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FINAL REPORT - APPENDICES

Benchmarking biomass sustainability criteria for energy purposes

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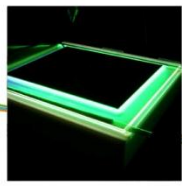
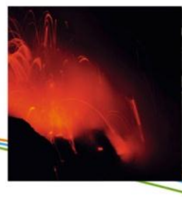
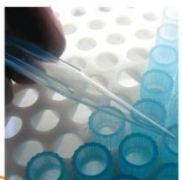

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APPENDIX I DESCRIPTIONS OF THE SELECTED REGULATIONS

AT_ÖSG (Green Electricity Act)
The Austrian Green Electricity Act is a key policy instrument at the national level by setting Feed-in Tariffs for renewable electricity. It has been amended several times in order to foster the development of specific energy technologies (including the utilization of solid and gaseous biomass). Additionally feed-in of (conditioned) biogas into the gas grid is specially subsidized.
Systems need to be state-of-the-art, with a degree of efficiency of at least 60The application for admission of a bioenergy plant (solid, liquid, gaseous biomass; waste with high biogenic content), in order to be eligible for feed-in tariffs, has to include details on feedstock supply over the whole period the feed in tariff is applied for, as well as information on feedstock supply from own agricultural production and forestry.
Prices for feed-in tariffs need to be set in a form such that feedstocks are not detracted from material utilisation or use as comestible goods. To cushion rising feedstock prices in 2008 a special regulation on the additional costing supplement for feedstock (Rohstoffzuschlag VO) has been put forward; it has to be adopted every year.

AT_UFG (Environmental Measures Support Act)
This act defines measures and support for environmental protection. The main topics focus on areas of support, financing, responsibility and procedural regulations. Various general areas of support are covered; the promotion of renewable energies is laid down in detail in the guidelines for domestic environmental support (Umweltförderung im Inland).
Specific criteria have to be met in order to apply for investment subsidies for renewable energy systems. For firing equipment for solid biomass above 400kW and CHP, a sustainability bonus of 5% investment cost applies if regional (<50km) biomass is used; a flue gas treatment bonus of 5% can be received for solid biomass; there are additional maximum allowable limits for dust and NO_x.
For conditioned biogas, also a sustainability bonus of 5% investment cost applies if the GHG emission reduction is above 45% (only for inland consumption); transport distance max. 100km.

AT_ÖN9466
Emission legislation for boilers, linked with ÖNORM M 9466. Emission limits for air contaminants of wood incineration plants of a nominal fuel heat output from 50 kW onwards. This ÖNORM Standard classifies wood chips with and without bark into different categories, defines testing requirements and methods, and can be used to assess the value of wood chips.

BE_FL-GSC (Flemish Green Power Certificates)
This regulation promotes the production of electricity from renewable sources in Flanders (BE). The producer of the renewable electricity receives one green power certificate (GSC) per MWh. For biomass, the energy use in transport and pretreatment is deducted from gross electricity production; only for the net electricity production certificates are awarded. To meet the requirements of the Flemish and the Walloon system, a verification procedure for the energy balance and the sustainability of the wood pellets supply chain has been developed by SGS and Laborelec (Electrabel). Apart from the allocation of GSC for renewable electricity produced, the system also includes an obligation for electricity suppliers to deliver a certain number of GSC to the regulating authority (VREG). If not, they have to pay a penalty of 125€/MWh. There is also a minimum price level for the different renewable electricity options. GSCs are not awarded for biomass streams, which can be used in wood processing industry, or for recycling.

BE_Wall-CV (Green certificate granting system in the Walloon Region)
Promotion of green electricity and CHP through a green certificate system. Base is avoided CO2 emissions, in comparison to the electricity reference of gas turbine with 55% efficiency and the heat reference of a gas boiler with 90% efficiency. One certificate is equivalent to 456 kg CO_2 avoided. Emissions in the entire life cycle are included through LCA analysis. Bioenergy plants can only receive green certificates if the GHG emission threshold of minimum 10% CO_2 savings in comparison with the best available technology (BAT) for electricity and heat production can be proven. Above that there is a direct incentive to optimize GHG since the amount of green certificates issued depends on the avoided GHG emissions: The less GHG emissions a plant produces, the more GC it generates.
For imported biomass audits are needed to verify the CO2 balance. The system also includes an obligation for electricity suppliers (minimum number of CV) and a penalty system (100 € penalty per missing certificate) in case they don't fulfil the obligation. The regulatory administration is CWaPE. The regulation makes reference to the sources of the material (agriculture, forestry and residues). The focus so far has been on woody material, less on agricultural products. Wood from sustainable forest management (FSC or similar) is stimulated but not mandatory, to be reported.

BE_BRU-CV (Green certificate granting system in Brussels)
The system is similar to the Walloon green certificate system (see above).

BE_FL_GH (draft Green Heat Support system)
Draft promotion system for heat from biomass. The same feedstock restrictions apply as for the Flemish Green Power Certificates (for woody resources and biomass from waste).

BE_FL_ES (Flemish Ecology Subsidy)
This regulation promotes the environmental friendly investments in industry and SMEs. Support is given for the added cost in investment costs than is strictly needed to meet legal requirements. Installations producing heat from biomass are eligible. The amount of investment subsidy is dependent on the technology. Minimum efficiencies of 80% are asked for. Level of investment subsidy is dependent on the size of the company (different subsidy level for SMEs and big industry).

BE_Wall-BoilerSubs
Walloon subsidy scheme for wood boilers for residential. Grant for residential buildings investing in an automatic biomass boiler of 50 kW_{th} or more.

BE_PelletNorm
Minimum requirements for wood pellets for use in non-industrial heating installations. The origin of wood is restricted to sustainable forestry. 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.

BE_SmallHeating
Royal Decree 2010-3943 for small scale heating installations, defining minimum requirements for efficiency and emission levels of small scale heating systems operating on solid fuel.

CY_170/2004
Law 170/2003 defining gaseous pollutants limitations from burning biomass and giving permission for burning dried olive-cells and nut shells.

CZ_Decree-482/2005
Regulation No. 482/2005 Coll., which makes provision to the determination of types, utilization modes and parameters of biomass for the promotion of electricity generation from biomass, as amended by Regulation No. 5/2007 Coll. The decree states which kinds of biomass and which ways of electricity production are subject of support. The regulation puts a specific focus on locally available biomass resources.

DE_EEG (German Renewable Energies Act)
Feed-in tariffs for electricity from renewable energy resources. There are two articles (Arts 27 and 64) and one appendix (Appendix 2) where there is reference to the source of the biomass and the consideration of landscape and habitat protection. The source of the material and the protection of landscapes and habitats are part of the indicators considered for biodiversity and ecosystems services. The topics are not clearly identified in the RED but as mentioned in the methodology, these are part of the Biodiversity Policy and the EU Ecosystem Assessment.

DE_EEG-2012 (German Renewable Energies Act) – draft update 2012
Higher payments for sustainable feedstocks with less competition in the usage (for instance agricultural residues, cuttings from biotop management, intermediate crops). Additionally, short rotation coppice (SRC) is 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_BioV (Biomass Ordinance)
The ordinance defines biomass and technical procedures & environmental requirements in the scope of the EEG, including minimum efficiency requirements.

DE_OSSI
The ordinance defines requirements for small scale heating installations concerning air pollution, efficiency ratios and heat storage capacity.

DE_MAP (Investment Aid Programme)
Investment aid programme for wood heating vessels (pellets, chips and cord firewood) and waste gas filter technology. The programme includes requirements for minimum efficiency and maximum emission levels.

DK_GreenGrowth (Agreement on Green Growth)
Long-term plan defining environment and nature policies and the agriculture industry's growth conditions. A strategy for a green agriculture and food industry undergoing growth. A collective and focussed initiative will be implemented in order to create better framework conditions for a self-sustaining agriculture industry that (1) will develop dependent on market conditions, (2) will protect the environment and nature, and (3) will deliver green energy. This plan includes as a goal that up to 50% of livestock manure in DK can be used for green energy in 2020, promoting the biogas production and stimulating the cultivation of perennial energy crops. This will create opportunities for the domestic agricultural sector.

DK_CHP
Act on Heat Supply, Proclamation of the law on electricity production subsidy and subsequent amendments. During the 1990s many heating plants were converted to decentralised CHP according to this Act. Most of the plants producing district heating today also produce electricity. The regulations on subsidy for electricity production, calculation procedures for state subsidies and surcharges for renewable energy, as well as taxes on district heating from CHP, are regulated by subsequent arrangements of this Act and electricity regulation. The Act defines a surcharge for CHPs using wood chips, straw and biogas. The law only applies to CHP as an energy efficiency concern.

DK_PEC
Order on special support to farmers for the establishment of perennial energy crops. The order sets the priorities and conditions for obtaining support, including which types of land can be used.

ES_RD661/2007 (Real Decreto 661/2007)
The Royal Decree 661-2007 defines the electricity market, including the different fuels used in plants, related tariffs and plant size. The law gives higher tariffs to biomass/biogas plants achieving higher energy efficiency through cogeneration, provided that they reach minimum electric conversion efficiency.

ES_RD949/2009 (Real Decreto 949/2009)
Royal Decree 949-2009 establishes rules and grants for the promotion of anaerobic digestion. The whole scheme is meant to provide an efficient and effective way to reduce GHG (methane) emissions from slurry and manure in zones with high concentration of intensive animal productions; restrictions on the input of energy crops.

ES_ENV_RD430/2004 (Real decreto 430/2004)
Royal Decree 430/2004 establishes emission limits for large plants and 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_NREAP
Summary of the national policy on renewable energy. This plan expounds current and future (on progress) requirements for renewable energies. This plan does not obligate/ restrict but the expounded requirements do. Only wood is considered and promoted. It states that the harvesting of energy wood is to ensure the sustainability of timber production (Act on the Financing of Sustainable Forestry). It is also related to the Forestry regulation and aims to maintain biological diversity.
There is no regulation for other feedstock. There are 'heat premiums' for CHP installations on wood and biogas, thereby promoting higher energy efficiency installations.

FI_SustForestry
Act on the Financing of Sustainable Forestry (1094/1996) and Decree (1311/1996).
The Act defines the scope of application of budget destined for the promotion of the sustainable management and use of forest in accordance with the Forest Act, ensuring the sustainability of timber production and maintaining the biological diversity of forests. It promotes utilisation of wood felled in connection with the tending of young stands to be supplied for energy use.

FR_BCIAT (Grenelle Environnement: Fonds "Chaleur renouvelable", Biomasse Chaleur Industrie, Agriculture et Tertiaire)
This regulation promotes the production of heat from biomass through a call for projects. Successful projects will receive subsidies. The producer of the renewable heat receives subsidy support. Some biomass types are excluded from support, for instance those for which there is potential competition with food, as well as installations under 1000 toe/yr. 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 a criterion in the evaluation for a winning project. Minimum efficiency requirements are also included.

FR_CRE
This regulation promotes the production of CHP out of biomass through a call system. The producer of the renewable heat and electricity receives subsidy support per MWh electricity produced. Certain biomass streams are excluded from the support. Installations under 12 MWe are excluded from support. Minimum energy efficiency of 60%, and support energy for the process needs to be deducted from electricity production. Environmental impacts: report with the descriptions of the environmental impacts should be in the application form. Risk of competition is an evaluation criterion for the application (restrictions on the use of woody biomass are built in to preserve biomass resources for the wood industry). Local biomass is promoted and given bonus points in the evaluation process (depending on transport distance).

FR_FITE (Grenelle Environnement I & II: Fixed tariffs for renewable electricity)
This regulation obligates electricity distributors to buy renewable electricity at a fixed price. Differentiation is made for different renewable technologies and min. efficiencies and restrictions on certain biomass resources are given.

FR_ITC (Income Tax Credit on equipment for using renewable energy)
This regulation promotes the production of heat from biomass in the residential sector. The producer of renewable heat from the residential sector receives income tax credit. Minimum efficiencies are asked for.

FR_LOAN
0% loan for investments in renewable and energy efficiency measures for private persons. Minimum efficiencies requirements are included for biomass boilers.

HU_ENER_FIT (Gov Decree No 389/2007 (XII.23), amended by Decree Nr. 287/2008)
Governmental Decree on obligatory off-take and purchase price of electricity generated from waste, from RES, or from CHP. Biomass used for electricity production has to come from sustainably managed forests and/or to have a Forest Stewardship certificate. The seller has the main responsibility to prove that the biomass cannot be used for human food consumption. Waste power plants have to possess a declaration from the Environmental Authority that the waste cannot be used for purposes other than fuel. Minimum efficiency requirements are also included.

IE_BES (Bioenergy Action Plan - Bioenergy Scheme for production of non-food crops)
Grant support for the plantation of perennial biomass (willow & miscanthus). All crops used for energy purposes must be environmentally sustainable. They should comply with Cross Compliance and the two codes of practice for Miscanthus and Willow from Ireland. Land use for a particular crop/forest must be suitable for that particular use e.g. land suitable for willow plantation, while at the same time avoiding direct competition with food crops.

IT_ BL2008 (Budget Law 2008)
Budget Law 2008 introduces 2 different regimes for renewable electricity (green certificates or feed-in tariff) and differentiating value for GC and FIT depending on different biomass sources. A "Decreto Ministeriale del Ministero Politiche Agricole Alimentari e Forestali" defines the procedure to apply the multiplication coefficient of 1.8 to Green Certificates introduced in the Budget Law 2008 and the type of biomass that is eligible for this. The procedure requires that energy producers indicate the origin and the traceability of biomass in order to demonstrate that is it supplied from a distance of less than 70 km from the plant.

IT_ RE-Aut
Guidelines about authorisation procedures for renewable energy plants. The guidelines differentiate among authorisation procedures between biomass/biogas plants up to 1MWe (or 3MWth) working in cogeneration and plants producing only electricity. Plants working in cogeneration are subject to an easier authorisation procedure.

IT_ RED_Transp (Transposition law of the EC Directive 28/2009)
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_ Frame Env. (Framework Environmental law)
This law defines the characteristics of biomass and the conditions for its energy use and a norm defining the emission limits for biomass plants and residential heating units.

LU_ FIT (Feed-in tariff for renewable electricity)
This regulation promotes the production of electricity from renewable sources. The feed-in tariff is calculated with a formula that takes into consideration the type of biomass (biogas, biogas from waste water treatment, solid biomass, woody biomass), the size of the installation and whether the heat generated is used.

NL_EIA (Energy Investment Deduction Scheme)
The Energy Investment Deduction Scheme stimulates investment in renewable energy or energy saving technologies via a profit tax deduction. To obtain the deduction, the invested technology has to meet the requirements on issues such as efficiency that are listed in the scheme and updated annually.

NL_LAP (National Waste Management Plan)
The National Waste Management Plan implements the policy on waste management for the Netherlands. Relevant for biomass, the LAP includes criteria on whether biomass is considered waste or not. For combustion of waste on the 'yellow list', the BVA (Decree Waste Incineration) applies. The BVA includes strict regulations on emissions and required exhaust gas cleaning. For biomass on the 'White list', the BEMS or BEES (Decrees on emission limits for combustion plants) applies depending on the size of the installation.

NL_BVA (Decree waste incineration)
The decree applies to emission standards for combustion plants that combust or co-combust waste streams that are on the "Yellow List". Waste streams that are on the "White List" do not have to comply with the emission standards of the BVA. The "White List" thus describes waste streams that are exempted from the BVA.
For instance, biomass that is not directly produced for energy generation, such as trimmings, is considered waste, whereas dedicated energy crops are considered non-waste. The BVA makes the combustion of biomass streams on the Yellow list more expensive than biomass on the White list by the additional requirements on e.g. exhaust gas cleaning stated in the BVA.

NL_FERTI (Decree on the use of manure)
The decree on the use of manure regulates the use of manure as fertilizer. If manure is digested, the digestate is allowed to be used as fertilizer, similar to manure. For co-digestion, a "Positive list" of materials is published in the implementation decree on the use of manure. If materials are used that are not on the "Positive list", the co-digestate is considered waste and is not allowed to be used as fertilizer, for soil quality reasons. If materials for co-digestion are used that are on the "Positive list" to a maximum share of 50%, the co-digestate is allowed to be used as fertiliser. This rule has important impact on the potential feedstocks for biogas production. Furthermore, the SDE subsidy is only awarded to co-digestion plants if these requirements are met.

NL_SDE (Incentive Scheme for Sustainable Energy Production)
The SDE is an operating subsidy for the production of renewable electricity and gas. The SDE subsidy covers the unprofitable margin, that is the difference between the basic amount and the energy price. For MSW combustion, the efficiency has to be >22% (weighted monthly average). The subsidy increases for higher efficiencies. In the case of co-digestion, only materials on the positive list are allowed (see NL_ FERTI).
While some of the SDE agreements will continue to run for the next few years, new applications will fall under the new SDE+ system.

NL_SDE+ (Incentive Scheme for Sustainable Energy Production, successor of SDE)
The SDE+ is the follow up policy to the SDE on stimulating the generation of sustainable energy in the Netherlands. The main difference between the SDE and the SDE+ is that the SDE+ will be financed from a surcharge on the electricity price of consumers and industry and possibly partly from incomes on gas and coal taxes. Co-firing will be excluded from the SDE+, but might potentially be stimulated via alternative measures. Efficiency and emission requirements are alike the SDE system.
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_ BEMS (Decree on emission regulation mid-sized combustion plants)
Emission restrictions, distinguishing between fossil fuels and biomass and between different biomass types (no SCR required for biogas in gas engines due to limited experience). The BEMS is relatively strict compared to other European countries.

PL_ draftCoO (draft decree on renewable electricity)
Draft regulation by the Ministry of Economy stating that electricity producing units >5MW, claiming to produce renewable energy from biomass among other fuels used, have to assure that agricultural biomass (energy crops, agricultural residues and residues coming from food processing industry) weight ratio is at least: 5% - in 2008 ; 10% - in 2009 ; 25% - in 2010 ; 40% - in 2011 ; 55% - in 2012 ; 70% - in 2013 ; 85% - in 2014 ; 100%- in 2015. Energy producing units >20 MW, claiming to produce renewable electricity from biomass among other fuels, have to assure that agricultural biomass weight ratio is at least: 5% - in 2008 ; 10% - in 2009 ; 20% - in 2010 ; 20% - in 2011 ; 20% - in 2012 ; 25% - in 2013 ; 30% - in 2014 ; 40% - in 2015 ; 50% - in

2016 ; 60% - in 2017. The above means that power units will strive for the increase of agricultural biomass use.
In 2011 the draft Decree was updated: for big installations (>5MW) roundwood is excluded from green certificates, in terms of woody biomass only forestry *residues* are allowed.

PT_FIT (DL 225/2007)
Establishes the legal framework for the generation of electricity from renewable energy sources and setting the feed-in tariffs. For calculation of the FIT for electricity from biomass the norm introduces specific coefficients for "Residual Biomass from Forestry" (forestry fellings, residues from forestry fellings), animal biomass, MSW and biogas from landfills. The introduction to the law refers to the valorisation of the energy use of biomass as a means to reduce the risk of forest fires.

SE_ OoEC (Ordinance 2003:120 on electricity certificates)
The ordinance defines which types of biomass are eligible for electricity certificates. Some biomass types only receive certificates when burnt in CHP plants.

SI_EE-CHP
Regulation on support for the electricity generated in cogeneration with high efficiency. CHPs that use wood biomass from forests with FSC, PEFC are entitled to 10% higher referential costs (consequently allowing a higher subsidy).

SI_EE-RES
Regulation on support for the electricity generated from renewable energy sources. Power plants that use wood biomass from forest with FSC, PEFC are entitled to 10% higher referential costs (consequently allowing a higher subsidy).

SK_Boiler
Financial support scheme aimed at increasing the use of biomass installations for households. State support is up to 30% of the boiler price. There are technical requirements (efficiency and emissions) for the eligible biomass boilers.

UK_ROO2011 (The Renewables Obligation (Amendment) Order 2011)
The ROO places an obligation on UK suppliers of electricity 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_RHI (Renewable Heat Incentive)
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 Renewable Energy Directive requirements.

UK_SBHS (Scottish Biomass Heat Scheme)
The scheme is aimed at SMEs considering investing in the installation of biomass heating systems. Operators need to report on CO_2 savings and source of feedstock. The GHG calculation method only covers the consumption phase.

UK_BCGS (Bioenergy Capital Grants Scheme, England)
The scheme supports biomass-fuelled heat and combined heat and power projects in the industrial, commercial and community sectors in England. The scheme is aimed at SMEs considering investing in the installation of biomass heating systems.
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.

UK_ECS (Energy Crops Scheme)
The Energy Crops Scheme establishes grants for approved energy crops. The scheme is part of the Rural Development Programme which implements the EU Rural Development Regulation in England. The scheme supports the cost of establishment of Miscanthus or Short Rotation Coppice (SRC). Guidelines contain a list of different agricultural, environmental and forestry regulations as a minimum. This includes the application of Good Agricultural Practices. Applicants 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.

APPENDIX II FORESTRY MANAGEMENT AND BIODIVERSITY

In terms of Forestry Standards that require certification in forestry management, the Program for the Endorsement of Forestry Certification (PEFC) and the Forest Stewardship Council (FSC) are represented in the EU. Both standards consider issues on biodiversity, soil, water, management and in the case of FSC carbon stocks.

Table 1 presents the main criteria and principles of the PEFC and FSC standards, and two voluntary national standards, the Dutch Green Gold Label Program (Forest Source Criteria) and the UK Forestry standard.

The biodiversity principles vary among the standards but all of them look at the following topics:

a) Conservation: of biodiversity, threatened species, ecosystems,
b) Forest management or integrity (e.g. considering water, soil)
c) Enhancement: of habitats, landscape
d) Description of species, of ancient forests and semi-natural forests,
e) Impacts: on ecosystems, forest functions, exotic species

It is important to note that the standards are voluntary and only the case of the UK standard is linked to the Forestry Commission (Diaz-Chavez, 2010). The Green Gold Label standard has reported only two cases in Europe which did not succeed in the certification (Green Gold Label, 2011).

The application of the voluntary standards for the use of biomass for bioenergy can be covered with some of the principles of the standards. As examples, the UK and the Dutch standards are provided.

For instance, the Green Gold Label considers harvest, growth rates and impacts, while the UK standard considers ”the supply of timber and other forest produce for industrial use is available at levels indicated in long-term forecasts, or is increased without reducing the annual increment potential of future crops”.

Other countries with large forest cover include Finland (85% of the country is forest area) and Sweden (67% of the land area is forested) have forestry management standards with national interpretation such as the Finish Forest Certification System (FFCS) based on the PEFC and which has 95% of the forested area certified (Alakangas, 2010).

Nevertheless, there is a gap in terms of the biomass imported to the EU from the forestry sector. FSC and PEFC have national interpretations in most parts of the world but these are voluntary standard and therefore for non-timber products will not be applicable but advisable to review.

Table 1: Main criteria and principles of the PEFC and FSC standards, and two voluntary national standards

	Program for Endorsement of Forestry Certification (PEFC)	Green Gold Label Program (Dutch) (Forest Source Criteria)	UK Forestry Standard	Rainforest Alliance Forest Stewardship Council Forests (Smartwood) (10 Principles)
BIODIVERSITY	Concept: Representative, rare and vulnerable forest ecosystems • Changes in the area of natural and ancient semi-natural forests • Strictly protected forests • Forests protected by special management regime Descriptive: legal/regulatory framework; existence and capacity of institutional framework; economic policy framework and financial instruments; Informational means to implement policy framework. Concept Threatened species: Changes in number and percentage of threatened species in relation to total number of forest species Concept: Biological diversity in production forests • Changes in the proportion of stands managed for the conservation and utilisation of forest genetic resources; differentiation between indigenous and introduced species • Changes in the proportion of mixed stands tree species • Annual area regeneration/total area (proportions)	Principle 3 Environmental Impact • Conservation of biological diversity and forest integrity, water resources, soil, ecosystems and landscape • Description of biodiversity • Harvest and reforestation Principle 6 Other sources than natural forests and plantations • Includes a management plan	Nature conservation • Biodiversity in and around woods and forests is conserved or enhanced and species and habitats subject to EU directives or UK Biodiversity action Plan • Important but previously disturbed semi-natural habitats are restored	Principle 6 Environmental Impact • Forest management shall conserve biodiversity, fragile ecosystems and landscapes • Assessment of EI • Protection of rare, threatened and endangered species • Ecological functions and values maintained intact • Record landscapes on maps • Use of exotic species control and record
CARBON STOCKS		No specific (related to Principle 4 yield of all forest products harvested)	• The values of forest sinks and stores of carbon are recognised in policies and protected and enhanced in practice • Pollution is avoided by using the best available techniques which do not entail excessive costs	

WATER	Concept: Water conservation in forests • Proportion of forest area managed primarily for water protection	Principle 3 • Conservation of water resources 1. Pollution control 2. Roads, waterways and air routes providing maps and procedures Principle 6 Other sources than natural forests and plantations • Pollution control	• Water quality is protected or improved • Water yields are maintained above any critical level • Water discharge patterns are disturbed only when unavoidable	Principle 6 Environmental Impact • Written guidelines for control of water pollution • Maps and topographic maps for operation areas
SOIL FERTILITY	Concept: Soil erosion • Proportion of forest area managed primarily for soil protection	Principle 3 • Conservation of soil resources • Pollution control Principle 6 Other sources than natural forests and plantations 3. Pollution control	Forest soil condition • Is stable or improving towards a more stable condition	Principle 6 Environmental Impact • Written guidelines for control of erosion • Maps and topographic maps for operation areas
CROP management		NA		Principle 6 Environmental Impact • Management systems adopt for environmentally friendly use of pest management (non-chemicals)
WASTE management				Principle 6 Environmental Impact • Disposal of waste in an environmentally appropriate manner at off-site locations

Table 1: (continued)

	Pan European Forestry Commission PEFC	Green Gold Label Program (Forest Source Criteria)	UK Forestry Standard	Rainforest Alliance Forest Stewardship Council Forests (Smartwood) (10 Principles)
OTHERS	Concept General protection Legal/regulatory framework; existence and capacity of institutional framework; economic policy framework and financial instruments; Informational means to implement policy framework. Concept: Significance of the forest sector • Share of the forest sector from the gross national product Concept: Recreational services • Provision of recreation: area of forest with access per inhabitant, % of total forest area Concept: Provision of employment Concept: Research and professional education Concept: Public awareness Concept: Public participation Concept: Cultural values	Principle 1 Tenure and use rights to land Principle 2 Management Plan • Including objectives and means of achieving • Provide info on sustainability of forest, environment and economics • Info about harvesting techniques, equipment, maps, species, protection rate Principle 4 Monitoring and assessment • Harvests, growth rates, environmental impacts	Timber production • The supply of timber and other forest produce for industrial use is available at levels indicated in long-term forecasts, or is increased without reducing the annual increment potential of future crops Workforce • Safe and efficient practices are promoted and their effectiveness kept under review Rural development • Opportunities are enhanced for: rural development; access and recreation; quality of life; increased awareness and participation; community involvement; skills training Heritage • Important heritage features are protected (cultural, historic or designed landscapes) • Landscape quality is enhanced	Principle 1 Compliance with laws and FSC Principles • Respect national and local laws/administrative requirements • Comply with CITES, ILO Conventions, ITA and Convention on Biological Diversity Principle 2 Tenure and use rights and responsibilities Principle 3 Indigenous People's rights Principle 4 Community relations and worker's rights Principle 5 Benefits from the forest • Forest management operation shall encourage economic, environmental and social benefits Principle 7 Management Plan Principle 8 Monitoring and Assessment • To assess conditions of forest, yield, chain of custody, management activities and social and environmental impacts Principle 9 Maintenance of High conservation value forests Principle 10 Plantations

APPENDIX III DESCRIPTIONS OF THE VOLUNTARY SYSTEMS

In this section, a short description of the voluntary systems is presented, based on van Dam (2010). A detailed comparison is presented in Table 2.

The Dutch National Technical Agreement (NTA) **NTA8080** describes the minimum requirements for sustainable biomass for the Netherlands by defining sustainability criteria. These criteria are mainly based on the Cramer criteria, laid down in the 2007 report "Testing framework for sustainable biomass (Toetsingskader voor duurzame biomassa)". The NTA 8081 describes the certification scheme and includes the rules for certification to the requirements of the NTA 8080. The NTA 8080 includes a list of exceptions with biomass residues that have a negligible economic value such as bark, trimmings, saw dust, tertiary wood etc. These residue streams only have to comply with the GHG balance and improvement of soil quality criteria.

The **Green Gold Label (GGL)** is a business to business certification initiative started by the Dutch energy company Essent and Skall International (Control Union) in 2002. The system is in implementation to companies that deliver biomass to Essent. The label includes eight sustainability standards for the different process steps within the supply chain of biomass as well as the supply chain as a whole. Green Gold Label aims for partnerships with the NTA8080 and the EU CEN as well as third party users[1].

The UK energy company **DRAX** Power ltd established seven sustainability principles that cover biomass sourcing until delivery at factory gate for power generation in the UK. These principles are based on the policy and regulatory initiatives now being developed in the UK, EU and other markets. DRAX uses purchase contracts with requirements to suppliers that these sustainability principles are being met. In the future, they also want to engage a third party for auditing. DRAX aims to reduce GHG emissions by at least 70% relative to coal fired generation.

The **Swan label** for biofuels and biofuel pellets are part of the Nordic Swan eco-label for Scandinavian countries (Denmark, Finland, Iceland, Norway, Sweden). The label covers 67 product groups of which one is wood pellets. The requirements for wood pellets cover the whole life cycle (GHG emissions and energy) as well as manufacturing (e.g. materials that are used and traceability), transportation and storage and end use (e.g. exhaust gas emissions).

The **Laborelec label (LBE)** is, similar to GGL, a business to business certification system developed by the research centre Laborelec (part of RDF Suez) and SGS for the electricity company Electrabel in 2005. The label focuses mainly on woody biomass, but could also be used for agricultural residues. The label includes also an evaluation process for the (fossil) energy balance and CO_2 balance of the supply chain of biomass including transport of feedstocks. Laborelec does not have its own sustainability standards, but requires that biomass is produced in a sustainable way.

[1] http://www.greengoldcertified.org

Table 2 Criteria covered in the selected voluntary biomass certification initiatives[2]

Criteria	NL_NTA 8080/81		NL_GGL		BE_LBE		UK_DRAX		SC_SWAN (pellets)	
GHG-savings	X	GHG reduction: For electricity and heat at least 70% in case of reference of Dutch mixture of electricity or coal, or at least 50% in case of reference of natural gas; If in the chain of biomass innovative preparation technology or technologies are demonstrably used to enlarge the availability and / or applicability of sustainable biomass, a minimum of 50% applies.	X	According to the NTA8080 standard	X	Evaluation required	X	Significantly reduce GHG emissions compared with coal-fired generation and give preference to biomass sources that maximize this benefit. Drax strives to reduce GHG emissions by at least 70% in comparison to coal-fired generation	X	15. Fuels that are used during pellets production must produce a maximum greenhouse gas contribution of 100 kg CO2 per ton of pellets. The requirement covers the following processes: boiling and drying.
Energy balance		No energy requirements.	X	S8-1b. Minimum level of energy saving for certification: - Biomass for electricity: 35% - Biofuels: 35%	X	Evaluation required			X	14. The manufacture of the pellets must not consume more than 1200 kWh of primary energy per ton of pellets. An estimate of energy consumption shall be made. The annual average energy consumption per ton of pellets shall be specified. The different energy sources shall be specified separately.
Biodiversity	X	Biomass production must not affect protected or vulnerable biodiversity and will, where possible, have to strengthen biodiversity. 5a. National regulations and laws biomass production and production area 5b. Protected areas 5c. Areas with HCV 5d. Maintenance and recovery of biodiversity 5e. Strengthening of biodiversity.	X	S5-3. The forest management is aimed at conservation of biological diversity and forest integrity, water resources, soils, unique ecosystems and landscapes. S7-1a. The area to be converted must not contain high conservation value forest or areas of high conservation value. HCV areas are defined as areas of outstanding and critical importance due to their environmental, socio-economic, biodiversity + landscape values (WWF).			X	Not adversely affect protected or vulnerable biodiversity and where possible we will give preference to biomass production that strengthens biodiversity.	X	10. If virgin raw materials are used to manufacture the pellets, the pellets manufacturer must ensure that raw materials do not originate from forest environments meriting protection due to their high biological and/or social value. Nordic Ecolabelling may revoke a license if it is found that wood raw materials are derived from forest environments of this type.

[2] Van Dam et al. (2010)

Carbon stock	X	3a.The installation of new biomass production units must not take place in areas in which the loss of aboveground carbon storage cannot be recovered within a period of ten years of the intended biomass production. The reference date is 1 January 2007, with the exception of those biomass flows, for which a reference date already applies from other certification systems (currently under development).					X	Not result in a net release of carbon from the vegetation and soil of either forests or agricultural lands.		
Land use change	X	3b. The installation of new biomass production units must not take place in areas with a great risk of significant carbon losses from the soil, such as certain grasslands, peat areas, mangroves and wet areas (wetlands). The reference date is 1 January 2007, with the exception of those biomass flows for which a reference date already applies from other certification systems (currently under development).	X	S5-5a Plantations shall be planned and managed in accordance with the principles 1-4, and principle 5. They should complement the management of, reduce pressures on and promote the restoration and conservation of natural forests. S5-5b For existing plantations the management has to demonstrate, that the plantation was not established by converting a forest. S7-1a. The area to be converted must not contain high conservation value forest or areas of high conservation value. S7-1b. Conversion and maintenance must achieve clear, additional and long term conservation benefits.					X	
Soil protection	X	In the production and processing of biomass, the soil, and soil quality must be retained or even improved. 6a. National regulations and laws for soil management 6b. Preservation and improvement of the soil quality 6c. Use of residual products.	X	S2-4c. Proper dispose of sewage and waste from the farm and human settlements and of manure produces by intensive life stock breeding. S2-4e. Measures have to be taken to minimize soil run-off and sedimentation.			X	Deploy good practices to protect and/or improve soil, water (both ground and surface) and air quality.		

Protection of fresh water	X	In the production and processing of biomass ground and surface water must not be depleted and the water quality must be maintained or improved. 7a. National regulations and laws for water management 7b. Preservation and improvement of water quality 7c. Renewable sources	X	S2-4d. Water quality has to be monitored on biological, physical and chemical quality. S2-4f. Irrigation has to be planned in a long term program. S2-4g. Long term strategies and implementation program have to be developed on water use under scarce conditions. S2-4h. Waste water re-use has to be part of the agriculture management system.			X	Deploy good practices to protect and/or improve soil, water (both ground and surface) and air quality.		
Air protection	X	In the production and processing of biomass the air quality must be maintained or improved. 8a. No violation of national laws and regulations for air emissions and air quality. 8b. Reducing emissions and air pollution 8c. No burning during the installation or management					X	Deploy good practices to protect and/or improve soil, water (both ground and surface) and air quality.		
Restoration of degraded lands	X	5d. Maintenance and recovery of biodiversity The organization shall: Record whether the biomass production contributes to the recovery of degraded areas within the PU	X							
Social criteria	X	10a. Working conditions The organization shall: - Create practices in accordance with the most recent established version of the Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy (compiled by the International Labour Organization) with respect to employment, labour relations, safety and health, training and education, and diversity and equal opportunities, treatment of complaints. The production of biomass must contribute towards the social well being of the employees and the local population. 10a. No negative effects on the working conditions of employees 10b. No negative effects on human rights	X	S7-1m. All work is carried out in accordance with industry best practice and takes into account a risk assessment of the site.S5-6b Management of sources other than natural forest and plantations shall conserve the ecological, social and cultural functions and integrity. S7-1i. Conversion and maintenance does not affect the availability of food to local Inhabitants.			X	Not endanger food supply or communities where the use of biomass is essential for subsistence (for example, heat, medicines, building materials). Contribute to local prosperity in the area of supply chain management and biomass production. Contribute to the social well being of employees and the local population in the area of the biomass production	X	8. The manufacturer must guarantee adherence to safety regulations, working environment legislation, environmental legislation and conditions/concessions specific to the operations at all sites where the Swan labelled fuel is manufactured.

		10c. The use of land shall not lead to the violation of official property and use, and customary law without the free prior consent of the sufficiently informed population 10d. Positive contribution to the well-being of the local population 10e. Insight into possible violations of the integrity of the company.								

APPENDIX IV ENERGY BALANCE CORRECTION OF FLEMISH GREEN POWER CERTIFICATE SYSTEM IN BELGIUM

In the Flemish region in Belgium, two certificate systems exist: one for green electricity promotion, based on the amount of green electricity produced and one for the promotion of CHP[3], based on the amount of primary energy avoided. Green certificates for electricity are calculated based on the energy balance taking the use of fossil energy over the chain into account (VREG 2007):

$$E_{GSC} = G * (E_{gross} - E_{aux}) - E_{pre} - E_{trp}$$

In this formula E_{GSC} is the amount of electricity (in MWh) that is eligible to be granted for Green Certificates; E_{gross} and E_{aux} are the gross electricity production and the auxiliary energy consumption of the power plant respectively. The green factor G is applicable to co-firing and represents the fraction of biomass relative to the total fuel input (in net calorific value). Also subtracted from the green certificates is the amount of fossil energy required for transport (E_{trp}) and pre-treatment (E_{pre}), like chipping or pelletisation. Energy for drying is only taken into account if fossil energy is used whereas the use of electricity is always taken into account, regardless of the source. Note that if biomass is a primary product, also the energy consumption for cultivation and harvesting etc. must be considered (Ryckmans and André, 2007).

Energy use for the production and transportation of biomass is collected by an audit procedure followed by monthly reporting based on measurements. Primary energy, diesel use for transport, is converted to electric equivalent with a factor of 55% (natural gas combined cycle plant reference).

One of the major differences between the Walloon and the Flemish system for electricity generation is the reference system used in the Walloon Region where the avoided CO_2 is calculated based on a natural gas combined cycle plant (η = 55%). With the system in Flanders, it is not possible to consider the emission factor of different fossil fuels (e.g. coal vs. natural gas). Another limitation of the energy balance system is that emissions other than combustion of fossil fuels are not taken into account. These include, for example, N_2O emissions from the application of N-fertilizers or methane leakage from biogas plants.

One implication of the system in the Walloon Region is that co-firing only qualifies for green certificates if the biomass to coal ratio is at least 70% (mass) due to the assumed fossil reference system (gas fired power plant, η = 55%) that emits about half the amount of CO_2 compared to a coal fired power plant. To receive green certificates, the 80 MW_e coal fired power plant Les Awirs, Unit 4 in the Walloon Region was converted to 100% biomass (Van Stappen, Marchal, *et al* 2007).

[3] The CHP Certificate system in Flanders is not specific to biomass and therefore not discussed in this section

APPENDIX V GREENHOUSE GAS EMISSIONS AND COST OF INTRA-EUROPEAN TRADE OF SOLID BIOMASS

In the past decade we have seen that new biomass resources have been mobilized, both from EU as non-EU resources to meet the growing European demand for bioenergy. It is however yet unclear how much of the future demand can be supplied by untapped resources, both residues and dedicated energy crops within the EU, and how much is likely to be sourced from outside the EU. Policy makers are faced with this and other uncertainties. Similarly, energy and non-energy users of biomass in industry sectors are faced with increasing competition. In order to assess the potential supply of biomass from EU and non-EU sources and the expected logistic chains of biomass distribution, insight is required in the current and future options for biomass transport and the related economic and greenhouse gas (GHG) performance.

To analyse the impact of intra- and inter-EU biomass trade on economic and GHG performance with the energy modelling tool Green-X, the database of Green-X was extended with country-to-country specific trade links for bioenergy commodities and related cost and GHG emissions of the total supply chain. Emissions related to cultivation and pre-treatment (such as chipping or pelletisation) are consistent with the typical values of the biomass pathways based on calculations done by the Joint Research Centre (JRC, 2011). However, to address the variety in transport routes of bulk bioenergy commodities, including different transport modes and transhipment, additional modelling was required.

This section describes the methodology and results of the modelling work required to calculate the input parameters of Intra-EU biomass trade in Green-X.

V.1 Methodology

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. 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 (e.g. from truck to ship). The model optimizes 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.

V.1.1 The transport network

The transport model uses a hub - spoke method similar to Winebrake, Corbett *et al* (2008) that connects different transport nodes via connectors (the spokes) to transhipment hubs. The transhipment hubs and connectors are artificial and located in the geographical centre of each NUTS - 3 region. The nodes represent existing harbours, road exits and rail terminals. Links connecting these nodes represent existing roads, railways and canals or rivers. The centroids are connected to the nearest road, rail and waterway nodes via connectors. Cost evaluators were applied to these connectors representing the cost for transhipment (loading/unloading and storage) between different transport modes. Figure 1 depicts an example of a transhipment hub in a region including all transport modalities, for instance Rotterdam. Note that in most regions only road and rail networks are available.

Network data for road, rail and inland waterways (Figure 3) were based on the TRANS - TOOLS V2 model (JRC 2009), a decision support model for transport impact analyses. Sea harbours were derived from the EC GISCO database. Links between sea harbours were created in ArcGIS, distances between harbours were derived from the WN Network database (WN 2010) and SeaRates.com (SeaRates.com 2010). Cost and GHG evaluators specific to biomass logistics were added to the TRANS - TOOLS freight network. The performance parameters (cost and emissions) were based on literature review and expert interviews and added as evaluators to the logistic network in ArcGIS (Table 3).

Because biomass supply potentials in Green-X are available on country level, the spatial distribution of energy crops within the EU-27 MS were derived from the results of the REFUEL project (de Wit and Faaij 2010) that provides the supply potential on NUTS-2 level (example in Figure 3). Relative availability of forestry residues and products were assumed to be similar to the forestry cover on NUTS-2 level (EUROSTAT 2010). The potentials per NUTS-2 region within a country were combined with the biomass potentials and farm-gate costs on country level of the Green-X model.

Figure 1: The network model approach (hub-spoke)

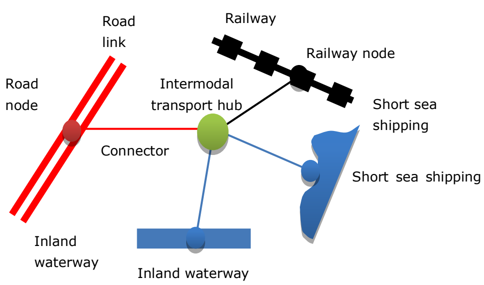


Figure 2: EU destinations (largest cities per NUTS-1 region and important harbours in the EU)

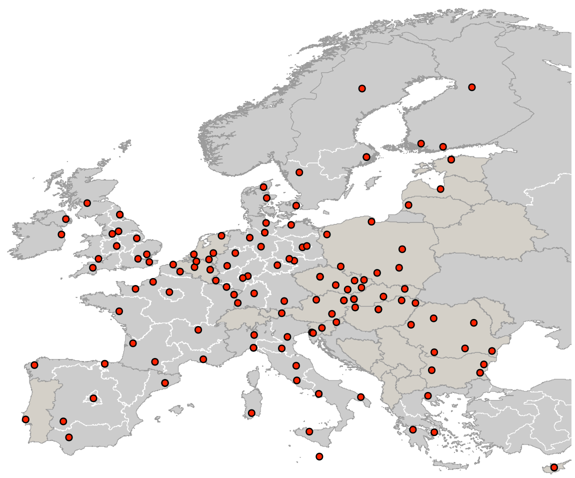
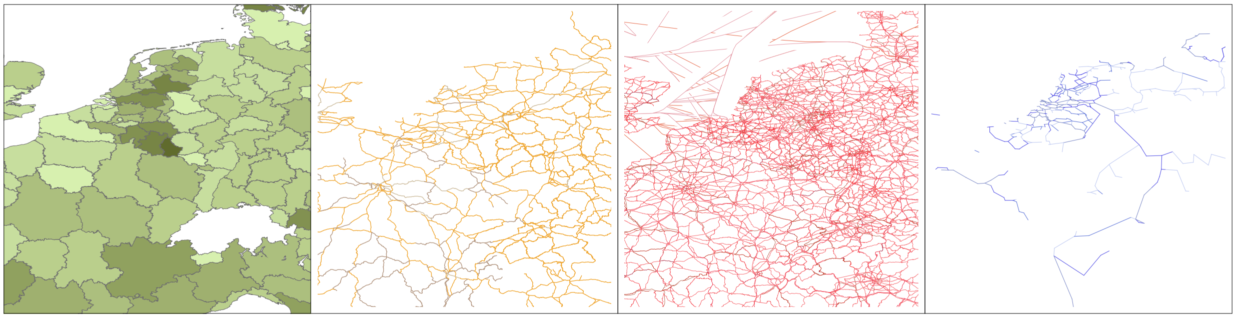


Figure 3: Depiction of biomass distribution (NUTS-2 level) and network links in the biomass logistics model



a: biomass distribution (NUTS-2) **b: rail network** **c: road network and ferry links** **d: inland waterway network**

V.2 Transport and transshipment

The model assumptions on transport and transshipment are depicted in Table 3. The specific transport cost depends on the fuel and labour costs which vary per country. For road transport by truck, also the speed, which varies per road type and for some highways, toll cost impact the total transport cost. The ranges in loading and unloading cost are based on country specific labour cost per country. For inland navigation, four ship types are included as not all ship sizes can navigate on all channels or rivers.

Table 3: Performance parameters of transport parameters included (based on NEA 2004, TML 2005, Smeets et al 2009)

Parameter	Unit	Truck	Inland navigation				Short Sea Shipping	Rail
			Class 2	Class 3	Class 4	Class 5/6		
		Dry bulk	Kempenaar	Rhine-Herne Canal ship	Large Rhine ship	Four-barges convoy set	Dry bulk	Dry bulk
Load	tonne	27	550	950	2500	10800	5700	1625
Load factor (during laden trips)		0.93	0.86	0.90	0.86	0.73	0.79	1.00
Laden trips of total trips		0.55	0.73	0.81	0.75	0.65	0.94	0.50
Fixed cost (excl. labour)	€/vh	18	10	22	72	214	123	
Variable cost (excl. fuel)	€/vkm	0.11	0.0	0.0	0.7	17.8	5.71	
Required labour	person/v	1.00	1.28	1.44	2.62	3.76		
Fuel consumption full	l/vkm	0.37	6.1	8.8	13.1	20.0		
Fuel consumption empty	l/vkm	0.23	4.9	7.6	11.8	18.4		
Fuel consumption average	l/vkm	0.31	5.7	8.4	12.6	19.2	35.3	5.8
Fuel type		Diesel	MDO	MDO	MDO	MDO	HFO	Diesel
Loading/unloading min.	€/t	1.14	1.14	1.14	1.14	1.14	1.14	1.86
Loading/unloading max.	€/t	2.74	2.74	2.74	2.74	2.74	2.74	4.46

V.3 Calculation of origin – destination cost and greenhouse gas emissions

To calculate the cost and GHG emission premiums for biomass transport between EU-27 MS, origin – destination (OD) matrices were made with the ArcGis transport model. The origins include the NUTS-2 regions in the EU-27 (n=262) (excluding some islands). The destinations include the largest cities per NUTS-2 region and important sea harbours (n=121) in the EU-27 as depicted in Figure 2. The model calculates the lowest cost routes between all origins and all destinations for the given years (2005, 2010, 2020 and 2030) including related GHG emissions. These calculations were made outside the Green-X model and do not include any policy criteria. This implies that, if the total GHG balance of the supply chain does not meet the criteria, Green-X will redistribute the biomass. The routes between countries will however not change.

Because biomass supply potentials are provided on a NUTS-2 level, the cost-supply curves can be calculated per destination. To calculate the cost per destination country, it was assumed that 50% is transported to the cheapest destination per country and 50% is distributed equally among the destinations (average cost).

V.4 Results and discussion

This section covers the result on cost and GHG emissions of the total supply chains of the biomass feedstocks used for electricity and heat generation in Green-X. The results, as implemented in Green-X, exist of country to country tables (27 rows and 27 columns) per year and per feedstock for both cost and GHG emissions. For reasons of readability, these results are summarized here in average values and ranges. The ranges represent the minimum and maximum values of either domestic use or export to other countries within the EU27.

Table 4 summarizes the cost of biomass feedstocks that can both be exported and used for electricity and/or heat in Green-X. The cost at farm gate covers the cost of biomass including cultivation and harvesting. Processing cost for baling, chipping and pelletisation are included in the cost of domestic use or export. The additional cost for processing are especially large for pelletisation (11-12 €/MWh). In most cases, the additional cost for pelletisation does therefore not pay off for the cheaper transport cost relative to transport of wood chips within the EU. Domestic transport (50 km) only adds 1 to 3 €/MWh to the total cost for domestic use. In the case of grassy crops (miscanthus and switchgrass) and straw, it was assumed that bales are used domestically whereas exported biomass is processed to pellets first. The cost of exported grassy crops and straw is therefore significantly higher than domestic use. Pelletisation of these products is however cheaper than pelletisation of woody biomass (5 – 6 €/MWh).

The total cost of exported biomass chips ranges from 9 €/MWh (FR2 and FR3 in 2010) to 60 €/MWh (FP3 in 2030). The cost for exported wood pellets ranges from 16 €/MWh (FR5 in 2010) to 70 €/MWh (AP5 in 2030). For straw, domestic production of straw bales is always cheaper than importing straw pellets. Some imported crops are cheaper than domestically produced biomass. For Austria, it is for example cheaper to import wood chips from Slovakia or Hungary (25-26 €/MWh in 2010) than to produce them domestically (26 MWh in 2010).

Table 4: Cost related to the total supply chain of domestic and Intra-European supply of biomass feedstocks in Green-X (€$_{2006}$/MWh primary biomass)

Feedstock	Transported as	Year	Feedstock (farm gate)[1] Av.	Feedstock (farm gate)[1] Range	Domestic[2] Av.	Domestic[2] Range	Export[3] Av.	Export[3] Range
AP4 (SRC willow)	Chips	2010	23	21 - 26	25	23 - 28	33	24 - 46
		2020	29	26 - 33	32	29 - 35	39	30 - 52
		2030	34	30 - 38	36	33 - 40	44	35 - 58
	Pellets	2010	23	21 - 26	35	33 - 38	40	34 - 50
		2020	29	26 - 33	42	39 - 45	47	40 - 57
		2030	34	30 - 38	47	43 - 51	52	44 - 63
AP5 (miscanthus)	Bales/pellets[4]	2010	29	25 - 33	32	28 - 36	42	32 - 53
		2020	37	32 - 43	41	36 - 45	50	39 - 63
		2030	43	36 - 49	47	41 - 52	56	44 - 70
AP6 (switch grass)	Bales/pellets[4]	2010	29	25 - 33	29	19 - 33	39	24 - 49
		2020	37	32 - 43	37	23 - 42	46	28 - 58
		2030	43	36 - 49	42	27 - 48	52	32 - 65
AR1 (straw)	Bales/pellets[4]	2010	11	10 - 13	14	13 - 15	24	18 - 34
		2020	13	12 - 16	17	15 - 19	27	20 - 37
		2030	15	14 - 19	19	17 - 21	30	22 - 40
FP1 (forestry products - current use (wood chips, log wood) and FP2 (forestry products - complementary fellings (moderate))	Chips	2010	19	15 - 22	21	18 - 24	29	21 - 44
		2020	21	17 - 25	24	21 - 27	32	23 - 47
		2030	23	18 - 27	26	22 - 29	35	25 - 50
	Pellets	2010	19	15 - 22	31	28 - 34	37	30 - 47
		2020	21	17 - 25	34	31 - 37	40	33 - 50
		2030	23	18 - 27	36	32 - 40	42	35 - 53
FP3 (forestry products - complementary fellings (expensive))	Chips	2010	27	23 - 31	30	27 - 32	38	29 - 51
		2020	31	26 - 35	34	30 - 37	42	33 - 56
		2030	34	29 - 38	37	32 - 39	45	36 - 60
	Pellets	2010	27	23 - 31	40	36 - 42	45	39 - 54
		2020	31	26 - 35	44	40 - 47	50	43 - 59
		2030	34	29 - 38	47	42 - 50	53	46 - 63
FR2 (forestry residues - current use) and FR3 (forestry residues - additional)	Chips	2010	17	6 - 31	12	7 - 17	20	9 - 37
		2020	19	7 - 35	14	8 - 19	22	10 - 39
		2030	21	7 - 38	15	9 - 21	23	11 - 41
	Pellets	2010	17	6 - 31	22	17 - 27	27	19 - 39
		2020	19	7 - 35	24	18 - 30	29	20 - 42
		2030	21	7 - 38	25	19 - 31	31	21 - 44
FR5 (additional wood processing residues (sawmill, bark)	Pellets[5]	2010	6	3 - 9	16	14 - 18	22	16 - 30
		2020	7	4 - 10	18	15 - 19	23	18 - 32
		2030	7	4 - 11	18	15 - 20	24	19 - 34

1) Farm gate cost excluding processing (baling/chipping/pelletisation). The feedstock cost varies per country.

2) Processing (baling/chipping/pelletisation and transport of 50 km by truck)

3) Intra-European transport, based on lowest cost routes between countries. Emissions depend on distance and used transport modes (ship, rail, truck).

4) Bales for domestic use, if traded internationally, bales are transported by truck to a pelletisation plant (50 km). Pellets are exported.

5) No chips available (part of this stream exists of saw dust).

Table 5 depicts the GHG emissions of biomass cultivation, processing and domestic use or ranges of emissions if biomass is transported to other countries in the EU-27. The ranges show the difference between international transport routes that have the lowest emissions and international transport routes that have the highest transport emissions. For domestic supply and transport within the same country, similar transport distances were assumed for all countries (50 km). The GHG balance of domestic biomass supply is therefore similar for all EU Member States. In Green-X, all country-to-country results are included. Note that in some cases, the emissions of Intra-European trade routes might be higher than some inter-continental supply chains (e.g. Canada).

Table 5: Greenhouse gas emissions related to the total supply chain of domestic and Intra-European supply of biomass feedstocks in Green-X (g CO_2-eq/MJ_{fuel})

Feedstock category	Transported as	Cultivation	Total if used domestically[1]	Total if exported (depending on destination)[2]					
				2010		2020		2030	
				Av.	Range	Av.	Range	Av.	Range
AP4 (SRC willow)	Chips	2.0	2.7	8.2	3.0 - 16.9	7.4	2.9 - 13.7	7.2	2.9 - 13.0
	Pellets	2.6	12.9	16.7	13.1 - 22.9	16.2	13.0 - 20.6	16.0	13.0 - 20.1
AP5 (miscanthus)	Bales/pellets[3]	3.6	5.0	13.0	9.1 - 19.5	12.4	9.0 - 17.1	12.3	9.0 - 16.8
AP6 (switch grass)	Bales/pellets[3]	3.6	5.0	13.0	9.1 - 19.5	12.4	9.0 - 17.1	12.3	9.0 - 16.8
AR1 (straw)	Bales/pellets[3]	0.5	1.7	9.4	4.9 - 17.1	8.7	4.8 - 14.3	8.6	4.7 - 13.9
FP1 (forestry products - current use (wood chips, log wood)	Chips	1.0	1.7	7.2	2.0 - 15.9	6.4	1.8 - 12.7	6.2	1.8 - 12.3
	Pellets	1.0	11.3	15.2	11.6 - 21.3	14.6	11.4 - 19.0	14.5	11.4 - 18.8
FP2 (forestry products - complementary fellings (moderate))	Chips	1.0	1.7	7.2	2.0 - 15.9	6.4	1.8 - 12.7	6.2	1.8 - 12.3
	Pellets	1.0	11.3	15.2	11.6 - 21.3	14.6	11.4 - 19.0	14.5	11.4 - 18.8
FP3 (forestry products - complementary fellings (expensive))	Chips	1.0	1.7	7.2	2.0 - 15.9	6.4	1.8 - 12.7	6.2	1.8 - 12.3
	Pellets	1.0	11.3	15.2	11.6 - 21.3	14.6	11.4 - 19.0	14.5	11.4 - 18.8
FR2 (forestry residues - current use)	Chips	0.0	0.7	6.2	1.1 - 14.9	5.4	0.8 - 11.7	5.2	0.8 - 11.3
	Pellets	0.0	10.4	14.2	10.6 - 20.3	13.7	10.5 - 18.1	13.5	10.5 - 17.8
FR3 (forestry residues - additional)	Chips	0.0	0.7	6.2	1.1 - 14.9	5.4	0.8 - 11.7	5.2	0.8 - 11.3
	Pellets	0.0	10.4	14.2	10.6 - 20.3	13.7	10.5 - 18.1	13.5	10.5 - 17.8
FR5 (additional wood processing residues (sawmill, bark)	Pellets[4]	0.0	5.6	9.5	5.9 - 15.5	8.9	5.7 - 13.3	8.8	5.7 - 13.0

1) Transport of 50 km by truck
2) Intra-European transport, based on lowest cost routes between countries. Emissions depend on distance and used transport modes (ship, rail, truck).
3) Bales for domestic use, if exported, bales are transported by truck to a pelletisation plant (50 km) and pelletised. Only pellets are exported.
4) Only pellets, part of this stream exists of saw dust.

APPENDIX VI ASSESSMENT OF THE GREEN-X DATABASE ON POTENTIALS AND COST FOR BIOMASS SUPPLY

This section covers an assessment of available biomass for bioenergy production and costs in the EU27 between 2005 and 2030, and a long-term outlook beyond 2040. The 2009 COWI consortium (COWI, 2009) conducted a review of the assumptions in Green-X on the cost and availability of biomass for bioenergy in the EU-27 including imports of biomass and biofuels to 2020. For the domestic potential in the EU-27, COWI concludes that the estimated potentials in Green-X are relatively conservative. However it was also noted that other studies were criticized for being too optimistic. Different from COWI, this study compares the potential on a country level. Furthermore, medium and long term assumptions beyond 2020 were reviewed.

Green-X includes assumptions on actual production, import and use of biomass for bioenergy which is defined as "implementation-economic potential" (COWI, 2009), but will be referred to as "Green-X potential" in this section. Figure 4 shows the current Green-X potential for bioenergy in the EU-27 per feedstock type in the model.[4] [5] The total potential increases from 159 Mtoe in 2005 to 257 Mtoe in 2030 with the share of forestry products (FP) reducing from 37% in 2005 to 28% in 2030 and the share of dedicated energy crops (AP) increasing from 22% in 2005 to 33% in 2030. Mainly second generation energy crops (maize, whole plant, SRC, miscanthus and switchgrass) show the highest growth in potential between 2005 and 2030. A detailed discussion of these assumptions per resource type is provided in the following sections.

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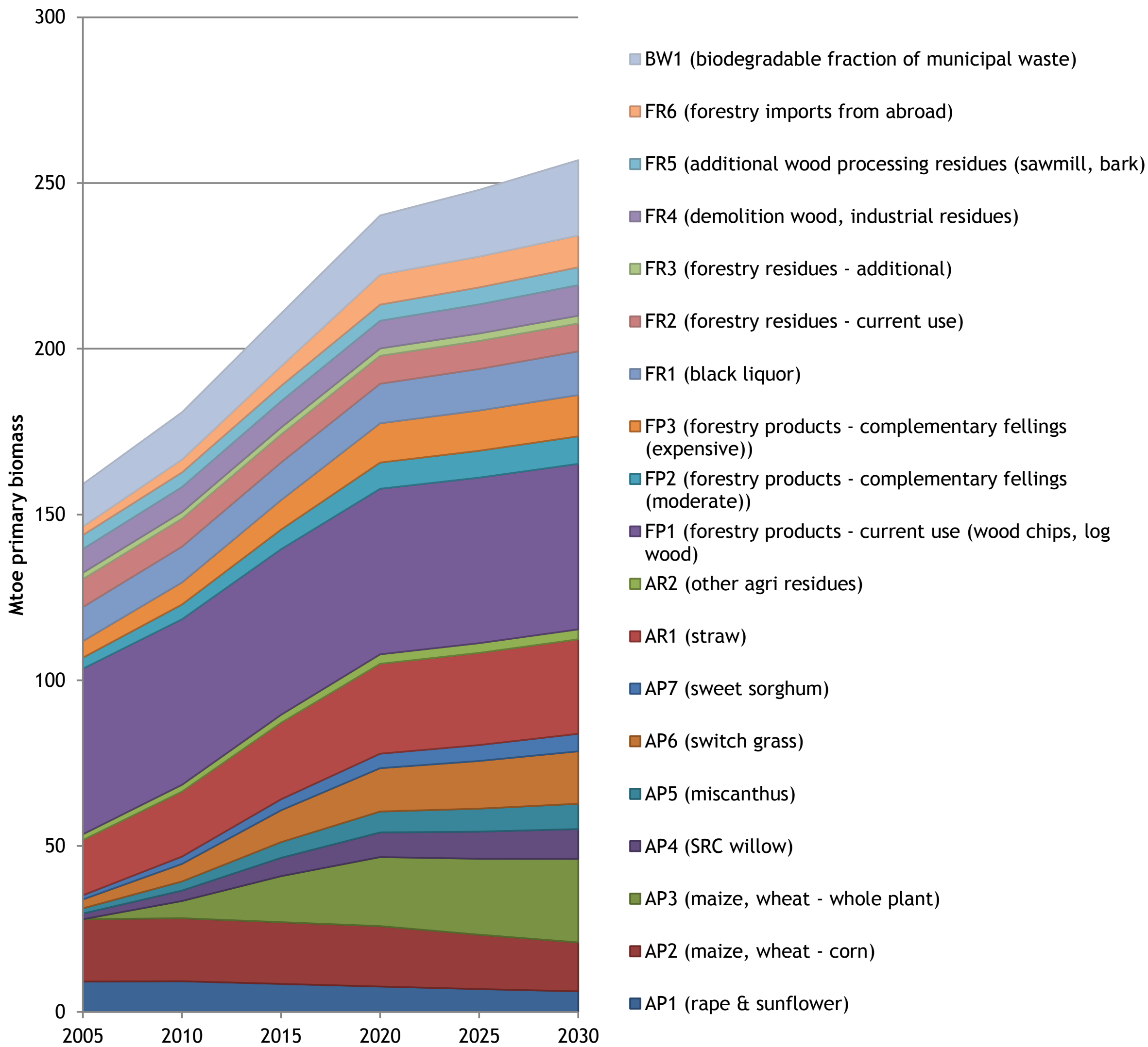
[4] Note that thereby biogas-related feedstocks are excluded.

[5] Data for 2020 illustrated in Figure 4 are identical to the information provided in Table 30 within the main report, which provides a concise summary of potentials and related costs for bioenergy feedstock according to the Green-X database.

Figure 4: Implementation-economic potential of bioenergy sources in Green-X

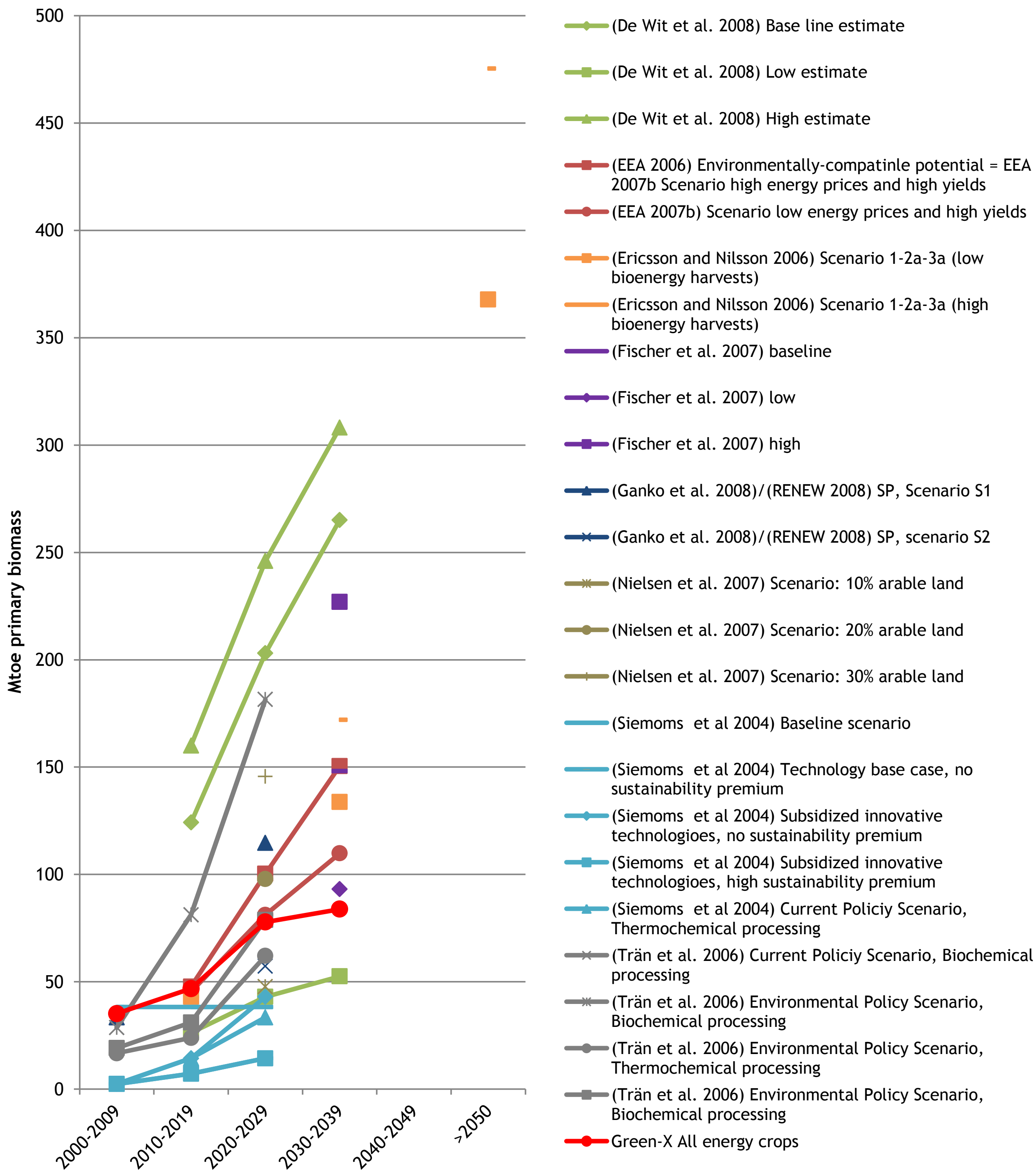


VI.1 Energy crops

VI.1.1 EU-27 potential

Based on the recently conducted biomass resource assessment for bioenergy in context of the Biomass Energy Europe (BEE) project, Rettenmaier (2010) compared several studies that estimated the potential for energy crops within Europe. As these studies cover different regions within Europe ranging from the EU20 to EU27+3 countries, the potentials were, amongst others, calibrated for the EU27 based on for example the relative share of country specific potentials. Figure 5 shows the calibrated results of the projected biomass potentials for the EU-27. For reason of comparison, the Green-X potential for energy crops (AP) was added to the results of Rettenmaier (2010).

Figure 5: Total energy crops calibrated for the EU27 (Rettenmaier et al, 2010) with the energy crop potentials from Green-X added[6] and alternative projections[7].



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[6] Note that the results of Figure 5 differ from the results of De Wit et al. (2008) in Figure 6 because crops produced on pasture land are excluded in Figure 6..

[7] Alternative projections used for this comparison comprise: Siemons, Vis et al. 2004; EEA 2006; Ericsson and Nilsson 2006; Thrän, M. Weber et al. 2006; Fischer, Hizsnyik et al. 2007; Nielsen, Oleskowicz-Popiel et al. 2007; EEA 2007b; Gańko, Kunikowski et al. 2008; Wit, Faaij et al. 2008.

Until 2020, the potentials in Green-X for energy crops are in line with the projections from the EEA Low energy high yields scenario (EEA 2007b) and the Environmental Policy Biochemical Processing scenario from Thrän *et al* (2006) (79 to 81 Mtoe in 2020). Other studies and scenarios show a wide range in the projections for 2020 (14 to 246 Mtoe). For 2030, despite partly substitution of first generation energy crops by second generation energy corps in Green-X (Figure 5), there is little increase (8%) in the potential for energy crops relative to 2020. The biomass resource assessment studies depicted in Figure 5 that include results for 2020 and 2030 show much higher increased potentials between 2020 and 2030, ranging from 22% (low estimate de Wit et al. (2008)) to 50% (EEA 2006). It appears therefore that the trend in biomass potentials in Green-X between 2020 and 2030 is conservative. It should be noted though that some of these resource assessment studies have been criticized for being too optimistic. The EEA (2006), for example, for its degree on liberalization in trade of agriculture and de Wit *et al* (2008) for being too optimistic on productivity increases in new EU Member States (COWI 2009).

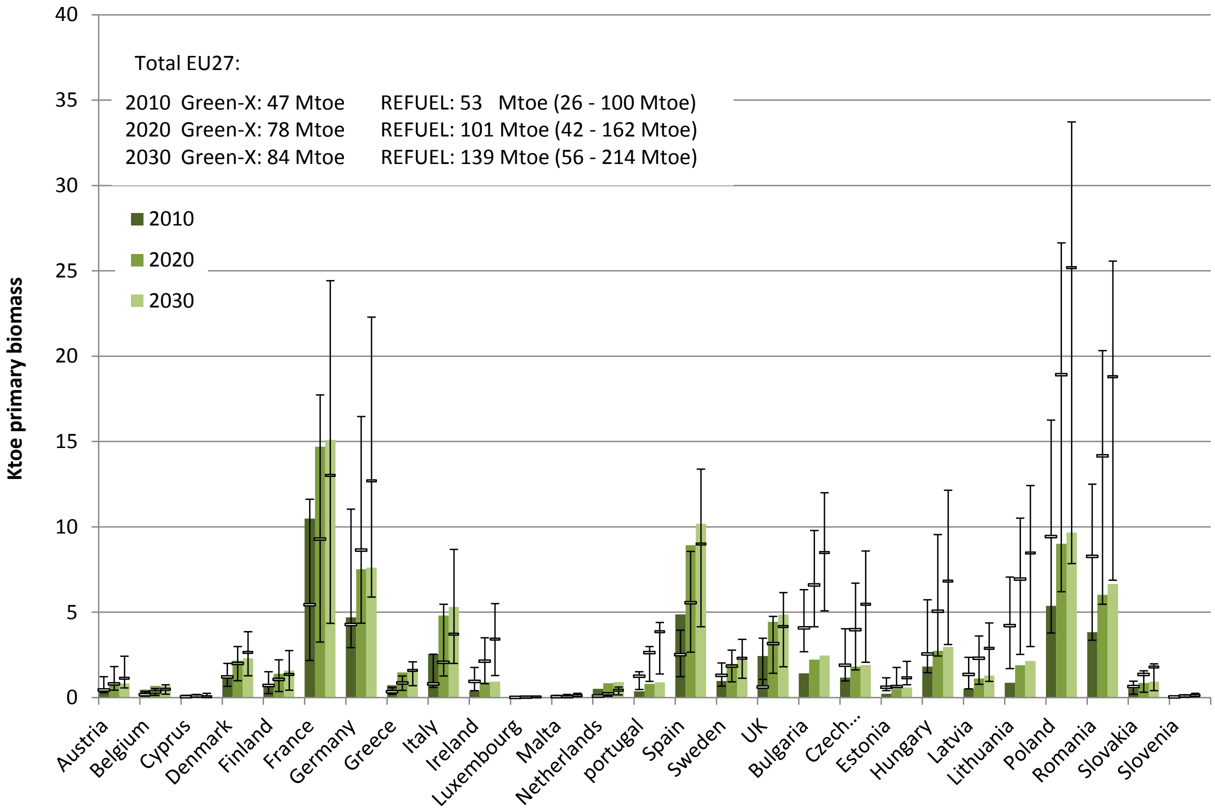
Most of the studies on EU potentials include potential estimates up to 2030 likely due to the horizon of energy and climate policies (Rettenmaier, Schorb *et al* 2010). For long term potentials beyond 2030, only Ericsson and Nilsson (2006) provide projections for 2050. According to Ericsson and Nilsson, the potential for energy crops increases with over 175% between 2030 and 2050 for both scenarios. It should be noted however that these results are based on simple statistical methods without particular crop types (Rettenmaier, Schorb *et al* 2010).

VI.1.2 Energy crop potential per country

To compare the biomass supply potentials on a country level, similar to COWI (COWI 2009), the cost-supply curves of biomass of the REFUEL project and the studies that underlie the results of this project (de Wit and Faaij 2009; Fischer, Prieler *et al* 2009a; Fischer, Prieler *et al* 2009b) were used. Figure 6 depicts the potential of dedicated energy crops in the EU27 for Green-X (columns) and REFUEL (markers). The markers for REFUEL show the potential for the same crop mix as assumed in Green-X[8] produced on available arable land. The crop mix in Green-X is depicted in Figure 4 and includes rapeseeds, sunflower, maize and wheat (corn and whole plant), short rotation coppice willow, miscanthus, sweet sorghum, etc. The negative error bars show the range if only low yield energy crops (oil crops) are produced on available land. The positive error bars show the potential if only high yield (grassy) crops are produced on available land. Results of REFUEL are based on the base scenario and exclude potentials of cultivation of lignocellulosic crops on pasture land (2009) since this option was not considered within Green-X.

[8] To harmonize the crop production mix between Green-X (fixed shares) and REFUEL (variable crop shares), the MS Excel solver was used to estimate the maximum total biomass production with the REFUEL database with the Green-X crop shares per country.

Figure 6: Supply potential of dedicated energy crops in the EU27 for Green-X (columns) and REFUEL (markers) for the same crop type production mix



The comparison of Green-X potentials and REFUEL potentials of dedicated energy crops shows that the higher estimated potentials in 2030 in REFUEL (138 Mtoe) compared to Green-X (84 Mtoe) are mainly due to differences in Central and Eastern European Countries (CEEC[9]). In France, Spain and Italy and the UK, the estimated potentials are more conservative in REFUEL compared to Green-X. In REFUEL, the estimated potential for energy crops in CEEC increases from 33 Mtoe in 2010 to 79 Mtoe in 2030 (57% of the EU27 potential). In Green-X, the potential in CEEC countries increases from 17 Mtoe in 2010 to 29 Mtoe in 2030 (34% of the EU27 potential).

VI.1.3 Costs of energy crops

The costs for biomass production depend on the cost per hectare including land, labour, capital and fertilizers which differ per country and region. The costs of bioenergy crops in Green-X are estimated on country level per crop type. To compare the cost of bioenergy crops in Green-X with REFUEL, cost supply curves were made for the EU-27 using the Green-X database and the REFUEL NUTS-2 level database for the same region. In order to compare the costs more consistently, similar crop type shares were assumed in REFUEL. Figure 7 shows the cost-supply curves of energy crop cultivation in the EU27 for REFUEL (left) and Green-X (right).

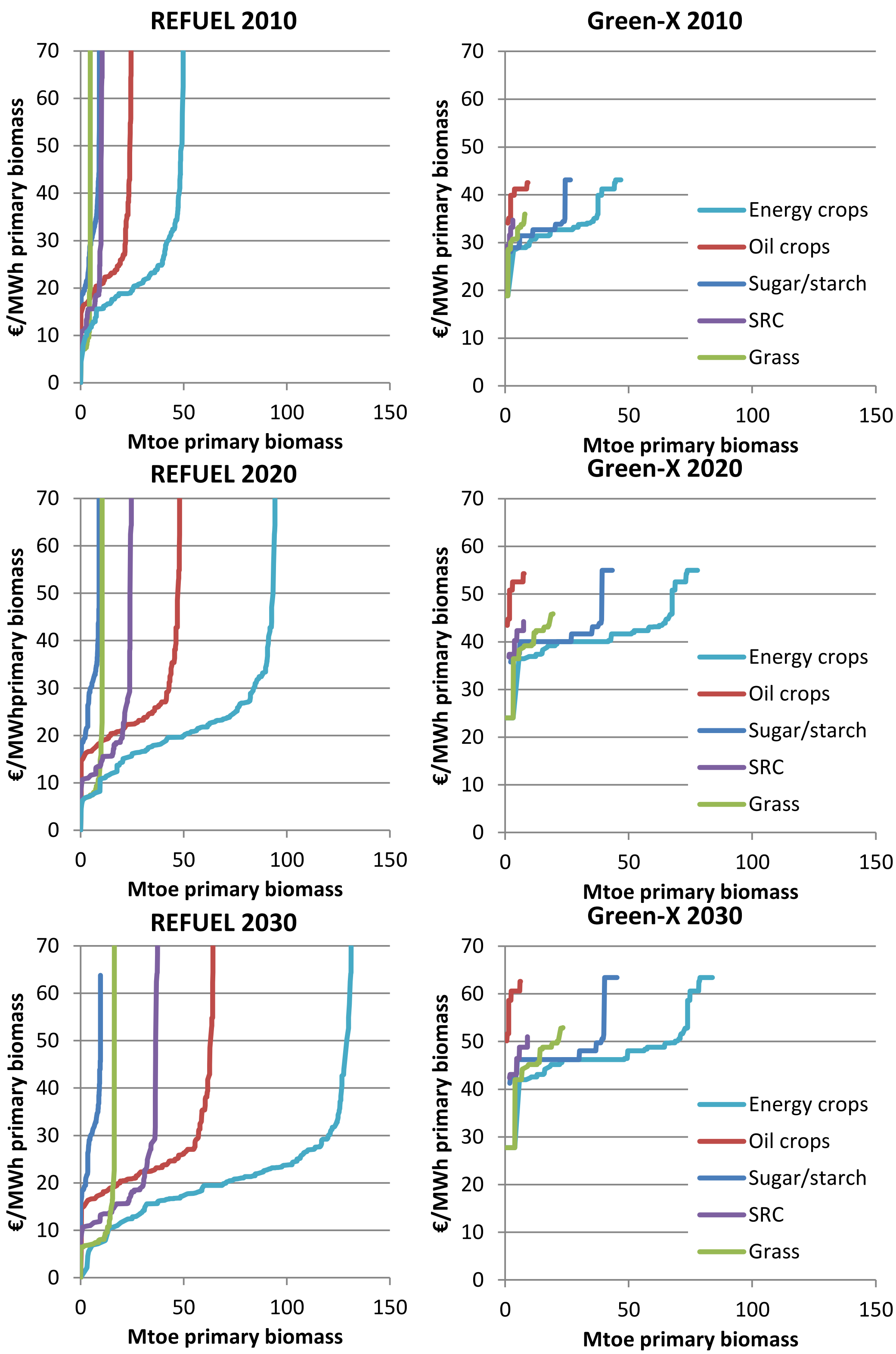
[9] Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia.

Both in Green-X and REFUEL, lignocellulosic energy crops (grassy crops and SRC) are the cheapest, whereas oil crops (rapeseed and sunflower) are the most expensive. The main differences between REFUEL and Green-X are:

- The cost for biomass in REFUEL is significantly lower compared to Green-X, partly due to the relatively high potential in CEEC countries with lower production cost due to land and labour prices in these regions;
- In REFUEL, the cost of, especially lignocellulosic crops, is assumed to decrease in time due to accumulated experience (learning) whereas in Green-X, the cost increase over time in relation with increasing trends in fossil fuel prices.[10]

[10] 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). Thereby, the following reasons have been identified for the empirically observable and partly 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 (i.e. bioenergy is used as substitute of fossil energy). Thus, price volatility on one market (e.g. oil) impacts the price stability on the other market (e.g. vegetable oil).

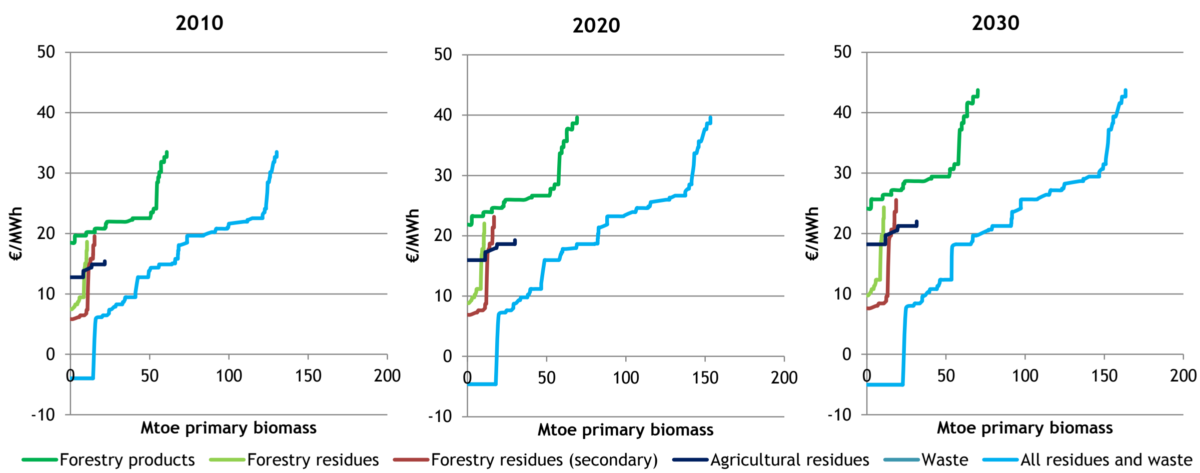
Figure 7: Farm gate cost-supply curves for bioenergy crops in the EU27 in Refuel and Green-X for the same crop type production mix.



VI.2 Biomass from forestry, agricultural residues and waste

Figure 8 shows the cost-supply curves of biomass from forestry products (current used log wood and wood chips and complementary fellings), forestry residues, secondary forest residues (demolition wood, black liquor and wood processing residues) agricultural residues (mainly straw) and the organic fraction of waste in Green-X. The total supply increases from 129 Mtoe in 2010 to 162 Mtoe in 2030 of which 67% (2030) to 72% (2010) are forestry products & residues and 17 (2010) to 19% (2030) are agricultural residues. Waste has a negative value (-4 €/MWh in 2010, -5 €/MWh in 2030).

Figure 8: Cost-supply curves of forestry products (primary and secondary), agricultural residues and waste in Green-X.*



** The waste curve is not visible, as it completely overlaps with the first horizontal line of the overall supply curve.*

From all forestry products and forestry residues in Green-X, forestry products current use is the largest category with a share of 55% in 2005 to 46% in 2030 (Figure 8). This category includes the current use of all forestry products for decentralized and domestic heat production. Because this category is heterogeneous, it is not possible to compare the potentials in Green-X with other resource assessment studies per feedstock type. Nevertheless, it is possible to compare the total amounts of primary and secondary products from forestry on an aggregated basis. For the Biomass Energy Europe (BEE) project, Rettenmaier (2010) compared several studies on the forest biomass potential for energy purposes in Europe with different geographical scopes and time frames. The differences in geographical scope were calibrated to the geographical coverage of the EU27 by taking the area included in the selected studies multiplied with the potential forest area in the EU27. The calibrated results of this study are depicted in Figure 9 for primary and secondary forestry products and residues. To compare these results to Green-X, the primary forestry products[11] in Green-X and secondary forestry products and residues[12] were added to these results. The Green-X demolition wood category was excluded.

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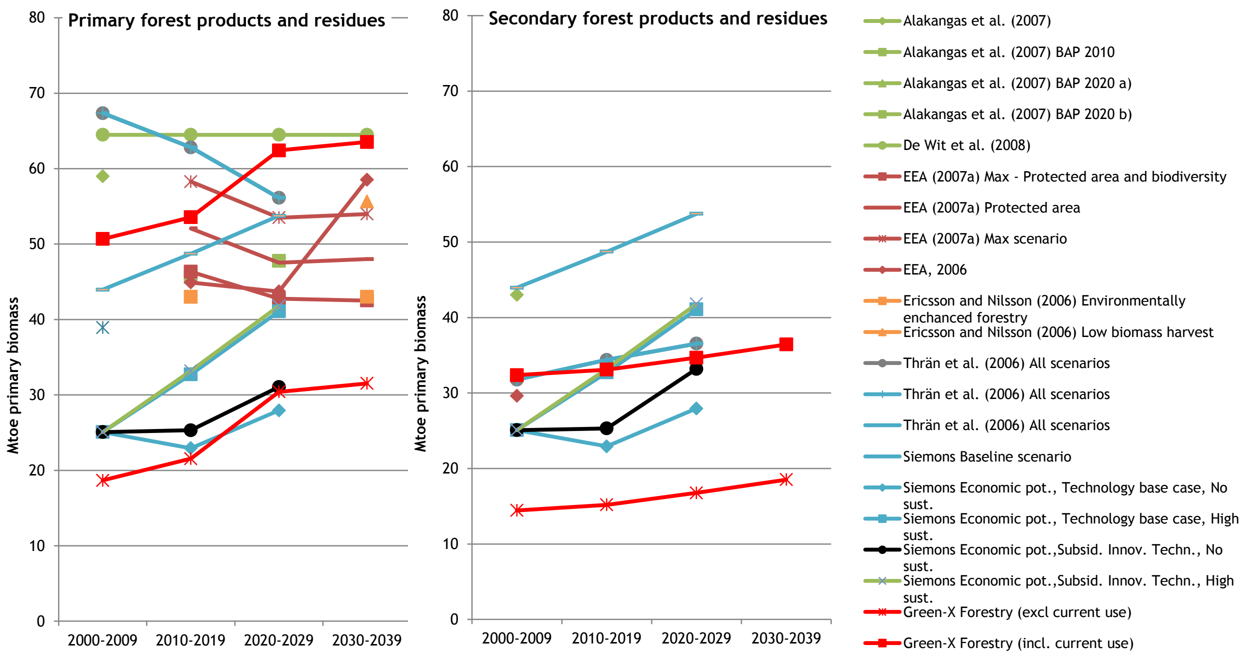
[11] Primary forestry products refer to the following categories of the Green-X database on biomass feedstock: FP1 (forestry products - current use (wood chips, log wood)), FP2 (forestry products - complementary fellings (moderate)), FP3 (forestry products - complementary fellings (expensive)), FR2 (forestry residues - current use) and FR3 (forestry residues – additional)

[12] Secondary forestry products and residues according to the Green-X classification include: FR1 (black liquor), FR5 (additional wood processing residues (sawmill, bark))

Figure 9: Total forestry potential (calibrated for the EU27) of stemwood and primary forestry residues and secondary forestry residues, assessed in different studies [13]



The comparison of these forestry resource assessment studies show very different results for primary and secondary forestry products and residues between the studies depicted. For primary forestry products and residues, Green-X is close to the most optimistic estimates, specifically with regard to long-term prospects. For secondary forestry products and residues, Green-X is in range with the average estimates if the current decentralised use of forestry residues is taken into account. The differences are mainly the result of wood categories included and a result of different potential types (technical, economical, sustainable), approaches (demand or supply driven) and future scenario assumptions including demands from non-energy uses. The total potential of primary and secondary products and residues from forestry ranges from 30 Mtoe (EEA 2006) to 102 Mtoe (Alakangas, Heikkinen et al. 2007) for the current situation (2000-2009). The total potential in Green-X (primary and secondary forestry products and residues) increases from 83 Mtoe in 2005 to 100 Mtoe in 2030, the highest from the combined results of Figure 9 for 2030.

A potential explanation for the high potentials of primary forestry products and residues in Green-X could be the use for small-scale heating in households as well as in industry. The results for Green-X are therefore shown with and without this category. Many studies such as the EEA (EEA 2007a) did not consider the use of forestry biomass for small scale heating in households in their assessment because the affected volumes of wood are usually not included in the harvested statistics. In Green-X, the current use of forestry products for small-scale decentral heating forms a significant share of the total potential of forestry products. Wide ranges are found in the total potential of small-scale heat generation from biomass, especially in households, due to the uncertainty and lack of data. The potentials in Green-X are therefore shown with and without *current decentral use*[14] in Figure 9. Mantau,

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[13] from Rettenmaier et al. (2010) with alternative projections, and forestry products and residues in Green-X excluding demolition wood, and results with and without current decentral use of forestry biomass

[14] Current decentral use of forestry biomass in Green-X covers forestry biomass commodities that have been used for heating purposes in small-scale applications within the residential, service and industry sector in the year 2005.

Saal *et al* (2010) estimated the total production of heat in traditional wood stoves by private households based on the Joint Wood Energy Enquiry of the UNECE/FAO Forestry and Timber section for 13 available countries in the EU-27 for the EUwood study. For the other MS, an indicator was used (forest area (ha)/rural population). If the results are compared to Held, Ragwitz *et al* (2010), based on similar results to Green-X, it appears that there is a large difference in the production of heat from households. Held, Ragwitz *et al* estimated 55 Mtoe final heat to be produced in decentralized and 7.6 Mtoe final heat in centralized systems in 2008. EUwood estimates 35 Mtoe primary biomass to be used by households within the EU-27. It is noted in the EUwood study that the use of biomass from households is very uncertain.

Another important factor is the allocation of biomass to material users such as the wood panel industries and pulp and paper mills. Mantau, Saal *et al* (2010) estimated for the EUwood study that, if the demand for materials remains constant, the future potential of primary forestry products available for energy use could increase in the medium mobilization scenario (Figure 8) from 37 to 60 Mtoe in 2030 and from 64 to 86 Mtoe if high mobilization is assumed.

Since scenario calculations within Green-X start by 2006, the year 2005 represents the latest year of the Green-X database on existing RES installations.

APPENDIX VII PELLETS IMPORTS FROM THIRD COUNTRIES – BASELINE SCENARIO

For data availability reasons, the baseline estimates on biomass imports used for this impact assessment focus only on wood pellets. Other sources of biomass (such as woodchips, waste wood, wood industry residues, palm kernel, olive cakes etc.) are and will be imported for energy uses in Europe. Unlike wood pellets, statistics reporting does not make possible to identify with certainty the final use of such imports. It is estimated that these other imported wood sources amount to around 53 PJ today[15]. While the imports of these streams may increase somewhat in the next decade as well, it is certainly not expected to show the same strong increase as projected for wood pellets. For all these reasons, biomass imports under the baseline scenario are probably underestimated.

VII.1 Low import scenario

This scenario is based on announced industry projects up to 2015. It projects an increase by more than a factor of 6, from 42 PJ in 2011 to 270 PJ in 2020. Projections for the post-2015 period are more uncertain as industrial projects have not yet been announced. In addition, these estimates are based on today's main supply regions and routes but they cannot forecast possible new sources of imports (such as pellets from Argentina or Mozambique for example). The key imported pellet sources and import routes in the scenario are the following:

- *Canada:* British Columbia has been an exporter of wood pellets to Europe since 1998, and is one of the major supply regions for large power plants in the Netherlands and Belgium. The total capacity of the existing 34 wood pellet mills is today 2.6 million tonnes, more than 70% of which is located in western Canada. In western Canada, while the largest part of the feedstock is still based on wood residues form wood processing, it is notable that in past years, wood of trees killed by the Mountain Pine Beetle (MPB) has also become an important source of feedstock for wood pellet production. Currently, this share is about 30%, but in 2020, it is estimated that up to 50% of the feedstock used for wood pellet production may be from MPB wood. The estimated future maximum export potential is 4.7 million tonnes, 55% of which on the west side of Canada and which could partially be exported to Korea. The development of pellets production is likely to be based on additional sawmill residues, increasing forest residues uses (collected at the roadside) and Mountain Pine Beetle wood.

- *Southeast US*A: The 'fibre-basket' in the South-East of the USA encompasses (parts of) the states of Georgia, North Carolina, South Carolina, Alabama and Florida. This area has been a major producer of wood for the pulp and paper and construction sector for decades. Due to the housing crises and decreasing demand for roundwood for construction, large amounts of wood are currently under utilized in this region. According to Bioenergy International (2011) the total capacity in this area was about

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[15] Regarding woodchips total global trade amounted to 26.5 million tons (dm) in 2009 and 33 million tons (dm) in 2010 Most of these imports are used for industrial purposes (pulp and paper industry). Part of it is used for energy generation. However, official statistics do not report separately woodchips imports for different uses. Woodchips imports for energy could also increase but the estimate of this supply is unclear, due to higher transport cost and higher end-use flexibility.

1.1M tonnes at the end of 2010. The existing plans typically utilize wood residues from the existing saw mills except from the RWE Waycross plant which utilizes 100% roundwood from Southern pine. For the years to come, additional facilities are planned using both wood industry residues as well as southernern pine species.

- *North West Russia*: In the past years, the Russian wood pellet market was rather turbulent and erratic. Pioneer companies, which started the development of pellet production withdrew from the market several years ago. A second generation of pellet mills are also on the stage of closing or business diversification. The third generation of pellet plants, which are constructed on a base of big woodworking factories work stable. Two big Russian wood pellet producers have about one third or even half of wood pellet export from Russia to Europe. These companies are "Dok Enisey" (from Krasnoyarsk region, Siberia) and Lesozavod-25 (from Archangelsk region, North-West Russia). Both companies export about 120-130 k tonnes per year. For most of the new projects planed, it is assumed that sawdust is the main feedstock. The biggest new pellets plant, situated close to the Finnish border is commissioned by Vyborskaya (900 ktonnes capacity). According to experts, the raw material would primarily consist of logs from Russia and, to a small extent, Belarus.

- *North East Brazil*: Up untill 2011, no meaningful wood pellet production capacity in Brazil exists, and no wood pellets have been exported so far. However, according to several press releases, Suzano Papel e Celulose is negotiating with the Brazil's Alagoas state authorities about the construction of one million tonne wood pellet plant, requiring about 30,000 ha of eucalyptus plantations to deliver the feedstock.

- *Liberia*: In April 2011, Swedish utility company Vattenfall AB has agreed to buy 1 million tons of woodchips sourced from Liberian rubber trees in a five year agreement with Buchanan renewables who works with rubber tree plantation owners in Liberia to clear old, unproductive rubber trees and replant with new stock. The cleared trees are then used for the production of high quality, low moisture wood chips. Current production levels are about 400,000 tons of wood chips per year, but it is estimated that Liberia has the potential to provide between 2 million and 3 million tons of wood chips every year. The wood chips are destined for Germany, where Vattenfall intends to co-fire them in coal-fired power plants.

VII.2 High import scenario

This scenario was developed in order to explore a possible higher increase of pellets imports, under worst land use change assumptions. In addition to the low imports scenario, imports of woody crops (short rotation forestry) from several geographical reagions was added. These additional imports are partly based on direct conversion of existing forests to short rotation forestry. This scenario was based on the following assumptions:

- *South America* : Up until 2020, a deficit of woody biomass (for timber, pulp and paper and energy) is mainly expected in the EU and in South East Asia. Also, it is assumed that within the next decade all regions/countries bordering the Atlantic will export mainly to the EU, whereas all regions bordering the Indian and Pacific Ocean will export to South East Asia. In these regions, short rotation woody energy crops will likely be established in the same regions as currently pulp plantations are established (Brazil and Uruguay). The scenario asusmes that Brazil rapidly increases production of (additional) short-rotation (i.e. 2-3 years) eucalyptus plantations from 2014 onwards to produce 2 million tonnes of wood pellets in each of the following States: Bahia, Rio Grande do Sul and Minas Gerais. Similarly, in Uruguay, 2 million additional tonnes are produced.

- *Western Africa* : New plantations will be established in the western cost countries of Sub-Saharan Africa such Liberia, Sierra Leone and Ghana. These regions have been in the news lately mainly with regard to projects for biofuel production (e.g. a 57,000 ha project in Sierra Leone for the production of ethanol), it is deemed reasonable to assume that these countries may also produce woody biomass for export. In the Western African countries of Liberia, Sierra Leone, Cote d'Ivoire and Ghana, a total of 3 million tonnes of wood pellets will be produced by 2020.

- *Russia* : Given the geographic vicinity, additional roundwood from Russia may be used for energy purpose (nb: incentive under the current export tax system). This scenario assumes that 3 million tonnes of wood pellets may be sourced from (unmanaged) forests in North-west Russia, and replaced by pine plantations.

These asumptions would lead to an additional amount of 14 million tonnes of wood pellets in 2020, roughly the same as the amounts assumed in the low import scenario. These assumptions of the amounts are rought, but reflect the current dominant position of Latin America, the expected rise of Sub-Saharan production potential, and the large (existing) potential from standing forests is North-West Russia. In all these cases, a change in above-ground carbon stock (AGCS) would occur. These changes were taken into account. As they only occur once (other than the annual emission form cultivation, processing transport etc.), the resulting GHG emissions have been distributed over a period of 20 years. The most important choice is to assume the type of land the woody biomass will be produced on. As the aim of this exercise was to demonstrate the worst-possible case, it was assumed that in Brazil, Uruguay and Russia, natural forest is replaced by eucalyptus plantations. In Western Africa, it was assumed that 50% would be on natural forests, and 50% on arable land. However, in many countries, unmanaged forests are protected, and it is extremely unlikely that 14 million tonnes would all be produced on current unmanaged forest land.

To illustrate the effects of this choice, emissions from direct LUC were calculated when using (the more likely cases of) arable land or scrubland. In the case of replacement of unmanaged forest, the (annual) GHG emissions are extremely high, reaching up 4-8 times the amount of others emissions (cultivation, processing and transport) in the case of Brazil, Uruguay and Western Africa, and about 20% higher emissions in Russia. However, when looking at the most likely land use, in cases of Rio Grande do Sul, Minas Gerais and Uruguay, net GHG emission are in fact negative, and even outweigh the direct emissions from cultivation, transport etc. In other words, wood pellets from these regions would then have negative emissions. It should be noted that the establishment of new plantations is not by default a bad development. If done on e.g. degraded soils, following sustainable forest management principles etc., these plantations can actually act as a net carbon sink, and environmental and socio-economic effects can also actually be positive.

Table 6: Emissions from land use change, high imports scenario [16]

		Emissions per year (assuming a 20 year lifetime) (g $CO_{2\ eq.}$/ MJ pellet delivered to Rotterdam)		For comparison: other (direct) emissions from cultivation, transport etc.(g $CO_{2\ eq.}$ / MJ pellet delivered to Rotterdam)
Region		Previous land use change (mixed)	Land use change (100% unmanaged forest)	
Brazil	Rio Grande do Sul	-24,54	52,59	11,54
	Bahia	15,78	62,52	13,19
	Minas Gerais	-10,46	62,52	12,00
Uruguay		-20,57	52,59	13,34
West coast Sub-Saharan Africa	Liberia,SL,IC,Ghana	25,71	85,31	10,51
North West Russia		30,38	30,38	25,89

[16] Source: JRC, 2011 and VITO Consortium 2011

APPENDIX VIII DETAILED RESULTS OF THE QUANTITATIVE ASSESSMENT OF SUSTAINABILITY REGULATIONS

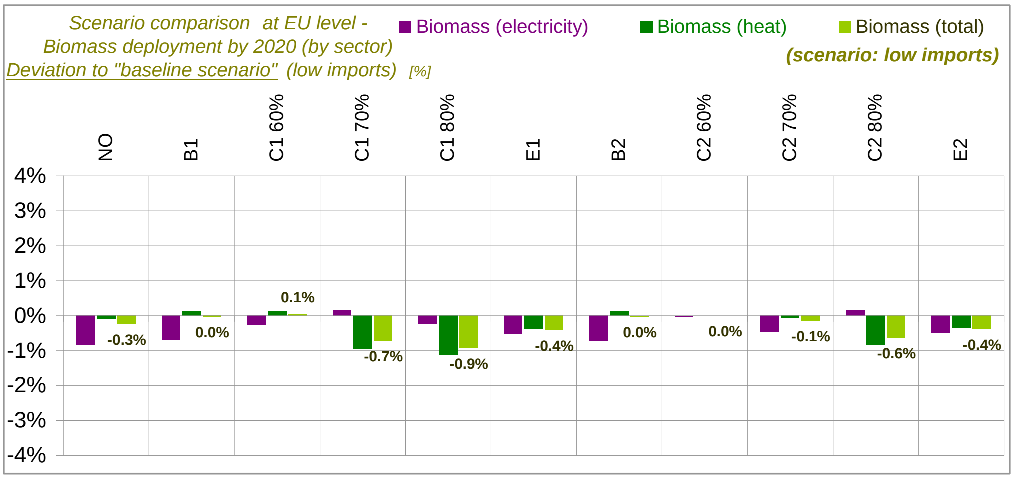
On the following pages detailed outcomes of the model-based assessment of policy options for sustainability regulations are depicted in topical order, starting with deployment impacts, followed by environmental consequences (constraint to GHG reduction) as well as indicators on economic impacts. This serves to complement the discussion and interpretation of results within section 4.2 of this report.

VIII.1 Impact on bioenergy use (and overall RES deployment)

Table 7: Biomass deployment in terms of final energy

(Sector-specific) biomass deployment (solid and gaseous, used for electricity and heat supply) in terms of final energy by 2020; deviation compared to corresponding baselines (of low and high biomass imports) in absolute (ktoe) and relative terms (%).

Coverage (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 1MW	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%



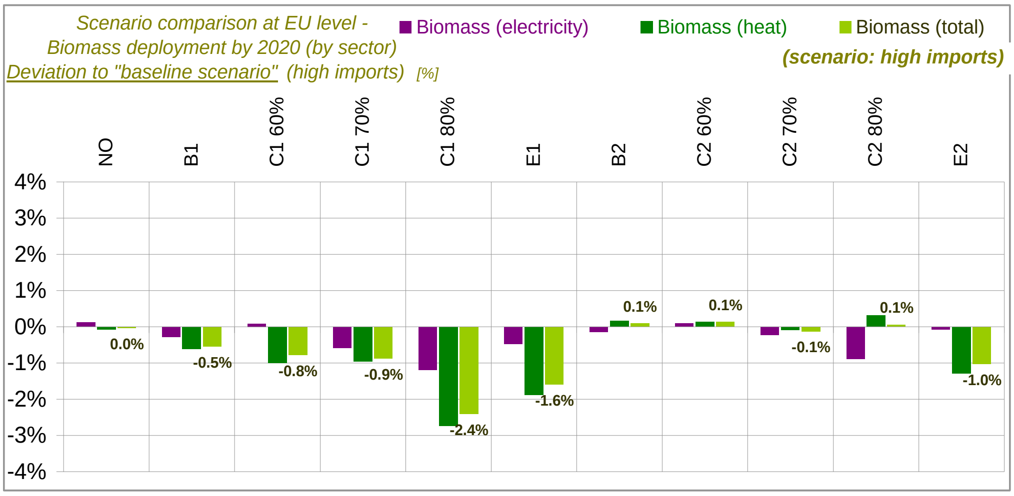
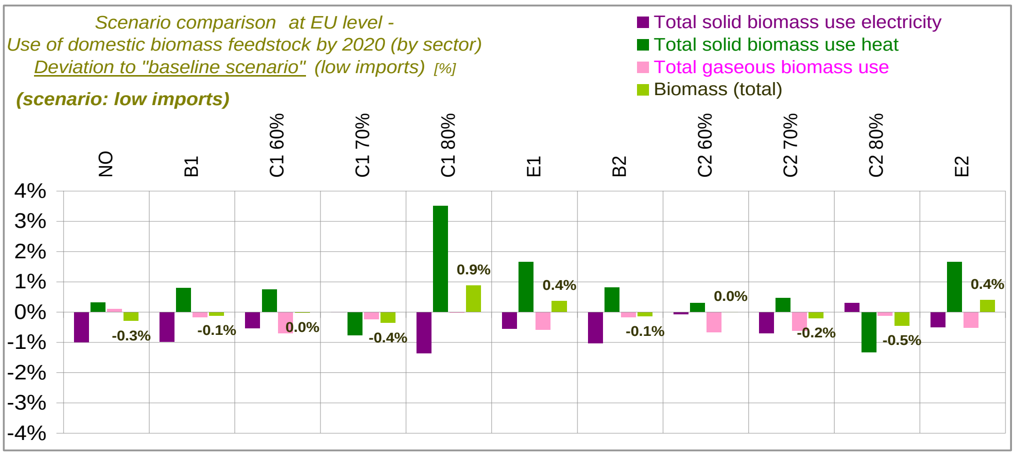


Table 8: Use of European biomass feedstock

(Sector-specific) European biomass feedstock use (i.e. solid and gaseous biomass feedstock within the EU, expressed in primary energy) by 2020; deviation compared to corresponding baselines (of low and high biomass imports) in absolute (ktoe) and relative terms (%).

Coverage (i.e. scope of policy options)	Policy options	Low imports scenario [ktoe]	Low imports scenario [%]	High imports scenario [ktoe]	High imports scenario [%]
	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 1MW	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%



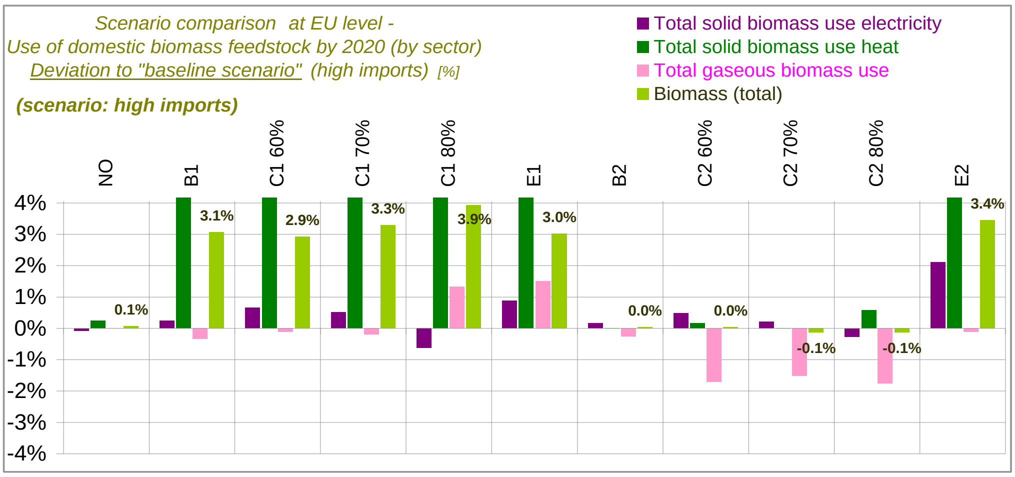
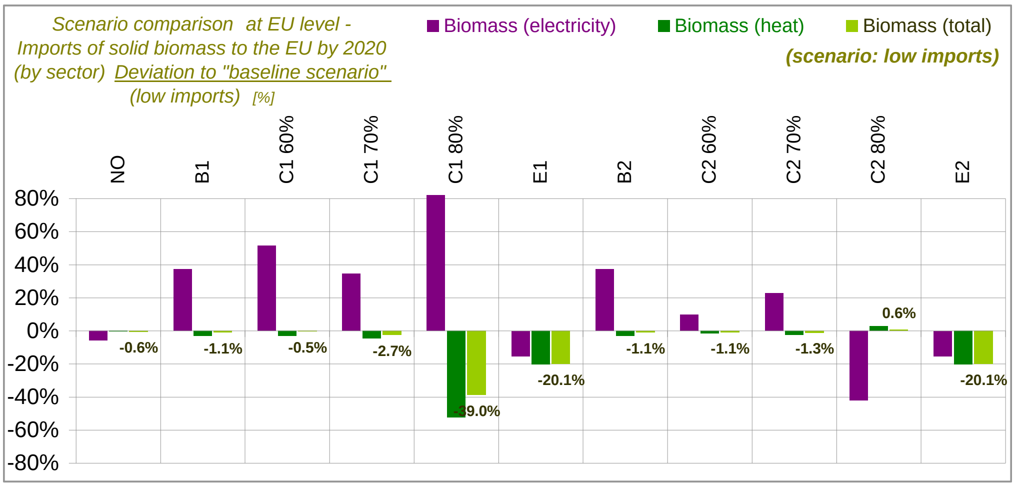


Table 9: Biomass imports from non-EU countries

(Sector-specific) (Additional) imports of solid biomass feedstock from non-EU countries by 2020; deviation compared to corresponding baselines (of low and high biomass imports) in absolute (ktoe) and relative terms (%).

Coverage (i.e. 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 1MW	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%



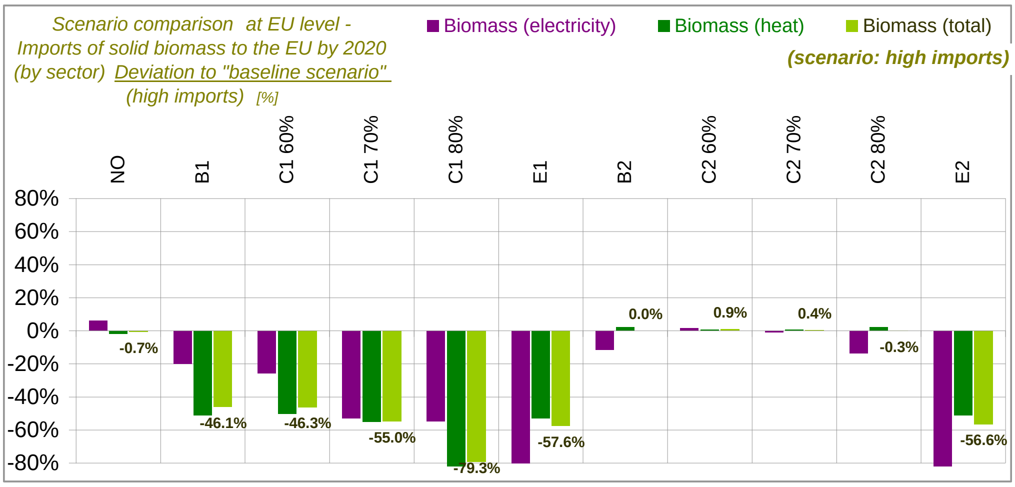


Figure 10: RES deployment in terms of final energy

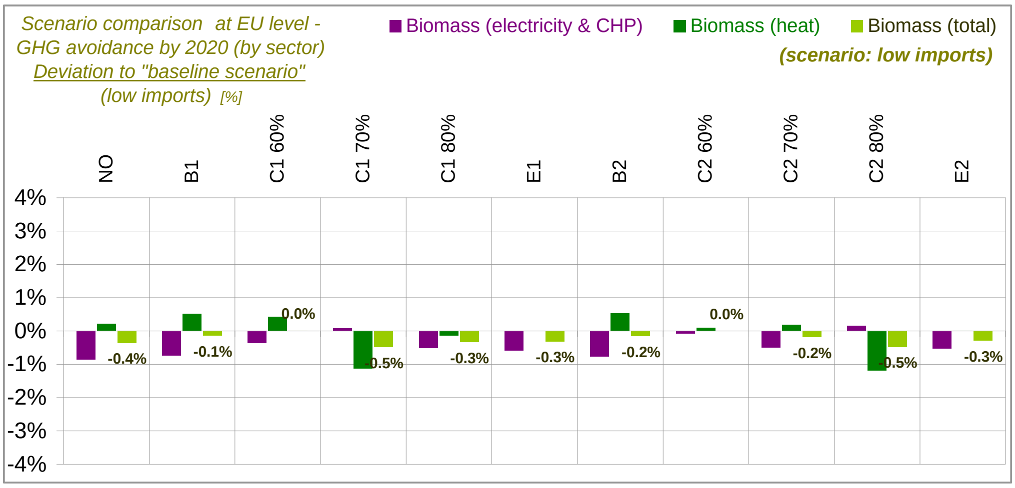
Sector-specific RES deployment in terms of final energy by 2020; deviation compared to corresponding baselines (of low and high biomass imports) in absolute (ktoe) and relative terms (%).

VIII.2 Environmental impacts – impact on GHG emission reduction

Table 10: GHG emission avoidance by 2020 due to biomass

(Sector-specific) GHG emission avoidance for biomass (solid and gaseous, used for electricity and heat supply) by 2020; deviation compared to corresponding baselines (of low and high biomass imports) in absolute terms (M tonnes CO2-eq.) and in relative terms (%).

Coverage (i.e. scope of policy options)	Policy options	Low imports scenario		High imports scenario	
		[M tonnes]	[%]	[M tonnes]	[%]
	Baseline case	*526.6*	-	*506.9*	-
All generators	B1	-0.8	-0.1%	18.1	3.6%
	C1 60%	0.0	0.0%	17.5	3.5%
	C1 70%	-2.6	-0.5%	17.4	3.4%
	C1 80%	-1.8	-0.3%	12.8	2.5%
	E1	-1.7	-0.3%	14.6	2.9%
Equal or above 1MW	B2	-0.9	-0.2%	0.0	0.0%
	C2 60%	0.0	0.0%	0.3	0.1%
	C2 70%	-0.9	-0.2%	-0.9	-0.2%
	C2 80%	-2.5	-0.5%	-0.5	-0.1%
	E2	-1.5	-0.3%	17.4	3.4%



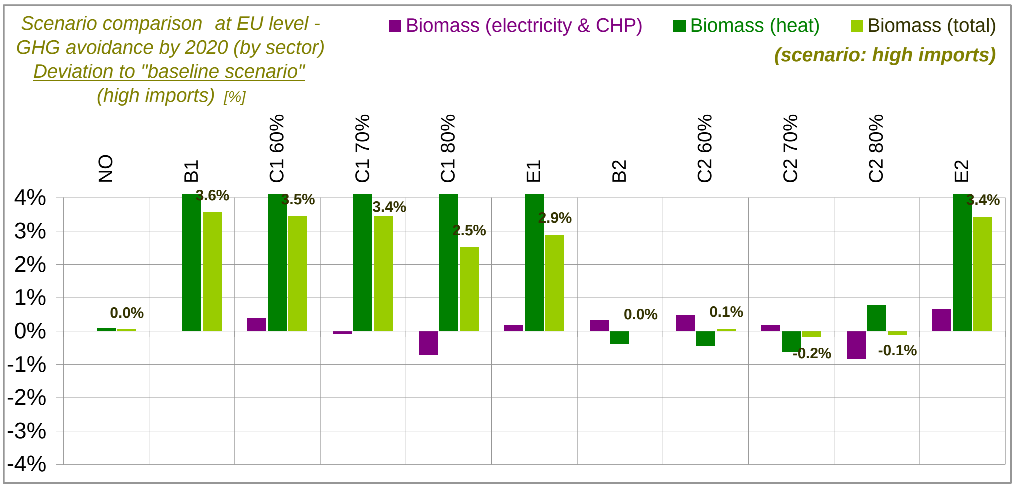
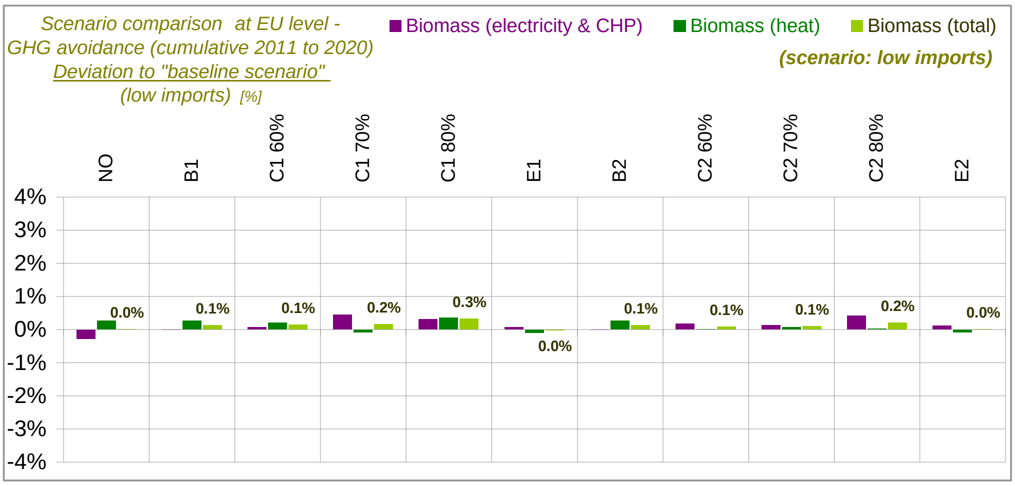


Table 11: Cumulative (2011 to 2020) GHG emission avoidance due to biomass

(Sector-specific) Cumulative (2011 to 2020) GHG emission avoidance for biomass (i.e. solid and gaseous, used for electricity and heat supply); deviation compared to corresponding baselines (of low and high biomass imports) in absolute terms (M tonnes CO2-eq.) and in relative terms (%).

Coverage (i.e. scope of policy options)	Policy options	Low imports scenario [M tonnes]	Low imports scenario [%]	High imports scenario [M tonnes]	High imports scenario [%]
	Baseline case	*4,132*	-	*4,060*	-
All generators	B1	6	0.1%	72	1.8%
	C1 60%	6	0.1%	73	1.8%
	C1 70%	7	0.2%	75	1.9%
	C1 80%	14	0.3%	57	1.4%
	E1	-1	0.0%	64	1.6%
Equal or above 1MW	B2	6	0.1%	3	0.1%
	C2 60%	4	0.1%	4	0.1%
	C2 70%	4	0.1%	5	0.1%
	C2 80%	9	0.2%	1	0.0%
	E2	0	0.0%	69	1.7%



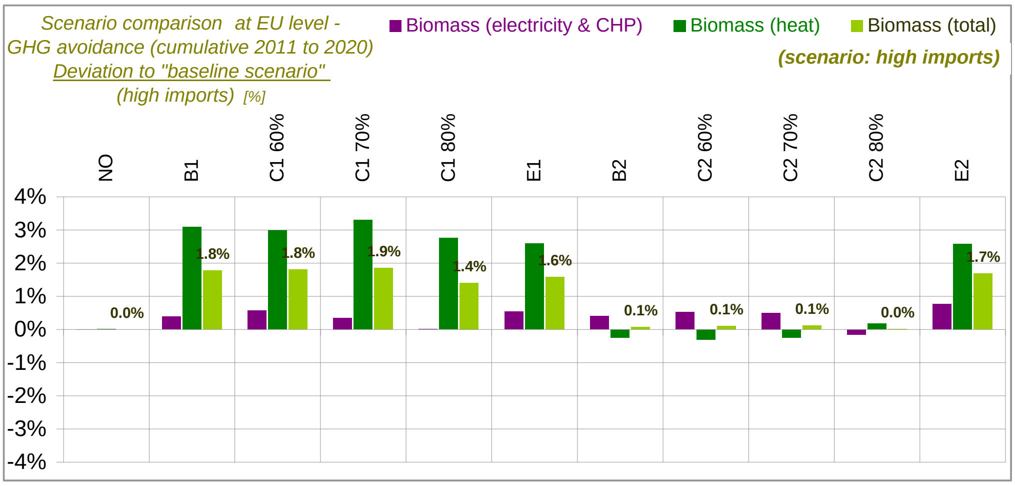
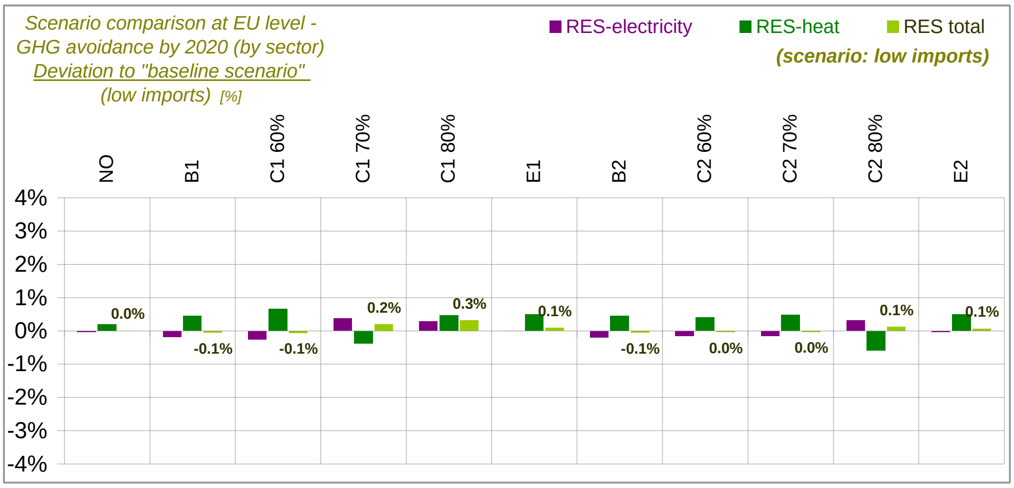


Table 12: GHG emission avoidance by 2020 due to RES in total

(Sector-specific) GHG emission avoidance for total RES by 2020, deviation compared to corresponding baselines (of low and high biomass imports) in absolute terms (M tonnes CO2-eq.) and in relative terms (%).

Coverage (i.e. scope of policy options)	Policy options	Low imports scenario		High imports scenario	
		[M tonnes]	[%]	[M tonnes]	[%]
	Baseline case	*1,365.4*	-	*1,343.2*	-
All generators	B1	-0.7	-0.1%	22.0	1.6%
	C1 60%	-0.9	-0.1%	22.8	1.7%
	C1 70%	2.6	0.2%	23.6	1.8%
	C1 80%	4.3	0.3%	34.1	2.5%
	E1	1.2	0.1%	27.3	2.0%
Equal or above 1MW	B2	-0.8	-0.1%	-0.9	-0.1%
	C2 60%	-0.6	0.0%	-0.8	-0.1%
	C2 70%	-0.5	0.0%	-0.6	0.0%
	C2 80%	1.6	0.1%	-1.2	-0.1%
	E2	0.9	0.1%	24.8	1.8%



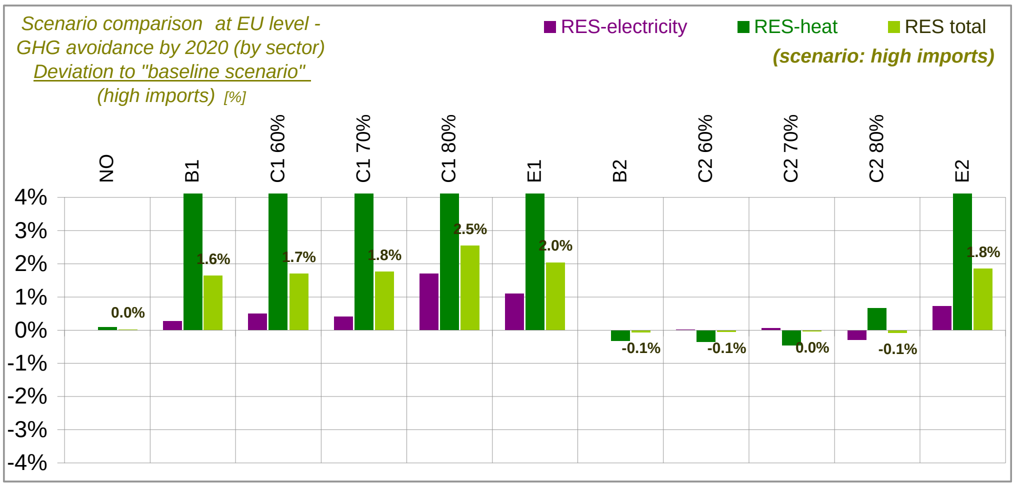
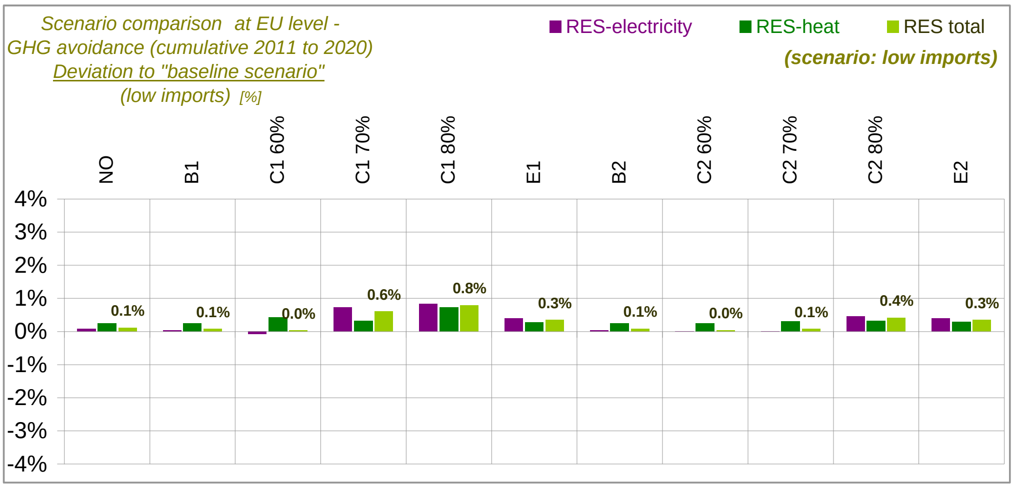
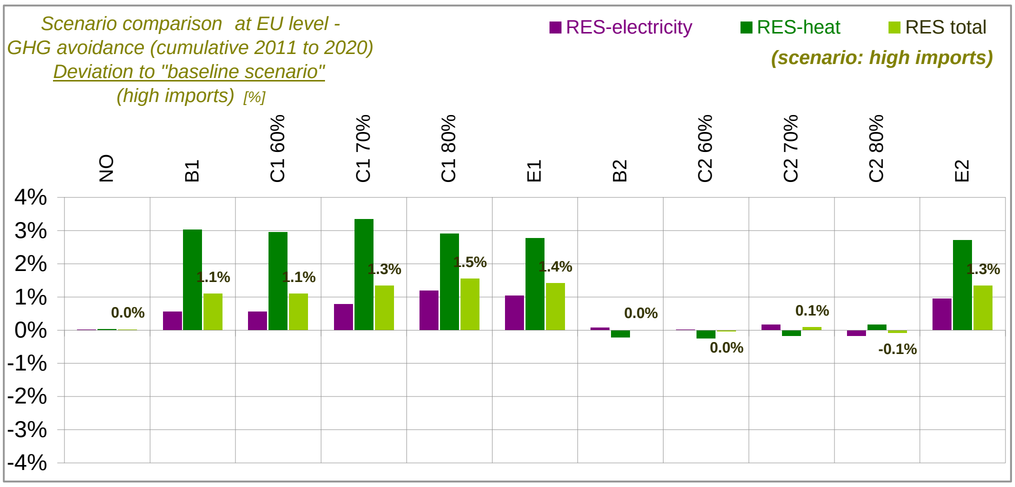


Table 13: Cumulative (2011 to 2020) GHG emission avoidance due to RES in total

(Sector-specific) Cumulative (2011 to 2020) GHG emission avoidance for total RES; deviation compared to corresponding baselines (of low and high biomass imports) in absolute terms (M tonnes CO2-eq.) and in relative terms (%).

Coverage (i.e. 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%



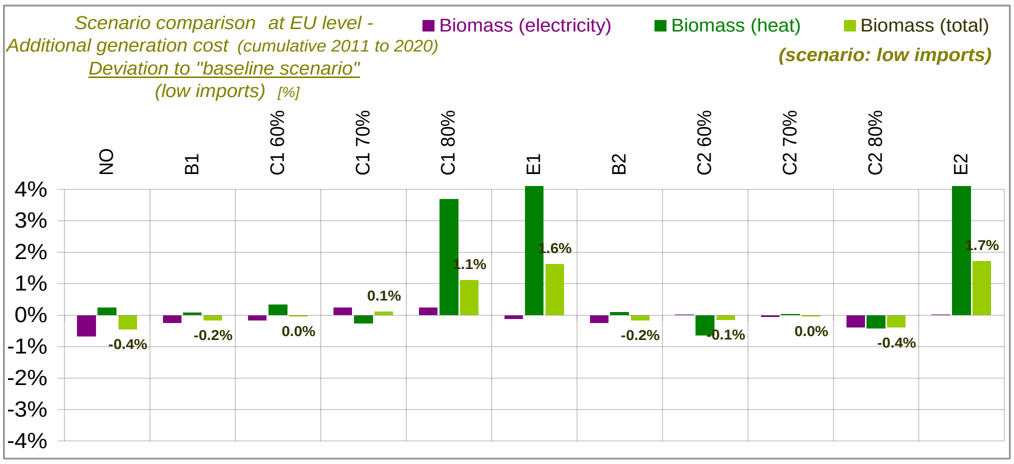


VIII.3 Economic impacts – impact on costs and expenditures

Table 14: Cumulative (2011 to 2020) additional generation cost for biomass

(Sector-specific) Cumulative (2011 to 2020) additional generation cost for biomass (i.e. solid and gaseous, used for electricity and heat supply); deviation compared to corresponding baselines (of low and high biomass imports) in absolute (billion €) and relative terms (%).

Coverage (i.e. scope of policy options)	Policy options	Low imports scenario		High imports scenario	
		[Billion €]	[%]	[Billion €]	[%]
	Baseline case	*66.7*	-	*66.5*	-
All generators	B1	-0.1	-0.2%	0.5	0.8%
	C1 60%	0.0	0.0%	0.2	0.3%
	C1 70%	0.1	0.1%	0.2	0.3%
	C1 80%	0.7	1.1%	0.7	1.1%
	E1	1.1	1.6%	1.4	2.0%
Equal or above 1MW	B2	-0.1	-0.2%	-0.2	-0.2%
	C2 60%	-0.1	-0.1%	-0.4	-0.6%
	C2 70%	0.0	0.0%	-0.3	-0.5%
	C2 80%	-0.3	-0.4%	-0.8	-1.1%
	E2	1.1	1.7%	1.4	2.1%



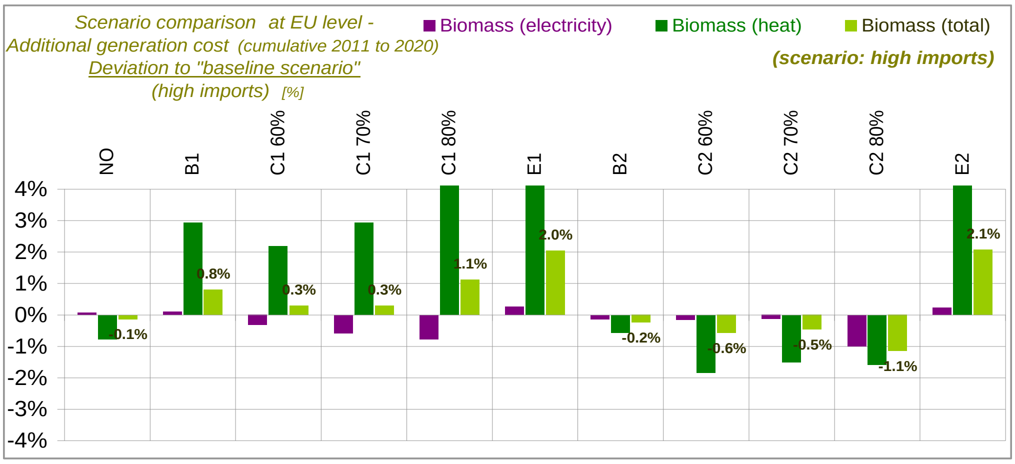
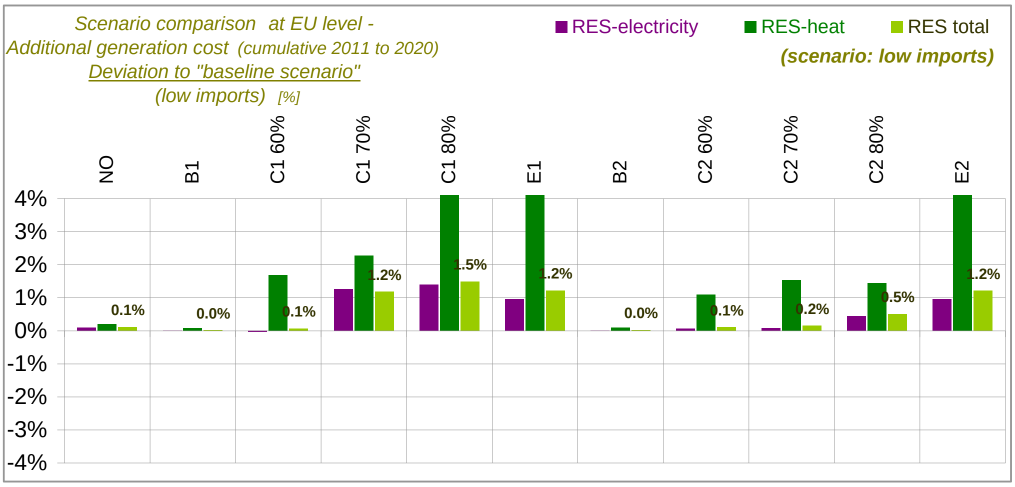


Table 15: Cumulative (2011 to 2020) additional generation cost for RES in total

(Sector-specific) Cumulative (2011 to 2020) additional generation cost for total RES; deviation compared to corresponding baselines (of low and high biomass imports) in absolute terms (billion €) and in relative terms (%).

Coverage (i.e. 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%



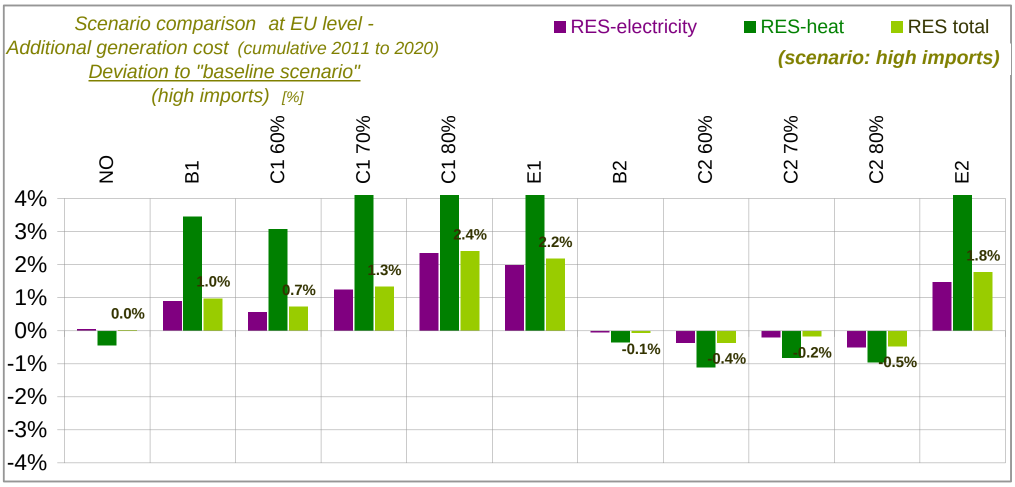
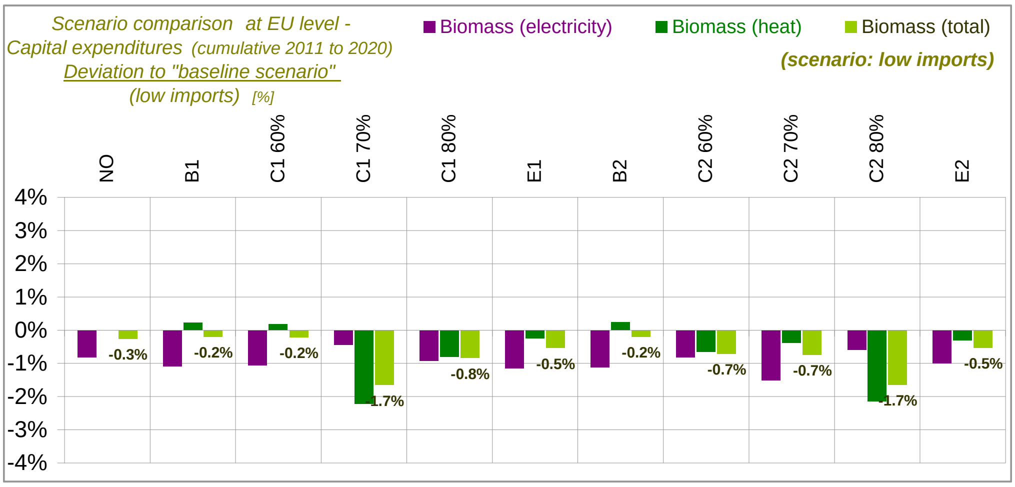


Table 16: Cumulative (2011 to 2020) capital expenditures for biomass

(Sector-specific) Cumulative (2011 to 2020) capital expenditures for biomass (i.e. solid and gaseous, used for electricity and heat supply); deviation compared to corresponding baselines (of low and high biomass imports) in absolute (billion €) and relative terms (%).

Coverage (i.e. scope of policy options)	Policy options	Low imports scenario		High imports scenario	
		[Billion €]	[%]	[Billion €]	[%]
	Baseline case	*271.0*	-	*271.1*	-
All generators	B1	-0.5	-0.2%	1.4	0.5%
	C1 60%	-0.6	-0.2%	-1.9	-0.7%
	C1 70%	-4.5	-1.7%	-1.3	-0.5%
	C1 80%	-2.3	-0.8%	-4.9	-1.8%
	E1	-1.5	-0.5%	-6.4	-2.4%
Equal or above 1MW	B2	-0.5	-0.2%	0.2	0.1%
	C2 60%	-1.9	-0.7%	-0.9	-0.3%
	C2 70%	-2.0	-0.7%	-1.1	-0.4%
	C2 80%	-4.5	-1.7%	-0.1	0.0%
	E2	-1.4	-0.5%	-4.0	-1.5%



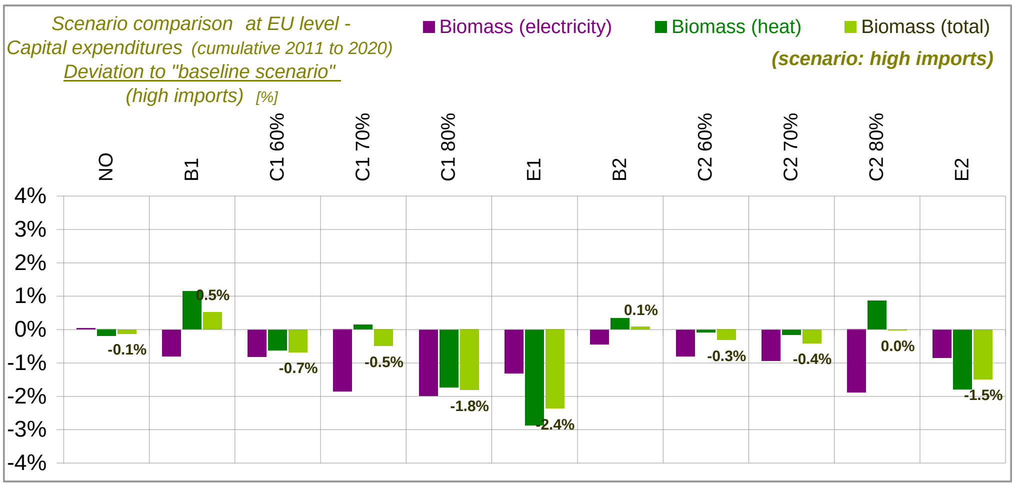
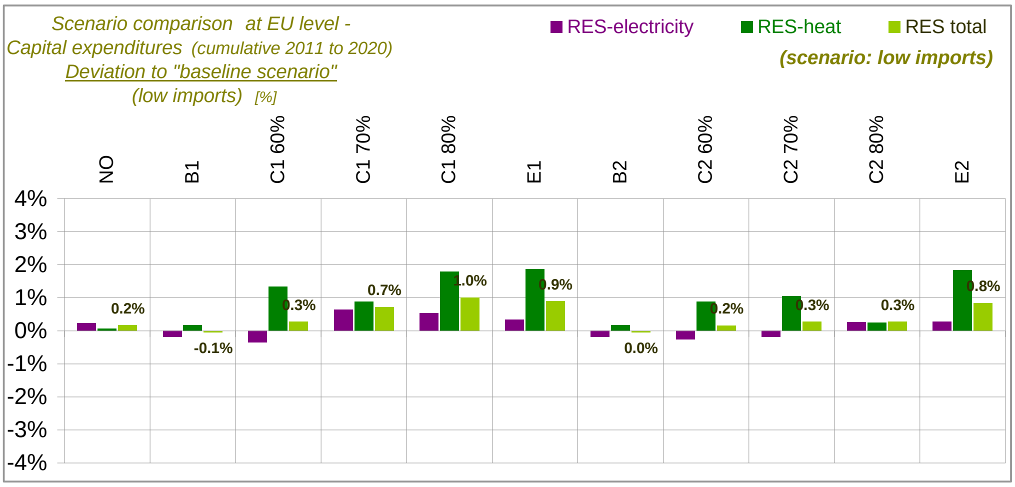


Table 17: Cumulative (2011 to 2020) capital expenditures for RES in total

(Sector-specific) Cumulative (2011 to 2020) capital expenditures for total RES; deviation compared to corresponding baselines (of low and high biomass imports) in absolute terms (billion €) and in relative terms (%).

Coverage (i.e. 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 1MW	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%



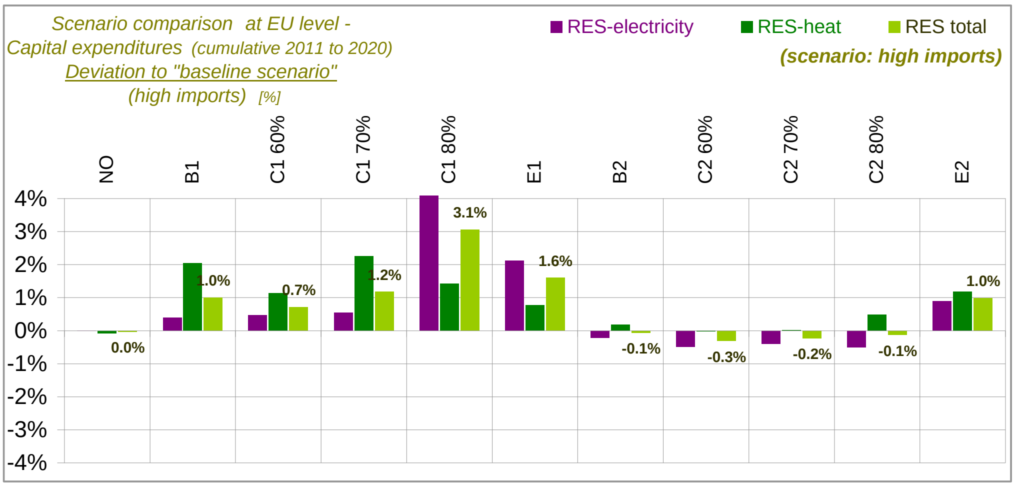
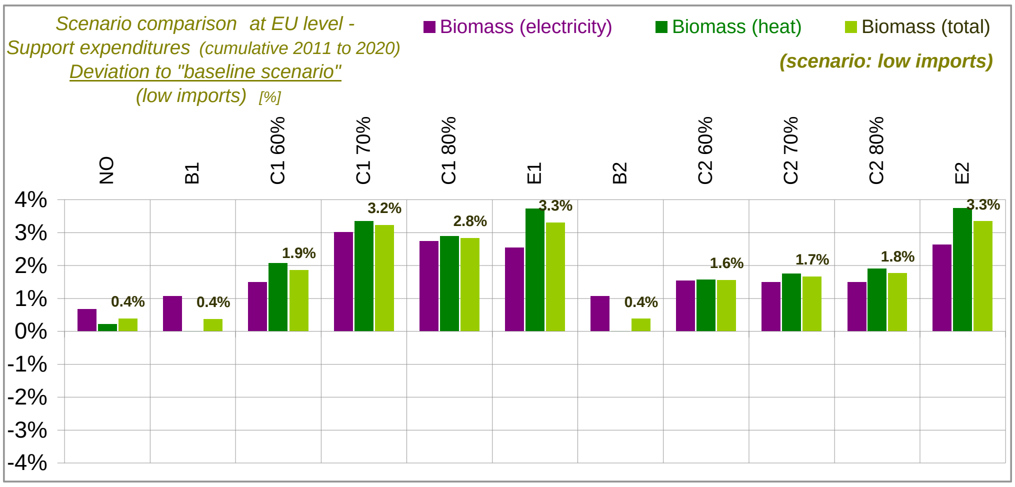


Table 18: Cumulative (2011 to 2020) support expenditures for biomass

(Sector-specific) Cumulative (2011 to 2020) support expenditures for biomass (i.e. solid and gaseous, used for electricity and heat supply); deviation compared to corresponding baselines (of low and high biomass imports) in absolute (billion €) and relative terms (%).

Coverage (i.e. scope of policy options)	Policy options	Low imports scenario		High imports scenario	
		[Billion €]	[%]	[Billion €]	[%]
	Baseline case	*255.2*	-	*257.4*	-
All generators	B1	1.0	0.4%	5.9	2.3%
	C1 60%	4.8	1.9%	2.3	0.9%
	C1 70%	8.2	3.2%	6.8	2.7%
	C1 80%	7.2	2.8%	11.6	4.5%
	E1	8.4	3.3%	11.1	4.3%
Equal or above 1MW	B2	1.0	0.4%	1.4	0.5%
	C2 60%	4.0	1.6%	-1.6	-0.6%
	C2 70%	4.2	1.7%	-1.9	-0.7%
	C2 80%	4.5	1.8%	-2.3	-0.9%
	E2	8.5	3.3%	5.2	2.0%



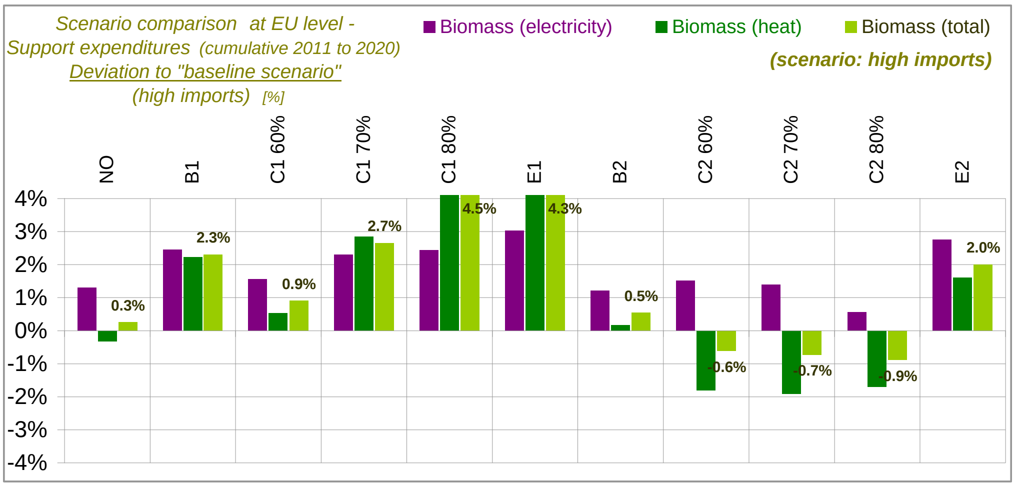


Table 19: Cumulative (2011 to 2020) support expenditures for RES in total

(Sector-specific) Cumulative (2011 to 2020) support expenditures for total RES, deviation compared to corresponding baselines (of low and high biomass imports) in absolute terms (billion €) and in relative terms (%).

Coverage (i.e. scope of policy options)	Policy options	Low imports scenario [Billion €]	Low imports scenario [%]	High imports scenario [Billion €]	High imports scenario [%]
	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%