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FINAL REPORT

Benchmarking biomass sustainability criteria for energy purposes

Luc Pelkmans[1], Nathalie Devriendt (VITO), Martin Junginger[2], Ric Hoefnagels, (Utrecht University), Gustav Resch[3], Julian Matzenberger, Lukas Kranzl, Christian Panzer (TUVienna), Rocio Diaz-Chavez, Frank Rosillo-Calle (Imperial College), Klaus Hennenberg, Kirsten Wiegmann, Rocio Herrera, Uwe Fritsche (Öko-Institut), Maurizio Cocchi (ETA Florence), Judit Bálint (REC)

[1] Task 1 leader, [2] Task 2 leader, [3] Task 3 leader

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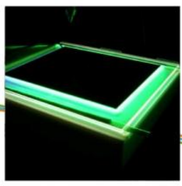

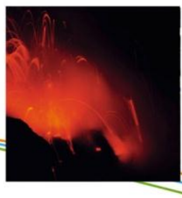

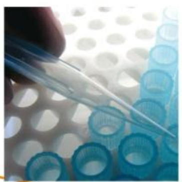

VITO NV
Boeretang 200 – 2400 MOL – BELGIUM
Tel. + 32 14 33 55 11 – Fax + 32 14 33 55 99
vito@vito.be – www.vito.be

VAT BE-0244.195.916 RPR (Turnhout)
Bank 435-4508191-02 KBC (Brussel)
BE32 4354 5081 9102 (IBAN) KREDBEBB (BIC)

Partners

vito vision on technology

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EXECUTIVE SUMMARY

1. Introduction

The Renewable Energy Directive (2009/28/EC) introduced sustainability requirements for biofuels and bioliquids. The Directive also announced that the European Commission would suggest requirements for a sustainability scheme for other energy uses of biomass as well. In February 2010, the Commission adopted a report on requirements for a sustainability scheme for solid and gaseous biomass used for generating electricity, heating and cooling (COM(2010)11), hereafter called the '2010 Biomass Report'.

At that stage, no binding criteria were suggested at the European level. Nevertheless, the Commission formulated recommendations for Member States (MS) developing sustainability schemes. By the end of 2011, the Commission has committed to carry out a further assessment with a view to revisiting this decision. The present study provides background analysis for such an assessment. The aim is to compare national regulations on biomass sustainability and to assess the economic and environmental impacts of national and EU sustainability criteria.

The report is structured according to the main tasks of the study:

- Chapter 1 describes the overall methodology of the study;
- Chapter 2 provides an inventory of national regulations on the sustainability of biomass used in electricity, heating and cooling (study task 1);
- Chapter 3 presents a comparative analysis of national regulations with each other and with the sustainability criteria recommended in the 2010 Biomass Report (study task 2);
- Chapter 4 includes an assessment of the economic and environmental impacts of national and EU level regulations (study task 3).

2. Inventory and comparative analysis of national regulations

MS legislation on energy, environment, agriculture and forestry were screened to ascertain if they include specific obligations, restrictions or other requirements that promote, financially or otherwise, the sustainable production and efficient use of biomass for energy. Regulations were only considered where they were additional to, or stricter than European requirements, and only if they specifically addressed the use of solid and gaseous biomass in electricity and heating/cooling sectors. This study has surveyed 56 biomass sustainability regulations, introduced by 20 MS. Regulations were classified according to the policy driver, sustainability theme, policy instrument, affected market actors, affected raw material and according to the life cycle phases covered. In the following discussion regulations are considered according to the life cycle phase where they apply.

Biomass production

With regard to the production of biomass feedstocks, the study found a rather heterogeneous picture, often highly feedstock- or technology-specific. Only one country (UK) has introduced regulations specifically referring to the biodiversity and carbon stock criteria laid down in the 2010 Biomass Report. In several MS biodiversity protection is indirectly covered in energy legislation through the requirement of

Sustainable Forest Management (SFM) certification (FSC or PEFC) of woody biomass. It should be emphasised that, especially with respect to agricultural and forestry biomass, many sustainability criteria are likely included in other European and national regulations that have not been assessed here as they do not make a specific link with energy use. It seems that most MS rely on their existing agricultural and forestry regulations to address the sustainability of biomass production and harvesting, as far as domestic production is concerned. Issues related to biomass produced outside the EU are not addressed by these regulations.

In addition to regulations referring to environmental sustainability of biomass production, other regulations aim to promote or protect the economic sustainability of local actors in relation to the biomass. Two types of measures have been identified: a first group of regulations promotes the use of local biomass in energy applications with the view to create development opportunities for local actors and to minimize environmental impacts related to long transport chains; a second group limits certain feedstocks for energy applications with the aim to protect other existing economic sectors relying on these biomass streams (such as the wood processing industry), thereby indirectly promoting biomass imports for energy.

We conclude that energy regulations do not appear to sufficiently address the sustainability of biomass production, particularly as concerns imports of raw material. The few MS that have introduced sustainability regulations in relation to energy use of biomass seem to follow different (potentially conflicting) approaches.

Life cycle GHG performance

The 2010 Biomass Report tables a common GHG emission accounting methodology for biomass use in electricity and heating. Differently from the methodology applied to biofuels and bioliquids, emissions from the conversion of biomass into electricity, heating or cooling are included in the GHG accounting calculations.

Only two out of 27 MS (UK and Belgium) have so far included comprehensive binding criteria for GHG emission reduction levels. Whereas the UK has followed the recommended EU GHG accounting methodology, the Belgian (Walloon) regulation – which was introduced in 2006 – has been using a slightly different methodology.

It is clear that Belgium and UK have introduced these requirements because they expect to rely heavily on large imports of solid biomass from overseas for energy purposes. Evidence from the National Renewable Energy Action Plans (NREAPs) suggests an increase of imports can also be expected for other MS. Furthermore, with the generally increasing scarcity of (high-quality) solid biomass residues, it is quite possible that in the near future, both in EU and non-EU countries, supply will be covered with energy wood plantations or dedicated short-rotation energy crops. Depending on the cultivation practices, GHG emissions may be higher than from comparable residue streams. Particularly for woody biomass, we conclude that there seems to be insufficient legislation in place on MS level to ensure or monitor whether optimal GHG emission savings are achieved on life cycle basis.

End use efficiency

In its 2010 Biomass Report, the Commission recommended that MS should differentiate their support schemes in favour of installations that achieve high energy conversion efficiencies, such as high efficiency cogeneration plants. Quite a large number of MS have implemented such regulations, either requiring mandatory minimum efficiencies for the production of heat, electricity or both, or providing financial incentives to stimulate higher efficiencies or heat recovery. However, they often only aim at a specific technology, both in terms of size and output (heat, electricity, or both). Also, the vast majority of regulations are found in the EU-15; almost no regulations are present in the new MS.

Voluntary systems

Given diverging national regulations, a growing number of voluntary sustainability schemes have been developed by both the private sector and NGOs. Five voluntary schemes relevant for the EU market were investigated in the study. We conclude that these schemes address most of the sustainability criteria laid down in the 2010 Biomass Report, particularly as regards GHG emission saving requirements. However, like national regulations, they also present different approaches and different levels of environmental stringency. Of interest in this respect is the recent initiative of international wood pellet buyers (IWPB), which joins several large European utilities and other market players, with the aim of harmonising several of the existing voluntary systems in order to facilitate trade through common sustainability principles. Voluntary schemes may in some cases go further than is strictly required by law or suggested in the 2010 Biomass Report and may effectively serve as voluntary safeguards for big amounts of imported biomass. This said, given their voluntary nature, there is no guarantee that they will be able to address the whole biomass market. In this respect they cannot be considered as an effective alternative to binding regulation, whether at national or EU-level.

Trade effects

In the absence of mandatory EU-wide sustainability criteria for solid biomass, it is quite likely that a number of individual MS will unilaterally develop further sustainability criteria, while others maintain the status quo. Such a development could undermine the environmental effectiveness of national schemes as leakage effects towards MS with less strict criteria may arise. Moreover, a heterogeneous regulatory approach to biomass sustainability raises concerns from an internal market perspective, including potential distortions to trade in biomass, market segmentation and overall market inefficiency.

3. Impacts of biomass sustainability regulations

Policy scenarios

The Green-X model was used to assess how different policy scenarios, including additional EU measures on biomass sustainability, would impact future deployment of renewable energy technologies (RES) in the EU in general, and biomass use in electricity and heating in particular. The following policy scenarios were modelled:

- a “no criteria” scenario, assuming that MS do not introduce any specific national sustainability regulations for biomass;
- a “baseline” scenario, (named as policy option A), which assumes the full implementation of existing or draft national regulations on biomass sustainability;
- an “EU criteria” scenario, which assumes the introduction of a number of additional EU measures on biomass sustainability, building on the recommendations made in the 2010 Biomass Report. More specifically, the following different options of EU criteria were modelled:
    - criteria similar to those applying to biofuels (option B),
    - biofuels criteria with higher GHG threshold (60%, 70% and 80%) (option C),

- option B, supplemented with SFM requirement (option E).

All three options were modelled for two different scopes: 1) application to all installations, 2) application only on large installations (above 1 MW), following the recommendation of the 2010 Biomass Report.

Biomass imports from third countries are expected to increase significantly over the next decade. Two different import reference scenarios were developed: a "low imports" scenario that builds on industry expectations as presented in the first half of 2011 that are likely to anticipate the compliance with EU sustainability criteria, and an alternative "high imports" scenario, in which roughly twice as much biomass from wood pellets is imported. The production of the additional wood pellets is assumed to be based 100% on dedicated energy crops.

Results

In broad terms, impacts are very much dependent on the assumptions underpinning the baseline scenario. Under a "low imports" scenario, even the introduction of high GHG saving requirements (80%) to all biomass installations results in only a minor decrease in biomass use of 0.9% compared to the baseline case. This indicates that generally only few biomass supply streams would be affected and may face problems in meeting strict sustainability constraints. In other words, the majority of solid and gaseous biomass used for energy purposes in the EU has a high carbon performance, while only few biomass supply chains show low GHG savings due to high cultivation emissions. Several waste streams characterised by zero emissions supply a significant share of the resulting demand for biomass for energy purposes. Thus, even if emissions for processing and transport are added, researched GHG constraints can mostly be met if biomass is used by various (efficient) conversion technology options.

Under a "high imports" scenario, EU-wide sustainability criteria applied to all biomass installations or a SFM requirement result in significant emission savings. EU criteria applied only to large size installations (above 1 MW) would not result in GHG savings because non compliant biomass feedstocks could be diverted to other markets (for instance, residential and small scale markets), causing a "leakage effect". Applying effective sustainability regulations for solid and gaseous biomass imposes a certain cost. The results of the modelling exercise show that there is a correlation between the stringency of criteria and the total cost increase.

Finally, the following gives a closer look at the performance of individual policy options. The evaluation of the performance of assessed policy *options B* to *E* indicates that EU action has a positive impact related to environmental protection, and one can expect that a harmonised regulation appears beneficial also for creating an internal market. The inclusion of all relevant operators, that is the scope of the regulation to affect all generators (or e.g. suppliers), appears however essential to avoid "leakage" and, consequently, to achieve the high level of effectiveness.

Conclusion

Findings related to the performance of individual policy options can be summarised as follows:

- The *baseline case (option A),* where solely national criteria are applied, appears not effective in establishing sufficient environmental protection. Currently GHG saving requirements for solid and gaseous biomass have been introduced only in two MS. This situation creates an uneven playing field, whereby biomass pathways that deliver less than optimal GHG emission savings are still being incentivised in most MS. As a consequence, this option is likely to result in less than optimal GHG savings in the case of massive biomass imports to the EU (assuming worst land use change). Such negative environmental impacts may lead to a decrease of public acceptance for biomass use in the energy sector. The patchwork of different national regulations in place may also cause distortions to the creation of an internal market, in particular related to intra-EU biomass trade.

- *EU criteria similar to biofuels (option B)* would establish a safeguard against worst biomass production practices. The model-based assessment has shown that applying similar GHG constraints as used for biofuels (35%) would lead to moderate savings. The economic impacts in turn appear also moderate, that is only a limited increase of cost and expenditures can be expected.

- The use of *EU criteria with stricter GHG thresholds (option C)* would be effective in establishing environmental protection. The modelling results indicate a clear correlation between the stringency of criteria and the amount of GHG savings, that is savings are highest with 70% and 80% thresholds. On the contrary, economic impacts are also highest in the case of stringent criteria, that is cost and expenditures increase comparatively strong under these variants.

- *EU criteria (similar to biofuels) plus sustainable forest management requirement (option E)* show similar environmental and economic impacts as the use of a stringent constraint under option C. It can however be expected that the practical implementation may lead to higher costs for forest owners.

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LIST OF ACRONYMS

Art	Article
CAP	Common Agricultural Policy
CEEC	Central and Eastern European Countries
CEN	European Normalisation Committee
CHP	Combined Heat and Power
CN	Combined Nomenclature
COM	Communication
DWLSOC	Dead wood, litter and soil organic carbon
EC	European Commission
EEA	European Environmental Agency
EJ	Exa(10^{18})joule
ELV	Emission Limit Values
EN	European Norm
EU	European Union
EuP	Energy using Products
FIT	Feed-In tariff
FP7	Framework Programme 7
FSC	Forest Stewardship Council
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GGL	Green Gold Label
GIS	Geographic Information System
GJ	Giga(10^{9})joule
IEA	International Energy Agency
IEE	Intelligent Energy for Europe
ILO	International Labour Organization
iLUC	Indirect Land Use Change
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre of the European Commission
ktoe	Thousand tonnes of oil equivalent
LBE	Laborelec-SGS verification scheme
LCA	Life Cycle Assessment
LUC	Land Use Change
Mha	Million hectares
MJ	Mega(10^{6})joule
MSW	Municipal Solid Waste
Mt	Million tonnes
Mtoe	Million tonnes of oil equivalent
MS	Member States
MW	Mega(10^{6})watt
MW_e	Megawatt (electric power)
MW_{th}	Megawatt (thermal power)

MWh	Megawatt hour
MWh-p	Primary energy content, expressed in Megawatt hour
N	Nitrogen
NGO	Non-governmental organisation
NO_x	Nitrogen oxide emissions
NREAP	National Renewable Energy Action Plan
NUTS	Nomenclature of Territorial Units for Statistics
η_e	Electrical efficiency
η_h	Thermal efficiency
PEFC	Programme for the Endorsement of Forest Certification schemes
PJ	Peta(10^{15})joule
PM	Particulate Matter emissions
RED	Renewable Energy Directive (2009/28/EC)
RES	Renewable Energy Sources
SFM	Sustainable Forest Management

1 INTRODUCTION

1.1 Background of the study

The Renewable Energy Directive (2009/28/EC) introduced sustainability requirements for biofuels (transport) and bioliquids (electricity, heating and cooling) (Art. 17-19). Following Art. 17(9), in 2010 the European Commission published a report on requirements for a sustainability scheme for solid and gaseous biomass used for generating electricity, heating and cooling (COM(2010)11) (hereafter, *2010 Biomass Report*). At that stage, the Commission tabled non-binding sustainability criteria in the form of recommendations to Member States (MS). In order to ensure greater consistency and to avoid unwarranted discrimination in the use of raw materials, the 2010 Biomass Report recommended MS that had or planned to introduce sustainability criteria on solid biomass and biogas to follow in almost all respects the criteria applying to biofuels, as laid down in the Renewable Energy Directive.

By 31 December 2011, the Commission committed to assess the implementation of its recommendations to MS, including whether national sustainability schemes have sufficiently addressed the sustainability issues related to biomass for energy use, and whether these schemes have created barriers to trade and hampered development of bioenergy markets. The present study supports such an assessment.

Against this background, the aim of the study is **to compare national regulations on biomass sustainability and to assess the economic and environmental impacts of national and EU sustainability criteria.** Results of the analysis are described in the following 3 chapters, corresponding to the 3 main tasks of the study:

- Chapter 2 provides an inventory of national and sub-regional regulations on the sustainability of biomass used in electricity, heating and cooling;
- Chapter 3 presents a comparative analysis of national regulations with each other and with the sustainability criteria laid down in the 2010 Biomass Report;
- Chapter 4 includes an assessment of the economic and environmental impacts of national regulations and EU additional measures.

1.2 Methodology

The study covers regulations (in place or in draft form) addressing the use of solid and gaseous biomass (agricultural crops and residues, forestry, wood-processing industries, organic waste) in electricity, heating and cooling, where such regulations are additional to or stricter than European requirements.

The research methodology undertaken included the following tasks:

- Task 1.1: data collection of all relevant national and sub-regional regulations, on the sustainable use of solid and gaseous biomass in electricity, heating and cooling. This was based on a thorough review of available literature and online resources, combined with contacts with the national administrations through email and telephone interviews;

- Task 1.2: classification of the national sustainability regulations and analysis of the different phases of the life cycle covered;

- Task 2.1: comprehensive comparison of national regulations with each other and with the non-binding sustainability criteria laid down in the EU 2010 Biomass Report;

- Task 2.2: additional overview and comparison with voluntary systems developed by industry, NGO's and international organisations, particularly focussing on systems that have a significant impact on the import or use of biomass in the EU MS, taking into account varying and possibly conflicting national legislation in the relevant areas;

- Task 3.1: definition of a number of policy scenarios concerning the introduction of additional EU sustainability measures;

- Task 3.2: translation of the regulations identified into quantitative impacts, focussing mainly on costs and availability of solid and gaseous biomass, but also taking into account other factors such as GHG emission reduction;

- Task 3.3: quantitative assessment of the economic and environmental impacts of the above-mention policy scenarios;

- Task 3.4: qualitative evaluation of economic/environmental impacts that are difficult to quantify.

1.3 Team

The study was carried out by the following team of partners:

- **VITO, the Flemish Institute for Technological Research** (Belgium), a renowned European research centre with wide expertise in biofuels and bioenergy policy as well as sustainability analysis;

- **Copernicus Institute, Utrecht University** (the Netherlands), which specialises in Sustainable Development and Innovation and is the co-ordinator of Task 40 of the implementing agreement Bioenergy for the International Energy Agency (IEA);

- **TUWien/EEG, the Energy Economics Group at Vienna University of Technology** (Austria) that has been coordinating several EU-projects in the area of renewable energy (including Green-X, GreenNet, Invert, futures-e);

- **Öko-Institut** (Germany), a leading European research and consultancy institution working for a sustainable future;

- **LCAworks, Imperial College London** (UK), the lifecycle and sustainability analysis arm of Imperial College London's Porter Institute, with extensive experience in lifecycle and sustainability analysis, development and benchmarking of sustainability standards;

- **ETA Florence Renewable Energy** (Italy), an engineering and consultancy firm that is active in the promotion, development, design and integration of renewable energy systems;

- **The Regional Environmental Center for Central and Eastern Europe** (REC) is an international organisation that has its head office in Hungary and country offices and field offices in 17 beneficiary countries.

A core team of VITO, Copernicus Institute and TU Vienna were in charge of managing the content work, with VITO leading task 1, Copernicus Institute leading task 2 and TU Vienna leading Task 3. All partners were involved in task 1, while companies specialised in sustainability analysis and modelling formed part of the teams working in tasks 2 and 3.

2 INVENTORY OF NATIONAL BIOMASS SUSTAINABILITY REGULATIONS

This chapter provides an overview of the biomass sustainability regulations introduced or announced thus far in the EU Member States. Section 2.1 explains the methodology used to identify relevant regulations. Section 2.2 briefly describes the national sustainability regulations and section 2.3 classifies them according to their characteristics.

2.1 Methodology

Relevant regulations containing biomass sustainability criteria for use in electricity, heating and cooling were collected for the 27 European Member States (MS). To cover all the MS, the project partners have screened the assigned countries following the distribution in the table below.

Table 1: Overview of the country analysis distribution between the partners

	Austria	Belgium	Bulgaria	Cyprus	Czech Rep.	Germany	Denmark	Spain	Estonia	Finland	France	Greece	Hungary	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Poland	Portugal	Romania	Slovenia	Slovakia	Sweden	UK
VITO		X									X							X									
Cop.																				X							
TUV	X																										
Öko						X	X			X																X	
Imp.														X													X
REC			X		X				X				X			X	X				X		X	X	X		
ETA				X				X				X			X				X			X					

Country legislations on energy, environment, agriculture and forestry were screened to check if there were specific obligations, restrictions or other policies that promote (financially or otherwise) the use of 'sustainable biomass' and the efficient use of biomass for energy (heating and cooling and electricity). The definition of sustainable biomass, or what is perceived as efficient use of the biomass, may differ by MS; it may refer to environmental, economic and social aspects of sustainability.

The following sources were used:

- National Renewable Energy Actions Plans (NREAPs) that were submitted by all MS to the European Commission in 2010,
- reports on renewable energy and specifically bioenergy support schemes available from several on-going projects and activities. Examples include:

- REN21 – Renewables Interactive Map,
- RESHAPING,
- EUBIONET III (WP4 – biomass sustainability criteria and national legislation),
- ELOBIO (WP3 – biomass for stationary energy),
- BAPDriver,
- IEA-Bioenergy Task 40 (country reports),
- SUPERGEN,

- national and regional legislation documents available through administrations and experts,
- drafts for legislation on sustainability rules and restrictions on the use of biomass for stationary energy.

Administrations and local experts in every MS were contacted to check if any draft or approved legislation that includes regulations on the sustainable use of solid or gaseous biomass for stationary energy had been missed.

For every MS, an ***initial listing*** of potentially relevant regulations was made addressing the following two basic research questions:

- Does the regulation introduce sustainability requirements on the *production of biomass* for energy use? This includes for instance requirements on sustainable forest management, greenhouse emission savings for the supply chain, or in some cases, criteria promoting the use of local biomass feedstocks.
- Does the regulation introduce sustainability requirements for the *end use* of biomass for energy? This includes for instance minimum efficiency requirements or air quality emission limits.

Sustainability regulations were then selected according to the following guiding questions:

- Does the regulation place restrictions on, or make a clear differentiation between biomass feedstocks? General regulations on bioenergy promotion were excluded.
- Does the regulation introduce requirements on technology performance stricter than EU regulation (for instance minimum efficiency, maximum emission levels)?
- Is there a clear sustainability basis for the identified regulations? For instance, is there a differentiation in feed-in tariff or green power certificates? Is this on the basis of the extra cost or on the basis of a higher sustainability ranking?
- In case of sub-regional regulations, is the region important in terms of biomass and bioenergy development?
- Is the sustainability standard (for instance, pellet norm, sustainable forestry management system) specifically referring to energy legislation or to subsidy schemes/support mechanisms for bioenergy? Different implementations or interpretations of forest management schemes (like FSC, PEFC) were not analysed, unless they had a clear link to energy legislation.
- Is the regulation part of legislation in place or planned? Policy plans and papers that do not have a direct regulatory impact were not considered.
- Regulations for 'good agricultural practices' were not included, unless there was a clear link to energy legislation.

- Legislation defined by European Directives was not considered, for instance, regulations implementing the Waste Frame Directive or the Large Combustion Plants Directive, unless the MS went further than strictly required by the Directive.

The consortium has performed a first review of regulations in the period November 2010 – January 2011. As development in this area is currently quite dynamic, the consortium has performed an update review in June 2011 to see if new regulations were added or draft ones have in the mean time been approved. This review also took into account the contributions of the public consultation launched by the Commission in February 2011 (in part C, the Commission asked stakeholders whether they are aware of national or regional regulations in place and what are the impacts of such regulations).

Box 1: Assessment template

The information on all regulations marked as relevant was assembled using a common template, listing following information:

Section 1: general information
- name of regulation
- short description of the regulation
- link where information can be found
- status of the regulation, valid since …
- geographical area where the regulation is valid
- valid for energy only or broader in scope?

Section 2: type of legislation
- specific part of overall legislation (for instance, energy, environment, agriculture, forestry)
- type of regulation (for instance, financial, obligation, restriction, use of certificates)

Section 3: applicable for which type of biomass? (see listing NREAP template)
- biomass from Forestry (direct supply – indirect supply)
- biomass from Agriculture and fisheries (crops – by-products/residues)
- biomass from waste (MSW, industrial waste, sewage sludge)
- other

Section 4: life cycle phase affected
- production (for instance, agriculture, forest, waste management)
- transformation (for instance, processing into pellets, waste pre-treatment)
- transportation (for instance, limits on transport distances)
- conversion (for instance, efficiency of conversion into electricity or heating/cooling)
- integrated for all phases

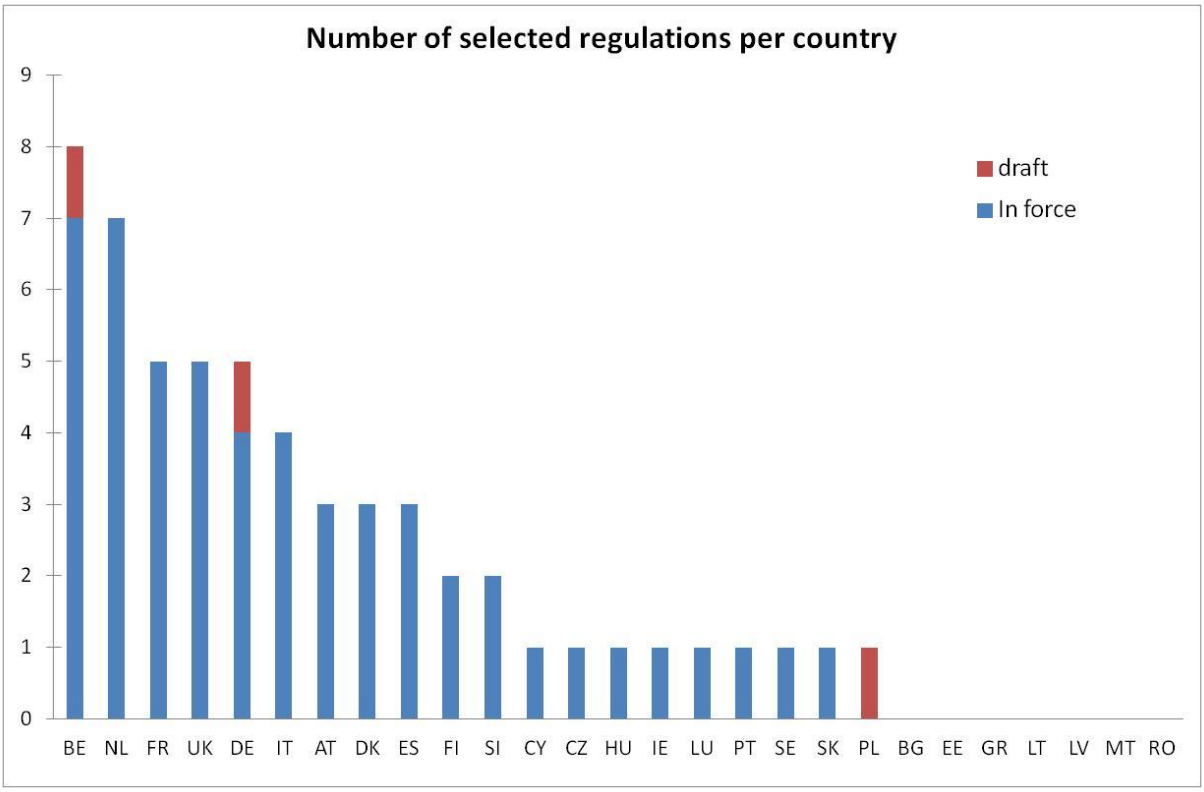
Section 5: affected stakeholders
- biomass producers (farmers, foresters, managers of green areas, waste managers, members of the biomass industry and industry with biomass residues)
- biomass traders
- energy producers (Utilities, medium- and small-scale producers)
- end consumers (households, industries, services)
- others

Section 6: aspects of sustainability and criteria covered
- overall aspects (environmental, economic, social)
- indicators (GHG-savings, energy use/efficiency, biodiversity, carbon stock, land use change, ecosystem services, soil protection, protection of fresh water, air protection, restoration of degraded lands, implementation of ILO conventions, other social criteria)

2.2 Overview of national sustainability regulations

This study has surveyed **56** biomass sustainability regulations, introduced thus far by 20 MS (see Figure 1), 53 of which are in force and 3 are in draft. The initial review (January 2011) identified 53 regulations. From the review of June 2011, 1 approved and 2 draft regulations were added, while 3 drafts were in the meantime being approved.

Figure 1: Number of biomass sustainability regulations per MS



The number of regulations per country is not a decisive parameter as certain regulations may cover the whole biomass life cycle (production, transport, conversion and end-use) while others address only one phase of it (for instance, end-use). Nevertheless, it is clear that the 'older' European Member States (EU-15[1]) have included more sustainability requirements for biomass in their regulation than the 12 countries that entered the EU in the past decade.

Most regulations are included in national legislation, only 9 were in regional legislation: 6 in Belgium (Flanders, Walloon Region, Brussels Capital District) and 3 in the UK (England, Scotland).

Table 5 (presented at the end of this chapter) gives an overview of the 56 regulations. The short names mentioned in Table 5 will be used in subsequent tables. More details on the regulations can be found in Appendix I.

[1] Members of the European Union per 1 January 1995: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

2.3 Classification of sustainability regulations

The 56 regulations selected can be classified according to the policy driver, sustainability theme, policy instrument, affected market actors, affected raw material and according to the life cycle phases covered. This will be discussed in the following sections.

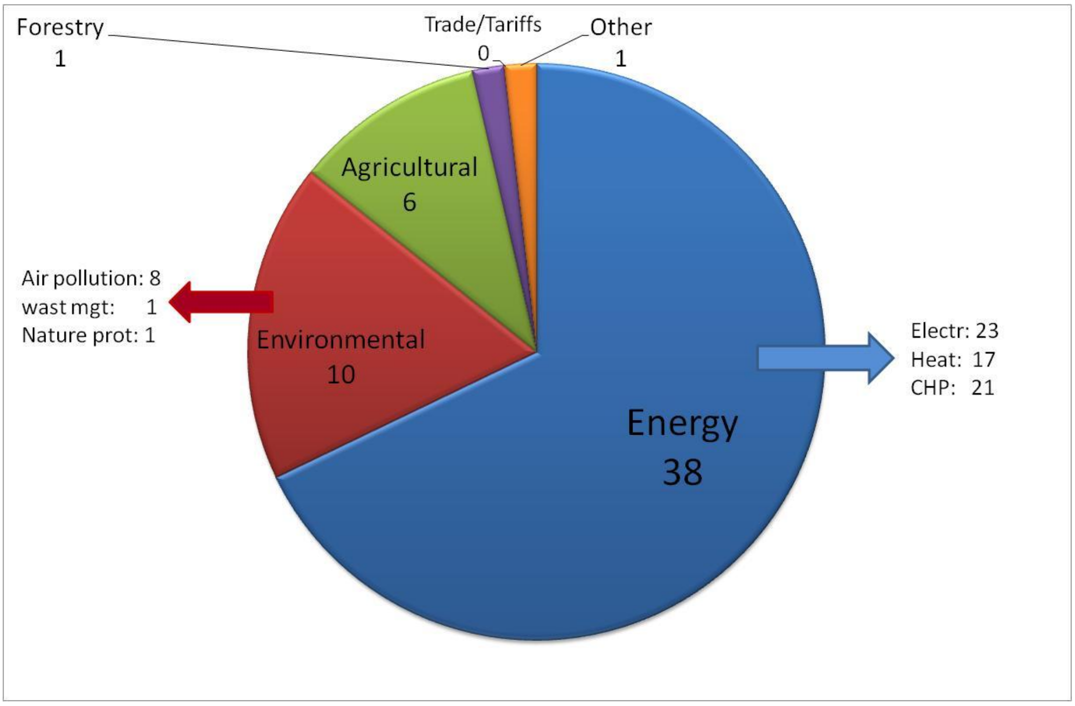
2.3.1 Policy drivers

Sustainability regulations on biomass for energy are mainly included in energy legislation. Figure 2 shows that overall around two-third of the regulations were part of energy legislation, 20% were part of environmental and 10% agricultural legislation. One was part of forestry legislation, and one was a product norm ('other').

Amongst the 38 regulations in *energy* legislation, 23 referred to electricity, 17 to heating and cooling, and 21 to CHP (combined heat and power). In half of the cases, there is a focus on one single type of energy conversion; in the other cases the legislation applies to combinations of electricity, CHP and heat.

Most *environmental* regulations establish requirements on air pollution, one concerns waste management and one focuses on nature protection.

Figure 2: Type of legislation that the selected regulations were part of



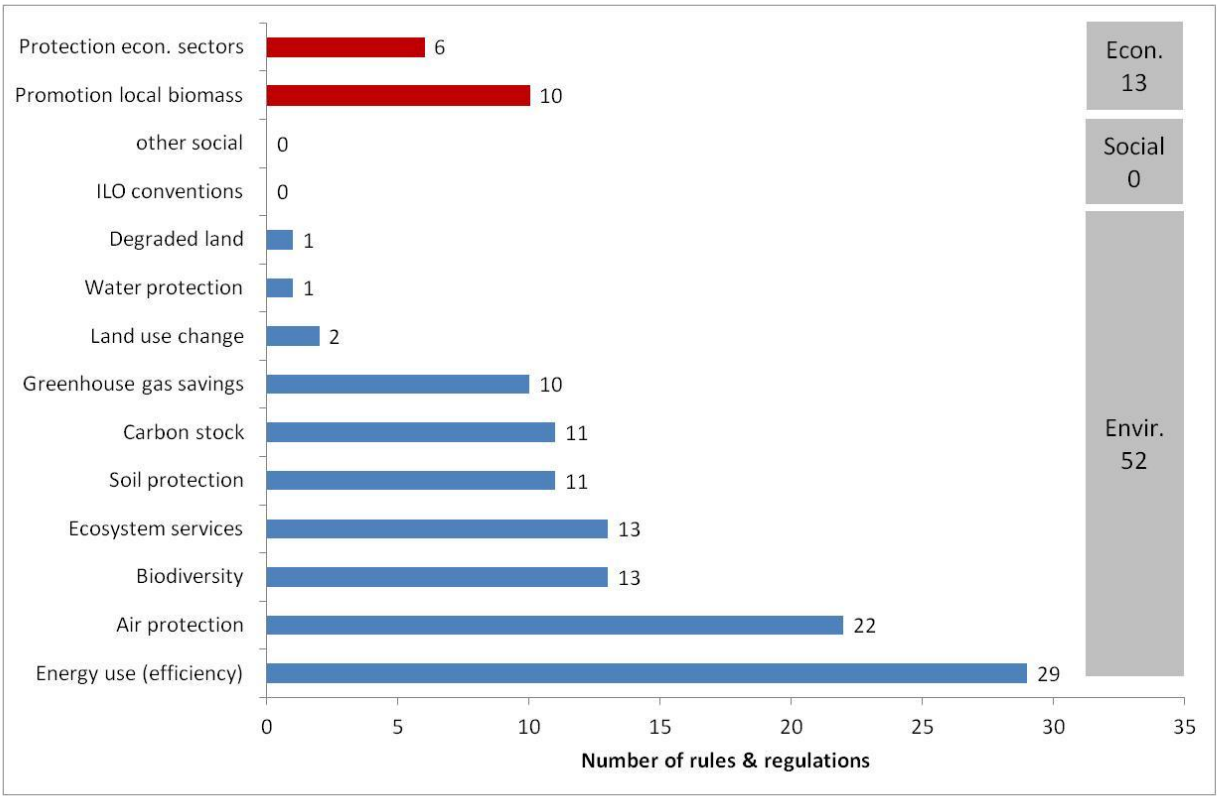
2.3.2 Sustainability themes

As shown in Figure 3, the vast majority of regulations (52 out of 56) include environmental sustainability provisions. 13 out of 56 included economic sustainability principles (either favouring local biomass or protecting local industry). There were no specific regulations referring to social sustainability. It should be born in mind that some regulations include more than one sustainability aspect.

Regulations regarding *energy efficiency, greenhouse gas emissions and air emissions* are in most cases specifically aimed at the energy producer (see further discussion below). In total, 45 out of 56 sets of regulations deal with at least one of these criteria. For regulations containing energy efficiency criteria (29), in 12 cases this was in conjunction with air emission regulations.

Regulations referring to *biodiversity*, *ecosystem services*, *soil protection* and *carbon stock* may also be interrelated. In total 19 regulations include at least one of these criteria. In 7 cases, there is a clear link to sustainable forest management (FSC, PEFC), where all four of these aspects are included.

Figure 3: Number of regulations mentioning specific sustainability criteria



2.3.3 Policy instruments

MS can use a variety of policy instruments where biomass sustainability criteria can be embedded. Typically, two main categories can be identified: economic and regulatory instruments, as well as a number of subcategories. As shown in Table 2, 35 of the regulations contained economic instruments such as subsidies and feed-in tariffs, whereas 22 contained regulatory instruments, mostly quota obligations and restrictions. In 2 cases, both regulatory and economic instruments are included in the legislation.

The use of a *green certificate system* is indicated in 7 regulations, 6 of which were linked to a quota obligation system, one with a feed-in tariff. In 7 cases reference is made to *voluntary schemes* like FSC or PEFC, 4 times linked to a subsidy scheme, 2 times linked to a quota obligation and 1 as an obligation in a product norm.

Table 3 provides an overview of policy instruments related to different types of legislation. Energy legislation typically uses economic instruments such as subsidies and feed-in tariffs, or regulatory instruments such as quota obligation systems (these are also the ones containing reference to sustainability criteria). On the other hand, environmental legislation is more focused on standard settings and restrictions, as also shown in the table. Most instruments in agricultural and forestry legislation are subsidies.

Table 6 at the end of the chapter gives a detailed overview of the types of policy instruments used in the different regulations.

Table 2: Policy instruments used by Member States

Category regulations	N° of regulations	N° of countries
Economic instruments	35	17
Grants / subsidies	21	12
Tax credits	3	4
Feed-in tariffs	17	10
Regulatory instruments	22	12
Restrictions / bans	11	8
Quota obligations	10	7
Other	2	2

Table 3: Policy instruments by type of legislation

	Total	Energy	Envir.	Agri.	Forest	Other
Economic instruments	*35*	28	2	4	1	0
Grants/subsidies	*21*	*13*	*2*	*5*	*1*	*0*
Tax credits	*3*	*2*	*0*	*1*	*0*	*0*
Feed-in tariffs	*17*	*16*	*0*	*1*	*0*	*0*
Regulatory instruments	*22*	11	8	2	0	1
Restrictions/bans	*11*	*9*	*0*	*1*	*0*	*1*
Quota obligations	*10*	*2*	*7*	*1*	*0*	*0*
Other	*2*	*0*	*0*	*0*	*0*	*0*
Total regulations	***57***	***39***	***10***	***6***	***1***	***1***

2.3.4 Affected market actors

Table 4 and Table 7 (in detail, see end of chapter) provide an overview of which market actors are directly responsible or indirectly affected by the different legislation types. We consider a certain sector directly **responsible** when this sector is responsible for complying with the regulations mentioned in the legislation (for instance, meeting efficiency requirements or emission limits), or is the receiver of the economic incentives (subsidies, tax reductions, higher feed-in tariff). Market actors are **indirectly affected** when they are not directly responsible for complying with the regulation, but will feel an impact (for instance, in terms of higher demand for 'sustainable' biomass, proving certain sustainability conditions set at the end of the chain).

All regulations related to energy legislation are directed towards energy producers or end consumers, depending on the scale of the installation. Environmental regulations are also mostly directed towards energy producers. The agricultural and forestry regulations are logically mostly connected to the biomass producers, namely the farming and forestry sectors.

When looking at the sectors that are indirectly impacted, it is clear that biomass producers and traders are in most cases affected by the energy legislation as the demand for their products is affected by the energy regulations. The other way round, energy producers are impacted by agricultural legislation as it may increase or limit their potential feedstock. In the 'other category' manufacturers of biomass boilers and installations represent an important sector as they need to manufacture installations that meet the prescribed energy and emission requirements. In some cases, mainly those involving small scale installations, manufacturers will need to certify their installations to prove compliance to these requirements.

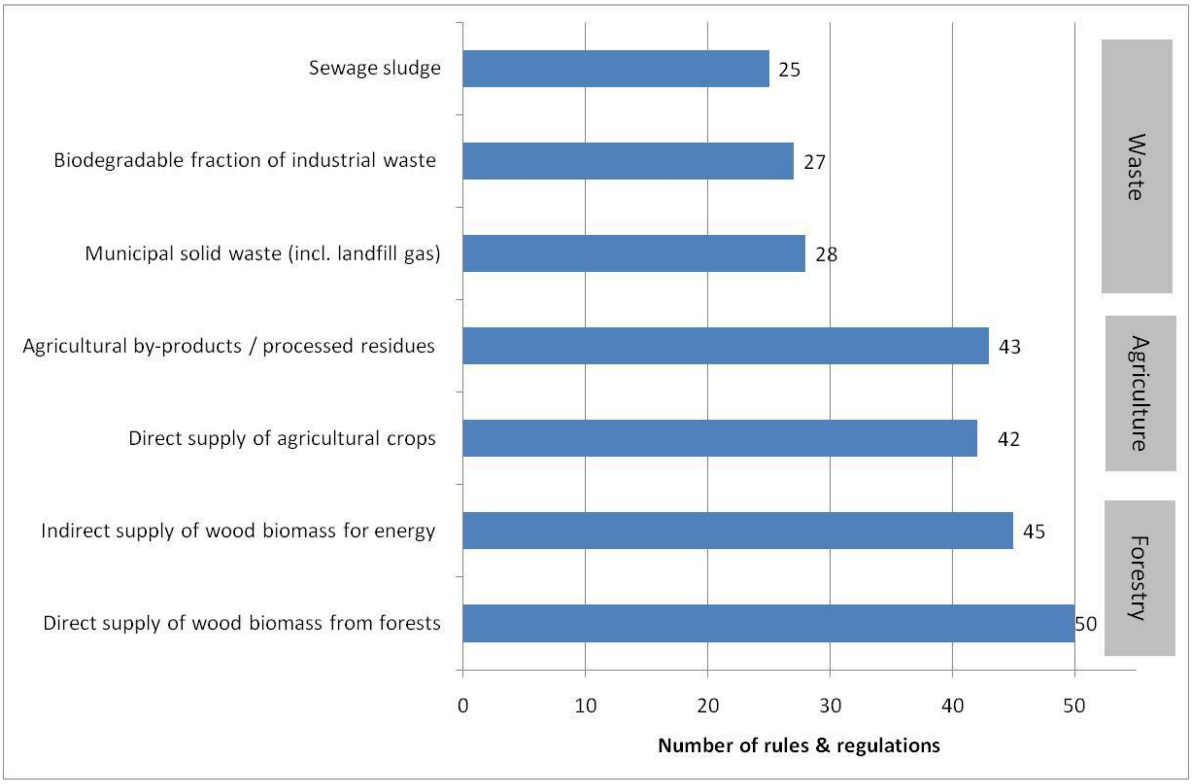
Table 4: Categorisation of affected economic operators (responsible and indirectly affected), according to the legislation types

Economic operators	Responsible for implementing the regulations					Indirectly affected by the regulations				
	Energy	Envir	Agri	Forest	Other	Energy	Envir	Agri	Forest	Other
Biomass producers	0	1	5	1	0	23	1	1	0	0
Biomass industry and traders	0	0	1	0	1	20	1	1	1	0
Energy producer	35	8	2	0	0	0	1	3	1	1
End consumers	7	0	0	0	0	0	1	0	0	1
Others	1	1	0	0	0	7	2	0	0	0
Total regulations	***39***	***10***	***6***	***1***	***1***	***39***	***10***	***6***	***1***	***1***

2.3.5 Affected biomass raw materials

Some regulations focus on specific biomass feedstocks, however, most sustainability regulations affect all biomass raw materials. As shown in Figure 4 and Table 8, it is clear though that woody biomass from forestry (both direct and indirect supply) is a major feature of biomass criteria as it is affected in almost 90% of the regulations. Other affected raw materials include agricultural products (~75% of regulations), both direct and residues, and waste (50% of regulations).

Figure 4: Biomass raw materials subject of sustainability criteria



2.3.6 Life cycle phases

The identified regulations can also be classified according to the biomass life cycle phases:

1. Production of biomass feedstocks (regulations focusing specifically on production standards and on restrictions on the use of certain feedstocks),
2. Transformation/pre-treatment (for instance, processing into pellets, waste pre-treatment),
3. Transportation (for instance, energy use in transportation, limits on transport distances),
4. Conversion to energy (for instance, energy efficiency or air pollutant levels).

The results are shown in Table 9 at the end of the chapter. The vast majority, 51 out of 56 regulations, included the final step of conversion to energy. The other phases (biomass production – 19; transformation – 11; transportation - 11) were much less covered.

Some regulations (indicated in blue) cover the whole chain in an integrated way: the three green certificate systems in Belgium, and three systems in the UK (Renewables Obligation Order 2011, Renewable Heat Incentive and Scottish Biomass Heat scheme). These systems require auditing along the entire chain.

Other regulations either only focus on the fourth step (conversion to energy), either look at different steps in a separate way (for instance, promotion of local biomass or biomass from sustainable forest management on one hand, and efficiency requirements for the conversion step on the other hand).

Table 5: Overview of selected regulations containing sustainability requirements for biomass and its uses

MS[2]	Regulation (short name)	Short description on sustainability requirements
AT	Green Electricity Act (ÖSG)	Sets Feed-in Tariffs for renewable electricity. The Act contains minimum efficiency requirements. To be eligible for feed-in tariffs, bioenergy plants have to include details in their application on feedstock supply including how much is intended to come from domestic agriculture and forestry.
AT	Environmental Measures Support Act (UFG)	Investment subsidies, also for renewable energy systems. For firing solid biomass (>400 kW and CHP) and biogas, the Act includes a sustainability bonus for regional biomass.
AT	Emission legislation for boilers, linked with ÖNORM M 9466 (ÖN9466)	Specific emission limits for wood incineration plants of a nominal fuel heat output >50 kW.
BE	Royal Decree containing minimum requirements for wood pellets for use in non-industrial heating installations (PelletNorm)	Minimum requirements for wood pellets to be used in non-industrial heating installations will be regulated. Pellets need to be chemically untreated wood from forest with FSC, PEFC or similar label.
BE	Royal Decree containing minimum requirements for small scale heating installations (Small Heating)	Minimum requirements for efficiency and emission levels of small scale heating systems operating on solid fuel.
BE	Flemish Green Power Certificates (FL_GSC)	Promotion of green electricity through a green certificate system (per MWh produced). Fossil energy needed for biomass production and transport is subtracted, as well as on-site electricity need. Electricity from (regional) wood resources is not eligible for green certificates if these can be used by the wood processing industry. Biomass from waste is not eligible if it has commercial value by recycling into materials such as fodder.
BE	Draft Flemish Green heat support system (FL_HS)	Draft promotion system for renewable heat. For the use of wood biomass and biomass from waste, the same feedstock restrictions apply as for the Flemish Green Power Certificates.
BE	Flemish Ecology Subsidy (FL_ES)	Subsidies for environmental-friendly investments in industry and SMEs. The amount of investment subsidy depends on the technology and size of the company. There are minimum efficiency requirements for biomass installations.
BE	Green certificate granting system in the Walloon Region (Wall_CV)	Promotion of green electricity through a green certificate system. The value of certificates is determined by the GHG savings compared to the best available technology for electricity (natural gas STAG, 55% efficiency) and heat production (natural gas boiler, 90% efficiency).
BE	Walloon subsidy scheme for wood boilers for residentials (Wall_BiolerSubs)	Grant for residential buildings, investing in an automatic biomass boiler of ≥ 50 kW_{th}. The scheme contains minimum efficiency requirements.

[2] AT: Austria, BE: Belgium, BG: Bulgaria, CY: Cyprus, CZ: Czech Republic, DE: Germany, DK: Denmark, EE: Estonia, ES: Spain, FI: Finland, FR: France, GR: Greece, HU: Hungary, IE: Ireland, IT: Italy, LT: Lithuania, LU: Luxembourg, LV: Latvia, MT: Malta, NL: Netherlands, PL: Poland, PT: Portugal, RO: Romania, SE: Sweden, SI: Slovenia, SK: Slovakia, UK: United Kingdom

BE	Green certificate granting system in Brussels (Bru_CV)	Promotion of green electricity through a green certificate system, based on GHG savings. Similar to the Walloon green certificate system.
CY	Law 170/2004, technical specifications of gaseous pollutants for unlicensed installations (170/2004).	Gaseous pollutants limitations from burning biomass and permission for burning dried olive shells and nut shells.
CZ	Ordinance 482/2005, amended by Ordinance 5/2007 Coll., stating which kinds of biomass and which ways of electricity production are subject to support for Act No. 180/2005 on the promotion of electricity production from renewable energy sources. (482/2005)	Green bonuses for renewable energy production. The ordinance states which kinds of biomass and which ways of electricity production are subject of support. The listed eligible biomass types are typical domestic sources such as residues and specific agricultural crops.
DE	German Renewable Energies Act (EEG)	The Act includes feed-in tariffs for electricity from renewable energy resources. There are bonuses for the use of cuttings from landscape preservation for CHP and heat use.
DE	Draft 2012 update of the German Renewable Energies Act (EEG-2012)	The draft update foresees higher payments for sustainable feedstocks with less competition in the usage (for instance, agricultural residues, cuttings from biotop management, intermediate crops). Additionally, short rotation coppices (SRC) are part of this category if sustainable cultivation criteria are fulfilled (for instance, no cultivation on grassland). Forest residues from PEFC and FSC certified forests get higher grants than other forest wood. Furthermore, the input of maize and cereal corn in biogas plants is limited to 50% of the energy content ("diversity factor").Waste wood and liquid biofuels are no longer eligible.
DE	Biomass Ordinance (BioV)	The ordinance defines biomass, technical procedures and environmental requirements in the scope of the EEG. Includes minimum efficiency requirements.
DE	Ordinance on requirements for small scale heating installations (OSSI)	The ordinance defines requirements for small scale heating installations concerning air pollution, efficiency ratios and heat storage capacity.
DE	Investment aid programme (MAP)	Investment aid programme for wood heating vessels (pellets, chips and cord firewood) and waste gas filter technology. Includes requirements for minimum efficiency and maximum emission levels.
DK	Agreement on Green Growth (Green Growth)	Long-term plan defining environment and nature policies and the agriculture industry’s growth conditions. This plan includes as a goal that up to 50% of livestock manure in Denmark can be used for green energy in 2020, promoting biogas production and stimulating the cultivation of perennial energy crops. This will create opportunities for the domestic agricultural sector.
DK	Law on electricity production subsidy and subsequent amendments (CHP)	The law defines electricity production subsidies. There is a surcharge for CHPs using wood chips, straw and biogas. The law only applies to CHP as an energy efficiency concern.
DK	Order on special support to farmers for the establishment of perennial energy crops (PEC)	Investment support for perennial energy crops. The order sets the priorities and conditions for obtaining support including which types of land can be used.
ES	Royal Decree 661/2007 defining the electricity market and tariffs (661/2007).	The Decree gives higher tariffs to biomass/biogas plants achieving higher energy efficiency through cogeneration provided that they reach a minimum electric conversion efficiency.

ES	Royal Decree 949/2009 establishing rules and grants for the promotion of anaerobic digestion (949/2009)	The decree establishes rules and grants for the promotion of anaerobic digestion to reduce GHG (methane) emissions from slurry and manure. Slurry or other animal wastes should be the predominant input.
ES	Royal Decree 430/2004 establishing emission limits for large plants (430/2004)	The decree allows for use of wastes from food processing industry and pulp/paper industry only if the produced heat is recovered and used in the production site, thus promoting higher energy conversion efficiency for such processes.
FI	National action plan for promoting energy from renewable sources (NREAP)	Summary of national policy on renewable energy. This plan sets out current and future (in progress) requirements for renewable energy. This includes energy subsidies for small scale use of wood in connection with the Sustainable Forestry Financing Act. There are 'heat premiums' for CHP installations using wood and biogas thereby promoting more energy efficiency installations.
FI	Act on the Financing of Sustainable Forestry (Sust. Forestry)	The Act defines the scope of application of the budget destined for the promotion of the sustainable management and use of forest in accordance with the Forest Act. It includes support of harvesting and forestry transport of timber sold for fuel as part of the management of young plantations.
FR	Grenelle Environnement, Fonds "Chaleur renouvelable" : Call for projects for renewable heat (BCIAT)	This regulation promotes the production of heat from biomass through a call for projects. Successful projects will receive subsidies. Some biomass types are excluded from support, for instance, those for which there is potential competition with food. Imported wood should come from sustainable production. For forestry biomass, the good practice guide related to forest residues in indicated forests must be followed; FSC and PEFC wood receives more points in the evaluation process; forests transport distance is criterion in the evaluation for a winning project. Minimum efficiency requirements are also included.
FR	Call for projects for biomass CHP (CRE)	This regulation promotes the production of CHP from biomass through a call for projects to receive subsidies. Certain biomass streams are excluded from support. Risk of competition is an evaluation criterion for the application. Local biomass is promoted and given bonus points in the evaluation process (depending on transport distance). Minimum efficiency requirements are also included.
FR	Grenelle Environnement I and II: fixed tariffs for renewable electricity (FITE)	This regulation obligates electricity distributors to buy renewable electricity at a fixed price. There is a bonus tariff for certain biomass types. Energy efficiency is used to calculate the tariff.
FR	Income Tax Credit on equipment for using renewable energy (ITC)	This regulation promotes the production of heat from biomass in the residential sector with an income tax credit. Includes minimum efficiency requirements.
FR	0% loan for investment in renewable and energy efficiency measures for private persons (Loan)	This regulation promotes the production of renewable energy in the residential sector. The producer of the renewable energy in the residential sector can ask for a 0% loan. Minimum efficiency requirements are included.
HU	Governmental Decrees on obligatory off-take and purchase price of electricity generated from waste, renewable energy sources, or from CHP (FIT)	Wood biomass used for electricity production has to come from sustainably managed forests and/or have a Forest Stewardship certificate. For arable crops, the supplier has the main responsibility to prove that the biomass cannot be used for human food consumption. For waste biomass, power plants have to possess a declaration from the Environment Authority that the waste cannot be used for purposes other than fuel. Minimum efficiency requirements are also included.

IE	Bioenergy Action Plan – Bioenergy Scheme for production of non-food crops (BES)	Grant support for the plantation of perennial biomass (willow and miscanthus). Land use for a particular crop/forest must be suitable for that particular use, while at the same time avoiding direct competition with food crops.
IT	Budget Law 2008, introducing different regimes for renewable electricity (BL2008)	This law introduces two different regimes for renewable electricity (green certificates and feed in tariff) and differentiates values for GC and FIT depending on different biomass sources. Local biomass (<70 km) is valued at a higher rate by applying a multiplication coefficient of 1.8 to the number of MWh produced.
IT	Ministerial Decree, guidelines for the authorisation procedure of renewable energy plants (RE-Aut)	Guidelines of the Ministry of Economic Development about authorisation procedures for renewable energy plants. Plants working in cogeneration are subject to an easier authorisation procedure.
IT	Transposition law of directive 2009/28/EC (RED_Transp)	Support mechanisms for renewable energy plants, including biogas, biomass and bioliquids. The law aims at prioritising the use of residual biomass from agriculture, forestry and animal breeding and sets minimum efficiency performances for biomass heating plants.
IT	Framework Environmental Law (Frame Env)	The Law defines the types of biomass that can be used in different conversion technologies and their respective emission limit requirements.
LU	Feed-in tariff for renewable electricity (FIT)	This regulation promotes the production of electricity from renewable sources (FIT, per MWh). The feed-in tariff is calculated with a formula that takes into consideration the type of biomass, the size of the installation and whether heat generated is used.
NL	Energy Investment Deduction Scheme (EIA)	The Energy Investment Deduction Scheme (EIA) stimulates investment in renewable energy or energy saving technologies via a profit tax deduction. To obtain the deduction, the invested technology has to meet requirements on issues such as efficiency that are listed in the scheme and updated annually.
NL	National Waste Management Plan (LAP)	The National Waste Management Plan (LAP) includes criteria on whether biomass is considered waste or not (yellow and white lists). If it is considered waste, stricter emission requirements apply.
NL	Decree on waste incineration (BVA)	The decree applies to emission standards for combustion plants that combust or co-combust waste streams that are on the "Yellow List" (see LAP).
NL	Decree on the use of manure (FERTI)	The decree defines a "positive list" of biomass streams for co-digestion. If materials are used that are not on the "Positive list", the co-digestate is considered waste and, for soil quality reasons is not allowed to be used as fertiliser. Furthermore, the SDE subsidy is only awarded to co-digestion when biomass streams are used that are on the positive list.
NL	Incentive Scheme for Sustainable Energy Production (SDE)	The SDE is an operating subsidy for the production of renewable electricity and gas. The scheme includes requirements on efficiency and emissions to obtain subsidies. While some of the SDE agreements will continue to run for the next few years, new applications will fall under the SDE+ system.
NL	Incentive Scheme for Sustainable Energy Production, (SDE+)	The SDE+ is the follow up policy to the SDE on stimulating the generation of sustainable energy in the Netherlands. Co-firing will be excluded from the SDE+, but may potentially be stimulated via alternative measures. Renewable heat will be included as an individual category from 2012 onwards. Efficient conversion is stimulated via a bonus on the use of heat from CHP plants.

NL	Decree on emission regulation mid-sized combustion plants (BEMS)	Emission limit values for mid-sized systems installed after 1 April 2010. Emission restrictions distinguish between fossil and biomass and between different biomass types.
PL	Draft decree on electricity and heat from renewable sources of the Ministry of Economy (draft CoO)	The draft decree was updated in 2011: for large installations (>5MW) roundwood is excluded from green certificates; in terms of wood biomass, only forestry residues are allowed and a minimum (increasing) share of agricultural biomass is required.
PT	Decree defining the legal framework for electricity from renewable energy and setting the feed-in tariffs (FIT)	Different coefficients are used depending on the type of biomass. There is a clear emphasis on residual forestry biomass and waste in general. Reference is made to energy use of biomass as a means to reduce the risk of forest fires.
SE	Ordinance 2003:120 on electricity certificates (OoEC)	The ordinance defines which types of biomass are eligible for electricity certificates. Some biomass types only receive certificates when burned in CHP.
SI	Regulation on support for the electricity generated from renewable energy sources (EE-CHP)	Power plants that use wood biomass from forest with FSC or PEFC are entitled to 10% higher referential costs (consequently allowing a higher subsidy).
SI	Regulation on support for the electricity generated in cogeneration with high efficiency (EE-RES)	CHPs which use woody biomass from forest with FSC or PEFC are entitled to10 % higher referential costs (consequently allowing a higher subsidy).
SK	Programme of the Ministry of Economy for higher utilisation of biomass boilers and solar energy for households (Boiler)	Financial support scheme aimed at increasing use of biomass installations for households. Includes efficiency and emission requirements.
UK	The Renewables Obligation Order, update 2011 (ROO2011)	The RO places an obligation on UK electricity suppliers to source an increasing proportion of their electricity from renewable sources. For electricity from biomass, from 2011, mandatory reporting is required that is consistent with the Renewable Energy Directive (>50kW), and from April 2013, generators of 1MW and above will need to meet the sustainability criteria, including a 60% GHG emission saving.
UK	Renewable Heat Incentive (RHI)	Scheme to provide long-term support for renewable heat technologies, from household solar thermal panels to industrial wood pellet boilers. For heat plants larger than $1MW_{th}$, it will be mandatory to report on sustainability, according to the Renewable Energy Directive requirements.
UK	Scottish Biomass Heat Scheme (SBHS)	The scheme includes support to install biomass heating, either at new premises or through retrofit of current premises. Operators need to report on CO_2 savings and source of feedstock. The scheme is meanwhile closed to new applicants.
UK	Bioenergy Capital Grants Scheme in England (BCGS)	The scheme supports biomass-fuelled heat and CHP projects in the industrial, commercial and community sectors in England. Operators need to report on the quantity of greenhouse gas emissions saved through using the biomass boiler instead of a fossil-fuelled one, given in tonnes of carbon dioxide equivalent per annum. The scheme is meanwhile closed to new applicants.
UK	The Energy Crops Scheme in England (ECS)	The scheme aims to increase the amount of energy crops grown in England, in appropriate locations. Applicants (farmers) need to present a map of the farm including the area of the energy crop plantation, according to guidelines provided. Planting is prohibited on permanent pasture and a variety of designated land types. Applications are encouraged for plantings on degraded land.

Table 6: Overview of policy instruments used in the different regulations

	AT_ÖSG	AT_UFG	AT_ÖN9466	BE_FL-GSC	BE_Wall-CV	BE_BRU-CV	BE_FL-ES	BE_FL_GH	BE_Wall-BSubs	BE_PelletNorm	BE_SmallHeat	CY_170/2004	CZ_482/2005	DE_EEG	DE_EEG_2012	DE_BioV	DE_OSSI	DE_MAP	DK_GrGrowth	DK_CHP	DK_PEC	ES_661/2007	ES_949/2009	ES_430/2004	FI_NREAP	FI_SustForest	FR_BCIAT	FR_CRE
Economic instruments																												
Grant/subsidy		X					X		X				X	X	X			X	X		X		X		X	X	X	
Tax credit/incentive																			X									
Feed-in tariff	X							X						X	X				X	X		X			X			X
Regulatory instr.																												
Restrictions/bans			X								X	X					X							X				
Quota obligation				C	C	C				X						X			X									
Other																												

	FR_FITE	FR_ITC	FR_LOAN	HU_FIT	IE_BES	IT_BL28	IT_Reaut	IT_REDTr	IT_Frame	LU_FIT	NL_EIA	NL_LAP	NL_BVA	NL_FERTI	NL_SDE	NL_SDE+	NL_BEMS	PL_draftCoO	PT_FIT	SE_OoEC	SI_EECHP	SI_EERES	SK_Boiler	UK_ROO2011	UK_RHI	UK_SBHS	UK_BCGS	UK_ECS
Economic instruments																												
Grant/subsidy					X										X	X							X		X	X	X	X
Tax credit/incentive		X						X			X																	
Feed-in tariff	X			X		C				X									X		X	X						
Regulatory instr.																												
Restrictions/bans									X				X	X			X	X										
Quota obligation	X			C														X		C				C				
Other							X					X																

Abbreviations: see Table 5 ; 'C' = combined with green certificates

Table 7: Overview of which market actors are directly responsible or indirectly affected in the different regulations

	AT_ÖSG	AT_UFG	AT_ÖN9466	BE_FL-GSC	BE_Wall-CV	BE_BRU-CV	BE_FL-ES	BE_FL_GH	BE_Wall-BSub	BE_PelletNorm	BE_SmallHeat	CY_170/2004	CZ_482/2005	DE_EEG	DE_EEG_-012	DE_BioV	DE_OSSI	DE_MAP	DK_GrGrowth	DK_CHP	DK_PEC	ES_661/2007	ES_949/2009	ES_430/2004	FI_NREAP	FI_SustForest	FR_BCIAT	FR_CRE
Biomass producers	i			i	i	i							i	i	i				i		R		R		i	R	i	i
Biomass industry and traders	i			i	i	i				R			i													i	i	i
Energy producers	R	R	R	R	R	R	R	R		i		R	R	R	R	R	R	R	R	R		R	R	R	R	i	R	R
End consumers									R	i	i						R	R										
Others			i				i		i		R						R	i										

	FR_FITE	FR_ITC	FR_LOAN	HU_FIT	IE_BES	IT_BL2008	IT_Reaut	IT_REDTr	IT_Frame	LU_FIT	NL_EIA	NL_LAP	NL_BVA	NL_FERTI	NL_SDE	NL_SDE+	NL_BEMS	PL_draftCoO	PT_FIT	SE_OoEC	SI_EECHP	SI_EERES	SK_Boiler	UK_ROO2011	UK_RHI	UK_SBHS	UK_BCGS	UK_ECS
Biomass producers	i			i	R			i	i	i		R		R				i	i		i	i	i	i	i	i		R
Biomass industry and traders	i			i	i			i	i	i				R							i	i	i	i	i	i		
Energy producers	R			R	i	R	R	R	R	R	R	i	R	i	R	R	R	R	R	R	R	R		R	R	R	R	i
End consumers		R	R																				R		R		R	
Others		i	i																				i					

R = directly responsible; i = indirectly affected ; Abbreviations: see Table 5

Table 8: Biomass resources for which the regulations are applicable

	AT_ÖSG	AT_UFG	AT_ÖN9466	BE_FL-GSC	BE_Wall-CV	BE_BRU-CV	BE_FL-ES	BE_FL_GH	BE_Wall-BSub	BE_PelletNorm	BE_SmallHeat	CY_170/2004	CZ_482/2005	DE_EEG	DE_EEG-2011	DE_BioV	DE_OSSI	DE_MAP	DK_GrGrowth	DK_CHP	DK_PEC	ES_661/2007	ES_949/2009	ES_430/2004	FI_NREAP	FI_SustForest	FR_BCIAT	FR_CRE
Direct supply of wood biomass from forests	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x
Indirect supply of wood biomass for energy	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x						x		x	x		x	x
Agricultural crops directly for energy	x	x		x	x	x	x	x	x			x	x	x	x	x	x		x		x	x	x				x	x
Agricultural byproducts /processed residues	x	x		x	x	x	x	x				x	x	x	x	x	x		x	x		x	x	x			x	x
Municipal solid waste	x	x		x	x	x	x	x						x	x	x						x					x	
Industrial waste	x	x		x	x	x	x	x					x	x	x	x						x		x			x	
Sewage sludge	x	x		x	x	x	x	x						x	x	x						x					x	

	FR_FITE	FR_ITC	FR_LOAN	HU_FIT	IE_BES	IT_BL2008	IT_Reaut	IT_REDTr	IT_Frame	LU_FIT	NL_EIA	NL_LAP	NL_BVA	NL_FERTI	NL_SDE	NL_SDE+	NL_BEMS	PL_draftCo	PT_FIT	SE_OoEC	SI_EECHP	SI_EERES	SK_Boiler	UK_RO2011	UK_RHI	UK_SBHS	UK_BCGS	UK_ECS
Direct supply of wood biomass from forests	x	x	x	x		x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Indirect supply of wood biomass for energy	x	x	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	
Agricultural crops directly for energy	x	x		x	x	x	x	x	x	x	x			x	x	x	x	x		x			x	x	x	x	x	x
Agricultural byproducts /processed residues	x	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x		x	x	x	x	
Municipal solid waste	x			x		x	x			x	x	x	x		x	x		x	x	x				x		x	x	
Industrial waste				x		x	x			x	x	x	x		x	x		x		x				x				
Sewage sludge				x		x	x			x	x	x	x		x	x		x		x				x				

Table 9: Sustainability regulations and life cycle phases

	AT_ÖSG	AT_UFG	AT_ÖN9466	BE_FL-GSC	BE_Wall-CV	BE_BRU-CV	BE_FL-ES	BE_FL_GH	BE_Wall-BSub	BE_PelletNorm	BE_SmallHeat	CY_170/2004	CZ_482/2005	DE_EEG	DE_EEG-2012	DE_BioV	DE_OSSI	DE_MAP	DK_GrGrowth	DK_CHP	DK_PEC	ES_661/2007	ES_949/2009	ES_430/2004	FI_NREAP	FI_SustForest	FR_BCIAT	FR_CRE
Biomass production/sourcing				x	x	x				x					x				x		x				x	x	x	x
Transformation/pre-treatment				x	x	x				x															x	x		
Transportation	x	x		x	x	x																					x	x
Conversion to energy	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x	x	x	x		x	x

	FR_FITE	FR_ITC	FR_LOAN	HU_FIT	IE_BES	IT_BL2008	IT_Reaut	IT_REDTr	IT_Frame	LU_FIT	NL_EIA	NL_LAP	NL_BVA	NL_FERTI	NL_SDE	NL_SDE+	NL_BEMS	PL_draftCoO	PT_FIT	SE_OoEC	SI_EECHP	SI_EERES	SK_Boiler	UK_ROO2011	UK_RHI	UK_SBHS	UK_BCGS	UK_ECS
Biomass production/sourcing	x			x	x			x						x							x	x		x	x	x		x
Transformation/pre-treatment	x											x												x	x	x		
Transportation						x		x																x	x	x		
Conversion to energy	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	

3 COMPARATIVE ANALYSIS OF NATIONAL REGULATIONS

3.1 Introduction

This chapter presents a comparative analysis of national sustainability regulations in order to identify whether there are synergies or conflicts amongst national approaches and whether MS have followed the EU recommendations.

The 56 regulations presented in chapter 2 can be classified according to the following biomass life cycle phases:

1. Biomass production: This includes regulations introducing requirements addressing the sustainability of production and transport of biomass feedstocks.
2. Biomass end use: These regulations include requirements addressing either the efficiency of biomass conversion into heat or power or the air quality emissions.
3. Life cycle greenhouse gas performance: This category includes regulations requiring GHG reporting based on the whole life cycle of biomass supply chains.

This classification will be used in the comparative analysis in the following sections. In section 3.2 (biomass production), section 3.3 (end use) and 3.4 (life cycle greenhouse gas performance), national regulations are compared against each other and, where possible, against the non-binding sustainability criteria laid down in the 2010 Biomass Report (see Box 2). Section 3.5 reviews the most relevant voluntary biomass sustainability schemes developed by industry and other stakeholders and compares them against the EU non-binding sustainability criteria. Section 3.6 summarizes and discusses the findings of this chapter.

Box 2: EU recommendations on sustainability of solid biomass and biogas

In the 2010 Biomass Report (COM(2010)11) the Commission recommends MS that either have or plan to introduce national sustainability criteria for solid and gaseous biomass used in electricity, heating and cooling, ensure that these in almost all respects are the same as those laid down for biofuels in the Renewable Energy Directive (2009/28/EC). These non-binding sustainability criteria include:

(a) a general prohibition on the use of biomass from land converted from forest, other high carbon stock areas and highly biodiversity areas;

(b) a common GHG calculation methodology which could be used to ensure that minimum greenhouse gas savings from biomass are at least 35% (rising to 50% in 2017 and 60% in 2018 for new installations) compared to the EU's fossil energy mix; the EU GHG methodology includes emissions from the conversion of the biomass fuel into electricity, heating and cooling.

It is also recommended not to apply sustainability criteria to wastes, as these must already fulfil environmental rules in accordance with waste legislation at national and at European level, and that the sustainability requirements should apply to energy producers larger than 1 MW thermal or 1 MW electrical capacity.

In addition to the above, the Commission recommended MS to:

- differentiate national support schemes in favour of installations that achieve high energy conversion efficiencies, and
- monitor the origin of biomass.

3.2 Regulations related to biomass production

As shown in Table 9, 24 regulations in 12 MS contain reference to biomass production. Table 10 lists the regulations addressing the environmental sustainability of biomass production.

Table 10: Regulations with reference to sustainable biomass production[3]

	Country / regulation	Aspects of environmental sustainability
Energy legislation		
BE	Minimum requirements for wood pellets (PelletNorm)	SFM precondition
BE	Green certificate granting system in the Walloon Region (Wall_CV)	Request of reporting if the wood is produced under SFM
FI	National renewable energy plan (NREAP)	Link to Forest Act to maintain biological diversity of the forests
FR	Fonds "Chaleur renouvelable" (BCIAT)	'Good practice guide' related to forest residues to be followed; advantage in project evaluation if SFM wood is used.
HU	Feed-in Tariff (FIT)	SFM precondition for electricity from wood biomass
PT	Feed-in Tariff (FIT)	Reference to forest management (to avoid fires)
SI	Support for CHP (EECHP)	Higher subsidies for CHPs using SFM wood
SI	Support for renewable electricity	Higher subsidies for electricity from SFM wood

[3] For more details on each regulation, see Table 5

	(EERES)	
UK	Renewables Obligation Order, update 2011 (ROO2011)	Reference to Renewable Energy Directive land use requirements (high biodiversity value, high carbon stock land)
UK	Renewable Heat Incentive (RHI)	Reference to Renewable Energy Directive land use requirements (high biodiversity value, high carbon stock land)
Forestry regulations		
FI	Act on the Financing of Sustainable Forestry (Sust. Forestry)	Promotion of felling of young stands for energy use in view of maintaining the biological diversity of forests.
Agriculture legislation		
DK	Order on special support to farmers for the establishment of perennial energy crops (PEC)	Land restrictions for perennial energy crop support
IE	Bioenergy Scheme for production of non-food crops (BES)	Land restrictions for non-food crop support
UK	Energy Crops Scheme (ECS)	Land restrictions for energy crop support
NL	Decree on the use of manure (FERTI)	Co-digestate from digestors on 'waste' biomass not allowed as fertiliser for soil quality reasons
Waste legislation		
NL	National Waste Management Plan (LAP)	Criteria on whether biomass is considered waste and for which stricter emission requirements apply

In terms of environmental sustainability requirements, the table above shows a very heterogeneous picture. It should be emphasised that, especially with respect to agricultural and forestry biomass, many sustainability criteria are likely included in other European and national regulations that have not been assessed here as they don't make a specific link with energy use. It seems that most MS rely on their existing agricultural and forestry regulations to address the sustainability of biomass production and harvesting, as far as domestic production is concerned. Issues related to biomass produced outside the EU are not addressed by these regulations.

In addition to regulations referring to environmental sustainability of biomass production, other regulations aim to promote or protect the economic sustainability of local actors in relation to the biomass. Two types of measures have been identified: a first group of regulations promotes the use of local biomass in energy applications with the view to create development opportunities for local actors and to minimize environmental impacts related to long transport chains; a second group limits certain feedstocks for energy applications with the aim to protect other existing economic sectors relying on these biomass streams (such as the wood processing industry).

Table 11 presents the regulations that explicitly promote the use of locally produced biomass feedstocks. They either focus on technologies which use biomass that is typically available locally or even put maximum distance requirements for eligibility to financial incentives, also with the view to reduce the risk of unwanted negative side effects associated with transporting biomass over long distances. These regulations mostly favour typically locally available biomass like wastes or agricultural residues. The conversion sector (energy producers) is primarily responsible for proving that the requirements have been met. Nevertheless biomass producers are clearly affected by these regulations, as well as other sectors relying on the same type of biomass.

Table 11: Regulations specifically promoting the use of local biomass for energy

	Country / rule	Aspect of economic sustainability
AT	Green electricity act (ÖSG)	Concept of feedstock supply: during application information should be supplied on feedstock supply from own agricultural production and forestry
AT	Environmental Measures Support Act (UFG)	Sustainability bonus for regional biomass
CZ	Regulation No. 482/2005 Coll	Green bonus for biomass electricity, focus on regionally available biomass
DK	Agreement on Green Growth	Specific focus on biogas from Danish livestock manure and perennial energy crops
ES	Royal Decree 949-2009	Rules and grants for the promotion of anaerobic digestion based on typical local feedstocks
FR	Fonds "Chaleur renouvelable" (BCIAT)	Call for projects: for forestry biomass, transport distance is a criterion in the evaluation for a winning project.
FR	Call for projects: CHP biomass (CRE)	Call for projects: local biomass is given bonus points in the evaluation process.
IT	Budget Law 2008 defining regimes for renewable electricity (BL2008)	Higher coefficients for Green Certificates for biomass supplied from local sources (< 70 km)
IT	Transposition law of directive 2009/28/EC	The law aims at prioritising the use of residual biomass from agriculture, forestry and animal breeding.
PL	Draft decree on renewable electricity (draftCoO)	Minimum ratio (increasing over time) for agricultural biomass to protect the economic sector relying on forest biomass and create opportunities for agriculture
PT	Framework for renewable electricity and Feed-in Tariffs (FIT)	Higher coefficients for typical local biomass, namely residual forestry and waste

Table 12 presents the five MS regulations that limit the use of certain feedstocks for bioenergy, with the aim of protecting existing (mostly wood) users, such as the wood processing industry, that rely on wood biomass input. Some sectors relying on biomass streams claim that their business is disturbed by the incentives given to the bioenergy sector. A number of countries have included wording in the legislation that competition should be avoided, whilst other countries specifically exclude certain streams for bioenergy. In the latter case, these regulations may have a significant impact on biomass for energy markets. This is already reflected in Belgium (Flanders), and is also anticipated for the draft Polish system.

Table 12: Regulations taking into account risk of competition with other sectors

	Country / rule	Aspect of economic sustainability
AT	Green electricity act (ÖSG)	Feed-in tariffs need to be set in a form such that feedstocks are not detracted from material utilisation or use as comestible goods.
BE	Flemish Green Power Certificates (FL-GSC)	Certain biomass types are excluded to protect the wood processing industry. Waste legislation determines which biomass can go to energy and which is excluded. The same conditions are taken over to the draft Flemish Green Heat support system.
FR	Call for projects: CHP biomass (CRE)	Risk of competition is an evaluation criterion for the application.
HU	Feed-in Tariff (FIT)	For waste a declaration is needed that it cannot be used from other purposes than fuel. For other biomass the seller has to prove that the biomass cannot be used for human food consumption.
PL	Draft decree on renewable electricity (draftCoO)	Updated proposal in the draft Decree: for large installations (>5MW_{el}) round wood is excluded from green certificates; in terms of wood biomass only forestry residues are allowed, and a minimum (increasing) share of agricultural biomass is required.

We conclude that the policies of the MS diverge to some extent: while some do promote the use of local biomass for energy, others exclude some (domestic) biomass from energy use in order to avoid competition with other sectors relying on these types of biomass, and may therefore indirectly promote imports of biomass for energy.

Comparison with the 2010 EU recommendations

In the following sections, the above mentioned regulations addressing biomass production will be compared against the biodiversity, carbon stock and degraded land requirements laid down in the 2010 Biomass Report.

Biodiversity protection

The 2010 Biomass Report refers to the Renewable Energy Directive (2009/28/EC) articles containing biodiversity protection requirements:

- Art 17(3) requires that raw material should not come from high biodiversity value areas;
- Art 17(6) requires that agricultural raw materials cultivated in the Community are obtained in accordance with specific agricultural regulations of the European Union[4].

In total, 13 regulations from Table 10 were assessed in chapter 2 to be related to biodiversity and ecosystem services. Several MS only indirectly cover biodiversity protection in energy legislation through the requirement or promotion of Sustainable Forest Management (SFM) certification (FSC or PEFC) of woody biomass. Only three — the Finnish Sustainable Forestry Financing Act, the UK Renewables Obligation Order 2011 and the UK Renewable Heat Incentive — specifically include a reference to biodiversity conservation. Only the UK regulations follow the Renewable Energy Directive requirements as suggested in the 2010 Biomass Report, specifically referring to high biodiversity grassland. The Finnish law lists a number of project types which can

[4] These rules refer to preservation of habitats, biodiversity, water management and use, and mitigating climate change among other issues regarding sustainability issues, along with cross-compliance from the Common Agricultural Policy (CAP).

receive financing for promoting the management and use of forests – harvesting of energy wood in connection with the tending of young stands is one of the categories[5]. Preservation of the biological diversity of the forests is one of the basic requirements. Criteria are however not further specified. Therefore, a comparison against the EU criteria is not possible.

National regulations in Belgium, France, Hungary and Slovenia refer to voluntary systems on sustainable forest management (SFM) (see Table 13). We present this overview here as well, as sustainable forestry systems also contain provisions to protect biodiversity, as shown in Table 14.

Box 3: SFM certification schemes

There are several small national sustainable forest certification systems, for instance, the UK Woodland Assurance Standard or the Austrian Forest Programme, but most systems fall either under the Programme for the Endorsement of Forest Certification schemes (PEFC) or the Forest Stewardship Council (FSC). PEFC is an umbrella organization, which works by endorsing national forest certification systems that are tailored to local priorities and conditions. PEFC works throughout the entire forest supply chain, offering a certification system with criteria for good practice in the forest and ecological, social and ethical standards. Any national certification system seeking to obtain PEFC endorsement or re-endorsement is subjected to an assessment process, including independent evaluation and public consultation. FSC is an independent, non-governmental, not-for-profit organization established in 1993 to promote the responsible management of the world's forests. It is an international association of members consisting of a diverse group of representatives from environmental and social groups, the timber trade and the forestry profession, indigenous people's organizations, responsible corporations, community forestry groups and forest product certification organizations from around the world. FSC works with national initiatives to promote FSC in their country and to support the development of national or sub-national standards.

In 2009, 45% of the forest area in Europe was certified by either PEFC (58 Mha) or FSC (188 Mha) (Martikainen and van Dam, 2010). On a country level, certified forest areas ranges from 0.6% in Greece to 100% in Austria in 2009. Countries that include only PEFC-certified areas are Austria, Finland and Norway (harvest) and countries that include only FSC certified areas are Hungary, Ireland, Poland, the Baltic states, the Netherlands, Slovenia, Romania and the UK (Martikainen and van Dam, 2010). Wood fuels as such are not defined in the international FSC standard or PEFC Terms and Definitions and also on a national level, wood fuels are rarely defined in forestry standards (Stupak *et al* 2011). However, the revised Finnish Forest Certification System (FFCS), recognised by PEFC, now covers questions on energy wood harvesting (van Dam *et al* 2010).

The Belgian regulations (BE_Wall-CV and BE_Pelletnorm) require reporting or proof of sustainable forest management and stimulate FSC or PEFC certification (see the text box for a short description of these systems). The French FR_BCIAT provides grants to biomass heating projects and includes proof of sustainable forest management as an evaluation criterion to select winning projects. The Slovenian SI_EE_CHP and SI_EE_RES stimulate the use of certified forestry products by providing higher subsidies (10%).

[5] Act on the Financing of Sustainable Forestry, http://www.finlex.fi/fi/laki/kaannokset/1996/en19961094.pdf

Table 13: Regulations that are linked to voluntary schemes for sustainable forest management

MS	Regulation	SFM reference
BE	Green certificate granting system in the Walloon Region (Wall-CV)	Request to report if the wood was produced under SFM, but no consequences if operators fail to do so.
BE	Wood pellets (PelletNorm)	There is a strict precondition that the wood pellets are produced from material produced under SFM (for instance, FSC, PEFC or equivalent).
FR	Fonds "Chaleur renouvelable" (BCIAT)	For forestry biomass, sustainable forestry management (through FSC, PEFC) is a criterion in the evaluation for a winning project.
HU	Feed-in Tariff (FIT)	Biomass used for electricity production has to come from sustainably managed forests and/or to have a Forest Stewardship certificate
SI	Support for CHP (EECHP)	CHPs which use of wood biomass from forest with FSC, PEFC are entitled to 10 % higher referential costs
SI	Support for renewable electricity (EERES)	Power plants which use wood biomass from forest with FSC, PEFC are entitled to 10% higher referential costs

In principle, comparing the voluntary forestry certification systems in detail goes beyond the scope of this study. However, some of the national or regional sustainable forestry systems have already been compared to the Renewable Energy Directive (2009/28/EC) criteria by others. Van Dam *et al* (2010) compares, amongst others, the FSC and the Finish Forest Certification System (recognized by PEFC) to the Renewable Energy Directive. Also other studies compare FSC and PEFC standards to each other and/or the Renewable Energy Directive (BTG, 2008; Martikainen and van Dam, 2010; Scarlat and Dallemand, 2011). A comparison of criteria and indicators in national, regional and global sustainable forest management systems is provided in Stupak *et al* (2011).

Table 14 presents a comparison of sustainability criteria in the Renewable Energy Directive and the FSC and PEFC sustainable forest management certification standards. For a specific comparison of how biodiversity is covered in PEFC, FSC and two other voluntary systems, we refer to Appendix II.

Table 14: Comparison of sustainability criteria in the Renewable Energy Directive and the FSC and PEFC sustainable forest management certification standards[6]

Criteria	Renewable Energy Directive	FSC	PEFC (based on FFSC)
GHG emissions	Article 17.2: The greenhouse gas saving from the use of biofuels and bioliquids shall be at least 35% (increasing to 50% in 2017 and 60% in 2018 for installations where production starts after 1 January 2017).	Not included	Principle not included, but a positive carbon balance is required in a period of 5 years and forest should be preserved as healthy carbon sinks.
Biodiversity	Article 17.3: Biofuels shall not be made from raw material obtained from land with high biodiversity value, namely land that had one of the following statuses in or after January 2008, whether or not the land continues to have the status:	Reference date for plantations: November 1994, plantations converted from natural forest areas after this period do not qualify for certification	Principle not included
	- Primary forest and other wooded land (no clearly visible indication of human activity and the ecological processes are not significantly disturbed)	Included: forest conversion to plantation or non-forest land uses shall not occur	Included: typical features of valuable habitats shall (be) preserved
	- Areas designated by law or by the relevant competent authority for nature protection purposes	Included: forest management shall respect all applicable laws of the countries in which they occur	Included: conservation value of the protected areas or areas belonging to Natura 2000 network shall not be deteriorated by forestry measures
	- For the protection of rare, threatened or endangered ecosystems or species recognised by international agreements	Included: in signatory countries, the provisions of all binding international agreements such as CITES, ILO conventions, ITTA, and Conventions on Biological Diversity, shall be respected	Included: known habitats of endangered species shall be safeguarded
	- Highly biodiverse grassland	Not covered, FSC only refers to forests, however some criteria also cover grasslands	Not covered, PEFC only refers to forests, however some criteria also cover grasslands
Carbon stock	Article 17.4: Biofuels and bioliquids shall not be made from raw material obtained from land with high carbon stock, namely land that had one of the following statuses in January 2008 and no longer has that status:	Principle not included	Principle not included
	- Wetlands, namely land that is covered with or saturated by water permanently or for a significant part of the year	Not included	Not included
	- Continuously forested areas (more than one hectare with trees higher than five metres and a canopy cover more than 30%)	No forest conversion to plantations, reference date: November 1994	Not included
	- Land spanning more than one hectare with trees higher than five metres and a canopy cover of between 10% and 30%		
	Article 17.5: Biofuels and bioliquids shall not be made from raw materials obtained from land that was peatland in January 2008, unless evidence is provided that the cultivation and harvesting of that raw material does not involve drainage of the previous undrained soil	Not included	Included, but without reference date.
Soil, water and air	Cross-compliance with rules of the Common Agricultural Policy should provide assurance of compliance with a set of environmental impacts on soil, water and air for production in the EU (Scarlat and Dallemand, 2011)	Beyond the scope of this study	Beyond the scope of this study

[6] adapted from Martikainen and van Dam, 2010

In conclusion, only three regulatory instruments (UK_ROO2011, UK-RHI, FIN-SustForestry) refer specifically to biodiversity conservation. Several other MS (indirectly) consider biodiversity in the regulations linked to forest management, mainly through certification (FSC or PEFC) that remains voluntary. The Common Agriculture Policy also considers biodiversity, but the amount and detail of the regulations vary from one MS to another. We conclude that very few national energy regulations explicitly address the risks posed to biodiversity by biomass harvesting. However, it should be noted that these risks may be also addressed through general forestry or agriculture regulations whose assessment fell outside the scope of this study.

Carbon stock

The Renewable Energy Directive identifies lands with high carbon stock (Art 17. 4 and 17.5), from which raw material for biofuels and bioliquids shall not be obtained, including:

- wetlands, namely land that is covered with or saturated by water permanently or for a significant part of the year,
- certain forested areas, including forested areas (more than one hectare with threes higher than five metres and with a canopy cover of 30% or more) and land spanning more than one hectare with three higher than five metres and a canopy cover between 10 and 30%,
- certain types of peatland, including peatland that has not previously been drained to any extent.

As shown in Table 15, only the UK Renewables Obligation Order 2011 (ROO2011) and Renewable Heat Incentive (RHI) have an explicit reference to carbon-rich land types as defined in the Renewable Energy Directive. The land criteria listed in 'Schedule A2' of the ROO2011 includes all land types mentioned in Art 17.3 and 17.4 of the Renewable Energy Directive as not being permitted sources for cultivation of biomass in the ROO2011. While from 2011, only a well-founded report is required for installations larger than 50kW$_e$, from 2013, generators of 1MW$_e$ and above will need to meet the sustainability criteria.

This staged approach will also be considered by the Renewable Heat Incentive (RHI): after an initial period of mandatory sustainability reporting, mandatory criteria will be introduced, probably starting also from 2013[7], following other renewable financial incentive schemes and their requirements, particularly the Renewables Obligation. From 2011, biomass installations with a capacity of 1 MW$_{th}$ and above and all producers of biomethane will be required to report quarterly on the sustainability of their biomass feedstock. This requirement will apply to both feedstock sourced in the UK and imported from abroad. Smaller players will be exempted from this reporting requirement.

As can be observed in Table 15, with the exception of the UK systems, the other regulations analyzed allow the extraction of biomass in forest and wooded land as long as good practices are followed or a certification of sustainable forest management system is available. However, as shown in Table 14, the existing SFM systems do not cover wetlands, and only partially cover the other protected land types. We therefore conclude that current SFM systems do not comprehensively protect lands with high carbon stocks. We also conclude that currently, very few national regulations explicitly protect areas of high carbon stock.

[7] Impact Assessment – Renewable Heat Incentive. http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/policy/incentive/incentive.aspx

Table 15: Benchmarking legislation with a direct or indirect link to carbon stock changes.

MS	Regulation	Identification of carbon stock as sustainability criterion	Forest	Wooded land	Wetland/ Peatland	Prohibition extraction of biomass in these areas (with excepted cases for wooded land)	Control regulated by Law or Vol. Certificate	Baseline date	Comments
BE	Green certificate granting system in the Walloon Region (Wall_CV)	N	Y	Y	N	N	Voluntary Certificate	N	Request to report if the wood was produced under SFM, but no consequences if operators fail to do so.
BE	Minimum requirements for wood pellets for use in non-industrial heating installations (PelletNorm)	N	Y	Y	N	N	Law	N	FSC, PEFC or equivalent is required for wood pellets
FR	Call for projects, renewable heat (BCIAT)	N	Y	Y	N	N	Voluntary Certificate	N	For forestry biomass, it is required to follow the good practice guide for leaving enough forest residues in indicated forests. FSC and PEFC wood receive more points in the project evaluation process.
HU	Gov Decree on obligatory off-take and purchase price of electricity generated from waste, RES or CHP (FIT)	N	Y	Y	N	N	Law	N	Woody biomass has to come from sustainable forest management and/or FSC
UK	Renewable Heat Incentive (RHI)	N	Y	Y	Y	Y	Law	Y	Reporting requirement on sustainability according to the Renewable Energy Directive, for heat plants larger than 1MWth.
UK	The Renewables Obligation Order 2011 (ROO2011)	N	Y	Y	Y	Y	Law	Y	Reporting requirement from 2011 according to the Renewable Energy Directive for installations >50kW. Sustainability criteria need to be met from April 2013 for generators >1MW

Restoration of degraded lands

The Renewable Energy Directive (Annex C No. 9a) defines 'severely degraded land' as land that for a significant period of time, has either been significantly salinated or has significantly low organic matter content and has been severely eroded. 'Heavily contaminated land' means land that is unfit for the cultivation of food and feed due to soil contamination.

There is no national rule or legislation that includes this criterion. The English Energy Crops Scheme (ECS) mentions the restoration of degraded or contaminated land, but in fact, does not cover any incentives for cultivation of energy crops on those land types. We conclude that this topic has (thus far) not been high on national policy makers' lists of priorities for the sustainable production of biomass.

3.3 Regulations regarding biomass end use

The vast majority of the national sustainability regulations promote better end use efficiency or define specific air quality emission limits. These regulations only deal with the conversion process itself (and the energy producer) and generally do not make a distinction between biomass types. The sector of biomass installation manufacturers is an important affected stakeholder. The actual limits of efficiency and emissions will be discussed further on in sections 3.3.1 and 3.3.2.

Table 16 provides an overview of the 34 regulations that target end use.

It seems that these types of restrictions for biomass installations — either to be entitled to receive subsidies or actual requirements to get a license — are used quite commonly among the MS. Sometimes it is difficult to determine whether these regulations are specifically valid for biomass installations or also valid for fossil or non-biomass waste fuelled installations (for instance, for emission regulation, often also linked to European regulation).

A specific remark for small scale heating installations has to be made. While there are currently national standards setting out minimum standards for these types of heating systems, a preparatory study on Solid Fuel Small Combustion Installations is being carried out for the European Commission in the context of the Framework Directive on Ecodesign of Energy using Products (EuP) (2005/32/EC)[8]. The idea is to evolve to EU-wide minimum standards for small scale heating systems that will supersede national regulations. Work is still going on and is unlikely to be finalised in 2011. National requirements for small scale installations were therefore still included in the analysis.

Table 16: Regulations containing specific end use requirements for biomass installations (efficiency and/or emissions)

	Country / rule	Efficiency requirements	Limits on air pollutants
In connection to energy legislation			
AT	Green Electricity Act, Feed-in tariff (ÖSG)	X	X
AT	Environmental Measures Support Act, investment subsidies for renewable energy systems (UFG)		X

[8] www.ecosolidfuel.org

BE	Flemish Ecology Subsidy (FL-ES)	X	
BE	Walloon subsidy scheme for wood boilers for residential (Wall-BoilerSub)	X	
DE	German renewable energies act (extra payment for CHP and heat use) (EEG)	X	
DE	Biomass ordinance, technical procedures and environmental requirements for electric power generation from biomass (BioV)	X	X
DE	Investment aid programme for wood vessels (MAP)	X	X
DK	Act on Heat Supply, Proclamation of the law on electricity production subsidy and subsequent amendments (Feed-in tariff only applies to CHP) (GreenGrowth)	X	
ES	Royal Decree 661/2007 defining the electricity market and tariffs	X	
FR	Grenelle Environnement: Fonds "Chaleur renouvelable" Biomasse Chaleur Industrie, Agriculture et Tertiaire. Subsidy scheme for biomass heat systems in a call system. (BCIAT)	X	X
FR	Call for projects: CHP biomass. Subsidy per MWh through a call system. (CRE)	X	
FR	Grenelle Environnement I and II: Fixed tariffs for renewable electricity (FITE)	X	
FR	Income Tax Credit on equipment for using renewable energy (ITC)	X	
FR	0% loan for investment in renewable energy and energy efficiency measures for private persons (LOAN)	X	
HU	Government Decree No 389/2007 (XII.23), amended by Decree Nr. 287/2008 on obligatory off-take and purchase price of electricity generated from waste, from RES, or from CHP. (FIT)	X	
IT	Guidelines about authorization procedures for renewable energy plants. Simplified procedure for CHP plants. (RE-aut)	X	
IT	Draft transposition law of the EC Directive 28/2009, defining the support mechanism for RE plants (REDTr)	X	
LU	Feed-in tariff for renewable electricity (heat use extra rewarded) (FIT)	X	
NL	Energy Investment Deduction Scheme (EIA)	X	
NL	Incentive Scheme for Sustainable Energy Production (SDE)	X	X
NL	Incentive Scheme for Sustainable Energy Production Plus (SDE+)	X	X
SE	Ordinance (2003:120) on electricity certificates; some biomass types only receive certificates when burned in CHP (OoEO)	X	
SK	Program for higher utilization of biomass boilers and solar energy for households (Boiler)	X	X
UK	Renewable Heat Incentive (RHI)		X

UK	Scottish Biomass heat scheme (SBHS)		X
UK	Bio energy Capital Grants Scheme (BCGS)	X	
In connection to environmental legislation			
AT	Emission legislation for boilers, linked with ÖNORM M 9466.		X
BE	Royal Decree 2010-3943 for small scale heating installations (product norm)	X	X
CY	Law 170/2004, Gaseous pollutants limitations from burning biomass		X
DE	Ordinance on requirements for small scale heating installations (OSSI)	X	X
ES	Royal Decree 430/2004 establishing emission limits for large plants		X
IT	framework environmental law, incl. section defining the characteristics of biomass and the conditions for its energy use (Frame)		X
NL	Decree waste incineration (BVA)		X
NL	Decree on emission regulation mid-sized combustion plants (BEMS)		X

3.3.1 End-use energy efficiency

The amount of final energy produced per unit of primary biomass is considered in half of the regulations included in this study (29/56). Most of these regulations focus on end-use and have minimum efficiency requirements to obtain grants or subsidies. Other regulations stimulate high conversion efficiencies via bonuses or restrictions for heat recovery (for instance, CHP) or via efficiency dependent subsidies. Some regulations also incorporate the energy requirements for pre-treatment and/or transport and logistics stimulating the use of local biomass.

This section compares the regulations that include minimum efficiency requirements for heat (Table 17), electricity and CHP (Table 18) or stimulate efficiency improvements via economic incentives or restrictions on heat recovery (Table 19).

The efficiency requirements for heat range from 65% (BE, Royal Decree 210-3943) to 89% (DE_MAP) depending on the type of technology and feedstock used and the policy phase. The majority of these regulations are targeted to residential use of boilers/heating systems, but also industry and small to medium enterprises (SMEs) in Belgium and France need to meet minimum efficiency requirements to obtain grants or subsidies for biomass heating. In the specific case of Belgium, minimum efficiency and maximum emission levels are defined for small heating installations (BE_SmallHeating). At the European level, under the eco-design for energy-using products directive (Directive 2009/125/EC), common efficiency and environmental performance standards are being developed for household boilers[9]. The improvement options (product cases) range from 79% (advanced cooker) to 92% (pellet stove or boiler) compared to the base cases of 70% for the cooker and 88% for the pellet stove or boiler. These are above the minimum efficiency requirements in phase III (2016) of the BE_SmallHeating

[9] http://www.ecosolidfuel.org/docs/Base-Case_Datasheets.pdf

(75% for a boiler and 85% for a pellet stove or boiler) and do therefore not conflict with each other.

Table 17: Regulations including minimum efficiency requirements for biomass heating plants

Country/rule		System and/or target group	Criteria	Type of rule
BE	FL-ES	Industry and SMEs	$\eta_{e+h} \geq 80\%$	Financial (investment subsidy)
BE	BE Wall BoilerSubs	Boiler size ≥50 kW_{th} in residential buildings	$\eta_h \geq 80\%$	Financial (grant for investment)
BE	BE_SmallHeating	Small scale heating systems (stoves, boilers) for households	Open fireplace, phase I: $\eta_h \geq 65\%$ Pellet stove, phase III: $\eta_h \geq 85\%$	Restriction (product normation on minimum efficiencies)
DE	OSSI	Small scale heating (<500 kW_{th})	heat storage capacity (55 l/kWh)	Restriction
DE	MAP	Wood heating vessels (pellets, chips and cord firewood) and waste gas filter technology	$\eta_h \geq 89\%$	Financial (Grant/subsidy)
FR	FR-ITC	Heating and cooling from biomass in the residential sector (households)	Auto boilers: $\eta_h \geq 85\%$ Manual boilers: $\eta_h \geq 80\%$ Other heating: $\eta_h \geq 70\%$	Financial (Tax credit)
FR	FR-LOAN	Residential sector/households	$\eta_h \geq 70\%$	Financial (0% loan)
FR	BCIAT	Heat systems > 1000 toe/yr, some cases for cooling	$\eta_h \geq 85\%$	Financial (subsidy scheme). Minimum efficiency requirements, transport distance and alternative transport are considered in the project selection.
IT	RED_TRANSP		$\eta_h \geq 85\%$	Financial (Tax credit)
SK	Boiler	Biomass boilers for households	$\eta_h \geq 84\%$	Financial (subsidy scheme)

Table 18 depicts the minimum efficiency requirements for electricity generation and CHP. Most of these regulations include minimum efficiency requirements that have to be met to obtain financial support in the form of Feed-In Tariffs (AT_ÖSG, DE_BioV, ES_661_07, HU_FIT) or subsidy support per MWh produced (NL_SDE, NL_SDE+ and FR_CRE). For the Dutch NL_SDE+ regulations the details are still unknown. The NL_EIA is an investment support system allowing for profit tax deduction for, amongst others, investments in efficient biomass heating and electricity generation systems.
In the 2010 Biomass Report, the Commission recommends similar efficiency requirements for fossil and biomass plants to avoid the risk of switching to fossil fuels; however, financial support is only provided if biomass is used as an energy carrier in these regulations.

For CHP plants, similar requirements for combined efficiencies of 60% were found in AT_ÖSG, FR_CRE and NL_EIA. For electricity generation plants, the highest electric efficiency requirements are included in the HU_FIT for biogas units (35%) or 40% in case of biogas co-firing[10]. We observe that when comparing these efficiency requirements to typical values for biogas plants, the minimum efficiency requirements in the HU_FIT are rather ambitious. The IEA (ETP 2008) estimates typical efficiencies for anaerobic digestion plants <10MW$_e$ of 10-15% (60-70% for heat).

Table 18: Regulations that include minimum efficiency requirements for biomass electricity and CHP plants

Country/rule		Scope				Criteria	Type of rule
		System			System and/or target group		
		EL	CHP	H&C			
AT	ÖSG	X	X			$\eta_{e+h} \geq 60\%$ (can only be achieved through CHP)	Financial (FIT)
DE	BioV	X			Max. 20 MW$_e$	5-10 MW: $\eta_e \geq$ 25% 10-15 MW: $\eta_e \geq$ 27% 15-20 MW: $\eta_e \geq$ 29%	Obligation (technical procedures and environmental requirements in scope of the EEG)
DE	EEG	X	X			Minimum electrical efficiency factors, minimum heat use and positive list of heat use from gas conditioning	Financial (FIT). Extra Payment for CHP and heat use
ES	RD-661_07	X	X		Max. 50 MW$_e$, distinction in tariff setting below and above 2 MW (biomass), and below and above 500 kW (biogas)	< 5 MW: $\eta_e \geq 18\%$ 5-10 MW: $\eta_e \geq 20\%$ 10-20 MW: $\eta_e \geq 22\%$ 20-50 MW: $\eta_e \geq 24\%$	Financial (FIT with higher tariffs to biomass/biogas plants achieving higher energy efficiency through CHP)
FR	CRE		X		CHP, or combined with generation of second generation biofuels,>12 MW$_e$	$\eta_{e+h} \geq 60\%$	Financial (subsidy support per MWh electricity produced). Transport distance and alternative transport are considered in the project selection.
HU	FIT	X	X		Max. capacity: <20 MW$_e$ or <50 MW$_e$ + heat produced through CHP used for district heating	Biomass solid: $\eta_e \geq 30\%$ Co-firing (biomass + fossil): $\eta_e \geq 32\%$ Biogas<500 kW$_e$: $\eta_e \geq 32\%$ Biogas>500 kW$_e$: $\eta_e \geq 35\%$ Biogas co-firing: $\eta_e \geq 40\%$	Financial (FIT, obligation for distributors to buy renewable electricity and feed-in tariff)
NL	EIA		X	X	Excluding private owners and non-profit organizations.	CHP: $\eta_{e+h} \geq 80\%$ Waste: $\eta_{e+h} \geq 55\%$ Biomass: $\eta_{e+h} \geq 60\%$ Biomass heat: $\eta_h \geq 80\%$	Financial (tax credit, 44% tax deduction from the fiscal profit)
NL	SDE	X	X	X	Stand-alone biomass, but excluding co-firing	MSW combustion: $\eta e \geq 22\%$, higher efficiencies get higher subsidies	Financial (subsidy scheme)
NL	SDE+	X	X	X	Excluding co-firing		Financial (subsidy scheme)

[10] The HU_FIT system is under revision and the new system is expected by July 2011. Major changes are expected in the new system (incentives, tariffs, differentiation and structure).

The regulations that do not ascribe minimum efficiency requirements, but stimulate more efficient generation of electricity (and heat) are set out in Table 19. The BE_FL_GSC links the green electricity certificates to the full system chain[11] efficiency, including transport and pre-treatment of biomass. By contrast, the FR_FITE links the system efficiency to the feed-in tariff and provides additional bonuses for certain feedstock types such as last category wood. Other systems included stimulate the use of CHP via a premium for heat production (FI_NREAP, LU_ELEC_FIT) or restrict the use of certain feedstocks such as waste (ES_RD430/2004) or peat (SE_OoEC) to systems with heat recovery only.

[11] Other systems that (indirectly) stimulate reduced energy requirements for transport via the stimulation of local biomass use are discussed in section 3.2.

Table 19: Regulations that stimulate higher efficiencies with economic incentives or restrictions on heat recovery/use

Country/rule		Scope				Criteria	Type of rule
		System			System and/or target group		
		EL	CHP	H&C			
BE	FL-GSC	X	X				Obligation (to deliver an amount of GSC to the regulating authority) and assignment of certificates (including energy audit of transport and pretreatment).
DK	CHP		X		CHPs using biogas, straw and wood chips.	No specific rules for feedstock sustainability or requirements for installations.	Financial (FIT)
FR	FITE	X			Electricity producers		Financial (FIT). The tariff is related to the efficiency plus a bonus if certain feedstocks are used.
FI	NREAP	X	X	X	Electricity generation from wood chips and biogas CHP, new plants of <3 MW_e and an input of 20 MW_{th}		Financial (FIT with supplemented premium for heat production from CHP)
IT	RE-Aut	X	X		Stimulation of CHP (biomass/biogas)		Guidelines to regional/local administration with simplified authorisation procedure for cogeneration plants
LU	ELEC_FIT	X	X				Financial (FIT with bonus incentive if the heat of the electricity installation is used).
ES	430/2004			X	Waste combustion from food processing industry and pulp/paper industry, refers only to plants > 50 MW_{th}	Only allowed if heat is recovered.	Restriction (feedstock)
SE	OoEC	X	X		Peat and biomass combustion	Some biomass types only receive certificates when burned in CHP	Assignment of certificates (feedstock criteria)

Comparison with 2010 EU recommendations

In its 2010 Biomass Report, the Commission recommended that MS should differentiate their support schemes in favour of installations that achieve high energy conversion efficiencies, such as high efficiency cogeneration plants as defined under the Cogeneration Directive (2004/08EC). Based on the findings presented above, we conclude that, at present, this is partially the case. Quite a large number of European MS (13) have implemented such regulations, either requiring mandatory minimum efficiencies for the production of heat, electricity or both, or providing financial incentives to stimulate higher efficiencies or heat recovery. Ranges of minimum efficiencies required range somewhat between the individual legislations. This may be linked to different types of biomass feedstock and technologies used and the varying policy ambition level. While a large number of regulations focus on end use efficiency, they are often only aiming at a specific technology (both in terms of size, and output of heat and/or electricity). Finally, the vast majority of regulations are found in the EU-15; almost no regulations referring to end use efficiency of bioenergy installations are present in the new MS.

3.3.2 Air protection

The types of criteria for air protection implemented in the regulations that focus on end use, can be divided into rules that include emission limit values (ELVs) (for instance, CO, NO_x, SO_2 or dust (PM)), and regulations that include feedstock quality requirements such as chemical characteristics (such as heavy metals, chlorine content) to avoid emissions to air. As the Renewable Energy Directive does not cover end use criteria on air protection, the regulations of the MS that include criteria on air protection (21) are compared to each other. Systems ≥50 MW_{th} and waste combustion plants[12] are also covered by ELVs set by the European Commission. To the best of our knowledge, systems smaller than 50 MW thermal input that do not combust waste are not covered by the European directives on emissions to air[13].

The regulations shown in Table 20 mainly cover emission limit values (ELV) for small scale heating systems, including, amongst others, dust (PM) and CO. These ELVs are mostly specific per system. For example, the ELV for dust in the BE_SmallHeating ranges from 30 mg/Nm^3 for a pellet boiler to 300 mg/Nm^3 for an open fire place.

Medium size combustion plants that are not covered by EU legislation (<50 MW_{th}) are covered by the NL_BEMS in the Netherlands and the UK_RHI in the UK. The NL_BEMS applies to installations between 1 MW_{th} and 50 MW_{th}. The UK_RHI applies to installations between 20 and 50 MW_{th} and sets, similar to the NL_BEMS, strict ELVs.

[12] The European Commission sets emission limit values (ELVs) for stationary sources. Specific to combustion plants, these include the Large Combustion Plants Directive (LCP) (2001/80/EC) and the IPPC (Integrated Pollution Prevention Control 2008/01/EC) and the Waste Incineration Directive (2000/76/EC) for waste combustion. The LCP Directive and IPPC apply to combustion plants ≥50 MW thermal input and set emission limits to SO_2, NO_x and PM. The Waste Incineration Directive sets emission limit values to NO_x, SO_2, HCl, HF, heavy metals, dioxins and furans for installations of over 3 tonnes per hour. Furthermore, it includes restrictions to releases to water from emission control processes (http://ec.europa.eu/environment/air/review_air_policy.htm).

[13] This could potentially be a gap in the European context that needs to be addressed by individual national regulations. However, we were so far unable to confirm this with experts.

Table 20: Regulations including emission limit values (ELV) and/or emission control requirements

Country/rule		System			Remarks	Emission types
		EL	CHP	H&C		
AT	ÖSG	x	x			Respirable dust
AT	UFG				Large biomass firing (systems>400 kW)	PM, NO_x
AT	ÖNORM M 9466			X		PM, NO_x
BE	SmallHeating			X	Small scale heating systems (stoves, boilers) for households	PM, CO
CY	Law 170/2004			X	Small and medium size furnaces burning wood biomass.	PM, CO
DE	EEG				Small scale CHP	
DE	OSSI			X	Small scale installations	PM, CO
DE	MAP			X	Investment aid program with ELVs and vessel and waste gas filter requirements	PM, CO
ES	RD-430/2004	X	X		Large plants > 5 MW_{th} burning biomass	
FR	BCIAT			X	Only for heating, some cases for cooling too, dependent on the efficiency.	PM (stricter for biomass)
IT	RED_TRANSP	X		X		Formaldehyde, radioactivity
IT	Framework Env			X	Limits for biomass plants and residential heating units	VOC, NO_x and SO_x
NL	BVA	X	X	X		
NL	SDE	X	X	X	Stand-alone biomass, excluding co-firing	VOC, SO_x, NO_x (IPPC BREF)
NL	BEMS	X	X	X	Installations of ≥ 1 MW_n (nominal), <50 MW	NO_x, SO_2, C_xH_y, PM
SK	Boiler			X	Biomass boilers for households	
UK	RHI	X	X	X	Strict ELVs for installations of 20-50 MW_{th} input. Large-scale installations (>50 MW_{th} input) fall under IPPC.	
UK	SBHS			X	Biomass heating systems for SMEs	Air quality management (according to regulations)

To illustrate potential issues that can arise from differences in ELVs on national levels, the ELVs for NO_x from biogas piston engine systems are depicted in Table 21 for the Netherlands (NL_BEMS) and Germany (TA Luft). For systems <3 MW_{th}, biogas engines are allowed to emit more than twice as much NO_x in Germany compared to similar biogas engines in the Netherlands. Due to the limited size of the market for biogas engines in the Netherlands, most installations are imported from Germany and Austria and these are not optimized to the emission requirements of the Netherlands. Therefore, end-of-pipe options such as selective catalytic reduction (SCR) are required to meet the standards set for the Netherlands (Meddeler *et al* 2010). Meddeler *et al* estimated that the relative strict requirements of the NL_BEMS for medium size biomass installations could increase the payback time for combustion of clean wood by 22% (because of the required electrostatic precipitator, ESP) and up to 60% for the combustion of chipboard that also requires low-dust SRC. For biogas installations smaller than 1 MW_e, SNCR (selective non-catalytic reduction) is required to meet the ELV for NO_x in the Netherlands.

Table 21: NO_x emission limit values for biogas piston engine systems in the Netherlands and Germany[14]

Engine type	BEMS (mg/Nm^3) for NO_x	TA Luft (mg/Nm^3) for NO_x
Biogas engine <3 $MW_{th\ input}$	340	880
Biogas engine >3 $MW_{th\ input}$	340	440
Piston engine, biogas mix with <90% biogas	100	440

Apart from ELVs, the BE_Pelletnorm, the DE_BioV and the NL_LAP include criteria for the feedstocks to avoid certain emissions to air (Table 22). The BE_Pelletnorm restricts chemical characteristics for good combustion such as dust, heavy metals, moisture content and acid content. These restrictions are made to ensure minimum emissions to flue gases of the installations. The DE_BioV and NL_LAP include criteria on the contamination of waste wood and whether biomass should be considered waste or is allowed to be used in conventional combustion plants (NL_LAP). These regulations are not directly comparable as they have different objectives.

Table 22: Feedstock quality requirements to avoid emissions to air

Country/rule		Scope	Description of feedstock quality requirements
BE	**PelletNorm**	Non-industrial heating installations	Wood pellets to be used in non-industrial heating installations should fulfil certain conditions: origin (chemically untreated wood from forest with FSC, PEFC or similar label); chemical characteristics for a good combustion like dust, heavy metal, moisture, acid content is restricted in the wood pellet to ensure minimum emissions in the flue gases of the installations
DE	**BioV**	Max. 20 MWe	Criteria on contamination levels of waste wood
NL	**LAP**	Processing of (organic) waste	The LAP includes the criteria if biomass will be considered waste or not

Note that this study only focused on the inventory of national regulations that include specific requirements on bioenergy systems. Emission criteria could also be included in regulations that are general for all combustion systems (fossil and biomass). Without this information, it is not possible to conclude whether or not air protection for systems <50 MW is covered by the MS national legislations.

We conclude that in 10 MS, regulations were found concerning emissions to air for biomass installations smaller than 50 MW thermal input. Differences in maximum emission levels between MS may have impact on costs and markets. In the example of maximum NO_x emission levels for biogas engines, technology designed for emission levels in Germany and Austria does not meet the emission requirements of the Netherlands, requiring additional end-of-pipe solutions.

[14] Meddeler et al. 2010, NO_x emission limit values for biogas piston engine systems converted to 3% O_2.

3.4 Life cycle greenhouse gas performance

The 2010 Biomass Report tables a common GHG emission accounting methodology for biomass use in electricity and heating. Differently from the methodology applied to biofuels and bioliquids, emissions from the conversion of biomass into electricity, heating or cooling are included in the GHG accounting calculations. Additionally, the accounting method allocates appropriate respective fractions of the GHG emissions coming from cogeneration of heat and electricity to the amount of electricity and heat produced.

This study identified all existing biomass regulations in the European MS requiring GHG and/or energy reporting based on the whole life cycle of biomass supply chains. This section compares these regulations with the Renewable Energy Directive and among each other. The selected regulations are listed in Table 23.

Table 23: Overview of relevant regulations concerning the GHG savings sustainability criterion

Country/rule		Relevance in terms of GHG emissions
AT	UFG	Sustainability bonus of 5% investment cost for conditioned biogas, if GHG emission reduction >45%, according to the Renewable Energy Directive
BE	FL-GSC	No GHG reference, only energy Balance of the entire chain. Life cycle fossil energy use deducted from green power certificates. For more details, see Appendix IV.
BE	Wall_CV	GHG calculation of the entire chain is included to determine the amount of green certificates. Fossil reference is steam and gas turbine (55% efficiency) for electricity and gas boiler (90% efficiency) for heat).
BE	Bru-CV	Comparable to the Walloon system
DK	GreenGrowth	Focus on GHG (methane) reduction from manure by promoting biogas production in agriculture. No specific reduction level required.
ES	RD_949_09	Subsidy for digestion plants to reduce (GHG) methane emissions from slurry and manure. It allows market actors to obtain a subsidy for digestion plants with the specific aim of reducing methane greenhouse gas emissions, but neither a GHG emission threshold nor an own or Renewable Energy Directive-based GHG methodology is developed or requested. Control measurements for greenhouse gas savings are not available.
UK	ROO2011	For electricity from biomass, from 2011 mandatory reporting is required consistent with the Renewable Energy Directive (>50 kW). From April 2013 generators of 1 MW and above will need to meet the sustainability criteria, including a 60% GHG emission saving. Method close to the Renewable Energy Directive.
UK	RHI	Heat plants larger than 1 MW_{th} will be required to mandatory report on sustainability (including GHG savings), according to Renewable Energy Directive requirements.
UK	SBHS	Reporting on source of the feedstock and CO_2 balance for biomass heat support

As shown in Table 23, only two MS have introduced comprehensive sustainability regulations with minimum GHG saving requirements calculated on the basis of the whole biomass life cycle[15]. These systems require auditing along the entire chain.

[15] In addition, Austria has a regulation on biogas, but as this obviously only focusses on a single conversion pathway, we do not consider it comprehensive.

Generally the energy producers are responsible for the auditing of the supply chain, however all actors in the chain are involved.

The *Walloon green certificates regulation BE_Wall_CV* establishes a GHG emission threshold and a concrete method[16] applying a full chain LCA (Cornélis, 2010). Details of the method are presented below.

The *UK_ROO2011* launched a standard GHG calculating tool in autumn 2011 that embraces the full life cycle from cultivation to combustion — the UK Biomass Carbon Calculator[17]. This tool incorporates the calculation methodology set out in the Renewable Energy Directive and additionally takes into account the recommendations on sustainability requirements for solid and gaseous biomass set out in the 2010 Biomass Report.

The *UK_RHI* requires mandatory sustainability reporting from 2011 for biomass installations with a capacity of 1 MW_{th} and above and for all producers of biomethane. The approach is consistent with the one initially used by the UK_ROO2011: participants have to provide information on their biomass feedstock including the country of origin, the source material and details of any applicable environmental quality assurance schemes.

Finally, another regulation refers directly to the Renewable Energy Directive methodology for the analysis of GHG emissions: the Austrian *AT_UFG*. This regulation demands a 45% GHG saving only in case of an investment aid of the following types of plants:

- biomass plants >400 kW,
- production plants of biofuels including biomethane.

The Netherlands has developed a norm for sustainable biomass (NTA 8080), resulting from the work carried out by the Cramer Commission on sustainable biomass[18]. However, so far the norm has not been used as reference in any legislation, and with the current government it is not expected to be used in, for instance, the new SDE+. For the time being, it can be regarded as a voluntary system (see for more details section 3.5).

Other countries like Italy and Spain have announced that they will use the upcoming CEN norm EN16214, developed in the CEN Technical Committee 383[19] that so far focussed on biofuels for transport and bioliquids, but currently considers extending this work to solid and gaseous biomass for stationary bioenergy. However, these plans were not concrete enough to include them in the list of regulations.

We conclude that currently only the UK and Belgium have regulations that comprehensively cover GHG emission reduction requirements (and Austria, but only for biogas production). The other MS have no regulations in place. This may either imply that they deem the issue not relevant, or they have chosen to wait for a decision by the Commission. Thus, there is no common approach discernible.

[16] The systems of green certificates. www.cwape.be%2Fservlet%2FRepository%3FIDR%3D587
[17] http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/FuelledStations/bbcc/Pages/bbcc.aspx
[18] Cramer et al. (2007): Testing Framework for Sustainable Biomass.
[19] http://www.cen.eu/cen/Sectors/Sectors/UtilitiesAndEnergy/Fuels/Pages/Sustainability.aspx

Comparison with 2010 EU recommendations

To compare the Walloon regulation BE_Wall_CV with the GHG accounting methodology tabled in the 2010 Biomass Report, an overview of differences in GHG emission factors for a number of biomass feedstocks is provided in Table 24. The key difference concerns the fossil fuel comparator (FFC). In the EU methodology, the FFC is based on the EU fossil fuel mix in electricity and heating. The fossil fuel reference system in the BE-Wall-CV is a natural gas combined cycle power plant engine with a net 55% electric efficiency. The reasoning for this is that such a plant would be the adequate (new) fossil fuel-based alternative for electricity generation.

Additional minor differences include: differences in transportation distances and emissions factors for different transportation systems (sea, river, road, train), and the number of supply chains considered - BE_Wall_CV contains mainly emission factors for those feedstocks that are actually used in Belgium. For wood biomass, a comparison of the emission factors reveals that the assumptions are reasonably comparable: the numeric values of the emission factors differ, but do not represent completely different orders of magnitude. Since the production and transportation of pellets causes about 10-20% of the GHG emissions, the variation of the emission factors of all schemes seems to be acceptable.

The UK regulations introduced a requirement for minimum 60% GHG emission saving against the EU fossil fuel comparator. In order to avoid concerns regarding the potential change of the EU's fossil fuel electricity comparator as the EU mix decarbonises, the UK set the threshold as a specific carbon intensity figure (285.12 kg CO_2 per MWh) rather than a 60% based comparator that could change over time.

Overall, we conclude that only two out of 27 MS (UK and Belgium) have so far included binding GHG emission reduction levels in a comprehensive way. Whereas the UK regulations are designed to be conform to (or be close to) the recommendations in the 2010 Biomass Report, the Belgian regulation that has been active since 2006, has several aspects that differ from the JRC methodology, such as a 55% natural gas plant as fossil reference (compared to several different references in the JRC methodology), and different reference emission factors for varying biomass feedstocks.

Table 24: Reference emission factors of different biomass feedstocks of different GHG calculation methods.

g CO2/MJ-fuel	JRC[20]	BE-Wall-CV
Pretreatment / transport		
milling		1.1
transport <200km		1.4
transport >200km		6.9
drying		2.8
Straw (EU)	1.7	
Wood		6.4
chips from forest residues		
EU	1	
BR	21	
pellets from forest residues		8.3
EU (natural gas = process fuel)	17	
BR (wood = process fuel)	15	
BR (natural gas = process fuel)	30	
pellets from SRC		12.5
SRC (EU) (wood = process fuel)	4	
SRC (EU) (natural gas = process fuel)	19	
SRC (BR) (wood = process fuel)	18	
SRC (BR) (natural gas = process fuel)	33	
Biogas		
from wet/dry manure	6 / 7	
from wheat (whole plant) or straw	18	
from maize	19.3	
Fossil fuels		
Natural gas	66.6	69.7
EU el-mix	129.8	
Coal		106.9
Hard coal	112.0	
Lignite	117.0	
Fuel oil	85.0	88.9
Nuclear		16.7
Fossil baseline (g CO_2/MJ-el)		
Power plant 55% eff. natural gas		126.8

EU = European Union, BR = Brazil

20 http://re.jrc.ec.europa.eu/biof/pdf/documents/SEC_2010_65_Impact_sustainability_requirements_biomass.pdf

3.5 Voluntary systems

3.5.1 Overview of voluntary systems

This section presents an up-to-date overview of initiatives from industries, NGOs, roundtables and international organisations as far as they are relevant for solid and gaseous biomass in European countries.

These are likely to be compliant with the national legislation, but may include additional (voluntary) topics, for example, social criteria. For these criteria, stricter standards may apply (for example, higher avoided GHG emissions). This analysis builds on the work by van Dam *et al* (2010) and includes the most relevant systems developed and/or used in Europe. A special focus is on systems developed by large-scale end-users such as utilities, that often import biomass from several countries (both within and outside the EU) and might therefore already be confronted with varying and possibly conflicting national legislation. Other selection criteria for the initiatives included are:

- the systems are voluntary,
- they cover solid and/or gaseous biomass for Bioenergy,
- they are applicable to national or regional levels in the EU27.

Systems that are not voluntary but restricted by regulations are covered in sections 3.2 to 3.4. Initiatives that focus on liquid biofuels or its feedstocks, for example the Roundtable on Sustainable Palm Oil (RSPO) and the Roundtable on Sustainable Biofuels (RSB) are excluded as they are less relevant for solid and gaseous biomass. Also agricultural standards and sustainable farming initiatives, such as the Assured Combinable Crop Scheme, are excluded if they do not cover solid or gaseous biomass for heat, electricity and cooling explicitly. Table 25 shows the relevant voluntary systems. A more detailed description of these voluntary systems is provided in van Dam *et al* (2010) and in Appendix III.

Table 25: Selected voluntary systems relevant for solid and gaseous biomass in European countries[21]

Country[22]/ short name		Initiative/certification system	Short description
NL	**NTA8080/ 81**	NTA 8080 and 8081 (Dutch sustainability standard)	Defines sustainability criteria which biomass has to meet. The NTA8080 is still a voluntary system and it is not expected (although still unclear) that it will be implemented in the SDE+.
NL	**GGL**	Green Gold Label (biomass for electricity)	Defines 8 sustainability standards that biomass has to meet.
UK	**DRAX**	Drax Power Limited (biomass for electricity)	The DRAX Power Limited company has established sustainability principles for biomass for power generation in the UK.
SC	**SWAN**	Swan Label (biofuels and biofuel pellets)	The Nordic Swan Ecolabel is consistent with the criteria of the EU-Ecolabel, but criteria are developed for fuels and for biofuel pellets, among 66 other product groups. The criteria for biofuel pellets include requirements on manufacturing methods, transportation and storage. The criteria for fuels include requirements for fuels with at least 1/3 volume of renewable raw materials.

[21] van Dam et al 2010

[22] SC: Scandinavia (Denmark, Finland, Iceland, Norway, Sweden)

BE	**LBE**	Laborelec-SGS (biomass for electricity)	Includes sustainability principles, but no criteria, mainly aimed at wood biomass, but also relevant for agricultural residues.

Table 26 shows the sustainability criteria covered by the selected voluntary systems. A similar table with the principles/criteria of these sustainability systems is provided in Appendix III. The NTA8080 covers, apart from energy balance, all sustainability criteria, whereas the LBE label does not include criteria, but only sustainability principles: full traceability of the resources, the evidence that these resources were manufactured in a sustainable way by independent reporting on local resource management and respect for local and international legislations, and evaluation of the energy or CO_2 balance, including transport.

Table 26: Sustainability criteria covered by the selected voluntary systems

Criteria	System				
	NTA8080	LBE*	DRAX	GGL	Swan**
GHG savings	X	X***	X	X	X
Energy balance		X***		X	X
Biodiversity	X		X	X	X
Carbon stock / land conversion	X		X	X	
Ecosystem services	X			X	
Soil protection	X		X	X	
Protection of fresh water	X		X	X	
Air protection	X		X		
Restoration of degraded lands	X			X	
Social principles	X		X	X	X

* Laborelec does not have its own sustainability standard
** Swan label for pellets
*** no criteria, but required evaluation and approach

In addition to the initiatives described above, industry led initiatives have developed to apply on a voluntary basis the Renewable Energy Directive sustainability criteria for solid biomass, including the Vattenfall AF joint climate protection agreement with the State of Berlin and the Initiative of the Wood Pellet Buyers Group (IWPB) (see boxed texts below).

Box 4: Vattenfall joint climate-protection agreement with the State of Berlin

In October 2009, the State of Berlin and Vattenfall AG signed a joint climate-protection agreement concerning governing criteria for sustainability in the purchase of wood biomass (Vattenfall, 2010). This agreement was made in the frame of the Vattenfall project in Liberia, exporting wood chips from non-productive rubber trees to Berlin for the production of heat and electricity. The criteria include GHG emission reduction (following the recommendations of the 2010 Biomass Report), protection of ecosystems with high biodiversity and preservation of carbon stocks and protection of environmental quality, including soil quality and structure, water quality and use, air quality and noise abatement. In addition, a number of social criteria have been agreed upon as well: protecting employment rights, protection of land and land-use rights, protecting operational transparency, making a positive contribution to improvement of living conditions of stakeholders in the project environment and a responsible approach to the local population. These criteria are in addition to the general criteria of Vattenfall to their suppliers, that include provisions against issues such as child labour and slavery. However, as this is not a general voluntary system, but rather a specific agreement between Vattenfall and the State of Berlin, it is not included in the comparison in section 3.5.

Box 5: Initiative of Wood Pellet Buyers

Recently a number of major utilities companies, certification experts and traders, including Laborelec/Electrabel, RWE-Essent, E.On, Drax Power, Dong Energy, Peterson Control Union, Vattenfall, SGS, Argus Media, Fortum and Nidera have created the Initiative of Wood Pellets Buyer (IWPB). The objective of this initiative is to facilitate trade between utilities through uniform contracting and, amongst others, through uniform sustainability criteria. To this end, they are developing a meta-system that covers most of the existing voluntary schemes. The new system focuses on wood, but does not exclude agricultural biomass such as cultivated wood. It will focus on 8 sustainability principles: 3 being verified in details (based on the Renewable Energy Directive) and 5 being assessed and improved in time (environmental and socio-economic criteria). The work base includes a check-list based on the 8 sustainability principles, and verification and reporting by an independent body. The aim is to establish cross-compliance of meta-standards and legislation in the country of origin, although it is yet to be clarified how this would limit or change verification procedure. The final output will be a voluntary scheme, that is transparent (documented on a webpage) and compatible with obligations/recommendations from the EC and key Member States. For the latter aim, the initiative also plans to prepare a roadmap to move the harmonised scheme to an official EU standard.

3.5.2 Comparison with the 2010 EU recommendations

GHG emissions

As GHG emission reduction is one of the main aims of bioenergy, all selected voluntary systems cover greenhouse gas reduction principles. These principles require net GHG savings over the total life cycle of the chain compared to a fossil reference plant (NTA8080, LBE, GGL, DRAX), or are specific to processing (Swan label). Compared to the required emission reduction levels in the Renewable Energy Directive, the NTA8080 (also included in the Green Gold Label) is more ambitious. The NTA8080 requires emission reduction targets of 70% for electricity and heat if the Dutch electricity mix or coal is used, and at least 50% if natural gas is the reference system. Also DRAX aims to reduce GHG emissions by at least 70% compared to coal-fired power generation, but does not include required reduction levels. The Swan label for pellets[23] requires maximum GHG production of 100 kg/1000 kg pellets produced, but only covers emissions that are related to boiling and drying. Depending on the region in Belgium, the LBE label requires evaluation of the energy or GHG balance to comply with the Green Certificate systems in Flanders and the Walloon Region/Brussels.

Criteria on energy consumption (not included in the 2010 Biomass Report) are included in the Swan label (1200 kWh primary energy), but cover conversion processes only (barking, chipping and pelletisation). Transport from and to the processing plant is excluded. The Green Gold label includes minimum energy savings for certification of at least 35% for electricity generation over the total chain.

[23] Different from the Swan label for biofuel pellets, the Swan label for biofuels requires full lifecycle emissions not to exceed 50 g $CO_{2\text{-eq}}$/MJ biofuel.

Biodiversity and land use change

Biodiversity is considered a key principle in sustainability standards for bioenergy (van Dam *et al* 2010) and therefore covered in all the selected voluntary systems, apart from LBE that requires biomass production in a sustained way, but does not include a sustainability standard. There are two opposite approaches or an in-between approach, used by sustainability standards to protect biodiversity (van Dam *et al* 2010):

a) assuming that feedstock production may harm biodiversity;
b) assuming that feedstock production may enhance biodiversity of a region under certain conditions.

The first approach is used by the Swan label and the Renewable Energy Directive by excluding areas for bioenergy production that includes a certain degree of biodiversity. Apart from excluding biomass that may adversely affect protected or vulnerable biodiversity, DRAX and NTA8080 also give preference to options that strengthen biodiversity if possible.

To prevent emissions from direct land use change, the NTA8080 excludes, similar to the Renewable Energy Directive, bioenergy production from high carbon land that has recently been converted. Also the Swan label for biofuels includes these requirements. However, these are not included in the Swan label for biofuel pellets. For the GGL, the management has to demonstrate that the plantation was not established by converting forests. DRAX only requires no net release of carbon from the vegetation and soil of either forests or agricultural land.

Other environmental impacts

Criteria for other environmental impacts on for instance soil and water are not included in the 2010 biomass report, but are included in the NTA8080, GGL and DRAX systems. The NTA8080 and DRAX criteria require maintaining or even improving current quality of soil, water and air, whereas the GGL sets specific measures to protect soil and water, for instance a long term irrigation plan and measures to prevent minimize soil run-off or sedimentation. For more details, see Appendix III.

Social criteria

Also socio-economic principles are not included in the 2010 Biomass Report, but are included in all selected voluntary systems that include sustainability standards to safeguard local prosperity and the social well-being of employees and the local population. Apart from prevention of negative impacts, NTA8080 and DRAX also require positive contributions to social well-being of the employees and local population of the area where biomass is produced. A detailed comparison of voluntary systems and related socio-economic principles is provided by van Dam *et al* (2010).

3.5.3 Conclusions on voluntary systems

Comparing the most relevant voluntary systems to the Renewable Energy Directive and the mandatory regulations, we can conclude that all five systems investigated contain criteria regarding GHG emissions, whereas such rules were only found in a comprehensive way in UK and Belgian regulations. Also, many other criteria that were not addressed in the Renewable Energy Directive or in MS legislations are included in these voluntary systems (especially the NTA8080), including protection of water and soil, air emissions and social criteria. Particularly in the Netherlands, where no binding criteria for issues such as GHG emission reductions have been implemented so far, systems such as the GGL and NTA8080 may effectively serve as voluntary safeguards.

We conclude that companies that adhere to these voluntary standards may in some cases thus go further than is strictly required by law or suggested in the 2010 Biomass Report.

3.6 Conclusions

3.6.1 Summary

The overview only includes regulations that have a specific link to the use of biomass for energy. This means that many more national and EU regulations exist that have an impact on the sustainable production or use of biomass, but which have not been taken into consideration in the comparison as they were outside the scope of the study. For example, no regulations were found specifically addressing the environmental impacts on soil and water connected to bioenergy production. However, cross-compliance with rules of the Common Agricultural Policy will likely provide assurance of compliance with a set of environmental impacts on soil and water for production in the EU (Scarlat and Dallemand, 2011). Similarly, while we found a few regulations concerning the emissions from biomass combustion in installations smaller than 50 MW thermal input, such criteria could also be included in regulations that are general for all combustion systems (fossil and biomass).

Biomass production

With regard to the production of biomass feedstocks, we found a rather heterogeneous picture, with many different regulations, often highly feedstock- or technology-specific. We emphasise that, especially with respect to agricultural and forestry biomass, many sustainability criteria are likely included in other European regulations that have not been assessed here. Regarding the use of forestry biomass for energy purposes, some countries refer to (or require compliance with) voluntary SFM systems or to good practises for forest management, while only one country (UK) has introduced regulations specifically referring to the biodiversity and carbon stock criteria laid down in the 2010 Biomass Report. Also the approaches followed by the MS are to some extent diverging. In some cases, local biomass production is promoted, whereas other countries try to protect existing non-energy sectors relying on local biomass, thereby indirectly promoting biomass imports for energy.

End use efficiency

We conclude that at present about half of the European MS have regulations or support schemes for biomass based electricity, heating and cooling installations in place that differentiate in favour of installations that achieve high energy conversion efficiencies, such as high efficiency cogeneration plants. Ranges of minimum efficiencies required range somewhat between the individual legislations. While a large number of regulations focus on end use efficiency, they are often only aiming at a specific technology (both in terms of size, and output of heat, electricity, or both). Also, the vast majority of regulations are found in the EU-15; almost no regulations referring to end use efficiency of bioenergy installations are present in the new MS.

GHG savings

Only two out of 27 MS (Belgium and UK) have so far included binding criteria for GHG emission reduction levels in a comprehensive way[24], and these partially follow the recommendations as given in the 2010 Biomass Report. As pointed out earlier (and also in the 2010 Biomass Report), currently mainly locally sourced solid biomass residues are used, with generally high GHG emission reductions. It is probably no coincidence

[24] In addition, Austria implemented a regulation promoting GHG savings of more than 45%, but only for biogas production.

that specifically Belgium and the UK, countries that (expect to) import large amounts of solid biomass from overseas, cover GHG emission criteria. However, imports of wood pellets strongly increased in past years also to countries other than Belgium and the UK, for instance, the Netherlands, Denmark, Sweden or Italy. Furthermore, with the generally increasing scarcity of (high-quality) solid biomass residues, it is quite possible that in the near future, both in EU and non-EU countries, existing plantations or dedicated short-rotation energy crops will increasingly supply solid biomass for energy[25] to the EU. Depending on the cultivation practices, GHG emissions may be higher than from comparable residue streams. We conclude that particularly for biomass from energy plantations, insufficient legislation is in place in EU MS to ensure or monitor whether sufficiently high GHG emission reductions are achieved.

Regarding sustainability topics not covered in the Renewable Energy Directive and the 2010 Biomass Report, it would seem that solid biomass production and use is to some extent safeguarded in many MS in existing forestry and agriculture legislation as far as domestic production is concerned. Issues related to biomass produced outside the EU is essentially ignored by the regulations. Also, it is observed that there is a significantly lower number of regulations in the new MS in Eastern Europe.

In summary, very few MS have adopted comprehensive national criteria to address the possible unwanted side effects related to the establishment of energy crop plantations for energy purposes. As a consequence, under the current situation, the above mentioned issues concerning GHG balance and protection of high biodiversity value and high carbon stock lands do not appear to be sufficiently and effectively addressed in MS regulations, particularly with respect to biomass production outside the EU.

3.6.2 Possible effects on trade patterns

In the absence of mandatory EU-wide sustainability criteria for solid biomass, it is quite likely that a number of individual MS unilaterally will develop (further) sustainability criteria, while others maintain the status quo. Such a development could have two consequences:

(1) diverging sustainability criteria could undermine the environmental effectiveness of national schemes. This situation is likely to promote leakage effects with less sustainable raw materials, subject to mandatory requirements, being moved to parts of the EU where they will not receive the same level of environmental scrutiny;

(2) a heterogeneous regulatory approach to biomass sustainability raises a number of concerns from an internal market perspective, including causing potential distortions to biomass trade, market segmentation and overall market inefficiency.

[25] As is described in more detail in the following chapters, roundwood from existing plantations in the USA and Russia is already used for wood pellet production, and a company in Brazil plans to use short-rotation eucalyptus plantations for wood pellet production in the near future.

We note that a number of large European utilities and other market players have already identified the second matter as an issue of concern and in 2010 called for the rapid EU-wide introduction of mandatory sustainability criteria. Since the end of 2010, the members of the IWPB initiative (see section 3.5) have been working to set up their own meta-certification system, in which the sustainability principles of the Renewable Energy Directive are included. Such a system would partly address the second issue by creating a widely accepted voluntary sustainability standard, but it is questionable if such a meta-standard would be able to also cover all (new) requirements of individual MS. Also, there is no guarantee that *all* producers, traders and users within the EU will adopt this voluntary standard, so the leakage issue would remain.

4 IMPACTS OF BIOMASS SUSTAINABILITY REGULATIONS

Building on the findings of chapter 2 and 3, this chapter presents a quantitative assessment of the impacts of existing and alternative sustainability regulations on biomass markets, modelling a number of scenarios using the Green-X model. A "baseline scenario" was developed, including national sustainability criteria ready to be adopted or already adopted by MS until April 2011. It therefore reflects both achievements and deficiencies of the 2010 EU recommendations, which left the introduction of sustainability criteria to the discretion of MS. The baseline projection served as a benchmark for evaluating the impacts of a number of alternative policy options, including additional EU policy measures on biomass sustainability. Section 4.1 describes the methodology used and lists the assumptions taken. Results of the modelling exercise and the complementary qualitative assessment[26], based on expert and stakeholder inputs, are presented in section 4.2 solely for the baseline case, while section 4.3 discusses impacts of alternative policy options on biomass/RES deployment as well as environmental and economic impacts. Finally, conclusions are discussed in section 4.4.

4.1 Methodology and assumptions

4.1.1 The Green-X model

As in previous projects, such as FORRES 2020, EMPLOYRES or RES-Financing, the Green-X model was applied to perform a detailed quantitative assessment of the future deployment of renewable energies (RES) in general and of biomass in particular, on country, sectoral, as well as technology level.[27] The core strengths of this tool are its detailed representation of RES resources and technologies, and its detailed incorporation of energy policy instruments. This allows various policy design options to be assessed with respect to resulting costs and benefits as well as environmental impacts. Box 6 below provides a brief description of the model; for a detailed description refer to www.green-x.at.

[26] The discussion of qualitative aspects is done via textboxes, directly integrated into the report where suitable.

[27] The impact assessment within this study focuses on solid and gaseous biomass used for electricity and heat supply. The appropriate consideration of substitution effects resulting from a change of biomass deployment (directly affected by the sustainability regulation) requires however to include all other biomass and RES technologies in this analysis. This aims further to put impacts on biomass markets into a general perspective.

Box 6: Short characterisation of the Green-X model

The model Green-X has been developed by the Energy Economics Group (EEG) at the Vienna University of Technology under the EU research project "Green-X–Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market" (Contract No. ENG2-CT-2002-00607). Initially focussed on the electricity sector, this modelling tool, and its database on renewable energy (RES) potentials and costs, has been extended to incorporate renewable energy technologies within all energy sectors.

Green-X covers the EU-27, and can be extended to other countries, such as Turkey, Croatia and Norway. It allows the investigation of the future deployment of RES as well as the accompanying cost (including capital expenditures, additional generation cost of RES compared to conventional options, consumer expenditures due to applied supporting policies) and benefits (for instance, avoidance of fossil fuels and corresponding carbon emission savings). Results are calculated at both a country- and technology-level on a yearly basis. The time-horizon allows for in-depth assessments up to 2020, accompanied by concise outlooks for the period beyond 2020 (up to 2030).

The Green-X model develops nationally specific dynamic cost-resource curves for all key RES technologies, including for renewable electricity, biogas, biomass, biowaste, wind on- and offshore, hydropower large- and small-scale, solar thermal electricity, photovoltaic, tidal stream and wave power, geothermal electricity; for renewable heat, biomass, sub-divided into log wood, wood chips, pellets, grid-connected heat, geothermal grid-connected heat, heat pumps and solar thermal heat; and, for renewable transport fuels, first generation biofuels (biodiesel and bioethanol), second generation biofuels (lignocellulosic bioethanol, biomass to liquid), as well as the impact of biofuel imports. Besides the formal description of RES potentials and costs, Green-X provides a detailed representation of dynamic aspects such as technological learning and technology diffusion.

Through its in-depth energy policy representation, the Green-X model allows an assessment of the impact of applying (combinations of) different energy policy instruments (for instance, quota obligations based on tradable green certificates / guarantees of origin, (premium) feed-in tariffs, tax incentives, investment incentives, impact of emission trading on reference energy prices) at both country or European level in a dynamic framework. Sensitivity investigations on key input parameters such as non-economic barriers (influencing the technology diffusion), conventional energy prices, energy demand developments or technological progress (technological learning) typically complement a policy assessment.

Within the Green-X model, the allocation of biomass feedstock to feasible technologies and sectors is fully internalised into the overall calculation procedure. For each feedstock category, technology options (and their corresponding demands) are ranked based on the feasible revenue streams as available to a possible investor under the conditioned, scenario-specific energy policy framework that may change on a yearly basis. Recently, a module for intra-European trade of biomass feedstock has been added to Green-X that operates on the same principle as outlined above but at a European rather than at a purely national level. Thus, associated transport costs and GHG emissions reflect the outcomes of a detailed logistic model (see Appendix V). Consequently, competition on biomass supply and demand arising within a country from the conditioned support incentives for heat and electricity as well as between countries can be reflected. In other words, the supporting framework at MS level may have a significant impact on the resulting biomass allocation and use as well as associated trade.

For the purpose of this study, the policy coverage of Green-X was extended to allow an endogenous modelling of sustainability regulations for the energetic use of biomass. This comprises specifically the application of GHG constraints that exclude technology/feedstock combinations not complying with conditioned thresholds. The model allows flexibility in applying such limitations, that is to say, the user can select which technology clusters and feedstock categories are affected by the regulation both at national and EU level, and, additionally, applied parameters may change over time.

4.1.2 Modelling biomass transport chains in Europe

In order to assess the potential supply of biomass from EU and non-EU sources and the expected logistic chains of biomass distribution, the Green-X database was extended to include feedstock specific costs and GHG emissions for cultivation, pre-treatment (for instance, chipping, pelletisation) and country-to-country specific transport chains. Below we give a brief description of the methodology for calculating the input parameters of Intra-European biomass trade in Green-X. For a detailed description of this approach, as well as a discussion of related results, see Appendix V.

In order to identify likely trade routes of solid biomass and to quantify the specific costs and GHG emissions of the logistic chains of solid biomass trade, a geospatial network model was developed in the ArcGIS Network Analyst extension by the Copernicus Institute at Utrecht University. The model includes an intermodal network with road, rail, inland waterways and short sea shipping in Europe. The networks are connected via transhipment hubs, where biomass can be transferred to other transport modalities (for instance, from truck to ship). The model optimises for least cost or GHG emissions from demand to supply regions. Total cost and GHG emissions depend on the routes taken, transport modes used and number of transfers between different transport modes.

For illustrative purposes, Figure 5 depicts an example of a transhipment hub in a region including all transport modalities, such as Rotterdam. Note that in most regions only road and rail networks are available. In addition, Figure 6 provides an exemplary overview on EU-27 destinations (largest cities per NUTS-1 region and important harbours in the EU-27).

Figure 5: The network model approach (hub-spoke)

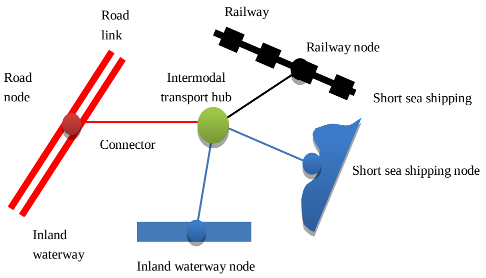
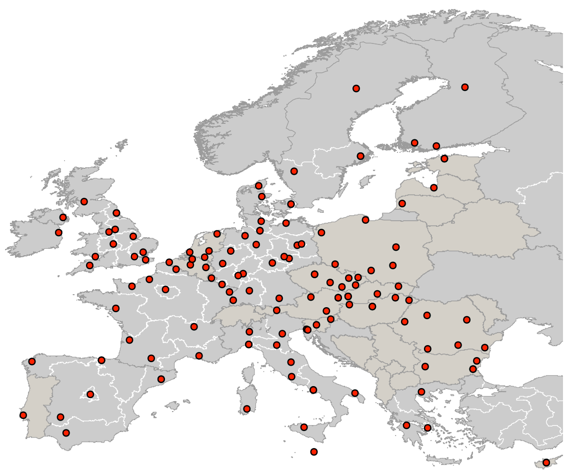


Figure 6: EU-27 destinations (largest cities per NUTS-1 region and important harbours in the EU-27)



4.1.3 Assumptions on biomass supply and imports

Biomass supply

The total domestic availability of biomass (including solid and gaseous biomass feedstock) that can be mobilised for energy purposes by 2020 was set at 280 Mtoe/yr.[28] Table 27 indicates the identified biomass primary potentials on EU-27 level by feedstock category as well as corresponding fuel price assumptions.[29] Accordingly, default ranges of fuel costs (including costs for cultivation, pre-processing and domestic transport) for various fractions of biomass are comparatively large at an EU level, indicating differences between countries in the available resources and the related harvesting conditions as well as transport specifics.[30] The country-specific price assumptions are based on information gained from various recent studies or projects (such as EUBIONET III, IEA Bioenergy Task 40 on bioenergy trade). In the case of biowaste, a negative price is used as default, representing a "gate fee" for the waste treatment and, consequently, a revenue for the power producer.

The future development of fuel prices for biomass is internalised in the overall model, linked to fossil fuel prices[31] as well as the available additional potentials. A depiction of the future evolution up to 2020 of biomass feedstock prices (on average at EU-27 level) is given in Figure 7 for the default case of moderate energy prices.

[28] This figure includes also biomass imports from third countries for which exact quantities cannot be provided due to a lack of data. Estimates indicate a volume of 3% of current (2010) forestry use for energy purposes at the EU level.

[29] The market assessment was based on the processing of statistical information on agriculture and forestry (for instance, FAOSTAT, Eurostat), complemented by other related information, as applicable from the National Renewable Energy Action Plans, as well as previous / ongoing assessments in this topical area. A non-exhaustive list of studies on potentials and costs for biomass considered for this analysis includes the EU FP7 project "Biomass Energy Europe" (for European potentials), the IEE project RE-Shaping as well as the corresponding global assessment as undertaken within IEA Bioenergy Task 40 on bioenergy trade. Moreover, previous studies conducted at the European level (for instance, the REFUEL project) provide useful insights. New findings gained within the currently ongoing IEE project "Biomass Futures" were not considered for this assessment since they were not available at the time of conducting this analysis. For the outcomes of this assessment please see Appendix VI.

[30] Please note that these prices refer to 2010, but are expressed in €$_{2006}$.

[31] The linkage and correlation of fossil and bioenergy prices and in particular their price volatility has been comprehensively assessed recently in Kranzl *et al* (2009). Two reasons have been identified for the empirically observed high correlation of various biomass commodities to the historic oil price development. On the one hand, volatile fossil energy prices are indeed a cost factor for the production of biomass, specifically for biomass stemming from the agricultural sector. On the other hand, the coupling of bioenergy to energy markets is increasing (bioenergy is used as substitute of fossil energy). Thus, price volatility on one market (for instance, oil) impacts the price stability on the other market (for instance, vegetable oil).

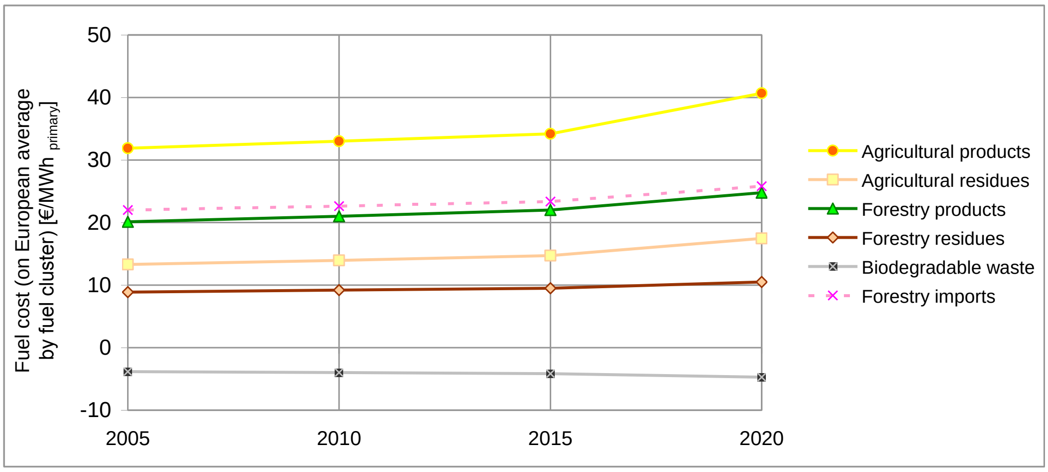
Table 27: Breakdown of average biomass fuel prices (2010) and corresponding primary potentials for 2020 (at EU-27 level) by feedstock category [32]

Solid and gaseous biomass at EU-27 level - Primary potentials by 2020 & corresponding fuel cost (2010)	Realisable mid-term potential for 2020 in terms of primary energy	Fuel cost ranges (2010)		
		Minimum	Maximum	Weighted average
	[Mtoe/yr.]	[€/MWh-p]	[€/MWh-p]	[€/MWh-p]
AP1 - rape & sunflower	77.9	34.1	42.6	39.5
AP2 - maize, wheat (corn)		28.1	35.0	31.8
AP3 - maize, wheat (whole plant)		31.4	31.4	31.4
AP4 - SRC willow		23.1	27.8	24.5
AP5 - miscanthus		28.6	36.0	32.3
AP6 - switch grass		18.9	33.6	28.8
AP7 - sweet sorghum		32.7	43.1	43.1
Agricultural products - TOTAL		18.9	43.1	33.0
AR1 - straw	30.0	12.8	15.4	13.9
AR2 - other agricultural residues		12.8	15.4	14.1
Agricultural residues - TOTAL		12.8	15.4	14.0
FP1 - forestry products (current use (wood chips, log wood))	69.7	17.4	21.8	19.6
FP2 - forestry products (complementary fellings (moderate))		19.6	24.5	22.3
FP3 - forestry products (complementary fellings (expensive))		26.6	33.2	30.2
Forestry products - TOTAL		17.4	33.2	21.0
FR1 - black liquor	35.8	5.8	7.9	6.3
FR2 - forestry residues (current use)		7.4	10.1	8.5
FR3 - forestry residues (additional)		13.5	18.5	14.9
FR4 - demolition wood, industrial residues		7.4	10.2	8.8
FR5 - additional wood processing residues (sawmill, bark)		14.2	19.4	15.7
Forestry residues - TOTAL		5.8	19.4	9.2
BW1 - biodegradable fraction of municipal waste	17.9	-4.0	-4.0	-4.0
Biowaste - TOTAL		-4.0	-4.0	-4.0
BG - agricultural biogas	48.6	16.8	19.9	18.2
SG - sewage gas		0.0	0.0	0.0
LG - landfill gas		0.0	0.0	0.0
Biogas - TOTAL		0.0	19.9	13.6
FR6 - forestry imports from non-EU countries	12.4	22.6	22.6	22.6
Solid and gaseous biomass - TOTAL	292.2	-4.0	43.1	19.1
… of which domestic* biomass	279.8			

Note: * current use of ("domestic") forestry products and residues contains also imports from third countries. Due to lack of corresponding information exact quantities cannot be provided; estimates indicate a volume of 3% of current (2010) forestry use for energy purposes.

[32] Green-X, 2011

Figure 7: Future development of biomass fuel prices (on average at EU-27 level) in case of moderate energy prices [33]



Biomass imports

Biomass imports from third countries are expected to increase significantly over the next decade. These expectations are also confirmed by the NREAPs that estimate a significant deficit in biomass supply for the EU in total. Principally, an increase of biomass imports represents a continuation of past trends. However, some changes can be expected both in scope of trade items as well as in speed.

Given that the Green-X model does not allow modelling of the global trade in biomass, a specific database for feasible amounts of biomass imports from third countries was developed exogenously, based on a bottom up scenario, largely in line with current industry expectations. Due to the limited availability of data, the estimate focused almost[34] only on wood pellets, currently the most traded solid biomass feedstock for energy purposes. Estimating the evolution of imports is a rather difficult exercise due to the inherent uncertainties associated with key parameters, such as biomass commodities markets as well as cost-supply curves until 2020.

Two different import reference scenarios were developed: a "low imports" scenario that builds on industry expectations as presented in the first half of 2011, that is likely to anticipate the compliance with EU sustainability criteria, and an alternative "high imports" scenario, in which roughly twice the amount of wood pellets is imported. The production of the additional wood pellets is assumed to be based 100% on dedicated energy crops (such as eucalyptus and pine trees).

For both reference scenarios, the GHG emissions during cultivation, production and various transport steps (truck, train, ocean vessel) were estimated according to the EU GHG accounting methodology. With regard to the GHG emissions in the high import scenario, their production is associated with unwanted direct land use change (that is conversion of unmanaged forest into short rotation forestry), resulting in significant GHG emissions.[35] This corresponds to a worst case situation, a deliberate choice to enable the modelling of the effects of such a scenario. However, it could be argued that a 100% conversion of unmanaged forest to plantations is unlikely to happen. In this

[33] Green-X, 2011

[34] As an exception, one existing project of wood chips imports from Liberia is included in the analysis as well.

[35] GHG emissions caused by direct land use change as shown in Figure 8 have been calculated by the JRC, and are distributed over a period of 20 years.

context, Figure 8 shows calculated GHG emissions for wood pellet imports into the EU, including all assumed import streams. As shown in this depiction, direct LUC-related emissions (as accounted to the additional import streams conditioned for "high imports" scenario) lead to a significant increase of GHG emissions.

Figure 8: GHG emissions for wood pellet imports into the EU, according to different pathways[36]

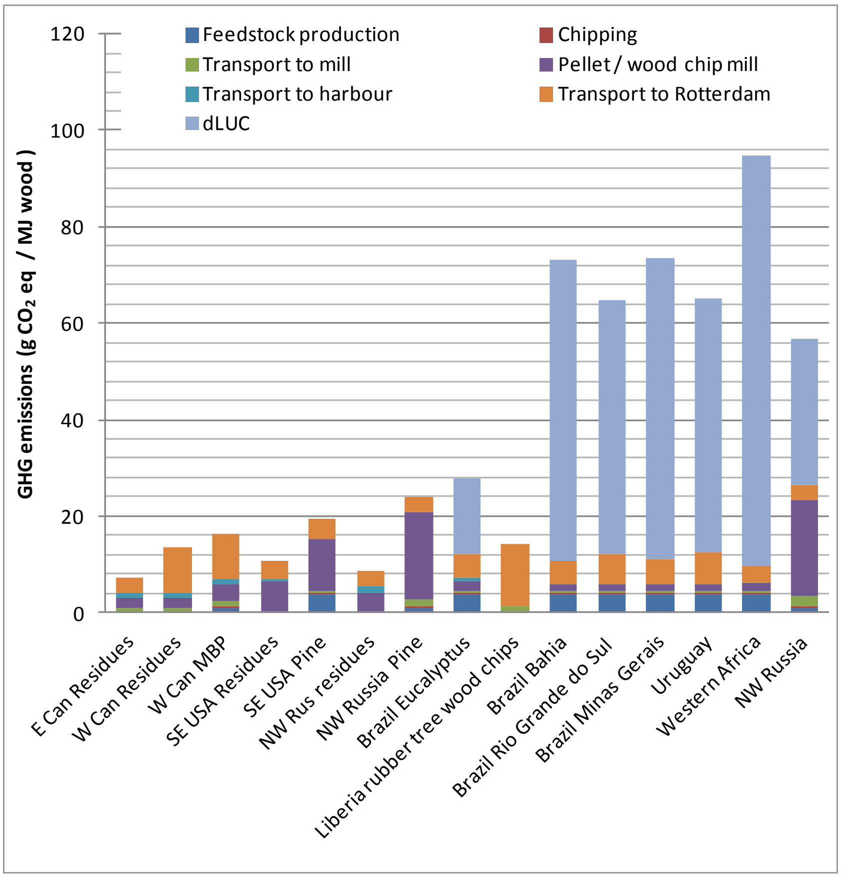


Figure 9 shows the "low imports" scenario. Accordingly, pellet imports increase by over 6 fold, from 41.8 PJ in 2010 (1 Mtoe) to 269.2 PJ (6 Mtoe) in 2020, coming mainly from existing trade routes including North America (US and Canada) and Russia, and smaller imports from South America (Brazil) and Africa (Liberia). Figure 10 presents the alternative "high imports" scenario that starts with the same amounts of imports in 2010, but assumes significant increases from 2014 onwards up to 521.2 PJ (12 Mtoe) by 2020, equal to a doubling of imports compared to the "low imports" scenario. Based on ongoing developments in the pulp and paper sectors and on new bioenergy projects making use of additional land (including biofuels), additional import streams were projected, involving (short rotation) woody crop production and use of existing forests from Latin America (mostly Brazil, but also Uruguay) and Sub-Saharan Western Africa. Further details on the import scenarios are available in Appendix VII.

[36] Own estimates based on JRC, 2011. The "low imports" scenario includes from left to right the chains from "E Can residues" to "Liberia rubber tree wood chips"; the "high imports" scenario includes all chains depicted.

Figure 9: "Low imports" scenario for wood pellet imports into the EU [37]

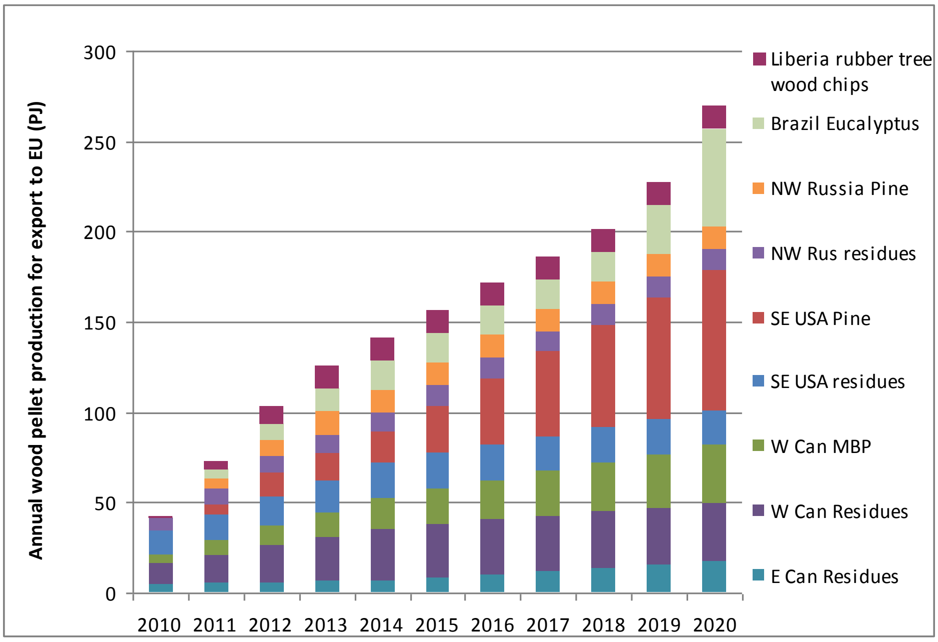
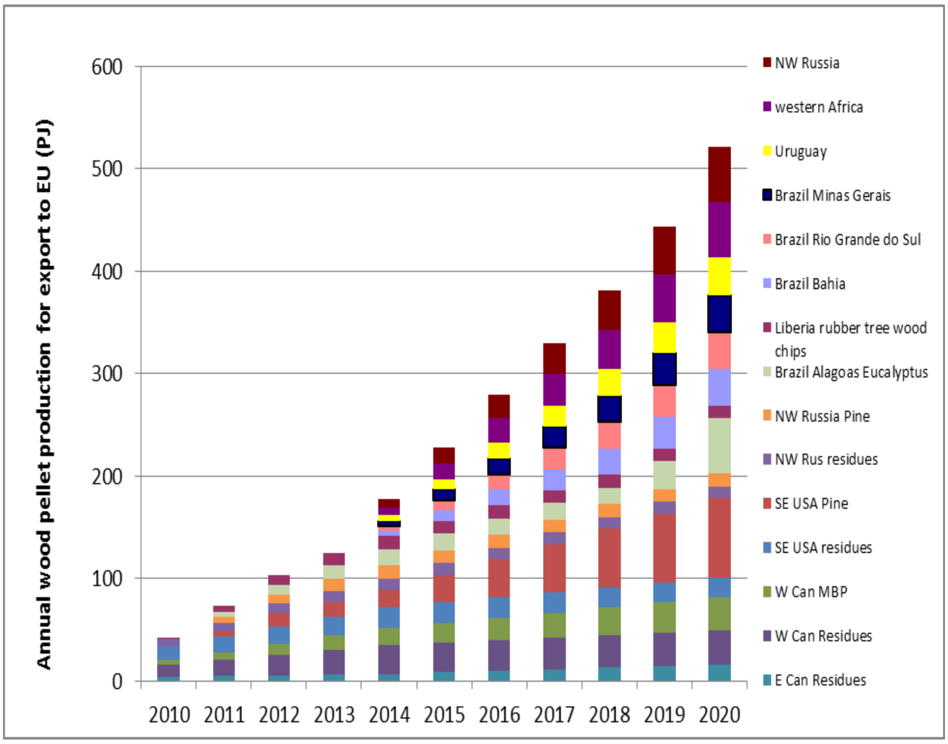


Figure 10: "High imports" scenario for wood pellet imports into the EU [38]



Overall, in the baseline scenario, it is assumed that woody biomass imports from third countries will rise from 3 Mtoe in 2010 (including not only pellets but other types of woody biomass) to between 9 and 15 Mtoe in 2020, representing between 6 to 9% of

[37] Own assumptions, based on industry expectations

[38] Own assumptions: on top of the "low imports" scenario, additional wood pellets are assumed to be based on dedicated energy crops (for instance, eucalyptus and pine trees)

biomass primary energy needs in 2020.[39] The difference with the estimations made in the NREAPs (20 Mtoe, equal to around 12% of primary needs) can be explained by the limitations in the assessment that focuses only on pellets and does not take into account other imported biomass feedstock. Moreover, it also has to be taken into account that intra-EU trade may play a key role for meeting demand for biomass in individual MS, and that estimates of feasible domestic biomass supply as presented in the NREAPs generally appear conservative.

A discussion of qualitative aspects complements this section on biomass imports from third countries, discussing the role of emerging new feedstocks (Box 7).

Box 7: Emerging new feedstocks

An additional issue not considered in some global models is the emergence of new feedstocks that may not have voluntary standards (because they are not considered woody biomass) or which are not currently regulated or are dependent on only newly available technologies.

One example is bamboo which in the last few years has been under research in different countries (India, China, Colombia) to be used as a bioenergy crop. Other species which have potential are miscanthus and switchgrass (Madhu *et al* 2008; Clifton-Brown *et al* 2010; Halford and Karp, 2011) which could both be used for second generation ethanol production but also for energy generation. Bamboo plantations in some countries have started to be certified by the FSC, but mainly in cases where they are to be used in the construction of furniture. Any broader energy use will also go through the same certification (sustainable forest management and chain of custody). However, that may imply a competition with the current market. For perennial grasses, there is no standard or certification available.

The future availability of technologies at industrial scale could also be considered within the supply chains. Torrefaction may be available at industrial level in a short time, for crops such as bamboo, and this will allow further exports to the EU. The Dutch Environmental Agency is currently funding different projects that look at the feasibility of this production.

4.1.4 Modelling sustainability regulations

Following the categorisation of national biomass regulations in chapter 3, modelling of national as well as alternative EU-wide harmonised sustainability regulations was carried out as follows:

- For modelling requirements on *minimum life cycle GHG emissions* the following approach was taken: *GHG emissions* for assessed biomass pathways were based on calculations by the Joint Research Centre (JRC) and complemented by transport-related emissions derived from the logistic model, as outlined in section 4.1.2. The JRC calculated full life cycle emissions for the most common biomass feedstocks, whereby for domestic biomass feedstock as well as several import streams from third countries, land use change emissions were defined to be zero, the assumption being that no carbon loss is taking place to produce the biomass, as in the case of waste or sustainably managed forests. The implemented *approach for calculating GHG performance* of solid and gaseous biomass used in electricity, heating and cooling followed the methodology outlined in the 2010 Biomass Report. For modelling purposes, the policy coverage of Green-X was extended in order to allow an *endogenous modelling of sustainability regulations for the energetic use of biomass*. If GHG-saving criteria were selected, as done within alternative policy options of applying EU-wide harmonised criteria, the GHG calculation procedure

[39] It is estimated that 164 Mtoe primary energy would be needed to reach final energy consumption projected in the baseline scenarios.

served to evaluate whether biomass pathways (technology/feedstock combinations) fulfil conditioned GHG constraints or not.[40] [41]

- *Sustainable forest management* (SFM) was assumed to be a proxy of all national regulations introducing biodiversity and ecosystem services criteria for wood fuel. Therefore, compliance costs of these regulations were assumed to be equal to compliance with SFM certification schemes, including costs resulting from both compliance with SFM requirements and chain of custody certification.

  For these, data from literature is used to estimate average costs. A premium of 1 €/MWh primary feedstock (corresponding to about 5 €/Mt in mass terms) was identified as suitable, representing a relatively high but reasonable estimate to reflect the associated burden for a biomass producer. Although SFM certification is not always required, for instance, it is encouraged, but not mandatory to obtain Green Certificates in Belgium (Walloon and Brussels region), proof of SFM is difficult without these certificates and therefore also considered as mandatory in the baseline scenario.
- *Minimum conversion efficiency standards* have been introduced in various countries as a condition for receiving financial support. Typically, they promote implicitly biomass use in CHP plants rather than electricity-only facilities or they promote biomass use in efficient heating installations. Thus, model implementation in the baseline case was done to apply financial incentives in countries that make use of such standards only to efficient biomass supply streams.[42]
- In addition to the above, some MS have been stimulating the *use of biomass CHP* via additional financial incentives, for instance, a bonus for CHP within a feed-in tariff system or a dedicated investment incentive for CHP. The detailed policy coverage within Green-X allows the inclusion of such dedicated financial incentives for CHP in the respective countries in a baseline case or the exclusion of them in a "no criteria" world.[43]
- Several MS introduced financial bonuses to promote *locally produced biomass* feedstocks. The model assumes that such additional financial incentives are offered to all domestic biomass in a baseline case and that all domestic biomass is used locally, that is without long-distance transport within the country. In some cases such incentives are constrained to certain feedstock types (for instance, energy crops or forestry biomass).
- To model those national regulations introducing *air emission limits* higher than EU standards, literature data was used to estimate the additional investment costs for biomass conversion plants to comply with these regulations in the respective countries.

4.1.5 Policy options

[40] In the case a pathway did not meet the threshold because of a too long transport distance, the model reattributed the biomass feedstock to another closer market that would allow the GHG saving criteria to be met.

[41] As described in Box 6, Green-X allows flexibility in applying such limitations. For example the user can select which technology clusters and feedstock categories are affected by the regulation both at national and EU level, and, additionally, applied parameters may change over time.

[42] Within Green-X and internal selection procedure was implemented to offer support only to those technology/feedstock combinations that fulfil the given constraint for the conversion efficiency.

[43] Note that in the baseline case and all other assessed cases an improvement of the efficiency and effectiveness of national RES support policies is already conditioned for the forthcoming years up to 2020. This implies already a dedication to technologies offering an efficient conversion of biomass feedstock and, thus, a prioritisation of combined heat and power (CHP) production compared to electricity-only facilities. Consequently, for those MS having used a stimulation of CHP differences in the support framework for RES CHP in the baseline case compared to the "no criteria" scenario are only applicable for the historic record – i.e. the years 2006 to 2011.

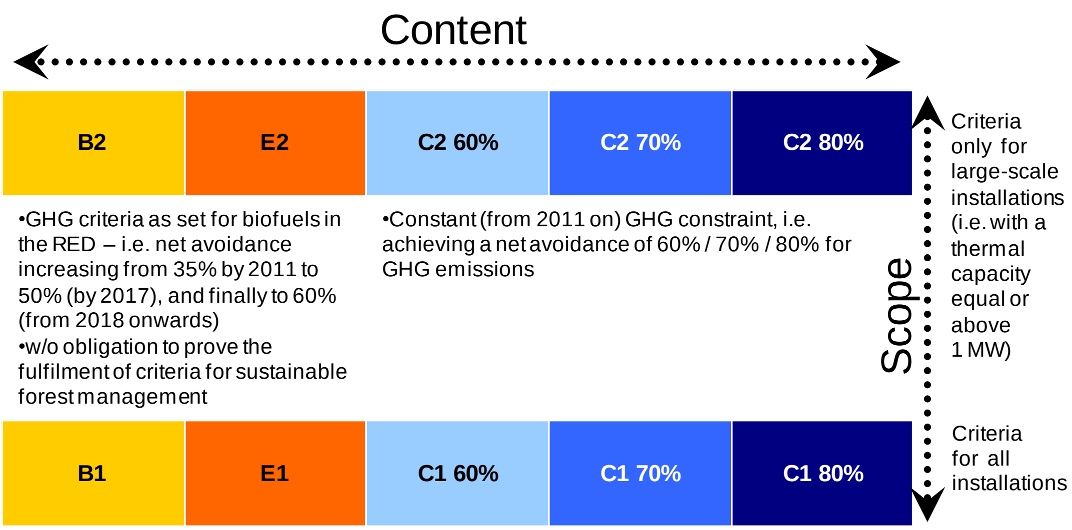
Three distinct policy pathways were defined that can be characterised as follows:

- A *"no criteria" scenario*, assuming no specific national sustainability regulations for biomass in place. This is constructed for all 27 MS separately and results are aggregated at EU level.
- A *"baseline" scenario*, subsequently named as policy option A, assuming a full implementation of national sustainability regulations for solid and gaseous biomass that have been developed (or announced for the near future) in the various MS (as listed in chapter 2 and contrasted in chapter 3).
- An *"EU criteria"* scenario assuming the adoption of common EU binding sustainability criteria for solid and gaseous biomass at the EU level, building on the recommendations made in the 2010 Biomass Report.

  As shown in Figure 11, a number of alternative policy options were modelled, including: option B (EU criteria similar to the biofuel ones), option C (biofuels criteria with higher GHG threshold), option E (option B + SFM requirement). The latter was modelled as a SFM certification obligation, building on cost data related to FSC and PEFC schemes.

  All three options were modelled in two different scenarios related to their scope: 1) application to all installations, 2) application only on large installations (above 1 MW), following the recommendation of the 2010 Biomass Report.

Figure 11: Policy options for EU-wide harmonised sustainability criteria



4.1.6 Overview on key energy parameters

In order to ensure maximum consistency with existing EU scenarios and projections, the key input parameters of the scenarios presented in this report are derived from PRIMES modelling and from the *Green*-X database with respect to the potentials and cost of RES technologies. Table 28 shows which parameters are based on PRIMES and which have been defined for this study. More precisely, the PRIMES scenario used is the "Reference Scenario" as of April 2010 (NTUA, 2010).

Table 28: Main input sources for scenario parameters

Based on PRIMES	Defined for this study
Sectoral energy demand	National RES supporting framework (in line with national 2020 RES targets)
Primary energy prices	Reference electricity/heat/transport fuel prices
Conventional supply portfolio and conversion efficiencies	RES cost (Green-X database, including biomass)
CO_2 intensity of sectors	RES potential (Green-X database)
	Technology diffusion and learning rates (Green-X database)
	Biomass supply – including biomass imports to the EU and specific costs for intra-EU transport
	GHG emissions of biomass cultivation, transport and use
	Sustainability regulations for solid and gaseous biomass for electricity and heating /cooling supply

Key energy developments include:

- Energy prices and demand: as stated above, key modelling parameters, such as future development of energy prices and final energy demand, are taken from the latest "Reference Scenario" of the PRIMES model (April 2010) for which key trends are summarised in Table 29.

Table 29: Evolution and projections of main energy indicators 1990-2020 [44]

Main indicators	1990	2000	2005	2008	2010	2020	Change over 2005-2020	Difference in 2020 (PRIMES 2010 vs 2008)
Population [Million]	470	481	489	498	499	514	5,0%	3,5%
GDP [1000 bn EURO'05]	8,1	10,1	11,1	12,5	11,4	14,2	27,9%	-9,7%
Gross/primary Inland Consumption	1660	1723	1826	1799	1767	1781	-2,5%	50,0%
Gross/primary Inland Consumption minus non Energy Uses [Mtoe]	1562	1611	1709	1685	1655	1664	-2,6%	1,0%
Final Energy Demand [Mtoe]	1069	1113	1174	1167	1169	1216	3,6%	-1,5%
Industry	366	327	326	318	313	330	1,2%	-6,2%
Residential	264	287	308	297	309	314	1,8%	0,8%
Tertiary	158	160	177	179	176	179	1,5%	4,4%
Transport	280	339	362	374	370	393	8,4%	-1,8%
CO2 emissions (Mt of CO2 ref approach)	4031	3811	3947	3787	3740	3404	-13,8%	2,0%
Energy Intensity (GIC/GDP [toe/M€'05])	204	171	165	167	155	126	-23,8%	11,4%
Import Dependency [%]	45%	47%	53%	55%	55%	57%	8,6%	-3,7%
Total Cost of Energy [bn €'05]	-	995	1161		1215	1750	50,7%	6,2%
Total Cost of Energy [% of GDP]	-	10%	10%		11%	12%	17,7%	17,6%

- Potentials and cost for RES: the potential and current and future cost of renewable energy technologies are derived from the *Green*-X model database on potential and cost for RES technologies in Europe. This database provides detailed information on current cost (that is the investment, operation and maintenance, fuel and generation cost) and potential for all RES technologies within each MS. The assessment of the economic parameters and accompanying technical specifications for the various RES technologies builds on data from other European and global

[44] Source: Eurostat until 2008 and PRIMES 2010 projections from 2010 onwards (reference case)

studies on this topic. The starting point for the assessment of realisable mid-term potential was the EU as of 2001 (EU-15), where corresponding data was derived for all MS initially in 2001, based on a detailed literature survey and an expert consultation. In the following, within the framework of the study "Analysis of the Renewable Energy Sources' evolution up to 2020 (FORRES 2020)" (see Ragwitz *et al* 2005) and various follow-up activities, comprehensive revisions and updates have been undertaken, taking into account recent market developments.

The latest revision was performed within the study "Financing Renewable Energy in the European Energy Market (RES-Financing)" (see Ecofys *et al* 2011). Again, a comprehensive update of cost parameters was undertaken, incorporating recent developments – that is the past cost increase mainly caused by high oil and raw material prices, and, later on, the significant cost decline as observed for various energy technologies throughout 2008 and 2009. The process included a survey of related studies (for instance, Krewitt *et al* 2009, Wiser *et al* 2009 and Ernst and Young 2009) and data gathering with respect to recent RES projects in different countries.

- National RES supporting framework: the modelling assumes full implementation of the European 20% renewable energy target in 2020, as required by the Renewable Energy Directive. It also assumes that national renewable energy support schemes will be further optimised in the future with regard to their effectiveness and efficiency. A "national perspective" is used in which each MS aims to fulfil its national renewable energy target on its own. The use of cooperation mechanisms as agreed in the Renewable Energy Directive is reduced to a necessary minimum: in the event that a MS does not possess sufficient RES potential, cooperation mechanisms could serve as a complementary option. Additionally, if a MS has sufficient RES potential, but its exploitation would cause significantly higher support expenditures compared to the EU average, cooperation could serve as complementary tool to ensure that the target is achieved. As a consequence of the above, the required RES support will differ by comparatively large amounts among the countries.[45]

- Reference prices for electricity, heat and transport fuels: reference prices for the electricity sector are taken from the *Green*-X model. Based on primary energy prices and the CO_2 price as used in the PRIMES reference case, and merged with country-specifics related to the power sector, the *Green*-X model determines country-specific reference electricity prices for each year in the period 2006 to 2020. Reference prices for the heat and transport sector are based on primary energy prices and the typical country-specific conventional conversion portfolio. Default sectoral reference energy prices, as conditioned in this assessment, are shown in Table 30. More precisely, these prices represent the EU average using the PRIMES reference case in 2010. Please note that heat prices in the case of grid-connected heat supply from district heating and CHP-plant do not include the cost of distribution. Instead, they represent the price directly at the defined hand-over point.

[45] In the "national perspective" case only weak economic restrictions are applied to limit differences in financial RES support applied among countries, that is maximum differences in country-specific support per MWh RES are set to 20 €/MWh. This approach taken for the use of cooperation mechanisms and for the RES policy scenario definition, respectively, is consistent to the one used in the RES-Financing study (Ecofys *et al*, 2011).

Table 30: Reference prices for electricity, heat and transport fuels[46]

Sectoral reference energy prices - on average at EU-27 level						
(default reference price development - based on PRIMES reference case)						**average (2011-20)**
(expressed per MWh output)	[Unit]	2006	2010	2015	2020	
Electricity price (wholesale)	[€/MWh electricity]	59.9	54.9	47.8	57.0	**51.5**
Heat price (grid-connected)	[€/MWh heat, grid]	38.1	40.0	37.7	45.2	**40.7**
Heat price (decentral)	[€/MWh heat, decentral]	69.6	73.3	66.5	75.8	**70.2**
Transport fuel price	[€/MWh transport fuel]	41.0	44.3	41.8	51.4	**46.6**

[46] Green-X, 2011 – based on PRIMES reference case (NTUA, 2011)

4.2 Baseline scenario

4.2.1 The role of biomass for meeting 2020 RES targets

Solid biomass and biogas are key for meeting the EU's 2020 RES target. According to the National Renewable Energy Action Plans (NREAPs), biomass for heating, cooling and electricity will supply about 44% of the 20% RES target by 2020 (110 Mtoe out of 244 Mtoe). The majority of this would come from solid biomass (94 Mtoe).

In principle, the Green-X baseline case confirms this expectation: according to the baseline scenario, the final demand of electricity and heating/cooling from biomass will amount to 25 and 94 Mtoe respectively by 2020, and 119 Mtoe in total. With this, bio-electricity and bio-heat will contribute about 47% to the total RES volumes (253 Mtoe) required for meeting the 2020 RES targets.[47]

Table 31: Overview of RES deployment by 2020 and the role of biomass according to the "baseline case" [48]

Overview of RES deployment by 2020 at EU level	Deployment by 2020 (final energy) [Mtoe]	Share in total RES [%]	Deployment by 2020 (final energy) of new installations (2011 to 2020) [Mtoe]	Share in total new RES [%]
Electricity sector				
Biomass	25.3	10.0%	17.0	11.2%
Hydro	32.0	12.6%	1.5	1.0%
Solar	8.9	3.5%	7.0	4.6%
Wind	47.5	18.7%	34.2	22.7%
Other RES	1.9	0.8%	1.2	0.8%
RES-electricity total	115.6	45.6%	60.8	40.3%
Heat sector				
Biomass	93.5	36.9%	60.4	40.0%
Geothermal	1.6	0.6%	0.7	0.4%
Heat pumps	6.5	2.6%	5.7	3.8%
Solar	8.1	3.2%	7.3	4.9%
RES-heat total	109.7	43.3%	74.1	49.1%
Transport sector				
Biofuels	28.1	11.1%	16.0	10.6%
RES total	253.4	100.0%	150.9	100.0%
of which Biomass	118.8	46.9%	77.4	51.3%

Table 31 (above) provides an overview of overall RES supply by 2020 and the role of biomass within it. Moreover, this table also offers an indication of the required RES expansion in forthcoming years, depicting the amount of electricity/heat/biofuels produced by 2020 that stems from new plants installed in the period 2011 to 2020 (including replacement of old plants). Electricity and heat from biomass is expected to

[47] For comparison, according to Green-X projections bioelectricity and bioheat contribute more than half of EU's overall RES supply at present (2010).

[48] Green-X, 2011

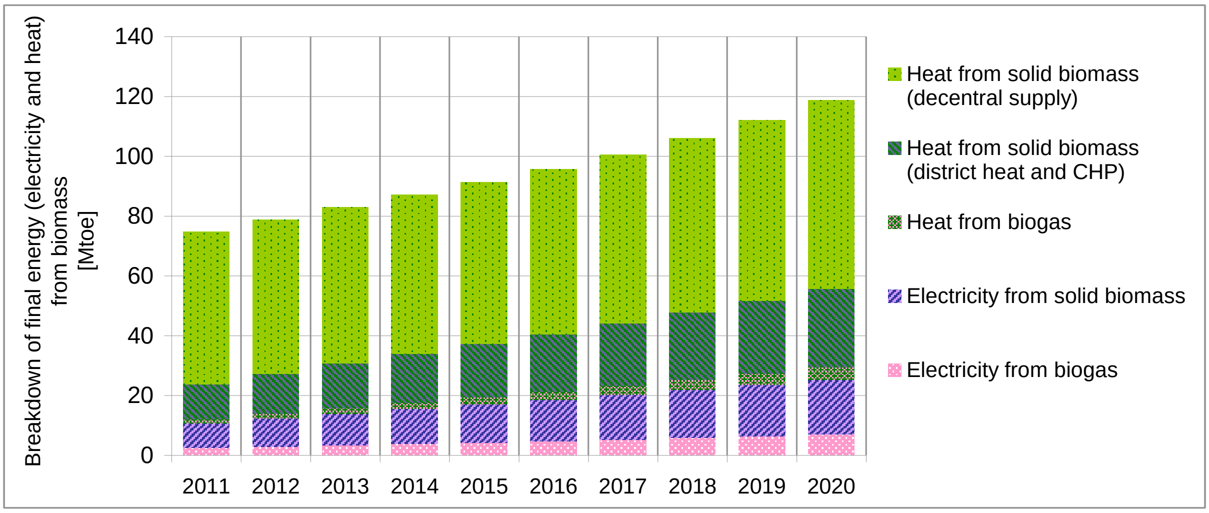
account for 51% of all energy produced from new installations by then. For heat, the replacement of the stock of existing biomass installations represents the substantial addition.

4.2.2 Biomass supply and demand in the heating, cooling and electricity sector

Figure 12 shows the deployment of biomass-based electricity and heat in the final energy demand between 2011 and 2020. Non-grid residential heating will continue to be the main final use, with a slight increase from 51.3 to 62.8 Mtoe, although its share will decline from 70.5% in 2006 to 44.6% in 2020 due to the rapid growth of Combined Heat and Power applications (CHP). Biomass use in district heating and in pure power generation shows a steady increase over time and reaches 6.7% and 6.6%, respectively in 2020.

The Green-X theoretical potential for domestic biomass[49] (equal to 280 Mtoe in 2020) serves as a basis for evaluating the domestic supply that can be effectively mobilised. In the Green-X baseline scenario, domestic biomass use is projected to increase by 57%, from 86 Mtoe in 2010 to 154 Mtoe in 2020. Forestry biomass will continue to be the main biomass source, rising from 66 Mtoe in 2010 to 89 Mtoe in 2020. Agricultural biomass is second, representing 38 Mtoe in 2020 (6 Mtoe in 2010), followed by waste which is projected to increase from 14 Mtoe in 2010 to 27 Mtoe in 2020.

Figure 12: Deployment of biomass-based electricity and heat generation [50]



4.2.3 Differences between Green-X and the National Renewable Energy Action Plans (NREAPs)

As far as biomass supply is concerned, Green-X projections (154 Mtoe in 2020) are higher than NREAPS projections. According to estimates based on available data available in 24 NREAPs, domestic biomass supply would amount to 110 Mtoe in 2020: 72 Mtoe from forestry biomass (up from 60 Mtoe in 2006), 16 Mtoe from waste (up from 8 Mtoe in 2006) and 21 Mtoe from indirect supply of agricultural biomass (up from 5 Mtoe in 2006). This gap can be explained by 1) not all data being available for the 27

[49] Green-X theoretical potential is presented briefly in section 4.1.3 and discussed in further detail in Appendix VII. To summarise, it indicates per country the maximum amounts of biomass that can be mobilised. Biomass from expensive resources such as expensive complementary fellings (forestry direct) is included in Green-X. The price of these biomass types are more expensive than forestry imports from abroad and are therefore likely only used in scenarios with high biomass demand.

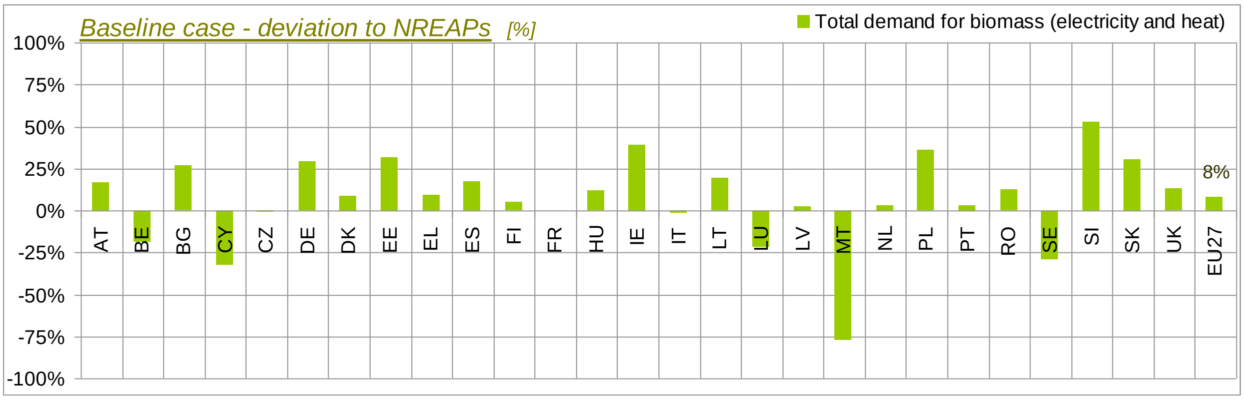
[50] Green-X, 2011

NREAPs, and 2) a conservative approach in the NREAPs analysis where it was considered that all direct supply of agricultural biomass would be dedicated to biofuels production (whereas part of this biomass was allocated to heat and electricity production in the Green X model).

On bio-heat and bio-electricity final consumption, NREAPs projections indicate that these could reach 110 Mtoe in 2020. Figure 13 shows the variation in final bio-electricity and bio-heat demand between the Green-X projections and national MS estimates contained in the NREAPs, where a positive variation means that Green-X projection is higher that NREAP estimate. At EU level, the reference scenario deviation compared to NREAPs estimates remains quite low, close to 8% (3% for the heating sector and 14% for the electricity sector). Power projections of the Green-X reference scenario do not take into account the impacts that recent nuclear phase-out plans in a number of MS may have on RES electricity.

Besides differences in the potential for various RES technologies, deviations between the reference scenario and NREAP estimates are due to assumptions on overall energy demand trends. The Green-X model demand projections are taken from the PRIMES model (PRIMES reference case 2010), for which gross final energy consumption in the EU by 2020 is about 9% higher than estimated in the NREAPs. This implies a higher final energy supply from renewable energy.

Figure 13: Deviation in final bio-electricity and bio-heat demand between reference scenario and NREAPS estimates [51]



4.2.4 Sensitivity analysis for the baseline scenario

The uncertainty of estimating future biomass mobilisation, including imports from third countries, implies that several sensitivities should be investigated. For this assessment, the sensitivity analysis is limited to the following elements:

- feasible potentials for imports of solid biomass from non-EU countries,
- design of underlying support schemes for biomass,
- the combination of both.

As default, the baseline scenario was assessed assuming a "best case" related to overall RES policy design, that is with strengthened and redesigned RES support to assure the meeting of 20% RES by 2020 at EU level in an effective and cost-efficient manner. Moreover, as default a conservative estimation was made to define feasible

[51] Green-X, 2011

future imports of solid biomass from non-EU countries, that is the "low imports" scenario. In order to assess the impact of using national sustainability regulations under non-perfect conditions, a sensitivity analysis was conducted for alternative assumptions, related to both imports and policy design. More precisely, the following assumptions were made:

- As discussed previously, imports of solid biomass from non-EU countries represent a key exogenous input to this modelling exercise. As default, industry expectations are reflected in the definition of pathways for such imports to the EU from various countries worldwide, characterising feasible amounts and related GHG emissions. Complementary to this default "low imports" scenario, a "high imports" case was developed. This assumes strong demand for biomass globally, creating increasing environmental pressure (for instance, land use change impacts). For analytical purposes, “dirty” import streams were formulated involving (short rotation) woody crop production and use of existing forests. With that, the volume of feasible biomass imports to the EU was assumed to double by 2020 in comparison to default expectations (that is imports of wood pellets rising from 6.4 to 12.8 Mtoe by 2020). For further details, refer to Appendix VII of this report.

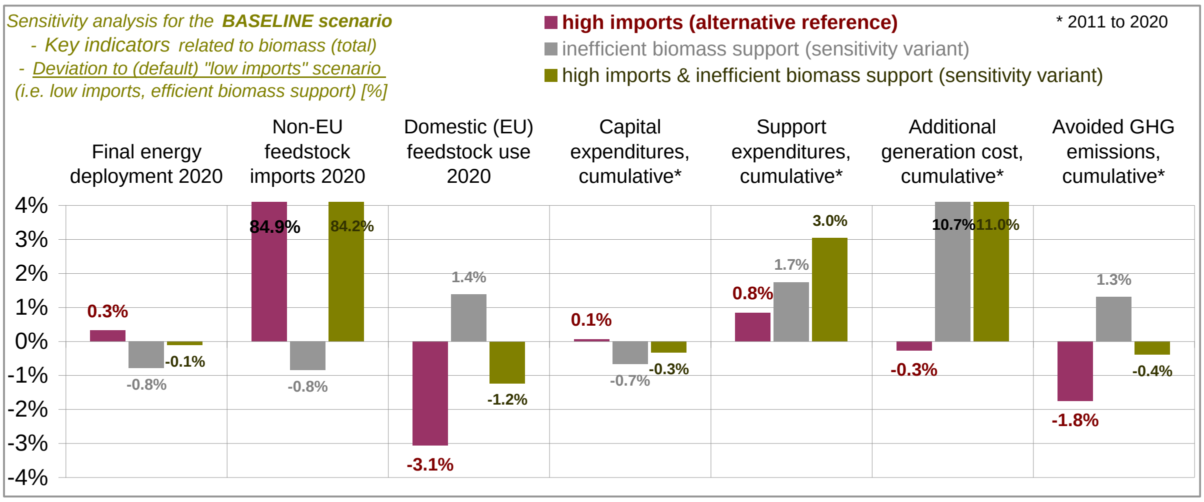
- The modelling assumes full implementation of the European 20% RES target in 2020, as required by the Renewable Energy Directive. For this policy pathway, a continuation of national RES policies until 2020 is assumed, whereby the assumption is taken that national RES support schemes will be further optimised in the future with regard to their effectiveness and cost-efficiency in order to meet the 2020 RES commitment. For the use of solid and gaseous biomass in the power sector, this implies a dedication to technologies offering an efficient conversion of biomass feedstock and, thus, a prioritisation of combined heat and power (CHP) production compared to electricity-only facilities. Under a “worst case” related to policy design, we assume however that no such dedication would be applied. It can be expected that under these policy conditions an inefficient use of biomass resources in the electricity sector and comparatively higher cost and expenditures occur.

Subsequent figures illustrate the impact of the above discussed alternative framework conditions on biomass deployment, feedstock use as well as on cost and GHG avoidance, for RES at the aggregated level and biomass in particular.[52] Both sensitivity options are assessed separately as well as in combination, and the deviations to default framework conditions are indicated.[53] Note that for total RES, the impact on RES deployment is neglected, as in all cases a similar RES volume (that is RES generation in final energy) is conditioned at EU level for 2020 (that is in all cases the fulfilment of the 2020 RES targets is preconditioned).

[52] Note that this sensitivity analysis refers to the baseline case. Thus, the assumption is taken that within all assessed scenarios national sustainability regulations remain in place.

[53] Default framework conditions shall mean “low imports” and a “best case” related to RES policy design, that is prioritising the use of CHP.

Figure 14: Comparison of key indicators for biomass at EU-27 level for the baseline case of applying "national (sustainability) criteria" under distinct framework conditions [54]

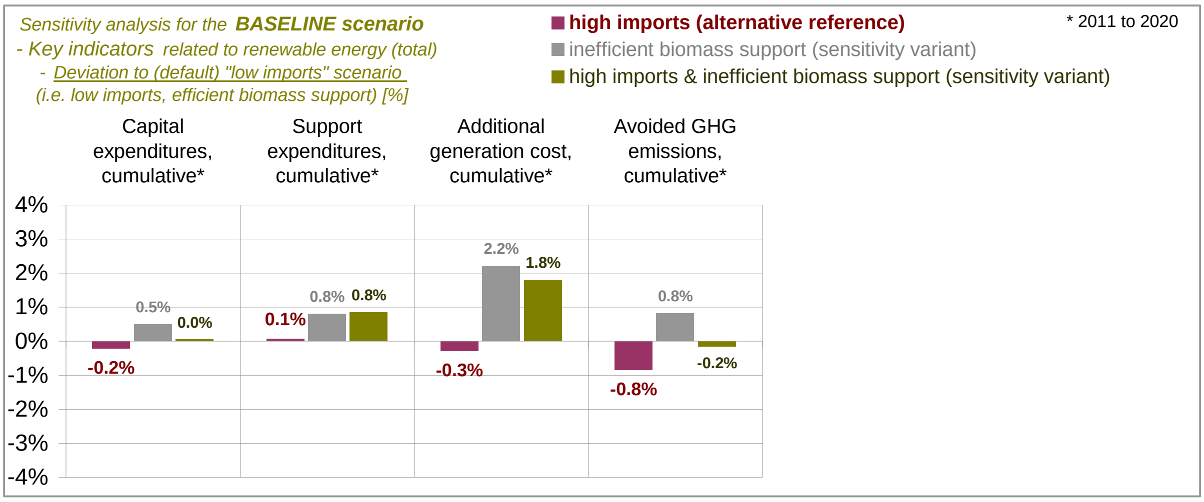


As shown in Figure 14, imports of solid biomass show the strongest deviations. An increase of import volumes is only applicable for the variants where "high imports" are assumed to be available to enter the EU market, these refer to the "high imports" scenario. In other words, in a baseline scenario no protection can be achieved against a (from an environmental viewpoint) "worst case" imports scenario. An increase of such imports leads to a decrease of GHG avoidance (see Figure 14 (biomass) and Figure 15 (total RES)) and coincides with a decreased use of domestic biomass feedstock. From an economic perspective the overall impact is less pronounced, that is for total RES additional generation cost and capital expenditures decrease, while for support expenditures an insignificant increase is applicable.

The modelling shows that inefficient biomass support has no impact on the share of biomass in final energy consumption. However, at sectoral level a redirection of biomass from heat to electricity takes place. The inefficient biomass use causes an increase in additional generation cost and support expenditures for biomass as well as for total RES, and, at first glance, surprisingly leads to an improved GHG performance. This impact is caused by the higher deployment of biomass in the electricity sector where GHG avoidance is generally higher in specific terms (replacing one MWh electricity generated from fossil fuels avoids more GHG emissions than in the case of fossil-based heat). Besides, in contrast to support expenditures and generation cost, capital expenditures appear less sensitive to changing framework conditions.

[54] Green-X, 2011

Figure 15: Comparison of key indicators for RES in total at EU level for the baseline case of applying "national (sustainability) criteria" under distinct framework conditions[55]



Finally, the combination of both "high (biomass) imports" and inefficient biomass support leads to a cost increase (additional generation cost, support expenditures) and a decrease of GHG avoidance, although overall impacts are less pronounced compared to the other sensitivity cases.

[55] Green-X, 2011

4.3 Assessment of impacts

This section presents the outcomes of the quantitative impact assessment, discussing key findings including impact on deployment (biomass and total RES, imported and domestic feedstock use), as well as environmental impacts (GHG reduction, land use) and economic consequences (capital and support expenditures). Moreover, qualitative aspects beyond the scope of the model-based assessment are presented.

4.3.1 Impact on bioenergy use (and overall RES deployment)

Generally, it can be expected that the introduction of sustainability regulations for biomass will have an impact on bioenergy deployment, by reducing feedstock availability or increasing costs. This could result in reduced deployment of renewable energy if financial support remains unchanged. Alternatively, in order to ensure that the 20% RES target for 2020 is reached, additional financial support is likely to be required to mobilise new biomass supply chains and non-biomass RES technologies.

Within this model-based assessment the assumption is taken that if stronger incentives are required to mobilise additional RES (including alternative biomass options), all countries increase their financial incentives in equal terms for all applicable RES technologies. While overall RES deployment at EU-27 level by 2020 would finally remain unchanged, it can be expected that as a consequence of modified support conditions, both the technology mix as well as the country-specific RES deployment would change compared to the default (reference) case.

A similar approach is also taken within the sensitivity analysis of the availability of biomass imports. Increased availability of comparatively cheap biomass feedstock, through imports from abroad, may affect RES support in a contrary way, leading to a decrease of financial incentives to avoid an overachievement of 20% RES by 2020.

Subsequently the impact of assessed sustainability regulations on the use of solid and gaseous biomass for electricity and heat production by 2020 is discussed. Firstly, the impacts on biomass-based production of electricity and heat / cooling are analysed, followed by an assessment of biomass supply via domestic (EU-based) feedstock and imports from third (non-EU) countries. Finally, the impact of applying different sustainability regulations for solid and gaseous biomass on overall RES deployment, specifically the resulting changes in sector and technology-specific deployment is discussed.

Biomass deployment in terms of final energy

Table 32 indicates the impacts of assessed sustainability policy options on biomass deployment, specifically in terms of final energy consumption.[56] Further details on the policy impact on sector-specific biomass deployment is subsequently given in Figure 16 for the "low imports" scenario of biomass feedstock from non-EU countries and in Figure 17 for the "high imports" scenario of biomass feedstock from non-EU countries, respectively. Both figures also contain a “no criteria” case assuming no specific sustainability regulations for biomass in place (in order to contrast the impacts of assessed sustainability regulations to a further extent).

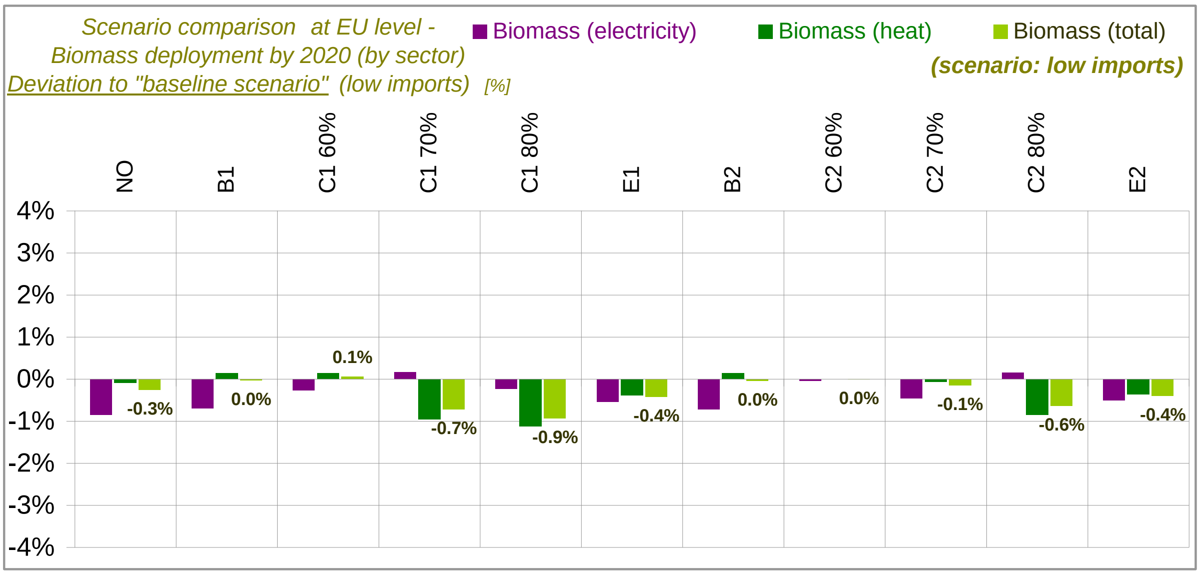
[56] More precisely, this table illustrates the change of biomass-based electricity and heat generation by 2020 at EU-27 level for all policy options (assuming EU wide harmonised sustainability criteria) against the corresponding baseline case of national criteria, assuming a “low” and “high imports” scenario from third countries. Thereby, changes to corresponding baseline case are expressed in absolute (produced ktoe of electricity and heat) and relative terms (the deviation expressed in percentage figures).

Table 32: Biomass deployment in terms of final energy by 2020, and change against the baseline [57]

Coverage (that is scope of policy options)	Policy options	Low imports scenario		High imports scenario	
		[ktoe]	[%]	[ktoe]	[%]
	Baseline case	*118,755*	-	*119,139*	-
All generators	B1	-39	0.0%	-640	-0.5%
	C1 60%	65	0.1%	-921	-0.8%
	C1 70%	-856	-0.7%	-1,048	-0.9%
	C1 80%	-1,111	-0.9%	-2,872	-2.4%
	E1	-503	-0.4%	-1,887	-1.6%
Equal or above 1 MW	B2	-53	0.0%	108	0.1%
	C2 60%	-12	0.0%	154	0.1%
	C2 70%	-178	-0.1%	-145	-0.1%
	C2 80%	-758	-0.6%	63	0.1%
	E2	-468	-0.4%	-1,228	-1.0%

Under "low imports", applying criteria to large installations leads to a certain decrease of biomass deployment, specifically where the most stringent criteria are in place (option C2 70% and 80% and option E2). This analysis is also valid when criteria apply to all installations, but the decrease is even more pronounced. Regarding the balance between EU domestic supply and imported biomass, there is a correlation between the decrease of overall biomass deployment and the decrease of imports of biomass from third countries that would be partly (but not fully) compensated by EU domestic biomass.

Figure 16: Sector-specific biomass deployment in terms of final energy by 2020 under "low (biomass) imports", change in % against the baseline [58]



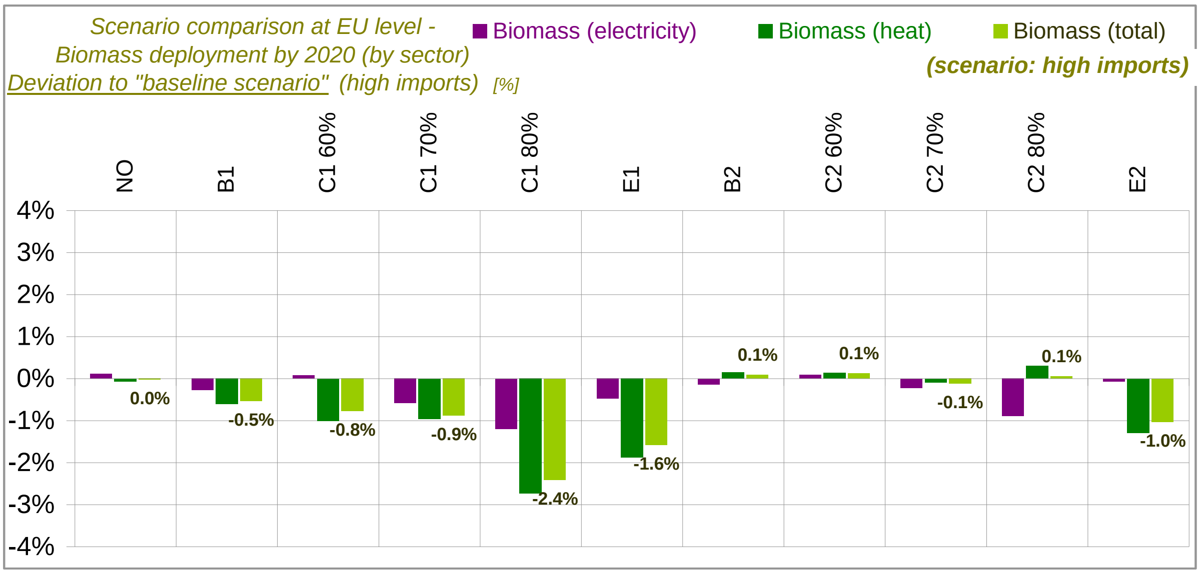
[57] Green-X, 2011
[58] Green-X, 2011

Next, we discuss the deployment impacts of individual policy options in further detail, all referring to a "low imports" scenario:

- The "No criteria" scenario, policy option B (1 and 2) and C (1 and 2) 60% show no significant change compared to the baseline case ("national criteria"), even if EU-wide harmonised criteria are applied to all installations (option 1 regarding scope of regulations).
- SFM as conditioned in case E (1 and 2) plays a role and has a certain impact on biomass deployment, which can be explained as twofold: on the one hand, the overall potential for imports is reduced (compare Table 34 on use of imports) as certain import streams do not match SFM requirements, and, on the other hand, the corresponding certification requirement represents additional cost for the affected biomass streams (affecting import chains as well as forestry biomass, specifically the "non-waste" streams such as complementary fellings), obviously with negative impact on their competitiveness.
- Stricter GHG constraints (option C with 70% and 80%) cause a certain redirection of biomass use towards more efficient conversion and feedstock options. This depends, however, on whether the whole biomass market is affected (option C1 criteria applied to all installations) or only a limited segment (option C2 criteria applied to large size installations). A 70% GHG constraint applied to large installations only (case C2 70%) creates some "leakage", that is biomass feedstock that cannot meet the GHG constraint is diverted from large- to small-scale operators that do not have to meet any criteria. Thus, a (moderate) decrease of deployment in the electricity sector becomes apparent. Under an 80% GHG constraint similar problems with respect to leakage are applicable, but the overall impact on biomass deployment is more pronounced, that is less biomass use in total.[59] Only if all biomass installations have to fulfil the GHG constraints, leakage can be avoided and sustainability regulations perform as expected, that is causing a phase-out of unwanted supply streams.

[59] Under a stringent 80% GHG constraint (C2 80%) a comparatively strong decrease of bio-heat is apparent, while bio-electricity appears unaffected. This stands in contrast to C2 70% where rather the opposite trend is observable (less bio-electricity, but also less pronounced). The reason for these trends is that under more stringent criteria more biomass supply streams (also within the heat sector) are no longer eligible, and not all of them can be diverted to unaffected small-scale operators. In order to assure overall RES target compliance, stronger support is now required to mobilise alternative RES options (including alternative biomass streams) that have to compensate the resulting gap. Within the biomass sector this leads to an increased deployment of more costly, but obviously also more efficient conversion technologies (for instance, CHP) and/or "cleaner" feedstock (characterised by less GHG emissions). Thus the electricity sector offers a broader variety of such options.

Figure 17: Sector-specific biomass deployment in terms of final energy by 2020 under "high (biomass) imports", change in % against the baseline [60]



In the case of "high imports" we observe similar trends as under "low imports", but, overall, impacts of individual policy options on biomass deployment appear more pronounced. A closer look on individual policy options is taken subsequently:

- Options B2 and C2 (all variants, from 60% to 80%) would only have a limited impact on overall biomass deployment (+/-0.1%). Here, one can clearly observe the possible leakage phenomena as discussed above for "low imports". In contrast to "low imports", stringent GHG criteria would not impact the level of biomass supply (domestic and imported) as imported pellets that cannot meet GHG constraints applied to large-scale plants appear perfectly suitable for use in small-scale installations.[61]
- Under option E2 (with SFM criteria), biomass imports and overall biomass deployment would decline. The reasons are similar to what has been discussed previously for "low imports", that is SFM introduces additional cost and certain import streams would not qualify with SFM standards and, consequently, such imports would not happen.
- Options B1, C1 and E1 would all lead to a significant decrease of imports from third countries, partially (but not fully) compensated by an increase of EU biomass supply. Overall, less biomass would be used in the energy market. Due to the strong impact on biomass imports the magnitude of decrease is significantly higher compared to "low imports". The strongest decrease is applicable for option E1 (1.6%) and C1 80% (2.4%).

[60] Green-X, 2011

[61] A stringent 80% GHG constraint applied only to large scale users causes a decrease of bio-electricity while the demand for bio-heat shows a slight increase. This stands in contrast to the observation under "low imports" where the opposite trend is apparent. The reason for this is the high amount of imported pellets that appear perfectly suitable for heat and electricity production in large- and small-scale installations. Thus, a strong regulation for large installations causes a rededication towards small-scale uses. Wood pellet heating systems play an important role in heat supply already in several countries, and, thus, such systems posses a competitive advantage to other small-scale options in the electricity sector.

Use of EU biomass feedstock

The impact of assessed sustainability policy options on the use of EU[62] biomass feedstock is illustrated in Table 33.[63]

Table 33: EU biomass feedstock use by 2020, change against the baseline [64]

Coverage (that is scope of policy options)	Policy options	Low imports scenario		High imports scenario	
		[ktoe]	[%]	[ktoe]	[%]
	Baseline case	*157,369*	-	*152,536*	-
All generators	B1	-188	-0.1%	4,673	3.1%
	C1 60%	-29	0.0%	4,454	2.9%
	C1 70%	-563	-0.4%	5,023	3.3%
	C1 80%	1,381	0.9%	5,985	3.9%
	E1	586	0.4%	4,604	3.0%
Equal or above 1 MW	B2	-210	-0.1%	51	0.0%
	C2 60%	10	0.0%	57	0.0%
	C2 70%	-315	-0.2%	-198	-0.1%
	C2 80%	-709	-0.5%	-203	-0.1%
	E2	635	0.4%	5,253	3.4%

Similar to overall biomass deployment, the impact of assessed sustainability regulation options on the use of EU biomass feedstock remains small in a "low imports" scenario. In contrast, in the case of a "high imports" scenario and sustainability regulations that effectively protect against undesired “dirty” (GHG emission intensive) biomass streams a strong increase of EU feedstock use is apparent. This underpins the fact that certain EU biomass feedstock streams represent the marginal option in the biomass market, and, consequently, they would (partly) compensate a decrease of imports in the case of more stringent regulations.

Biomass imports to the EU

As shown in Table 34, biomass imports from non-EU countries are sensitive to sustainability regulations.[65] Strong differences exist between both baseline cases with respect to the projected use of inter-EU biomass imports. This appears obvious, as in the baseline case, referring to the "high imports" scenario, the potential of feasible biomass imports is 94% higher. Interestingly, under baseline conditions the projected use of imports for electricity and heating/cooling increases by only 85%. This is a consequence of an increased use of imported biomass for second generation biofuels in the transport sector in the case of "high imports" scenario.

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[62] From a country perspective, EU biomass feedstock means the use of domestic as well as imported biomass from other MS, incorporating intra-EU biomass trade.

[63] This table illustrates the change of EU-27 biomass feedstock use (for electricity and heating/cooling) against the corresponding baseline case (of national criteria) by 2020 at EU-27 level for all policy options (assuming EU wide harmonised sustainability criteria). Again, two distinct scenarios of biomass feedstock imports to the EU, assuming a “low” and “high imports” scenario, are applied to set the frame, and changes to the corresponding baseline case are expressed in absolute (ktoe of feedstock use) and relative terms (deviation expressed in percentage figures).

[64] Green-X, 2011

[65] This table illustrates the change related to biomass feedstock imports from non-EU countries (used for electricity and heating/cooling) against the corresponding baseline case (of national criteria) by 2020 at EU-27 level for all policy options (assuming EU wide harmonised sustainability criteria) under two distinct biomass import scenarios. Thereby, changes against the corresponding baseline case are expressed in absolute (ktoe of feedstock use) and relative terms (deviation expressed in percentage figures).

Table 34: (Additional) imports of solid biomass feedstock from non-EU countries by 2020, change against the baseline [66]

Coverage (that is scope of policy options)	Policy options	Low imports scenario		High imports scenario	
		[ktoe]	[%]	[ktoe]	[%]
	Baseline case	*6,261*	-	*11,579*	-
All generators	B1	-69	-1.1%	-5,340	-46.1%
	C1 60%	-33	-0.5%	-5,361	-46.3%
	C1 70%	-171	-2.7%	-6,367	-55.0%
	C1 80%	-2,440	-39.0%	-9,186	-79.3%
	E1	-1,260	-20.1%	-6,671	-57.6%
Equal or above 1 MW	B2	-69	-1.1%	2	0.0%
	C2 60%	-66	-1.1%	105	0.9%
	C2 70%	-79	-1.3%	45	0.4%
	C2 80%	37	0.6%	-36	-0.3%
	E2	-1,261	-20.1%	-6,556	-56.6%

Generally, imports of solid biomass appear highly sensitive to the detailed design of sustainability regulations and the magnitude of changes is significant compared to domestic supply. This is caused by the fact that imports possess comparatively high GHG emissions, generally related to transport and pre-processing. Moreover, in the "high imports" scenario for certain import streams high GHG emissions occur due to the associated direct land use change.

Notes on the individual policy options include:

- Independently from the detailed framework conditions (scope of regulations and volume of feasible import potentials) SFM, as conditioned in case E1 and E2, has a strong impact on imports as those streams not matching with the underlying criteria would actually not be imported to the EU. Thus, in the "low imports" scenario only one import stream is non-eligible, causing a reduction of 20% compared to baseline. Under "high imports" scenario, all undesired “dirty” import streams would not be eligible, reducing imports by 57 to 58% compared to the corresponding baseline.
- Besides SFM, in the case of "high imports" scenario only a common EU-wide regime applied to all installations would protect against undesired “dirty” imports (compare B1 or C1 with B2 or C2).
- Strict and even moderate GHG criteria would cause a redistribution of imports from heat to electricity, as an efficient CHP plant allows the best means to meet higher GHG constraints. However, that would only take place if leakage of affected biomass streams from large to small operators is avoided, meaning the application of sustainability criteria to all and not only to large operators (compare C1 with C2 variants).

Trade aspects – Inter- & intra-EU trade of biomass

Intra-EU trade of biomass, used for heating & cooling and electricity generation, is not clearly accounted in current statistics. We observe at present a significant amount of overall biomass trade within the EU, but only a certain fraction of that refers to energy uses. The majority of traded biomass falls under material use, whereby energy

[66] Green-X, 2011

represents only a by-product in the overall production chain. Thus, the challenge is to identify which amount of traded biomass refers directly to the energy-related uses.

From January 2009 onwards, the statistical accounting has however improved, as *wood pellets* are recorded by EUROSTAT (CN code: 4401 30 20).[67] Although these statistics provide insight into the production, import and export of wood pellets for intra- and extra-European markets, these statistics are not complete and inconsistencies between import and export figures are still found. Total imports of wood pellets at EU-27 level amounted to 3.9 million tonnes in 2009, whereby 55% can be classified as "Intra-EU trade". In energy terms this corresponds to about *0.9 Mtoe* (2009). It can be expected that total volumes of Intra-EU biomass trade (including wood chips, fuel wood and waste wood) that refers to energy-related uses are twice as high.

The Green-X model indicates an increase of such Intra-EU trade of solid biomass used for heating and cooling and electricity generation to about *7 Mtoe by 2020* (corresponding to 4% of total biomass supply in the related energy sectors). Obviously, the absolute and relative volume differs by scenario, depending on the overall support framework, the availability of inter-EU imports and the sustainability criteria conditioned. Overall, this does not appear impressive at first glance; however the following aspects are of relevance in this respect:

- As stated above, the majority of current biomass traded within Europe refers to other than energy-related uses. Thus, if energy represents only a by-product in the overall production (for instance, in the pulp and paper industry) this is not accounted for in the figure above that includes only energy-related intra-EU biomass trade.
- Imports from third countries are often cheaper than domestic potentials or imports from other EU countries. Thus, strong competition is observable at present and is also expected for future years.
- Biomass from waste represents a significant part of current and future biomass supply used for heating and cooling and electricity generation. Such feedstock options are generally less suitable for trade.
- For achieving national 2020 RES targets, all EU countries require strong growth in the RES sector and, consequently, demand for biomass is expected to increase in all countries significantly. Thus, for a domestic biomass producer, there is less need to look for export possibilities.

According to the conducted scenarios, <u>total trade flows of both inter- and intra-European biomass</u> are expected to range from 13.5 to 18.8 Mtoe in the EU-27 by 2020 under a "high imports" scenario (related to imports from third countries). Green-X calculates the amounts of traded bioenergy commodities based on cost of domestic biomass resources compared to marginal cost of imported biomass commodities and the cost of competing RES technologies. In the "low imports" scenarios, less biomass is available from non-EU countries. In these scenarios, intra-European trade of biomass commodities is generally about 1.1 to 1.3 Mtoe larger compared to the "high imports" scenario whereas biomass imported from non-EU countries is at maximum about 5.7 to 5.8 Mtoe smaller.[68] This implies that intra-European resources cannot fully compensate for the reduced imports from outside the EU.

[67] According to expert opinions wood pellets can be classified as the main traded commodity of solid biofuels due to its relatively high calorific value and manageability.

[68] Data on imports and domestic biomass use differ by assessed policy case, expressed data refer exemplarily to the baseline case (option A) and option C2 (70%).

As illustrated in Appendix VI, forestry residues and forestry products are almost used to their full potential in all scenarios by 2020. Marginal supply of lignocellulosic feedstocks therefore comes from agricultural products, including grassy crops or short rotation coppice. Intra-European trade flows of agricultural products and agricultural residues are therefore up to 30% larger if fewer imports from 3rd countries occur.

Box 8: Competition with other wood industry

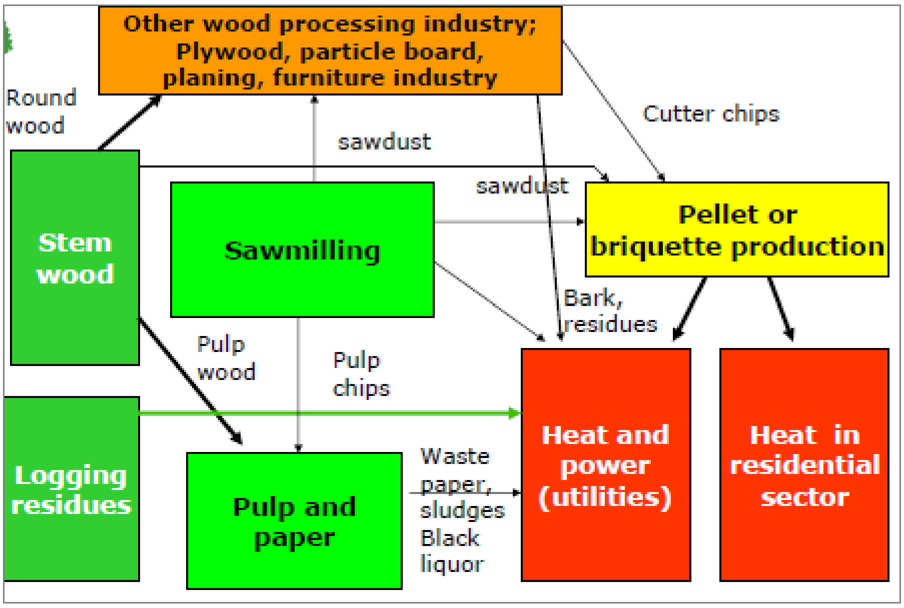
The potential competition in final use of wood raw material was reviewed at the EU level by the Eubionet III project where the use of wood in the different MS was reported. The differences arise from the total growing stocks of each country and other uses such as the production of pulp and paper, industry demand prospects of this industry and the flow of the raw material among countries in the EU. Figure 18 presents some of the sectors of competition of woody raw material as they were reported by the Eubionet III project in each MS.

The Eubionet project conducted a survey with the woody industry and some important remarks regarding the sustainability assessment of the sources of the wood and the competition included:

- sustainable wood energy development is needed,
- price elasticity of raw material (increased demand means higher biomass prices) needs to be reviewed,
- danger of disappearance of forest industry and lack of raw material (policies favour the energy sector, but whole value chain should be considered),
- wood panel industry has traditionally used lower value forest products, and this is threatened by the bioenergy support actions
- increase biomass and wood production (production support for wood),
- different sectors have to co-exist in a balanced and sustainable market, maybe a segmentation of the wood (with national support actions),
- competition against other countries,
- policies have huge impact on the forestry sector,
- national regulation of woody material specification for biomass,
- rules should be long term.

The EU has strong standards for forestry such as the Forest Stewardship Council (FSC) or the PEFC. In addition, some countries, such as the UK, have additional standards, such as the Woodland Assurance Standard (UKWAS). This standard has been designed for use in the certification of UK woodlands and forests, enabling independent third party verification of sustainable forest management practices (Moore, ny). Other countries (such as Sweden) have national interpretations of the PEFC.

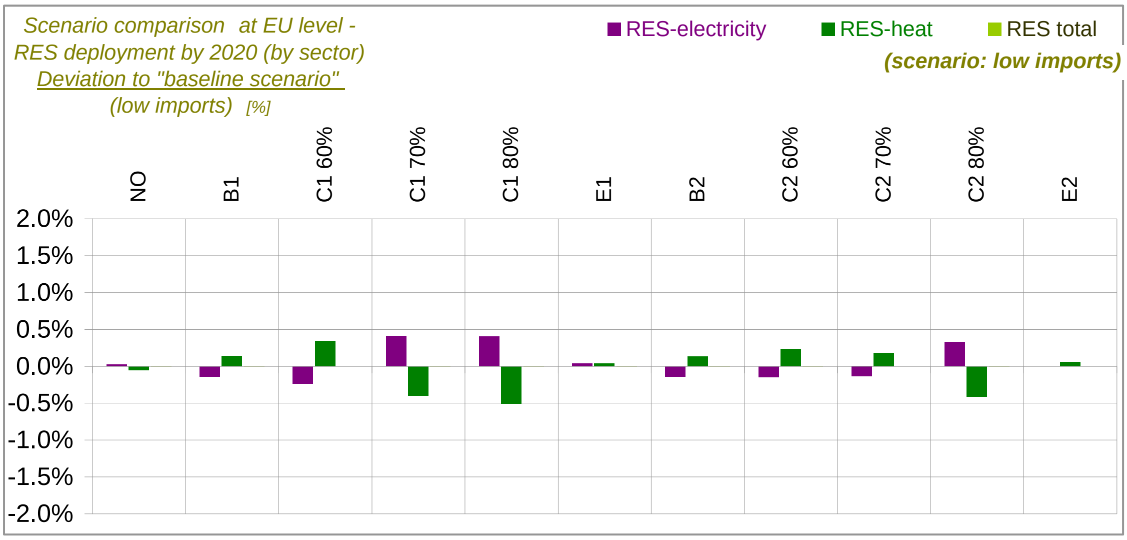
Figure 18: Competition of woody raw material [69]



RES deployment in terms of final energy

Impacts of assessed sustainability policy options on overall RES deployment (in terms of final energy) at the sector level are illustrated in Figure 19 for the "low imports" scenario and in Figure 20 for the "high imports" scenario, respectively.[70]

Figure 19: Sector-specific RES deployment in terms of final energy by 2020 under "low (biomass) imports", change in % against the baseline [71]



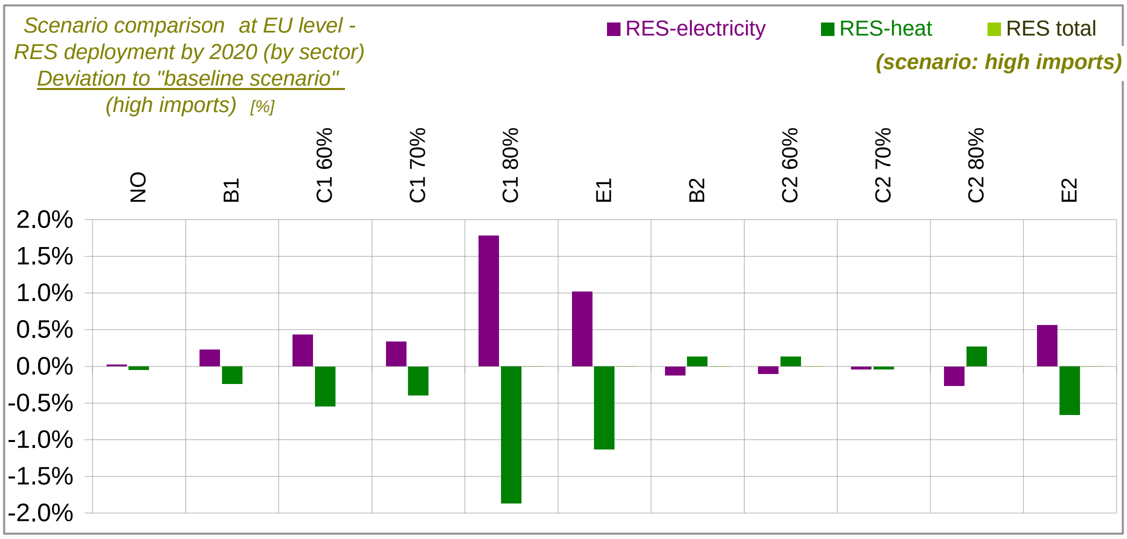
69 Source: Keränen and Alakangas, 2011

70 These graphs depict the change (against the corresponding baseline) of total RES-electricity and total RES-heat generation by 2020 at EU-27 level for all policy options (assuming EU wide harmonised sustainability criteria) under distinct scenarios of biomass feedstock imports from third countries. Thereby, changes to corresponding baseline case are expressed in relative terms (the deviation expressed in percentage figures). Both figures also include a "no criteria" case assuming no specific sustainability regulations for biomass in place (in order to contrast the impacts of assessed sustainability regulations further).

71 Green-X, 2011

It should be noted that the achievement of the 20% RES target is a given condition for all the modelled scenarios. Generally, impacts on sectoral RES deployment are only apparent in the case of strict GHG constraints and/or if criteria are applied to all installations (and not only to large ones). Another more general trend is that with effective sustainability regulations, a shift from RES-heat towards RES-electricity takes place. Two aspects appear of relevance in this respect: on the one hand, RES-electricity may serve better as a mitigation option since more RES options are applicable that compensate the decrease of biomass in case of strict regulations. On the other hand, the decrease of RES-heat in total coincides well with the decrease of bio-heat due to the substantial amount of biomass used in the heating sector of most MS.

Figure 20: Sector-specific RES deployment in terms of final energy by 2020 under "high (biomass) imports", change in % against the baseline[72]



4.3.2 Environmental impacts

The assessment of environmental impacts is limited to implications on GHG emission avoidance and land use change. With respect to GHG savings, we first assess the direct impact on biomass-related GHG emission avoidance and then discuss the overall impact for RES.

GHG emission savings

Under the baseline scenario GHG saving requirements for solid and gaseous biomass have been introduced only in two MS.[73] This situation creates an uneven playing field, whereby biomass pathways that deliver less than optimal GHG emission savings are still being incentivised in most MS. Additionally, MS may opt for calculating GHG emissions differently compared to the EU methodology, which may lead to significant divergence in results. As a consequence, this option is likely to result in less than optimal GHG savings under the "high imports" baseline scenario (assuming worst land use change). According to the modelling exercise related to the baseline scenario (section 4.2), biomass-related GHG emission savings would decrease by 1.8% under "high (biomass) imports" compared to the default case of "low imports". The overall

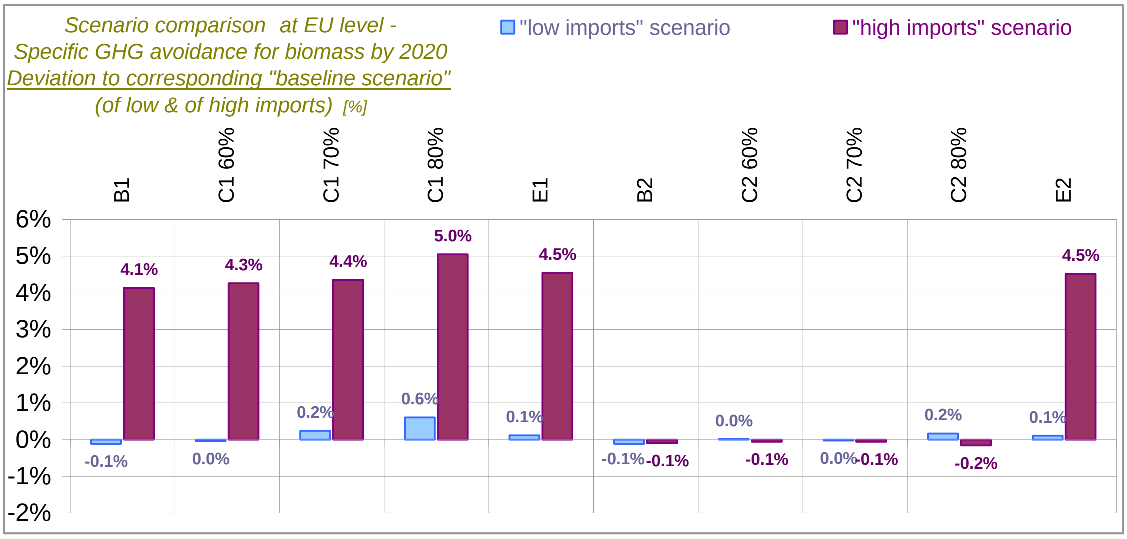
[72] Green-X, 2011

[73] UK and Belgium. In addition, Austria implemented a regulation promoting GHG savings of more than 45%, but only for biogas production

impact on GHG emission savings from total RES is obviously less pronounced as applicable in Figure 15, GHG savings decrease by 0.8% in the baseline case under "high imports" scenario (compared to "low imports").

To illustrate the impact of assessed sustainability policy options on GHG emission avoidance, we start with a closer look on the direct impact on biomass-related GHG savings. In this context, Figure 21 illustrates the impact of different sustainability criteria on specific[74] GHG savings for biomass, as change against the baseline.

Figure 21: Specific GHG emission avoided by biomass use by 2020, change in % against the baseline [75]



Under the "low imports" scenario, the introduction of sustainability criteria can lead to either a minor increase or decrease in GHG emissions depending on the policy option implemented. This is particularly true when criteria are applied only on large installations (above 1 MW). If criteria are applied on all bioenergy installations, a clear correlation between the level of stringency of criteria and the increase of carbon savings can be observed, that is GHG savings increase from 0.0% (C1 60%) to 0.6% (C1 80%).

Under the "high imports" scenario the scope of a regulation has a significant impact: if criteria are applied only to large operators, there is no change in specific carbon savings against the baseline scenario, with the exception of option E2 where SFM requirements will lead to substantially higher GHG savings (+4.5%). This shows that such policy option would do little to avoid the use of biomass supply chains that deliver low or no GHG savings. The application of the GHG saving requirements to all bioenergy facilities leads to significant GHG savings, with a change against the baseline ranging from 4.1% (option B1) to 5.0% (option C1 80%).

Table 35 shows the changes against the baseline of the cumulative GHG emission reduction for all RES for the period 2011 to 2020.[76] Further details on the policy impact

[74] Specific emission savings shall hereby mean the amount of GHG savings per unit of final energy (stemming from biomass).

[75] Green-X, 2011

[76] More precisely, this table indicates the change of cumulative (2011 to 2020) GHG emission avoidance for total RES at EU-27 level for all policy options (assuming EU wide harmonised sustainability criteria) against the corresponding baseline case of national criteria, assuming a "low" and "high imports" scenario. Changes

on sector-specific cumulative carbon savings due to RES(-electricity, -heat and total) is subsequently given in Figure 22 for "low imports" baseline scenario of biomass feedstock from non-EU countries and in Figure 23 for "high imports" baseline scenario of biomass feedstock from non-EU countries, respectively. A "no criteria" case assuming a scenario where neither national nor EU sustainability criteria were introduced was also developed to provide further reference for the assessment.

Table 35: Cumulative GHG emission savings for total RES, change against the baseline (2011 to 2020, M tonnes CO_2-eq. and % change)[77]

Coverage (that is scope of policy options)	Policy options	Low imports scenario		High imports scenario	
		[M tonnes]	[%]	[M tonnes]	[%]
	Baseline case	*10,430*	-	*10,341*	-
All generators	B1	9	0.1%	114	1.1%
	C1 60%	3	0.0%	113	1.1%
	C1 70%	64	0.6%	139	1.3%
	C1 80%	82	0.8%	160	1.5%
	E1	36	0.3%	145	1.4%
Equal or above 1MW	B2	9	0.1%	0	0.0%
	C2 60%	4	0.0%	-5	0.0%
	C2 70%	7	0.1%	9	0.1%
	C2 80%	43	0.4%	-9	-0.1%
	E2	36	0.3%	138	1.3%

Since biomass is expected to comprise less than half of total RES volumes by 2020, the overall impact of sustainability regulations for biomass on GHG emission savings from total RES is obviously less pronounced than direct impacts related to biomass as discussed previously. Changes in carbon savings for total RES under assessed policy options are however generally a result of modified biomass deployment.

Under the "low imports" scenario, options B2 and C2 (60% and 70%) lead to no carbon savings (up to 0.1%). Carbon savings become more apparent in the case of an 80% threshold (0.4%). Under options B1 and C1, whereby criteria are applied to all bioenergy installations, only a 70% threshold leads to significant GHG savings. The leakage phenomenon, whereby biomass could be diverted away from large to small scale operators in the case of criteria applied only to large installations, appears to be limited, that is the comparison of C2 and C1 for an 80% threshold indicates additional GHG savings of 39 Mt CO_2-eq., corresponding to an increase by 0.4%. This result is due to two factors:

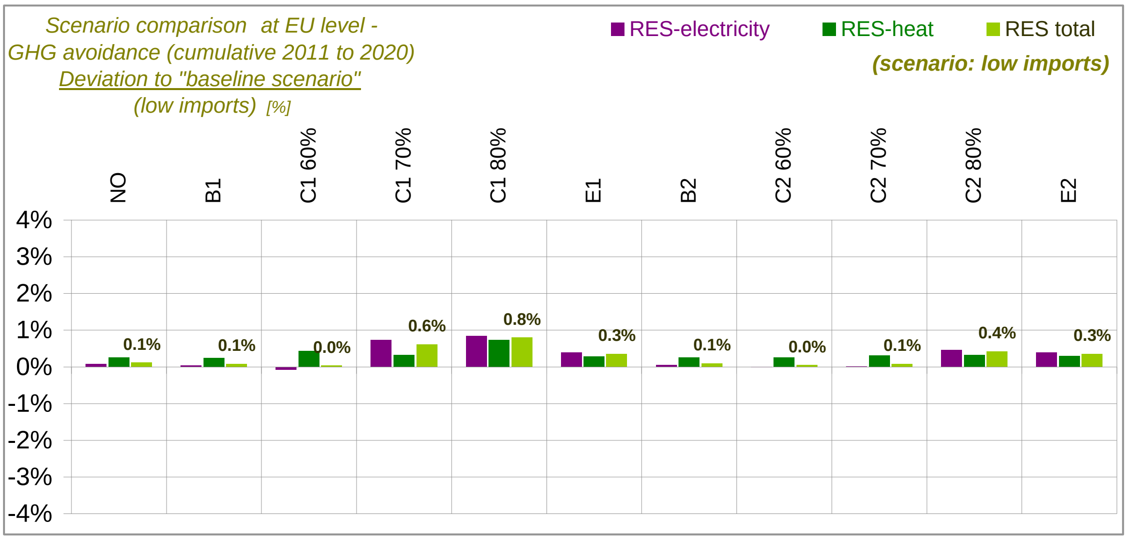
a) under the "low imports" scenario, imported biomass is not associated with worst land use change impacts and the related emissions;

b) typical EU biomass feedstocks are not associated to land use change and therefore have a good GHG performance.

to corresponding baseline case are expressed in absolute (that is avoided Mt CO_2-eq emissions) and relative terms (the deviation expressed in percentage figures).

[77] Green-X, 2011

Figure 22: Sector-specific cumulative (2011 to 2020) GHG emission savings for total RES under "low (biomass) imports", change in % against the baseline [78]



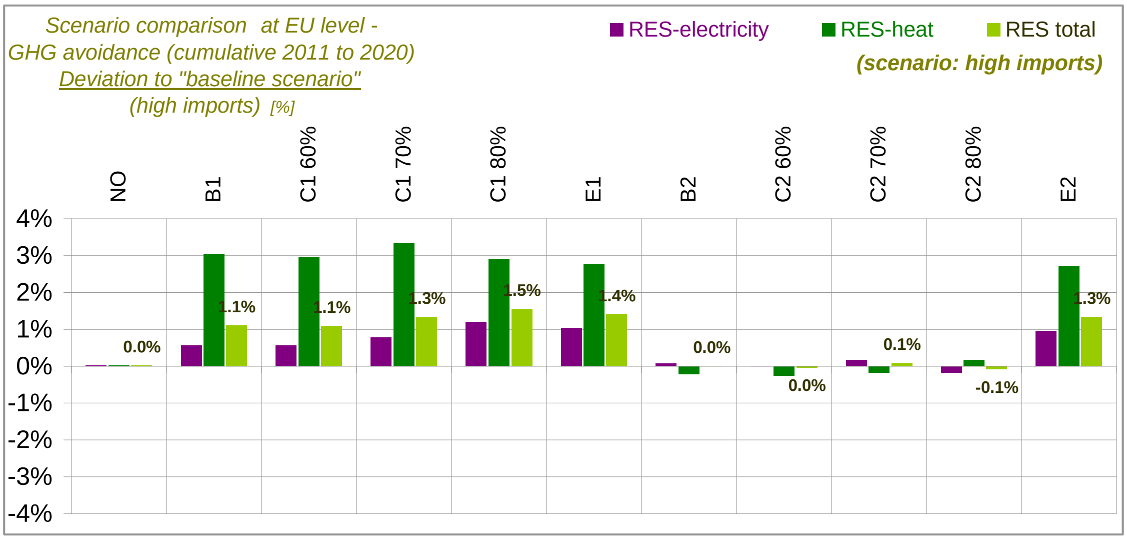
Under a "high imports" scenario, similar to the "low imports" scenario, options B2 and C2 (all thresholds) would have a limited effect on carbon savings in comparison to the corresponding baseline case (of "national criteria"). Under these policy options massive biomass imports would enter the EU market. As discussed in detail in section 4.3.1 imports only partly replace EU biomass feedstocks and, consequently, a slight increase of overall biomass use is apparent. At first glance, surprisingly, stringent GHG constraints (C2 70% or 80%) do not affect this overall trend. This counterintuitive impact suggests that the introduction of sustainability criteria causes a leakage effect as discussed previously.[79] As a result, there would be an overall increase of unsustainable biomass use by small-scale producers, instead of the large-scale operators that would have used it in a baseline case ("national criteria") or if no regulation had been in place.

Only a SFM requirement as conditioned in option E2 would lead to higher GHG emissions avoidance due to its direct impact on imports, that is with SFM standards in place certain import streams would not qualify and, consequently, such imports would not happen. When sustainability criteria are applied to all installations, all options (B1, C1 and E1) would cause a significant increase of carbon savings (1.1% to 1.5%). Under these scenarios, biomass imports would decrease as they would not be able to meet the sustainability criteria, and would be partly compensated by an increased use of EU biomass feedstocks.

[78] Green-X, 2011

[79] The worst performing feedstocks (mainly certain import streams causing land use change and associated emissions) are diverted away from large to small scale generators that are not affected by regulation.

Figure 23: Sector-specific cumulative (2011 to 2020) GHG emission savings for total RES under "high (biomass) imports", change in % against the baseline [80]



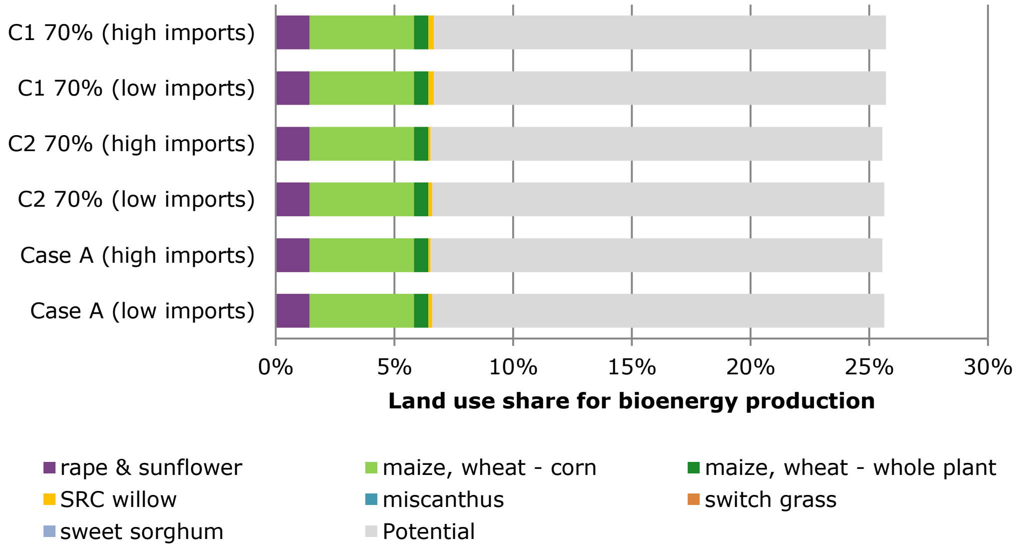
Land use impacts at EU level

Subsequently, possible land use impacts at EU level are discussed, whereby a distinction between biomass stemming from agriculture and from forestry is applied.

- Biomass from domestic agriculture: Figure 24 shows the amount of land used for the production of dedicated energy crops for electricity, heat and fuels under policy Option A, Option C2 70% and Option C1 70%. The results are shown relative to the total arable land in 2007 (EUROSTAT, 2011). It can be seen that the total estimated land potentially available for bioenergy crop production (grey columns) is not exploited in any of the scenarios. Agricultural residues are not shown in these figures as they do not directly require arable land. Note, however, that agricultural residues are one of the major traded commodities within Europe. The share of dedicated energy crops used for electricity and heat remains moderate compared to forestry products and residues as discussed subsequently. Therefore, future use of arable land use is more sensitive to changes in biofuel production than electricity and heat generation.

[80] Green-X, 2011

Figure 24: Land use for energy crop production in the EU27, change against the baseline of total arable land in 2007 [81]



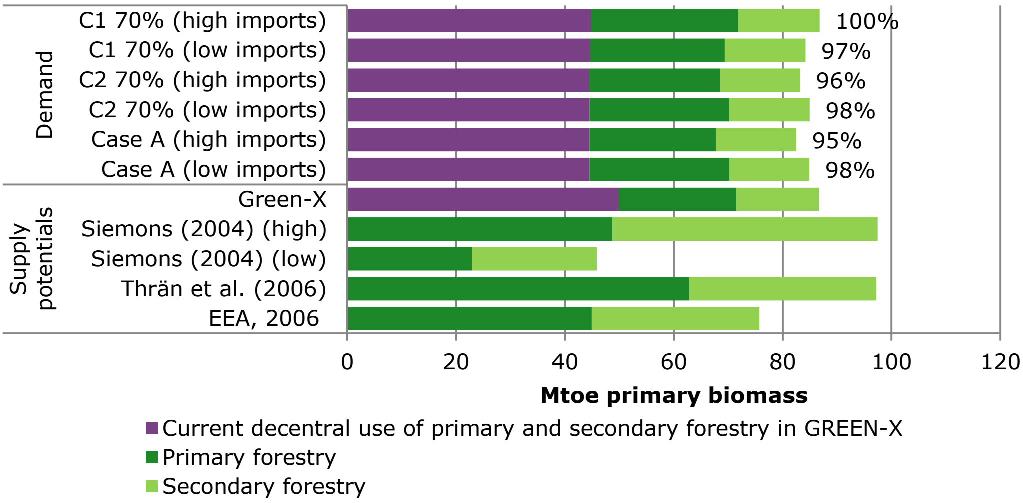
- Biomass from domestic forestry resources: Figure 25 shows the total demand for primary forestry products and residues and secondary forestry products and residues in the scenarios for 2020. The supply potentials of primary and secondary forestry biomass in the EU-27 have been compared by Rettenmaier *et al* (2010) for the BEE project. As the studies included in the BEE project were made for different regions (such as EU-25, EU-27), the results were calibrated to the EU-27 region. Figure 25 shows the supply potential of primary and secondary forestry products from available studies that were calibrated to the EU-27 region for 2020.

  In all scenarios, the total exploitation potential is 95% or higher. This implies that most of the forestry biomass, available for energy production, will be exploited in the scenarios. The supply potential and exploitation of the supply potential of forestry biomass is on the high end of the potential range. The "current small-scale use of forestry products and residues" category in Green-X includes some imported biomass.[82] Because the Green-X model has a different purpose and scope than biomass potential studies, it is impossible to distinct between imported and domestic forestry biomass in this category in Green-X. This category is therefore shown individually in Figure 25.

[81] Green-X, 2011, in relation to Eurostat, 2011

[82] Current decentralised use of forestry biomass in Green-X covers forestry biomass commodities that are used for heating purposes in small-scale applications within the residential, service and industry sector. Since statistics are poor on these categories, the amount of biomass is calculated using a top-down approach based on final energy generation. It is therefore impossible to distinct between the sources of origin (such as domestic or imported) or (sub)type.

Figure 25: Ranges of supply and demand projections for forestry products and residues in the EU-27 [83]



Domestic primary and secondary forestry products and residues are sourced from existing forests in Europe and therefore no additional land use is modelled in the scenarios for these categories. As most of the potential is exploited in the scenarios, additional woody biomass has either to be imported from non-EU countries, or to be produced from dedicated energy crops such as SRC, or to come from intensification of forest harvesting in already managed forests. As shown in Figure 24, the impact on arable land between high and low import from non-EU country scenarios is small.

4.3.3 Economic impacts

This subsection is dedicated to discuss economic impacts of assessed sustainability regulations for solid and gaseous biomass used for electricity production and heating & cooling. Generally, economic impacts arise in various dimensions. There are costs for public administrations to monitor compliance with biomass sustainability criteria, or there are costs for biomass generators to implement the criteria that may be transferred through the value chain to biomass suppliers and producers. The latter costs affect the overall competitiveness of biomass in the European RES market. While public administration cost associated with the introduction of biomass sustainability criteria have been analysed in COWI (2009), a technical report accompanying the Commission's 2010 Biomass Report, impacts on the competitiveness of biomass and on overall costs and expenditures for total RES deserve key attention within this assessment.

As applicable in previous section 4.3.1 (related to impacts on biomass and overall RES use), the role of biomass for meeting 20% RES by 2020 is affected by the introduction of sustainability criteria. Subsequently, we focus on economic consequences in the broader context, specifically the impact on additional generation costs, capital expenditures and support expenditures, all related to total RES.[84]

The indicators used to illustrate economic consequences of applying sustainability regulations for biomass are defined as follows:

[83] BEE D 3.6: Rettenmaier *et al* 2010

[84] For an illustration of the direct impact on costs and expenditures for biomass refer to Appendix VIII of this report. Note however such costs and expenditures generally coincide also with corresponding biomass deployment.

- *Capital expenditures* characterise the required investments in RES technologies.
- *Additional generation costs* shall mean the equalised cost of energy (from RES) minus the reference price for conventional energy supply.
- *Support expenditures*, that is the transfer costs for consumers (society) due to RES support, are defined as the financial transfer payments from the consumer to the RES producer, compared to the (reference) case of consumers purchasing conventional energy. Thus, support expenditures describe the direct financial impact of RES support, while indirect costs or benefits are ignored (such as environmental benefits, change of employment).

Firstly, it should be noted that an indication of the required investments does not provide insights on the resulting costs – it simply depicts the need for adequate financing, but without further analysis it is impossible to judge if such impulses in the economic system lead to positive or negative overall impacts. In contrast to capital expenditures, both additional generation costs and support expenditures are suitable to indicate the direct cost burden associated with a certain policy intervention, and, within this study, are specifically related to indicate the economic consequences associated with the introduction of sustainability criteria for biomass.

However, a significant difference between additional generation costs and support expenditures can be observed. The following aspects are important to consider in this respect:

- Additional generation costs are calculated by summarising the average additional generation costs at technology level by country. Hence, some averaging trend occurs that underestimates the actual costs, specifically if costs differ substantially between feedstock subcategories or sites.
- Additional generation costs are risk-neutral while for support expenditures the policy-, feedstock- and technology-inherent investor's risk is taken into consideration.
- In the case of additional generation costs, costs are equalised over the lifetime. In contrast to this, investors typically insist on a shorter depreciation time, which needs to be taken into account in policy design. This is consequently reflected in the resulting support expenditures.
- Up-front support by means of investment incentives represents a common practice, especially in the heat sector. For the calculation of related support expenditures, such costs are not equalised in order to indicate correctly the budgetary requirements.

Capital expenditures

Table 36 shows the changes related to cumulative (2011 to 2020) capital expenditures for RES technologies compared to the corresponding baseline case (of national criteria) at EU-27 level for all policy options (assuming EU wide harmonised sustainability criteria) under two distinct biomass import scenarios. Thereby, changes to the corresponding baseline case are expressed in absolute (billion €) and relative terms (deviation expressed in percentage figures).

Capital expenditures generally coincide with technology deployment, specifically with capacity additions. Given that small-size heat, electricity and CHP installations possess higher capital cost, any change in their deployment consequently leads to higher overall capital expenditures. Also, in the cases where sustainability criteria are established, economic operators would have to take into account sustainability requirements in their future investment plans and possibly adapt or change their default choices related to technological processes. Overall, additional capital expenditures correlate with the level and scope of sustainability requirements.

Table 36: Cumulative capital expenditures for total RES (2011 to 2020), change against the baseline [85]

Coverage (that is scope of policy options)	Policy options	Low imports scenario		High imports scenario	
		[Billion €]	[%]	[Billion €]	[%]
	Baseline case	*865.8*	-	*864.0*	-
All generators	B1	-0.4	-0.1%	8.6	1.0%
	C1 60%	2.4	0.3%	6.2	0.7%
	C1 70%	6.3	0.7%	10.2	1.2%
	C1 80%	8.7	1.0%	26.5	3.1%
	E1	7.8	0.9%	13.8	1.6%
Equal or above 1 MW	B2	-0.4	0.0%	-0.6	-0.1%
	C2 60%	1.4	0.2%	-2.7	-0.3%
	C2 70%	2.4	0.3%	-2.0	-0.2%
	C2 80%	2.3	0.3%	-1.1	-0.1%
	E2	7.3	0.8%	8.5	1.0%

Under the "low imports" scenario, options B2 and C2 (all variants), where sustainability criteria are applied only to large installations, cause only comparatively insignificant changes of cumulative capital expenditures, such as an increase of 0.3% occurs in the case of stringent GHG constraints. When the scope of regulations concerns all installations (options B1 and C1), there is a clear correlation between the strictness of the requirement and the increase of capital expenditures: a limited impact is observable for options B1 and C1 60% (from -0.1% to +0.3%) whereas additional capital expenditures amount to 6.3 billion € (+0.7%) for C1 70%, and to 8.7 billion € (+1.0%) for C1 80% respectively. This correlation is explained by high GHG requirements increasing the need for high-efficient technologies, which possess comparatively higher capital cost (such as CHP).

Under the "high imports" scenario, options B2 and C2 (criteria applied to all installations), only minor impacts on capital expenditures are shown, that is changes range from -0.1 to -0.3%. Under these options the additional efforts needed to comply with the GHG saving criteria in affected market segments (large-scale installations equal or above 1 MW thermal capacity) would be mostly neutralised by the leakage effect. When sustainability criteria are applied to all installations (options B1 and C1), as discussed previously, a significant amount of biomass in third countries would not qualify under the GHG saving requirements. This would lead to a decrease of imports, partly compensated by an increase of domestically produced raw material. Thus, additional capital expenditures are comparatively substantial, ranging from 6.2 (+0.7%) to 26.5 billion € (+3.1%) whereby a clear correlation between the stringency of criteria and the increase of investment needs is becoming apparent, that is a 60% GHG constraint leads to a limited increase (+0.7%) while the highest expenditure rise (+3.1%) refers to the stringent 80% GHG criteria.

Under both import scenarios, options E1 and E2 entail higher capital expenditures, because of a decrease of biomass competitiveness due to lower imports and additional costs related to SFM certification. Similar to policy options targeting all biomass installations (options B1 and C1), the increase of costs is more pronounced in the case

[85] Green-X, 2011

of "high imports" scenario, that is increases range from 1.0% (E2) to 1.6% (E1) for "high imports" scenario, and from 0.8% (E2) to 0.9% (E1) for "low imports" scenario respectively.

Additional generation costs

Table 37 shows changes against the baseline of cumulative (2011 to 2020) additional generation cost for achieving the 20% RES target. Changes are expressed in absolute (billion €) and relative terms (the deviation expressed in percentage figures).

Similar to capital expenditures, additional generation costs coincide with the level of stringency and the scope of sustainability regulations for biomass. The use of strict GHG constraints, specifically if applied to all biomass installations, (for instance, option C1 with 70% and 80%), causes a redirection of biomass use towards more efficient conversion technologies (for instance, CHP) and/or "cleaner" feedstock (characterised by less GHG emissions). These biomass conversion streams are in general also more costly with respect to capital cost and/or feedstock prices (an increase of additional generation cost is indispensable).

In the case of "low imports", options B2 and C2 (all thresholds), applying sustainability criteria only to large installations, leads to only comparatively insignificant changes of cumulative additional generation cost. The highest increase is observable for a stringent 80% GHG constraint (+0.5%) while no changes occur for the less stringent constraint as conditioned under option B2. If regulations are applied to all biomass installations (options B1 and C1), there is again a clear correlation between the strictness of the requirement and the increase of additional generation cost applicable: a limited impact is observable for options B1 and C1 60% (from 0.0% to +0.1%) whereas additional generation cost increase by 4.4 billion € (+1.2%) for C1 70%, and by 5.6 billion € (+1.5%) for C1 80% respectively. As discussed previously, the increase coincides with the need for high-efficient technologies and "clean" but more costly feedstock. Options E1 and E2 cause a comparatively large cost increase (+1.2% in both variants), resulting from the cost adder due to SFM certification and the modified biomass deployment, specifically the phase-out of, for instance, import streams that do not meet SFM requirements.

Table 37: Cumulative additional generation cost for total RES (2011 to 2020), change against the baseline [86]

Coverage (that is scope of policy options)	Policy options	Low imports scenario		High imports scenario	
		[Billion €]	[%]	[Billion €]	[%]
	Baseline case	*375.0*	-	*373.9*	-
All generators	B1	0.1	0.0%	3.7	1.0%
	C1 60%	0.3	0.1%	2.7	0.7%
	C1 70%	4.4	1.2%	5.0	1.3%
	C1 80%	5.6	1.5%	9.0	2.4%
	E1	4.6	1.2%	8.2	2.2%
Equal or above 1MW	B2	0.1	0.0%	-0.3	-0.1%
	C2 60%	0.4	0.1%	-1.4	-0.4%
	C2 70%	0.6	0.2%	-0.7	-0.2%
	C2 80%	1.9	0.5%	-1.8	-0.5%
	E2	4.6	1.2%	6.6	1.8%

Under the "high imports" scenario, options B2 and C2 (all constraints) show a decrease of additional generation cost, ranging from -0.1 to -0.5%. As discussed previously, under these circumstances the additional cost for achieving an efficient use of biomass for meeting the GHG criteria in affected market segments (large-scale installations) would be more than compensated by the leakage effect. Applying sustainability criteria to all installations (options B1 and C1) leads to a significant cost increase since a large amount of biomass from third countries would not qualify for meeting GHG constraints. Thus, a decrease of imports is indispensable, partly compensated by an increase of sustainable EU biomass deployment. The increase of additional generation cost is comparatively substantial, ranging from 2.7 (+0.7%) (option C1 60%) to 9.0 billion € (+2.4%) (option C1 80%). Hence, similar to capital expenditures, a clear correlation between the stringency of criteria and the cost increase is becoming apparent. A significant cost increase is also observable for option E1 (+2.2%) and E2 (+1.8%).

Support expenditures

Finally, the impacts of assessed sustainability policy options on support expenditures for total RES are assessed. Table 38 shows the changes of cumulative (2011 to 2020) support expenditures for total RES for all assessed policy options against the corresponding baseline under different scenarios of biomass feedstock imports from third countries.[87] Further details on the policy impact on sector-specific cumulative support expenditures for RES(-electricity, -heat and total) are subsequently expressed in Figure 26 for "low imports" scenario of biomass feedstock to the EU and in Figure 27 for "high imports" scenario, respectively. For contrasting, the impacts of assessed sustainability regulations further, both figures also include a "no criteria" case assuming no specific sustainability regulations for biomass in place.

[86] Green-X, 2011

[87] This table shows the changes of cumulative (2011 to 2020) support expenditures for total RES at EU-27 level for all policy options (assuming EU wide harmonised sustainability criteria) compared to the corresponding baseline case (of national criteria) under different scenarios of biomass feedstock imports from third countries assuming a "low" and "high imports" scenario. Changes against the corresponding baseline are expressed in absolute (billion €) and relative terms (the deviation expressed in percentage figures).

Table 38: Cumulative support expenditures for total RES (2011 to 2020), change against the baseline [88]

Coverage (that is scope of policy options)	Policy options	Low imports scenario		High imports scenario	
		[Billion €]	[%]	[Billion €]	[%]
	Baseline case	*712.3*	-	*712.8*	-
All generators	B1	0.9	0.1%	13.0	1.8%
	C1 60%	7.2	1.0%	8.0	1.1%
	C1 70%	18.1	2.5%	17.5	2.4%
	C1 80%	17.7	2.5%	27.9	3.9%
	E1	17.1	2.4%	25.5	3.6%
Equal or above 1MW	B2	0.9	0.1%	1.0	0.1%
	C2 60%	6.6	0.9%	-3.5	-0.5%
	C2 70%	7.0	1.0%	-2.8	-0.4%
	C2 80%	9.6	1.4%	-4.2	-0.6%
	E2	17.1	2.4%	16.7	2.3%

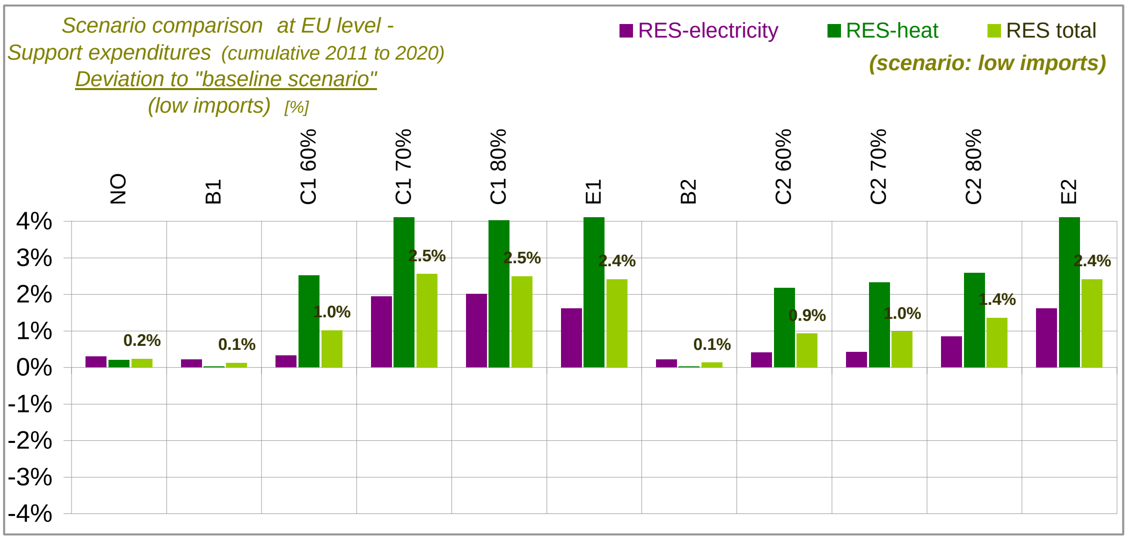
Similar to other cost indicators, it can be observed that support expenditures correlate well with the level and the scope of the requirements. More stringent GHG savings requirements exclude "dirty" biomass feedstock and inefficient conversion technologies. Thus, the gap for overall 2020 RES target fulfilment needs to be filled by "clean" but more costly technology/feedstock combinations within the biomass sector and / or by other (more costly) RES options. This leads to higher capital expenditures and generation cost and, consequently, it has its price that needs to be reflected in the support framework.

Under the "low imports" scenario, support expenditures are expected to increase proportionally to the level of GHG. Additional expenditures range from 0.9 billion € (+0.1% compared to baseline) for option B1 and B2 to 18.1 billion € (+2.5%) for option C1 70%. Two effects are of relevance in this respect: on the one hand, the "compensation effect" is observable, that is a decrease of biomass deployment due to sustainability criteria leads to increased financial incentives to compensate the resulting gap towards 2020 RES targets with additional deployment of and related expenses for other renewable energy technologies (including biomass). On the other hand, a redirection of biomass towards more efficient uses (more costly in terms of support expenditures) is observable. Both effects coincide with the level and scope of sustainability criteria.

The increase of support expenditures is of a similar magnitude for the individual policy options independent from the scope of regulation, that is the fact that criteria are applied to all installations (options B1 and C1) or to only large installations (options B2 and C2). An exception to this trend is observable for options C with 70% and 80% GHG thresholds where the increase of support requirements is twice as high if criteria are applied to all installations (and not only to large operators), that is options C2 (70% and 80%) lead to an increase ranging from 1.0% to 1.4% while options C1 (70% and 80%) cause that expenditures rise by 2.5%. The reason for this variation lies in the leakage phenomena, explained before. A closer look at the changes at sector level indicates that RES-heat appears more affected because of the fact that default expenditures are generally lower and, consequently, any increase of financial incentives causes higher percentage changes.

[88] Green-X, 2011

Figure 26: Sector-specific cumulative support expenditures (2011 to 2020) for total RES under "low (biomass) imports", change in % against the baseline [89]

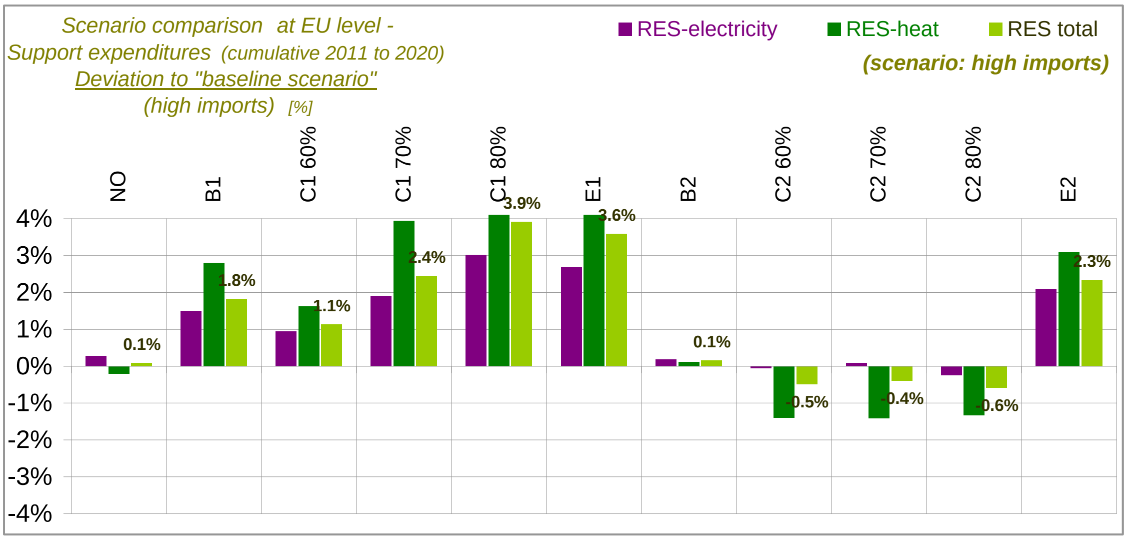


Under the "high imports" scenario, option B2 has only a minor impact on support expenditures (only +0.1%). Option C2 (all thresholds) leads to a decrease of support expenditures, ranging from 0.4% to 0.6%. This decrease is explained by slightly higher imports and related increased deployment used in less costly conversion technologies. Also, when redirecting biomass towards efficient large installations, the stringent GHG requirements would lead to streamlined financial support and an overall decrease of support expenditures. However, because of the "leakage effect" as described before, this decrease is only limited. When EU criteria are applied to all installations (options B1 and C1), additional support expenditures are more significant, ranging from 8 billion € (+1.1%) to 27.9 billion € (+3.9%). A correlation between the stringency of criteria is becoming apparent, that is a moderate increase is applicable for C1 60% (+1.1%), while the stringent 80% GHG constraint would cause the highest increase of support costs (+3.9%).

Under both import scenarios, comparatively high increases of support expenditures are applicable for options E1 and E2, caused by a decrease of biomass competitiveness due to a lower level of imports and additional costs related to SFM certification. This loss of competitiveness needs to be compensated by other RES technologies. However, similar to B1 and C1 (all thresholds), a protection against non-sustainable biomass supply and use would also be achieved.

[89] Green-X, 2011

Figure 27: Sector-specific cumulative (2011 to 2020) support expenditures for total RES under "high (biomass) imports", change in % against the baseline [90]



4.3.4 Summary of impacts

Table 39 summarises the impacts of the analysed policy scenarios on biomass deployment, GHG emission savings as well as costs and expenditures, all against the "low imports" scenario. The corresponding results for the "high imports" scenario are shown in Table 40.

[90] Green-X, 2011

Table 39: Key indicators on impacts of assessed policy options for "low (biomass) imports", change in % against the baseline [91]

Change against the baseline [%], **"low imports" scenario** / Coverage (i.e. scope of policy options)	All generators					Equal or above 1 MW				
Impact category / Policy options	B1	C1 60%	C1 70%	C1 80%	E1	B2	C2 60%	C2 70%	C2 80%	E2
Impact on bio-energy use										
Biomass deployment in terms of final energy by 2020	0.0%	0.1%	-0.7%	-0.9%	-0.4%	0.0%	0.0%	-0.1%	-0.6%	-0.4%
EU biomass feedstock use by 2020	-0.1%	0.0%	-0.4%	0.9%	0.4%	-0.1%	0.0%	-0.2%	-0.5%	0.4%
(Additional) biomass imports from non-EU countries by 2020	-1.1%	-0.5%	-2.7%	-39.0%	-20.1%	-1.1%	-1.1%	-1.3%	0.6%	-20.1%
Environmental impacts										
Specific GHG emission avoided by biomass use by 2020	-0.1%	0.0%	0.2%	0.6%	0.1%	-0.1%	0.0%	0.0%	0.2%	0.1%
Cumulative GHG emission savings for total RES (2011 to 2020)	0.1%	0.0%	0.6%	0.8%	0.3%	0.1%	0.0%	0.1%	0.4%	0.3%
Economic impacts										
Cumulative capital expenditures for total RES (2011 to 2020)	-0.1%	0.3%	0.7%	1.0%	0.9%	0.0%	0.2%	0.3%	0.3%	0.8%
Cumulative additional generation cost for total RES (2011 to 2020)	0.0%	0.1%	1.2%	1.5%	1.2%	0.0%	0.1%	0.2%	0.5%	1.2%
Cumulative support expenditures for total RES (2011 to 2020)	0.1%	1.0%	2.5%	2.5%	2.4%	0.1%	0.9%	1.0%	1.4%	2.4%

[91] Green-X, 2011

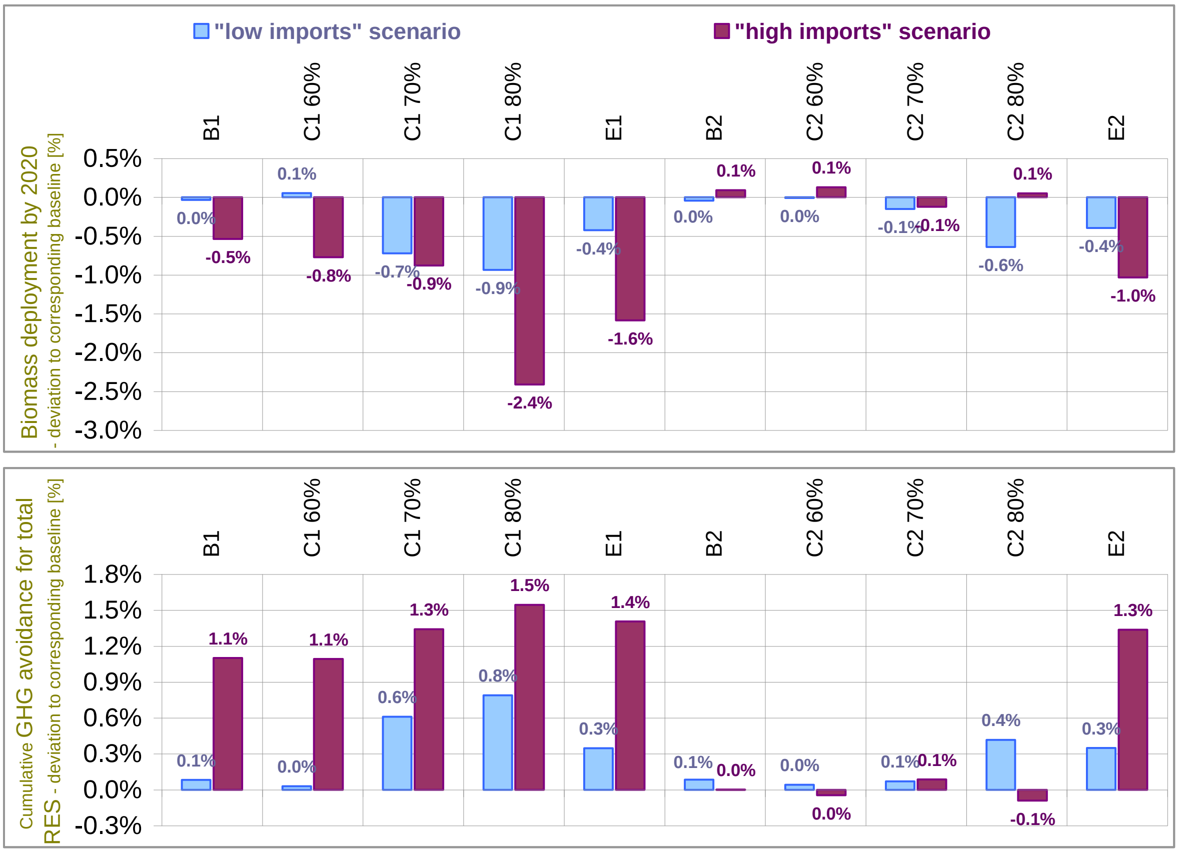
Table 40: Key indicators on impacts of assessed policy options for "high (biomass) imports", change in % against the baseline [92]

Change against the baseline [%], **"high imports" scenario** / Coverage (i.e. scope of policy options)	All generators					Equal or above 1MW				
Impact category / Policy options	B1	C1 60%	C1 70%	C1 80%	E1	B2	C2 60%	C2 70%	C2 80%	E2
Impact on bio-energy use										
Biomass deployment in terms of final energy by 2020	-0.5%	-0.8%	-0.9%	-2.4%	-1.6%	0.1%	0.1%	-0.1%	0.1%	-1.0%
EU biomass feedstock use by 2020	3.1%	2.9%	3.3%	3.9%	3.0%	0.0%	0.0%	-0.1%	-0.1%	3.4%
(Additional) biomass imports from non-EU countries by 2020	-46.1%	-46.3%	-55.0%	-79.3%	-57.6%	0.0%	0.9%	0.4%	-0.3%	-56.6%
Environmental impacts										
Specific GHG emission avoided by biomass use by 2020	4.1%	4.3%	4.4%	5.0%	4.5%	-0.1%	-0.1%	-0.1%	-0.2%	4.5%
Cumulative GHG emission savings for total RES (2011 to 2020)	1.1%	1.1%	1.3%	1.5%	1.4%	0.0%	0.0%	0.1%	-0.1%	1.3%
Economic impacts										
Cumulative capital expenditures for total RES (2011 to 2020)	1.0%	0.7%	1.2%	3.1%	1.6%	-0.1%	-0.3%	-0.2%	-0.1%	1.0%
Cumulative additional generation cost for total RES (2011 to 2020)	1.0%	0.7%	1.3%	2.4%	2.2%	-0.1%	-0.4%	-0.2%	-0.5%	1.8%
Cumulative support expenditures for total RES (2011 to 2020)	1.8%	1.1%	2.4%	3.9%	3.6%	0.1%	-0.5%	-0.4%	-0.6%	2.3%

Figure 28 compares the impacts of the analysed policy scenarios, against the two baseline cases ("low imports" and "high imports" scenarios) which are differentiated using a distinct colour code.

[92] Green-X, 2011

Figure 28: Selected key indicators on impacts of assessed policy options, change in % against the baseline [93]



4.4 Conclusions

In broad terms, impacts are very much dependent on the assumptions underpinning the baseline scenario.

Under a "low imports" scenario, even the introduction of high GHG saving requirements (80%) to all biomass installations results in only a minor decrease in biomass use of 0.9% compared to the baseline case. This indicates that generally only few biomass supply streams would be affected and may face problems in meeting strict sustainability constraints. In other words, the majority of solid and gaseous biomass used for energy purposes in the EU has a high carbon performance, while only few biomass supply chains show low GHG savings due to high cultivation emissions. Several waste streams characterised by zero emissions supply a significant share of the resulting demand for biomass for energy purposes. Thus, even if emissions for processing and transport are added, researched GHG constraints can mostly be met if biomass is used by various (efficient) conversion technology options.

Under a "high imports" scenario, EU-wide sustainability criteria applied to all biomass installations or a SFM requirement result in significant emission savings. EU criteria applied only to large size installations (above 1 MW) would not result in GHG savings because non compliant biomass feedstocks could be diverted to other markets (for instance, residential and small scale markets), causing a "leakage effect".

[93] Green-X, 2011

Applying effective sustainability regulations for solid and gaseous biomass imposes a certain cost. The results of the modelling exercise show that there is a correlation between the stringency of criteria and the total cost increase.

Finally, we take a closer look at the performance of individual policy options. Table 41 provides a qualitative evaluation of the performance of assessed policy options according to key impact categories – that is the impact on bioenergy use, environmental impacts, in particular related to GHG savings, and economic impacts.[94]

Table 41: Evaluation of the performance of assessed policy options

Coverage (i.e. scope of policy options)	All generators					Equal or above 1MW				
Impact category / Policy options	B1	C1 60%	C1 70%	C1 80%	E1	B2	C2 60%	C2 70%	C2 80%	E2
Impact on bio-energy use	-	-	-	---	--	+/-	+/-	+/-	-	-
Environmental impacts	+	+	++	+++	++	+/-	+/-	+/-	+/-	++
Economic impacts	-	-	--	---	--	+/-	+/-	+/-	+/-	--

+/- Insignificant changes compared to the baseline,
+ to +++ Improvement compared to the baseline,
– to ––– Worsening compared to the baseline.

The evaluation of the performance of assessed policy *options B* to *E* indicates that EU action has a positive impact related to environmental protection, and one can expect that a harmonised regulation appears beneficial also for creating an internal market. The inclusion of all relevant operators, that is the scope of the regulation to affect all generators (or e.g. suppliers), appears however essential to avoid "leakage" and, consequently, to achieve the high level of effectiveness. Findings related to the performance of individual policy options can be summarised as follows:

- The *baseline case (option A),* where solely national criteria are applied, appears not effective in establishing sufficient environmental protection. Currently GHG saving requirements for solid and gaseous biomass have been introduced only in two MS. This situation creates an uneven playing field, whereby biomass pathways that deliver less than optimal GHG emission savings are still being incentivised in most MS. As a consequence, this option is likely to result in less than optimal GHG savings in the case of massive biomass imports to the EU (assuming worst land use change). Such negative environmental impacts may lead to a decrease of public acceptance for biomass use in the energy sector. The patchwork of different national regulations in place may also cause distortions to the functioning of an internal market, in particular related to intra-EU biomass trade.
- *EU criteria similar to biofuels (option B)* would establish a safeguard against worst biomass production practices. The model-based assessment has shown that applying similar GHG constraints as used for biofuels (35%) would lead to moderate

[94] Note that the individual policy options are evaluated against the baseline case (option A), assuming a continuation of currently applied national sustainability regulations. Accordingly, a positive appraisal indicates that there is value added, while a negative rating means that impacts may be worsened compared to the baseline.

savings. The economic impacts in turn appear also moderate, that is only a limited increase of cost and expenditures can be expected.

- The use of *EU criteria with stricter GHG thresholds (option C)* would be effective in establishing environmental protection. The modelling results indicate a clear correlation between the stringency of criteria and the amount of GHG savings, that is savings are highest with 70% and 80% thresholds. On the contrary, economic impacts are also highest in the case of stringent criteria, that is cost and expenditures increase comparatively strong under these variants.
- *EU criteria (similar to biofuels) plus sustainable forest management requirement (option E)* show similar environmental and economic impacts as the use of a stringent constraint under option C. It can however be expected that the practical implementation may lead to higher costs for forest owners.

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