International Institute
for Sustainability Analysis
and Strategy

Possibilities of sustainable woody energy trade and impacts on developing countries

Summary Report for GIZ

prepared by

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Note on this Report

This is a summary of key findings from a study concerning "Possibilities of sustainable woody bioenergy trade and impacts on developing and emerging countries" prepared by IINAS for GIZ.

In parallel, a case study for Brazil was carried out by CENBIO through a subcontract with IINAS[1].

This report presents the **key findings** of the study, while the **full report with Annexes** providing results from interviews with resource persons is available as a separate document[2].

Acknowledgments

This study benefited from many inputs, especially those from interviewees (see Annex to Full Report) and discussions with colleagues from GIZ, BMELV, BMU, BMZ, IEA Bioenergy, and GBEP.

All views expressed here and any omission or errors are the sole responsibility of the authors.

1 CENBIO (Centro Nacional de Referencia em Biomassa) 2013: Possibilities of sustainable woody energy trade and impacts on developing countries: Country Case Study Brazil; Coelho S, Escobar J; prepared for GIZ under subcontract with IINAS; Sao Paulo http://www.iinas.org/tl_files/iinas/downloads/CENBIO_2013_Brazil-Case-Study_GIZ.pdf

2 Full study report (including Brazil Case Study and Annexes):
IINAS (International Institute for Sustainability Analysis and Strategy), CENBIO (Centro Nacional de Referencia em Biomassa) 2014: Possibilities of sustainable woody bioenergy trade and impacts on developing countries - final report; Fritsche U et al.; prepared for GIZ; Darmstadt, Madrid, Sao Paulo
http://www.iinas.org/tl_files/iinas/downloads/IINAS_CENBIO_2014_Sust_Woody_Bioenergy_GIZ_full.pdf

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Acronyms

AMS	Associação Mineira de Silvicultura
BEFSCI	Bioenergy and Food Security Criteria and Indicators
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (German Federal Ministry for Environment, Nature Protection and Nuclear Safety)
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Development)
BNDES	Banco Nacional do Desenvolvimento - Brazil
CEN	European Committee for Standardization
CENBIO	Centro Nacional de Referência em Biomassa
CFS	Committee on World Food Security
CIFOR	Center for International Forestry Research
DENA	Deutsche Energie-Agentur
EC	European Commission
ECOWAS	Economic Community of West African States)
ECREEE	ECOWAS Regional Centre for Renewable Energy and Energy Efficiency
EEA	European Environment Agency
EMBRAPA	Brazilian Agricultural Research Corporation
ESMAP	Energy Sector Management Assistance Program
ETS	EU Emissions Trading System
EU	European Union
EUEI PDF	European Union Energy Initiative Partnership Dialogue Facility
FAO	Food and Agriculture Organization of the United Nations
FLEGT	Forest Law Enforcement, Governance and Trade
FSC	Forest Stewardship Council
GBEP	Global Bioenergy Partnership
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit GmbH
IBGE	Brazilian Institute of Geography and Statistics
IC	Imperial College
IEA	International Energy Agency
IDB	Inter-American Development Bank

IFEU	Institute for Energy and Environmental Research
IIED	International Institute for Environment and Development
IINAS	International Institute for Sustainability Analysis and Strategy
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ISO	International Standardization Organization
ITTO	International Tropical Timber Organization
IWPB	Initiative Wood Pellet Buyers (now SBP)
JRC	Joint Research Centre
M	Million
MDG	Millennium Development Goals
MRNF	Ministère des Ressources Naturelles et de la Faune. Gouvernement du Québec-Canada
MS	Member States
MMA	Ministério do Meio Ambiente – Brazil
MME	Ministério de Minas e Energia- Brazil (Ministry of Mines and Energy – Brazil)
NLBI	Non-Legally Binding Instrument
NREAP	National Renewable Energy Action Plans
OECD	Organisation for Economic Cooperation and Development
PIC	Pinchot Institute for Conservation
PISCES	Policy Innovation Systems for Clean Energy Security
PFEC	Programme for the Endorsement of Forest Certification Schemes
RED	Renewable Energy Directive (EU 28/2009)
REDD+	Reducing Emissions from Deforestation and Forest Degradation
REEGLE	Clean Energy Info Portal
REN21	Renewable Energy Policy Network for the 21st century
RSB	Roundtable on Sustainable Biomaterials
SAE	Secretaria de Assuntos Estratégicos da Presidência da Republica-Brazil
SBP	Sustainable Biomass Partnership (formerly IWPB)
SEI	Stockholm Environment Institute
SFM	Sustainable Forest Management
SRC	Short rotation coppice
t	tones
toe	tonnes of oil equivalent

TERI	The Energy and Resources Institute
TR	Timber Regulation (EU 995/2010)
UN	United Nations
UN GA	United Nations General Assembly
UN-REDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VPA	Voluntary Partnership Agreements
VGGT	Voluntary Guidelines on the Responsible Governance Tenure of Land, Fisheries and Forests in the Context of National Food Security
WB	The World Bank
WBGU	German Advisory Council on Global Change
WHO	World Health Organization
WTO	World Trade Organization
WWF	World-Wide Fund for Nature

EXECUTIVE SUMMARY

Many OECD countries, particularly within the EU, have set ambitious plans for the use of woody bioenergy. While the woody biomass consumed for household use is most likely to be sourced locally and is quite independent from public support, large-use consumption, especially for co-firing, is driven by policy and energy sector decisions and requires trade of large amount of woody biomass. The volume of imports of woody biomass in the EU will depend on a range of factors such as the capacity and price to mobilize domestic resources, on policy support measures as well as the price of fossil fuels, and CO_2 certificates.

In developing countries, about 2.6 billion people rely on inefficient, unhealthy and often unsustainable consumption of mostly woody biomass to cover their basic energy needs such as cooking. Despite international and multilateral initiatives reduce the dependency on unsustainable wood supply and use, the amount of people dependent on woody biomass is not expected to change much in the coming years.

At present, increasing global demand and international trade of woody bioenergy (mainly in form of pellets) is met by well-positioned countries such as Canada, USA and Russia. These countries have not only the largest forest areas, but also infrastructures, expertise and capabilities to continue being suppliers to international woody bioenergy markets.

Particular emerging countries, especially Brazil, may enter the global woody bioenergy market if bioenergy costs are competitive. The higher the international demand, the easier emerging and developing countries might enter the market, with impacts on:

- Offering opportunities of investment and economic development
- Recognizing the importance of sustainable woody bioenergy for domestic supply both at small-scale and large-scale. This may lead to improve governance of the forest sector in general and contribute to achieve domestic renewable energy goals.
- Moving woody bioenergy higher on the international renewable energy agenda.

To avoid negative impacts and maximize benefits for emerging and developing countries, the production and trade of woody bioenergy need favorable national and international framework conditions and agreed sustainability criteria need to be applied.

The sustainability of woody bioenergy from forests and plantations depends on land use management, and availability of fuelwood use in households. The "domestic fuelwood first" principle needs to be respected.

Without further domestic and foreign public and private investments in avoided deforestation; in both sustainable forest management and reforestation/afforestation, fuel wood demand in many developing countries will not be met. As a way forward this study suggests a three-fold approach:

- Importing countries (e.g. DE, NL and UK) and the EU need to conditionalize preferential treatment of woody bioenergy in their renewable energy support policies to establish mandatory sustainability safeguards which need to build upon the current international forest and timber trade regulations and private sector initiatives to avoid illegal logging and deforestation. In that regard, the EU Renewable Energy Directive needs extension to cover also woody bioenergy for electricity and heat.
- Exporting countries in emerging and developing countries need improved domestic forest and land tenure policies to address social and environmental risks. Given the rising demand woody bioenergy, this needs better recognition in international processes such as the EU FLEGT Action Plan, GBEP and REDD+.
- International finance institutions such as the GEF, the World Bank and bilateral donors should require sustainability safeguards - including social aspects - for woody bioenergy projects, and expand funding for capacity building on and implementation of the Voluntary Guidelines on the Responsible Governance Tenure of Land, Fisheries and Forests in the Context of National Food Security and voluntary forest certification standards as useful tools.

Study Objectives and Methodology

This study commissioned by GIZ Program Social and Environmental Standards on behalf of the German Federal Ministry for Economic Development and Cooperation (BMZ) Division for environment and sustainable use of natural resources, has the following objectives, as given in the Terms of Reference:

1. **Analysis of demand and development of woody bioenergy trade**
   - What and how much woody bioenergy is exported from which countries to the EU and Germany for which energy uses, and which concrete planning exists to increase imports of woody bioenergy?
   - How much of this wood is certified (by which standards), and what is the potential of certification?
   - Which woody bioenergy products are used on local and regional woody bioenergy markets in developing countries which already export woody bioenergy to the EU, and what is availability and respective trends?
   - Who are key stakeholders on the supply and demand side? What are their interests for electricity and heat production from sustainable woody bioenergy (especially focusing on co-firing globally, governmental institutions as producers, procurers and consumers of woody bioenergy)?
2. **Overview on and influence of national and international regulations and support instruments as well as market based standards** on the mobilization of sustainable production of and trade with woody bioenergy (e.g., FLEGT, RED, support of co-firing, CO_2 Emission Trading) - what works well, what not, and why?
3. **Identification of options to mobilize sustainable woody bioenergy in emerging and developing countries for an exemplary country** which already exports, with a focus on the assessment of:
   - Priority for local energy needs and food security
   - Consistency of sustainability requirements for woody bioenergy with relevant forest related processes (e.g. EU Timber Regulation, FLEGT, public procurement policies, European Forest convention, sustainability standards such as FSC, PEFC, etc.)
   - Opportunities and risks for preserving forests and impacts on sustainable development
   - Strengthening of a positive image of woody bioenergy Extension of forest certification and optimization of sustainable value chains

To achieve these objectives, the study used the following methodologies:

- Compilation and assessment of data on relevant governmental and private sector regulation;
- structured interviews with key stakeholders, and
- Qualitative scenario development on mobilizing sustainable woody bioenergy.

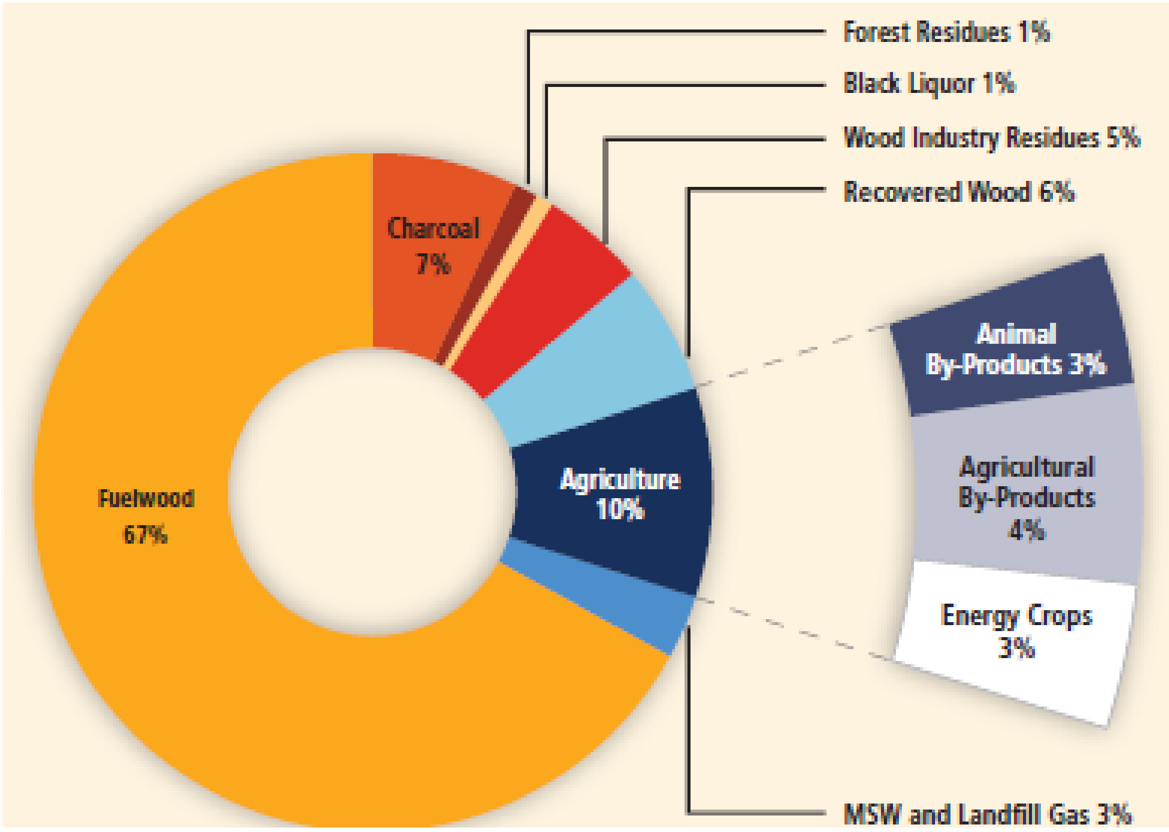
An extensive review of literature provided the base for the overall analysis and assessment.

1 The Current Role of Woody Bioenergy and its Prospects

Bioenergy is the most important renewable source of energy providing 10 % of global primary energy supply (IEA 2011), with fuelwood[3] dominating (

Figure 1).

Figure 1 Shares of biomass sources for global energy



Source: IPCC (2011)

Currently, most bioenergy comes from forests and is consumed in developing countries, particularly in rural households as fuelwood for cooking and heating, representing the major energy source especially in African countries (IEA 2012a).

3 In this study, "fuelwood" describes unprocessed woody bioenergy harvested or collected from forests and woodlands (logs, twigs, branches). "Woody bioenergy" comprises a variety of woody biomass used for energy: from roundwood and forest residues to deadwood and salvaged wood, and from sawmill and pulp & paper residues to post-consumer wood. "Woodfuels" refers to all types of bioenergy originating directly or indirectly from woody biomass (FAO 2007).

In the OECD, the use of woody bioenergy is quite different: typically, it accounts for less than 5% of primary energy, and is used in modern heating systems and powerplants (IEA 2012a). However, several industrialized countries - especially in the EU - have ambitious plans to **increase woody bioenergy** use:

The EU Renewable Energy Directive (RED) established the mandatory target of producing 20 % of the final energy demand from renewables by 2020 (EU 2009), in which bioenergy - especially woody biomass from forests - is expected to double its contribution (IC et al. 2012).

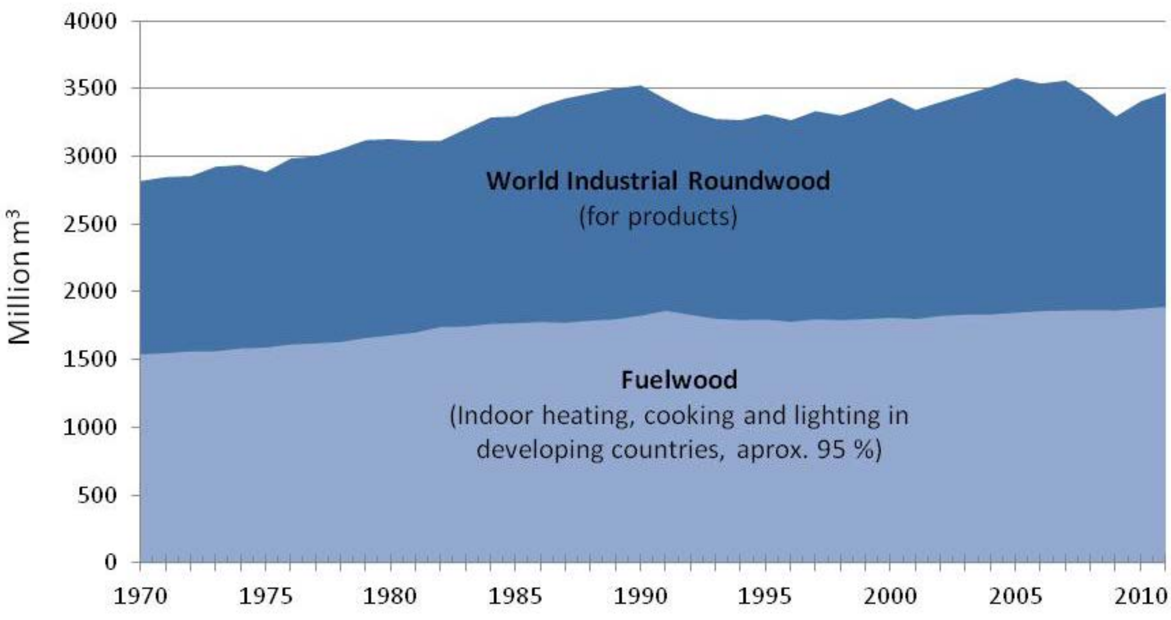
Other countries in Asia, the Americas and Southern Africa also promote the use of biomass, and plan to increase the use of woody bioenergy. As not all of these countries could fulfill these demands with domestic feedstock, international trade is projected to increase significantly (Section 2.4).

Many developing and emerging countries in the tropics and subtropics have **vast potentials for bioenergy** due to high productivity. Considering the dependence of many developing countries on fuelwood and the ambition to increase woody bioenergy in the OECD - at least in part through imports - there is a need to consider both opportunities and risks of these developments.

1.1 Woody Bioenergy in Developing Countries

The amount of fuelwood for heating and cooking in developing countries is still higher (Figure 2), and has an enormous importance for forests and livelihoods.

Figure 2 Fuelwood and industrial roundwood production



Source: Own compilation from FAOSTAT (2013); roundwood= saw logs/veneer and pulpwood

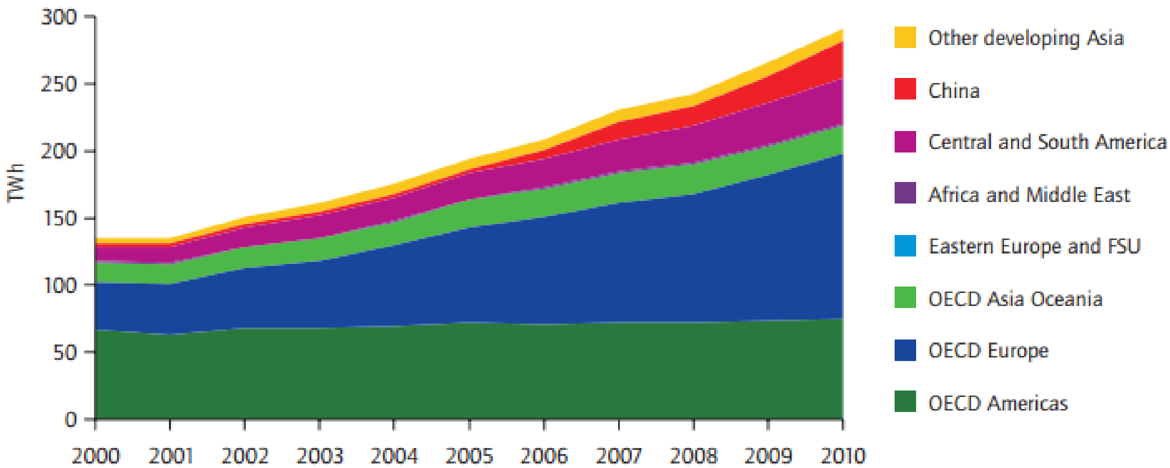
1.2 Woody Bioenergy in Industrialized Countries

In OECD countries, woody bioenergy is also used for heating, but with more efficient systems and lower consumption levels. Woody bioenergy competes with fossil fuels such as oil and natural gas, and especially for small-scale residential heating, energy prices of fossil fuels are quite high (IEA 2012a) so that woody bioenergy is often competitive[4].

In addition to this decentralized use, woody bioenergy is increasingly used for larger-scale (district) heat and power generation where the competing fossil fuel typically is low-cost coal or natural gas which, depending on the country, can also be comparatively low-cost.

In consequence, the use of woody bioenergy in larger-scale plants - especially for electricity generation (Figure 3) - depends on subsidy schemes, or regulation which requires industry and utilities to make use of renewables through quota systems, CO_2 taxes or CO_2 emission trading schemes which increase the price of fossil competitors (see Section 2.5).

Figure 3 Global electricity generation from bioenergy



Source: IEA (2012a)

4 Still, investment in modern bioenergy systems such as pellet boilers is more expensive than in those for gas or oil.

1.3 Global Woody Bioenergy Potentials

Most studies give the sustainable global bioenergy potential as a range from 100 to 300 EJ by 2050, although there are many uncertainties playing a role when biomass potentials are determined[5]. IEA (2012a) projects global primary bioenergy to increase from 50 EJ today to 160 EJ per year by 2050, with 100 EJ for electricity and heat, mainly from woody bioenergy.

Regarding wood, studies indicate a significant future potential of forest bioenergy – other than residues – in the range from 10 to 100 EJ by 2050 and it seems feasible to extract 60 to 100 EJ of additional wood from existing managed forests without reducing the re-growth potential.

Thus, woody bioenergy will play a **more important role** in the future. However, woody bioenergy can only contribute to energy supply in the long term if it is sustainably produced, and its conversion efficiency is improved (WBGU 2009).

1.4 Is Woody Bioenergy Cost-effective in Reducing GHG Emissions?

Mitigating climate change is one of the main reasons why renewable energies receive policy support. Thus, the potential of GHG emission reductions from woody bioenergy systems is a key factor of its attractiveness, but - as there are alternative options to reduce CO_2 such as wind and solar energy or efficiency measures - also respective costs have to be considered.

The cost-effectiveness of GHG emission reductions by woody bioenergy depends on the source of the woody biomass, the reference system it is compared with, and the time horizon for the comparison (short- versus long-term).

Currently, co-firing woody bioenergy in coal powerplants is among the most cost-effective near-term options in terms of GHG reduction (see Section 2.5).

Given the variety of situations influencing woody bioenergy's cost and GHG emissions it is not possible to make general statements on this issue, but some aggregated findings can be given:

- If wood is sourced from residues (e.g. forest thinnings, harvest leftover) and processing wastes (e.g. sawdust), the GHG mitigation compared to coal is typically higher than 60%, with up to 90% for local sources.

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5 See i.e. IPCC (2011) and Lysen, Egmond (2008).

- For international trade, pelletization of wood is required, and shipping adds to the carbon footprint so that net reductions compared to coal are 60-70%.
- Bioenergy derived from stemwood harvested in boreal forests has comparatively long regeneration periods which reduce net GHG reduction in the near-term significantly.
- If the biomass comes from temperate forests, net GHG reduction is higher, while woody bioenergy from tropical forests show the highest GHG reduction (and potentially shortest payback time) due to high annual forest growth.
- There is plenty of salvage wood (e.g. from insect infestation and storms) for which net GHG reduction is similar to that of woody residues.
- Woody bioenergy from short-rotation plantations cultivated on non-forested land can achieve direct GHG reductions far higher than 60%, but possible **indirect** effects due to displacement of earlier land-use must be considered[6].

6 The GHG implications of indirect land use changes (iLUC) can be significant (EEA 2013) and can offset CO_2 reductions. To avoid iLUC effects, plantations need to be established on under- or unused (e.g. fallow) land.

2 Production and Trade in Woody Biomass and Bioenergy

Woody biomass can be used for materials and energy production. Supply and international trade are well established for material use whereas only a small part of total woody bioenergy production is being traded internationally - but this share is expected to grow significantly in the near future.

2.1 Production and Trade of Woody Biomass for Materials

Global production and international exports shares of forest products in 2011 are shown in the following table.

Table 1 Global production and trade of forest products in 2011

Product	**Unit**	**Production**	**Exports**	**% (Exports/ Production)**
Roundwood	Mm^3	3469	123	3.6
- Fuelwood	Mm^3	1891	8	0.4
- Industrial roundwood	Mm^3	1578	115	7.3
Sawnwood	Mm^3	406	120	29.6
Wood-based panels	Mm^3	288	71	24.6
Wood and other fiber pulp	Mt	191	54	28.3
Recovered paper, paper and paperboard	Mt	614	171	27.8

Source: FAOSTAT Forestry database (2013)

The construction sector is the principal driver for the demand of forest products so the availability of co-products such as pellets is linked to the demand for "material" forest products (UNECE, FAO 2011).

Currently, fuelwood is the least internationally traded forest product with a share of exports in relation to production of less than 1 %.

Northern Europe, Russia and North America are the main exporting countries of wood based products in international timber trade.

As importers, European and Asian markets play the central role.

2.2 Production and Trade of Certified Wood Products

Interest in procurement of sustainably produced woody products is growing, as retailers and public procurers and consumers want to make positive social and environmental contributions when buying these products.

The development of green-building codes in the EU, the US and Asia-Pacific countries also fosters certified wood products (UNECE, FAO 2012).

In 2012 the share of roundwood from certified forests was 26.4 % with an uneven distribution among regions (see Table 2)[7]. The same year nearly 10% of the world forest area was certified (UNECE, FAO 2012)[8]. Western Europe and North America account for the majority of certified forest area.

Table 2 Global and regional supply of certified roundwood in 2012

Region	Total forest area (Mha)	Certified forest area		Estimated industrial roundwood from certified forest	
		Mha	% in region	Mm^3	% of total
North America	614.2	198.0	32.2	224.0	12.7
Western Europe	168.1	95.4	56.7	224.7	12.7
CIS (incl. Russian Federation)	836.9	47.5	5.7	9.1	0.5
Oceania	191.4	13.2	6.9	3.8	0.2
Africa	674.4	7.3	1.1	0.8	0.0
Latin America	955.6	14.7	1.5	2.9	0.2
Asia	592.5	9.5	1.6	3.2	0.2
World total	**4,033.1**	**385.5**	**9.6**	**468.6**	**26.5**

Source: UNECE, FAO (2012). The year 2012 covers May 2011 - May 2012

Other relevant players are Brazil and Malaysia, with 7.8 Mha and 5.1 Mha of certified forests, respectively, while China, Chile and the Democratic Republic of Congo have certified more than 2 Mha each (UNECE, FAO 2012).

7 More detailed information about the state of the art on forest certification can be found in the literature (e.g. UNECE, FAO 2012) and on the website of FSC (www.fsc.org) and PEFC (www.pefc.org).

8 If only larger-scale forest operations are considered, the global certified share in 2010 was approx. 50 % (Liedeker 2012).

2.3 Production and Trade of Woody Bioenergy

In 2011, fuelwood represented about 55 % of the total roundwood produced globally, but its significance differs regionally (Table 3).

In Africa, fuelwood represented 90% of total roundwood production in 2011, in South America and in the Caribbean 73 % and in Asia 57 %, respectively.

However, in Europe and North America, woody bioenergy amounted only to 24 % and 9 % of total roundwood production in 2011, respectively.

Total exports of fuelwood accounted for less than 1% of total roundwood production. Thus, most fuelwood is produced and consumed locally.

Table 3 Global production and trade of woody bioenergy (2011)

Region	**% Fuelwood/ roundwood**	**Roundwood Production (Mm^3)**	**Exports (1,000 m^3)**	**Import (1,000 m^3)**	**Consumption (Mm^3)**
Europe	24	162	6980	5022	160
- EU-27	22	92	4361	4680	93
- Russia	22	44	271	0	44
Africa	90	631	28	9	631
Asia	73	756	52	256	756
- China	64	185	2	4	185
- India	93	309	0	5	309
- Indonesia	49	57	1	26	57
North America	9	44	631	207	43
Latin America	57	288	12	4	288
- Brazil	51	144	0	0	144
Oceania	15	11	1	1	11
World	**55**	**1891**	**7704**	**5,499**	**1,889**

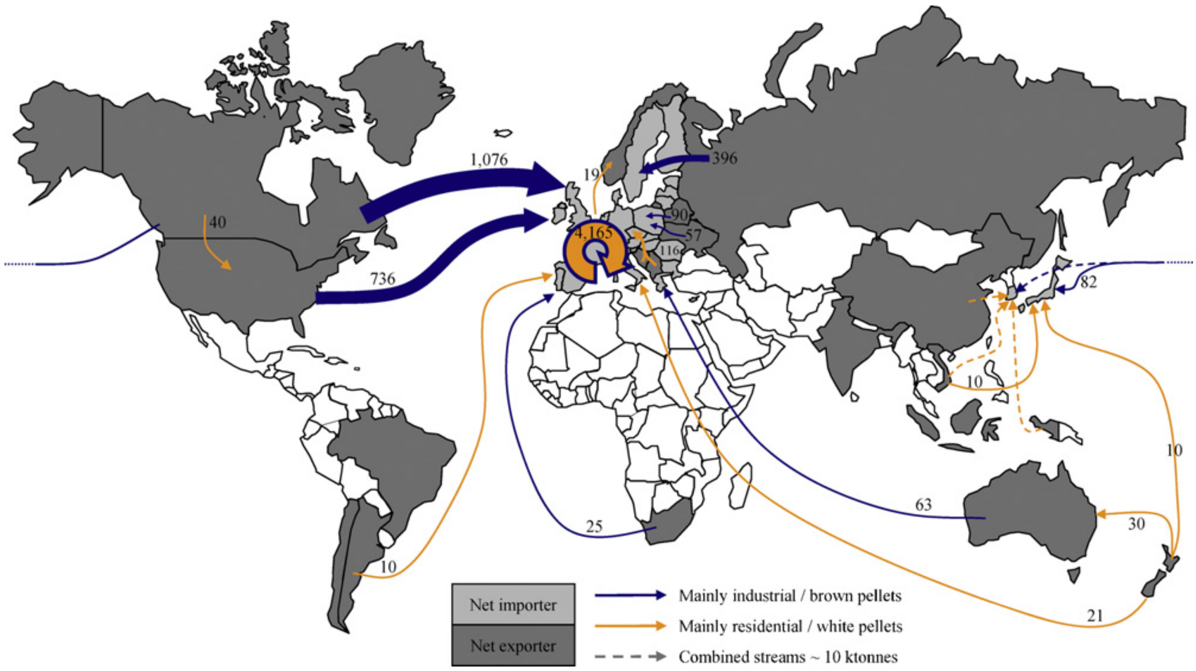
Source: FAOSTAT Forestry Database (2013); consumption is calculated as production + imports - exports

The international trade of woody bioenergy is dominated by **pellets for large-scale users**, mainly between Northern America and Europe (IEA Bio 2013), and has significantly increased over the last years.

Canada, the US and the Russian Federation, followed by European countries such as Austria, Germany and Sweden, show the highest increase in production capacity.

In 2010, the **European** pellet industry covered 81 % of the demand, but the gap between production and consumption in the EU is growing. Wood pellets imports mainly come from North America and Russia to the EU (Figure 4).

Figure 4 World wood pellet trade streams in 2010



Source: Lamers et al. (2012); only trade flows above 10 kt are shown

The main feedstock to produce pellets are residues from sawmills (Cocchi et al. 2011). As producers are interested in a more diverse supply, other feedstocks such as forest residues, thinnings, salvage materials and "surplus" roundwood are being used or under consideration in some regions.

As regards certified woody bioenergy, there is **no international data** available.

Some pellet producers in the Southeast of the US source their material from certified forests, and domestic pellet production in the EU (e.g. Austria, Germany, Finland, Sweden) also uses feedstock from forests certified by FSC or PEFC, but quantitative figures are not available.

Given the interests of electric utilities in Europe to procure sustainable woody bioenergy (see Section 2.4) and the discussion on sustainability requirements for woody bioenergy in the EU (see Section 5.2) it can be expected that sustainability certification will **become more relevant** in future international woody bioenergy trade.

2.4 Future Demand for Woody Bioenergy Imports

To meet GHG mitigation and renewable energy goals, a number of (mainly industrialized) countries introduced policies to increase the share of bioenergy in their national energy mix, including an increasing demand for imports of woody bioenergy to these countries (IEA 2012a). Accordingly, global markets developed strongly over the last decade, with the EU as a key driver. Countries such as Canada, Japan, South Korea and the US, as well as emerging economies such as China and India announced to increase the share of biomass in their national energy systems. Both Canada and the US not only export woody bioenergy, but increasingly use this resource also domestically:

The Canadian "Go Pellets" initiative promotes developing a domestic pellet market, and Quebec announced to increase co-firing of domestic wood in its coal plants by 2020. In the US, pellet use for heating is increasing, but comparatively low oil and gas prices hamper markets. As there is not (yet) a domestic policy on GHG mitigation, exports to Europe yield higher revenues.

The final demand will depend on policy support measures, in particular for co-firing, as well as the price of fossil fuels, and CO_2 certificates (see Section 2.5).

The IEA Bioenergy Task 40 developed scenarios for future EU wood pellet imports ("low" and "high" variants in Figure 5 and Figure 6). According to the results of the interviews[9], the low scenario seems more realistic, though.

Furthermore, the price dynamics for CO_2 certificates under the European Emission Trading System (ETS) will determine to what extent co-firing will be of interest for utilities and industrial emitters. Major utilities such as e.on, RWE and Vattenfall have reduced their ambitions for co-firing due to low CO_2 certificate prices, and lack of EU regulation on the sustainability of woody bioenergy.

As comparatively low-cost import options exist for pellets from Canada, the US Southeast and Russia, utilities will use these options once future CO_2 certificate prices and EU sustainability regulation for woody bioenergy become clear.

This implies that overall prices for internationally traded woody bioenergy, especially to the EU, will remain low so that other potential market suppliers e.g. from developing countries would face low revenues for risky investments.

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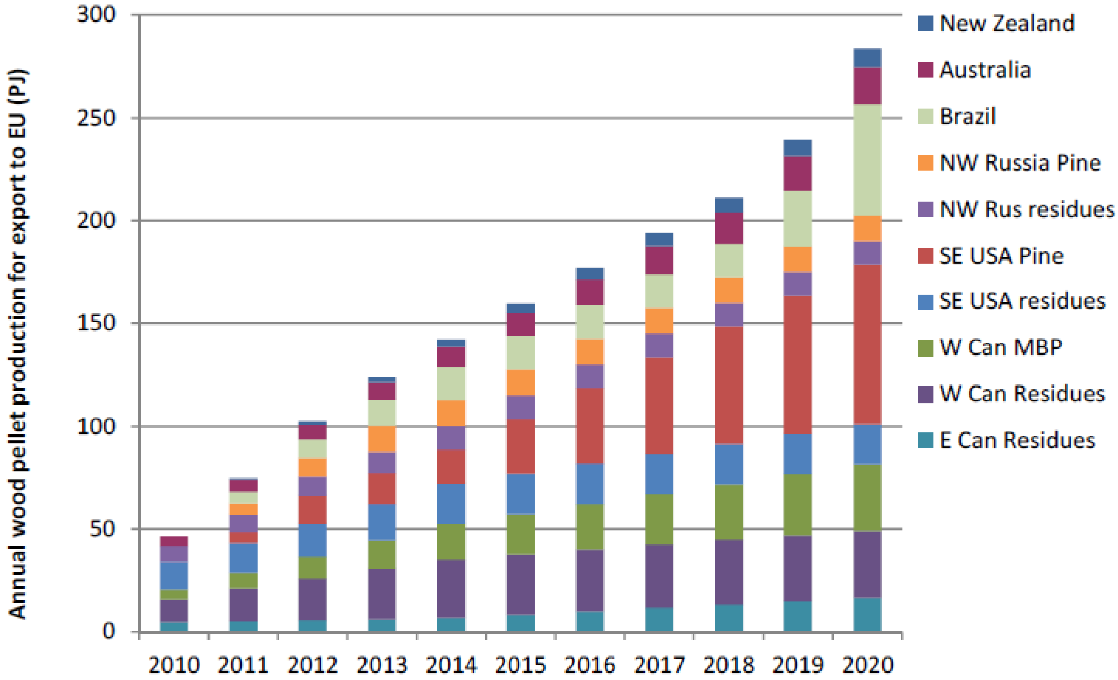
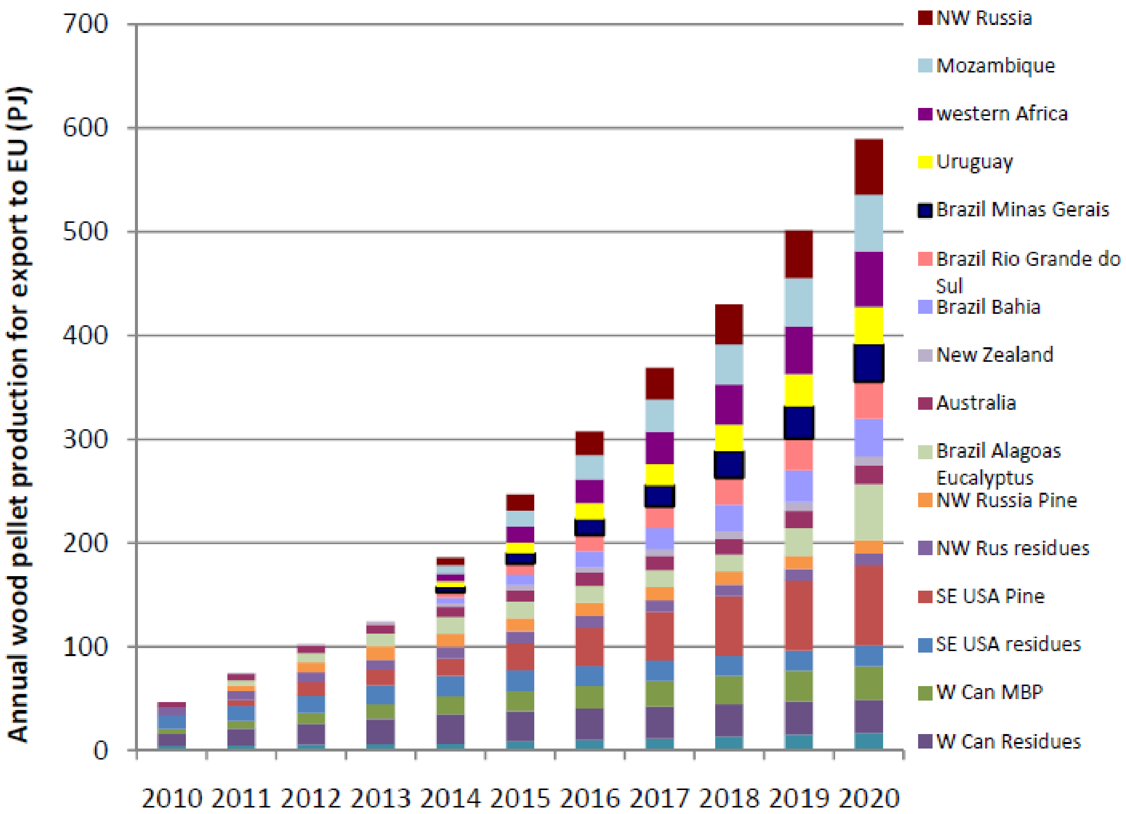
9 See Annex in the Full Final Report, available at http://www.iinas.org/tl_files/iinas/downloads/IINAS_CENBIO_2014_Sust_Woody_Bioenergy_GIZ_full.pdf

Figure 5 Growth in global wood pellet exports to the EU - Low scenario



Source: Cocchi et al. (2011); NW = Northwest; Rus = Russia; SE = Southeast; W= West; Can = Canada; E= East; MPB = Mountain pine beetle; residues = from wood industry

Figure 6 Growth in global wood pellet exports to the EU - High scenario



Source: Cocchi et al. (2011); residues = from woody industry; MPB = Mountain pine beetle

With regard to Russia it is noteworthy that although its Forestry Code was revised in 2006, it is still unclear how possible exports to the EU could comply with the due diligence requirement of the EU Timber Regulation (FERN 2011). Russia has vast forest resources but only about 25 % of annual allowable cut is harvested (Solberg et al. 2010). Aiming at encouraging value-added exports, Russia imposed high tariffs on roundwood exports. However, it is foreseen that Russia increases its export of woody bioenergy to EU as part of its new policies as a WTO member.

2.5 Cost-Effectiveness of Co-firing Woody Bioenergy

The cost of bioenergy from woody biomass depends on the wood source and the conversion technology. Typically, there are three types for this:

- biomass power plants using local forest residues,
- biomass co-generation unit using local wood chips, and
- large-scale co-firing in coal powerplant with imported pellets.

Electricity generation costs[10] are in the range of 90-120 €/MWh_{el} for small-scale plants using local forest residues, 75-100 €/MWh_{el} for cogeneration plants (depending on revenue from heat sales), and around 80 €/MWh_{el} for co-firing in existing coal plants, i.e. co-firing is typically the cheapest option.

However, co-firing is still **more expensive** than electricity from coal which has generation costs of 40-50 €/MWh_{el}. Under current circumstances, prices for bioenergy from European woody feedstocks do not allow for co-firing to be economic.

This situation could change if biomass from other (developing) countries could be supplied at considerably lower prices, but such prices only seem possible if sustainability, CO_2 mitigation and also social criteria are not fully taken into account.

Another possibility to make co-firing economic is higher prices for CO_2 certificates under the ETS. DENA (2011) gives a more detailed overview on co-firing for the situation in Germany, with high efficient and high capacity steam power plants. In this case it was calculated that the prices for CO_2 certificates should reach at least 40 to 57 €/t CO_2 to make biomass co-firing competitive to coal - this is about 10 times the value of current CO_2 certificate prices.

10 The values given are estimates using mean reference values. Costs can vary up to ±30% depending on local conditions.

However, it is currently open if the historical minimum CO_2 certificate prices can be increased through “back-loading” the carbon emission allowances so that it is difficult to foresee how attractive the ETS will become for woody bioenergy[11].

If the CO_2 prices remain low, alternative support and financial aid would be needed to make co-firing competitive. This could be done, for example, by higher feed-in tariffs for electricity from biomass co-firing. In Germany, higher feed-in tariffs can only be claimed by cogeneration plants with a capacity of less than 20 MW, and only if the generation plant operates **exclusively** on bioenergy, i.e. **no co-firing** is allowed.

There are various support schemes for renewable energies in the UK, but the main policy measure for stimulating growth of electricity generation from renewable energies is the Renewables Obligation (RO). It is applicable for renewable energy plants larger than 5 MW. Those plants receive Renewables Obligation Certificates (ROCs) depending on the technology and size of the plant. For electricity from biomass, ROCs also depend on the type of biomass. Plants which use “dedicated biomass”, i.e. whose consumption consists of more than 90% biomass, receive 1.5 ROCs/MWh. ROCs are tradable and prices vary.

The average ROC price from Nov. 2012 to Jan. 2013 was about 41 £/MWh (1.5 ROCs = 61.5 £/MWh). In addition to the earnings from the ROCs, plant operators get revenues if they sell the electricity at the UK power exchange. Average electricity prices were 50 £/MWh. Thus, the total price per MWh adds up to approx. 128 €/MWh. This is a good price and makes investment in large-scale biomass power plants attractive.

The UK government decided to establish sustainability requirements for woody bioenergy being co-fired under the ROC scheme which applies also to imported woody bioenergy (DECC 2013a+b).

3 Wood Supply and Demand in Developing Countries

As woody bioenergy import demand will grow especially in the EU, it must be acknowledged that woody bioenergy also plays a major role in developing countries, though its share differs among regions (Table 4).

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[11] In April 2013, the European Parliament voted against a “back-loading” of the carbon emission allowances under the EU ETS, but reversed this decision in July 2013. The Council has now to decide on the issue.

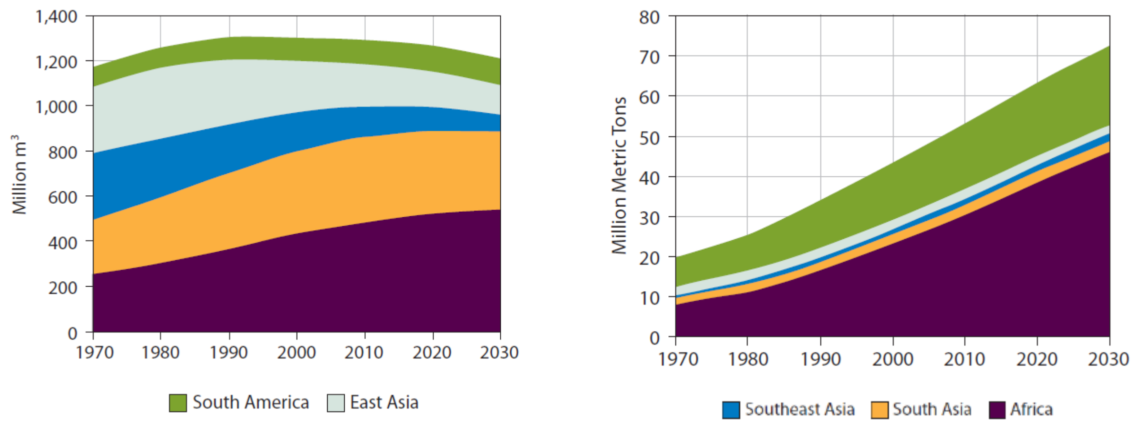
Table 4 Key figures for woody bioenergy in developing countries

	Forests	Roundwood	Fuelwood	People relying on
Region	**Mha**	**production in Mm^3**		**woody bioenergy**
Africa	674	703	631	68%
Asia	592	1033	756	51%
South + Central America	884	502	283	14%

Source: own calculation based on FAO (2010b) and IEA (2012b)

Despite the various international initiatives to improve access to clean energy in developing countries such as the Sustainable Energy for All (UN GA 2011), traditional bioenergy use is projected to increase globally, mainly due to increasing charcoal demands (Figure 7).

Figure 7 Projections for traditional bioenergy use in developing regions for fuelwood and charcoal



Source: Boucher et al. (2011); fuelwood (left); charcoal (right)

Charcoal is often used in cities and as energy source for industries, especially in developing countries. Global charcoal production increased by 30 % over the last 10 years. Moreover, international trade of charcoal doubled over the last decade, though on a low absolute level. Most charcoal is produced in Africa, Asia, Central America and the Caribbean. Latin America, Africa and Asia are main exporters while Europe and Asia are main importers.

The population share without clean cooking facilities in developing countries will decrease from 49 % in 2010 to 39 % by 2030, but the number of people relying on traditional bioenergy uses will increase to 2.6 - 2.8 billion (IEA 2012b; ESMAP 2011). At the same time, demand for modern woody bioenergy is expected to grow significantly in East Asia and Pacific (IEA 2012b).

3.1 Potentials for woody bioenergy in developing countries

Currently, there is no comprehensive database available on wood bioenergy potentials in developing countries, but some analysis exists for a few countries[12]. Furthermore, the availability of woody feedstocks at country level does not give the amount of bioenergy potentially available for international exports.

The potential of **existing** forest plantations[13] to provide woody bioenergy is determined by the profitability of products on the respective markets. For example, pulp & paper industries could divert current production to bioenergy markets if this rewards higher revenues, and profits. In case of **new** plantations, cultivation area could come from existing forests or degraded lands, since food production on agricultural land provides higher benefits[14] and, therefore, is not likely to be displaced by woody bioenergy cultivation. The extent to which land use change from natural forests to plantations could happen will depend on the economic and regulatory situation[15]. Also, marginal and **degraded land** in some areas could be used but its adequacy has to be evaluated locally[16].

Another feedstock for bioenergy is the utilization of **wood waste and residues**. Efficiency of wood processing industry in the tropics could be increased: For example, logging residues in the Amazon region are estimated as 45 % of the total biomass extracted, and in the wood processing industry more than 50 % with a total for tropical timber producers of 162 Mm^3 (ITTO 2006).

However, investment in technologies for wood waste and residues and infrastructure would be higher per hectare compared to plantations. Apart from the feedstock availability, other issues affecting the capacity of developing countries to supply woody bioenergy to the international markets are:

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12 Among the various tools and methodologies in place to determine woody biomass potentials, the WISDOM methodology developed by FAO assesses supply and demand of fuelwood in a given region in order to support planning and policy formulation. This methodology has been applied in Southeast Asia Countries, Rwanda and Argentina. See for more details http://www.wisdomprojects.net/global/pub.asp

13 Currently, planted forests account for about 300 Mha (7 % of global forest area), providing more than half the industrial wood produced worldwide, and their extent and productivity increase (FAO 2006a)

14 See Cushion, Whiteman, Dieterle (2010). For details on returns for various land uses see e.g. IIED (2008).

15 Woody bioenergy from new (short-rotation) plantations would require land and might imply risks of "land grabbing".

16 Marginal land can be used for fuelwood plantation, as has been demonstrated in the Philippines (FAO 2009d). For degraded land see Fritsche et al. (2010) which presents 3 country studies (Brazil, China, South Africa). Global estimates on degraded land for bioenergy production vary, but up to 100 EJ/a could come from these lands by 2050 (IINAS, IFEU 2012)

- **Development of infrastructure** (roads, harbors, communication, etc.) - a lack of handling and port infrastructure and resulting inefficient logistics are a key barrier to enhanced international trade of bioenergy (IEA 2012a).
- **Governance** - in terms of social stability, forest governance and securing foreign investments - affect the opportunities for private investments.
- **Technology development** - developing countries are far from EU markets and transport cost for woody bioenergy is an important part of total cost. Implementing processes to make transport cheaper (e.g. torrefaction) will improve competitiveness on international markets.

3.2 Woody bioenergy demand in developing countries and domestic consumption trends

Although global fuelwood demand in developing countries will slightly decrease until 2030, it will still be growing in some regions, especially in Africa and South Asia. In Africa there is also a growing demand for charcoal (Figure 7).

Some of these countries show a very high share of fuelwood production related to total roundwood. This means that national wood production is mainly used for fuelwood demands of in mainly rural areas. Only a small percentage of fuelwood in developing countries comes from plantations - the majority is either gathered from forests or from open land with low tree density.

IEA (2012a) assumes that in most countries the demand for fuelwood increases despite national programs to replace traditional bioenergy use by other options such as gas, liquid fuels and electricity. A high share of fuelwood in total roundwood indicates that there is little scope for woody bioenergy exports, but economic incentives in importing countries might lead to significant export rates even if this causes shortages in domestic fuelwood supply.

This study assumes possible woody bioenergy exports only for countries with a fuelwood share < 80% of domestic roundwood production, and also considers if deforestation rates are high. This precautionary approach is a proxy for a more detailed analysis using bottom-up country data, and can give only a rough indication of export possibilities, or respective restrictions.

3.2.1 Woody bioenergy demand in Asia

China has very ambitious plans for the use of renewable energy and biomass plays an important role within the renewable energy mix. But contrary to the current dominance of biomass for heat production in rural residential areas, the Chinese renewable energy plan for biomass is mainly focused on power generation. Under China’s Medium and Long-Term Development Plan for Renewable Energy and the

11th Five-year Renewable Energy Development Plan, the updated goals for 2010 comprised a biomass power generation capacity of 5.5 GW and an annual solid biomass briquetting of 500,000 tons.

The targets for 2020 include the total biomass power generation reaching 30 GW, from which agro-forestry biomass should reach 24 GW, the rest should come from waste and other sources. But according to reports (Gibson 2013) it seems unlikely that these targets will be met, because construction of small and medium-sized plants is not getting on as expected. It can therefore be assumed that co-firing will become dominant. All scenarios in the WEO (IEA 2012b) show that the woody bioenergy demand can be met by domestic biomass resources only if additional plantations will be established. Given the high value of land for food production and the poor transport infrastructure, it can be expected that China will import biomass especially for powerplants located in its coastal areas as long as prices for imported biomass are competitive compared to other renewable energies. Hence, it is **very unlikely** that China will be an export nation for biomass but might well choose **to import** biomass in the future to support its energy plan.

India is the country with the largest population relying on traditional biomass supply. More than 70% of the Indian population lives in rural areas and nearly 800 million people use biomass for cooking. Almost halve of this firewood and chips are obtained through “free” collection and 42 % is procured from forests (TERI 2010). Also, fuelwood collection serves as an economic livelihood option for millions of people (PISCES 2011).

The government is making efforts to increase renewable energy supply and has launched over 2000 CDM renewable energy projects (REEEGLE 2012) and the National Biomass Cookstoves Initiative aims to improve residential energy use (Venkataraman et al. 2010).

Still, India faces massive constraints on available land and water, and with the priority of food and feed production, it could achieve its energy goals only by massive imports of biomass and by establishing new biomass plantations.

As both China and India are likely to import bioenergy in the future, and both Malaysia and Indonesia have high deforestation rates (FAO 2010c), only Thailand remains as a possible export “candidate” in Asia.

Thailand has set up several environmental laws and regulations of importance to bioenergy (FAO 2009a) and aims at 25% of renewable energy in its energy consumption by 2020 (Haema 2011). Regarding biomass, key activities include:

- Promote plantation of fast growing trees
- Develop production and standard of biomass pellets

- Promote establishment of Distributed Green Generation as power production from biomass at community level.

3.2.2 Woody bioenergy demand in Africa

The total demand for woody bioenergy in Africa is given by IEA as about 13 EJ in 2008, with 10 EJ (78 %) for residential use. The **total** fuelwood production in Africa in the same year given by FAO was 608 Mm³ which is equivalent to 6 EJ - i.e. nearly half of the total woody bioenergy demand. Until 2011, fuelwood production rose only a little to 631 Mm³ (6.3 EJ). The share of roundwood used as fuelwood in Africa is about 90 %.

The country with the highest roundwood production is Ethiopia where 97% of the production is used as fuelwood. The country with the highest potential of wood not used as fuelwood is South Africa, with about 19 Mm³ per year. Considering restrictions and local use dynamics, only three African countries are potential export candidates: South Africa, Gabon and the Democratic Republic of Congo (DRC). For South Africa, a rising domestic demand is expected due to its renewable energy policies, while DRC and Gabon are low in infrastructure and governance, with deforestation becoming an issue (WB 2013).

3.2.3 Woody bioenergy demand in South America

In South America, most countries are interested more in biofuels (e.g. biodiesel in Argentina, sugarcane bioethanol in Brazil) and have achieved lower levels of residential woody bioenergy in households (IEA 2012b). Due to restrictions in available time, no further analysis of South American countries was possible, but the case study of Brazil[17] indicates relevant options for woody bioenergy.

4 Developing Countries Role in Woody Bioenergy Trade

The international development of the woody bioenergy market depends on a number of factors and dynamics, not just on availability of resources. From the results of the interviews (see Annex) and various recent studies, the role of various regions for supplying woody bioenergy to EU countries can be derived:

- **Boreal and temperate OECD countries** have a long tradition and availability of forest resources and are currently suppliers to Europe, especially Canada, the

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17 See Brazil Case Study available at http://www.iinas.org/tl_files/iinas/downloads/CENBIO_2013_Brazil-Case-Study_GIZ.pdf

Southeast of the USA, and Northwest Russia. They can increase their supply capacity in the coming years. Assuming continuation of domestic energy price trends, exports of woody bioenergy from those countries to Europe appear competitive and might continue to allow higher revenues than domestic use of bioenergy[18].

- **The "Global South"**, i.e. developing countries especially in Latin America and Asia **could** play a smaller role in providing international markets with woody bioenergy, depending on supply cost, and investments in infrastructure. Still, investments in these countries face higher risks and higher interest rates so that expected lower bioenergy cost may be offset.
- Most woody bioenergy imports to the EU - which dominate current international woody bioenergy trade - are expected to be used for co-firing. At present, European utilities reduced their co-firing targets so that the high-scenario projections of IEA Bioenergy for growth in global wood pellet exports to the EU are unrealistic for 2020. However, the scenarios show most likely regions of supply (see Figure 5 + Figure 6 in Section 2.4).
- Brazil might become an exporter if investments in pellet production materialize, but other Latin American or African countries such as Mozambique or Congo could only play a role in the longer-term as well.

The current pellet exporters in OECD countries have a large resource base for bioenergy feedstocks as well as respective expertise, infrastructures and capabilities to continue supplying international woody bioenergy markets, and they do not face structural problems prevalent in developing countries.

Therefore, a "boom" in exports of woody bioenergy from developing countries is not expected even if a few countries such as Brazil will promote woody bioenergy exports.

At present, one of the main barriers for sustainable woody bioenergy exports from developing countries is lack of infrastructure (harbors, rail, road), as logistics play a fundamental role in bioenergy trade. IEA (2012a) also highlights limited

18 This is relevant, as domestic fossil energy prices in North America and Russia are currently significantly lower than in the EU, and this is projected to remain in the medium-term (IEA 2012b).

financial resources, lack of skilled labor and lack of formal land ownership structures and unstable policy frameworks as barriers. Furthermore, there is a significant domestic supply in many developing countries.

Another challenge is the limited knowledge and interest in sustainable forest management and ecosystem services by decision makers in the energy sector in developing countries (Masera 2012).

In any case, the availability of developing countries to produce and export woody bioenergy must be seen in the context of local necessities which **need to be met first** - it would be counterproductive to export woody bioenergy to replace coal in other countries without improving forest management and woodfuel value chain and hence reducing domestic GHG emissions.

Thus, **sustainable supply** of bioenergy in developing countries is **the key issue**, disregarding if woody bioenergy is used domestically, or exported. For this, strong policies and safeguards are needed (see Section 6.2).

5 Implications of increased Woody Bioenergy Trade for Developing Countries

5.1 Opportunities and Risks for Developing Countries

From the analysis of future demand and potential supply dynamics in the previous sections it can be concluded that both developing and industrialized countries will continue **consuming large quantities of woody bioenergy** to fulfill their energy needs in the medium term (IEA 2012b).

Many rural people in developing countries will continue relying on woody bioenergy use for cooking (ESMAP 2011) while in industrialized countries, clean woody bioenergy will increase its share in heating (IEA 2012a). The evolution of large-scale industrial use and co-firing is more uncertain, as policy frameworks such as the RED and the ETS do currently not give adequate price signals. This means that existing suppliers of woody bioenergy for international markets, i.e. Canada, the US and Russia, will maintain their position, while new players especially from developing countries will face significant challenges:

On the **supply side**, making wood supply from forests and other wooded lands more **efficient and sustainable** is fundamental. Various approaches exist for this such as community forest management and improving harvest operations. Wood plantations present a wide range of advantages but have failed so far to achieve their potential due to limiting factors (tenure security, governance deficits) and unfavorable economics, as fuelwood is underpriced and wood produced through plantations can be diverted to other uses that offer higher revenues (EUEI PDF, GTZ 2009).

On the **demand side,** substituting existing fuelwood use on household levels with clean, more efficient cookstoves is promoted globally[19] which may contribute to reductions in black carbon and GHG emissions as well as to health improvements through reduced indoor air pollution (IIED 2013). Furthermore, time needed for fuelwood collection is saved, thereby lowering opportunity costs of bioenergy (ESMAP 2011).

Integration of supply- and demand-side issues is needed (Macqueen, Korhaliller 2011; IIED 2013) to foster sustainability.

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[19] See e.g. the international public-private partnership for clean cookstoves (http://www.cleancookstoves.org)

Currently there is little risk of massively replacing fuelwood in developing countries with exports, at least from an economic point of view (Cushion, Whiteman, Dieterle 2010; EUEI PDF, GTZ 2009). Still, the new interest of private actors such as international energy companies and traders interested in woody bioenergy could affect developing countries in various ways. Table 5 synthesizes respective key issues, opportunities and risks.

Table 5 Issues, opportunities and risks of woody bioenergy development for developing countries:

Issues	**Opportunities**	**Risks**
Governance	Improvement of implementing policies and regulations	Policies and regulations are ignored to foster woody bioenergy exports
Competitive industries	Improving efficiency and reduced operation costs	Low capacity for new technologies
Infrastructure development (e.g. road, rail)	Improved national and international market access	Inadequate infrastructure development
Energy security and trade balance	Increased energy security and better trade balance	Reduced access due to competition for resources
Forestry sector	Diversification	Promotion of monocultures
Pressure on forests	Sustainable Forest Management	Forest degradation, illegal logging
Land Use	Use of marginal and degraded land, re- and afforestation	Deforestation
Waste management and resources efficiency	Improved utilization of underused resources	Displacement of informal waste use
Access of local people to resources	Improving local resources through better forest management	Competition, limited access, displacement
Employment	Rural employment and respective income in rural areas	Potential exclusion of small farmers and women
Fuelwood prices	Higher value for forest products	Price increase and market disturbances

Source: own compilation based on FAO (2007 + 2009b), Masera (2012) and Clancy (2013)

To a great extent the impacts depend on the feedstocks used for woody bioenergy production (forest residues, current or new plantations etc.) and how their governance and management is performed.

Aiming at reducing costs and risks, FAO (2007, 2009b-d) recommended giving priority to established forest operations and proven technology and to utilize residues and by-products from wood processing industry and suggested that in a **second stage**, new plantations and technologies would be considered.

Contrary to what occurs with the biofuel sector, the impact of expanding woody bioenergy markets is unlikely to have significant effects on altering agricultural production or increasing food prices (Cushion, Whiteman, Dieterle 2010), but could raise prices of fuelwood, charcoal and roundwood (Buongiorno, Raunikar, Zhu 2011). New export markets could pose risks on local access to woody products, but this must be assessed at local level (see Box).

Box: The Vattenfall project in Liberia

In 2010-2011, Vattenfall planned a project together with Buchanan Renewables to export woodchips from Liberian rubber tree residues for co-firing in Germany. Most of the Liberian rubber plantations are old and unproductive and replacement started at larger plantations. The project planned to fund road and harbor infrastructures and a local wood-fired powerplant, and considered various sustainability schemes such as FSC and RSB.

According to some authors, charcoal was previously produced from rubber tree residues and sold in urban areas so that the planned project would displace this product, causing price increases (Wunder et al. 2012). Other studies found that charcoal is only a minor part of unproductive rubber tree residues, and moderate price effects are in line with rising costs for other commodities (Forestry for Development 2012; IFEU 2011).

In May 2012 Vattenfall decided to cancel the project due to unfavorable reactions in Germany, and overall low economic prospects.

5.2 Sustainability Schemes for Woody Bioenergy

International stakeholders, especially those in Europe, increasingly demand that bioenergy markets are developed in a sustainable way, and also the global discussions around bioenergy trade focus on the sustainability of biomass sourcing (e.g., Abid 2012; FAO 2011). Sound environmental and socioeconomic practices along the feedstock production could be promoted directly or indirectly through various policy instruments such as mandates with sustainability requirements, national standards for certification and financial incentives (FAO 2012b). Sustainability schemes could mitigate risks that woody bioenergy could pose for exports from developing countries.

The various initiatives were created to address different concerns and are inconsistent. Considering that voluntary forest certification schemes do not recognize each other even if aiming at sustainable forest management (SFM), it is not surprising that approaches from forest and energy sector have different understanding of which sustainability criteria have to be addressed.

The criteria established in the RED for biofuels and bioliquids (EU 2009) and the current discussions to require similar ones for solid and gaseous bioenergy used for electricity, heating and cooling (EC 2010 + 2013) aim to protect biodiversity and carbon storage in forests and other relevant zones.

However, SFM is not only based on determining “no-go” areas but on assuring sound management of productive (and protected) areas.

The variety of voluntary certification schemes developed for biofuels show **different** targets and, hence, different ambition towards sustainability. It has been acknowledged that the development of several sustainability certification schemes - if not properly aligned - could represent a trade barrier (IEA 2012a) so that it is necessary to harmonize the schemes (Cocchi et al. 2011). This is the reason why large European electric utilities interested in international woody bioenergy trade have called for EU-wide harmonized sustainability criteria (e.g. Bjerg 2012), and initiatives such as the IWPB exist.

With the EU being the main focus of international woody bioenergy trade (see Section 2.4), the calls for mandatory sustainability criteria for woody bioenergy are substantiated, and respective suggestions for a harmonized scheme have been made (Fritsche et al. 2012).

An internal draft of an EC proposal on sustainability requirements for woody bioenergy was leaked in August 2013 (EC 2013) - it uses the same approach as the RED provisions for biofuels and bioliquids.

Table 6 summarizes the various sustainability schemes at international and European levels.

Table 6 Overview of sustainability schemes related to woody bioenergy

Activity	Brief Description
GBEP	The Global Bioenergy Partnership endorsed Sustainability Indicators for Bioenergy in 2011, aiming at national policy development
REDD+	Reducing Emissions from Deforestation and Forest Degradation aims to create financial value for carbon stored in forests
CDM	The Clean Development Mechanism allows implementing projects in non-Annex I parties of the Kyoto Protocol to reduce GHG emissions
International Forest Processes	Non-legally binding instrument for all types of forests and on-going Criteria and Indicators processes for Sustainable Forest Management
Voluntary Forest Certification	Emerged in early 90s to mainly limit tropical deforestation, key are FSC and PFEC as international umbrellas of national standards
ISO	The International Standardization Organization works on a standard addressing sustainability issues related to bioenergy production (ISO 13065), expected to be published in April 2014
Voluntary schemes	Various schemes promoted by different stakeholders, e.g. ISCC, RSB and SPB (formerly IWPB)
FAO Sustainable Woodfuel	These general guidelines (FAO 2010d) give principles, criteria and indicators for developing sustainable woodfuels with a holistic approach.
Voluntary Guidelines	The Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (CFS 2012) aim to contribute to the achievement of food security by acknowledging the central role of land to development.
Responsible management of planted forests	The voluntary guidelines for responsible management of planted forests (2006) provide 12 guiding principles Based on the institutional, economic, social and cultural, environmental and landscape approach realms.
Extension of the RED	Internal draft of EC proposal on extending the RED criteria to solid and gaseous bioenergy - no official document available yet.
CEN	The European Committee for Standardization TC 383 ‘‘Sustainably produced biomass for energy applications’’ elaborates a European standard (prEN 16214) for sustainable biomass for energy applications
FLEGT and EU Timber Regulation	The EU introduced in 2003 the Forest Law Enforcement, Governance and Trade (FLEGT) Action Plan, in order to reduce deforestation (EU 2003). The EU Timber Regulation entered into effect in March 2013, aiming to avoide entrance of illegally harvested timber products into the EU
Forest Europe	International process for developing principles, criteria and indicators; legally binding agreement on forests in Europe expected in 2013

Source: own compilation

6 Conclusions and Recommendations

6.1 Conclusions

Developing countries will continue consuming large amounts of bioenergy for domestic uses so that increasing the efficiency of bioenergy use at household level should be a priority on the international agenda.

Most industrialized countries have incentives and targets to promote woody bioenergy so that their demand is projected to grow as well. Furthermore, demands from China and India become relevant for international trade.

The well-established forest industries in Canada, USA and Russia dominate current woody bioenergy exports to international markets, especially to the EU. Given their production base, they will continue to offer comparatively low-cost feedstocks unless domestic climate policies become stronger[20].

This implies that conditions for developing countries to take part in the growing international woody bioenergy market on a large scale **will remain unlikely** in the **short-term**. Still, some countries with high potentials and favorable infrastructures for exports such as Brazil might enter into this business.

Growing trade and opportunities for higher revenues could create interest in other developing countries to shift domestic uses of wood to bioenergy exports, and investors might seek to develop attractive “local spots” even in countries with low woody bioenergy potentials, and less favorable conditions.

If renewable energy targets in countries such as South Africa or high CO_2 prices in Emission Trading Schemes (i.e. in the EU, and Australia) drive international woody bioenergy trade further, market players **will** seek opportunities beyond established suppliers. Then developing countries with access to international trade routes **may become areas** for such activities.

In order to maximize the benefits that - private or governmental - investments in improved and verified sustainable supply chains of woody bioenergy could generate and to avoid negative tradeoffs, the governance of woody bioenergy **needs to be improved**, and respective policies be put in place.

20 This seems, unfortunately, not realistic in the near-term: Canada withdrew from the Kyoto Protocol, the US so far failed to introduce respective national legislation, and Russia opposed the Kyoto-II process.

6.2 Recommendations

6.2.1 Securing Fuelwood Supply

Similar to biofuel feedstock cultivation which implies additional pressure for food supply and prices, increased woody bioenergy demand for electricity and heat generation can imply **additional** pressure on fuelwood supply.

The livelihoods of rural - and especially poor and vulnerable - people could be significantly affected **both** positively and negatively from increased supply of woody biomass for modern uses - thus, a fundamental principle similar to the "food first" logic for biofuels is needed: **domestic fuelwood first**.

From the social sustainability point of view it is fundamental to secure and improve the fundamental **access** to clean energy of the rural and urban poor before considering further supply for other domestic or international markets.

6.2.2 Improving Sustainable Forest Management and Governance

Many studies analyzed causes for forest degradation and deforestation, indicating that to revise current trends will require secured land and forest tenure rights, capacity building for sustainable forest management, and local economic development to improve the income situation.

Inclusive smaller-scale and "bottom-up" approaches to sustainable forestry can deliver secure and increased fuelwood supply and foster rural development.

Larger-scale woody bioenergy collection (from existing forests) and cultivation of new plantations could, in principle, deliver similar results, but are prone to corruption and displacement of vulnerable groups so that improvement of (local) forest management and the establishment of (larger-scale) new forest projects require **adequate governance**.

Without further (domestic and foreign) investments in **both** forest management and new forest projects, the fuelwood demand will not be met in many countries unless the governance of energy access, and forest and land tenure is improved. Given the uncertain future of domestic bioenergy markets in developing countries and global trade opportunities, such investments are **risky** for the private sector, and may face low attractiveness.

Thus, public-private partnerships to ensure sustainable investments in forest management and new forest plantations are important, in parallel to strengthening people-oriented forest policies, and improved forest value chains.

6.3 A Way Forward

Based on the analysis of the current governance of the forestry sector with regard to woody bioenergy, review and assessment of international initiatives on sustainable bioenergy and results from ongoing research, this study recommends **a three-fold approach**:

1) **Importing** countries (e.g. DE, NL, SE and UK) and the EU as a whole need to **conditionalize** preferential treatment of woody bioenergy in their bioenergy support policies (e.g. feed-in tariffs, green certificates, quota systems etc.) to establish environmental **safeguards,** covering also **imports**. The pending extension of the RED to woody bioenergy is a key opportunity for this[21], and respective proposals (Fritsche et al. 2012; EC 2013) should be taken into account accordingly.
2) In parallel, **exporting** countries in the developing world need to improve their **domestic forest** and **land tenure** policies, building on existing voluntary guidelines (CFS 2012). Sustainable forestry certification could facilitate private sector involvement and improve access to preferential bioenergy markets, e.g. in Europe.
3) **International institutions** - especially for finance (e.g. World Bank, regional development banks) - and **donors** (e.g. GEF, bilateral agencies) should require specific **sustainability safeguards** for any woody bioenergy project (e.g. based on existing voluntary certification schemes such as FSC and PEFC), and expand funds to support implementation of voluntary guidelines on the governance of land (CFS 2012).
   Furthermore, existing approaches such as the IDB Sustainability Scorecard (IDB 2010), the GEF Guidelines for Biofuel Projects (Franke et al. 2013), or the UN Decision Support Tools for Sustainable Bioenergy (UN Energy, FAO, UNEP 2010), the Bioenergy and Food Security approach (FAO 2012c) need to be developed further to explicitly address woody bioenergy. In this, GBEP should expand its dialogue to support respective exchanges and cooperation to allow for coherent policies.

All three recommendations aim to recognize and endorse the "fuelwood first" principle suggested in this study, and call to implement respective policies.

[21] For further information on the implementation of the VGGT see www.fao.org/nr/tenure

Regarding recommendation 1) it is noteworthy that the EU Timber Regulation (TR) entered into force in March 2013, sanctioning the first placement of illegal timber and timber products on the EU market - an important first step for better governance in exporting countries which could help with regard to recommendation 2).

As the EU TR does not specify environmental or social criteria, the extension of the EU RED to woody bioenergy is crucial to establish environmental criteria for woody bioenergy imports to the EU (Fritsche et al. 2012).

If the Forest Europe negotiations on a legally binding agreement on forests in Europe are successful, the results need to be transferred into the criteria of a legislative proposal to extend the RED to solid bioenergy.

However, even an extended RED would **lack social** safeguards for imported bioenergy - but social criteria are necessary, as displacement of local people or non-timber use of forest products, changes in availability of woody bioenergy for traditional use, and related price effects could imply significant social risks against which safeguarding is needed.

With international trade law currently excluding key social concerns from mandatory regulation, and few perspectives to "reform" the WTO in that regard in the near-term, strengthening social safeguards **in exporting** countries is key[22].

Regarding recommendation 2), the typically weak governance of forests/land and respective low enforcement/implementation of regulation in many developing countries need to be considered. First, improving the overall woodfuel situation requires an integrated coordination strategy of the supply and demand side in which the implementation of the VGGT should be a priority. Respective donor programs should support this to improve the conditions for sustainable woody bioenergy on the national and local level, and include (international) investors, possibly in form of public-private partnerships[23].

Many voluntary certification schemes for bioenergy have been promoted by various stakeholders during last years. These schemes vary depending on the

[22] It should be noted that a more radical - and in the near-term less promising - approach would be to reform the WTO/GATT trade rules so that social safeguards could be implemented without violation.

[23] There are already some GEF projects on this (GEF 2010 + 2012) and several bilateral donors (e.g. Germany, Netherlands) have "bottom-up" projects in e.g. Madagascar and Senegal. These examples should be expanded to other countries, and multiplied within the respective countries.

purpose for which they were developed and the background of the organization working on it resulting in a great diversity in terms of ambitions. Most of them are focused on liquid biofuels but some have considered all types of biomass for bioenergy.

Here, **forest certification,** with long tradition in the forestry sector and as a voluntary and private-sector approach is a useful tool to assure sustainable forest management[24], as it is independent of the final use of forest biomass - it will be of value for the timber (i.e. non-energy) markets now, and for the (future) bioenergy markets as well:

At least within the EU it **cannot** be expected that co-firing of woody bioenergy will receive preferential treatment (via ETS or renewable energy legislation) **without** generally accepted sustainability certification - as can be seen in BE, NL and UK where national sustainability requirements for woody bioenergy areal ready formulated.

As co-firing of bioenergy is typically uneconomic without preferential policies (see Section 2.5), certified sustainability of wood should be a **pre-requisite** for large-scale wood production for exports to the EU. In parallel, the EU timber regulation requires proof of “legality”, and forest certification can deliver on this, too.

Regarding recommendation 3), countries such as DE, NL and UK should establish adequate safeguards for **their own donor programs** and agencies, and use their voting power in the international finance institutions (GEF, IFC, World Bank, Regional Development Banks etc.) to initiate and support similar activities.

The upcoming review of the World Bank Safeguards in 2014-2015 will be a key opportunity for this.

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24 Some specific adaptations of the schemes are needed to address particular concerns related to the use of biomass for bioenergy (see Fritsche et al. 2012).

References

Adib R 2012: Sustainable Biomass for Electricity Global Overview; REN21; presented at the UN-Energy/IEA/GBEP Sustainable Biomass for Electricity Conference, Guessing May 2-4, 2012. http://www.un-energy.org/sites/default/files/share/une/adib.pdf

AMS (Associação Mineira de Silvicultura) 2013: Evolução do consumo de carvão vegetal conforme sua origem (Brasil) http://www.showsite.com.br/silviminas/html/AnexoCampo/_consumo.pdf (accessed March 26, 2013)

Bjerg J 2012: Biomass 2020: Opportunities, Challenges and Solutions; presented at the UN-Energy/IEA/GBEP Sustainable Biomass for Electricity Conference, Guessing May 2-4, 2012. http://www.un-energy.org/sites/default/files/share/une/bjerg.pdf

Boucher D et al. 2011: The Root of the Problem. What´s driving tropical deforestation today?; Union of Concerned Scientists; Cambridge

Buongiorno J, Raunikar R, Zhu S 2011: Consequences of increasing bioenergy demand on wood and forests: An application of the Global Forest Products Model; in: Journal of Forest Economics Vol. 17, no. 2, pp 214-229

CFS (Committee on World Food Security) 2012: Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security; Rome http://www.fao.org/fileadmin/user_upload/nr/land_tenure/pdf/VG_Final_May_2012.pdf

Clancy J 2013: Biofuels and Rural Poverty; Routledge

Cocchi M et al. 2011: Global Wood Pellet Industry Market and Trade Study; IEA Bioenergy Task 40; Florence http://www.bioenergytrade.org/downloads/t40-global-wood-pellet-market-study_final.pdf

Coelho S T, Goldemberg J, Uhlig A 2008: O uso de carvão vegetal na indústria siderúrgica brasileira e o impacto sobre as mudanças climáticas; in: Revista Brasileira de Energia vol. 14 no 2, pp. 67-85

Cushion E, Whiteman A, Dieterle G 2010: Bioenergy Development Issues and Impacts For Poverty And Natural Resource Management; The World Bank; Washington

DECC (UK Department of Energy & Climate Change) 2013: Government Response (Part A) Biomass Sustainability Criteria for the RO; London https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/231102/RO_Biomass_Sustainability_consultation_-_Government_Response_22_August_2013.pdf

DECC (UK Department of Energy & Climate Change) 2013: Government Response (Part B) Biomass Sustainability Criteria for the RO; London https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/230495/Part_B_response.pdf

EC (European Commission) 2010: Report from the Commission to the Council and the European Parliament on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling; SEC(2010) 65/SEC(2010) 66; Brussels http://ec.europa.eu/energy/renewables/transparency_platform/doc/2010_report/com_2010_0011_3_report.pdf

EC (European Commission) 2013: Proposal for Directive of the European Parliament and of the Council on sustainability requirements for solid and gaseous biomass used in electricity and/or heating and cooling and biomethane injected into the natural gas grid; unpublished draft, Brussels http://www.endseurope.com/docs/130819a.pdf

EEA (European Environment Agency) 2013: EU bioenergy potential from a resource-efficiency perspective; Copenhagen http://www.eea.europa.eu/publications/eu-bioenergy-potential

EMBRAPA (Brazilian Agricultural Research Corporation) 2009: Agro-ecological Sugarcane Zoning http://www.cnps.embrapa.br/zoneamento_cana_de_acucar

EMBRAPA (Brazilian Agricultural Research Corporation) 2010: Agro-ecological Palm Oil Zoning http://www.cnps.embrapa.br/zoneamento_dende

ESMAP (Energy Sector Management Assistance Program) 2011: Household Energy Access for Cooking & Heating Lessons Learned and the Way Forward http://www.esmap.org/sites/esmap.org/files/Household_Energy_Access_ExecWeb_Resized.pdf

EU (European Union) 2009: Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC; Official Journal of the EU, June 5, 2009 L 140 pages 16-62 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

EUEI PDF (European Union Energy Initiative Partnership Dialogue Facility), GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit GmbH) 2009: Biomass Energy Strategy (Best). Wood Fuel Supply Interventions. Lessons Learned and Recommendations www.euei-pdf.org/sites/default/files/files/field_pblctn_file/EUEI%20PDF_BEST_Wood%20Fuel%20Supply%20Recommendations_Working%20Paper_Apr%202009_EN.pdf

FAO (Food and Agricultural Organization of the United Nations) 2006a: Global planted forests thematic study. Results and analysis; Rome http://www.fao.org/forestry/12139-03441d093f070ea7d7c4e3ec3f306507.pdf

FAO (Food and Agricultural Organization of the United Nations) 2006b: Responsible management of planted forests: voluntary guidelines. Planted Forests and Trees Working Paper 37/E; Rome ftp://ftp.fao.org/docrep/fao/009/j9256e/j9256e00.pdf

FAO (Food and Agricultural Organization of the United Nations) 2007: Forests and energy in developing countries; Forests and Energy Working Paper 2; Rome

FAO (Food and Agricultural Organization of the United Nations) 2009a: Case studies on bioenergy policy and law: options for sustainability; FAO Legislative Study 102; Rome http://www.fao.org/docrep/012/i1285e/i1285e.pdf

FAO (Food and Agriculture Organization of the United Nations) 2009b: Criteria and indicators for sustainable woodfuels - Case studies from Brazil, Guyana, Nepal, Philippines and Tanzania; Rome http://www.fao.org/docrep/012/i1321e/i1321e00.pdf

FAO (Food and Agricultural Organization of the United Nations) 2009c: Análisis del Balance de Energía derivada de Biomasa en Argentina WISDOM Argentina ftp://ftp.fao.org/docrep/fao/011/i0900s/i0900s00.pdf

FAO (Food and Agricultural Organization of the United Nations) 2009d: Asia-Pacific Forestry Sector Outlook Study II - Thailand Forestry Outlook Study; Working Paper Apfsos Ii/Wp/2009/22 http://www.fao.org/docrep/014/am617e/am617e00.pdf

FAO (Food and Agricultural Organization of the United Nations) 2010a: What woodfuels can do to mitigate climate change FAO Forestry Paper 162; Rome http://www.fao.org/docrep/013/i1756e/i1756e00.pdf

FAO (Food and Agricultural Organization of the United Nations) 2010b: Global Forest Resources Assessment. Main report; Rome http://www.fao.org/docrep/013/i1757e/i1757e.pdf

FAO (Food and Agricultural Organization of the United Nations) 2010c: Global Forest Resources Assessment. Global Tables; Rome http://www.fao.org/forestry/fra/fra2010/en/

FAO (Food and Agricultural Organization of the United Nations) 2010d: Criteria and indicators for sustainable woodfuels; FAO Forestry Paper 160; Rome http://www.fao.org/docrep/012/i1673e/i1673e00.pdf

FAO (Food and Agricultural Organization of the United Nations) 2011: Good Socio-Economic Practices in Modern Bioenergy Production; Bioenergy and Food Security Criteria and Indicators; Rome: FAO http://www.fao.org/docrep/015/i2507e/i2507e00.pdf

FAO (Food and Agricultural Organization of the United Nations) 2012: Bioenergy and Food Security Approach; Rome: FAO http://www.fao.org/energy/befs/en/

FAOSTAT-Forestry database 2013: Global production and trade of forest products in 2011; Rome: FAO *http://faostat.fao.org/site/626/DesktopDefault.aspx?PageID=626#ancor*

FERN 2013: Improving forest governance. A Comparison of FLEGT VPAs and their Impact http://bit.ly/12lNjOt

Forestry for Development 2012: How bioenergy projects in Sub-Saharan Africa can reduce climate impact, fight poverty and make money; Stockholm

Franke B, Fritsche U, Faaij A et al. 2013: Global Assessment Guidelines for Sustainable Liquid Biofuels Production in Developing Countries; GEF Targeted Research Project executed by UNEP, FAO, UNIDO; Heidelberg, Utrecht, Darmstadt http://www.unep.org/bioenergy/Portals/48107/publications/Global%20Assessment%20and%20Guidelines%20for%20Biofuels.pdf

Fritsche U et al. 2010: Sustainable Bioenergy: Summarizing Final Report of the research project "Development of strategies and sustainability standards for the certification of biomass for international trade", Oeko-Institut and IFEU; prepared for UBA; Darmstadt, Heidelberg http://www.umweltdaten.de/publikationen/fpdf-l/3961.pdf

Fritsche U et al. 2012: Sustainability Criteria and Indicators for Solid Bioenergy from Forests; Outcome Paper of the Joint Workshops on Extending the RED Sustainability Requirements to Solid Bioenergy; Darmstadt etc. http://www.iinas.org/redex.html

GEF (Global Environment Facility) 2010: Strengthening Sustainable Forest Management and the Development of Bio-energy Markets to Promote Environmental Sustainability and to Reduce Greenhouse Gas Emissions in Cambodia under the Global: SFM Programme Framework for Projects under the GEF Strategy for Sustainable Forest Management; GEF Project Document Washington DC http://www.thegef.org/gef/sites/thegef.org/files/documents/document/4-26-10%20-Web%20Posting%20-%203635_3.pdf

GEF (Global Environment Facility) 2012: Promoting Sustainable Biomass Energy Production and Modern Bio-Energy Technologies in Sri Lanka; GEF Project Document; Washington DC http://www.thegef.org/gef/sites/thegef.org/files/documents/document/04-23-2012%20Council%20document.pdf

GTZ-HERA (Household Energy for Sustainable Development Program of the German Agency for International Cooperation) 2010: Cooking Energy Compendium Manual for Programs and Projects to Implement Cooking Energy Interventions. 5. Assistance for Decision Makers on Policy Level; Eschborn http://www.hedon.info/CEC%3AAssistanceforDecisionMakersonPolicyLevel?bl=y. Consulted, February 13, 2013

IBGE (The Brazilian Institute of Geography and Statistics) 2005: Geoscience._Produção da extração vegetal e da silvicultura; Coordenação de Agropecuária; Rio de Janeiro

IC (Imperial College London) et al. 2012: Biomass Futures – Analysing Europe's Future Bioenergy Needs; collaborative IEE project; London etc. http://www.biomassfutures.eu

IDB (Inter-American Development Bank) 2008: Herramientas para mejorar la Efectividad del Mercado de Combustibles de Madera en la Economía Rural. Informe diagnóstico Paraguay; Washington http://www.ssme.gov.py/arch_temp/MMC_Infor_Diag.pdf

IEA (International Energy Agency) 2011: Renewables Information 2011; Paris

IEA (International Energy Agency) 2012a: Technology Roadmap Bioenergy for Heat and Power; Paris

IEA (International Energy Agency) 2012b: World Energy Outlook 2012; Paris

IEA Bio (International Energy Agency Bioenergy) 2013: Bioenergy Trade Reports; Utrecht www.bioenergytrade.org

IFEU (Institut für Energie- und Umweltforschung Heidelberg GmbH) 2011: Kriterien zur nachhaltigen Beschaffung holzartiger Biomasse für die Strom- und Wärmegewinnung im Land Berlin; i.A. von Vattenfall Europe New Energy und Land Berlin; Heidelberg http://www.ifeu.de/nachhaltigkeit/pdf/IFEU%20nachhaltiges%20Holz%20VattenfallSenGUV%2016-03-11_FINAL.pdf

IIED (International Institute of Environment and Development) 2008: The Cost of Avoiding Deforestation Update of the Report prepared for the Stern Review of the Economics of Climate Change; Grieg-Gran M; London http://digital.library.unt.edu/ark:/67531/metadc13712/m2/1/high_res_d/IIED_opportunity_costs_modelling.pdf

IIED (International Institute of Environment and Development) 2013: Demand-side interventions to reduce deforestation and forest degradation; Walker N et al.; London http://pubs.iied.org/pdfs/13567IIED.pdf

IPCC (Intergovernmental Panel on Climate Change) 2011: IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation; Edenhofer O et al. (eds.); Cambridge, New York http://srren.ipcc-wg3.de/report/srren-full-report

ITTO (International Tropical Timber Organization) 2006: Wood waste for energy: lessons learnt from tropical regions; International Seminar on Energy and the Forest Products Industry; Rome, 30 - 31 October 2006 ftp://ftp.fao.org/docrep/fao/009/j9425e/j9425e13.pdf

IINAS (International Institute for Sustainability Analysis and Strategy), IFEU (Institute for Energy and Environmental Research) 2012: Biofuels – what role in the future energy mix? Facts, trends and perspectives; commissioned by Shell Deutschland Oil; Fritsche U et al.; Darmstadt, Heidelberg http://www.iinas.org/tl_files/iinas/downloads/IINAS_IFEU_2012_Shell_Biofuels_en.pdf

JRC (Joint Research Centre) 2013: Carbon accounting of forest bioenergy. Conclusions and recommendations from a critical literature review; Agostini A et al.; Petten, Ispra http://iet.jrc.ec.europa.eu/bf-ca/sites/bf-ca/files/files/documents/eur25354en_online-final.pdf

Lamers P et al. 2012: Developments in international solid biofuel trade - an analysis of volumes, policies, and market factors; in: Renewable & Sustainable Energy Reviews vol. 16 no. 5, pp. 3176-3199

Leite E T, Roque C L, Macedo A P 1997: Produtos Solidos de Madeira; BNDS – Banco Nacional do Desenvolvimento; Rio de Janeiro

Liedeker H 2012: pers. comm. with Heiko Liedeker, EU FLEGT Facility, Barcelona, May 2012

Lucon O, Coelho S, Goldemberg J 2004: LPG in Brazil: lessons and challenges; in: Energy for Sustainable Development vol. 8 no. 3

Masera D 2012: Experience from UNIDO's biomass energy projects; presented at the UN-Energy/IEA/GBEP Sustainable Biomass for Electricity Conference, Guessing May 2-4, 2012 http://www.un-energy.org/sites/default/files/share/une/masera.pdf

MMA (Ministerio do Meio Ambiente) 2009: Projeto PNUD 00/20 - Levantamento sobre a geração de resíduos provenientes da atividade madeireira e proposição de diretrizes para politicas, normas e condutas técnicas para promover o seu uso adequado; Curitiba

MME (Ministério de Minas e Energia-Brazil) 2012: Balanço Energético Nacional - Resultados Preliminares 2011; Rio de Janeiro

Muller M 2005: Produção de madeira para geração de energia elétrica numa plantação clonal de eucalipto em Itamarandiba; MG. Tese de Doutorado – Universidade Federal de Viçosa; Minas Gerais

Muylaert M, Sala J, Freitas M 1999: The charcoal's production in Brazil - process efficiency and environmental effects; in: Renewable Energy vol. 16, p. 1037-1040

SAE (Secretaria de Assuntos Estratégicos da Presidência da Republica) 2011: Diretrizes para a estruturação de uma Política Nacional de Florestas Plantadas; Brasilia

SEI (Stockholm Environment Institute) 2011: Bioenergy Projects and Sustainable Development: Which Project Types Offer the Greatest Benefits?; Lee C, Lazarus M; Working Paper; Stockholm http://www.sei-international.org/mediamanager/documents/Publications/Climate-mitigation-adaptation/SEI-WP-2011-04-Bioenergy-Sustainable-Dev.pdf

Sikkema R, Steiner M, Junginger M, Hiegl W, Hansen M T, Faaij A 2011: The European Wood pellet markets: current status and prospects for 2020; in: Biofuels, Bioprod. Bioref. vol. 5 pp. 250-278 http://www.lippel.com.br/downloads/the-european-wood-pellet-markets-current-status-and-prospects-for-2020.pdf

Stupak I et al. 2013: Imported wood fuels – a regionalised review/analysis of sustainability issues and challenges; Copenhagen (forthcoming)

Suzano (Suzano Renewable Energy) 2013: Industria de Papel e Celulose e Energias Renovaveis http://www.suzano.com.br/portal/suzano-energia-renovavel.htm (accessed February 15, 2013)

UNDP (United Nations Development Programme) 2007: A Review of Energy in National MDG Reports; New York

UNDP (United Nations Development Programme), WHO (World Health Organization) 2009: The Energy Access Situation in Developing Countries ; New York, Geneva http://content.undp.org/go/cms-service/download/asset/?asset_id=2205620

UNECE (United Nations Economic Commission for Europe), FAO (Food and Agriculture Organization of the United Nations) 2011: Forest Products Annual Market Review 2010-2011; Geneva Timber and Forest Study Paper 27; Geneva http://www.unece.org/fileadmin/DAM/publications/timber/FPAMR_2010-2011_HQ.pdf

UNECE (United Nations Economic Commission for Europe), FAO (Food and Agriculture Organization of the United Nations) 2012: Forest Products. Market Review 2011-2012 http://www.unece.org.unecedev.colo.iway.ch/fileadmin/DAM/timber/publications/FPAMR_2012.pdf

UN-Energy, FAO (Food and Agricultural Organization of the United Nations), UNEP (United Nations Environment Programme) 2010: A Decision Support Tool for Sustainable Bioenergy. An overview; New York, Paris, Rome http://www.bioenergydecisiontool.org/overview/#/2/zoomed

UN General Assembly 2011: Resolution adopted by the General Assembly. 65/151. International Year of Sustainable Energy for All http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/65/151

WB (The World Bank) 2013: Deforestation Trends in the Congo Basin: Reconciling Economic Growth and Forest Protection; Washington DC http://www.profor.info/sites/profor.info/files/docs/Deforestation%20in%20Congo%20Basin_full%20report_feb13.pdf

WBGU (German Advisory Council on Global Change) 2009: Future Bioenergy and Sustainable Land Use. Summary for Policy-Makers

http://www.cbd.int/doc/biofuel/wbgu-bioenergy-SDM-en-20090603.pdf

Wunder S et al. 2012: Impact of EU bioenergy policy on developing countries; European Parliament DG for External Policies of the Union; Brussels http://www.europarl.europa.eu/committees/fr/studiesdownload.html?languageDocument=EN&file=72731