forest Land. The relevant carbon pools and non-CO2 gases for which methods are provided for are: Biomass (above-ground and below-ground biomass), dead organic matter (dead wood and litter), soil organic matter and non-CO2 gases (CH4, CO, N2O, NOX). However, there are uncertainties associated with aggregated sampling levels, uncertainty of the level of residue production, of soil carbon[43] etc and the guidelines apply to the preparation of national GHG inventories, and they are not readily applicable for use at the holding level.

Therefore for Option A5, it is recommended to consider the following minimum criteria:

1. Obligation on economic operator to ensure forest regeneration is taken within x years.

2. Obligations for measures in place to ensure viable population of forest-dependent species

3. Obligation that forest biomass extraction must not result in large scale net losses of nutrients or acid buffering capacity

4. Carbon stock of forests must remain at least balanced.

Option A6 (A3 + LULUCF accounting) would allow for all biomass which originates from countries which account carbon balances under LULUCF to count towards the renewable energy targets. Biomass which originates from countries that do not account would need to provide further evidence that the biomass comes from sustainable sources, as follows:

SPECIFIC SITUATION: ➔	REQUIREMENT:
Country of origin accounting under LULUCF	No requirement on operators (emissions from LULUCF are accounted at national level)
Country of origin not accounting nor reporting under LULUCF	(i) COM to introduce a specific emissions factor due to land use change in the GHG methodology at operator level, or (ii) COM to request alternative evidence on carbon stock balance at national level, or

43 Liski et al (2005) concluded that estimates of the amount of soil carbon are uncertain by nature because they depend mostly on uncertain humus parameters

	(iii) COM to request alternative evidence on carbon stock balance at operator level, or (iv) COM to monitor developments based on that reporting and to intervene if deficit/loss

Negotiations on the future international rules for LULUCF accounting are currently on-going. Under the Kyoto Protocol Annex-I carbon emissions related to energy from biomass are counted as zero on the basis that emissions are reported in the LULUCF sector. Under Article 3.3 of the Kyoto Protocol, Parties are obliged to account for afforestation, reforestation and deforestation activities (*obligatory accounting*). Under Article 3.4 of the Kyoto Protocol, Parties may choose to account for the following four activities: forest management, cropland management, grazing land management and revegetation (*optional accounting*). The method of accounting under existing accounting rules means that carbon emission reductions from the use of biomass are prone to overestimates.

In order to address *inter alia* this problem the EU is currently considering its position with respect to accounting options for forest management. Generally speaking, two preferred accounting options have emerged within the EU (although several more are still under consideration in the UNFCCC negotiations). First, a 'bar'-approach based on a reference level against which net emissions and removals are compared. Second, gross-net accounting with a discount factor where net emissions and removals from forest management occurring during the commitment period are discounted by a predetermined factor in order to address LULUCF specific issues like scale effects and natural disturbances. The bar-approach maintains full parity with non-LULUCF mitigation options and the gross-net accounting with a discount factor has the advantage that net removals lead to credits and net emissions to debit, however net emissions in the LULUCF sector are discounted in comparison to emissions that occur in other sectors. This gives an additional incentive to the use of forests as a way to substitute fossil fuel rather than to sequester carbon. Overall the effective delivery of the two options with respect to environmental integrity depends on the way they are implemented: e.g. the choice of discount factor and the national reference levels.

These options for LULUCF accounting would as such have no impact on the way biomass is accounted for the purposes of meeting renewable energy targets or for counting as zero-carbon emissions under ETS. However, the Effort Sharing Decision requires that the Commission looks into whether the outcome of the international negotiations on LULUCF provides sufficient guarantees for the accounting of emissions from forest management. Any action to redress the outcome of negotiations could reasonably be applied to forests in the EU. It would be more difficult to put obligations on third country imports of biomass. That is why the option of incorporating a LULUCF accounting system in a sustainability scheme for biomass is addressed here, in order to assess possible requirements that could allow the Community to intervene in case biomass production in certain countries would prove to be problematic from the perspective of related emissions to land use.

4.1.2. Policy options for ensuring GHG savings based on a life cycle approach

The GHG methodology adopted under the RES Directive was designed for biofuels used in transport and bioliquids. Analysis suggests that this methodology is also suitable for use for heating and electricity applications in general, with certain adaptations to allow for specificities of biomass use in heating and electricity. See Annex V for this analysis.

The RES Directive requires biofuels and bioliquids to meet a 35% minimum GHG requirement (35% 'threshold'). For biofuels, the extent of the savings (in percentage terms) is determined through comparison with the emissions from the fossil part of petrol and diesel consumed in the Community (fossil fuel comparator).

Putting in place comparable minimum requirements for GHG performance would be desirable (a) for biomass pathways which risk not achieving significant GHG emissions over the life cycle and/ or (b) to create general awareness of the GHG performance of products in general.

When setting minimum GHG requirements for bio-electricity and bio-heat pathways, the additional compliance cost of economic operators should be weighed up against the additional benefits in terms of GHG savings. It could be argued that as forest biomass delivers a significant GHG saving over the life cycle when used in electricity and heating applications (usually above 80% savings as compared to average EU fossil heat or electricity), it would introduce unnecessary administrative burden to prove the GHG savings achieved.

As most of the biomass used in electricity and heating is based on solid and gaseous biomass coming either from the forest or from agricultural residues (e.g. tree branches and straw) and processing residues (e.g. pellets from saw-dust), a business as usual policy scenario outlined in Option B1 (no new EU action) and B2 (labelling) would not require the introduction of minimum GHG performance requirements. However Option B2 would enable consumers to know the GHG performance of electricity and heating plants. As most of the emissions occur in the production and conversion phase, (not in the processing phase as with biofuels) there are less risks from not having a GHG minimum performance requirement.

Option B3 (minimum GHG savings for agriculture and forest biomass) would ensure that the same minimum requirements apply to all biomass[44] used for energy purposes. This would ensure consistency for feedstocks that can be used both in transport (biofuels) or electricity and heat. Having the same threshold for all end uses would also avoid calculation problems when allocating GHG emissions to heat and electricity or biofuels in a cogeneration or tri-generation plant[45]. On the other hand, the number of possible pathways could make this an overly complicated system and proxies may need to be developed with generic values for similar feedstocks and processes, such as digestion of energy crops having one value (e.g. for maize, rye etc.) or all energy grasses having one value etc.

Option B4 (minimum threshold based on best-practice) would ensure that best practice is followed, as all biomass has the potential to improve GHG savings by utilising best practices. However the same methodological questions as under Option B3 would remain.

4.1.3. Policy options to promote efficient resource use by increasing energy conversion efficiency

This issue looks only at the end of the bio-energy chain, and does not tackle resource management, therefore only considers one factor in a life-cycle assessment, the energy conversion efficiency. Therefore the options on energy efficiency can be considered together with the options under production and GHG performance.

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44 Short rotation coppicing and plantations, such as palm are included in the consideration of agricultural biomass.

45 Second generation biofuels have a minimum GHG requirement because they also count for the purposes of the Fuel Quality Directive 2009/30/EC.

The end-conversion of biomass to electricity and/or heat is generally influenced by the objectives and technical constraints of the end-user. Therefore it is relevant to understand which type of stakeholder is involved, and what technical opportunities and constrains for improvements exist.

Residential use: Small-scale boilers are generally used by households for heating purposes. These are considered outside of the scope of this impact assessment because Community legislation on energy efficiency and further environmental aspects, including particulate matter emissions, is currently under development for (mainly) residential boilers, including boilers fired by liquid, gaseous or solid biofuels, under

- the Eco-design for energy-using products directive 2005/32/EC,
- the Energy labelling directive 92/75/EEC,
- the recast of the Energy labelling directive proposed by the Commission end 2008, COM(2008)778, in particular Article 9 on public procurement and incentives,
- the recast of the Energy performance of buildings directive proposed by the Commission end 2008, COM(2008)780, in particular Article 8 related to minimum energy performance requirements of technical building systems.

These policies are expected to improve the conversion efficiency of (mainly) residential boilers to a satisfactory extent, and no additional action is required for residential boilers[46].

Three other characteristic stakeholder groups are relevant to distinguish for the purposes of this impact assessment:

Utility companies - Large companies (above 1MW capacity) produce electricity and/or heat from biomass through co-firing or large stand-alone installations. Their incentives are national support schemes and/ or the emission ceiling of the emissions trading scheme (ETS). They usually source their biomass over large distances and respond rapidly to price changes. It is a small and well-informed stakeholder group, often acting because of available support schemes.

Small commercial producers (below 1MW capacity) – These companies are not historically involved in electricity and/or heat production and they operate one or several stand-alone installations that produce heat and/or electricity from biomass. Their incentive comes from national support schemes or the local availability of affordable biomass. It is a small and well-informed stakeholder group, usually acting because of available subsidies. Biomass costs are a substantial part of their operations costs.

Industry - Some industries produce biomass by-products that they use to supply electricity and/or heat for their own processes. Their incentive is the availability of a cheap energy source that needs disposing of when not used, e.g. paper & pulp industry, sugar industry with bagasse surplus, saw mills with wood chips boilers. Support schemes for renewable energy production are usually not a motivation, though reducing the overall GHG emission can play a role.

[46] Link to website of preparatory studies: www.ecoboiler.org, www.ecosolidfuel.org

Depending on the user, different policy measures could be considered as effective or efficient in promoting higher energy conversion efficiency.

Option C1 (no new EU action) would continue to rely on existing policy tools such as the Cogeneration Directive[47] which sets benchmarks for high-efficiency cogeneration plants. Member States have also adopted national policies to improve energy efficiency (e.g. included in feed-in tariff, energy efficiency obligations), but few Member States currently explicitly consider the end-conversion of biomass installations in their policy.

Option C2 (bonus/ penalty) allows the economic operator to make the decision on the investment in the bio-energy installation to benefit from a bonus or to avoid a penalty. This can make investment in more expensive options more cost effective. If the incentive is sufficiently high, the economic operator will respond by shifting to more efficient options. If inefficient processes do not count towards targets, Member States are likely to respond by adapting their support schemes to ensure that only those bio-energy options are supported that really count for their national target. The penalty therefore has to be high in order to make a difference. However, Member States would be free to set the level of the bonus/ penalty and would be able to choose which efficient technologies to incentivise according to their national conditions and to respect subsidiarity.

Option C3 (minimum efficiency requirements) would exclude the application of certain biomass pathways or installations, but the decision not to use this pathway or installation does not depend on an economic calculation of the economic operator but is made by the government. Its effects can reach beyond support schemes, and in principle be applicable to all biomass conversion installation. If commonly used technology is banned, there is a risk that economic operators will make a different economic calculation on the use of biomass. This would be undesirable, especially in those cases where residue streams with no other purpose (like manure) are being used for energy production. However, this risk may be eliminated if only the worst-performing technologies are banned.

Option C4 (labelling) would create awareness, appealing to the environmentally conscious and highlight cost saving through more efficient biomass use. It does not exclude the use of inefficient pathways or installations, nor does it create a financial incentive to take this aspect into account. Therefore, the labelling of end conversion efficiency on installations is only relevant for consumer goods, when the creation of awareness can influence the decision making. Its relevance is small for commercially operating installations, as feedstock costs (directly related to efficiency) are a primary element of the cost calculations. So the policy option is most suitable for residential boilers which are not covered by this impact assessment.

Option C5 (improve supply chain efficiency) would only stimulate higher end-conversion efficiency if the inefficient biomass plant in question is compared to an average or high efficiency fossil alternative over the life cycle. The effectiveness of this option in effect comes down to the design of the GHG calculation method for the whole chain and improving efficiency is limited.

Options to be discarded:

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[47] Directive 2004/8/EC

The policy options have been screened for effectiveness, efficiency and consistency.

Option A2 is discarded because the science is not yet well developed to be able to develop guidelines at EU level on some issues such as stump harvesting. The UK and Swedish guidance indicate that even within one Member State, the removal of stumps would have different effects on different types of soils. Other practices such as removal of branches and tops are better understood but their effects vary locally. Reviewing data on harvesting forest residues, the Commission (JRC) observes that the impacts of more intense harvesting are small. This is partly because harvested forests absorb carbon dioxide faster than mature forest stands, so harvesting them for energy use increases the CO2 uptake from the atmosphere (Liski et al 2005[48]). The development of such guidance is more effective when left to Member States.

Option A4b is discarded because reporting would not give additional benefits in terms of ensuring sustainable forest management. This is because there are large differences between countries in criteria and more particularly in the indicators used to evaluate progress, even within Member States. Results of the FORSEE project[49] showed that sustainability assessment at local level offers the possibility of adapting forest management and improving forest operations. Monitoring of sustainable forest management at EU level would therefore be impossible unless common reporting requirements/ criteria were set. Another issue is that reporting based on MCPFE criteria and indicators could not be extended to third countries, as third countries have agreed to different criteria and indicators for reporting under other intergovernmental initiatives.

Option A6 is discarded because LULUCF accounting addresses the problems of accounting[50] for biomass emissions and not the problem of bad practices as regards unsustainable forest management. The problem of balancing carbon stocks is not unique to the energy sector and is not the problem identified in section 2 of the impact assessment. All activities on land, including production systems for food, feed and fibre have an impact on carbon emissions and removals from LULUCF. It is therefore not appropriate to simply look at emissions and removals from the LULUCF sector from a pure bio-energy sustainability perspective, as this can provide only a partial policy response to make the LULUCF sector contribute to climate mitigation. Instead a comprehensive framework may be needed to address the complex interactions between activities in the sector. More importantly, the accounting has not yet been agreed on, so it is not clear how carbon from forests would be accounted.

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48 If the felling residues and thinnings are left in the forest, they initially add to the stock of carbon in the forest litter, but they rot away with a characteristic exponential decay time of about 10 years and the balance of carbon emissions from using forest residues turns positive after 3 to 7 years. Removing residues also removes some fixed nitrogen from the forest, and replacing with artificial fertiliser would generate N2O emissions in the forest soils at about the same magnitude as those from the decomposition of the forest residues.

49 FORSEE "Sustainable management of forests: a European network of pilot zones for putting this into operational effect", information at: http://www.iefc.net/index.php?affiche_page=project_FORSEE

50 The combustion of biomass involves GHG emissions, but it is considered carbon-neutral following the practice of the IPCC national inventory guidelines, where emissions from biomass are included in the energy sector for information only, and not added to the total. The reason for this is that emissions from combustion are offset against CO2 absorbed from the atmosphere during the growing phase. In addition, any changes in the carbon stock on land are reported under the land use, land-use change and forestry category, therefore counting them under energy would constitute double counting.

Option C4 is discarded because the policy option of labelling of end-conversion efficiency is mostly relevant during the sales period, which is not relevant for large scale electricity or heating installations.

Option C5 is discarded because the effectiveness for improving the end-conversion efficiency is limited. This does not mean however that conversion to electricity and heat should not be part of the methodology. It is simply considered that it is not a tool for incentivising higher end-conversion efficiency. This issue is further elaborated upon in Annex V.

Section 5: Analysis of impacts

In deciding whether or not to include a particular type of impact, the findings of the Impact Assessment for the development of the sustainability criteria for biofuels and bioliquids were observed[51]. That assessment found that:

– it should be feasible to associate impacts with individual consignments of biomass and to associated negative impacts with biomass production.

– international law aspects should be observed.

– the cultivation of agricultural crops for different purposes (including biofuel production) can cause substantial environmental damage if this cultivation takes place on inappropriate land.

– biomass consignments are not easily associated directly with social impacts, such as respect for fundamental human rights or land rights associated with production

This impact assessment explores the following main effects of the policy options for biomass promotion:

1. environmental impacts

2. economic impacts

  – economic availability of biomass

  – costs to economic operators

  – costs to public administration

3. social impacts

  – employment

  – households

5.1. Policy option to foster sustainable biomass production

As set out in section 4, four options were retained for assessment:

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51 SEC(2008)85

Option A1: no new EU action

Option A3: criteria on biodiversity and land use

Option A4a: Option A3 + reporting on biomass origin

Option A5: Option A3 + SFM minimum obligations

When considering the impacts of the policy options for production, it must be considered that producers will come from both EU and non-EU. Currently the import of wood and wood waste for energy purposes, from outside the EU is around 3 Mtoe, or 3%[52], mainly imported in the form of pellets[53]. As a consequence, the impacts of introducing sustainability criteria will largely fall on EU biomass producers.

5.1.1 Environmental impacts

A sustainability scheme at EU level should ensure that biomass supported in the EU is coming from sustainable production irrespective of its origin. The RES Directive requires Member States to ensure that economic operators can prove where the biomass originates from and that the biomass used does not come from highly bio-diverse or converted high-carbon stock land.

a. Biodiversity

To avoid the use of land with high biodiversity value for the production of biofuels, Article 17(3) of the RES-Directive has identified different types of lands that are considered highly biodiverse:

– primary forests and other wooded land of native species where there is no clearly visible indication of human activity and the ecological processes are not disturbed

– areas designated by law or by the relevant competent authority for nature protection purposes, or areas designated for the protection of rare, threatened or endangered species recognised by international agreements or included in lists drawn up by intergovernmental organisations or IUCN

– highly bio-diverse grasslands (natural and non-natural).

Option A1 (no new EU action) would not afford any minimum protection for biodiversity and would not prevent negative environmental impacts.

All other options (Options A3, A4a and A5) extend the above (RES-Directive) biodiversity criteria to all biomass used for energy purposes, with the premise that some exceptions for forest biomass could be made, as follows:

52 Eurostat 2007 data

53 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

First, stakeholders said that there are instances where primary forests or protected areas are subject to natural disasters, where trees are felled or are degrading[54]. In this case the best option may be to use a share of the trees for energy or other purposes instead of leaving them in the forest to degrade.

Second, stakeholders argued that biodiversity criteria may lead to the value of timber from bio-diverse forests to be devalued and that owners should be compensated.

The first exception for forest biomass could be justified on environmental grounds where the need for deadwood for soil quality and maintenance of biodiversity are also taken into account. However the essence of primary forests is that they are undisturbed by man and deserve to remain protected from human interference even if they are subject to a natural disaster. In fact, the presence of natural disturbance regimes and the resulting dead and decomposing organic matter is the key attribute of such forest systems, and the main reason for their protection. The second exception is based on economic arguments and may no longer lead to the environmental protection that is deemed to be necessary for preserving ecosystems. Therefore neither the first nor the second exceptions are accepted.

b. Land use change

In the RES Directive, some high carbon stock lands cannot be converted for the use of biomass for energy purposes, as the loss of carbon could never result in the biofuel meeting a GHG threshold value. These areas are:

– wetlands

– forested areas with canopy cover of 30% or more

Option A1 (no new EU action) would not afford any minimum protection for conversion of high carbon stock areas.

Options A3, A4a, A5 all extend the land use criteria to all biomass. Moreover, GHG emissions from the conversion of land are also included in the proposed calculation of greenhouse gas emissions (see Annex V). Stakeholders in the public consultation pointed out that when converting forests, forest biomass can still count towards the target, even if the forest will not be regenerated, as at the time of conversion it was not yet known if the trees will be regenerated or not. Stakeholders also pointed out that the definition of continuously forested areas may need to be refined to avoid that natural forests[55] can be converted to plantations without any penalty for land use change.

To avoid negative land conversion of high carbon stock areas, it would be necessary that at least the land use criteria set in the RES Directive on land use should apply (as proposed by Option A3).

It should be considered whether further reaching requirements are needed to protect biodiversity and avoid negative land use change. Option A3 does not 'guarantee' that forest carbon balances remain neutral in the long term or that sustainable forest management

54 This is the case of Canada, where [x] hectares of primary forest are destroyed due to pine beetle infestation.

55 A forest composed of indigenous trees and not classified as forest plantations

principles are applied in production of biomass. Options A4a and A5 would go further to monitor areas where the biomass comes from or for promoting sustainable forest management.

Option A4a would have the added benefit of collecting information on the origin of all the biomass used for heating and electricity purposes in the EU. This would give a tool for monitoring those areas where the biomass comes from, and a basis for corrective action to be taken in respect of regions if the monitoring finds that forests are not regenerating in certain regions.

Option A5 would go further than reporting and require minimum requirements for SFM. Historically, it has been difficult to agree common SFM standards globally. Four possible minimum requirements (as identified in section 4) are considered.

1) A requirement for economic operators to ensure forest regeneration is taken within a certain number of years would create an obligation on economic operators to plan for regeneration activities. Forest law in most EU Member States already requires regeneration following harvesting. However, if the economic operator in the EU imports from countries which do not have such requirements, it is impossible to get such a guarantee, unless the economic operator enters into a contract with forest owners. It would be difficult for a Member State to know whether forest biomass can necessarily be counted towards the renewable energy targets, as at the time of using the biomass for energy production there is often no way of knowing whether the forest area where the biomass came from will be regenerated.

2) A requirement for measures in place to ensure viable population of forest-dependent species is difficult to define, as for each region there would need to be a list drawn up of forest-dependent species and the quantity or amount of a viable population would need to be defined. An alternative therefore is to draw up lists of areas for the protection of rare, threatened or endangered eco-systems or species. This is made possible under the biodiversity requirements in the Renewable Energy Directive, where such lists can be approved through a comitology procedure. It would therefore be achieved under Option A3.

3) A requirement for forest biomass extraction not to result in large scale net losses of nutrients or acid buffering capacity is also difficult to define globally, as the amounts of nutrients or scale of buffering would differ from region to region.

4) A requirement that the carbon balance of forest must remain at least balanced is a possible way forward. However, first stock needs to be taken of the carbon balance of each forest area or region. This is scientifically challenging as common measurement methods would need to be developed. Furthermore, such a requirement would also no longer only focus on the sustainability of the energy use of biomass, but would in effect introduce a stable land use requirement, so that all forests which are currently forests must remain forests. It remains to be seen whether international climate negotiations and international initiatives on SFM can lead to minimum requirements that can be applied to all forests.

In sum, verification of SFM at EU or global level would be impossible without setting common requirements. On the other hand, it is commonly accepted that SFM certification standards should not be considered as cast-iron measures of sustainability but as evolving tools in an adaptive management system with the ultimate aim of sustainability. For all these reasons, it would be undesirable to set minimum sustainability standards for forest management specifically for energy purposes.

Option A4a goes furthest in terms of environmental protection bearing in mind the impracticalities of Option A5. Option A4a ensures minimum protection of biodiverse and high carbon stock areas and provides a tool for collecting the necessary information on biomass origin to enable monitoring of biomass producing areas.

5.1.2. Economic impacts

a. Costs to public administration

The basic cost for public administrations to implement Options A3, A4a and A5 are assumed to be similar as authorities in each case would need to verify at least the origin of biomass i.e. the chain of custody. Using the EU's Standard Cost Model, the COWI Consortium distinguished between one-off and recurring costs. It was estimated that one-off costs are larger than recurring costs, based on the assumption that most of the resources are needed for the transposition of new legislation. One-off costs are calculated to be between €0.3-1.1 million (low cost and high costs respectively[56]) and recurring costs between €0.1-0.2 million per year for the EU-27. The recurring costs include the cost of the annual reporting requirements under Option A4a to the Commission.

Under Option A5, additional costs may be incurred depending on the minimum requirements for SFM. If forest vitality would be a minimum requirement, more expensive verification tools may be needed, requiring that the land is physically inspected.

It also has to be considered whether it is feasible to require Member States to verify compliance of household consumption of biomass. Households mainly use wood for heating purposes and often they procure wood from small local suppliers. Although the household-use of biomass is significant, it is considered that it would be burdensome to require households to verify the origin of the wood. Member States should therefore be responsible for regulating and monitoring household biomass use. Monitoring could be done by means of household surveys.

Surveys can be costly. The World Bank[57] estimated that specialised household energy surveys cost between US$50,000-150,000. Cost factors include sample and questionnaire size, local per diem, and salaries. Eurostat is collecting information on households via the European Union Statistics on Income and Living Conditions and the Household Budget Survey. Member States contribute to these surveys voluntarily. Many Member States also have existing household surveys to which questions related to biomass use could be added. In this way survey costs could be minimised.

b. Cost to economic operators

The estimated administrative costs to the economic operators under Options A3 and A4a are assumed to be similar. To estimate the cost of providing proof of the origin of biomass

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56 The difference between low and high scenarios correspond to differences in the average EU wages for legislators and clerks

57 O'Sullivan K., Barnes D. (2006) "Energy Policies and multi-topic household surveys ", The World Bank

through chain of custody (CoC) certification, under Options A3 and A4a, existing schemes in Europe were studied.

In Belgium, electricity producers are required to prove the sustainable character of forestry resources in order to receive green certificates. Electrabel for instance, uses SGS Belgium as an independent body to check the biomass supply chain data based on a certification procedure designed jointly by Electrabel and Research Centre Laborelec. Evidence is delivered according to a traceable chain of custody system and forest management certification or public documents originating from independent bodies such as FAO or NGOs who make a review of the forest management and control in the considered country. The proof then is supplied in the form of a "Biomass Supplier Declaration", which is 6 pages, consisting of declaration of the wood origin, the production chain, including energy consumption, and transportation and storage. Since 2003, 75 suppliers have been audited, including in Brazil, South Africa, Malaysia and North America (SGS Presentation, EU Sustainable Energy Week 2009). According to Laborelec, the certification cost is about 0,5 €/ton.

The costs of implementing Option A5 could be much higher, as on top of CoC certification, a sustainable forest management (SFM) certification is also required. The BTG 2008 report estimates that that direct costs in Finland, Sweden, Germany and Norway can vary between 0.01-€0.79/ha/year (excluding indirect costs). This is equivalent to around €0.01-0.38/ ton[58] and these costs were estimated for larger forest holdings (forest holdings of 10,000 – 2 million ha). For small private forests, the cost per can go up to €6/ha/yr for a 100 ha forest holding, or about €12.6/ ton[59]. The main difference between costs is due to the size of the certified area.

The estimated cost for SFM certification (Option A5) was assessed by the COWI Consortium (2009) using the EU's Standard Cost Model. They looked at costs for biomass producers, processing and manufacturing industry and traders as well as energy producers. One-off costs and recurring costs were distinguished. It was found that the recurring costs of running SFM certification systems, i.e. surveillance and reassessment audits, can be as costly as the initial certification for SFM[60]. Assuming that all biomass producers in the EU would need to be certified, the COWI Consortium estimated one-off costs for biomass producers in the EU-27 to be between €0.2-6.7 million and recurring costs €3.3-38.4 million per year. For individual biomass producers this could amount to recurring costs of €2,000 - 24,000 per year[61]. In contrast, recurring chain of custody certification costs (under Options A3 and A4) were estimated to be between €800-3,000 per year for individual biomass producers.

c. Economic availability of biomass

The COWI Consortium (2009) assessed whether sustainability criteria on land use and biodiversity (as in Options A3, A4a and A5) would have any impact on economic availability

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58 Based on 3m3/ha and 0.7 tonne/m3

59 Even the 100 ha average holding could still be considered large in overall EU terms. The EU average holding is about 10 Ha but many Member States have millions of much smaller units. In Greece, forest ownerships are measured in Stremmae (0.1 Ha).

60 The COWI Consortium distinguished between potential costs of FSC-type SFM certification and the Green Gold Label (GGL) type SFM certification. FSC certification generally implies costs 2.5 times higher than those related to the GGL approach.

61 At the individual operator level, the costs are highest for biomass producers. One-off costs can be up to 25 times higher than for other economic operators, while recurring costs can be 5-10 times higher.

of biomass. The scenarios from the consulted literature, that take into account a number of uncertainties and sustainability constraints, lead to a global biomass potential of 200-500 EJ/year in the longer term (2050-2100).

Forestry residues: Green-X projects imports of forestry residues of around 9 Mtoe. In a study by the EEA[62], no specific attention is paid to sustainability issues related to these imports. The IEA Bioenergy review[63] analysed global biomass availability and mentions a potential of forest residues of 30-150 EJ (700-3600 Mtoe) by 2050, of which a major share would become available in the coming one or two decades. However, these indications do not explicitly take into account any land exclusion criteria. It may be clear that not all forest import materials currently available will meet the land exclusion criteria as laid down in the RES Directive. Given the ratio between projected availability and the 9 Mtoe projected in GREEN-X by 2020, it could be concluded that there will be sufficient forestry material available for import that does meet the land exclusion criteria. Even if imports of pellets projected to be 33 Mtoe by AEBIOM are realised, this is still a small share of the available range identified above.

Agricultural crops: Biofuels and bioliquids are already covered by the land use and biodiversity criteria laid down in the RES-Directive. GREEN-X assumed that 30% of biofuels consumption will be met by ex-EU imports, mainly consisting of vegetable oils (rape seed, soy and palm oil) and bioethanol. At a 10% biofuels share in 2020, total imports would add up to almost 10 Mtoe, of which 3 Mtoe rapeseed, 2 Mtoe soy, 2 Mtoe palm and 2,5 Mtoe bioethanol. The IEA Bioenergy Review projects a production potential for energy crops of 0-700 EJ, with a moderate estimation of 120 EJ (or almost 3000 Mtoe) by 2050.

As the underlying studies for this assessment usually limit their analysis to currently available agricultural lands (see e.g. the detailed review by Dornburg et al, 2008[64]), it is expected that the lion's share of this potential will meet the land exclusion criteria. The share that can become available by 2020 is not further specified. Again, it should be stressed that these availability estimations strongly depend on developments in agricultural productivity, animal husbandry and food consumption. However, the current global trade volumes of palm and soy (ca 25 Mtoe and 10 Mtoe, respectively[65]), are substantially larger than 2020 demand for these sources. Therefore, it seems reasonable that this demand can be met by oils that meet the land exclusion criteria, provided a verification system is put in place.

5.1.3. Social impacts

It is presumed that there will be no impact on households (if they are exempted from the requirements) and on employment. Employment opportunities would arise under Option A5, as not only biomass origin but also the sustainable management of forests would need to be

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62 EEA (2007a): Environmentally compatible bio-energy potential from European forests. Copenhagen, European Environment Agency

63 IEA (2009): Bioenergy - A review of status and prospects. Paris, Bioenergy Agreement of the International Energy Agency

64 Dornburg V., A. Faaij, P. Verweij, H. Langeveld, G. van de Ven, F. Wester, H. van Keulen, K. van Diepen, M. Meeusen, M. Banse, J. Ros, D. van Vuuren, G.J. van den Born, M. van Oorschot, F. Smout, J. van Vliet, H. Aiking, M. Londo, H. Mozaffarian, K. Smekens, E. Lysen (ed.) and S. van Egmond (ed.) (2008): Assessment of global biomass portentials and their links to good, water, biodiversity, energy demand and economy. Bilthoven, MNP.

65 Thoenes, P. (2006): Biofuels and Commodity Markets – Palm Oil Focus. Rome, United Nations Food and Agriculture Organisation

verified. However this option is also associated with higher costs for administrations and for economic operators.

5.1.4. Impacts on third country actors

The countries most affected by setting GHG criteria are those that already export solid biomass to the EU. Although it is difficult to obtain information about biomass traded, some assessments suggest that most of Europe's imports come from Canada and Russia, and to a lesser extent from Switzerland, USA, South Africa, Norway and Ukraine.[66]

The total administrative costs associated with complying with these options are difficult to quantify as the number of actors who may be affected is highly uncertain. It is however possible to assume that the administrative costs per economic operator will be similar to those calculated for EU actors, as outlined in section 5.1.2.b.

5.1.4. Summary of impacts

Table 2: Assessment of impacts of options to foster sustainable biomass production

	Costs to public administration (EU-27)	Economic availability of biomass	Costs to economic operators	Environmental impacts Biodiversity and Land use	Employment	Households
A. Production						
Option A1: no new EU action	0 No effect	0 No effect	0 No effect	0 Does not minimise risk of loss of biodiverse or high carbon stock land	0 No effect	0 No effect
Option A3: criteria on biodiversity and land use	- Some costs due to verifying claims on biomass origin and household surveys	0 No effect	- Proof of origin of biomass will incur some costs in developing tracing mechanisms	+ Protection for highly bio-diverse and high carbon-stock areas	0 No effect	0 No effect
Option A4a: Option A3 + mandatory reporting on biomass origin	- Some cost due to verifying claims on biomass origin, household surveys and formalising reporting on SFM	0 No effect	- Proof of origin of biomass incurs costs in developing tracing mechanisms	+ Protection of highly biodiverse and high carbon stock areas	0 No effect	0 No effect

66 http://eubionet2.ohoi.net/ACFiles/Download.asp?recID=4705

	Costs to public administration (EU-27)	Economic availability of biomass	Costs to economic operators	Environmental impacts Biodiversity and Land use	Employment	Households
Option A5: Option A3 + SFM obligation	-- Costs of setting up verification tools	0 No effect	-- Increased certification or auditing cost	++ Protection of highly biodiverse and high carbon stock areas and promotes SFM	+ Additional jobs for certification and verification	0 No effect

Table 2 shows that Option A1 does not minimise negative environmental impacts. An argument in support of Option A1 however is that sustainable forest management is not specifically energy related and may be better tackled under current land management tools whether at national or EU level. Options A3 and A4a have similar environmental impacts, as reporting requirements are not able to serve as a precautionary measure to ensure that forest areas will be regenerated after harvesting, nor that forests will be managed in a way to ensure the long-term production of forests. Option A5 would have additional positive impacts on biodiversity and land use, but has much higher costs to public authorities and economic operators. Options A3 and A4a can be achieved at a reasonably low cost, given that Member States are obliged under the RES Directive to develop verification methods for determining the origin of biomass used to produce biofuels and bioliquids. No significant impacts are expected on households or on employment, and the economic availability of biomass is not likely to be affected under Options A1, A3, A4a and A5. This is because the estimated economic potentials of biomass in 2020 already exclude highly biodiverse areas.

5.2. Policy options to ensure greenhouse gas emissions savings

As set out in section 4, four options were retained for assessment:

Option B1: no new EU action

Option B2: labelling of GHG savings

Option B3: minimum GHG savings for agricultural and forestry biomass (minimum 35%, increasing to 50-60% in 2017/2018, as compared to fossil alternative)

Option B4: minimum GHG savings in accordance with GHG saving potential (except for waste biomass)

Greenhouse gas methodology

In order to measure the greenhouse gas impacts of bioenergy pathways, a methodology is needed to calculate GHG emissions incurred through the use of biomass in electricity and heating.

In recent years a wide range of methods of measuring the greenhouse gas impacts of fuels have been devised. Differences in method have sometimes led to significant divergence in results. In designing the greenhouse gas methodology used in the RES Directive, the Commission brought together representatives of the biofuels and agricultural sectors with JRC, CONCAWE and EUCAR to work intensively on the methodological issues (as well as data improvements). The methodology agreed was to take into account greenhouse gas emissions throughout the processes of production and use of fuels, including the effects of land use change.

It is proposed to build on the existing methodology in the RES Directive, but as "final energy" in the case of biomass implies heat or electricity, it is possible to extend the scope to include conversion. In this way, it would be possible to determine the GHG performance of heat and power uses of biomass.

The proposed methodology thus follows life cycle principles, by calculating emissions from "cradle to final energy", including end conversion efficiency for larger energy facilities.

If minimum emissions savings are to be agreed, it is proposed to compare the GHG emissions to the emissions of the average fossil fuel plant at EU level. EU-wide figures are chosen since a distinction between e.g. Member States, would imply that some biomass is sustainable in some countries and not in others, which makes biomass trade overly complicated.

Annex V gives further details about the proposed methodology.

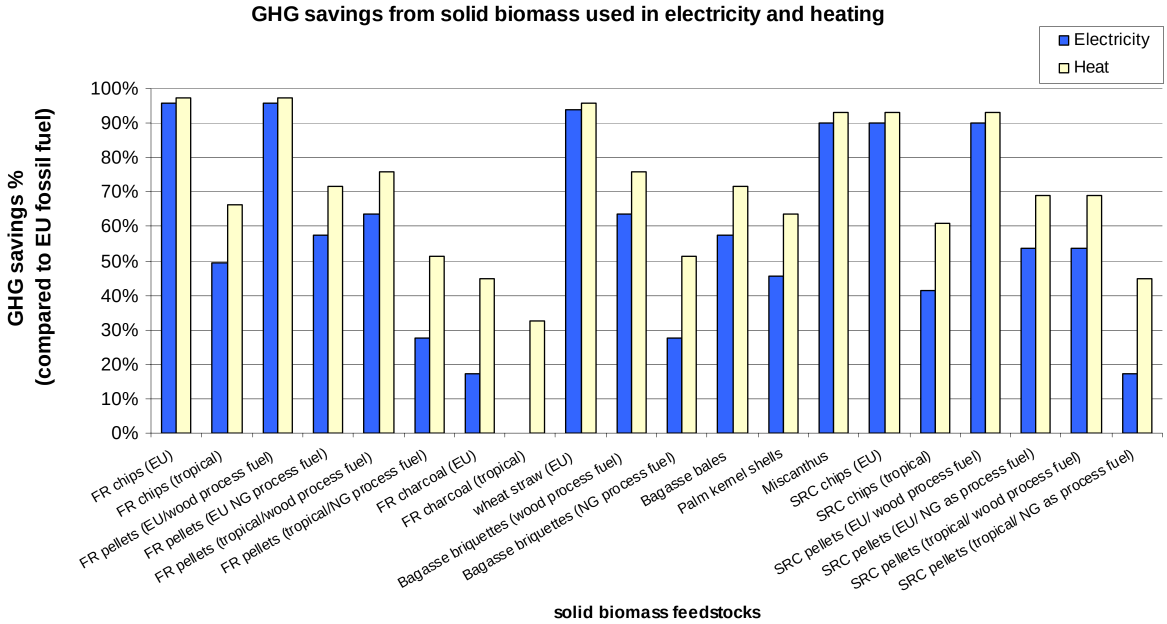
5.2.1. Environmental impacts

To establish the greenhouse gas performance from solid and gaseous biomass used in electricity and heating, the Joint Research Centre (JRC) was asked to develop pathways for several different uses of biomass, e.g. pellets, charcoal etc., these emissions are then compared to the average greenhouse gas emissions in the EU from electricity and heating in the EU. Annex VII includes the disaggregated emission values for solid and gaseous biomass pathways (calculated using JRC data, 2009), and some of the key assumptions used for the calculations.

Graph 1 gives typical values for greenhouse gas savings for selected solid and gaseous biomass chains, including biogas, wood chips and pellets used in electricity and heating[67] (losses for energy conversion are included, based on assumptions of 25% electrical conversion efficiency, and 85% thermal conversion efficiency).

67 Source JRC, 2009 [Typical values can be estimated at the mid-points of ranges, but it cannot be excluded that production processes are sometimes worse than these typical values.]

Graph 1: GHG savings potential of solid biomass used in electricity and heating



*SRC refers to short rotation coppicing and FR to forest residues

The GHG savings in almost all cases are significant compared to the EU average fossil alternatives. This indicates that production of bio-energy from solid biomass and from biogas typically delivers significant greenhouse gas savings (compared to fossil alternatives). Pellets from processed forest residues (i.e. post-processing) has not been included in the graph as it is assumed that it has similar emissions to pellets from forest residues in the EU[68]. Black liqueur is also not considered as it is difficult to imagine black liquor being sold outside the pulp mill. It is therefore considered as a waste.

In these calculations, land use emissions are assumed to be zero, the assumption being that no land conversion is taking place to produce the biomass, as in the case of waste or sustainably managed forests. It should be noted that this can normally be expected to be the case, especially as the EU is experiencing afforestation rather than deforestation.

The greenhouse gas emissions performance figures for forest biomass are supported by the UK's Environment Agency report[69], which finds that the worst case scenario for chips from forest residues is 82% saving (bearing in mind that a different methodology was used to calculate the savings). In contrast, for pellets and chips from short-rotation coppicing (SRC)[70], greenhouse gas savings range from 38% to 81% respectively (when compared to natural gas[71]). In the RES Directive default values were set for each biofuel chain, making default values conservative enough so as to be set at a level that is typical of normal production processes where the contribution to overall emissions is small. These default values were

68 Pellets (and charcoal) are normally produced from sawmill residues (not short rotation coppicing) as a high level of dryness and bark removal is required.

69 Environment Agency (2009) "Minimising greenhouse gas emissions from biomass energy generation"

70 Short rotation coppicing is considered as agriculture in this analysis, as usually arable land is used.

71 These figures are based on a different methodology to the one proposed in Annex V, where for instance the comparator is not natural gas, but average EU fossil heat or electricity.

calculated by increasing the assumed emissions from production by 40%. As the production emissions is routinely low (below 1g CO2eq/MJ biomass for forest residues (FR) and between 2-6g CO2eq/MJ for wood from short rotation forestry (SRC)), the default value would still in most cases lead to above 80% savings.

It could be argued that some of the possible greenhouse gas emissions saving opportunities are already tackled elsewhere. In case of municipal solid waste, under the Waste Framework Directive, waste incinerator operators have to meet a given energy efficiency threshold. Moreover, there are also incentives to reduce GHG emission in general through the ETS and the GHG reduction targets agreed. Nevertheless those incentives do not create standards to ensure that those with the worst performance are avoided.

The GHG savings in almost all cases are significant compared to the EU average fossil alternatives. This indicates that production of bio-energy from solid biomass and from biogas typically delivers significant greenhouse gas savings (compared to fossil alternatives). In these calculations, land use emissions are assumed to be zero, as in the case of forest or waste biomass, the assumption is that no land conversion is taking place to produce the biomass. As stated above, this can be expected to be the case, especially as the EU is experiencing afforestation rather than deforestation.

Given the data above, Options B2 would not lead to additional GHG savings.

Option B3 will lead to between 5-20% additional GHG savings for some pathways which fall below 35% and 50-60% (maize biogas, charcoal and pellets from short rotation coppicing from tropical regions). For feedstocks such as charcoal, the impact is not likely to be significant because charcoal is mainly used by small-scale users in developing countries for cooking and heating and for recreational use (barbeques) in the EU. It is not likely that putting minimum GHG requirements on charcoal would deliver much more environmental benefits in terms of GHG reduction in the EU[72]. Option B3 would also ensure that minimum GHG requirements are set in line with the RES-Directive and provides consistency for those feedstocks that can be used both for transport purposes (biofuels) and for electricity and heating, such as straw, energy grasses and energy crops.

Option B4 will lead to some additional GHG savings by leading to improvements in the chain, such as using wood instead of natural gas for the processing fuel. This could lead to an additional saving of around 15g CO2 eq/ MJ energy. In the case of pelletising, switching from natural gas to wood as process fuel, would lead to an improvement of around 35% GHG savings for electricity production.

5.2.2. Economic impacts

a. Costs to public administrations

Options B3/B4 have higher cost because more claims from economic operators would have to be checked.

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72 Trade in charcoal from Africa to the EU is not significant, however. The largest importers of charcoal in the EU (Germany, Poland, Spain, Bulgaria and UK) source charcoal mainly from other countries inside the EU (the largest exporters of charcoal are Poland, France and Germany). The largest exporters to Europe are Malaysia and Indonesia. The largest exporter from Africa is South Africa which does have strong policies on reforestation and forest management.

The cost for Options B3 and B4 were calculated using the EU's standard cost-model (see COWI Consortium 2009).

Table 3: Costs of GHG verification on public administrations (EU-27)

Type of costs	Low cost scenario (€/year)	High cost scenario (€/year)
One-off costs	€0.3 million	€1.1 million
Recurring costs	€0.1 million	€0.2 million

A single threshold for GHG savings under Option B3 may decrease the administrative burden to a certain extent, as it delivers consistency in applications which can generate both heating and electricity. In order to take account of differences in processing of feedstocks, an option is to develop default values for pathways using natural gas or using wood as process fuel. This would enable a single threshold to be used under Option B3, while ensuring that differences in emissions due to different processes are reflected.

b. Costs to economic operators

Under the RES Directive, economic operators are required to use the mass balance method[73] to prove chain of custody, because the 'book and claim' method is open to fraud and will not deliver a price premium, and the 'track and trace' method is more costly. In the impact assessment accompanying the RES Directive, it was calculated that cost of mass balance chain of custody were about €0.44/ toe or €1.36/ton[74]. As seen in the case of Electrabel in section 5.1.2, these costs will be lower for solid and gaseous biomass users, because less operators are involved in the chain[75].

The COWI Consortium (2009) found that the cost of GHG certification is substantially higher when economic operators have to show actual GHG savings of the bio-energy chain. Where default values are used, the costs to all operators in the chain are 10-20% lower.

The COWI Consortium calculated the costs for the whole EU-27 using the EU's Standard Cost Model. They showed that for processors, manufactures, traders and energy producers, the recurring costs are 60-70% higher when GHG certification is imposed compared to CoC certification alone. One-off costs were unaffected. As reporting obligations would fall on energy producers, their costs increase by an order of 10-20% compared to processors, manufacture, traders etc. energy producers). For individual energy producers above 1 MW capacity the recurring costs can vary between €898-5,643 per year. In total, EU-27 energy producers (assumed to be around 48,000 entities), would face one-off costs of between €9.8-39.4 million, and recurring costs between €68-270 million per year (the lower range is based on current average wages and the high range on an assumption that wages would rise 4-fold).

73 A mass balance system would allow the mixing of sustainable and unsustainable wood, but only the percentage of sustainable input would count towards the renewable energy targets. Existing certification schemes mainly use a method which permits a whole batch of wood to count as sustainable as long as a minimum threshold, say 70% is from sustainable sources.

74 Based on 1 tonne = 0.3215 toe

75 For forest residues, plants in general receive their individual biomass loads directly from a supplier, even where independent biomass suppliers organise the purchase.

c. Economic availability of biomass

Options B1 and B2 do not have any impact on the economic availability of biomass. Option B3 would set a 50-60% minimum threshold for all electricity and heat plants from 2017-2018.

In order to derive the total economic availability of biomass in 2020 for Option B3, it needs to be considered which agricultural biomass pathways (including biomass used for biofuels and bioliquids) will not be able to meet the 50-60 % threshold[76]. The COWI Consortium (2009) carried out an assessment of the possible improvements of the GHG performance of agricultural biomass pathways, using the following assumptions:

– a 90% reduction of nitrous oxide emissions in N fertiliser to be realised on a relatively short term,

– a 25% reduction of CO_2 emissions in N fertiliser production by 2020,

– a 5% reduction of GHG emissions in feedstock production by 2020, for emissions other than those related to N fertiliser

– a 10% reduction of CO_2 emissions in the biofuel processing industry by 2020, with a linear development towards that level from 2008,

– a 20% average reduction in methane emissions at palm oil mills by 2020,

– a 15% efficiency improvement of digester and gas engine up to 2020, also valid for new plants by 2018,

– a 40% reduction of methane emissions in processing, as these are mainly attributed to methane slip in the gas engine which can be well avoided by better engine management. This assumption also applies to new plants after 2018.

– a 5% efficiency improvement of the related diesel engines, also valid for new plants by 2018;

– a 10% efficiency improvement in long-distance transport, also valid for new plants by 2018;

Using the GHG methodology, the 2017 and 2020 typical greenhouse gas emissions which would result from the projected autonomous emission reductions were calculated. These are summarised in Table 4 below. Many biofuel and CHP chains that do not meet the 50-60% thresholds by their 2008 values are projected to do so by their 2017 (existing plants) and 2018 (new plants) values. However, the biofuel chain that falls short of the 2017 (existing plants) 50% threshold is:

– Biodiesel from soy

The biofuel chains that fall short of the 2018 (new plants) threshold of 60% are:

– Wheat ethanol with lignite as process fuel

76 The minimum savings requirement for established plants is 50% from 2017 and for new pants is 60% from 2018.

– Wheat ethanol with natural gas (conventional boiler) as a process fuel

– Biodiesel from rapeseed

– Biodiesel from soy

– Biodiesel from palm (process not specified)

Table 4: Typical GHG reduction values for 2008, 2017 and 2020.

Biofuel, chain	**Typical GHG reduction (%)**	**Typical GHG reduction (%) 2017**	**Typical GHG reduction (%) 2018 new**
Bioethanol (1st generation)			
Wheat			
- lignite as process fuel in CHP	32%	41%	42%
- natural gas as process fuel in conventional boiler	45%	53%	54%
natural gas as process fuel in CHP plant	54%	61%	62%
Corn (maize)			
- natural gas as process fuel in CHP	56%	61%	62%
Biodiesel			
- Rape seed	45%	54%	55%
- Soy bean	40%	43%	44%
- Palm oil (process not specified)	36%	38%	40%
Hydrotreated vegetable oil			
- Rape seed	51%	60%	61%
- Palm oil (process not specified)	40%	45%	47%
Pure vegetable oil			
- Rape seed	59%	67%	68%
Electricity and heat pathways			
- Power only on vegetable oils: soy	51%	56%	58%
- Power only on vegetable oils: palm (no CH4 cap)	44%	53%	55%

It can be seen from Table 4 that for non-biofuels, only the power generation options on the basis of soy and palm (process not specified) fall short of the 60% threshold.

However, it is important to consider the overall costs of reaching the 50-60% threshold also for other agricultural biomass used for biofuels and bioliquids. This is because in case these pathways cannot achieve the threshold, there may be shifts to use different types of feedstocks, which may have an impact on the economic availability of biomass and jeopardise reaching the 2020 renewable energy targets in a cost-effective way.

The COWI Consortium (2009) assessed that it is possible for most pathways to reach the threshold at a certain cost.

For ethanol production from wheat, the most straightforward way for the sector is to shift their process fuel towards CHP, on the basis of natural gas or biomass. This improves the GHG emission reduction to 62% for new plants by 2018 or higher.

For the biodiesel sector, the first-order option would be the introduction of biomethanol instead of fossil methanol (detailed data are specified in the COWI Consortium 2009 study). This option leads to a typical GHG reduction of 62%. For soy biodiesel, additional options to improve the GHG profile seem to be insufficient to meet the 50% and the 60% threshold. For existing installations by 2017, the 50% threshold can be met by the introduction of biomethanol instead of fossil methanol; it leads to a GHG emission reduction of just 50%. For new installations 2018, a shift in feedstocks for biodiesel would be expected, in which soy is phased out and substituted for rapeseed and sunflower.

For the options using palm (without methane capture) that do not meet the 50% and/or 60% threshold, it can be foreseen that methane capture will be implemented, which can be done relatively cost-effectively. This leads to a typical GHG reduction of well over 60%. For power generation from palm and soy, it can be assumed that soy oil is substituted by palm oil and that this palm oil can then be fully obtained from mills with methane capture. This increases the greenhouse gas emission reduction to 75%.

The impacts of carrying out these improvements were assessed by the COWI Consortium (2009). Table 5 summarises these costs. All costs are annual costs for the year 2020; no cumulative costs for 2008-2020 were calculated.

Table 5: Costs of meeting GHG thresholds until 2020

Biofuel chain	Autonomous GHG emission reduction	Improvement option	Resulting GHG emission reduction	Additional costs for the year 2020 (linear baseline)	Additional costs for the year 2020 (2015 biodiesel peak)
Ethanol from wheat (NG boiler)	54% (2018)	Shift to natual gas CHP	62% (2018)	0	0

Biodiesel from rapeseed	55% (2018)	Biomethanol in processing	62% (2018)	13 M€	0
Biodiesel from soy	43% (2017)	Biomethanol in processing	50% (2017)	18 M€	23 M€
Biodiesel from soy	44% (2018)	Shift to rape, sunflower	>62% (2018)	15 M€	0
Biodiesel/HVO from palm (p.n.s.)	45/47% (2017) 43/47% (2018)	Methane capture	> 62/68%[1] (2018)	15 M€	15 M€
Total additional costs				**61 M€**	**38 M€**

[1]:62% and 68% are the current typical values for respectively biodiesel and HVO from palm with methane capture at oil mill. 2017 and 2018 values have not been calculated but will be above these values.

A full shift to methane capture in palm oil production comes at an estimated cost of 0,2 €/GJ palm oil. The estimated 4 PJ of palm oil use as a bioliquid in power generation would then lead to additional costs in the order of € 1 million.

In sum, it is not expected that Option B3 will have any impact on the economic availability of biomass. There will however be some compliance costs mainly affecting the biofuels and bioliquids industry to improve their GHG performance. But this is a consequence of the RES Directive.

Option B4 would also not have an impact on economic availability of biomass, as it is assumed that high GHG requirements for forest biomass can be achieved by the sector. However, the additional compliance costs associated with Option B4 would not lead to significant additional GHG savings as identified in section 5.2.1.

5.2.3. Social impacts

It is not expected that the GHG savings obligations could be reasonably put on households, as it would be difficult to monitor their GHG savings. If households are exempted from these requirements, there is no impact on households. Employment effects are also considered negligible from putting in place greenhouse gas performance criteria.

5.2.4. Impacts on third country actors

The total administrative costs associated with complying with GHG criteria are difficult to quantify as the number of actors who may be affected is highly uncertain. It is however possible to assume that the administrative costs per economic operator will be similar to those calculated for EU actors. The COWI Consortium calculated costs for forest owners and farmers producing short rotation coppicing, as well as for wood processors manufacturing secondary woodfuels or raw materials for these (saw mills, pulp and paper mills, pellet and briquette factories) and biomass traders. The costs for these target groups are detailed in the COWI Consortium's report, and are summarised below:

Table 6: Administrative costs of GHG verification per biomass producer/ processors and traders

Type of costs	Biomass producers	Processors and traders
One-off costs	€205-820	€205-820
Recurring costs	€769-3076/ year	€898-3593/ year

Some third country producers, such as pellet factories, already provide evidence of meeting CO2 performance requirements, e.g. under company schemes such as the Laborelec scheme.

5.2.5 Summary of impacts

Table 7: Summary of impacts of policy options to ensure GHG savings

	Costs to public administration (EU-27)	**Economic availability of biomass**	**Costs to economic operators**	**Environmental impacts** **Biodiversity and Land use**	**House holds**	**Employ ment**
A. Production						
Option B1: no new EU action	0 No effect	0 No effect	0 No effect	0 Does not contribute to additional GHG savings	0 No effect	0 No effect
Option B2: labelling of GHG performance	- Costs to set up scheme and provide labelling	0 No effect	- Some additional costs for labelling scheme	0 No significant benefit, as differences in GHG performance are difficult to distinguish for most consumers of heat/ electricity	0 No effect	0 No effect
Option B3: 35% (increasing to 50-60% in 2017/2018) GHG savings for agricultural + forestry pathways	- Costs due to verification of GHG criteria	0 No significant change	- Some additional costs if biomass pathway does not typically reach GHG performance requirement	+ Some additional GHG savings (5% for biogas based on crops and 5-20% for SRC charcoal and 5-10% for charcoal from forest residues)	0 No effect	0 No effect
Option B4: GHG thresholds in accordance with GHG saving potential (except for waste	- Costs due to verification of GHG criteria	0 No significant change	- Some additional costs if biomass pathway does not typically reach GHG performance requirement	+ some additional GHG savings depending on the thresholds (e.g. pellets using wood as process fuel deliver 35% savings compared to pellet using natural gas as process fuel)	0 No effect	0 No effect

biomass)

Table 7 shows that that Options B3 and B4 would bring some additional environmental benefits in terms of GHG performance. Option B1 would not provide safeguards against some energy intensive practices and Option B2 would not bring any additional environmental benefits as there would be no minimum standards set. In particular, there are some pathways where high GHG performance may not be assured. This is partly because consumers would not be able to judge between good and bad practices without benchmarks.

The potential additional GHG savings over the life cycle are not immensely significant for Option B3 and B4. In particular, the additional burden of having different GHG requirements for different pathways (Option B4) may not outweigh the benefits of the additional GHG savings in all cases. This is because most of the pathways routinely achieve high (usually more than 80% GHG savings) throughout the lifecycle. Administrative costs are reduced if the GHG requirements are consistent over all biomass feedstocks (whether used as transport biofuels or for electricity and heat), as proposed in option B3. To take account the largest differences in emissions, i.e. due to the fuel used for processing, an option is to develop different default values for pathways depending on the process fuel. This would limit the administrative burden while ensuring that differences in emissions due to different processes are reflected.

5.3 Policy Options to foster higher end-conversion efficiency of biomass

Option C1: No new EU action

Option C2: Bonus for better end-conversion efficiency or penalty for lower end-conversion efficiency

Option C3: Minimum efficiency standards

Policy options for different technology combinations

The policy options will produce very different incentives for the different technology combinations and stakeholder groups.

Users of dedicated large scale power and CHP plants are usually well-informed and motivated by subsidies or other support mechanisms. Most efficiency improvements can be made through technology add-on's and heat use of these large installations. A bonus/ penalty system for higher efficiency or minimum performance standard for new installations could be appropriate policy measures as most installations already perform at their optimal efficiency and for further improvements additional investments are necessary through using 'add on' technology or to make more use of the heat produced. Therefore a specific attention on using heat in the bonus system could be considered. In Belgium for instance, in the Walloon and Brussels regions, subsidies are granted based upon the avoided fossil CO2 emissions with respect to a reference fossil plant, based on an LCA analysis, including the efficiency of the plant[77]. This means that biomass is not considered as fully CO2 neutral for the purposes of the Green certificate scheme, and in many cases power-only co-firing plants with coal would not meat requirements to benefit from the subsidy scheme.

[77] Van Stappen, Marchal, Ryckmans, Crehay, Schenkel "Green Certificate Mechanisms in Belgium: A useful instrument to mitigate GHG emissions", Laborelec/ Electrabel

Minimum performance standards for new installations might also be feasible, because these can be integrated in the design of a new installation. For dedicated large scale installations minimum performance standards could be a feasible way to stimulate either use of heat produced or use of add-on's to increase electricity production. Under the Eco-design Directive, the Commission has already undertaken a study on the energy efficiency of industrial ovens and furnaces that will cover all potential fuel sources, including biomass. Results of this study will be available at the end of 2011.

Labelling is not a feasible policy option for large scale power and CHP installations, because it is not a consumer good and acquiring such large installations is guided more by financial or technical reasons.

In co-firing plants, subsidy schemes are usually the drivers of the use of biomass, but it has to be born in mind that the original purpose of co-firing installations is not to provide bio-energy but to provide fossil energy. Setting minimum requirements for installations using biomass and not for other fossil fuels, may lead to decreased use of biomass in co-firing plants. Energy efficiency policies looking at all fuels therefore would be more appropriate in increasing energy conversion efficiency in this case.

The case of waste incineration is comparable to co-firing as main objective of energy recovery of waste is not energy generation but waste management. Setting minimum efficiency requirements for biodegradable wastes might therefore result in reducing the potential of green electricity produced from a feedstock with no alternative use (unless it is biologically treated). A bonus/ penalty system for higher efficiency may be an option, stimulating small increases in the installation due to technical performances and process management. The Waste Framework Directive also has some incentives for improving efficiency. It sets minimum efficiency requirements to serve as a threshold for the classification of waste incineration as recovery operation instead of as disposal operation.

In the case of co-digestion, methane emissions are reduced compared to conventional manure storage and spreading, or from landfilling bio-wastes, energy is produced and the digestate is a more valuable fertilizer than the manure itself. Large improvements could be made in efficiency due to heat use, up-scaling etc, but efficiency measures should not limit/discourage the practice of digesting given the environmental advantages (and waste management objectives). Therefore for waste digestion the most suitable policy option would be a bonus/ penalty system.

District heating systems are more efficient than individual heating systems therefore stimulation of those systems would increase efficiency. However the construction of district heating systems is quite costly. In several countries district heating systems already exist, which makes connection to the network with a new provider of energy relatively easy. This generates different opportunities and different policy options relevant for different regions in Europe. It must also be possible to fit the system with the local demand present. A bonus / penalty system could help optimise the system by stimulation CHP's which can also provide electricity.

Table 8 below depicts the possible efficiency improvements of the different biomass technology combinations and summarises the possible policy options to be used to stimulate increased end-conversion efficiency of the different technology combinations.

Table 8 (from Ecorys report 2009, table 21): Summary of biomass technology combinations and their improved efficiency potentials

	Main countries of application	Typical efficiency %	Order of magnitude of estimated current capacity	Order of magnitude estimate of maximum potential	Efficiency improvements	Possible policy options
Large scale power and CHP	FI, DK, SE, EE, LV, LT, AT	10-30 electrical	4.7GWe (+ unknown amount of heat)	5.8 MWe at ηe=20%->25% 15 GWth at full heat utilization	Large scale; heat utilization; -Improved heat Recovery by ORC of flue gas condenser	- Bonus/ penalty system for efficiency improvement -Minimum efficiency standard
Co-firing	DE, FI, UK, NL	35-43 electrical	1.2 GWe	8.3 GWe based on total technical potential	Heat utilization -(Improve impact: increase market penetration)	-No specific efficiency related policies -Efficiency is already high, with possibilities for stimulation of co-firing in general
Waste incineration	DE, NL, DK, SE, LU	15-30 electrical	2.2 GWe	3.8 GWe when all MSW is incinerated (no landfill)	- Higher steam pressures; -Corrosion resistant materials; -Heat utilization	- Bonus/ penalty system for efficiency improvement
Power Plant ORC	AT, DE	6-20 electrical	Unknown	Unknown	-Autonomous improvement of this new technology	-Bonus/ penalty system for efficiency improvement -Minimum efficiency standard
District heating	SE, FI, DK, EE, LV, AT	80-90 thermal	126 GWth	Improving efficiency from ηth80%->90% reduces primary energy consumption with 26PJ->14.4 GWth installed capacity	-Improved heat recovery by e.g. flue gas condensation; -Boiler efficiency improvements	-Investment Subsidy -Minimum efficiency standard
Manure (co)digestion	DE, DK, AT, NL, IT, PT, HU	Not relevant (motor: 38-42	1667 MWe	2037MWth (at electrical efficiency of 36%); 1852 MWe and 1852 MWth when electrical	-Heat utilization; -Avoid small scale gas	-Bonus/ penalty system for efficiency improvement

		electrical)		efficiency is 40% (scale advantages)	engines	
Diesel engines on vegetable oils	IT, DE	40-48 electrical	Unknown	Unknown	-Heat utilization; -Avoid small scale diesel engines	-Bonus/ penalty system for efficiency improvement -Minimum efficiency standard

Option C2 (Bonus/ penalty system) is best applicable where significant improvements in efficiency can be made, due to the costs for government. In this sense, stimulation of heat & power production over stand-alone electricity production plants brings additional energy savings, and reducing one-sided stimulation of electricity in current support schemes will create an incentive for this. A step-wise bonus system is a tool effectively used in some Member States to stimulate heat use. A bonus system is especially interesting for already existing installations. For new installations the use of heat can be taken into account in construction increasing the improvements obtained in the future. A bonus system is also most effective when installations serve other goals: such as waste treatment, as minimum efficiency requirements may hamper the supply of the main service of such plants.

Option C3 (minimum efficiency standards) is effective in excluding the application of certain inefficient biomass pathways. In principle this option can be applied to all biomass conversion installations, in particular to new installations, because these can be integrated in the design of a new installation. For dedicated large scale installations minimum performance standards could be a feasible way to stimulate either use of heat produced or use of add-on's to increase electricity production. However, there is a risk that economic operators will make a different economic calculation on the use of biomass and minimum standards might lead to the use of more fossil energy if the same standards do not also apply to fossil fuel applications. Moreover, the use of biomass waste streams which have no other use (e.g. manure), may be disincentivised.

5.3.1. Environmental Impacts

The impacts of higher efficiency gains on GHG performance are discussed under policy options to reduce GHG emissions. Overall GHG savings throughout the life cycle of existing biomass plants are only marginal compared to increasing the replacement of fossil fuels with biomass. In general the impact of end-conversion efficiency improvements of existing plants depends on what the biomass technologies are being compared to. When compared with similar size fossil fuel plants, there are hardly any differences in GHG improvements due to increased efficiency.

However, the policy options considered could have positive environmental effects if the policies result in more efficient use of biomass. The availability of biomass becomes a constraint on the scope for replacing fossil fuels. In that case, positive impacts would be dependent on the effectiveness of the different policy options to replace fossil fuel alternatives.

Table 7 in section 5.3.1 shows the range of efficiency improvements achievable by different technology combinations (typical efficiency). The biggest improvements could come from utilising the heat in electricity only plants (i.e. switching to biomass CHP).

Therefore policies which can encourage these improvements will have the highest environmental benefits.

Under Option C3, if minimum efficiency standards are set only for biomass and not for fossil fuels, the environmental impacts can be negative. Coherent energy efficiency policy is needed therefore on all energy production not only for bio-energy production.

Under Option C2 (bonus/ penalty), the negative impacts of switching away from biomass to fossil would be avoided, as a bonus usually means an additional incentive on top of other incentives to use renewable energy (e.g. more green certificates, price premium on top of feed in tariffs, investment subsidy etc). It is however important that Member States would set efficiency requirements to get a bonus at a level which is achievable for the specific biomass technology combinations.

5.3.2. Economic impacts

a. Costs to public administration

The administrative costs associated with each policy option are relatively low. They can be higher when there are disperse and diverse target groups. Ecorys estimated administrative costs using the EU standard cost model (See Ecorys 2009).

Total Administrative Costs			
No.	Type of obligation	Low cost scenario	High cost scenario
C2a	Bonus/ penalty system for large-scale power and CHP	€592,463	€2,369,852
C2b	Bonus/ penalty system for waste incineration	€404,240	€1,616,960
C2c	Bonus/ penalty system for co-digestion	€443,264	€1,773,056
C3b	Minimum efficiency standard for large scale power and CHP	€695,217	€2,780,868
C3c	Minimum efficiency standard for district heating	€934,573	€3,738,293

For Option C2, there may be additional costs to governments. This could depend on the support scheme used in Member States. In Austria, the support framework for highly efficient renewable electricity production is provided through the "Eco-Power Act" in 2003 which lays down criteria for energy efficiency (investments for installation of the heat extraction part are subsidised depending on the ensured heat extraction with 15%–30% of the investment cost), and provides a purchasing obligation and tariff support, which are funded via an extra charge on the electricity price.[78] (Electricity prices for households have increased from €13.19/ 100kWh in 2004 to €14.09/kWh in 2007[79]).

b. Costs to economic operators

[78] http://www.cospp.com/display_article/314976/122/ARCHI/none/none/1/CHP-support-mechanisms-in-different-countries---from-feed-in-tariffs-to-investment-incentives/

[79] Eurostat, taxes included

The cost of increasing efficiencies of the different types of biomass plants was studied by Ecorys (2009). In general, improvements in end-conversion efficiency can be achieved through:

- using the produced heat
- application of add-on's to increase electricity or heat production
- technology improvements of the combustion technology
- increase the plant size (capacity)[80]

The costs include the costs companies have to make to incur to comply with new legislation. In this case, costs necessary to improve the conversion efficiency of the biomass technology combination. The large variety of installations generating bioenergy obviously makes it difficult to give a reliable indication of these costs. The table in Annex VI gives examples of the costs to improve the end-conversion efficiency for different technologies.

Policy option C2 (bonus/ penalty), does not force companies to implement efficiency improvements, because a bonus does not exclude less efficient biomass plants. It is a voluntary measure, where a company is free to make use of the bonus. Only when companies are forced to comply with new efficiency standards, do actual compliance costs occur.

Where companies would need to comply with minimum efficiency standards, an overall quantification of compliance and administrative costs are presented in the table in Annex VI. It should be noted that the replacement rate, as presented in the table can be subjected to variation due to the set up of possible support schemes or legislation. A low and a high scenario are presented to indicate the range in gains that can be obtained. As efficiency improvements of around 8% are already assumed in the baseline scenario for new electricity plants, it can be concluded that the largest gains in end-use efficiency improvement can be obtained through use of heat in new installations. Nevertheless, an option for minimum efficiency requirements, which would require the use of heat, would lead to considerable compliance costs, between €50-200 million per installation.

c. Economic availability of biomass

The impacts on availability of biomass are deduced from the total savings of replacing efficient technologies with inefficient ones. The baseline scenario already takes account of increases in efficiency, through technology learning. If any impact arises, it is likely to be a positive one, as a product of using less biomass to replace more fossil.

5.3.3. Social impacts

a. Households

Minimum efficiency requirements or bonus/ penalty for large scale systems is not expected to have an impact on households, unless the extra costs to bio-energy plants are passed onto consumers in terms of higher prices for energy. This may lead to a substitution effect where

80 Although scale and size of an installation is moreover determined by location, supply of feedstock and an optimum cost effectiveness and scale.

money for consumption is shifted from other goods to the consumption of energy. However, if the additional investment, maintenance and operation for biomass induce more employment, the households will have more money available for consumption (total income of household increases). This might compensate the negative price effect and increase consumption.

b. Employment

Employment impacts can arise where the minimum efficiency requirements under Option C3 result in a need for upgrading systems. An increase in investments increases the demand in biomass related services and biomass-technology producing sectors. Hence, an increased demand leads to an augmentation of the production in these sectors. There will be sectors that are indirectly affected by the policy options, such as suppliers of biomass-technology producers or service providers like the forest and agricultural sectors, transportation sector etc. Besides the suppliers of the biomass technology producing sector, we also have to take into account the effect of biomass promotion on the fossil energy generation sector. Conventional investments in this sector will decrease since the generation of fossil energy will be replaced by biomass. Hence, revenues and employment will decrease at conventional (fossil) energy technology producers and service providers as well as at the suppliers of technology producers.

The employment effects are not expected to be significant, as the technological improvements needed to reach the 2020 targets have already been considered studying the baseline. Only where there are minimum efficiency standards introduced could some positive employment effects arise, given that the efficiency standards are set in a way that ensures continuing investments into the biomass sector.

5.3.4 Summary of impacts

Table 9: Summary of impacts of the policy options to foster energy efficiency

	Cost to public administrations (EU-27)	**Costs to economic operators**	**Economic availability (EU 27)**	**Environmental impacts**	**Employment**	**Households**
Option C1: Business as usual	0 No effect	0 No effect	0 No effect	0 No effect	0 No effect	0 No effect
Option C2: Bonus for better end-conversion efficiency or penalty for lower end-conversion efficiency	- Low additional administrative costs, as can be included in existing support scheme, but high costs for governments.	+ additional operation and investment costs are compensated by bonus and lower performing installation are not excluded from support.	+ More efficient burning of biomass leads to less quantity of biomass used per energy produced	+ leads to more effective use of resources	0 Some additional jobs from investments effects, but the impacts are negligible	0 No effect
Option C3:	-- High costs of	-- High	+ More efficient	Depends on response to	+ Additional	- Increased

	Cost to public administrations (EU-27)	Costs to economic operators	Economic availability (EU 27)	Environmental impacts	Employment	Households
minimum efficiency standards	setting up schemes to enforce standards.	increase in compliance costs where existing installations have to be upgraded, moderate when applied to new installations only	burning of biomass leads to less quantity of biomass used per energy produced	standards: - if biomass stoves are replaced by fossil + when a standard leads to more effective use of resources	jobs from investment effects	energy costs on consumers

Table 9 shows that option C1 has no effect on further improving end conversion efficiency. The environmental impacts of Options C3 depend on wider energy efficiency policy for fossil alternatives. Negative impacts can occur where the policy would lead to a shift from biomass to fossil use. In terms of costs, Option C3 (minimum requirements) is not effective if minimum requirements on fossil alternatives do not occur at the same time and this option has high administrative and compliance costs. Option C2 (bonus/ penalty) could be costly to governments, but it is the effective option in terms of delivering environmental benefits, while ensuring low compliance costs.

Section 6: Comparing the options

The options can be compared in accordance with the following requirements:

- consistency with other policies: biomass is a resource that can be used in liquid, solid or gaseous form to produce transport biofuels, heat or electricity. There should not be different sustainability requirements for biomass depending on the end-use. There should also not be requirements for biomass and not fossil alternatives if this will lead to more fossil being used instead.

- effectiveness: the policy options ability to ensure minimum requirements are in pace to avoid deforestation, loss of biodiversity and given that there is a maximum potential of biomass feedstocks, to avoid overuse of the resource.

- costs-efficiency: costs to public administration and economic operators should not outweigh the sustainability benefits, i.e. there should be proportionality in putting burden on administrations and industry. Burden is proportionate if real improvements in sustainability can be made.

The impacts of the different options can be compared as follows:

Legend:

Positive effect
Moderate effect
Negative effect
Not relevant X

	Effectiveness in achieving objectives	Efficiency (cost-effectiveness)	Consistency (with policy structures and socio-economic developments)
Option A1: no new EU action	Ineffective in avoiding negative land use changes	Not relevant X	Inconsistent with biofuels policy
Option A3: minimum biodiversity and land use criteria	Effective in ensuring further safeguards against negative land use changes	Administrative costs minimised as verification scheme for origin of biomass is required under RES-Directive	Consistent with biofuels policy
Option A4a: Option A3 + mandatory reporting and monitoring SFM	Effective in ensuring further safeguards against negative land use changes and effective in informing decision-makers about future trends	Administrative costs can be minimized where reporting is based on existing voluntary reporting tools (e.g. MCPFE)	Consistent with biofuels and with global SFM policies
Option A5: Option A3 + SFM obligation	Effective in avoiding negative land use impacts	High administrative costs for monitoring implementation of	Consistent with EU policy objectives to tackle

	Effectiveness in achieving objectives	Efficiency (cost-effectiveness)	Consistency (with policy structures and socio-economic developments)
	as well as ensuring SFM	SFM criteria and for certification of SFM	deforestation and forest degradation
Option B1: no new EU action	May lead to some biomass pathways not achieving high GHG performance	Not relevant X	Inconsistency of accounting GHG emissions for agricultural biomass under the RED
Option B2: labelling of GHG performance	Effective only for consumer products not large scale plants	Some costs to administrations and to economic operators	Not relevant X
Option B3: minimum GHG savings threshold for agricultural and forestry pathways of 35% (increasing to 50-60% in 2017/2018)	Effective in avoiding pathways with low GHG performance	Some costs for verification of GHG performance	Consistent with biofuels policy
Option B4: Minimum GHG performance in accordance with GHG performance potential (except for waste biomass)	Effective in avoiding worst practices and lowering GHG emissions	Some costs for verification of GHG performance	Consistent with GHG emissions reduction policy, but not with biofuels policy e.g. second generation biofuels
Option C1 – no new EU action	Some improvement due to existing policies	Not relevant X	Not relevant X
Option C2 - Bonus or penalty	Effective as bio-energy producers receive a direct incentive, but the effect depends on bonus/ penalty structure	Cost for governments can be significant	Easily included in existing policy framework and in line with general approach to reward good behaviour
Option C3 - Minimum efficiency performance standards	Effective in excluding poor performing installations, but difficult to set unambiguous thresholds	High compliance costs to economic operators if applied to existing installations	Requires development of new policy instrument and may conflict with aims of other policies (promotion of renewables vs fossil, waste treatment, rural development, security of supply)

On the production side, in the light of the analysis summarised above, the policy option for putting in place minimum requirements for avoidance of biomass production from highly biodiverse lands and avoidance of negative land use change (i.e. same criteria as in RES Directive) is the best one from a cost-efficiency point of view. Setting minimum thresholds or obligations for sustainable forest management could lead to high costs for industry. On the other hand, reporting the origin of biomass used for energy purposes is recommended, to improve statistics on biomass use and to monitor the effects of biomass use on the areas of origin. Member States could keep a record of the origin of biomass used for energy purposes, and the Commission would periodically monitor those areas. If, through monitoring, it is found that there are areas where forests were not regenerated, proposals could be made for corrective action. The country of origin's accounting for LULUCF emissions could serve as one of the factors in monitoring. For biomass used in households, Member States can monitor the use of biomass through surveys.

As regards greenhouse gas performance, it is recommended that for consistency operators use an EU-wide harmonised GHG methodology to calculate emissions. Also for reasons of consistency, biofuels, bioliquids and solid and gaseous biomass should meet the same GHG requirements. This will avoid distortions in the market. Therefore, the minimum GHG savings requirement should be set at 35%, increasing to 50% from 2017 for existing plants and 60% for new plants from 2018. It is recognised however that wastes and processing residues which routinely achieve high greenhouse gas savings should not be required to reach these requirements, as including them would not afford important environmental benefits, while adding costs to operators.

On improving efficiency, it is clear that most of the policy options would only be effective if fossil alternatives were also covered by them. It is therefore recommended not to set efficiency standards only for biomass pathways, because that may encourage more fossil energy being used instead. Moreover, it is difficult to set the right incentives without thinking about the technology that it will be applied to. The assessment shows that efficiencies of different technologies cannot be compared (because often they serve different purposes, e.g. waste management) and that all technologies have a role to play. For this reason, Member States should use a bonus/ penalty in their support schemes for higher efficiency levels for large (non-residential) electricity and heat installations of at least 1MW capacity. It would be for Member States to determine the detailed design of their scheme.

6.1. Possible EU initiatives to implement the policy options

Setting binding EU sustainability requirements for solid and gaseous biomass would enable consistency of requirements for the producers and users of biomass for energy purposes. However, biomass can be used for other purposes than energy, and policy developments in forestry, agriculture, waste, climate action etc. also need to be taken into account when considering EU-wide action. Many of the problems that need to be tackled, such as deforestation, have a much broader set of causes than the energy sector. Setting requirements only for the energy uses of biomass is not likely to go far enough in solving the wider problems.

The choice of whether or not to set binding criteria has to also consider the administrative burden to actors in the EU which, today, can already be seen to be acting sustainably, even in the absence of such criteria. This includes small and medium sized enterprises where the administrative costs will be more significant. This impact assessment suggests that bio-energy producers below 1MW capacity should be considered small-scale and should not be covered by sustainability criteria. Some Member States have hundreds of small producers which operate plants of between 1-2MW. Setting such a threshold therefore could have different cost implications on different Member States and a uniform approach across the EU may be difficult to achieve.

Analysis of the current situation suggests that the limited imports of biomass and the largely sufficient environmental performance inside the EU can give certain guarantees of the sustainability of biomass production and use. As a result, and in order to respect the "better regulation principle", it is proposed to use as far as possible existing instruments in the environmental, forestry, waste and agricultural policies both at EU and national level. This would suggest that binding criteria for the use of solid and gaseous biomass specifically for energy purposes should not be proposed at this stage, and the ensuing debate should remain focused on the issue of biomass sustainability in terms of the wider policy framework and in relation to the broad range of uses of biomass.

This would not prevent those Member States that rely heavily on large-scale imports of biomass from countries that may not have in place adequate environmental laws or governance structures from setting up their own safeguards. It would seem appropriate for such safeguards to be based on the recommended policy options identified in this impact assessment.

On the other hand, a lack of binding criteria may lead to unwanted effects, such as the development of widely different national schemes which may cause disruption to the internal market. Therefore it is important that national schemes are developed in a way to prevent any disruption to the internal market. This factor may play a part in future assessment of the need for Union legislation on the issues considered in this impact assessment.

Future reflections by the Commission on the need for Union action will also be able to take into account Member States' national renewable energy action plans, required by Article 4 of the RES Directive. These action plans are due to be submitted by the end of June 2010, and will give further indications about Member States' plans to support the use of biomass for energy purposes. The development of biomass production and trade can then be monitored through national reporting, to determine whether Community action may be necessary.

In summary, it is proposed to present recommendations for sustainability criteria for solid and gaseous biomass used for electricity and heating purposes, allowing Member States which are concerned about unsustainable uses, to put in place approaches that are consistent with the RES Directive. The Commission would encourage such Member States to work together to develop common approaches.

It has to be pointed out however, that such an approach would not allow Member States to refuse to count biomass which does not fulfil the obligations of the national scheme towards the renewable energy targets. Member States could however decide not to give financial support for biomass not meeting the national criteria.

Section 7: Monitoring and evaluation

The core indicator for meeting the objectives is the increasing use of biomass without leading to deforestation, forest degradation, the impoverishment of agricultural soils, or higher GHG emissions. Reporting and monitoring systems are available in particular at EU level, but will need to be strengthened for more accurate results. Monitoring requirements under the Renewable Energy Directive include the monitoring of commodity price changes associated with the use of biomass and any effects on food security as well as the impact of increased demand for biomass on biomass using sectors.

Eurostat collects information from Member States on forest biomass and bioenergy. New requirements for biomass used for energy could be built into those monitoring systems. Data collection, map references and information about forest management will need to be strengthened, including at national level, in the current context.

ANNEX I – Biomass primary potentials and fuel price for various fractions of biomass in the EU (EMPLOY-RES)[17]

Solid biomass	Potentials (in terms of primary energy)				Fuel cost (weighted average)	
	2005	2020	2005	2020	2005	2020
		GWh	Mtoe	Mtoe	€/MWh-p	€/MWh-p
AP1 - rape & sunflower	76,617	81,235	6.6	7.0	36.8	54.3
AP2 - maize, wheat (corn)	144,087	179,996	12.4	15.5	27.3	40.3
AP3 - maize, wheat (whole plant)	0	207,593	0.0	17.8	0.0	41.2
AP4 - SRC willow..	19,860	74,076	1.7	6.4	21.0	35.5
AP5 - miscanthus	18,246	62,943	1.6	5.4	19.4	37.1
AP6 - switch grass	31,365	130,318	2.7	11.2	16.3	33.2
AP7 - sweet sorghum	14,633	43,490	1.3	3.7	40.9	60.7
AR1 - straw	193,610	315,416	16.6	27.1	12.4	17.9
AR2 - other agricultural residues	20,452	33,302	1.8	2.9	12.7	18.3
FP1 - forestry products (current use (wood chips, log wood))	569,356	569,356	49.0	49.0	18.6	24.4
FP2 - forestry products (complementary fellings (moderate))	40,735	96,556	3.5	8.3	21.0	27.6
FP3 - forestry products (complementary fellings (expensive))	61,102	144,834	5.3	12.5	28.4	37.3
FR1 - black liquor	119,396	138,566	10.3	11.9	6.1	8.0
FR2 - forestry residues (current use)	98,024	98,024	8.4	8.4	7.2	9.4
FR3 - forestry residues (additional)	22,169	25,857	1.9	2.2	12.9	16.9
FR4 - demolition wood, industrial residues	83,516	97,195	7.2	8.4	5.6	7.1
FR5 - additional wood processing residues (sawmill, bark)	48,679	56,508	4.2	4.9	6.7	8.6
FR6 - forestry imports from abroad	29,740	101,429	2.6	8.7	16.6	25.5
BW1 - biodegradable fraction of municipal waste	149,056	207,815	12.8	17.9	-3.7	-4.7
Agricultural products	304,809	779,650	26.2	67.0	28.3	41.3
Agricultural residues	214,061	348,718	18.4	30.0	12.4	17.9
Forestry products	671,192	810,746	57.7	69.7	19.6	27.1
Forestry residues	371,784	416,150	32.0	35.8	6.7	8.8
Biodegradable waste	149,056	207,815	12.8	17.9	-3.7	-4.7
Forestry imports	29,740	101,429	2.6	8.7	16.6	25.5
Solid biomass - TOTAL	1,740,644	2,664,508	149.7	229.1	15.5	24.6

ANNEX II – Overview of typical energy conversion efficiency of biomass plants (EMPLOY-RES)17

RES-E	Plant specification	Efficiency (electricity) [1]	Efficiency (heat) [1]	Typical plant size [MWel]
Biogas	Agricultural biogas plant	28 – 34%		0.1 - 0.5
	Agricultural biogas plant - CHP	27 – 33%	55 – 59%	0.1 - 0.5
	Landfill gas plant	32 – 36%		0.75 - 8
	Landfill gas plant - CHP	31 - 35%	50 – 54%	0.75 - 8
	Sewage gas plant	28 – 32%		0.1 - 0.6
	Sewage gas plant - CHP	26 – 30%	54 – 58%	0.1 - 0.6
Biomass	Biomass plant	26 – 30%		1 - 25
	Cofiring	37%		
	Biomass plant - CHP	22 – 27%	63 – 66%	1 - 25
	Cofiring - CHP	20%	60%	
Biowaste	Waste incineration plant	18 – 22%		2 - 50
	Waste incineration	14 – 16%	64 – 66%	2 - 50

	plant - CHP			
Biomass district heating	Large-scale unit		89%	10
	Biomass - Medium-scale unit		87%	5
	District heat Small-scale unit		85%	0.5 - 1
Biomass - residential	log wood		75 - 85%	0.015 - 0.04
	wood chips		78 - 85%	0.02 - 0.3
	heat pellets		85 - 90%	0.01 - 0.25

ANNEX III– Analysis of actions undertaken to ensure sustainable production and consumption of biomass in different sectors

In the last quarter century a growing body of scientific research has revealed that the world's forests are under stress (BTG report, 2008). Voluntary measures have been taken to combat deforestation. The following analyses the actions taken in the forest sector, as well as in agriculture and the energy sector.

Forests:

Numerous studies in the EU indicate that there is a considerable potential to increase the use of forest products without harming the forest environment (e.g. EEA, 2006)[62]. However, it is accepted that there might be the risk that current voluntary initiatives (including certification schemes) do not cover all aspects arising from intensified use of forests. In most EU Member States the forest law promotes the concept of sustainable forest management (SFM) as defined by the MCPFE process and further developed by, among others, Criteria and Indicators for SFM (C&I) and the Pan-European Operational Level Guidelines (PEOLG). However, aspects such as intensive forms of forest harvesting or balancing carbon stocks are not always covered by voluntary or national initiatives.

There are also no assurances that countries outside the EU apply SFM principles and practices. The United Nations Forum on Forests agreed in 2007 a "Non-legally binding instrument on all types of forests", whose purpose is to strengthen political commitment and action at all levels to implement effectively sustainable management of all types of forests and to achieve the shared global objectives on forests. It reiterates that each state is responsible for the sustainable management of its forests and for the enforcement of its forest-related laws, with four global objectives in mind:

– Reverse the loss of forest cover worldwide through sustainable forest management, including protection, restoration, afforestation and reforestation, and increase efforts to prevent forest degradation;

– Enhance forest-based economic, social and environmental benefits, including by improving the livelihoods of forest dependent people;

– Increase significantly the area of protected forests worldwide and other areas of sustainably managed forests, as well as the proportion of forest products from sustainably managed forests;

– Reverse the decline in official development assistance for sustainable forest management and mobilize significantly increased, new and additional financial resources from all sources for the implementation of sustainable forest management.

There appears to be growing international consensus on the key elements of sustainable forest management and seven common thematic areas[81] of sustainable forest management have emerged in the UNFF document.

However, the ten regional and international initiatives to put in place criteria and indicators to monitor these developments[82] have seen great variations. The Centre for International forestry Research (CIFOR) and the African Timber Organisation do not use the same criteria for evaluating the sustainable management of forest. The criterion referring to the maintenance of forest contribution to global carbon cycles is only mentioned by the Montreal process, the Dry-Zone Africa Process on Criteria and Indicators for Sustainable Forest Management, and the Pan-European Forest Process on Criteria and Indicators for Sustainable Forest Management.

Even within one regional initiative, the national implementation of agreed principles varies widely. The Pan-European Operational Level Guidelines for Sustainable Forest Management, endorsed by the Lisbon Ministerial Conference on the Protection of Forests in Europe in June 1998 and improved by the MCPFE expert level meeting in Vienna in October 2002, are based on the following principles/ indicators:

– Maintenance and Appropriate Enhancement of Forest Resources and their Contribution to Global Carbon Cycles (such as maintenance and enhancement of forest area, forest per capita, maintenance of age structure and / or diameter distribution and carbon stock)

– Maintenance of Forest Ecosystem Health and Vitality (such as control of deposition of air pollutants, maintenance of soil conditions)

– Maintenance and Encouragement of Productive Functions of Forests - Wood and Non-Wood (such as balance between net annual increment and annual felling of wood, quantity of marketed roundwood and non-wood goods)

– Maintenance, Conservation and Appropriate Enhancement of Biological Diversity in Forest Ecosystems (such as maintenance of tree species composition, maintenance of share of natural regeneration and share of planting and seeding and maintenance of naturalness of forest, protection of threatened forest species

– Maintenance and Appropriate Enhancement of Protective Functions in Forest Management (notably soil and water i.e. prevent erosion and protect water supplies

– Maintenance of Other Socio-Economic Functions and Conditions (such as contribution of forest sector to GDP and existence of occupational safety and

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81 Extent of forest cover, Biological diversity, Forest health and vitality, Productive functions and forest resources, Socio-economic functions, Legal, policy and institutional framework, Water and soil protection (protective functions)

82 ITTO, Montreal Process, Regional initiative for the development and implementation of national level criteria and indicators for the sustainable management of dry forests in Asia, African Timber Organisation, The Dry-Zone Africa Process on Criteria and Indicators for Sustainable Forest Management, Lepaterique Process of Central America, The Pan-European Forest Process on Criteria and Indicators for Sustainable Forest Management, The Near east process, CIFOR

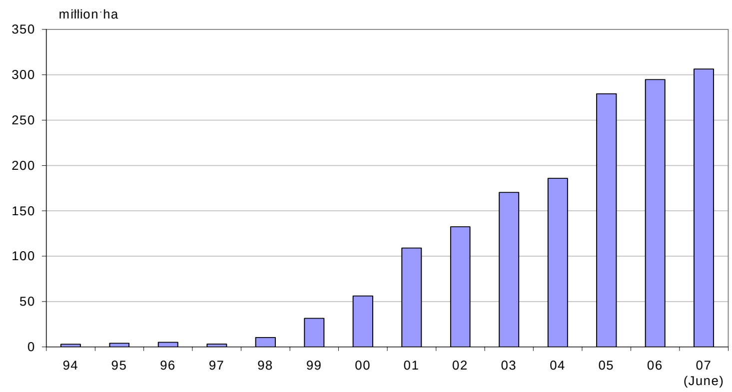
health requirements and accessibility for recreation and maintenance of cultural and spiritual values

As these principles are insufficiently precise to serve as clear obligations, their application varies from region to region. The MCPFE is currently discussing possible options for a legally binding agreement on forests in the pan-European region, to strengthen the instruments to deal with new challenges for forestry, including for climate change mitigation.

As inter-governmental responses have been strongly criticised and voluntary certification schemes started to develop. There exist a rather large range of certification standards, but most have been endorsed either by the Programme for the Endorsement of Forest Certification (PEFC) or the Forest Stewardship Council (FSC).

The global area of certified forests covered 306.3 million hectares in June 2007[83] (Figure 1). This is more than double the level in 2002 but since 2005 the growth rate has been slowing. The annual growth rate has fallen by more than half to about 10% per year while the pre-2005 rate was about 37% per year.

Figure 1: Global Certified Forests 1994-2007



Source: Indufor

Table 9 shows that by the end of 2006 193.7 million ha (65%) of forest is certified by PEFC, 84.2 million ha (29%) by FSC and 17 million ha (6%) by other systems (the American Tree Farm System, Malaysian Timber Certification Council and the Dutch Keurhout system). Some of these schemes rely on inter-governmental principles such as the Pan European Principles for European Forests, the Montreal Principles for other temperate and boreal forests, and the ATO/ITTO principles for tropical forests).

Table 10: Certified forest area by scheme and region in December 2006 (million hectares)[84]

	North America	South & Central America	Europe	Asia	Oceania	Africa	Russia	Total
FSC	27.3	9.6	29.6	1.6	1.3	2.5	12.3	84.2

83 ITTO (2008) "Comparability and acceptance of forest certification systems"
84 Source: http://www.forestrycertification.info/

PEFC	128.3	2.3	57.4		5.7			193.7
Other[a]	11.0			4.8		1.2		17.0
Total	166.6	11.9	87.0	6.4	7.0	3.7	12.3	294.9

[a] Other in North America refers to American Tree Farm System, in Asia refers to the Malaysian Timber Certification Council, in Africa refers to areas in Gabon recognised under the Dutch Keurhout system

In 2005, the total amount of forests worldwide was just under 4 billion hectares, equal to about 30 percent of the land area on Earth (FAO, 2005). This shows that only around 7% of all forests are certified in the world. The two charts below show that certification is increasing, but mostly in North America and Western Europe and in Europe the certification is much higher – and reaches 60 %.

Chart 1: Change in certified forest area (global)

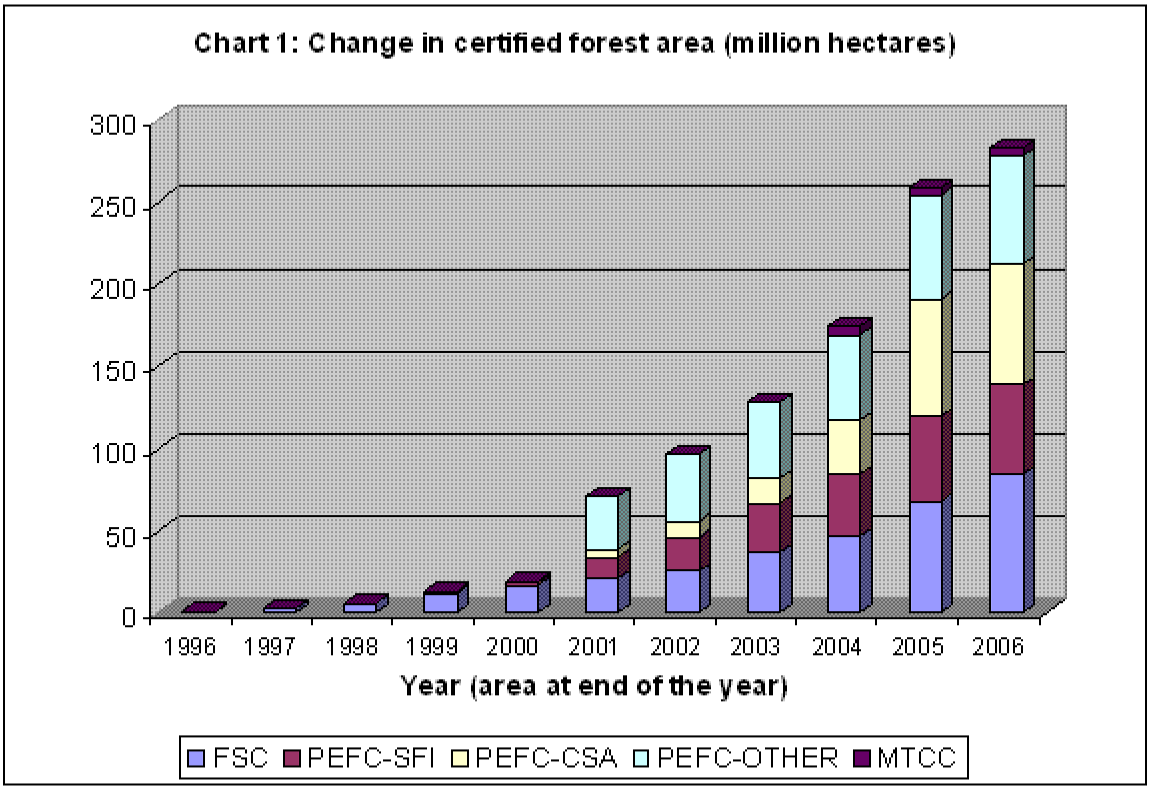
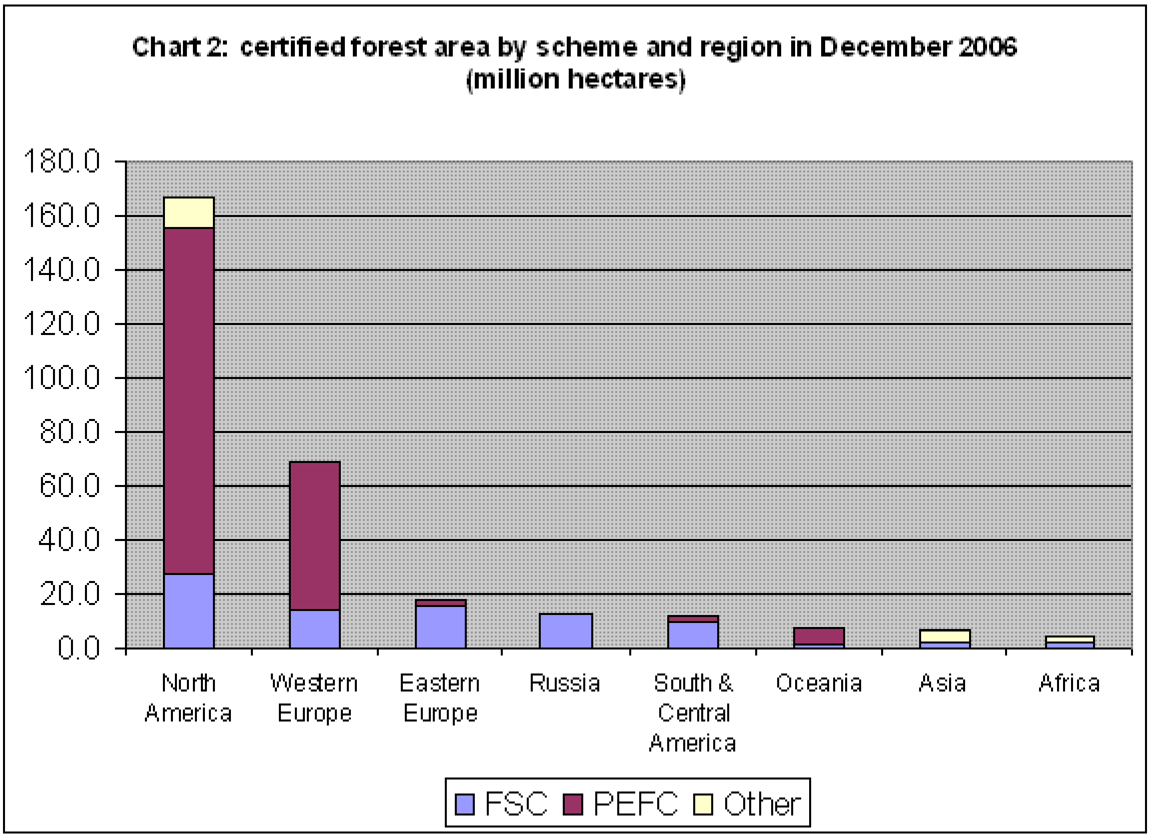
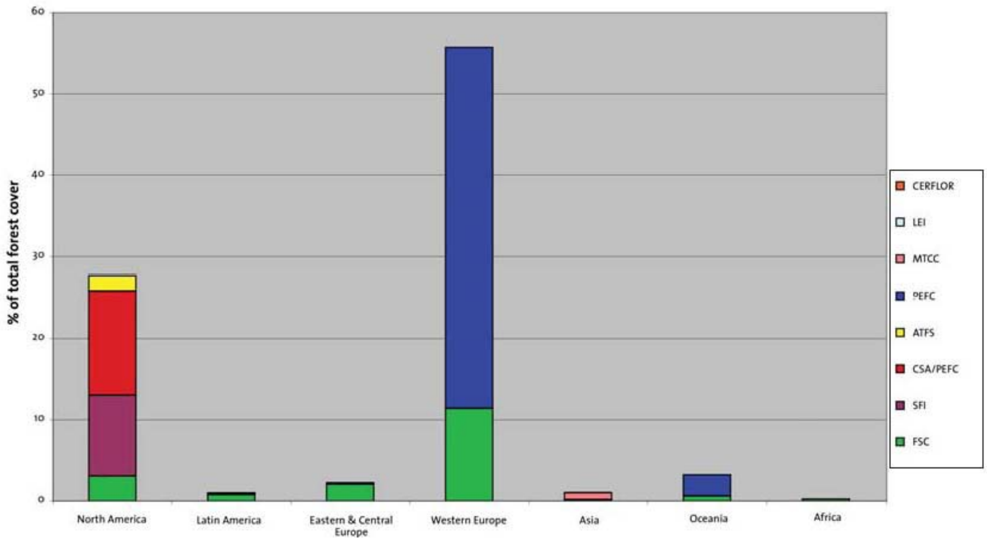


Chart 2: Certified forest area by scheme and region in December 2006 (global)



The third chart shows that almost 60% of Western European forests are certified.

Chart 3: Certified forest area by region



Total area of forest and other wooded land in the EU is about 177 million hectares, which corresponds to over 37% of the total EU area. It is calculated that annually the standing growing stock volume of wood in the EU forests grows by approximately 670 million m^3. Around 450 million m^3 of this wood every year is used for both industrial purposes as well as energy or other household needs. Roughly around 60% of forests (excluding other wooded land) in the EU are under private ownership, while around 40% are publicly owned. The share of private ownership is very diverse among the EU Member States. The highest share of privately owned forests is in Portugal (92.7%), followed by Austria (80.4%), Sweden (80.3%), and France (74%). According to the COWI Consortium (2009), there are a total of 10.7 million private forest holdings in the EU, and 77,000 public forest holdings. The average size of a public holding in the EU is about 1,200 ha while the average size of a private holding is 10.6 ha.

Agriculture: Sustainability criteria in the Renewable Energy Directive are mainly focused on agricultural biomass in the EU, as biofuels for transport and bioliquids for heating and electricity are mainly produced from agricultural feedstocks. In general inside the EU, sustainable agricultural production is ensured through tenforcing mandatory environmental standards and "cross-compliance" in the Common Agriculture Policy which links income payments to farmers and the respect of those standards. In addition, common environmental rules (inter alia NATURA 2000, the water Framework Directive, Nitrates Directive and EU legislation on Pesticides) apply to agriculture[85]. This impact assessment concerns solid and gaseous biomass for energy generation, and there is low likelihood of importing solid biomass or biogas from agriculture from third countries.

Energy sector:

Some Member States are already developing sustainability requirements for bio-energy. As a result, energy companies have developed their own standards for complying with such requirements. The BTG 2008 study assessed certification systems of energy companies, such as the Essent Green Gold Label standard and Laborelec's Sustainability Certification.

The Green Gold label uses forestry certificates or agricultural certificates such as Organic, EUREPGAP or a 'testimony of approval' based on forest management criteria or agricultural source criteria based on the United Nations sustainable development program Agenda 21 when no certification system is available. In the GGL Glossary[86] a certification body is defined as 'a third party certification company that is accredited ISO 65 (or equivalent) for GGL and is approved by the GGL foundation'. Most of the companies selling biomass to Essent are using certification schemes to prove sustainability. The Green Gold Label is establishing partnerships with emerging biomass sustainability standards like the Dutch NTA8080 based on the Cramer Criteria.

The Laborelec scheme was established in response to Belgian law giving support according to the sustainability and CO_2 balance of the supply chain. The system is based primarily on the FSC certification system, but also includes a GHG balance. The preferred types of biomass are residues from e.g. wood industry or low value residues from food industry, but wood from short rotation plantations would also be accepted. The Laborelec sustainability certification requires a supplier declaration, international transport declaration, overview of the energy balance, and an independent third party prepares an audit report. Costs associated with the certification system are to less than € 0,5/tonne imported biomass (Ryckmans 2007)[87]. SGS is the sole independent body performing verifications.

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85 Note all short-rotation coppicing (SRC) is considered under agriculture, as some Member States include SRC in the agricultural sectors, while others in the forest sector

86 GGL Glossary version 2005.2 See http://www.controlunion.com/certification/default.htm

87 Ryckmans Y, Andre, N (2007) "Novel certification procedure for the sustainable import of wood pellets", Laborelec

Developments in other Member States, such as the Biomass Environmental Assessment Tool (BEAT)[88] calculator in the UK, or the Cramer standard in the Netherlands, could lead to industry in those countries developing new standards.

Internationally, a labelling scheme for sustainable bio-energy based on the Eugene standard[89] has developed, which requires complete FSC certification of wood energy crops, or that wood biomass comes from sustainably managed forests, as defined by the label in a generic and sometimes more specific way. To verify claims, the national Eugene-accredited organisation must perform random checks of the auditor's work to ensure a sufficient degree of control.

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88 www.biomassenergycentre.org.uk/BEAT

89 www.eugenestandard.org

Annex IV: Member countries of the major inter-governmental organisations and processes or initiatives relevant to criteria and indicators for sustainable forest management

ITTO	Consumers: Australia, Canada, China, Egypt, European Community, Austria, Belgium, Luxembourg, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Poland, Portugal, Spain, Sweden, United Kingdom, Japan, Nepal, New Zealand, Norway, Republic of Korea, Switzerland, United States of America Producers: Cameroon, Central African Republic, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Gabon, Ghana, Liberia, Nigeria, Togo, Cambodia, Fiji, India, Indonesia, Malaysia, Myanmar, Papua New Guinea, Philippines, Thailand, Vanuatu, Bolivia Brazil, Colombia, Ecuador, Guatemala, Guyana, Honduras, Mexico, Panama, Peru, Suriname, Trinidad and Tobago, Venezuela
Montreal Process	Argentina, Australia, Canada, Chile, China, Japan, Republic of Korea, Mexico, New Zealand, Russian Federation, Uruguay and USA
Regional initiative for the development and implementation of national level criteria and indicators for the sustainable management of dry forests in Asia	Bangladesh, Bhutan, China, India, Mongolia, Myanmar, Nepal, Sri Lanka, and Thailand
African Timber organisation	Angola, Cameroon, Central African Republic, Congo, Cote-d'Ivoire, Democratic Republic of Congo, Equatorial Guinea, Gabon, Ghana, Liberia, Nigeria, Sao Tome et Principe and Tanzania
The dry-zone Africa process on Criteria and indicators for Sustainable forest management	Burkina Faso, Cape Verde, Chad, Gambia, Guinea Bissau, Mali, Mauritania, Niger and Senegal. IGADD (7): Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan, and Uganda. SADC (14): Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe

Lepartique Process of Central America on Criteria and Indicators for sustainable forest management	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama
The Ministerial Conferences for the Protection of forests in Europe, Pan-European Forest Process on Criteria and indicators for sustainable forest Management	Albania, Austria, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, European Community, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovak Republic, San Marino, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and Yugoslavia
The Tarapoto Proposal of Criteria and indicators of the Amazon forest	Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela
The Near East Process	Afghanistan, Algeria, Azerbeijan, Bahrain, Cyprus, Djibouti, Egypt, Islamic Republic of Iran, Iraq, Jordan, Kuwait, Kyrgyz Republic, Lebanon, Libya, Malta, Mauritania, Morocco, Oman, Pakistan, Qatar, Kingdom of Saudi Arabia, Somalia, Sudan, Syria, Tadjikistan, Tunisia, Turkey, Turkmenistan, United Arab Emirates and Yemen
CIFOR	Australia, Austria, Belgium, Bolivia, Brazil, Brazil, Cameroon, Canada, China, Costa Rica, Cote d'Ivoire, Finland, France, Gabon, Germany, India, Indonesia, Japan, Malawi, Malaysia, Mexico, Nepal, Netherlands, Philippines, South Africa, Sweden, Tanzania, Thailand, United Kingdom, USA, Zambia, Zimbabwe

ANNEX V – GHG methodological questions

This annex describes in more detail the choices made for the methodology. The choices are guided by some general principles concerning how the methodology should be developed:

– The methodology should be robust to changing the product in question, i.e. it can be used in other fields/sectors without much modification

– Takes into account the whole pathway from "cradle to grave", in this case from energy source to final energy

– Scientifically sound

– As simple as possible, although still being scientifically sound

– Robust in terms of assumptions on a EU-wide scale, avoiding regional differences, and avoiding the possibility of multiple interpretations of assumptions

– Works in a policy-context i.e. helps to fulfil the objectives of the policy in question.

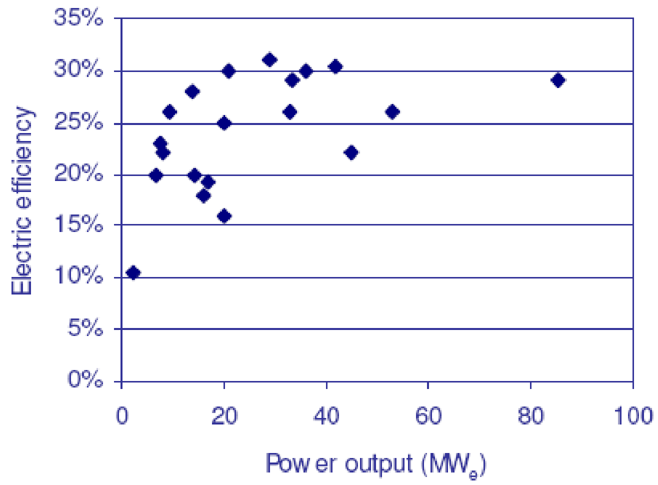
The Renewable Energy Directive requires Member States to have a certain percentage of final energy as renewable energy in transport and in the energy system as a whole. The GHG-methodology laid down in the RES Directive thus follows the energy chain from source to final energy, which in the case of transport means as final fuel. In the case of heating and electricity the final energy is electricity and heat, which implies that end-conversion efficiency should be included in the calculations if the life cycle assessment is to be carried out on the basis of final energy. An alternative is to calculate the GHG emissions only until the production of the fuel, e.g. biomass pellets, chips, charcoal etc, not reflecting its conversion to electricity and heat. These two options are considered in the analysis below.

The discussion then turns to the determination of fossil fuel comparator, which is closely interlinked with the first issue. The third section analyses five different ways of allocating between heat and other energy carriers. The last part of this annex discusses necessary amendments of the greenhouse gas methodology as laid down in the Renewable Energy Directive, for solid and gaseous biomass used in electricity and heating/ cooling.

V.1 Inclusion of end conversion efficiency

The GHG emissions from heat and electricity made from biomass is dependent on both upstream cultivation, processing etc. but also on end conversion. The efficiency of different technologies converting biomass to heat, electricity or both vary to a large extent, from 10 – 15 % for small electricity plants to 85-95 % for large scale CHP plants. There are thus large differences between technologies, but also within one technology cluster. An example of this is provided in Figure 2, where the electric efficiency as a function of capacity is shown for different CHPs (based on Ecorys, 2009):

Figure 2: Electric efficiency for different CHPs as function of power output



The same is the case for electricity-only plants, which vary the most according to whether it is a steam cycle, gas engine or diesel engine etc. End-conversion can vary considerably, but it is not evident that the only way of addressing the end-conversion efficiency is through its inclusion in the GHG calculation. However as the RES Directive sets targets for each Member State on the basis of final energy consumption, this could be a natural conclusion, and principle nr.2 above favours taking the whole chain into account. This aspect is discussed in the section below.

Cradle to fuel, or cradle to final energy, alternative A or B

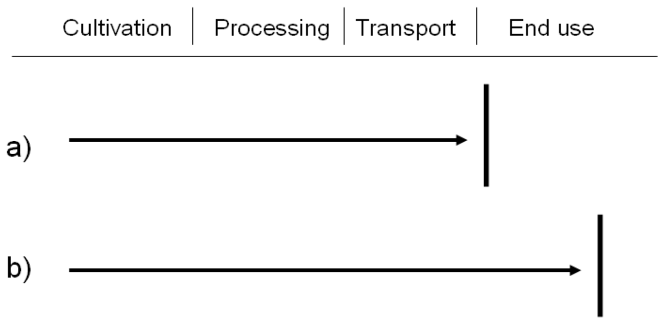
There are two main options for GHG calculation of biomass pathways

(a) Analysing the chain from "cradle to gate", i.e. from cultivation to fuel

(b) Analysing the whole chain from "cradle to final energy", i.e. from cultivation to final energy, including end use efficiency

The choice is to analyse the issue of allocation and fossil fuel comparator without or with the end-conversion efficiency included (alternative A or B), as indicated in Figure 3.

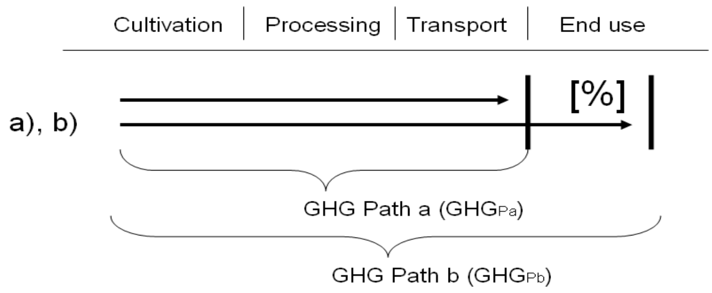
Figure 3: Depiction of alternative A or B for calculating emissions from biomass pathways



The choice between alternative A or B influences both choice of fossil fuel comparator and how e.g. heat is taken into account[90].

Alternative B is in fact much more complicated as both the efficiency of the bioenergy process as well as that of the fossil fuel comparator has to be taken in to account, as indicated in Figure 4 below. Apart from the question of what impacts this option would have in practice, it will be important to consider where the data on efficiency for this option would come from, particularly where it concerns a decentralised sector as heat.

Figure 4: Depiction of alternative B



The resulting GHG savings (S) is then derived by the following formula, where the fossil fuel comparator (FFC) is compared with the GHG emissions.

$$S_{a,b} = \frac{FFC_{a,b} - GHG_{Pa,Pb}}{FFC_{a,b}}$$

Alternative A is similar to existing RES Directive where it concerns bioliquids[91]. The downside is that low end conversion of biomass will not be included in the GHG claims, and most variation between biomass pathways lies in the end conversion efficiency, especially for smaller units. Alternative B will include end conversion efficiency and thus be more holistic than alternative A. However, alternative B may only incentivise higher efficiency if there is a bonus for lower emissions, or if higher efficiency can raise a certain pathway above the threshold if such a threshold is applied.

It will be difficult to apply alternative B to all biomass use, as e.g. demanding GHG claims from households would be an excessive administrative burden. Higher end use efficiency for small units might be obtained more effectively by labelling or other measures targeted at households and other small scale utilisations. Alternatively, the methodology may be differentiated for scale, i.e. applying alternative A for small scale utilisation and alternative B for large scale plants above a certain threshold.

90 Heat is not considered a co-product in the Renewable Energy Directive where it concerns biofuels and bioliquids.

91 For biofuels alternative A and B work out in principle the same, since the end use efficiency of biofuels and their fossil fuel alternatives is the same. The Renewable Energy Directive uses alternative A for biofuels, although it allows alternative B is evidence is provided.

V.2 Fossil fuel comparator

The choice of alternative A or B is influenced by decisions on fossil fuel comparator, as well as how heat is taken into account, and should thus not be concluded in isolation. These aspects are discussed below.

There are several methodological choices to make, in order to calculate the fossil fuel comparator for heat and electricity, related to compared technology and geographical scope. The substituted heat and/or electricity is highly dependent on local/regional conditions, like what types of fuels are available, biomass prices, technology choices etc. The choice is also dependent on whether one chooses alternative A or B, regarding inclusion of end use efficiency. If option A is preferred, it makes sense to take into account both heat and electricity in the comparator, since the fuel will be used for both. If option B is chosen one already knows the end energy service, and it is therefore more sensible to apply respective fossil comparators for heat and electricity.

In general the question of fossil fuel comparator can be dealt along two axis; geographical scope and end-use (electricity or heating or cogeneration).

Three options exist on geographical scope:

- EU wide comparators
- National comparators
- Regional comparators

Options for end-use types:

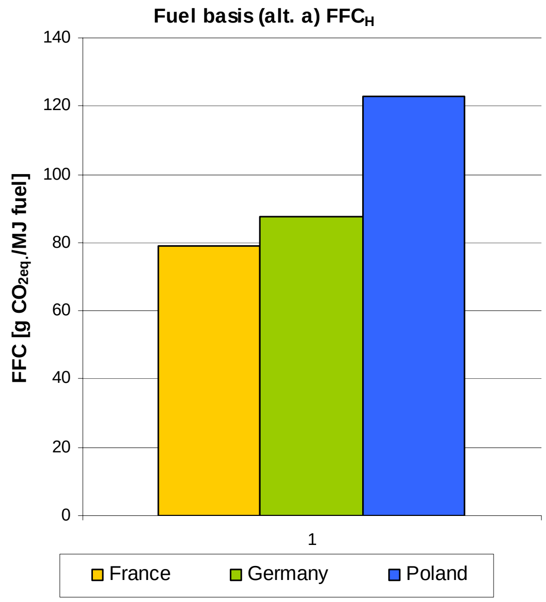
- One single comparator irrespective of the use (biofuels, heat, electricity, CHP)
- One single comparator to cover both heat and electricity respectively
- One comparator for each main technology cluster; heat plants, electricity plants and CHP (this is the approach in the Directive currently for bioliquids).

For certain options choices have to be made on whether to choose average or best practice technologies, and how to weight electricity vs. heat for CHP.

Geographical scope

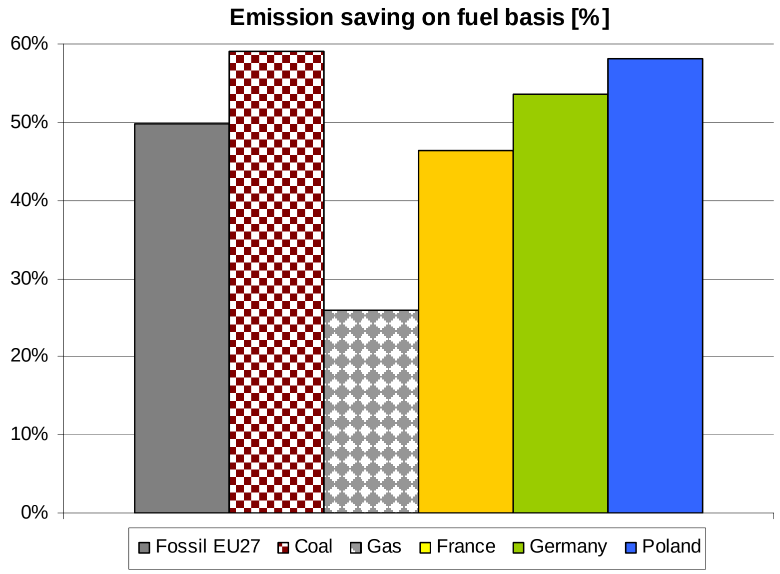
The Renewable Energy Directive applies an EU wide comparator as the fossil fuels used for transport are traded easily through Europe. It follows the same approach for bioliquids. The question is whether this approach should be used in general where it concerns electricity and heat or whether national or regional comparators should be used or allowed. These latter seem however to run into undesired effects as the different fossil fuel mixes and thus their potential comparators used in different Member States or regions would render the exact same biomass as sustainable in one country, but unsustainable in another. This is shown in Figure 5, where the heat mix of different nations is displayed in terms of the fossil fuel comparator. It is clear that in such a context certain biomass could be regarded as sustainable in Poland, but not in France or Germany. Such an approach would be suitable if biomass was not trade-able across regions or nations. However it is trade-able and such measures could create market distortions.

Figure 5: Effects of national Fossil Fuel Comparators



The savings from using e.g. soybean oil would be different in a country mainly using gas as a source of heat compared to a country using coal. This is shown in the Figure 6, where soybean GHG-savings on a fuel-basis is shown for different fossil fuel comparators for gas, coal and three countries, and regardless of end use.

Figure 6: GHG emissions savings on fuel basis



Use of soybean would thus lead to 46 % savings in France and 58 % in Germany, which might be unjustified in reality when one is looking at the actual heat-installations. While it can be argued that such differentiation could be justified as the fossil fuels replaced are different and the biomass should be used in those regions where it replaces the most GHG burdensome fossil fuels, it is not possible to say that this would actually happen in practice. It can usually not be known what specific fossil would be replaced and e.g. heat is often utilised in stand-alone systems where there is no marginal heat source as such. The electricity use pulls energy from a common pool (i.e. all electricity producers connected to the grid), where one can clearly consider a physical short-term substituting effect; this principle does not apply to the heat sector, where systems are highly diversified and decentralised. Besides; the national statistics for heat are often poor and different methodologies are applied in different countries. It would therefore be necessary to improve heat statistics in order to establish credible comparators. In sum, it is submitted that EU-wide fossil fuel comparators for different technologies should be used, which follows from principles 5. and 4. (robust assumptions and simple methodology).

End-use types alternative A

The simplest option is to apply one single comparator irrespective of the use (biofuels, heat, electricity, CHP). This would prevent that the biomass is diverted to a specific sector where the fossil fuel comparator is more favourable. Although that may actually lead to higher greenhouse gas savings, there is no guarantee that this will happen and it would not necessarily reach the objectives of renewable energy policy in a more cost-effective way. Since a comparator for biofuels is already well established, it would seem this comparator should be taken in such case, whereas it has no particular relevance or relation to heat or electricity. This would also deviate from the approach taken for bioliquids.

The other two options are very similar to each other and the main question is how to take into account CHP. The first option is simply to have a comparator for heat and one for electricity as those are already in the Directive for bioliquids:

Heat: 77 g CO_{2eq}/MJ_{fuel}

Electricity: 91 g CO_{2eq}/MJ_{fuel}

A separate comparator could be given for CHP as is in the Directive for bioliquids.

CHP: 85 g CO_{2eq}/MJ_{fuel}

However, when end conversion efficiency is not taken into account the result is that CHP comes with the current numbers out worse than stand alone electricity, which may give undesired consequences. An example would be e.g. the use of ethanol from wheat (lignite as process fuel). If it is used in an electricity plant it just makes the threshold with savings of 38 %, but in a CHP the savings are only calculated to be 33 %, and thus below the threshold. However, in reality, the CHP saves considerably more GHG emissions, because of much higher efficiency, but the incentives here encourages the option with the least savings.

Alternatively, a comparator for the CHP can be obtained in different way, even without completely taking into account the efficiency of the end use conversion. The alternative fuel use formula based on the CHP Directive could be taken as a basis to calculate the comparator, which follows the logic of the alternative fuel use methodology; taking into account the amount of biomass that would be needed in order to obtain the same amount of electricity and heat if it was produced in separate plants. The fossil fuel comparator (FFC) for CHP is thus obtained through the following formula:

$FFC_{CHP} = FFC_e * \eta_e / \eta_{e0} + FFC_h * \eta_h / \eta_{h0}$

Where:

- ηe and ηh are the electrical and thermal efficiency of the CHP plant, here assumed to be 25 % and 60 %, for electricity and heat respectively.

- FFC_e and FFC_h are the Fossil Fuel Comparators for electricity and heat (given as 91 and 77 g CO_{2eq}/MJ)

- ηe_0 and ηh_0 are reference values for the efficiencies of uncoupled generation of electricity and heat, for which in this case is suggested to be 33 % and 86 %, which is for solid wood fuel taken from annex I and II of the COM decision 21/XII/2006; reference values for separate production of electricity and heat in application of the CHP-directive (2004/8/EC).

This example would result in the following FFC:

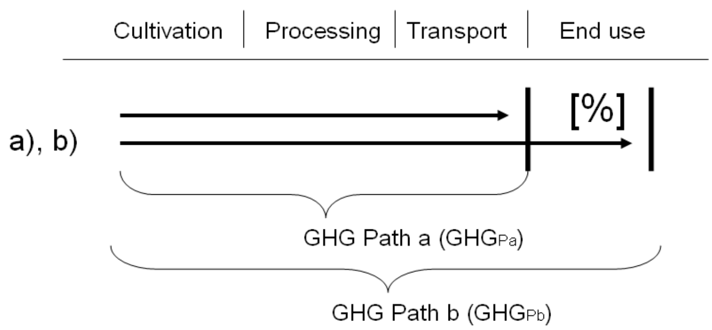
CHP: 123 g CO_{2eq}/MJ

The main disadvantage with this option is that it is still static: it disregards the different heat/electricity ratios for individual CHP installations, which in fact is a problem for all "alternative A" solutions where the emissions are accounted for the fuel, and not for the final energy. This would not encourage more efficient use of biomass, and as such be in breach with the 6. principle (contributing towards the policy objectives).

Biomass end conversion, alternative B

The analysis now looks at alternative B, as shown in Figure 7. This implies that the end-conversion efficiency is taken into account both for the fossil fuel comparator (FFC) and the actual biomass pathway i.e. what are downstream emissions of the biomass fuel when it is converted to final energy or other biomass based energy carriers (such as biofuel). This implies a wider assessment of the allocation between electricity, heat and eventually other products.

Figure 7: Depiction of Alternative B



The outcome of the analysis of national or regional FFC under alternative a, applies to alternative b as well, thus is EU-wide FFC appropriate. The remaining option regards end use technologies and how to determine the FFC.

Options for end-use types:

- One common FFC for heat, CHP and electricity.

- One comparator for each main technology cluster; heat plants, electricity plants, bioenergy plant[92] and CHP

- One FFC for heat and electricity respectively.

- One FFC for a range of possible products and energy carriers; such as biofuel, chemicals, electricity, heat etc.

For certain options choices have to be made on whether to choose average or best practice technologies, and how to weight electricity vs. heat for CHP.

The first option disregards the different efficiencies and utilities of technologies and energy carriers. The FFC for heat would be the same as for electricity although emissions stemming from a unit of fossil electricity are considerably higher than from a unit of fossil heat. Such an option would neither represent reality nor give desirable incentives, and be in breach with the principles 6. as well as 3. This option is thus discarded.

The second option takes into account different technologies, but does not regard the differences within a technology cluster, which is especially relevant for different heat/electricity ratios for CHP. In such a case a CHP with only a small amount of electricity produced obtain the same FFC as a CHP with much more electricity produced. This does not give the right incentives, as electricity has a higher value than heat, and generally a higher GHG intensity. The second option is thus discarded.

The third option reflects the alternative fossil production of heat and electricity for all heat-, electricity-, and CHP-technologies with different heat/electricity ratios, and integrates the difference between electricity and heat in a realistic manner in contrary to the two first options. The fourth option builds on the third option, but includes also biomass products other than heat and electricity. Under this option the FFCs would represent their fossil substitute, including for chemicals and process-industry feed stocks. The FFCs of the latter two would be as a function of the carbon content of their fossil substitutes. Possible problems could occur from bio-chemicals that can have a range of utilisation, all with different carbon savings. This can be solved by attributing a distinct FFC to groups of products. The simplest and perhaps the option that would be most appropriate in the beginning is one FFC for chemical bio-products. In total this would then lead to four FFCs: biofuel, heat, electricity and chemicals. The main issue with this option is the introduction of FFCs for commodities other than energy, and thus going beyond the purpose of this report.

To see how the FCC inflects the GHG performance of different technologies, one has to decide the weighting between different energy carriers, in the case of CHP: electricity and heat. This is discussed in the following section.

[92] A bio-energy plant is here a plant which uses biomass as feedstock, and produces various energy carriers and or products, like biofuel, chemicals, electricity, heat etc

V.3 Biomass end conversion, alternative B: Allocation between co-products for heat and other energy carriers

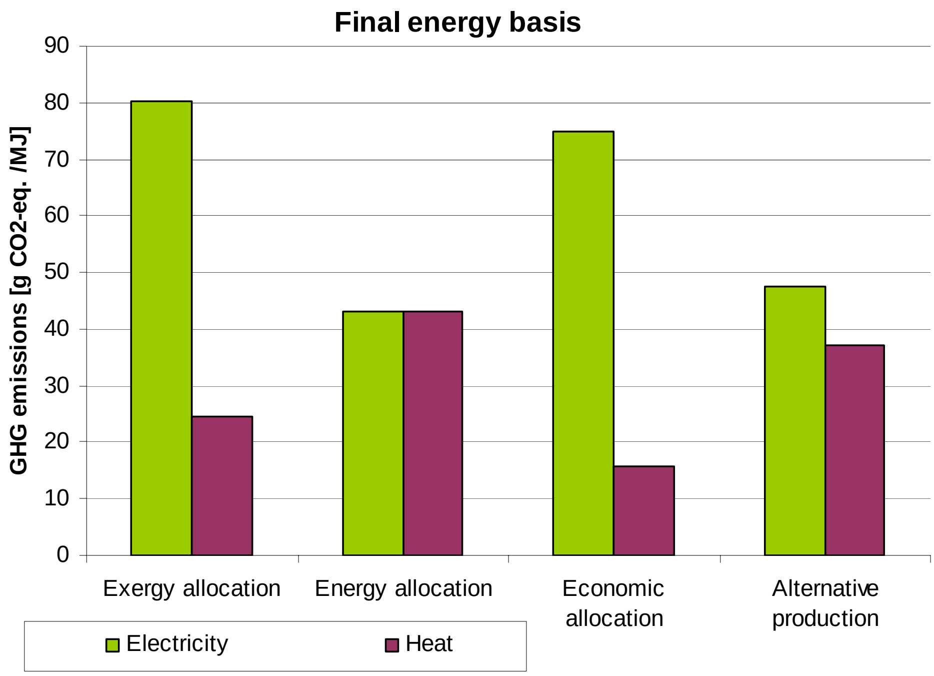
The discussion concerning which way to attribute upstream emissions to end products in case of combined heat and power (CHP) is best shown with an example. The basic question is how the up-stream emissions should be divided between the end products. Since e.g. electricity and heat have different utilisation possibilities and costs, it is not obvious that a simple energy allocation is sufficient. The alternatives analysed are:

- Exergy allocation
- Energy allocation
- Economic allocation
- Alternative production allocation

Finally, a fifth method for accounting for emissions between different co-products (the "energy allocation with common indicator") is analysed at the end. It differs from the above four alternatives, as one emission value is calculated for all products, and no allocation is taken place between the end products.

In this first example the CHP is producing with an overall efficiency of 90 %, of which 1/3 is electricity and 2/3 is heat (heat to electricity ration of 2). The resulting emissions for soybean as feedstock are shown in Figure 8, where 1 MJ of soybean is fed into the CHP, and it is producing 0.3 MJ electricity and 0.6 MJ of heat.

Figure 8: Emissions from soybean in cogeneration dependent on method of allocation of emissions between heat and electricity



The exergy allocation is assuming ambient temperature of 0 °C, and heat delivered at 120 °C. This assumption is further discussed below. The electricity is assumed to have 100 % exergy. It is clear that the higher exergy content of electricity have to bear more of the emissions. The allocation is based on the carnot efficiency, or the thermodynamic quality of the heat;

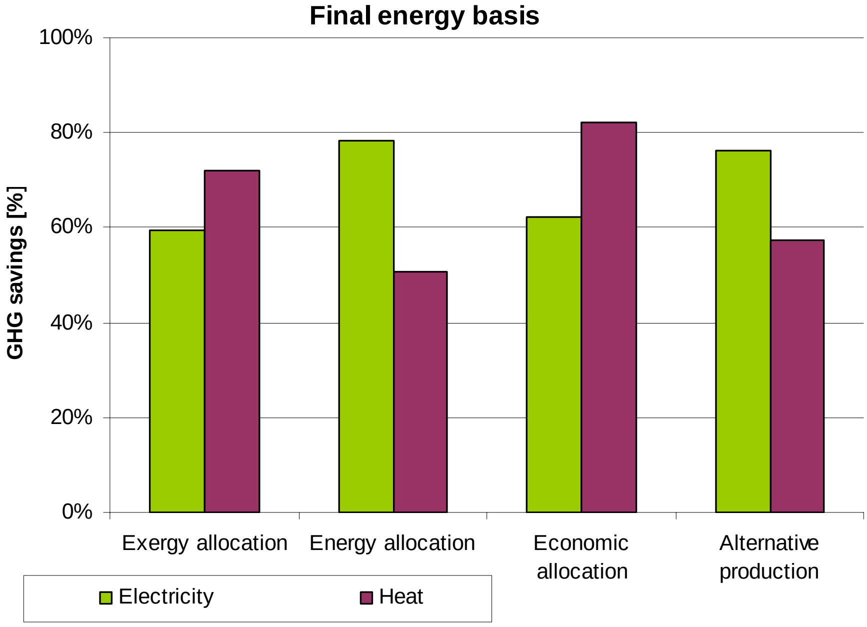
$$\eta = \frac{T_h - T_{env}}{T_h}$$

Where T is measured in absolute temperature (Kelvin), and T_h is the temperature of the heat and T_{env} is the temperature of the environment, or surroundings, set at 0 °C or 273 Kelvin. The allocation based on economic valuation uses average prices in EU25 2004 – 2007 for large industries, and heat delivered with natural gas (n = 90%)). This results in prices of 18.3 and 6.6 €/MJ for electricity and heat respectively. The economic and exergy allocation shows similar patterns and values, while alternative production allocation shows the same pattern as exergy and economic allocation, but with less difference between heat and electricity, all indicating that electricity has a higher value than heat. The energy allocation does not take this into account and allocates the emissions solely regarding energy content, not having regard to available work (exergy), market value (economic allocation) or alternative production of heat and electricity.

It is clear how all the allocation methods, except energy allocation, hold the electricity more responsible for the emissions, than the heat. When these numbers are further combined with fossil fuel comparators (FFC) for EU27, for electricity and heat respectively, the GHG-savings are obtained, as shown in Figure 10. The FFC are 198.4 g/MJ for electricity and 87.3 g/MJ for heat, and are based on the fossil mix of electricity and heat in EU27. For cooling the FFC is set to 57 g/MJ; which is based on the FFC for electricity, but adjusted for a coefficient of performance (COP) of 3.5. The COP depends mainly on the temperature difference, and will thus vary according to climate and cooling demands.

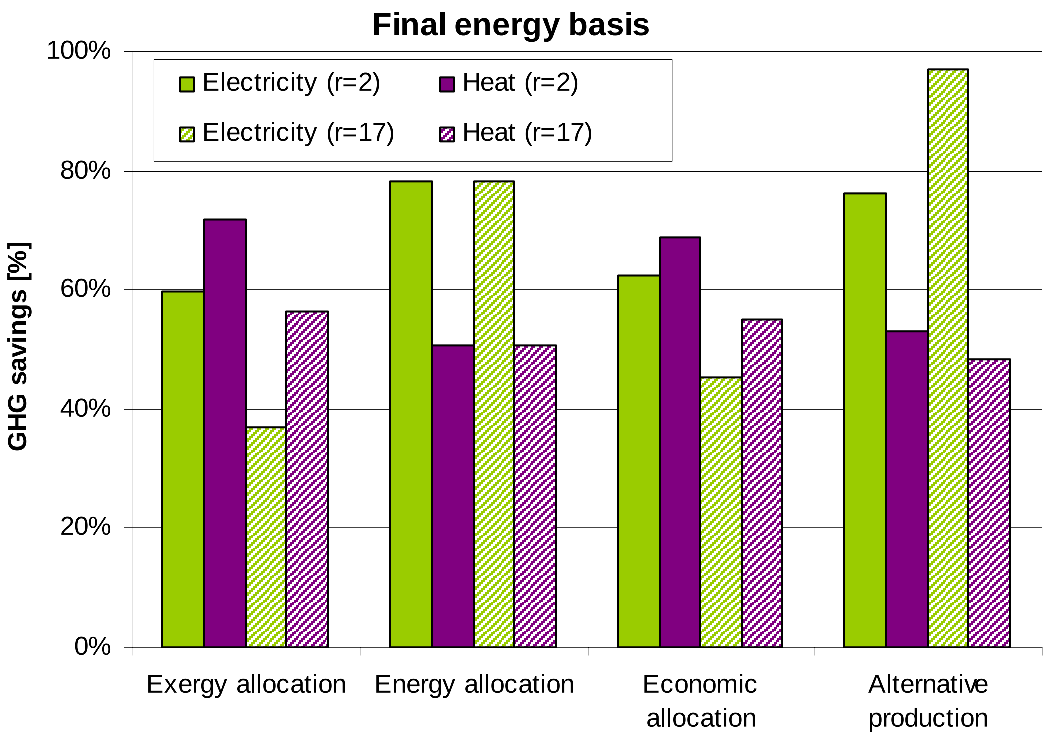
It is to be observed how the FFC of heat and electricity balances the GHG-savings results compared to the emission intensity as shown above. Electricity obtains a larger FFC, and thus a larger (than heat) saving per MJ substituted.

Figure 9: GHG savings of electricity and heat in cogeneration, using different emissions allocation methods



The resulting savings show a rather wide spread, as function of allocation method, but with values in the same range for all allocation methods except energy allocation, with Exergy and Economic allocation showing very similar results. One of the determining factors for which allocation method to apply is how the allocation method is valuing different heat/electricity ratios, and what kinds of "border-effects" to expect when the assumptions are more extreme. Figure 10 below compares the CHP from the example above (total efficiency of 90 % and heat/electricity ratio of 2) with a CHP with total efficiency of 90 % and heat/electricity ratio (r) of 17, implying an electricity efficiency of 5 % and a heat efficiency of 85 %.

Figure 10: GHG savings from two cogeneration plants with different efficiencies for heat and electricity conversion



It is evident how the change in heat/electricity ratio (r), changes the GHG-savings downwards for all allocation methods except for energy allocation for which they remains constant. This implies, in the case of energy allocation that e.g. a MJ of electricity from a soybean fed CHP with low electricity production has the same savings as for a MJ from a soybean fed CHP with higher fraction of electricity production. Interesting is also the high savings obtained from electricity in the case of high production of heat (85%) for "alternative production" allocation. This stems from the methodology, which is not suitable for CHP solutions with rather low fraction of electricity production (or heat production). There is a major drawback with this allocation method, and reason enough to discard the "alternative production" allocation method.

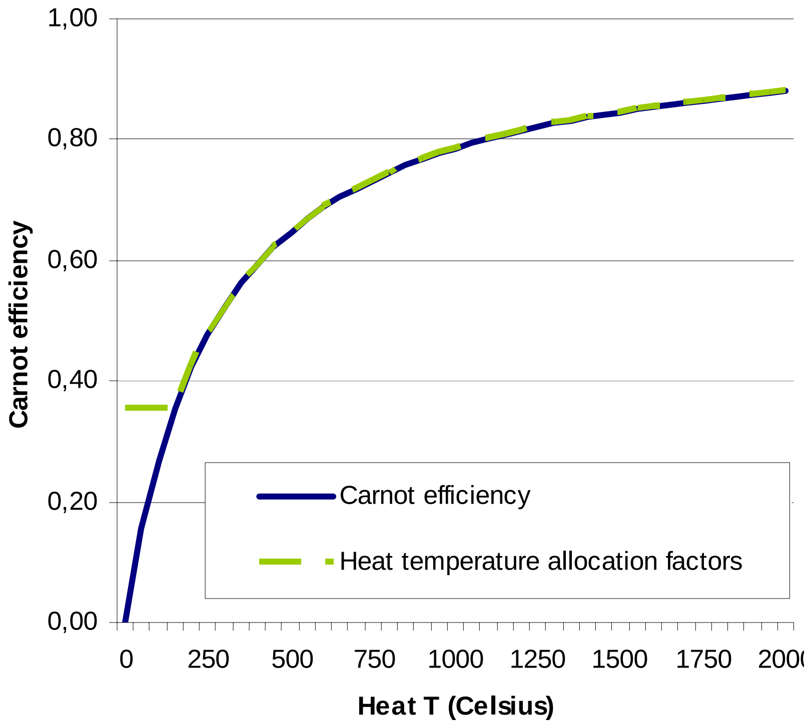
A further factor that sheds light into the issue of allocation methodology is the valuation of heat temperature. Economic allocation would manage to account for this, but with difficulties finding data, as there are no disaggregated heat markets for different temperatures, and would thus practically lead to rather arbitrary allocation numbers. Energy allocation does not make any difference between 1 MJ at 10 °C or 1 MJ at 1000 °C, nor does the alternative allocation method. The heat temperature is an important parameter, as it determines the amount of heat that is possible to convert to work. Heat of higher temperature has a higher utility, as the heat can be converted to other forms of energy than thermal energy (namely work). However, this conversion is limited by the carnot efficiency, mentioned above, and repeated here:

$$\eta = \frac{T_h - T_{env}}{T_h}$$

Where T is measured in absolute temperature (Kelvin), and T_h is the temperature of the heat and T_{env} is the temperature of the environment, set at 0 °C or 273 Kelvin. The carnot efficiency, or the exergy content of the heat, is a simple physical measure of the potential utility of heat, and thus useful as an instrument to differentiate between heat of different temperature. For the purpose of calculating the carnot efficiency, it is assumed that 0 °C, or 273 Kelvin, is the ambient temperature throughout EU, in order to keep the simplicity.

For heat of temperature lower than 150 °C it is assumed a constant carnot efficiency equal to that of 150 °C or 423 Kelvin (approximately 0.35). This is on order to avoid very low allocation values and confusion within the district heating sector, where most operators deliver heat at less than 150 °C. The price of for low-temperature heat is in the area of 1/3 of the price of electricity on an EU average level, and gives and additional argument for keeping a constant Carnot efficiency for this heat market. A price difference of 1/3 is very similar to the Carnot efficiency of heat delivered at 150 °C (approximately 0.35). For the heat of higher temperatures there are few statistics on prices, as mentioned, so the Carnot efficiency is applied directly as allocation factor. The proposed correlation factors are shown in figure 11, together with the Carnot efficiency for the whole temperature range.

Figure 11: Correlation factors for Carnot efficiency for the whole temperature range



Applying this method of allocation introduces an important aspect of energy efficiency, as more efficient use of the energy sources is incentivised through a realistic representation of the different utility of heat at different temperature. This is especially relevant for high temperature heat demands in the industrial sector, where heat delivery at higher temperature often comes at the cost of lower overall energy efficiency. In order to exploit the potential use of CHP in industrial usage, it should not be a drawback for the operator to deliver demanded high temperature heat compared to delivering low temperature heat, where the latter often can be done with higher overall energy efficiency, although with lower exergetic efficiency. The consequence of the proposed allocation is more GHG emissions attributed to higher temperature heat, and thus less to the co-generated electricity. A CHP delivering final heat at 200 °C (with energy efficiency of 0.5) would have the same GHG intensity of its electricity (energy efficiency of 0.3) as a CHP with half the electricity efficiency (energy efficiency of 0.15), but delivering the same amount of heat at 700 °C, everything else constant.

Common GHG indicator

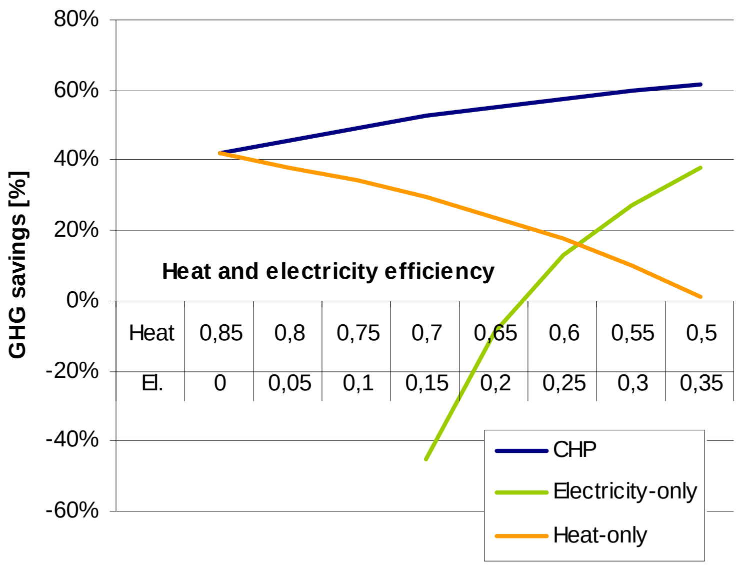
An issue with the allocation approach is that a plant may produce electricity with GHG-savings above the eventual threshold, but another co-product e.g. the biofuel, might fall below. To avoid this, it is necessary to develop a methodology for a common GHG-saving for the whole range of products. The easiest way of doing this is attributing one GHG-value to all products from one facility based on the weighting of the FFC for the different products, i.e. all emissions from the plant are attributed to all products, comparing with a weighted fossil fuel comparator, which is weighted according to the displaced products.

For a CHP this would lead to the same saving for both the heat and the electricity produced, but the more electricity produced, the more savings, as the FFC for electricity is considerably larger than for heat. The basis of the methodology thus becomes a question of what products that are replaced and what savings this brings. For a CHP the FFC is given by:

$$FFC_{CHP} = FFC_e * \eta_e/(\eta_e + \eta_h) + FFC_h * \eta_h/(\eta_e + \eta_h)$$

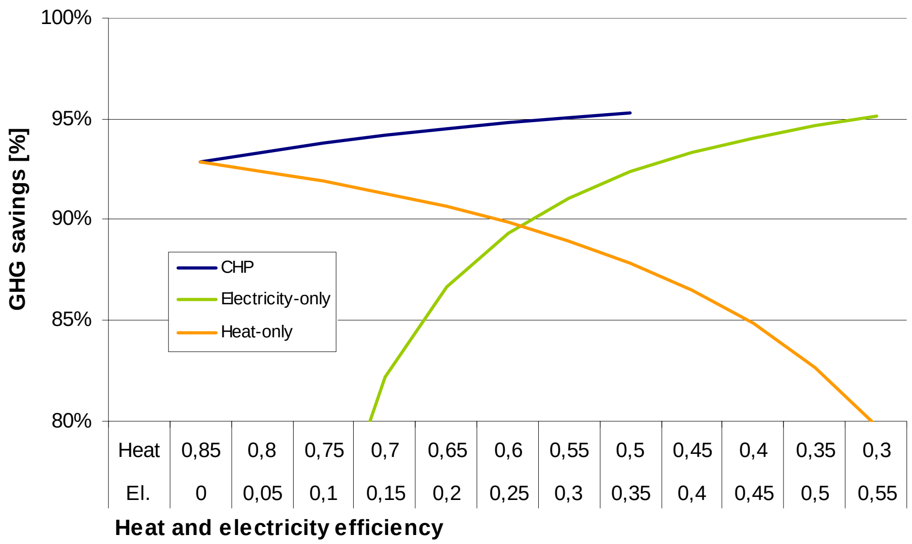
For different heat and electricity efficiencies the total savings will vary according to the replaced fossil energy. The example provided here is pure palm oil, as shown in Figure 12. The x-axis is electrical efficiency together with heat efficiency in descending order so that for the CHP the total efficiency is 0.85. For comparison is also the heat- and electricity-only plants shown as function of their respective efficiencies. With this methodology the electricity only plant needs an efficiency of around 55 % in order to give the same savings as the CHP with 35 % and 50 % electricity and heat efficiency respectively (the point far to the right for the CHP).

Figure 12: Heat and electricity efficiencies as a function of GHG savings (based on palm oil)



For cases where no FFC is available for some of the products (e.g. bio-refineries), the energy allocation between products will be used, and the portion of the products with available FFC will be given the weighted common FFC. The same figure applied to waste wood as source gives the same pattern, but at much higher savings, as shown in Figure 13.

Figure 13: Heat and electricity efficiencies as a function of GHG savings (based on waste wood)



Note that the numbers for CHP ends at 0.5 and 0.35 as this is assumed to be the maximum power to heat ratio with still a total efficiency of 85 % (assuming that higher efficiency for electricity requires a lower back-pressure, and thus less recoverable heat).

This method of weighted FFC applied to the examples given further up is summed up here (the soy CHP and third generation plant). The CHP fired with pure soy, which achieves 78.3 % and 50.7 % savings for electricity and heat (with energy allocation), obtains a saving of 65.4 % for both the heat and the electricity. This result is lowered to 53.9 % when the power to heat ratio is lowered, and only 5 % electricity efficiency is assumed (same total efficiency of 90 %). This shows how the weighted FFC method incorporates the strength of economic-, exergy- and alternative production allocation without being equally complicated. With energy allocation no credit is given for higher portion electricity produced, as one recalls from Figure 13. The third generation plant that produces electricity, heat and biofuel obtains a saving of 92.6 % for all the products, instead of 96.2 % for electricity, 91.1 % for biofuel and 91.4 % for heat (energy allocation).

The methodology would be expressed as follows, where a process have n different products, and each of them are produced in fraction f_i and each product i has a FFC of FFC_i:

$$S = \frac{FFC - GHG_{emissions}}{FFC}$$

Where:

$$FFC = \sum_{i}^{n} f_i \cdot FFC_i$$

With EU27 average and assumed efficiencies as in the CHP directive, the FFC_i for heat is 87.3 [g/MJ], electricity; 198.4 [g/MJ].

Summary of the discussion of choice of allocation method

The exergy allocation has its main advantage of expressing a physical unit that relates to how much "work" the energy can deliver, and is in that regard accurate and correct way of expressing the value or utility of heat of different temperatures. However; there are limitations regarding methodology, as there are uncertainties regarding how to calculate the exergy content of e.g. biofuel. It would be possible to determine an academically correct way of calculating the exergy content, but it would still be difficult to ensure that the methodology would be put in place correctly all over EU, as knowledge of exergy is limited. An alternative is to use exergy content only for heat, as the main concern is the allocation in the case of CHP. But still it would be difficult to determine how to set the temperature of the delivered heat and ambient temperature. Especially the first factor is possible to discuss at length. Is it the temperature at the conversion from energy carrier to energy service, or at the system boundary of the CHP? The conclusion here is the term "final energy" as defined in the Renewable Energy Directive (Directve/2009/28), and further used in this report, i.e. "energy commodities delivered for energy purposes". This would thus be at the point of delivery.

Energy allocation has its main disadvantage in its ignorance for the different value of different energy carriers and heat temperatures. The energy allocation is simple and applicable to most end products that might be produced even in bio-refineries as well, but does not represent the thermal physical laws, or the differentiated economic valuation of heat at varying temperature.

Economic allocation has its disadvantages related to the changing behaviour of prices, together with difficulties of choosing the right price, regarding taxing-, subsidising- schemes across different countries and regions. This option is thus discarded.

The alternative production allocation works well, and shows similar allocation pattern as economic and exergy allocation. The main disadvantage is the need for determining "alternative efficiencies", and especially in the case of more complex bio plants (refineries) It has also been shown that it is not suitable for not so common CHP configurations, with e.g. very low electricity efficiency. The alternative allocation method is thus discarded.

In order to avoid having different saving numbers for different products coming from one production facility, it is desirable to obtain one figure for all the products. All the options above result in one figure for the heat and another figure for the electricity coming from the CHP. The fifth alternative (energy allocation with common GHG indicator) avoids the difficulties in allocating emissions to different energy products. The main downside with this option is that it requires fossil fuel comparators for determining the results, and is thus not in line with the principle of applying a holistic methodology that might be applied in other sectors; in many sectors, like e.g. for the food and drinks, it would be illogical to have a fossil fuel comparator as in integral part of determining the GHG emissions, this would be in breach with the second principle for a sound methodology. This option is thus discarded.

Conclusion

For simplicity and coherence with the Renewable Energy Directive, energy allocation is kept for all allocation issues, except where heat is co-produced with other energy commodities. In such a case; other energy commodities are given an allocation factor (exergy content) of 100%, while the heat is attributed according to its temperature at delivery point, using the Carnot efficiency.

The equations necessary to describe the methodology is presented in section V.4.

V.4 Equations describing the methodology

Greenhouse gas emissions from the production of solid and gaseous biomass fuels, before conversion into electricity and/ or 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 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, and;

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

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

Greenhouse gas emissions from the use of solid and gaseous biomass in electricity and/ or 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:

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

For energy installations delivering only electricity:

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

For energy installations delivering only useful cooling:

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

Where:

EC_{hl} = 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

V.5 Other issues

Allocation for co-products upstream in the production pathway

Co-products encountered in the production of electricity and heating are different than the co-products in biofuels for transport, where an 'allocation method' based on energy content was chosen. In the case of electricity or heat production, the co-products do not always have energy content. Possible co-products include: digestates produced from biogas production (which can be used as fertiliser), ash, flue-gas (cleaning products) or surplus heat from combustion, char and gas as co-products of pyrolysis, compost as a sub-product of producing woodchips from gardening residues as well as nutriceuticals, fabric such as animal hides and pharmaceuticals, materials from the processing of sludge from waste water treatment (technosand) and cakes from oil processing.

When considering policy tools, the arguments for and against the different allocation approaches, as discussed in Annex 7, part F of the impact assessment for the renewables directive (based on exergy, energy, price and substitution), still apply. The substitution method brings substantial uncertainties (Ecorys 2007[93]), since it is difficult to know the marginal or the average process avoided. The economic allocation approach introduces uncertainties with regards to price changes, and methodological difficulties regarding which prices to apply. Should one apply prices before tax; because it is the market value, or after tax; since the tax supposedly represents external costs. Further; how to deal with prices of products that are subsidised upstream in the production chain? Exergy allocation leads to methodological uncertainties, since the definition and widespread use of "lower heating value" does not have a counter-part within exergy, and many processes would be difficult to assess on an exergy basis. Exergy (2. law of thermodynamics) is defined as the sum of "internal energy", "available PV work", "entropic loss" or "heat loss" and the final term "available chemical energy". To establish these terms for different pathways would be a methodological challenge. Energy allocation is thus used. This conclusion also bears on the arguments presented in Annex 7, part F of the impact assessment for the renewables directive.

However, since a pure energy allocation would imply that positive side-effects of using e.g. landfill gas to energy purposes (the avoided methane emissions) would be neglected, the energy allocation rule is accompanied by a set of appropriate default values, which gives the right incentives to utilise wastes, residues and by-products. This is discussed in the following section.

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[93] Ecofys (2007) "Towards a harmonised sustainable biomass certification scheme"

Land carbon stock figures

Land use change can lead to emissions and these should be accounted or as accurately as possible. In the public consultation, a few stakeholders explicitly commented on the need to develop carbon stock factors for short-rotation coppice and perennial grasses, as IPCC has not developed these. In the RES Directive it was deemed important to provide guidance on the emission factors to use when land use change occurs instead of providing single values in the legislation. This is because single value data cannot be used as instruments for regulation as production systems vary greatly depending on soils, water balance, nutritional status, climate, etc, and cannot reflect the real impact of land use change for land use types spanning across different climatic zone/ growth zone or with diverse range of soils (organic – inorganic soil). Respondents to the public consultation also argued that carbon stock figures should take account of tropical and temperate climatic conditions. Guidance will be provided in the Communication on practical guidance for implementing the biofuels/ bioliquids sustainability scheme (due in the first quarter of 2010). In this impact assessment, it is assumed that single values are not appropriate for the same reasons.

ANNEX VI – Costs to economic operators associated with efficiency measures (ECORYS, 2009)

Indicator BTC	Type of measure	Comments	Compliance cost range		Unit compliance costs	Efficiency increase possible (%)		Total installed capacity		Unit Installed capacity	GWh (based on Green-X estimations of work done)	Replacement rate		Total gains/savi (GW)	
			Low	High		Low	High	Low	High			Low	High	Low	H
Large-scale power and CHP	Heat delivery	Use of larger part of the heat	50,000,000	200,000,000	*Euro per installation*	33%	65%	24	24	*GW biomass*		15%	60%	**1**	
	Add on	Flue gas condenser	1,000,000	1,000,000	*Euro/MW*	8%	10%	24	24	*GW biomass*		20%	60%	**<1**	
Co-firing	Heat delivery	Use heat, existing installations	50,000,000	200,000,000	*Euro per installation*	30%	60%	1.1	1.1	*Gwelectric -> only biomass*	*4988*	5%	15%	**<1**	
	Heat delivery	Use heat, new installations	50,000,000	200,000,000	*Euro per installation*	28%	55%	4.8	9.5	*Gwelectric -> only biomass*	*37335*	20%	40%	**1**	
Waste incineration	Heat delivery	Use heat, existing installations	50,000,000	200,000,000	*Euro per installation*	35%	70%	2.2	2.2	*GW electric green*	*14008*	10%	20%	**<1**	
	Heat delivery	Use heat, new installations	50,000,000	200,000,000	*Euro per installation*	30%	60%	1.6	1.6	*GW electric green*	*9710*	20%	40%	**<1**	
	Electrical efficiency improvement	Improvements, existing installations	10,000	12,000	*Euro/kW*	1%	2%	2.2	2.2	*GW electric green*	*14008*	20%	50%	**<1**	
	Electrical efficiency improvement	Improvements, new installations	6,000	10,000	*Euro/kW*	6%	10%	1.6	1.6	*GW electric green*	*9710*	60%	90%	**<1**	
District heating	Add on	Flue gas condenser	1,000,000	1,000,000	*Euro/MW*	8%	10%	12	12	*GW thermal*	*42210*	20%	60%	**<1**	
Manure (co-) digestion	External heat delivery	Use heat	2,000,000	10,000,000	*Euro per installation*	20%	35%	2.0	1.9	*GW thermal*	*10,771*	10%	50%	**<1**	
	Add on	ORC on an average 700 kW digester	400,000	0	*Euro per installation*	8%	15%	1.7	1.9	*GW electric*	*10,771*	50%	90%	**<1**	

ANNEX VII – Typical and default emission values for solid and gaseous biomass pathways (calculated using JRC data, 2009)

JRC calculated the emissions of various pathways using the following assumptions:

- For EU forestry residues, transportation is assumed to be by truck 50 km, 100km in case of intermediate processing (e.g. briquetting, pelletising, chipping)
- For raw materials coming from tropical countries (Brazil, Indonesia, Thailand), transportation to the processing site is assumed to be by truck, 50 km, and transport to the export terminal, 700km, while transport to the EU vary for Brazil (by ship, 10186 km, and for Indonesia by ship, 13000 km and for Thailand by ship 12500 km).

Biofuel production pathway	**Typical** GHG emitted (g CO2eq/MJ)				**Default** GHG emitted (g CO2eq/MJ)		
	Cultivation	Processing	Transport & distribution	**Total**	Cultivation	Processing	Transport & distribution
Wood chips from forest residues (EU forest)	0.0	0.4	0.3	**1**	0.0	0.4	0.4
Wood chips from forest residues (Brazilian forest)	0.0	0.4	20.0	**21**	0.0	0.4	23.9
Wood chips from short rotation forestry (EU forest)	2.0	0.4	0.3	**3**	2.5	0.4	0.4
Wood chips short rotation forestry (eucalyptus)	2.9	0.4	20.0	**24**	3.5	0.4	23.9
Wood briquettes or pellets from forest residues (EU forest) – wood as process fuel	0.0	0.5	0.7	**2**	0.0	0.5	0.8
Wood briquettes or pellets from forest residues (EU forest) – NG as process fuel	0.0	15.4	0.9	**17**	0.0	18.4	1.1
Wood briquettes or pellets from forest residues (Brazilian forest) - wood as process fuel	0.0	0.5	13.7	**15**	0.0	0.5	16.4
Wood briquettes or pellets from forest residues (Brazilian forest) - NG as process fuel	0.0	15.4	13.7	**30**	0.0	18.4	16.4
Wood briquettes or pellets from short rotation forestry (EU) - wood as process fuel	2.1	0.5	0.7	**4**	2.5	0.5	0.8
Wood briquettes or pellets from short rotation forestry (EU) - NG as process fuel	2.1	15.4	0.6	**19**	2.5	18.4	0.7
Wood briquettes or pellets from short rotation forestry (eucalyptus) - wood as process fuel	3.6	0.5	13.7	**18**	4.4	0.5	16.4
Wood briquettes or pellets from short rotation forestry (eucalyptus) - NG as process fuel	3.6	15.4	13.7	**33**	4.4	18.4	16.4
Charcoal from forest residues (EU)	0.0	32.8	0.7	**34**	0.0	39.4	0.8
Charcoal from residues (Brazilian forest)	0.0	32.9	8.0	**41**	0.0	39.5	9.6
Charcoal from short rotation forestry (EU)	4.1	32.9	0.7	**38**	5.0	39.5	0.8
Charcoal from short rotation forestry (Eucalyptus)	5.9	33.0	8.0	**47**	7.0	39.6	9.6
wheat straw (EU)	0.0	0.8	0.3	**2**	0.0	1.0	0.3
Bagasse briquettes – (Brazil) wood as process fuel	0.0	0.0	13.5	**14**	0.0	0.0	16.2
Bagasse briquettes – (Brazil) NG as process fuel	0.0	15.0	13.5	**29**	0.0	18.0	16.2
Bagasse bales (Brazil)	0.0	0.8	15.8	**17**	0.0	1.0	18.9
Palm kernel (Indonesia)	0.0	0.0	21.8	**22**	0.0	0.0	26.2
Rice husk briquettes (Thailand)	0.0	0.0	23.3	**24**	0.0	0.0	28.0
Mischanthus bales (temperate continental climate)	3.6	1.1	0.3	**6**	4.4	1.4	0.3
biogas from wet manure	0.0	5.0	1.6	**7**	0.0	6.0	1.9
biogas from dry manure	0.0	5.0	0.5	**6**	0.0	6.0	0.6
Biogas from wheat and straw (wheat whole plant)	16.9	0.0	0.3	**18**	20.3	0.0	0.3
Biogas from maize as whole plant (maize as main crop)	14.3	5.0	0.0	**19.3**	17.2	6.0	0.0
Biogas from maize as whole plant (maize as main crop) – organic agriculture	10.7	5.0	0.0	**16**	12.8	6.0	0.0