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IEA Bioenergieprogramm 2010-2012
Task 40: Nachhaltiger Internationaler Bioenergiehandel

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Ein Projektbericht im Rahmen der Programmlinie

IEA FORSCHUNGS KOOPERATION

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Im Auftrag des Bundesministeriums für Verkehr, Innovation und Technologie

Vorbemerkung

Der vorliegende Bericht dokumentiert die Ergebnisse eines Projekts aus dem Programm FORSCHUNGSKOOPERATION INTERNATIONALE ENERGIEAGENTUR. Es wurde vom Bundesministerium für Verkehr, Innovation und Technologie initiiert, um Österreichische Forschungsbeiträge zu den Projekten der Internationalen Energieagentur (IEA) zu finanzieren.

Seit dem Beitritt Österreichs zur IEA im Jahre 1975 beteiligt sich Österreich aktiv mit Forschungsbeiträgen zu verschiedenen Themen in den Bereichen erneuerbare Energieträger, Endverbrauchstechnologien und fossile Energieträger. Für die Österreichische Energieforschung ergeben sich durch die Beteiligung an den Forschungsaktivitäten der IEA viele Vorteile: Viele Entwicklungen können durch internationale Kooperationen effizienter bearbeitet werden, neue Arbeitsbereiche können mit internationaler Unterstützung aufgebaut sowie internationale Entwicklungen rascher und besser wahrgenommen werden.

Dank des überdurchschnittlichen Engagements der beteiligten Forschungseinrichtungen ist Österreich erfolgreich in der IEA verankert. Durch viele IEA Projekte entstanden bereits wertvolle Inputs für europäische und nationale Energieinnovationen und auch in der Marktumsetzung konnten bereits richtungsweisende Ergebnisse erzielt werden.

Ein wichtiges Anliegen des Programms ist es, die Projektergebnisse einer interessierten Fachöffentlichkeit zugänglich zu machen, was durch die Publikationsreiche und die entsprechende Homepage **www.nachhaltigwirtschaften.at** gewährleistet wird.

Dipl. Ing. Michael Paula
Leiter der Abt. Energie- und Umwelttechnologien
Bundesministerium für Verkehr, Innovation und Technologie

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1. KURZFASSUNG / ABSTRACT

A) DEUTSCHE VERSION

IEA Bioenergy Task 40 beschäftigt sich mit der Dynamik von Bioenergiemärkten, mit internationalem Handel mit Bioenergie und mit den Chancen, aber auch mit den möglichen Problemen die mit dem internationalen Handel von Bioenergie einhergehen.

Die wichtigsten Ziele, die mit diesem Projekt und durch die Teilnahme an Task 40 verfolgt werden, sind die Datenbasis über Biomasse Importe und Exporte und ihre Bedeutung für Österreich zu verbessern, aktuelle Entwicklungen betreffend die energetische Nutzung von grenzüberschreitendem Handel mit Bioenergieprodukten in Österreich zu dokumentieren, die Auswirkungen durch die Implementierung von Nachhaltigkeitskriterien auf Nutzung von Bioenergie und den grenzüberschreitenden Handel mit Bioenergieprodukten in Österreich zu beobachten und durch Teilnahme an und Organisation von internationalen Meetings und Workshops die Vernetzung der nationalen und internationalen politischen, wissenschaftlichen und wirtschaftlichen Akteure zu fördern.

Ein Schwerpunkt in diesem Projekt ist die Teilnahme an den internen Task 40 Meetings und an Workshops, die regelmäßig von Task 40 organisiert werden.

Anfang 2011 wurde ein Workshop zu Torrefactions-Technologien, deren Entwicklung und potentiellen Auswirkungen auf die Biomassemärkte von IEA Bioenergy Task 40 gemeinsam mit Task 32 in Graz veranstaltet. September 2011 wurde ein Workshop zu „Quantifying and managing land use effects of bioenergy“ von IEA Bioenergy Task 40 gemeinsam mit Task 38 und Task 43 in Campinas, Brasilien veranstaltet.

Die Organisationsstruktur des IEA Bioenergy Implementing Agreements erlaubt es der Arbeitsgruppe, flexibel auf aktuelle Problemstellungen einzugehen. Es kommt im Rahmen des Arbeitsprogramms immer wieder zur Bildung kleinerer Arbeitsgruppen, die sich wissenschaftlich mit aktuellen Entwicklungen auseinandersetzen und Arbeiten dazu verfassen. Kooperationen, vor allem im Hinblick auf die Erhebung der derzeitigen Situation in Österreich, hat es im „survey on the implementation of sustainability requirements for biofuels and bio-energy in the different member countries of Task 40“, im Zuge des Projektes „Biobench - Sustainability criteria for solid and gaseous biomass", zur Erhebung von Nachhaltigkeitskriterien für feste Biomasse sowie für die T40 Wood Chips Study gegeben. Ein von IEA Task 40 gefördertes Projekt, das es zum Ziel hat, ein Tool zur Modellierung des europäischen Biomasse Handels zu entwickeln („Development of a tool to model european biomass trade“), wurde gemeinsam mit der Universität Utrecht abgeschlossen.

Weiters wurde ein Kooperationsprojekt unter der Leitung der EEG/TUW und Beteiligung der Universität Utrecht sowie der Norwegian University of Life Sciences zu „Future perspectives of bioenergy trade“ durchgeführt. Dieses liefert grundlegende Erkenntnisse zur möglichen zukünftigen Bedeutung internationalen Biomassehandels, die Modellierung desselben und möglicher Barrieren. Ein entsprechender Beitrag wird Mitte 2013 im „Bioenergy Trade Handbook“ publiziert, das von Bioenergy Task 40 herausgegeben wird.

Der Country Report für Österreich 2011 stellt eine eingehenden Analyse des Datenbestandes über grenzüberschreitenden Bioenergiehandel in Österreich dar. Neben der energetischen Nutzung von Biomasse werden vor allem Daten über Import- und Exportaktivitäten im Bereich der Biomasse systematisch dargelegt. Der Report zeigt unter anderem, wie sich Handelsströme forstlicher Biomasse und flüssiger biogener Treibstoffe in der vergangenen Dekade entwickelt haben und zeigt auf, dass der Handel von Biomasse in einigen Fällen einen substanziellen Anteil verglichen mit Inlandsproduktion bzw. Inlandsverbrauch einnimmt. Überdies wird ein umfassender Überblick auf Biomasseressourcen, Fördermaßnahmen, wesentliche Akteure und Biomassepreise gegeben. Alle Task 40 Publikationen können über die Webseite (www.bioenergytrade.org) bezogen werden.
Während des gesamten Projekts konnte ein intensiver nationaler sowie internationaler Vernetzungs-, Diskussions- und Verbreitungsprozess geführt werden, um die wesentlichen Akteure in die Arbeit einzubinden und auch den Zugang zu den nötigen Daten zu erhalten.

B) ENGLISH VERSION

IEA Bioenergy Task 40 deals with the dynamics of bio-energy markets, with international bio-energy trade and the opportunities, but also the potential problems and barriers associated with the international trade of bioenergy. The core objective of Task 40 is: 'to support the development of sustainable, international bioenergy markets and international trade, recognising the diversity in resources and biomass applications'
The main objective of the Austrian contribution in Task 40 is to prepare and provide high quality information and analyses about bioenergy trade in Austria, to document an overview of the developments in Austria, to monitor the impacts and effects of sustainability certification on the Austrian bioenergy markets and the international trade of bioenergy commodities, as well as to participate in the Task 40 meetings and in international Workshops. International collaboration and being a linking pin between different stakeholders by organising workshops and targeted dissemination activities is core part of the project. Several joint collaborations have been undertaken during the reporting period.

In early 2011, a workshop on torrefaction technologies, their development and potential effects on the biomass markets has been organized jointly by IEA Bioenergy Task 40 with Task 32 in Graz. In September 2011 a workshop on "Quantifying and managing land use effects of bioenergy" of IEA Bioenergy Task 40 was held jointly with Task 38 and Task 43 in Campinas, Brazil.

The organizational structure of the IEA Bioenergy Implementing Agreement allows the workgroup to flexibly respond to current problems. In the context of the work program repeatedly smaller working groups are formed, that deal with current scientific developments and publish actual reports. Cooperation, especially with regard to the the current situation in Austria, has taken place in the "Survey on the implementation of sustainability requirements for biofuels and bio-energy in the different member countries of Task 40", in the course of the project "BioBench - Sustainability criteria for solid and gaseous biomass", to the collect data on sustainability criteria for solid biomass as well

as for the T40 Wood chips Study. A project funded by IEA Task 40 that has the goal to develop a tool for modeling the European biomass trade("Development of a tool to model european biomass trade "), was completed in cooperation with the University of Utrecht.
Furthermore, a joint project lead by EEG / TUW under participation of Utrecht University and the Norwegian University of Life Sciences "Future perspectives of bioenergy trade" was carried out. This provides fundamental insights into the possible future importance of international biomass trade, its potential barriers and trade modeling. An corresponding contribution is published in mid-2013 in the "Bioenergy Trade Handbook"

The IEA T40 Country Report for Austria gives valuable insights on the use of bioenergy and the import and export activities with bioenergy products, including background information on the bioenergy system in Austria, a description of policies, data on traded biomass and information on drivers and barriers for biomass trade specific to Austria.
Further monitoring of impacts and effects from certification of sustainability on the Austrian bioenergy system and trade with bioenergy products is a central content of the Task 40 work. The participation in Task 40 allows for a closer look on the international developments and to benefit from international knowledge exchange. The flexible organization of Task 40 allows being responsive to actual development and adjusting content and reports on current issues.
Throughout the project support to and collaboration with national and international stakeholders such as policy makers, industry, producers and suppliers of biomass for energy, NGO’s and the scientific community is an important part. This is done by discussing actual issues at the internal Task 40 meetings and the related workshops and also by hosting the international community of Task 40 in Austria at workshops meetings and by the disseminating results from Task projects. Publications can be downloaded on the Task 40 website (www.bioenergytrade.org).

2. EINLEITUNG

A) KURZBESCHREIBUNG DER ZIELE UND DER INHALTE DES IMPLEMENTING AGREEMENTS

IEA Bioenergy ist eine Organisation der Internationalen Energie Agentur (IEA) zur Förderung von internationalen Kooperationen und des Informationsaustausches und der Vernetzung im Bereich der Bioenergieforschung. Im IEA-Bioenergy Programm arbeiten nationale Experten aus Forschung, Politik und Industrie mit Experten aus anderen Ländern eng zusammen. Neben Österreich nehmen heute weitere 20 Länder aus Europa und Übersee sowie die Europäische Kommission an IEA Bioenergy teil. Diese Kooperation ermöglicht damit einen weltweiten Informationstransfer und die Koordination nationaler Programme und Forschungsarbeiten im Bereich der Bioenergienutzung.
Die Ziele dieses Bioenergienetzwerks (IEA Bioenergy) sind die Förderung des Einsatzes umweltverträglicher und konkurrenzfähiger Bioenergie auf der Basis einer nachhaltigen Nutzung und die Bereitstellung eines substanziellen Beitrags für eine zukunftsfähige Energieversorgung. Eine wichtige Aufgabe von IEA Bioenergy ist es, einen Beitrag zur Beseitigung von umweltbezogenen, institutionellen, technologischen und finanziellen Barrieren für den Einsatz von Bioenergietechnologien in der Zukunft zu leisten. Im Zentrum stehen dabei die Initiierung, Koordinierung und Förderung von Forschungs-, Entwicklungs- und Demonstrationsprojekten durch internationale Zusammenarbeit und der gezielte Informationsaustausch zwischen Experten aus Forschung, Industrie und Politik in den teilnehmenden Ländern. Diese Strategie soll dazu beitragen, die Entwicklung und Vermarktung von umweltfreundlichen, effizienten und kostengünstigen Bioenergietechnologien voranzutreiben.
Die Zusammenarbeit wird in Form von thematischen Netzwerken, den Tasks, durchgeführt und von einem Executive Committee geleitet, in das die teilnehmenden Länder einen Vertreter entsenden. Diese Tasks haben üblicherweise eine Laufzeit von drei Jahren (Triennium).

Nach dem erfolgreichen Abschluss des ersten und zweiten Arbeitsprogramms (Arbeitsperiode 2004-2006 und Arbeitsperiode 2007-2009) von Task 40 ist die Zusammenarbeit nun in der dritten Arbeitsperiode 2009-2012 fortgesetzt worden.

B) AUSGANGSSITUATION UND MOTIVATION DES PROJEKTES

Die Weltwirtschaft ist in einem großen Ausmaß von fossilen Energieträgern abhängig. Da diese fossilen Ressourcen nur begrenzt verfügbar sind, oft in politisch instabilen Regionen liegen und ihre Nutzung einen großen Anteil an der Klimaerwärmung ausmacht, wird weltweit vermehrt auf erneuerbare Energieformen gesetzt. Die energetische Nutzung von Biomasse wird dabei in Zukunft eine wichtige Rolle spielen. Da Angebot und Nachfrage von Biomasse zeitlich und örtlich oft nicht übereinstimmen, kann davon ausgegangen werden, dass zukünftig die Bedeutung von internationalem Handel mit Bioenergie (z.B. Pellets, Pflanzenöl…) zunehmen wird.
IEA Bioenergy Task 40 beschäftigt sich mit den Chancen, aber auch mit den möglichen Problemen die mit dem internationalen Handel von Bioenergie einhergehen. Einerseits erwartet man, dass sich

die Bildung von internationalen Bioenergiemärkten stabilisierend auf Angebot und Nachfrage auswirkt. Andererseits weiß man, dass die energetische Nutzung von Biomasse auch ungewollte Auswirkungen haben kann.

Gerade aus diesem Grund ist es wichtig, die Dynamik und die Funktionsweise dieser Märkte noch genauer zu untersuchen. Die Analyse von vergleichbaren Biomassemärkten (z.B. Nahrungs- und Futtermittel) und von Versorgungsketten hilft das Verständnis über die Funktionsweise dieser Märkte zu verbessern. Hier kann Task 40 mit seiner Arbeit entgegenwirken.

Der Anstieg der Preise für Nahrungs- und Futtermittel im Jahr 2007 wurde in der öffentlichen Diskussion vor allem mit dem zunehmenden Einsatz dieser biogenen Rohstoffe für die Produktion von Biokraftstoffen in Zusammenhang gebracht. Dabei wurde die Nachhaltigkeit von Bioenergie generell in Frage gestellt.

Als Ergebnis dieser öffentlichen Diskussion gibt es weltweit verstärkte Bemühungen, die Nutzung von Bioenergie und den internationalen Handel mit Bioenergieprodukten nachhaltiger zu gestalten. Es werden Nachhaltigkeitskriterien und Zertifizierungsverfahren für Biomassehandel diskutiert und definiert und auch teilweise bereits umgesetzt. Beispiele dafür sind internationale Multi Stakeholder Prozesse wie RSPO (Roundtable on Sustainable Palmoil), oder Initiativen einzelner Firmen wie die Sustainable Ethanol Initiative (SEKAB) zwischen einer schwedischen und mehreren brasilianischen Firmen.

In der EU wurde mit der neuen EU-Richtlinie über erneuerbare Energien (EU-RED) beschlossen, den Anteil erneuerbarer Energie am EU-Energieverbrauch bis 2020 auf 20 % auszubauen. Die neue Richtlinie definiert auch erstmalig Nachhaltigkeitsanforderungen für die Herstellung von Biomasse zur energetischen Verwendung. Die Nachhaltigkeitskriterien regeln zunächst nur Biokraftstoffe und flüssige Bioenergieträger, es wird aber im Rahmen der Richtlinie festgelegt, dass die Kommission bis Ende 2009 einen Bericht vorzulegen hat, der Vorschläge zur Anpassung an gasförmige und feste Bioenergie enthalten soll.

Durch die Einführung von Mindeststandards für Bioenergieträger werden im Laufe des Jahres 2010 auch in der EU Zertifizierungssysteme zum Nachweis ihrer Einhaltung eingeführt werden.

3. HINTERGRUNDINFORMATION ZUM PROJEKTINHALT

A) ZIELE UND AUFGABENSTELLUNG DES TASK

Das Hauptziel von Task 40 ist die Analyse von internationalen Bioenergiemärkten, mit Rücksichtnahme auf den nachhaltigen und optimalen Einsatz der natürlichen Rohstoffe und die Diversität der Verwendungsmöglichkeiten.

Durch die Komplexität und die Kopplung der Bioenergienutzung mit anderen Märkten (z.B. Lebens- und Futtermittelmärkte) ist die Entwicklung von nachhaltigen und stabilen Bioenergiemärkten ein Langzeitprozess. Task 40 agiert als Bindeglied zwischen Marktteilnehmern, politischen Entscheidungsträgern, internationalen Organisationen und NGO's und stellt diesen qualitativ hochwertige Daten, Informationen und objektive Analysen zur Verfügung. Die Versachlichung von emotionalen Debatten durch eine ganzheitliche Betrachtungsweise und gezielte Verbreitung von Informationen steht dabei im Vordergrund.

Wichtige Komponenten der Arbeit von Task 40 sind der persönliche Kontakt, der Austausch von Informationen und die Erarbeitung von Themen in kleineren Arbeitsgruppen. Mit Ende des Trienniums (Ende 2012) waren 13 Länder aus Europa, Asien und Nord- und Südamerika und zusätzlich die Europäische Kommission in Task 40 vertreten (siehe Tabelle 1).

Ein wichtiges Ziel von Task 40 ist es, das Know-how der Teilnehmer zu Nutzen um den Informationsfluss über die Entwicklungen im Zusammenhang mit Handel von Biomasse, insbesondere in den Teilnehmerländern zu stärken. Ein wichtiges Ergebnis bilden die Country Reports sowie die Publikationen, die sich aus der Zusammenarbeit der Taskmitglieder ergeben. In den Country Reports wird die Entwicklung der jeweiligen Biomassemärkte in der Vergangenheit dokumentiert, der derzeitige Status im Bereich des internationalen Handels mit Bioenergie präsentiert und ein Ausblick über die mögliche zukünftige Entwicklung gegeben. Der Country Report für Österreich ist im Oktober 2009 fertiggestellt worden und kann über die Task 40 Homepage (www.bioenergytrade.org) und über die Homepage der Energy Economics Group (eeg.tuwien.ac.at) abgerufen werden. Mit Ende des Jahres 2009 wurden die aktuellen Country Reports aller Teilnehmerländer auf der Task 40 Homepage (www.bioenergytrade.org) veröffentlicht.

B) KURZBESCHREIBUNG DER INHALTE DES TASKS

Zur Erreichung der oben genannten Ziele wurden im Arbeitsprogramm für die Periode 2010-2012 fünf Schlüsselbereiche und Schwerpunkte definiert:

I) Biomassepotentiale (regional, national und global):
Analyse der Verfügbarkeit von regionalen, nationalen und globalen Biomasse-Ressourcen und Produktionspotentialen von Bioenergieprodukte unter der Berücksichtigung von Nachhaltigkeit, Nutzungskonkurrenzen, Landnutzungsänderungen, Entwicklungsmöglichkeiten und Barrieren.

II) Nachhaltigkeit und Zertifizierung

Feststellung der Randbedingungen unter denen die Nachhaltigkeit der Bioenergienutzung gewährleistet ist sowie Monitoring der Auswirkungen durch Zertifizierungsmaßnahmen für Nachhaltigkeit.

III) Dynamik von Märkten

Untersuchung der Funktionsweise und Dynamik von Märkten (Angebot, Nachfrage, Handel); Erforschung der Kopplung unterschiedlicher Märkte; Zusammenhang mit fossilen Rohstoffpreisen und Auswirkung auf Preisschwankungen.

IV) Transport und Logistik

Analyse von Schwachstellen, Transportkosten, Rohstoff Vorbehandlung, Transportkapazitäten, Optimierung der Versorgungskette.

V) Verbreitung der Ergebnisse

Schließlich und endlich ist die Verbreitung der Erkenntnisse und Erfahrungen dieser Arbeitsgruppe ein essentieller Schwerpunkt dieses Tasks.

C) PARTNER DES TASKS:

Die folgende Tabelle zeigt die Teilnehmenden Institutionen und Personen im Task mit Ende 2012. Wesentliche Player, sowohl in fachlicher Hinsicht als auch aus regionaler Sicht, sind vertreten. Mit den Ländern USA, Kanada und Brasilien sind neben Japan und europäischen Ländern wichtige derzeitige Biomasse-Export- und –Import-Länder im Task präsent.

Tabelle 1: Übersicht über beteiligte Institutionen in IEA Bioenergy Task40 zum Ende der Projektlaufzeit

Land	Vertreter	Bereich
Belgien	Luc Belkmans – VITO	Research
Brasilien	Arnaldo Walter and Paulo Dolzan - State University of Campinas	Research
Canada	Douglas Bradley, Climate Change Solutions	Consulting
Dänemark	Lars Nikolaisen – Danish Technological Institute	Research
Deutschland	Uwe R. Fritsche - Oeko-Institut Daniela Thrän - Deutsches Biomasseforschungszentrum Michael Deutmeyer – Green Carbon Group	Research, consulting, Industry
Finnland	Tapio Ranta & Jussi Heinimö - Lappeenranta University of Technology	Research
Großbritannien	Frank Rosillo-Calle & Jeremy Woods – Imperial College London	Research
Italien	Alessandro Berti - Api Nòva Energia S.r.l. Maurizio Cocchi - ETA - Renewable Energies	Italian Utility Consulting
Japan	Shinichi Goto, AIST Yiji Iwasaki, NEDO	Research
Niederlande	Andre Faaij & Martin Junginger & Chun Sheng Goh - Utrecht University Peter-Paul Schouwenberg – RWE Essent Kees Kwant, SenterNovem	Task Leader Trading Company Operating Agent T40
Norwegen	Øyvind Leistad – Enova Birger Solberg & Erik Trømborg, Norwegian University of Life Sciences	Government Agency Research
Österreich	Lukas Kranzl & Julian Matzenberger – TU Wien Michael Wild – Wild & Partner	Research Trading Company
Schweden	Bo Hektor (Representing Svebio) – First Bioenergy AB	Consulting
USA	J. Richard Hess - Idaho National Laboratory	Research

D) INHALTE DER ÖSTERREICHISCHEN KOOPERATION

Auf internationaler Ebene findet eine Kooperation mit anderen Mitgliedsstaaten von Task 40, insbesondere über die nationalen Teamleader statt. Die internationalen Taskmeetings bilden den Rahmen für diese Kooperationen. Dabei stehen die Analyse von aktuellen Entwicklungen und die Arbeit an gemeinsamen Projekten, teilweise in kleineren Teams im Vordergrund. Die schlanke Struktur und die große Expertise der einzelnen Teilnehmer erlauben es, schnell auf momentane Entwicklungen zu reagieren. Im Rahmen dieser Kooperationen sind mit österreichischer Unterstützung mehrere Arbeiten und Berichte realisiert worden, die auf der Task 40 Homepage und auf der Homepage der Energy Economics Group zum Download bereitgestellt wurden.

Wesentliche Eckpunkte die für die Inhalte der österreichischen Kooperation maßgeblich prägen sind:

- Daten über den grenzüberschreitenden Handel von Bioenergieprodukten zu sammeln und seine Bedeutung für Österreich zu erheben und zu analysieren.
- Dokumentation aktueller Entwicklungen betreffend die energetische Nutzung von Bioenergie in Österreich, insbesondere hinsichtlich ihrer Relevanz für Biomasse-Handel.
- Aktualisierung und Erweiterung der Datenbasis für weitere regionale und internationale Untersuchungen und Studien.
- Zusammenfassung der Ergebnisse dieser Analysen in einem Country Report und Veröffentlichung dieser Arbeit.
- Unterstützung der Zusammenführung von handelsspezifischen Daten aller Teilnehmerländer von Task 40, um Tendenzen und Entwicklungen auf den regionalen und internationalen Bioenergiemärkten zu analysieren und die Dynamik dieser Märkte besser zu verstehen.
- Beobachtung der Auswirkungen durch die Implementierung von Nachhaltigkeitskriterien auf Nutzung von Bioenergie und den grenzüberschreitenden Handel mit Bioenergieprodukten in Österreich.
- Beobachtung der Entwicklung von Zertifizierungssystemen in Österreich, auf EU-Ebene aber auch international.
- Nationale Vernetzung der relevanten Akteure in Österreich und Verbreitung der Ergebnisse.
- Förderung der Vernetzung der nationalen und internationalen politischen, wissenschaftlichen und wirtschaftlichen Akteure durch aktive Teilnahme an Task 40 Meetings und internationalen Workshops.
- Organisation von Task 40 Meeting und internationalem Workshop in Österreich

Auf der nationalen Ebene erfolgt eine Kooperation mit den wichtigen österreichischen Akteuren aus Politik, Wissenschaft und Wirtschaft, aber auch mit NGOs. Im Rahmen von Workshops und Expertengesprächen wird der Kontakt zu diesen nationalen Akteuren hergestellt. Besonders wichtig ist die Vernetzung mit den verschiedenen österreichischen Akteuren des internationalen Biomasse-Imports (z.B. Betreiber von Biokraftstoffanlagen etc.) und Exports (z.B. Produzenten von Pellets).

4. ERGEBNISSE UND HIGHLIGHTS DES PROJEKTES

A) COUNTRY REPORT AUSTRIA

Der Country Report („IEA Bioenergy Task 40 - Country Report for Austria 2011") basiert auf einer eingehenden Analyse des Datenbestandes über grenzüberschreitenden Bioenergiehandel in Österreich. Neben der energetischen Nutzung von Biomasse werden vor allem Daten über Import- und Exportaktivitäten im Bereich der Biomasse systematisch dargelegt.
Der Report zeigt unter anderem wie sich Handelsströme forstlicher Biomasse und flüssiger biogener Treibstoffe in der vergangenen Dekade entwickelt haben und zeigt auf, dass der Handel von Biomasse in vielen Fällen einen substanziellen Anteil verglichen mit Inlandsproduktion bzw. Inlandsverbrauch einnimmt. Im Report wird auch auf Biomasse Angebot und Nachfrage, Fördermechanismen, die Situation des internationalen Biomassehandels in Österreich und Barrieren hierfür detailliert eingegangen.
Abbildung 1 zeigt das Flussdiagramm des Österreichischen Bioenergie-Sektors (für den Country Report adaptiert aus Kalt & Kranzl, 2011). Dargestellt sind die Biomassefraktionen und die jeweilige Endnutzung.

Handelsstatistiken geben Auskunft über Biomasseströme nach Handelspartnern. Im Folgenden wird die historische Entwicklung des österreichischen Imports und Export von Energiehölzern dargestellt. Die österreichischenDatensätze der Handelsstatistiken basieren teilweise auf den CN Codes (siehe Europen Comission, 2010). Eine ausführliche Erklärung in Bezug auf die Nutzung biogener Energieträger ist in Kalt, G et. al., (2011) zu finden.

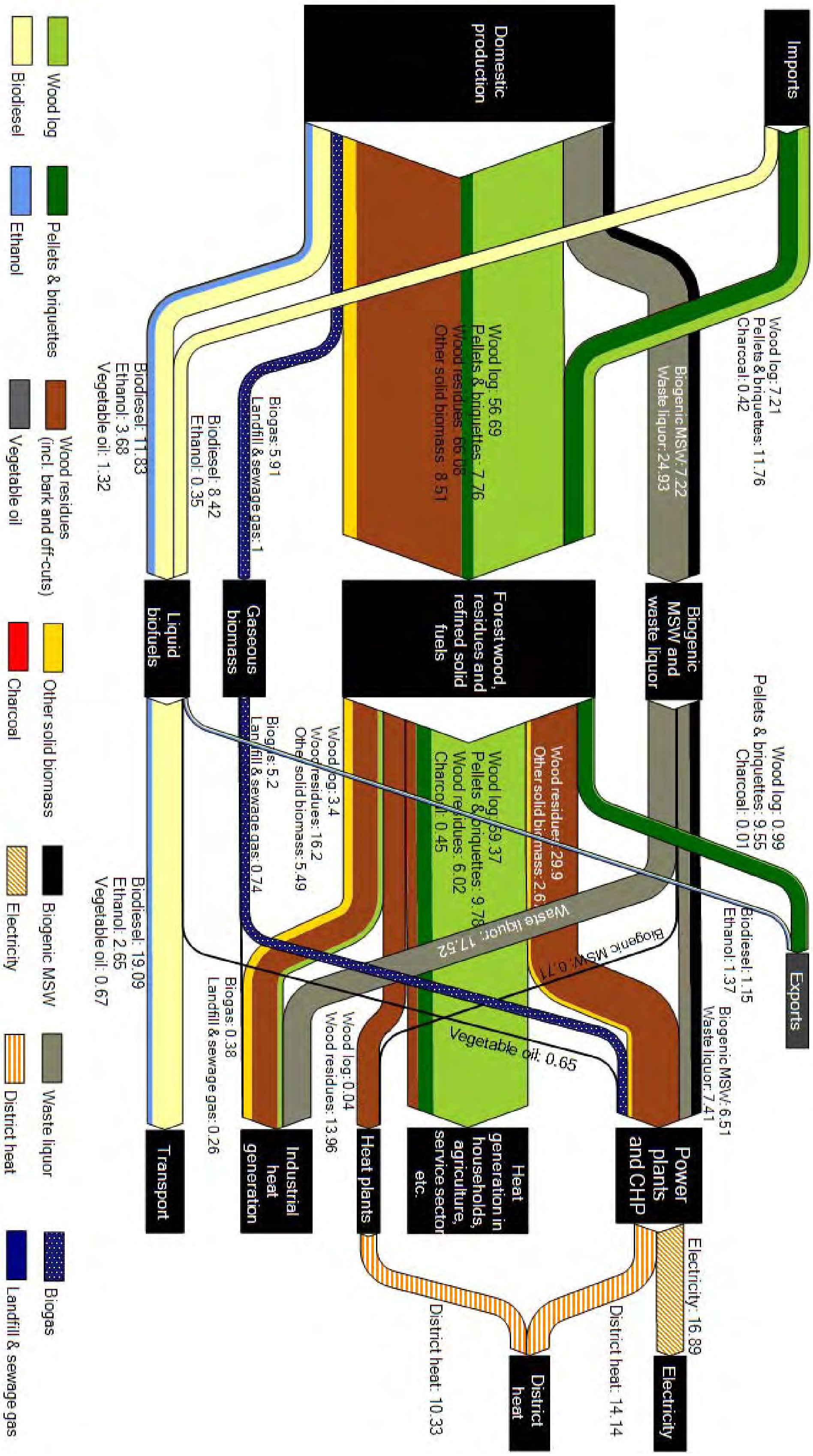
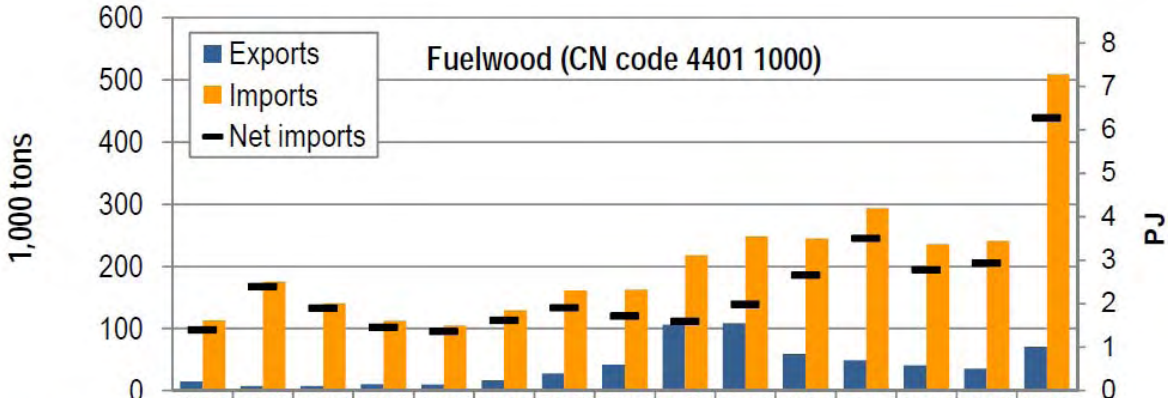


Abbildung 1 Fussdiagramm des Österreichischen Bioenergie-Sektors (Angaben in PJ; Importierte Rohstoffe sind als Equivalent der verarbeiteten Biotreibstoffe gegeben; Flüsse unter 0,5 PJ sind zur besseren Lesbarkeit teilweise vernachlässigt) Quellen: Kalt et Kranzl (2011), Daten: Statistik Austria (2011) und Winter (2011), eigene Berechnung

Feste Biobrennstoffe

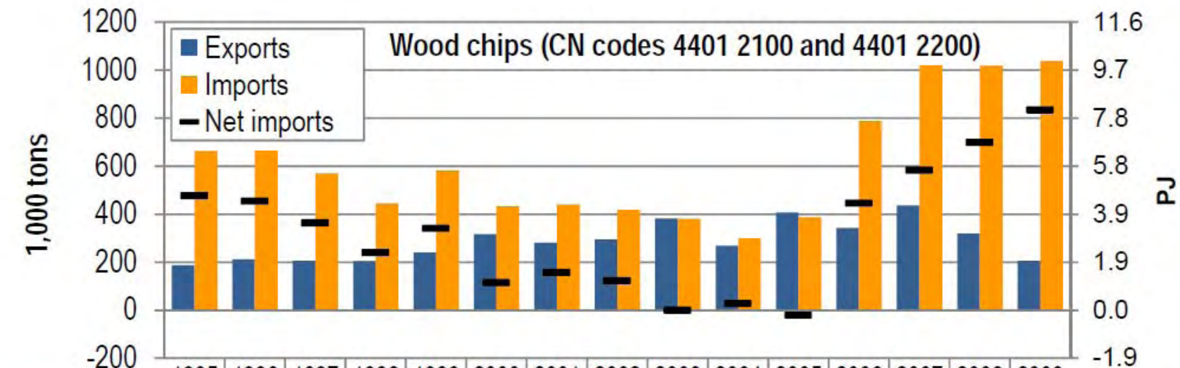
Österreich ist ein Nettoimporteur von Energieholz (siehe Abbildung 2) Bis 2004 betrugen die typischen jährlichen Nettoimporte ungefähr 100,000 t (1.5 bis 2 PJ). Der Jahresdurchschnitt der Periode 2005 bis 2008 war ungefähr doppelt so hoch und im Jahr 2009 betrug der Nettoimport mehr als 400,000 t (mehr als 6 PJ). Diese Zahl repräsentiert ungefähr ein Zehntel des gesamten Energieholzverbrauchs. Die wichtigsten Handelspartner sind Ungarn, Slowakei, Deutschland, Frankreich und die Tschechische Republik.



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exports	15	7	8	10	10	16	28	42	106	109	59	49	41	36	71
Imports	113	175	141	113	105	129	161	162	218	248	245	294	236	241	509
Net imports	98	168	133	102	95	113	133	120	111	139	186	245	195	205	438

Abbildung 2. Entwicklung des österreichischen Imports und Exports von Energieholz zwischen 1995 und 2009. Quelle: Eurostat (2011)

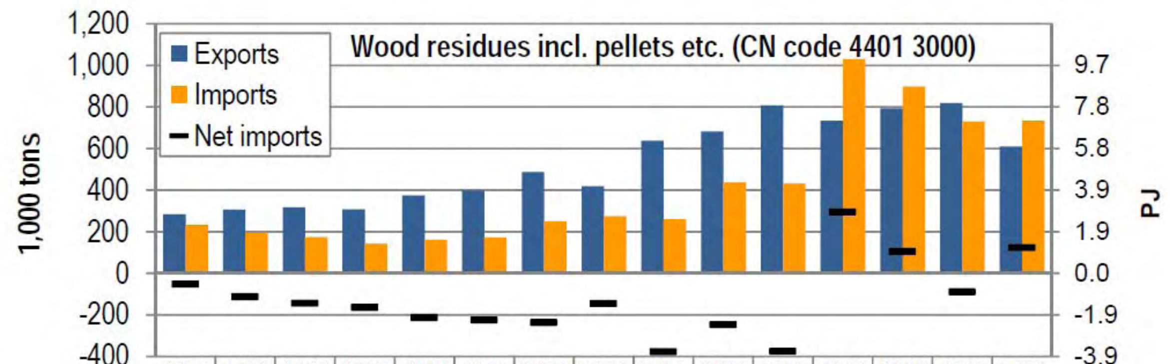
Abb. 3 zeigt die Entwicklung der Hackschnitzelimporte und –exporte. Während in den Jahren 1995 bis 2005 ein klarer Abwärtstrend der Nettoimporte zu erkennen ist (resultierend in einem Nettoexport von 20,000 t in 2005), zeigt sich eine bemerkenswerte Trendwende im Jahr 2006. Die Nettoimporte stiegen bis 2009 auf mehr als 800,000t (ungefähr 8 PJ) an.



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exports	187	211	206	204	241	317	282	295	381	270	407	344	436	320	205
Imports	664	665	571	445	582	433	440	418	381	299	387	789	1020	1019	1039
Net imports	476	454	364	241	341	115	158	123	0	29	-20	445	584	699	834

Abbildung 3. Entwicklung des österreichischen Imports und Exports von Hackschnitzel zwischen 1995 und 2009. Quelle: Eurostat (2011)

Die Kategorie „Waldrückstände“ beinhaltet Sägemehl und Holzabfälle in verschiedenen Formen unter Anderem in Pellets und Briquettes. Abbildung 4. Zeigt die Entwicklung der Handelsvolumina die unter dem CN Code 4401 3000 gemeldet wurden. Hier ist im Unterschied zu den Kategorien Energieholz und Hackschnitzel deutlich ein Nettoexport bis 2005 zu erkennen. Ab 2006 stieg jedoch auch hier der Import signifikant an. Im Jahr 2009 betrug der Nettoimport 124,000 t (1.2PJ).

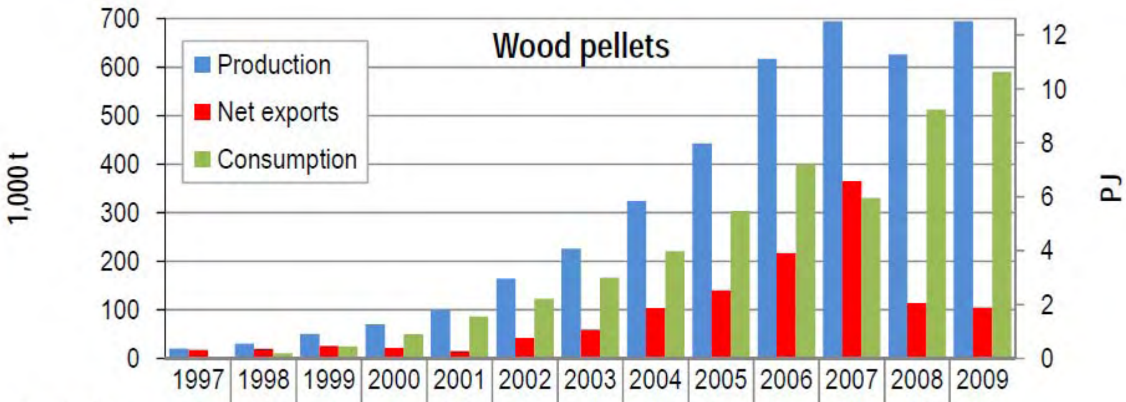


	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exports	284	306	316	307	374	397	487	419	637	682	807	735	793	819	611
Imports	233	195	173	143	161	172	250	274	261	436	432	1,030	898	730	735
Net imports	-52	-112	-143	-164	-213	-225	-237	-145	-376	-246	-375	295	104	-89	124

Abbildung 4. Entwicklung der österreichischen Importe und Exporte von Waldrückständen (Holzpellets inkludiert) von 1995 bis 2009. Quelle: Eurostat (2011)

Holzpellets werden erst seit 2009 unter einem eigenen CN Code dokumentiert. Die Importe im Jahre 2009 betrugen ungefähr 200,000 t (2.5 PJ; hauptsächlich aus Deutschland, Rumänien und der Tschechischen Republik), die Exporte 360,000 t (6.2 PJ, wobei mehr als 80% nach Italien flossen). Demnach war Österreich ein Nettoexporteur von Holzpellets (ungefähr 160,000 t oder 2.7 PJ).

Eine Einschätzung basierend auf die Produktions- und Verbraucherstatistiken gemäß Pellet@las (2011) ergibt einen Nettoexport leicht über 100,000 t im Jahr 2009 (Abb. 5). Beachtenswert in der geschichtlichen Entwicklung ist, dass der Nettoexport von weniger als 50,000 t im Jahr 2002 auf 365,000 t im Jahr 2007 anstieg. In den darauf folgenden Jahren lag der Nettoexport deutlich unter dem Wert von 2007.



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Production	20	30	50	70	100	165	225	324	443	617	695	626	695
Net exports	17	19	26	21	15	42	59	103	140	217	365	113	105
Consumption	3	11	24	49	85	122	166	221	303	400	330	513	590

Abbildung 5. Entwicklung der Produktion, des Verbrauchs und der Nettoimporte von Holzpellets. Quelle: Pellet@las (2011)

Handelsstatistiken liefern Daten von Biomasseströmen nach Handelspartner. Um die Dynamik der letzten Jahre zu verdeutlichen zeigt Abb. 6 einen Vergleich der durchschnittlichen jährlichen Handelsvolumina zwischen 2000 und 2005 mit dem Handelsstrom im Jahr 2009. Wie bereits erwähnt existieren eigene Daten für Holzpellets ab dem Jahr 2009. In den Jahren davor wurden Pellets gemeinsam mit anderen Arten von „Holzrückständen“ dokumentiert.

Auch hier ist es noch einmal wichtig zu erwähnen, dass Handelsstatistiken keinen Unterschied zwischen Endverbrauchern geben. Aus diesem Grund ist es nicht möglich, basierend auf Handelsstatistiken die Handelsvolumina anzugeben, die tatsächlich in Zusammenhang mit der energetischen Nutzung der Biomasse stehen. Es wird allerdings angenommen, dass Holzscheite, Holzpellets und Holzabfälle größtenteils ausschließlich zur Energieproduktion eingesetzt werden. Hackschnitzel und Waldrückstände betreffend zeigt die holzverarbeitende Industrie, dass deutliche Mengen der materiellen Nutzung zugeführt werden. Die Importe von Sägemühlennebenprodukten für die Papier-, Zellstoff- und Holzplattenindustrie im Jahr 2009 betrugen einen Gegenwert von 11 PJ (Berechnung basierend auf Austropapier, 2011 und Schmied, 2011). Diese Menge entspricht dem gesamten Import gemäß den Handelsstatistiken. Daraus wird geschlossen, dass zumindest im Jahr 2009 Waldrückstände ausschließlich für die materielle Verwendung importiert wurden.

Abb. 6 verdeutlicht, dass in den letzten Jahren vor Allem die Nettoimporte von biogenen Energieträgern der nördlichen und östlichen Nachbarländer signifikant gestiegen sind. Der gesamte Nettoimport der Tschechischen Republik, Slowakei und Ungarn betrug ungefähr 2 PJ pro Jahr in der Periode von 2000 bis 2005. Im Jahr 2009 waren es mehr als 10 PJ, und eine zusätzliche Menge von 1.3 PJ wurde aus Rumänien importiert. Zusammen ergibt das einen Gegenwert von 5% des gesamten österreichischen Biomassebruttoinlandverbrauchs im Jahr 2009. Deutschland und Italien waren 2009 jedoch immer noch die wichtigsten österreichischen Handelspartner. Der Nettoimport aus Deutschland betrug 7.7 PJ im Jahr 2009, verglichen mit dem Durchschnitt von 5.1 PJ zwischen 2000 und 2005. Der Nettoexport nach Italien wuchs von 6.1 auf 7.7 PJ. Mit einer Exportmenge von mehr als 5 PJ im Jahr

2009 war der Pelletsexport nach Italien mit Abstand der wichtigste Handelsstrom nicht nur in Bezug auf Pellets, sondern auch auf den gesamten österreichischen Exportstrom für Energiehölzer.

Ein weiterer erwähnenswerter Aspekt ist, dass die österreichischen Handelsströme in und von den Nachbarländern bzw. anderen europäischen Ländern mehr als 90% des gesamten internationalen Handelsvolumens für Österreich relevantes Energieholz ausmacht. Trotz der stark wachsenden Importaktivitäten ist der österreichische Energieholzhandel mit weiter entfernten Ländern eher vernachlässigbar.

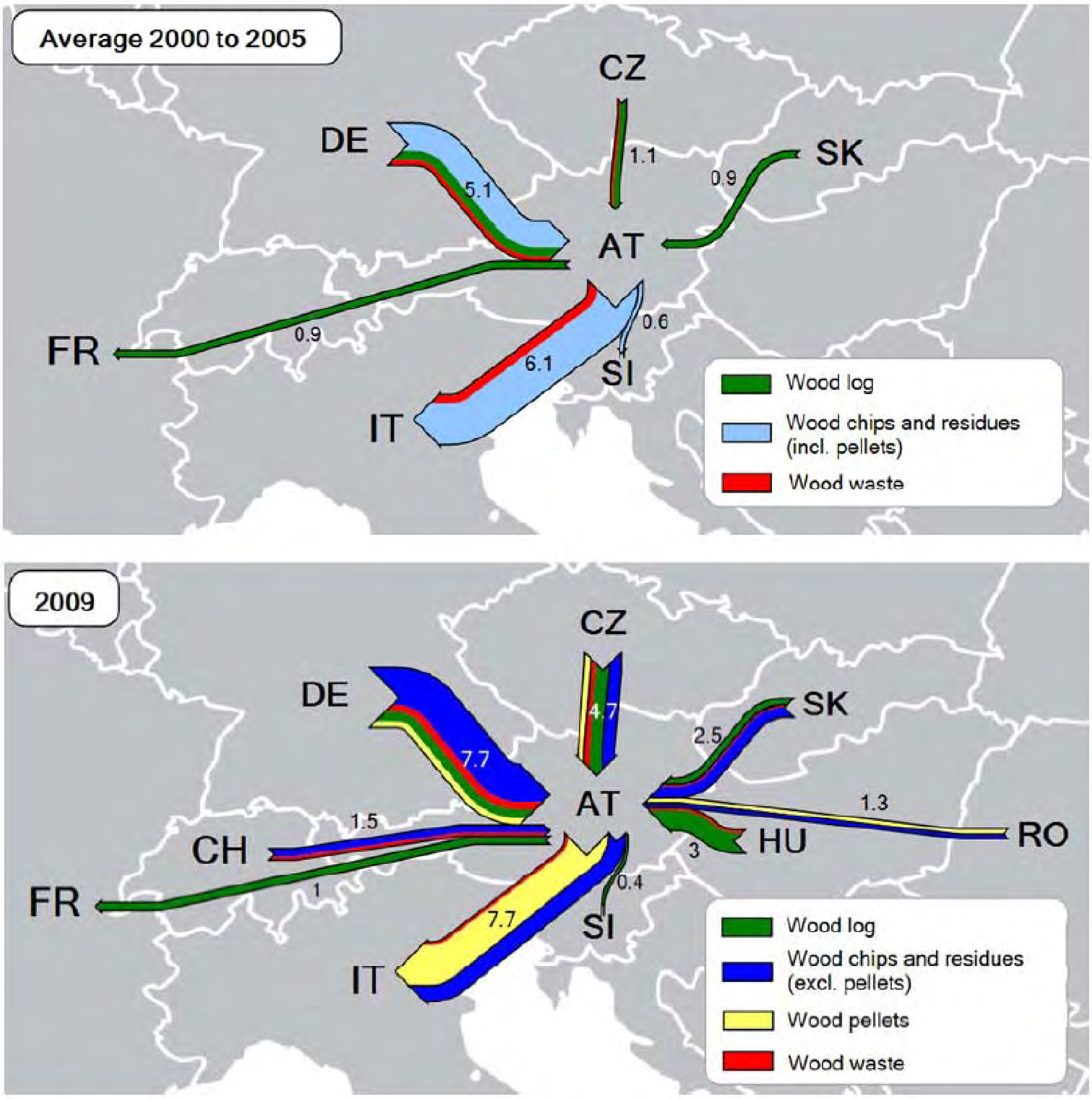


Abbildung 6. Vergleich der Nettoimportströme von Holzscheiten, Waldrückständen, Pellets und Holzresten im Jahr 2009 (unten) mit dem durchschnittlichen Jahreswerten zwischen 2000 und 2005 (oben). (Werte in PJ, nur Ströme über 0.3 PJ berücksichtigt) Quelle: Kalt (2011), basierend auf Eurostat (2011)

Flüssige Biobrennstoffe

Der wachsende Verbrauch von biogenen Treibstoffen im Transportsektor (Biodiesel, Pflanzenöl und Ethanol) in den letzten Jahren führte zu einem signifikanten Anstieg des grenzüberschreitenden Handels. Neben dem direkten Handel mit Biotreibstoffen ist es wichtig auch den grenzüberschreitenden Handel mit Rohmaterial zu betrachten, der für die Biotreibstoffproduktion eingesetzt wird.

Die folgenden Absätze sind wie folgt strukturiert: Zuerst werden Daten der Biotreibstoffproduktion, des –verbrauchs und des –handels aus den offiziellen Reporten bezüglich der Direktive 2003/30/EC (Winter 2011) dargestellt und analysiert. Als nächstes werden, basierend auf die Versorgungsbilanz und Daten über die Selbstversorgung mit landwirtschaftlichen Produkten, Schlussfolgerungen über den Einfluss der Biotreibstoffproduktion und des –verbrauchs auf die landwirtschaftlichen Handelsflüsse gezogen.

Abb. 7 zeigt die Entwicklung der Biotreibstoffproduktion und der direkten Importe und Exporte nach Winter (2011). Zu erkennen ist, dass die Importe ungefähr 50% des österreichischen Verbrauchs zwischen 2005 und 2009 ausmachen. Knapp ein Viertel der einheimischen Produktion von Biodiesel, welcher von 70,000t (2005) auf mehr als 320,000t (2009) anstieg, wurde exportiert.

Bezüglich des Verbrauchs von Pflanzenölen im Transportwesen gibt es kaum verlässliche Daten, da die Produktionsvolumina in den Statistiken nicht nach dem zugedachten Verbrauch unterschieden werden und da die Vertriebskanäle größtenteils nur regional ausgeprägt sind. Nach Winter (2011) wurden ungefähr 17,000 bis 18,000 t (0.6 bis 0.67 PJ) Pflanzenöle jährlich zwischen 2007 und 2009 für den Transport genutzt. Es wird angenommen, dass zumindest die, in der Landwirtschaft verbrauchten Menge (ungefähr 2,700 t oder 0.1 PJ im Jahr 2009) aus der einheimischen Produktion stammen.

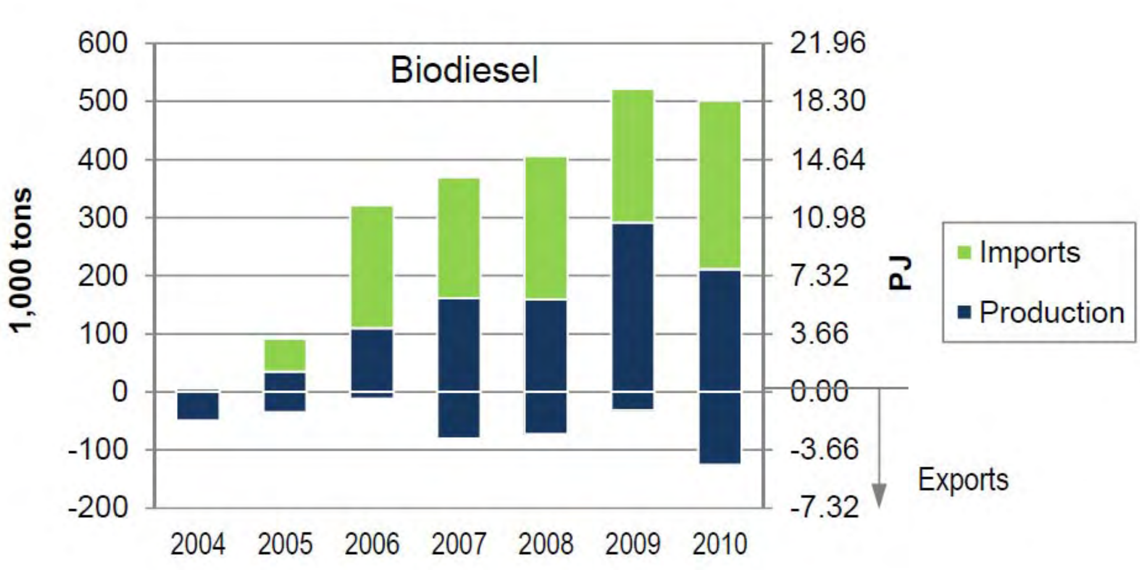


Abbildung 7 Österreichische Biodieselversorgung zwischen 2004 und 2010 aus dem offiziellen Biotreibstoffreport gemäß der Direktive 2003/30/EC. Quelle: Kalt (2011), basierend auf Winter (2011), Statistik Austria (2011c)

Die österreichische Produktion von Bioethanol für den Transportsektor ist auf eine Großanlage in Pischelsdorf in Niederösterreich limitiert. Betrieben wird diese von der AGRANA Holdinggesellschaft. Die Anlage ging im Sommer 2008 vollständig in Betrieb und hat eine Kapazität von ungefähr 190,000 t/a (5.1 PJ/a). Abb. 8 zeigt die Bioethanolproduktion, -importe und –exporte in Österreich von 2007 bis 2009. Während Österreich 2007 und 2008 ein Nettoimporteur von Bioethanol war betrugen die Nettoexporte im Jahr 2009 ungefähr 28% der gesamten einheimischen Produktion.

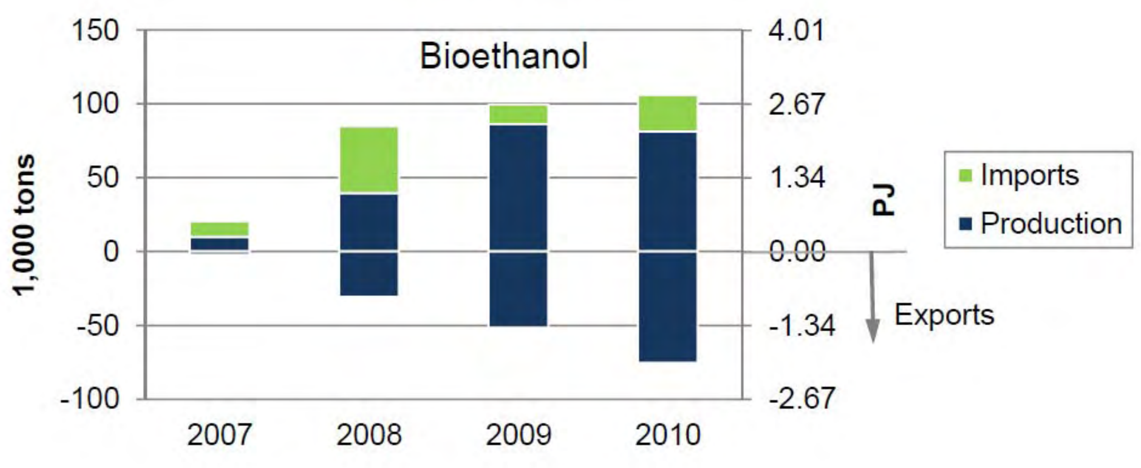


Abbildung 8. Österreichischer Bioethanolversorgung von 2007 bis 2010 nach dem offiziellen Biotreibstoffreport gemäß der Direktive 2003/30/EC. Quelle: Kalt (2011), basierend auf Winter (2011), Statistik Austria (2011c)

Es sind keine Daten zu den Importen von landwirtschaftlichen Produkten zur Herstellung von Biotreibstoff vorhanden. Allerdings liefern Trends in den Versorgungsbilanzen und Selbstversorgungsraten einen Einblick in den Effekt der steigenden Biotreibstoffproduktion auf ausländische Handelsflüsse.

Abb. 9 zeigt die Entwicklung der Selbstversorgungsrate von Getreide, Pflanzenfetten und -ölen. Offenbar ist Österreich stark abhängig von den Importen von Pflanzenölen und –fetten und der Trend zur Selbstversorgung war im letzten Jahrzehnt deutlich negativ: Zwischen 1999 und 2001 betrug die durchschnittliche Selbstversorgung (berechnet auf der Basis der Ölherstellung der einheimischen Ölsamenproduktion) ungefähr 60%, während sie zwischen 2008 und 2010 auf unter 30% fiel. Im Vergleich dazu blieb die Selbstversorgungsrate von Getreide (Weizen, Körnermais, Gerste, Triticale etc.) relativ konstant auf ungefähr 100%.

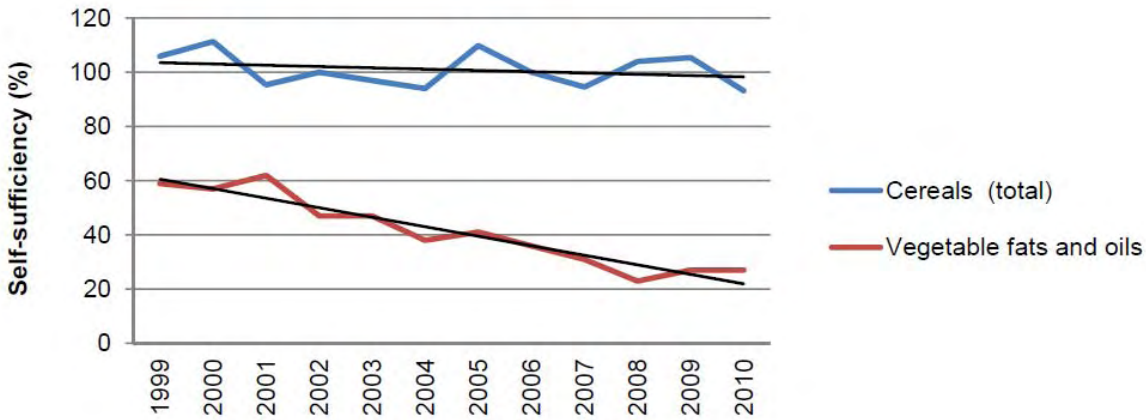


Abbildung 9. Entwicklung der Selbstversorgungsrate von Getreide und Pflanzenfetten und –ölen von 1999 bis 2010. Quelle: Statistik Austria (2011i)

Abb. 10 zeigt ein Flussdiagramm für die im österreichischen Transportsektor eingesetzten Biotreibstoffe im Jahr 2009. Rohmaterialimporte bezogen auf die Biotreibstoffproduktion in wurden auf Basis der Selbstversorgung mit landwirtschaftlichen Gütern und unter der Annahme, dass sich Importe und einheimische Versorgung mit gleichen Teilen auf die Endverbraucher aufteilen, berechnet. (siehe Kalt & Kranzl, 2011). Insgesamt betrugen Biotreibstoffnettoimporte und Rohmaterialimporte 70% des gesamten Biotreibstoffverbrauchs in Österreich im Jahr 2009.

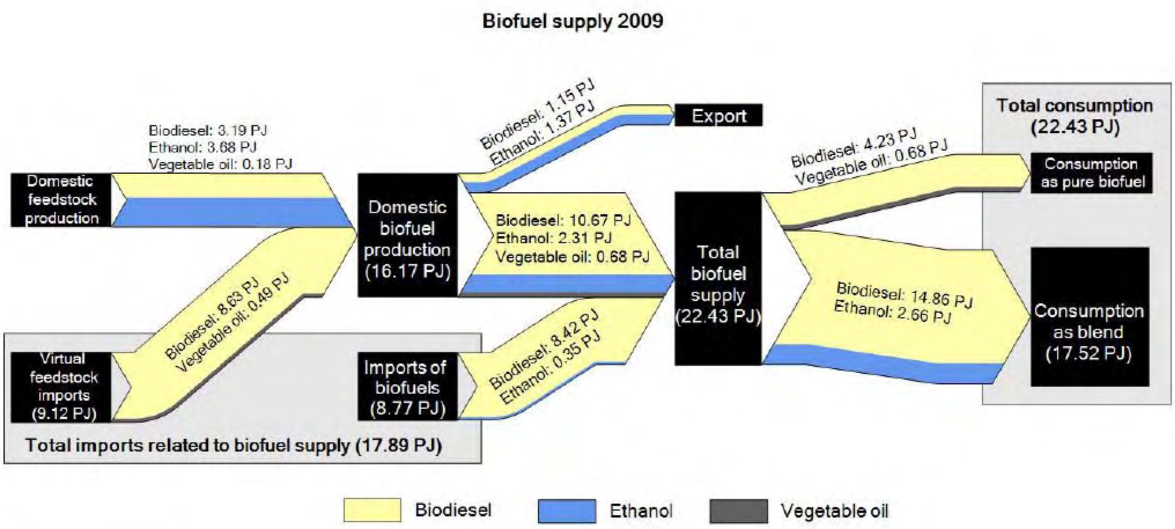


Abbildung 10 Flussdiagramm des österreichischen Biotreibstoffsektors im Jahr 2009. (Rohmaterialimporte sind als Gegenwert zu den produzierten Biotreibstoffen dargestellt; Rohmaterialimporte bezogen auf die Biotreibstoffproduktion wurden auf Basis der Selbstversorgung mit landwirtschaftlichen Gütern nach Kalt & Kranzl, 2011 berechnet.) Quelle: Kalt & Kranzl (2011)

Es kann gezeigt werden, dass Österreich bis 2005 ein netto Exporteur von biogenen Treibstoffen war (Abbildung 11). Von 2000 bis 2004 stiegen sowohl Exporte also auch Importe um etwa einen Faktor 2.5, was zu netto Exporten von 5,6% des brutto Inlandskonsums geführt hat. In den folgenden Jahren, die von einer rapiden Zunahme der Biomassenutzung gekennzeichnet waren, stiegen die Importe auf rund 30PJ/a, und machten damit etwa 10% des Inlandskonsums an Biomasse aus. Sowohl steigende

Importe von flüssigen biogenen Kraftstoffen als auch von festen biogenen Brennstoffen trugen zu diesem Trend bei.

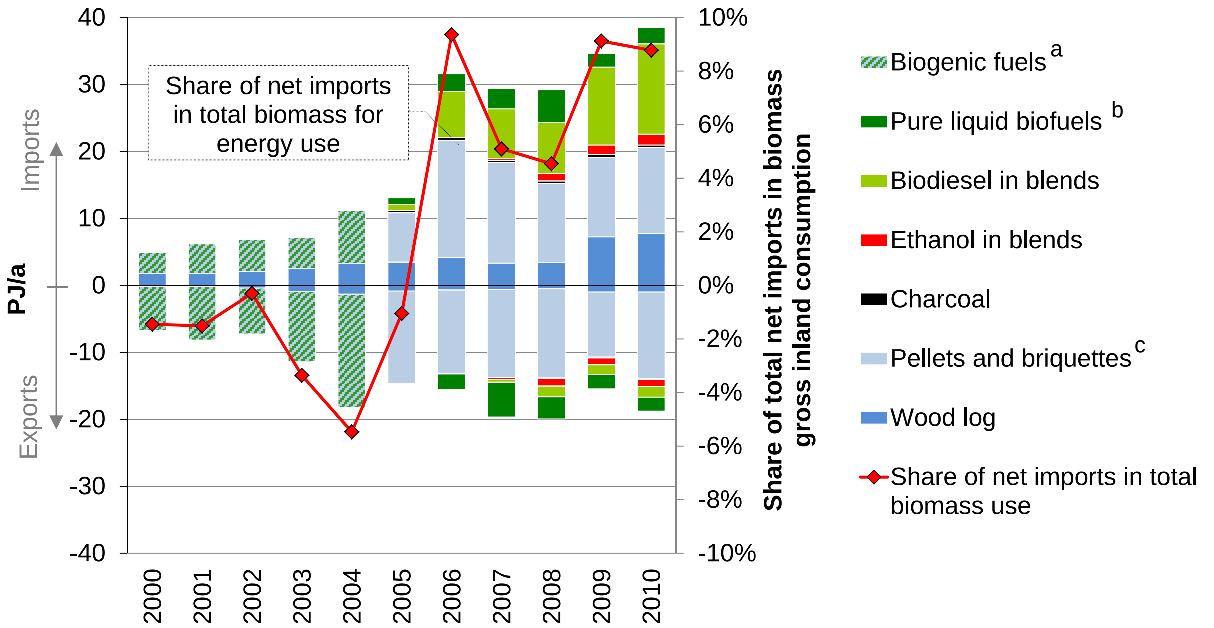


Abbildung 11 Imports and exports of biogenic energy carriers according to energy statistics of the national statistical authority Sources: Kalt & Kranzl (2011) based on (Statistik Austria 2011)

B) ENTWICKLUNG EINER ANWENDUNG ZUR MODELLIERUNG DES EUROPÄISCHEN BIOMASSE-HANDELS (DEVELOPMENT OF A TOOL TO MODEL EUROPEAN BIOMASS TRADE)

Da sich IEA Bioenergy Task 40 vor allem mit globalen Bioenergiemärkten auseinandersetzt ist es wichtig, die Entwicklungen in anderen Staaten zu verfolgen. Dazu erfolgt zuerst die Identifikation jener Staaten bzw. Regionen, die hinsichtlich eines künftigen globalen Biomasse-Handels für Europa und Österreich besonders wichtig werden könnten.

Die Analyse der NREAPs (National renewable energy action Plan) gibt Aufschluss über derzeitige und zukünftige Potentiale und Bedarf an Biomasse für alle EU Länder. Von der EEG/TU Wien Daten der NREAPs von Österreich und mehrerer europäischer Länder analysiert.

In Kooperation mit der Universität Utrecht wurde ein Tool zur Modellierung des Biomasse Handels („Trade Modelling Tool") in entwickelt, das Europäische Biomasse-Potentiale und deren potentielle Entwicklung, mithilfe von Green-X, eines an der EEG/TUWien entwickelten Modells erstellt und Daten der NREAPs gegenübergestellt. (Abbildung 12) .

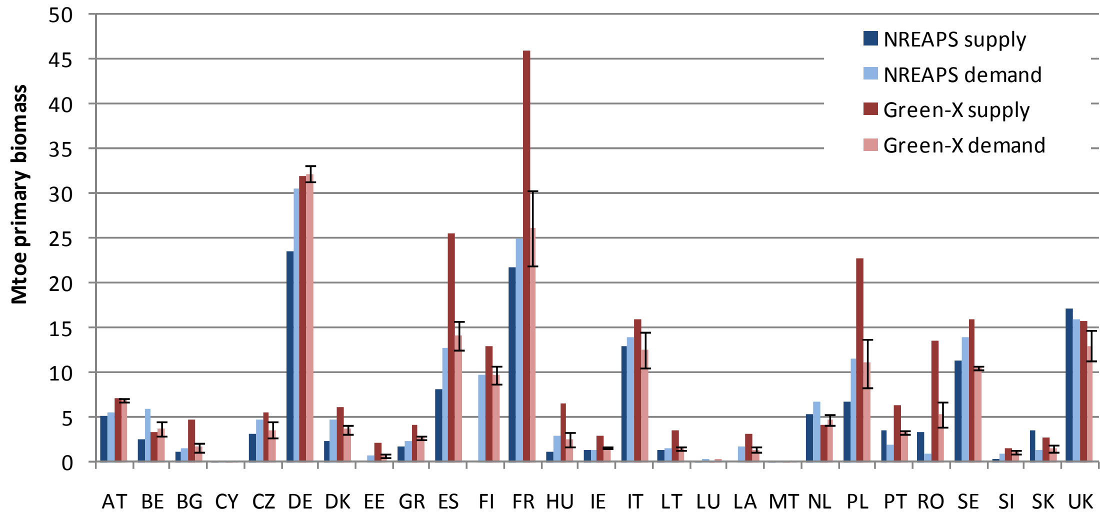


Abbildung 12 Primary biomass supply and demand for electricity, heat and biofuels in the National Renewable Action Plans and Green-X supply and demand ranges for the scenarios Business as Usual (BAU), BAU Mitigated barriers and Strengthened National Support for 2020 (Resch, 2011)

Die Studie gibt einen Überblick auf die erwartete Entwicklung der Biomasse Produktion und des Bedarfes nach Biomasse in den EU 27 Mitgliedsländern und daraus resultierende Engpässe und Überschüsse, die durch internationalen Handel mit Biomasse gedeckt werden könnten.

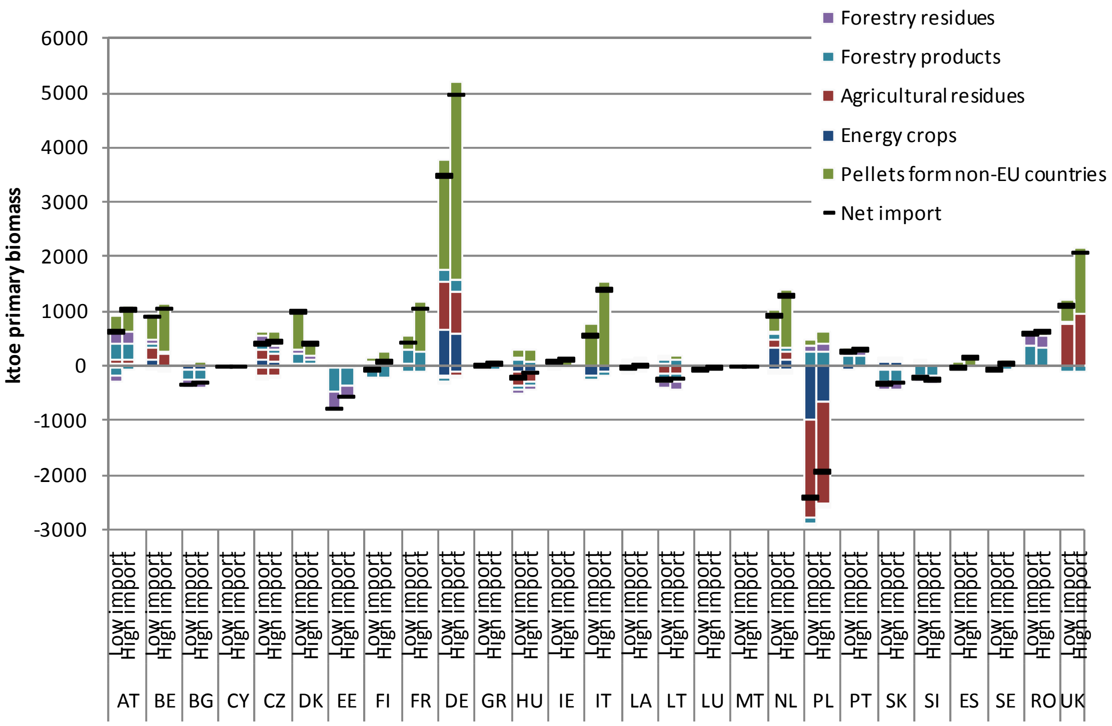


Abbildung 13 Import, export and net import of biomass from EU and non-EU countries in the Low Import and High Import scenario for 2020 per commodity type. Export is shown as negative.

Der verwendete Ansatz gibt wertvolle Einblicke in mögliche Handelsrouten, Regionen die zentral für die Bereitstellung der Biomasse sind und mögliche Auswirkungen auf die Kosten für die Erzeugung biogener Energie unter Berücksichtigung logistischer Aspekte.

Es kann gezeigt werden, dass Transportkosten einen substanziellen Einfluss auf die Gesamtkosten der Versorgung mit fester Biomasse haben. Für einzelne Regionen und Commodities können die Transportkosten bis zu 75% der Kosten eingesetzter Biomasse betragen. Weiters kann aus der Studie geschlossen werden, dass bei einer Betrachtung der Kosten pro Energieeinheit, die Kosten der Pelletierung die geringeren Kosten für Transport nicht aufwiegen können. Schlüsselregionen für die Deckung des steigenden Biomassehandels werden in Polen, Estland, Ungarn und der Slovakei verortet. Die Ergebnisse demonstrieren. das Potential des trade modeling tools Handelsströme zu simulieren.
Der gesamte Bericht ist auf der Seite www.bioenergytrade.org verfügbar.

C) NACHHALTIGKEIT UND ZERTIFIZIERUNG VON BIOMASSE

Global sind derzeit rund 9% der Waldflächen bzw. 26% des Industrierundholzes von einem Zertifizierungssystem erfasst. Es existiert eine Vielzahl an Zertifizierungssystemen- und initiativen. Die mit Abstand bedeutendste Regulierung die den Nachweis der Nachhaltigkeit von Bioenergie im europäischen Raum betriff, ist die Erneuerbare Energien Richtline.

Die Erneuerbare Energien Richtline der EU (Renewable Energy Directive, RED) ist die wesentlichste Gesetzgebung hinsichtlich der Einführung von Nachhaltigkeitskriterien für Biotreibstoffe und flüssige biogene Energieträger in der Europäischen Union. Durch die RED (2009/28/EC) werden ambitionierte Ziele für alle Mitgliedsstaaten gesetzt: Ein Anteil von 20% Energie aus erneuerbaren Energieträgern bis 2020 und ein Anteil von 10% Erneuerbaren im Transportsektor. Darüber hinaus führt die RED auch Nachhaltigkeitskriterien für biogene Treibstoffe und flüssige biogene Energieträger ein, die in Artikel 17 (Punkt 2 bis 5) und Artikel 18 (Punkt 1) und mit Verweis auf Artikel 7 der Fuel Quality Directive (2009/30/EC) dargelegt sind. Die Anforderungen umfassen:

- Eine Reduktion der Treibhausgasemissionen im Vergleich zu fossilen Brennstoffen um mindestens 35% bzw. um mindestens 50 % ab 2017 und mindestens 60% für neue Anlagen ab 2018
- Keine Nutzungsänderung von Flächen mit hohem Kohlenstoffgehalt, wie durchgehend bewaldete Flächen, Feuchtgebiete oder Torfgebiete
- Keine Rohstoffe von Flächen hoher Biodiversität, wie Primärwälder, Naturschutzgebiete oder Weideland mit hoher Biodiversität
- Rohstoffe aus landwirtschaftlicher Produktion in Europa müssen der „guten landwirtschaftlichen Praxis" nach der gemeinsamen Agrarpolitik entsprechen.

Diskussion und Handlungsableitungen der Anforderungen zum Nachweis der Nachhaltigkeit nach der RED:

- Derzeit sind nur für die Verwendung von Biomasse für Biokraftstoffe Nachhaltigkeitskriterien vorgesehen. Diese Diskriminierung in der Nutzung von Biomasse kann zu einer Beeinträchtigung der Bereitschaft der Land- und Forstwirtschaft führen, Rohstoffe für die Biokraftstoffproduktion zu liefern, wenn mit zertifizierten Produkten keine höheren Preie erzielt werden können. Kriterien für eine nachhaltige Produktion von flüssiger, fester und gasförmiger Biomasse sollten idealerweise den selben Kriterien folgen und für alle Anwendungen von Biomasse gelten.

- Während Anforderungen an Biokraftstoffe durch die EU in der RED festgelegt worden sind, haben die wichtigsten Importländer von fester Biomasse begonnen eigene Zertifizierungssysteme zu entwickeln und nationale Anforderungen an die Nachhaltigkeit von fester Biomasse zu definieren. Die entstehende Vielzahl an Initiativen für Nachhaltigkeit und Anforderungen kann zu Verwirrung, Mangel an Vertrauen und Akzeptanz bei den Beteiligten führen. Standardisierung und ein gemeinsames Vorgehen kann helfen, Bedenken hinsichtlich Herkunft und Qualität der importierten Biomasse zu reduzieren.

- Durch die unterschiedlichen Nachhaltigkeitsstandards betroffene Unternehmen beklagen oft die Unübersichtlichkeit der Zertifizierungssysteme, deren unterschiedliche Qualitäten den Konsumenten schwer zu vermitteln sind. Eine Zulassung mehrerer freiwilliger Zertifizierungssysteme durch die Europäische Kommission sollte dazu führen, die Zertifizierung der in der RED vorgegebenen Nachhaltigkeitskriterien zu möglichst niedrigen Kosten zu erreichen. Die Koordination der verschiedenen Standards und Regelungen und Fokussierung auf eine einzige Norm, statt einer Reihe von unterschiedlichen Standards und Regelungen, würden effizientere Strukturen ermöglichen und helfen, durch bessere Managementpraktiken Kosten zu sparen. Bei möglichst geringem Verwaltungsaufwand würde für die Industrie nicht die Notwendigkeit entstehen neue Standards zu schaffen. Rückblickend betrachtet wäre von Seite der Produzenten ein einheitliches europäisches System gegenüber der Vielzahl an nationalen und freiwilligen Systemen wünschenswerter gewesen.

- Die Debatte über einige methodische Fragen im Zusammenhang mit der Nachhaltigkeit von Bioenergie, wie die Rolle der indirekten Landnutzung (iLUC), der Nutzungskonkurrenz von Nahrungsmitteln und Biotreibstoffen oder die Methodik der Kohlenstoffbilanzierung („Carbon dept“) ist noch nicht abgeschlossen. Um eine ordnungsgemäße Auditierung und Einhaltung der Standards zu gewährleisten, müssen präzise und starke Kriterien formuliert sein, die durch die Angabe quantitative oder klarer qualitativer Indikatoren messbar sind und überwacht werden können. Diese Unsicherheit in Bezug auf zukünftige Nachhaltigkeitsanforderungen ist ein wichtigeres Thema für Investoren der Produktionsanlagen zur Herstellung von Bioenergie. Es wird als ein großes Problem wahrgenommen, dass methodische Fragen wie die Einbeziehung von indirekten Landnutzungsänderungen oder Kohlenstoffbilanzierung unklar bleiben. Die Bioenergie Märkte haben bereits gezeigt, dass Unsicherheiten in Richtlinien und Vorschriften zu Stagnation führen. Auf Seiten der Hersteller besteht das Risiko, dass unterschiedliche Märkte unterschiedliche Anforderungen an die Produktion von Biomasse stellen, was zu Verwirrung und Unsicherheit in den Märkten führt. Indirekt landuse-change soll, nach einer Kommunikation der europäischen Kommission (IP/12/1112, Oktober 2012), in die Berichterstattung der Kraftstofflieferanten und Mitgliedstaaten aufgenommen werden. Die Aufnahme verbindlicher iLUC werte in die THG Bilanzierung ist bis auf weiteres nicht vorgesehen. Ein weiterer Review der EU-RED, bei dem ein Vorschlag hinsichtlich der Aufnahme eines iLUC Faktors eingebracht werden könnte, erfolgt 2017 (und könnte eventuell bis etwa 2021 verpflichtend werden).

• Eine zentrale Frage ist, ob Anforderungen an die Nachhaltigkeit freiwillig oder obligatorisch sein sollen. Freiwillige Initiativen sind ein notwendiges, aber vermutlich nicht ausreichendes Element in einem Portfolio an Instrumenten um Nachhaltigkeit der Bioenergie sicher zu stellen. Möglicherweise stellt die Frage freiwilliger oder verpflichtender Kriterien keine "entweder / oder"-Position dar, vielmehr muss die Richtige Balance zwischen Regulierung und freiwilliger Regelung gefunden werden.

• Ein weiterer kritischer Punkt könnte der Verwaltungsaufwand gesetzlicher Anforderungen und Zertifizierung, insbesondere für kleinere Produzenten, sein. Cross-Compliance kann ein Schritt in die richtige Richtung sein, um administrative Hürden gering zu halten. Umfragen zeigen, dass Akteuren im Bereich fester und flüssiger Biokraftstoffe tendenziell eine staatliche Beteiligung bei Fragen der Nachhaltigkeit und eine damit verbundene Klarheit Bezug auf langfristige Ziele bevorzugen.

• Die Umsetzung von Nachhaltigkeitssystemen, wie von den Industriestaaten vorgesehen, erfordert, aufgrund eines Mangels an Technologie und Kapital, in der Regel größere Anstrengungen in Peripheriestaaten, Daraus können sich Hemmnisse für den internationalen Handel ergeben. Diese Länder benötigen Zeit aber auch Technologietransfer und Investitionen um an die Standards der Industriestaaten anschließen zu können.

• Während die Marktlogik auf die Bereitstellung von Produkten und Handelsgütern abzielt, ist ein Denken von Lebenszyklen – beispielsweise von THG Emissionen und Energieverbrauch – auch darauf ausgerichtet die Endnutzung der Güter einzubeziehen. Die Verfügbarkeit von Biomasse ist begrenzt und Nachhaltigkeitskriterien für Biomasse und Biokraftstoffe sollten daher auch eine effiziente (End-)Nutzung der Bioenergie beinhalten. Der Input an Energie muss in allen Phasen der Produktion minimiert werden und die Nutzung von Bioenergie sollte so effizient wie möglich gestaltet werden. Natürlich sollte dies nicht nur für Biomasse gelten, sondern auch für andere Ressourcen und Energieträger. Steigt der Energieverbrauch prinzipiell weiterhin, jagt die Entwicklung von Bioenergie einem sich entfernenden Ziel hinterher.

• Für Biomethan, als gasförmiger biogener Treibstoff, ist derzeit keine Massenbilanzierung vorgeschrieben. Wiewohl Biomethan bisher nur eine untergeordnete Rolle als Biotreibstoff spielt, müssten konsequenterweise für Biomethan die gleichen Regeln wie für andere biogene Treibstoffe gelten. Ein Vorschlag zur Ausdehnung der EU RED Zertifizierungssysteme auf Biomethan wurde im September 2012 von der europäischen Kommission angesprochen(SWD(2012) 262 final).

D) EFFEKTE DER TORREFIZIERUNG VON BIOMASSE AUF DEN BIOMASSE-HANDEL (POSSIBLE EFFECT OF TORREFACTION ON BIOMASS TRADE)

Die Zunahme des Bedarfs für Biomasse in Europa, Nordamerika und Asien wird zu einer Zunahme des internationales Handels führen. Torrefizierung ist eine Technologie, zur volumenspezifischen Verdichtung der Biomasse-Rohstoffe, die gleichzeitig die Eigenschaften der Biomasse für Transport, Lagerung und weitere Konversionspfade verbessern kann. Diese Versdichtung geht mit einer Steigerung des spezifischen Energiegehalts einher, wobei ein Teil des Energieinhalts bezogen auf den gesamten Massenstrom für den Konversionsprozess verwendet werden muss. Mehrere Torrefizierungstechnologien sind derzeit in Entwicklung, eine kommerzielle Verfügbarkeit der Technologie ist bisher aber nicht gegeben. Torrefizierte Biomasse könnte das Potential haben, Pellets, als bedeutendste Quelle industrieller Biomasse-Nutzung abzulösen; um erste Versorgungsketten aufzubauen, wären deutliche Investitionen nötig.

Der gesamte Bericht ist auf der Seite www.bioenergytrade.org verfügbar.

E) PERSPEKTIVEN DES INTERNATIONALEN BIOMASSE-HANDELS (BIOENERGY-TRADE PERSPECTIVES)

In dieser von der EEG/TUW geleiteten Studie werden modellbasierte Szenarien des internationalen Biomasse-Handels gegenübergestellt. Insgesamt wurden 28 Modelle identifiziert, die Biomasse-Handel bis zu einem gewissen Grad abbilden (siehe Abbildung 14).

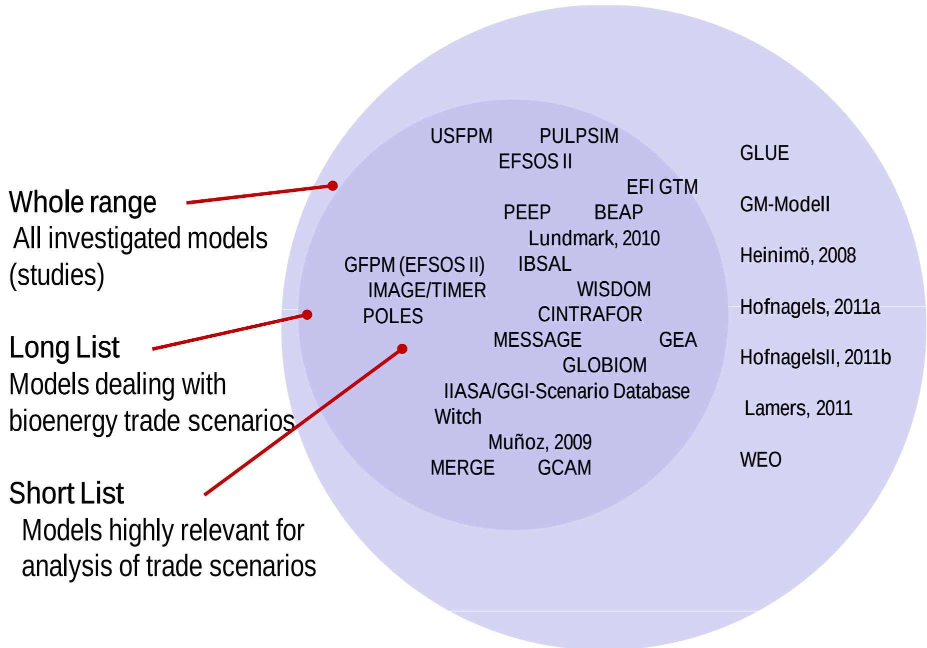


Abbildung 14 Identifizierte Biomasse-Handels-Modelle

Die drei Modelle GFPM, TIMER und POLES wurden für eine eingehende Analyse der Handelsströme ausgewählt und

- Globale Bioenergie-Nachfrage und Produktion (siehe Abbildung 15)
- Bioenergie-Nachfrage in 20 Weltregionen und
- Netto Handelsbilanzen für Bioenergie in 20 Weltregionen analysiert.

Der Modellvergleich zeigt, dass alle Szenarien zu einem signifikanten Anstieg der Bioenergie-Produktion und der Nachfrage nach Biomasse auf globaler Ebene führen. Das derzeitige Niveau von 50 EJ der globalen Bioenergieproduktion steigt auf 150-170 EJ im Jahr 2050, wobei sich nicht nur Nachfrage sonder auch Zusammensetzung und Struktur der Biomasseverwendung verändern. Traditionelle Biomassenutzung (vor allem Kleinfeuerung in Entwicklungsländern) wird schrittweise durch moderne Nutzungsarten abgelöst. Der hauptsächliche (absolute) Anstieg geht auf feste Biomasse zurück, die Produktion flüssiger Biobrennstoffe steigt in geringerem Ausmaß.

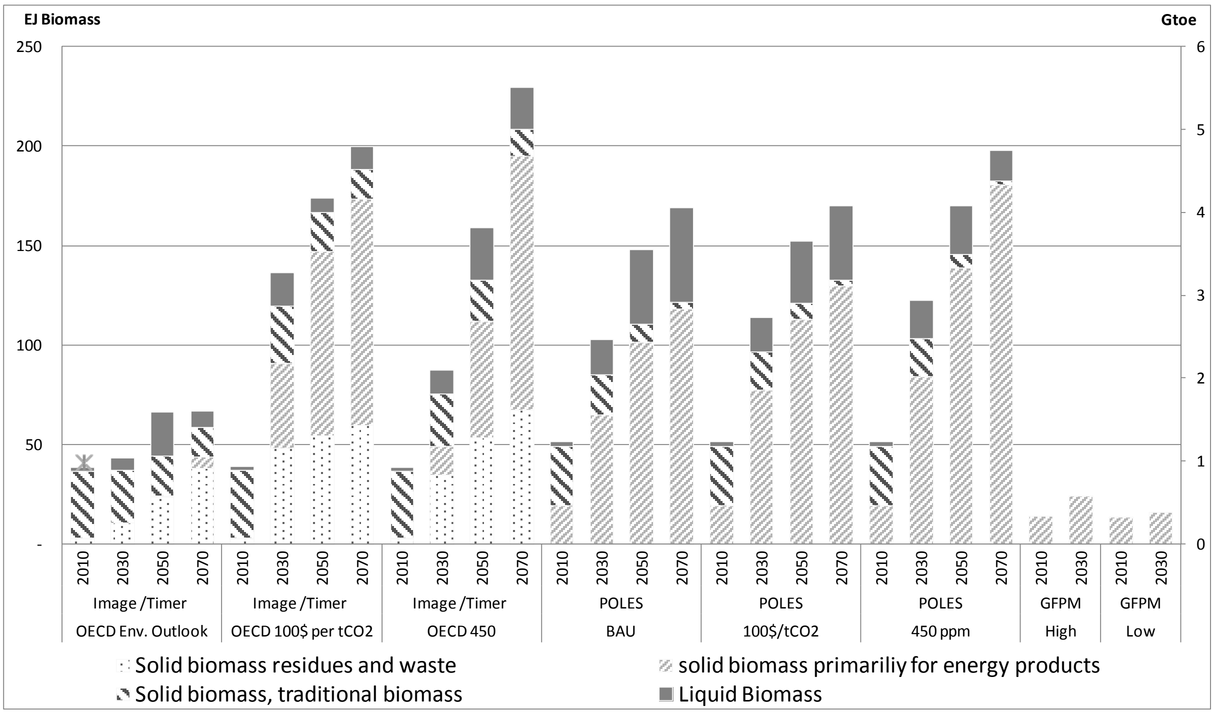


Abbildung 15 Globale Bioenergie Produktion in ausgewählten Szenarien

Zentrale Exportregionen von Biomasse (bis 2050) sind Russland (incl. der Staaten der ehem. UdSSR) mit rund 40% des internationalen Handelsaufkommens bei 10% der globalen Nachfrage, sowie Kanada, Südamerika, Zentral + Rest Afrika und Ozeanien mit zusammen ebenfalls rund 40% des internationalen Handelsaufkommens bei 10% der globalen Nachfrage. Zentrale Importregionen sind vor allem Indien, West Europa und China mit zusammen rund zwei Drittel der internationalen Biomasse-Importe. Die USA sind gleichzeitig ein bedeutender Exporteur von flüssigen Biobrennstoffen und Importeur von fester Biomasse. Dies gilt für ambitionierte Szenarien, die vor allem durch die Annahme strikterer Emissionsminderungsmaßnahmen getrieben sind. Insgesamt werden in den ambitionierten Szenarien 14-30% des globalen Bedarfs an Bioenergie zwischen den Regionen gehandelt. In moderaten Szenarien werden 0-26% des globalen Bedarfs gehandelt.

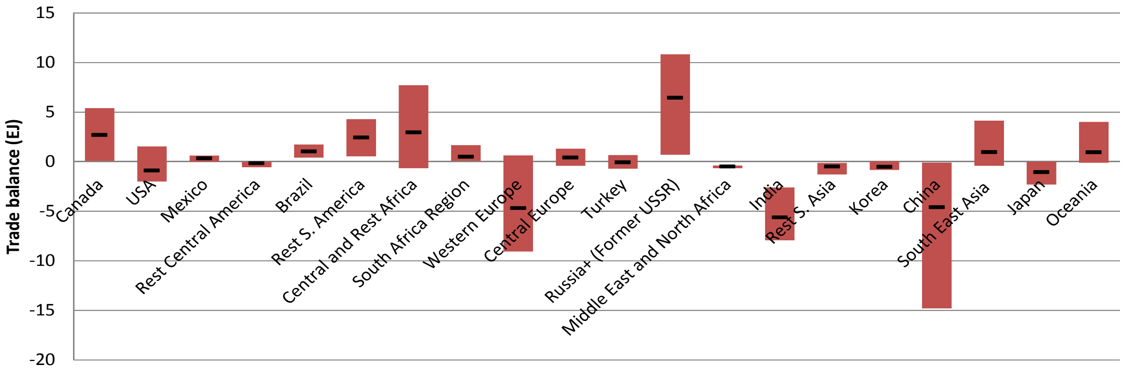


Abbildung 16 Vergleich ambitionierter Szenarien des internationalen Biomasse-Handels der Modelle POLES, IMASGE/TIMER und GFPM.

Aus dem Modellvergleich können zwei Schlüsse gezogen werden:

- Die verglichenen Modellergebnisse deuten darauf hin, dass die Relevanz zukünftigen Biomassehandel überschätzt werden könnten. Eine Erklärung dafür sind nicht ausreichend berücksichtigte Barrieren die der tatsächlichen Entwicklung entgegen stehen. Trifft das zu, so stellt sich die Frage wie sich die Szenrien verändern würden wenn Barrieren berücksichtig sind, bzw. welche Implikationen diese Erkenntnis für globale Energie- und TGH-Emissionszenarien haben.
- Die Modellergebnisse spiegeln die nötige Entwicklung des Biomassehandels wieder um regionales Angebot und Nachfrage von Bioenergie zusammen zu bringen. Ohne einen signifikanten Anstieg des Biomasse-Handels ist kein signifikantes Wachstum des Bioenergieanteils erreichbar. Folglich müssen gravierende Veränderungen hinsichtlich sozialer, ökologischer, technischer, logistischer und ökonomischer Aspekte des internationalen Biomasse-Handels bewirkt werden, oder Ziele für einen höheren Biomasse-Anteil müssen revidiert werden.

Die finalen Ergebnisse der Studie sind ab Mitte 2013 auf der IEA Bioenergy Task Webseite verfügbar.

5. DETAILANGABEN IN BEZUG AUF DIE FORSCHUNGSKOOPERATION INTERNATIONALE ENERGIE-AGENTUR (IEA)

Die internationale Kooperation mit den Teilnehmern des Task 40, findet insbesondere über die nationalen Teamleader statt, wobei die internationalen Taskmeetings den Rahmen für diese Kooperationen bilden und Analysen von aktuellen Entwicklungen und die Arbeit an gemeinsamen Projekten im Vordergrund stehen. Im Rahmen dieser Kooperationen sind mit österreichischer Unterstützung mehrere Arbeiten und Berichte realisiert worden.

Eine weitere wichtige Strategie für weitere Kooperationen und zur Verwertung und Verbreitung der Projektergebnisse ist die Teilnahme an internationalen Workshops und auch an Workshops auf EU-Ebene, die teilweise auch im Rahmen von Task 40 Meetings organisiert werden. Diese dienen neben dem Austausch von Daten und Erfahrungen auch zur Verbreitung der Ergebnisse.

Auf der nationalen Ebene erfolgt eine Kooperation mit den wichtigen österreichischen Akteuren aus Politik, Wissenschaft und Wirtschaft, aber auch mit NGOs. Im Rahmen von Workshops und Expertengesprächen wurde der Kontakt zu diesen nationalen Akteuren hergestellt. Besonders wichtig ist die Vernetzung mit den verschiedenen österreichischen Akteuren des internationalen Biomasse-Imports (z.B. Betreiber von Biokraftstoffanlagen etc.) und Exports (z.B. Produzenten von Pellets).

Im Dezember 2008 wurden mit der EU-Richtlinie zu Erneuerbaren Energien erstmals Nachhaltigkeitskriterien für Kraftstoffe aus regenerativer Biomasse eingeführt. Von der Umsetzung dieser Direktive sind auch österreichische Unternehmen von dieser Neuerung betroffen sein. In Expertengesprächen mit Produzenten von Biobrenn- und Kraftstoffen und Bioenergiehändlern wurden die Chancen und Probleme die sich aus dieser gesetzlichen Änderung ergeben haben analysiert. Wie die Vergangenheit gezeigt hat, sind diese Stakeholder stark an Informationen über internationale Entwicklungen interessiert. Eine intensive Kooperation innerhalb des Projektes hat auch mit der international agierenden EBES AG und dem Verein proPellets Austria stattgefunden.

Task 40 ist sehr gut mit einer Reihe weiterer IEA-Tasks vernetzt. In den letzten Jahren wurden sowohl gemeinsame Projekte als auch Workshops durchgeführt. Die Workshops dienen neben der Verbreitung und Verwertung der Ergebnisse auch der Diskussion mit relevanten anderen Stakeholdern sowie Akteurinnen und Akteuren. Beispielhaft seien hier die folgenden angeführt:

- iLUC-Workshop Brasilien: Dieser Workshop hat sich mit den direkten und inderekten Auswirkungen zusätzlicher Landnutzung durch die wachsende Nachfrage nach Biomasse auseinandergesetzt. Quantifizierung von Landnutzungsänderungen und Quantifizierungsmethoden sowie der Einfluss von Bioenergiesystemen auf THG Emissionen standen im Zentrum der Veranstaltung, die gemeinsam von Task 38, 40 und 43 durchgeführt wurde.
- Torrefaction ist eine Technlogie die zur Vorbehandlung von Biomasse um bessere Transport und Lagereigenschaften zu erreichen von Interesse ist. Gemeinsam mit Task 32 wurde im Rahmen der Mitteleuropäischen Biomassekonferenz in Graz ein international besetzer Workshop abgehalten.

- Certification: Ein Überblick auf erste Erfahrungen mit der Zertifizierung von Biomasseketten insbesondere anhand von Fallstudien und die Diskussion von Chancen und Barrieren stand im Fokus des Workshops, der gemeinsam mit EUBIONET III veranstaltet wurde.
- Biomethan-Handel: Biomethan hat den Vorteil auf eine bestehende Netz-Infrastruktur zurückreifen zu können. Die Kapazitäten zur Erzeugung von Biomethan wurden in der Vergangenheit ausgebaut, es ist zu erwarten, dass der Handel mit Biomethan zunehmen wird. Der Workshop fand im Zuge der Konferenz „Fuels of the Future" statt

Darstellung der österreichischen Zielgruppe, für die die Projektergebnisse relevant sind:
Es existiert eine Reihe unterschiedlicher Akteure, die im Zuge der Kooperations-, Vernetzungs- und Verbreitungsstrategie eingebunden wurden. Auf der nationalen Ebene ist eine Kooperation mit den wichtigen österreichischen Akteuren aus Politik, Wissenschaft und Wirtschaft, aber auch mit NGOs erfolgt. Im Folgenden wird ein kurzer Überblick über die wichtigsten österreichischen Akteure gegeben:

- Politische Entscheidungsträger und Energieagenturen, insbesondere: BMVIT, BMLFUW, BMWA, Austrian Energy Agency, Landesenergieagenturen, WIFO, Umweltbundesamt
- Industrie und Wirtschaft (z.B. Akteure des internationalen Biomasse-Imports und –Exports), OMV, AGIP Austria GmbH, EBES AG, Biodiesel Vienna, BDV, Biodiesel Krems GmbH, Biodiesel Zistersdorf GmbH, OÖ Biodiesel GmbH, Enns,
- Interessensvertretungen, Branchen- und Wirtschaftsvertreter: Wirtschaftskammer Österreich, ARGE Biokraft, Biomasse-Verband, Landwirtschaftskammer, Pro Pellets, Austropapier, die Vereinigung der österreichischen Papierindustrie, Forst Holz Papier, ARGE Kompost & Biogas Österreich, Austrian Biofuels Institute
- Wissenschaft: Bioenergy 2020+, BLT Josephinum, Joanneum Research, Institut für Energieforschung, Interdisciplinary Centre for Comparative Research in the Social Sciences (ICCR), IFA Tulln, Inst. Für Verbrennungskraftmaschinen, TU Wien, Institut für Politikwissenschaft, Universität Wien, Institut für Produktionswirtschaft und Logistik, BOKU Wien, Institut für Soziale Ökologie, IFF, Uni Klagenfurt
- NGOs, insbesondere: WWF, Greenpeace Österreich, Global 2000, Ökobüro, FIAN Österreich (Food First Information and Action Network), Fair-Trade, Klimabündnis Österreich,
- Stellen mit Erfahrung im Zertifizierungsbereich und Fair-Trade, insbesondere: Holzcert Austria, Österreichisches Normungsinstitut

Im Rahmen von Workshops und Expertengesprächen wurde der Kontakt zu nationalen Akteuren hergestellt. Besonderes Augenmerk wurde auf die Vernetzung mit den verschiedenen österreichischen Akteuren des internationalen Biomasse-Imports (z.B. Betreiber von Biotreibstoffanlagen etc.) gelegt.

6. SCHLUSSFOLGERUNGEN ZU DEN PROJEKTERGEBNISSEN

Durch die österreichische Mitwirkung und Beteiligung an IEA Bioenergy Task 40 seit Mitte 2008 konnte bereits wichtiges Know-how in Bezug auf internationalen Handel mit Biomasse, seine Bedeutung für Österreich und die Funktion von Bioenergiemärkten erworben und für österreichische Akteurinnen und Akteure nutzbar gemacht werden. Bioenergie hat bereits einen großen Stellenwert in Österreich, aber gerade mit Hinblick auf die weitere Steigerung des Anteils erneuerbarer Energie bis zum Jahr 2020 und darüber hinaus, wird die Bedeutung von Bioenergie weiter steigen.

Vor diesem Hintergrund bietet IEA Bioenergy Task 40 die Chance, gemeinsam mit internationalen Experten aus dem Bereich der Bioenergie, dieses komplexe und sehr dynamische Feld weiter und detaillierter zu erforschen. Durch eine objektive Herangehensweise an diese aktuellen Themen können Chancen aber auch Probleme die mit der Bioenergienutzung und dem Handel von Bioenergieprodukten einhergehen aufgezeigt werden. So können diese Forschungsergebnisse direkt in die energiepolitische Diskussion einfließen und als Grundlage für zukünftige Entscheidungen dienen.

Es kommt im Rahmen des Arbeitsprogramms immer wieder zur Bildung kleinerer Arbeitsgruppen, die sich wissenschaftlich mit aktuellen Entwicklungen auseinandersetzen und Arbeiten dazu verfassen. Kooperationen, vor allem im Hinblick auf die Erhebung der derzeitigen Situation in Österreich, hat es im „survey on the implementation of sustainability requirements for biofuels and bio-energy in the different member countries of Task 40“, im Zuge des Projektes „Biobench - Sustainability criteria for solid and gaseous biomass", zur Erhebung von Nachhaltigkeitskriterien für feste Biomasse sowie für die T40 Wood Chips Study gegeben. Ein von IEA Task 40 gefördertes Projekt, das es zum Ziel hat, ein Tool zur Modellierung des europäischen Biomasse Handels zu entwickeln („Development of a tool to model european biomass trade“), wurde gemeinsam mit der Universität Utrecht abgeschlossen.

Weiters ist ein von Task 40 gefördertes Kooperationsprojekt unter der Leitung der EEG/TUW und Beteiligung der Universität Utrecht sowie der Norwegian University of Life Sciences zu „Future perspectives of bioenergy trade“ derzeit in Bearbeitung und wird auch grundlegende Erkenntnisse für ein voraussichtlich Mitte 2013 erscheinendes „Bioernergy Trade Handbook“ liefern.

Die österreichische Bundesregierung hat sich im Bereich der Biokraftstoffe sehr ambitionierte Ziele gesteckt. Es ist klar, dass diese Ziele nicht allein mit heimischen Biomasse-Rohstoffen erreicht werden können. Importe werden in manchen Bereichen unabdingbar sein. Die Dokumentation und Analyse der derzeit und in Zukunft stark veränderten Marktbedingungen kommt daher große Bedeutung zu. Im Country Report Österreich wurde gezeigt dass ab 2005 Bioenergieträge für den österreichischen Markt importiert werden. Die Fragen, woher diese Rohstoffe importiert werden, welche ökologischen und sozialen Folgen damit verbunden sind, ist entscheidend für die gesamte Bilanz dieser Entwicklung und wird letztlich auch für die gesellschaftliche Akzeptanz der Bioenergie mitentscheidend sein.

Global sind derzeit rund 9% der Waldflächen bzw. 26% des Industrierundholzes von einem Zertifizierungssystem erfasst. Es existiert eine Vielzahl an Zertifizierungssystemen- und initiativen. Die mit Abstand bedeutendste Regulierung die den Nachweis der Nachhaltigkeit von Bioenergie im europäischen Raum betriff, ist die Erneuerbare Energien Richtline. Gemäß der EU RED (Renewable Energy Directive) muss die Rückverfolgbarkeit der zertifizierten Rohstoffe über die gesamte Lieferkette gewährleistet sein und damit auch jede Stufe der Wertschöpfungskette zertifiziert werden. Während des Projektzeitraums wurden verbindliche Nachhaltigkeitskriterien für flüssige Biobrennstoffe in nationales Recht überführt.

Auf internationaler und europäischer Ebene existieren zahlreichen freiwilligen Zertifizierungsinitiativen, deren Entwicklung im Rahmen von Task 40 beobachtet wird. In den nächsten Jahren wird es voraussichtlich zu einer Harmonisierung der unterschiedlichen Richtlinien kommen. Gemeinsame Standards nach ISO und CEN Norm sind derzeit in Ausarbeitung.

Die Zertifizierung nachhaltiger Biomasse-Ressourcen kann einen äußerst wertvollen Beitrag liefern, um die Nachhaltigkeit der Biomasse, auch für importierte Rohstoffe, zu garantieren. Es muss im Interesse Österreichs sein, hier auch zu einer nachhaltigen Entwicklung beizutragen und eine Zertifizierung von Biomasse-Rohstoffen und –Produkten zu implementieren. Durch diese Entwicklung wird es immer wichtiger das Verständnis von Biomasse-Handels-Systemen zu verbessern und das Know-how über Zertifizierung, auch in wissenschaftlicher Hinsicht, zu erhöhen. Die Etablierung entsprechender Analysen aus Österreich in der internationalen Szene stärkt dadurch auch das energiewirtschaftliche Forschungsgebiet in Österreich.

Unabhängige internationale Expertennetzwerke wie IEA Bioenergy Task 40 spielen aufgrund ihrer Glaubwürdigkeit und umfassenden Expertise dabei eine besonders wichtige Rolle. Die Dauerhaftigkeit und Regelmäßigkeit der IEA Plattform hat dabei einen besonderen Wert dargestellt und hat das Potential die Kontakte und Netzwerke zwischen heimischen und internationalen Experten bzw. Expertenorganisationen zu langfristig zu verstärken.

7. AUSBLICK UND EMPFEHLUNGEN

Task 40 setzt sich mit den aktuellen Problemen und Fragestellungen die mit der Nutzung und dem internationalen Handel von Bioenergie einhergehen auseinander und sucht Lösungen und Ansätze zur nachhaltigen Gestaltung der Bioenergiesysteme.

Grundlage für diese Untersuchungen bilden Daten über lokale und globale Biomassepotentiale, Biomassepreise, Import- und Exportaktivitäten, Transportsysteme und Logistik etc…

Auch wenn durch die Arbeit von Task 40 die Datenlage bereits erheblich verbessert werden konnte, bedarf es auch in Zukunft weiterer Anstrengungen, um die Komplexität und die Dynamik von Bioenergiemärkten noch genauer analysieren zu können.

Die Task 40 Mitglieder und externe Partner haben signifikante Fortschritte in der Entwicklung in der Modellbildung erzielt um einen besseren Einblick in die Verfügbarkeit von Biomasse, nötigem Design von Infrastruktur und quantitativen Assessment von Impacts politischer Maßnahmen (Förderungsschemen, Ziele, Nachhaltigkeitskriterien) einschließlich Bottom-up Modelle sowie makroökonomische Modelle. Der Modellierung von Angebot und Nachfrage in den Weltregionen kommt weiterhin eine zentrale Rolle zu.

Zukünftige Entwicklungsschwerpunkte, die sich aus der bisherigen österreichischen Teilnahme am Task in den vergangenen Jahren ableiten, werden insbesondere in einer weiteren Beobachtung der Entwicklung von sowohl freiwilliger als auch für Österreich verbindlicher Nachhaltigkeitskriterien gesehen. Task 40 hatte bisher einen gewichtigen Einfluss auf die internationale Diskussion von Nachhaltigkeitskriterien und strebt an, weiterhin ein wichtiger Akteur in diesem Feld zu sein. Verstärkt wird eine 1) weitere Harmonisierung der Zertifizierungssysteme 2) effiziente und effektive Einbeziehung neuer Märkte und 3) Analyse des Einflusses von Ernährungssicherheit und iLUC, etc. auf die Entwicklung der Biomasse Märkte ein zukünftiger Fokus der Arbeit sein müssen.

Zweitens wird der Betrachtung des Bio-Methan-Handels im Vergleich zur Analyse fester und flüssiger Biomasse bisher noch wenig Beachtung geschenkt. Biomethan hat den Vorteil auf eine bestehende Netz-Infrastruktur zurückreifen zu können. Die Kapazitäten zur Erzeugung von Biomethan wurden in der Vergangenheit ausgebaut, es ist zu erwarten, dass der Handel mit Biomethan zunehmen wird. In Zukunft könnten auch für gasförmige Biobrennstoffe verbindliche Bilanzierungsmethoden eingeführt werden.

Drittens werden Bereiche der Bio-Based-economy weiter an Bedeutung gewinnen. Es ist von wachsender Bedeutung internationales Know-How zu Entwicklungen ein diesem Bereich für Österreich zu sichern, internationale Stoffströme zu analysieren und innovative Produkte aus fester und aquatischer Biomasse, die in den nächsten Jahren auf kommerzieller Eben produziert werden können, zu identifizieren und deren möglichen Einfluss auf die Entwicklung an österreichischen Bioenergie-Märkten abzuschätzen.

Viertens ist in den nächsten Jahren eine stärkere Entwicklung von Bioenergieträgern auf internationalen Märkten hin zu einfacher handelbaren Commodities zu erkennen. Dazu zählen Anforderungen um aus Biomasse und Biotreibstoffen handelbare Güter zu machen sowie das Monitoring der Entwicklungen auf wichtigen Terminmärkten und nötiger Bedingen um eine gute Handelbarkeit von Biotreibstoffen, als auch Biomasse zu erzielen. Generell auch um ein Mobilisierung von nachhaltiger Biomasse für die internationalen Märkte in verschiedenen Weltregionen und vielversprechende Regionen (beispielsweise Russland, Kolumbien, Länder in Süd-Ost Afrika) zu befördern.

Aus der österreichischen Beteiligung an Task40 haben sich bereits gemeinsame FP7 Projekte sowie Projekte für die Europäische Kommission ergeben. Es ist damit zu rechnen, dass auch in Zukunft die gute Zusammenarbeit mit den Task-Mitgliedern zu einer fruchtbringenden Verwertung und Kooperation führt.

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ANHANG A

ENDBERICHT „IEA BIOENERGY TASK 40 - COUNTRY REPORT FOR AUSTRIA 2011"

TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Energy Economics Group

IEA BIOENERGY – TASK 40

Sustainable International Bioenergy Trade: Securing supply and demand

Country Report: Austria 2011

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November 2011

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Vienna, November 2011

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1 Introduction

Austria is a small country located in Central Europe with a population of 8.28 million (Statistik Austria, 2011a). It borders both Germany and the Czech Republic to the north, Slovakia and Hungary to the east, Slovenia and Italy to the south, and Switzerland and Liechtenstein to the west. Austria's terrain is highly mountainous and the weather conditions are characterized by a temperate and alpine climate.

The territory of Austria covers 84,000 km² (8.4 million ha). According to the latest forest inventory (BFW, 2011), 4 million ha (47.6% of Austria) are covered with forest. The total agricultural area is about 3.2 million ha; arable land accounts for 1.375 million ha and 1.8 million ha are grass land (approximately half of it is used extensively).

Austria's gross domestic product was € 284.4 bn in 2010 (Statistik Austria, 2011b). GDP per inhabitant amounted to about € 33.900.

1.1 Greenhouse gas emissions and greenhouse gas reduction requirements

The Kyoto Protocol stipulates a reduction of greenhouse gases (GHG) of the European Community by around 8% against the levels of 1990 over the commitment period 2008 to 2012. Austria's national target is a reduction of 13%.

Figure 1 shows the historic development of GHG emissions from 1990 to 2009 as well as the national "Kyoto target" of 68.8 million tons CO_2-equivalent (Mt CO_2-equ). In 2009 the GHG emissions were 2.6% higher than in the base year 1990. The main reason for this increase was a steep rise in energy consumption in the transport sector, which resulted in an increase in emissions of more than 50%. The emissions of the industry and manufacturing sector showed an increase of 6%, whereas the emissions in the other sectors declined.

Apparently, the GHG emissions in 2008 and 2009 were clearly than the target value (26% in 2008 and 17% in 2009). However, the emissions in 2009 were only 2% above the target for 2010 according to the Austrian Climate Strategy (see BMLFUW, 2007) which was passed by the council of ministers in 2007. According to the Climate Strategy, an average of 9 Mt CO_2-equ of emission permits per year should be acquired through "flexibility mechanisms" (Joint Implementation and Clean Development Mechanism) and 0.7 Mt CO_2-equ through afforestation and reforestation during the commitment period.

According to the European Union's climate and energy package, which was adopted in December 2008 (Directive 2009/28/EC; European Commission, 2009a), the EU intends to reduce its GHG emissions until 2020 by 20% compared to the reference year 1990. Apart from that, the contribution of renewable energy sources should account for 20% in the gross final energy consumption in 2020, and energy efficiency should be increased by 20% compared to a Business-as-usual scenario.

With regard to Austria's GHG emissions the package includes the following elements (cp.Schneider et al., 2011):

- *Reduction of GHG emissions until 2020 (effort sharing concerning the Member States' emissions).*

Austria is obliged to reduce the GHG emissions which are from not covered by the European Union Emission Trading Scheme (EU ETS) by 16% from 2005 to 2020. In the year 2005, Austria's total GHG emissions accounted for 92.8 Mt CO_2-equ. About one third (33.4 Mt CO_2-equ) was caused by facilities covered by the EU ETS. A reduction by 13% corresponds to a maximum permitted emission level of 50 Mt CO_2-equ for sources not covered by the EU ETS.

- *Amendment to the EU ETS after 2012.*
  According to the climate and energy package, the reduction of GHG emissions intended within the EU ETS until 2020 is minus 21% compared to the reference year 2005. The proposed amendments for the third trading period from 2013 to 2020 include a centralized allocation of emission allowances (no more National Allocation Plans), the inclusion of other greenhouse gases (N_2O and perfluorocarbons) and air traffic.

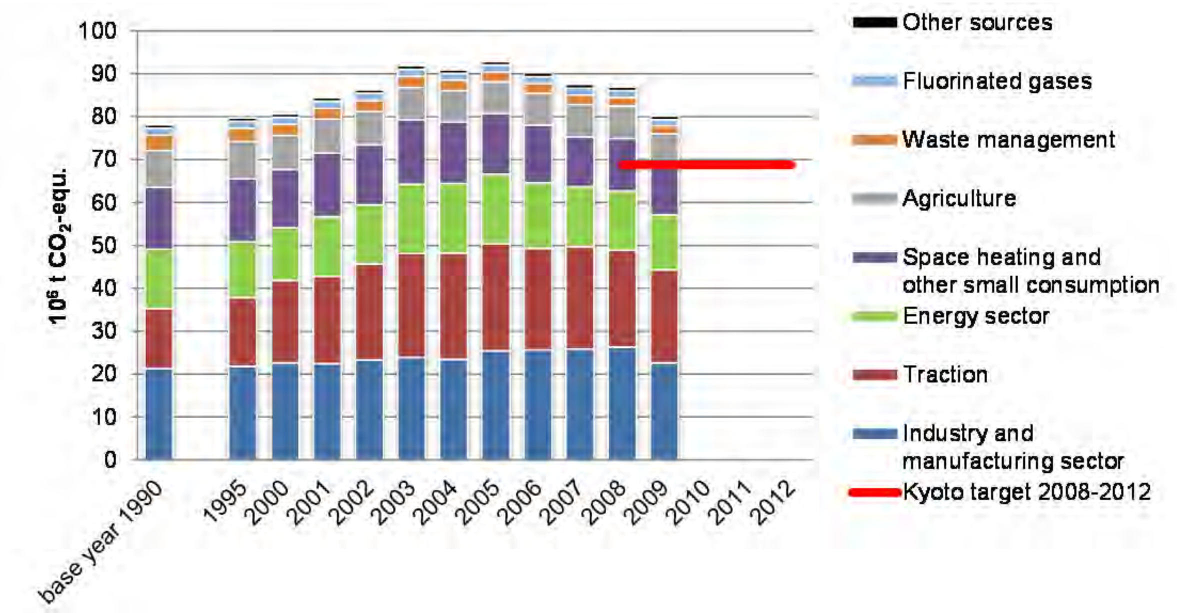


Figure 1. Greenhouse gas emissions from 1990 to 2009 compared to the national Kyoto target.
Source: Schneider et al. (2011)

1.2 Energy supply and demand

Table 1 gives an overview of the Austrian energy balances during the period 1970 to 2010. Whereas the indigenous production of primary fuels, which is dominated by renewable energy sources, has increased by 32% from 1970 to 2010, the net imports (defined as imports minus exports) have almost doubled. The gross inland consumption increased by 70% and the final energy consumption by 86%.

Table 1. Overall energy balances for the period 1970 to 2010 in Terajoule.
Source: Statistik Austria (2011c)

TJ	1970	1980	1990	2000	2005	2010
Indigenous production of primary energy	366,230	333,443	341,097	412,206	418,927	501,832
Imports	485,154	735,861	775,749	925,951	1,241,027	1,243,711
Stock rotation	-23,970	-45,165	-13,478	11,585	232	57,962
Exports	30,568	33,492	51,174	125,265	206,540	345,843
Gross inland consumption	796,846	990,647	1,052,193	1,224,477	1,453,645	1,457,662
Final energy consumtion	567,233	701,433	766,509	941,289	1,104,979	1,119,154

1.2.1 Primary energy

Fig. 2 shows the development and the structure of the gross inland consumption from 1970 to 2010. It increased from about 800 PJ in 1970 to 1,456 PJ in 2005. After the year 2005, the annual gross inland consumption declined by about 100 PJ to 1,354 PJ in 2009. In 2010, the consumption reached an all-time high of 1,458 PJ.

Fig. 2 also shows the development of the share of renewable energy sources as well as of biomass and renewable waste in the total primary energy consumption. The latter increased from about 10% in 2004 to 15.5% in 2010. A similar increase by approximately 5% occurred during the period 1978 to 1985. The share of all renewable energy sources is characterized by significant fluctuations, which are due to the high share of hydropower in Austria's electricity supply (see section 1.2.3). In 2010, renewable energy sources accounted for 26.4% of the total gross energy consumption.

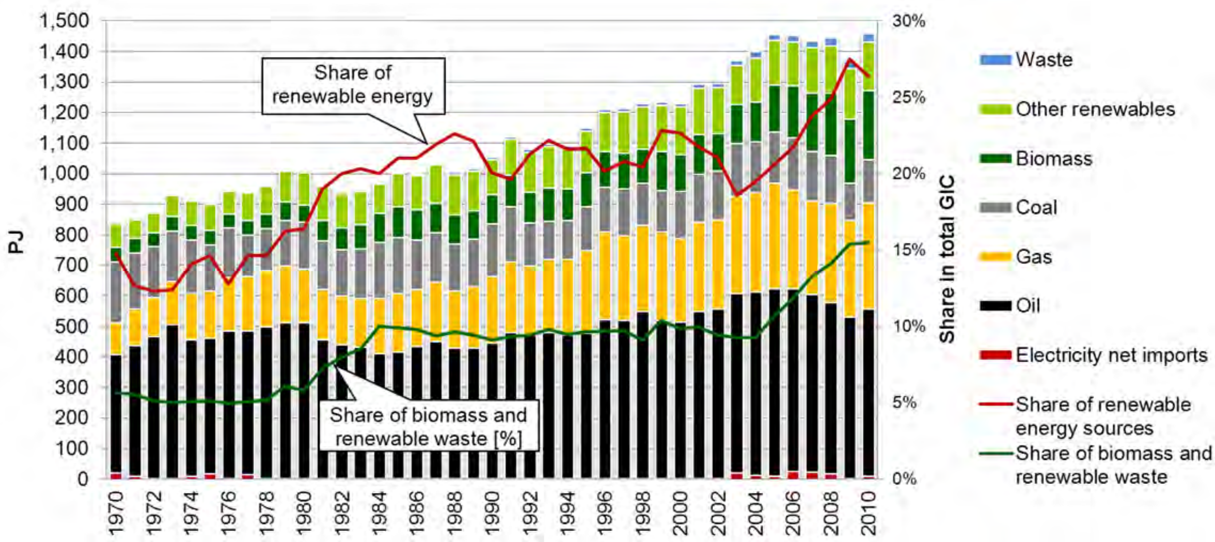


Figure 2. Development of the gross inland consumption of energy in Austria.
(Waste includes renewable as well as non-renewable fractions; other renewables include biomass, renewable waste, hydro power, wind, ambient energy, photovoltaic etc.)
Source: Statistik Austria (2011c)

The development of the indigenous primary energy production in the last four decades was characterized by a decline of oil and coal (the production of lignite was stopped in 2005), as well as a significant increase in renewable energy production, as Fig. 3 illustrates. Today, more than 70% of the indigenous primary energy production is based on renewable energy sources, with biomass accounting for more than 50% of all renewables.

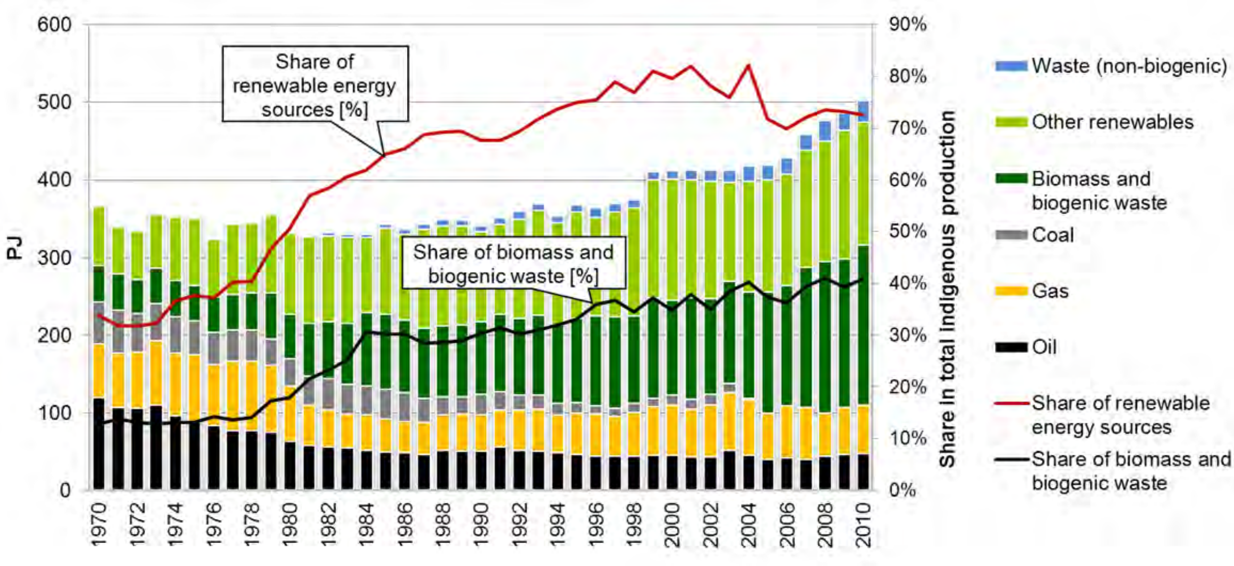


Figure 3. Development of the indigenous primary energy production from 1970 to 2010. Source: Statistik Austria (2011c)

Fig. 4 provides a more detailed illustration of the renewable energy production in Austria. It has increased from between 100 and 150 PJ in the 1970ies to about 364 PJ in 2010. The main increase during the last two decades was achieved with biogenic fuels, which includes different wood fuels (with the exception of wood log which is stated separately), waste liquor of the paper and pulp industry (black liquor), biofuels for transport, biogas and other solid, liquid or gaseous fuels of biogenic origin. Detailed data on the structure of “biogenic fuels” are available for the years 2005 to 2010. Apparently, wood waste (including wood-processing residues like wood chips, sawdust etc.) and black liquor are the most significant fractions, which is due to the large wood-processing and paper and pulp industry in Austria.

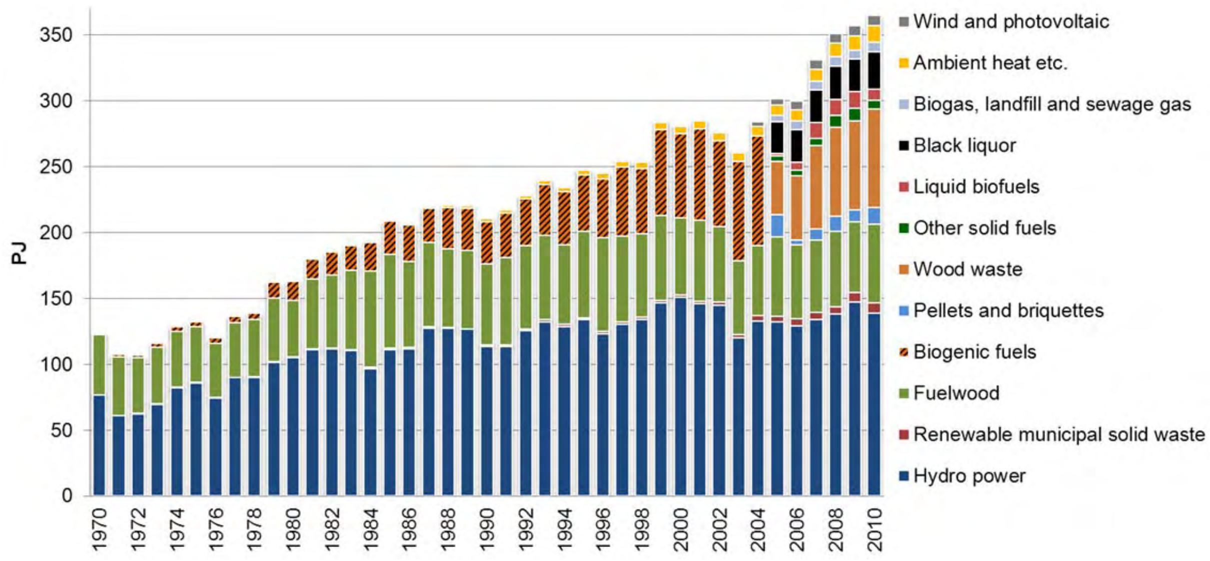


Figure 4. Development of the indigenous production of renewable energy in Austria.
Source: Statistik Austria (2011c)

1.2.2 Structure of energy consumption

In Fig. 5 the development of final energy consumption from 1970 to 2010 is shown broken down by sectors. During the considered period, the share of traction in the total energy consumption has increased from 20% to 33%, whereas the shares of industry, private households and agriculture have declined from 35%, 31% and 5.5% to 28%, 26% and 2.1%, respectively.

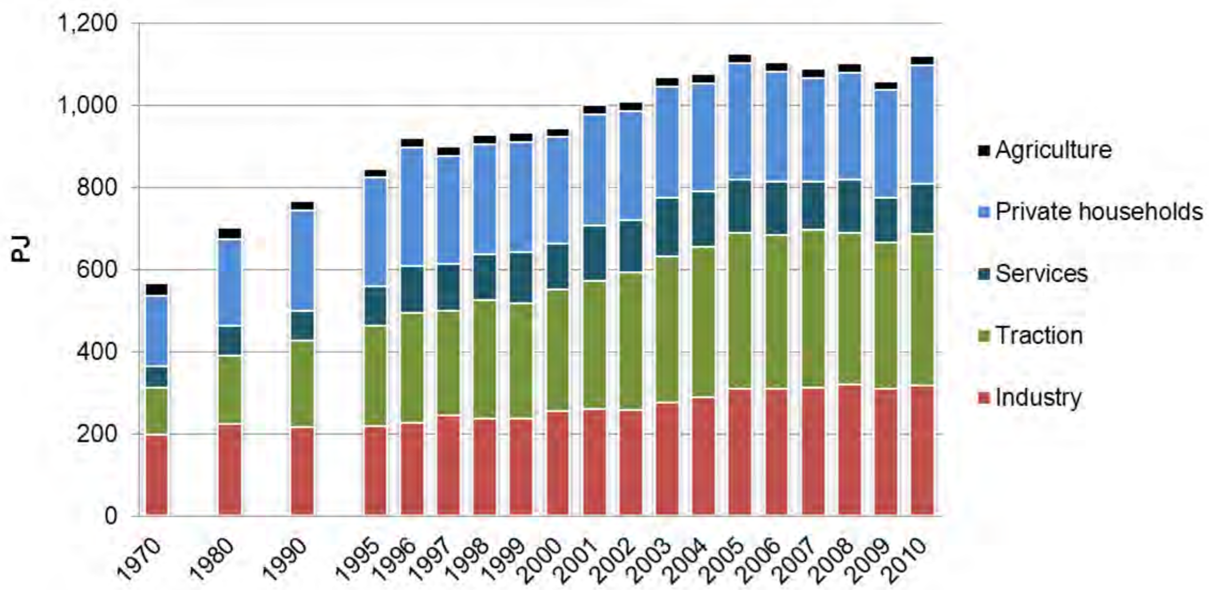


Figure 5. Development of the final energy use broken down by economic sectors.
Source: Statistik Austria (2011c)

Fig. 6 shows the structure of the final energy consumption in 2009 broken down by energy source and purposes, based on the "Useful Energy Survey 2005" (Statistik Austria, 2011d). "Space heating and air conditioning" comprises low-temperature space and water heating as well as air conditioning in buildings, "vapor production" industrial and commercial heat generation and process heat, and “industrial furnaces” industrial and commercial facilities, reaching from small bakery ovens to large blast furnaces. The category “stationary engines” includes the final energy consumption of all kinds of engines which are not used for mobility, reaching from small engines in household appliances to large engines in industrial production processes. “Traction” comprises road transport as well as rail, air and marine traffic. Further categories are “lighting and computing” and “electrochemical purposes”, which is not shown in Fig.6 due to its negligible importance (0.3 PJ of electricity in 2009).

With regard to the structure of energy sources used for the different purposes, it is obvious that both in low- and high-temperature heat applications, a wider variety of energy sources is used than in the other categories, where electrical energy (stationary engines; lighting and computing) and oil (traction) are dominant. Furthermore, the share of renewable energy sources in heat generation is relatively high. They account for more than one fourth of the total energy consumption for low- as well as for high-temperature heat generation, as Fig.6 illustrates (with the share of electrical energy and district heating from renewable sources not included – see sections 1.2.3 and 1.2.4).

Apparently, biomass is most relevant in the categories “space heating and air conditioning” and “steam production”. The latter includes biomass consumption in the wood-processing industries, which are very large industries in relation to the size of the country. Especially the paper and pulp industry is a major consumer of biomass (primarily in the form of waste liquor, but also wood residues and bark). The sawmill industry supplies large quantities of byproducts like sawdust and wood chips, which are demanded by the paper, pulp and panelboard industries as well as used for energetic purposes, partly in the form of wood pellets (see chapter 5).

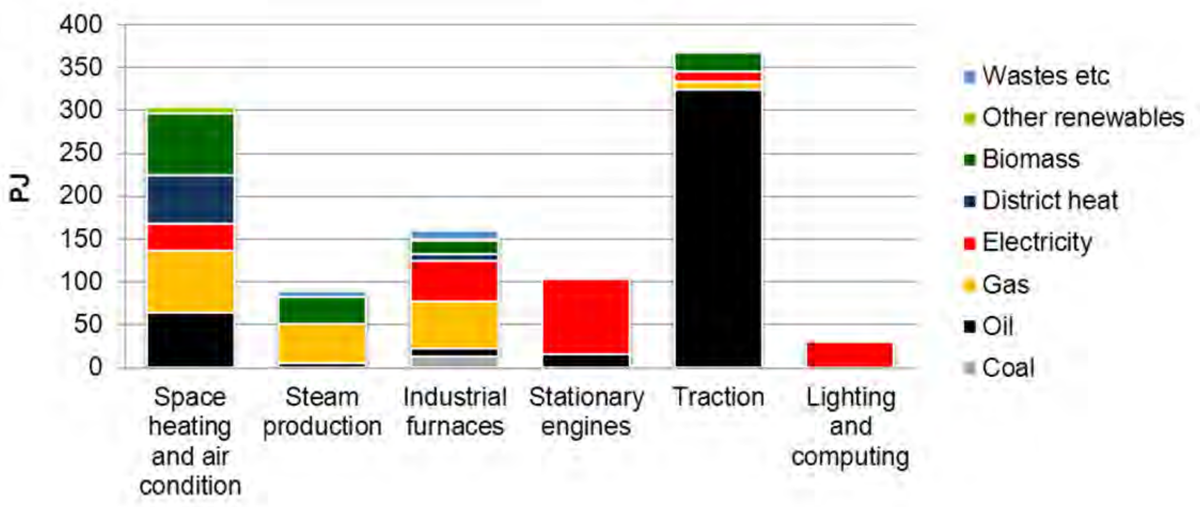


Figure 6. Useful energy consumption in 2009 broken down by energy sources and purposes.
Source: Statistik Austria (2011d)

1.2.3 Electricity

Electricity generation in Austria is primarily based on hydro power (see Fig. 7). Its average share in the gross electricity consumption (defined as the final energy consumption of electricity plus transport losses and energy sector use) was 74% during 1970 to 2000 and 64% during 2001 to 2010. Due to increasing electricity production from other renewable energy sources in recent years, the total share of renewables in the gross electricity consumption amounted to 70.5% in 2009. In 2010 it declined to 64.2%. With a share of 6.5% in 2010, biomass (including biogenic waste) is the second most important renewable energy source for electricity in Austria.

Fossil fuel-based electricity generation is dominated by natural gas. Whereas the contribution of coal and oil has declined from 13 and 6% in 1970 to 7 and 2% in 2010, the share of natural gas-based electricity generation has increased from 15 to 23% during the considered period.

The average annual growth rate of electricity consumption during 1970 to 2010 was as high as 2.7%. Hence, the gross electricity consumption has increased from about 90 PJ in 1970 to 253 PJ in 2010.

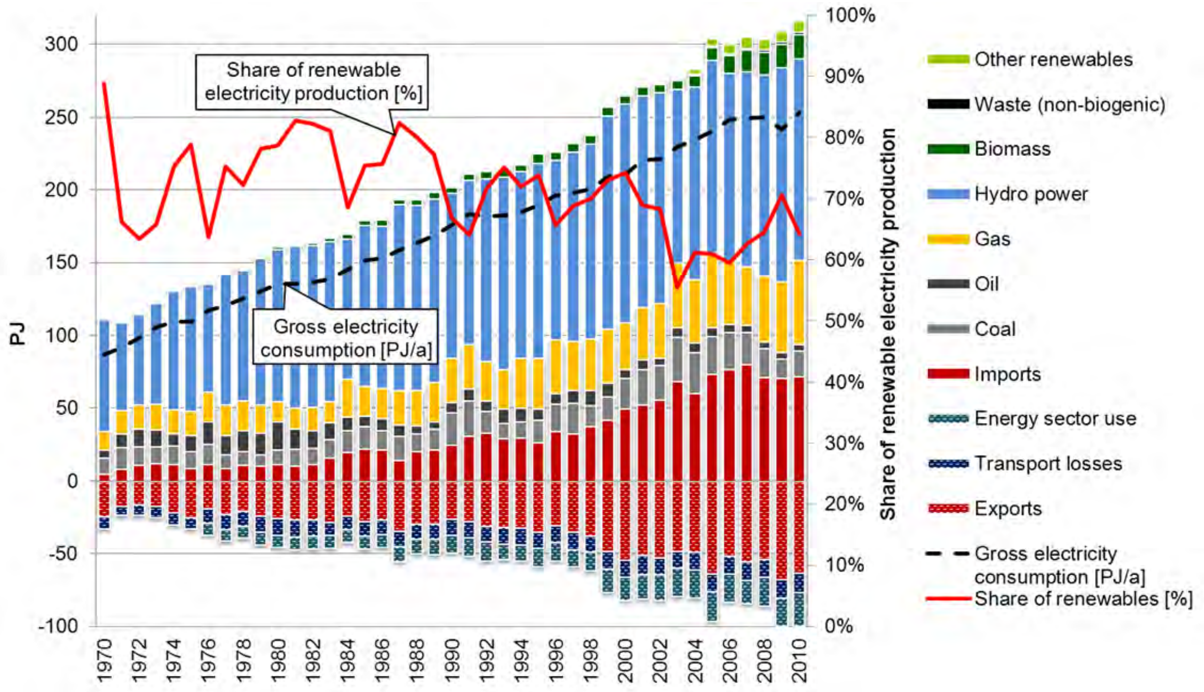


Figure 7. Development of electricity production and consumption and of the share of renewable electricity production.
Source: Statistik Austria (2011c)

1.2.4 District heat

As shown in Fig. 6, about one fifth of the useful energy supply in the category "Space heating and air conditioning" in Austria originates from district heating. Fig. 8 shows the historic development of district heat production broken down by plant types (CHP and heat plants) and primary energy carriers used. From 1970 to 2010, the annual production of district heat has increased from about 5 to 70 PJ. Natural gas-fired CHP plants account for the largest share of district heat production (28% in 2010). In recent years the contribution of biomass CHP plants to the district heat supply has risen rapidly, and currently accounts for about 21%. A notable diffusion of biomass heat plants already started in the early 1990ies but growth rates have been clearly lower than in the case of biomass CHP. In 2010 biomass heat plants accounted for 16% of the total district heat supply.

Fig. 8 also illustrates that the total contribution of biogenic energy carriers (biomass and biogenic waste) for district heat production has increased from less than 10% in the early 1990ies to more than 35% in recent years.

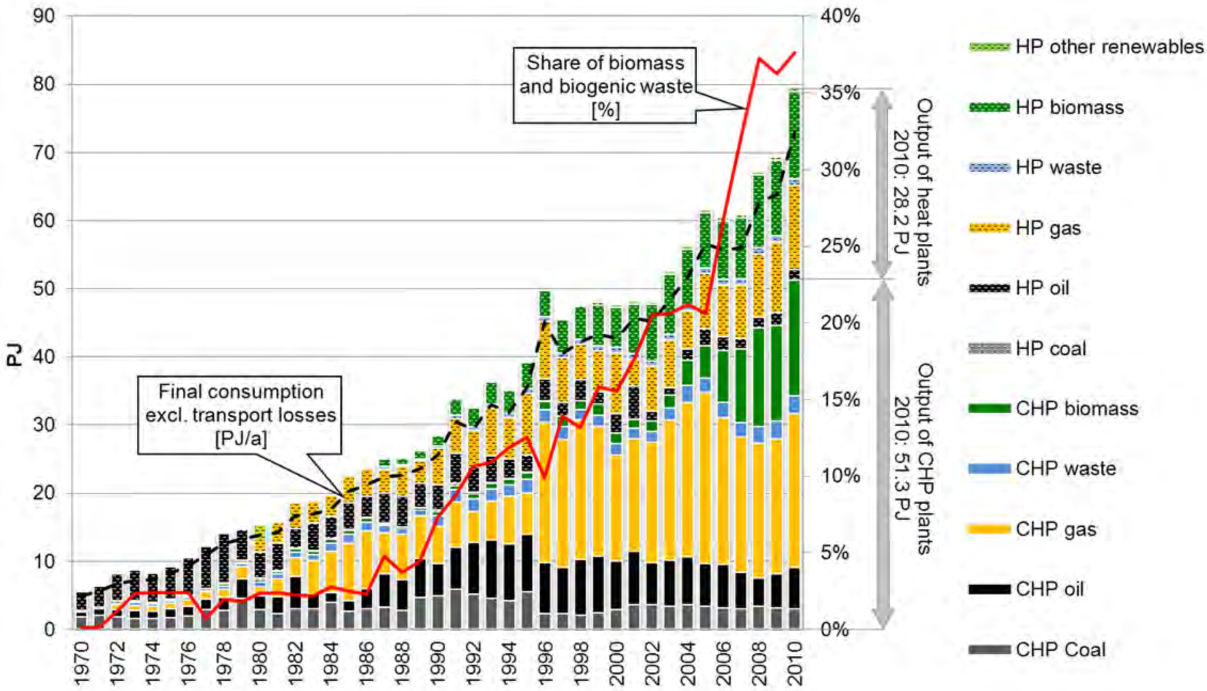


Figure 8. Development of district heat production broken down by CHP- and heat plants (HP) and fuels.
Source: Statistik Austria (2011c)

1.2.5 Transport

As already shown above, the increasing energy consumption in the transport sector was the main reason for the rising overall final energy consumption in Austria. As Fig. 9 shows, the annual consumption of diesel has increased more than twofold since the early 1990ies and currently accounts for 62% of the total energy consumption for transport. Gasoline, accounting for 21% in 2010, is the second most important energy carrier, and the rest is made up by kerosene, biofuels and electricity. The contribution of natural gas and coal is negligible.

Due to obligations to blend increasing quantities of biofuels into fossil diesel and gasoline, the share of biofuels in the transport sector has increased from almost zero until 2004 to 6% in 2009. In 2010 it declined to 5.6%. (The share of biofuels in road transport fuel consumption was 7% in 2009.)

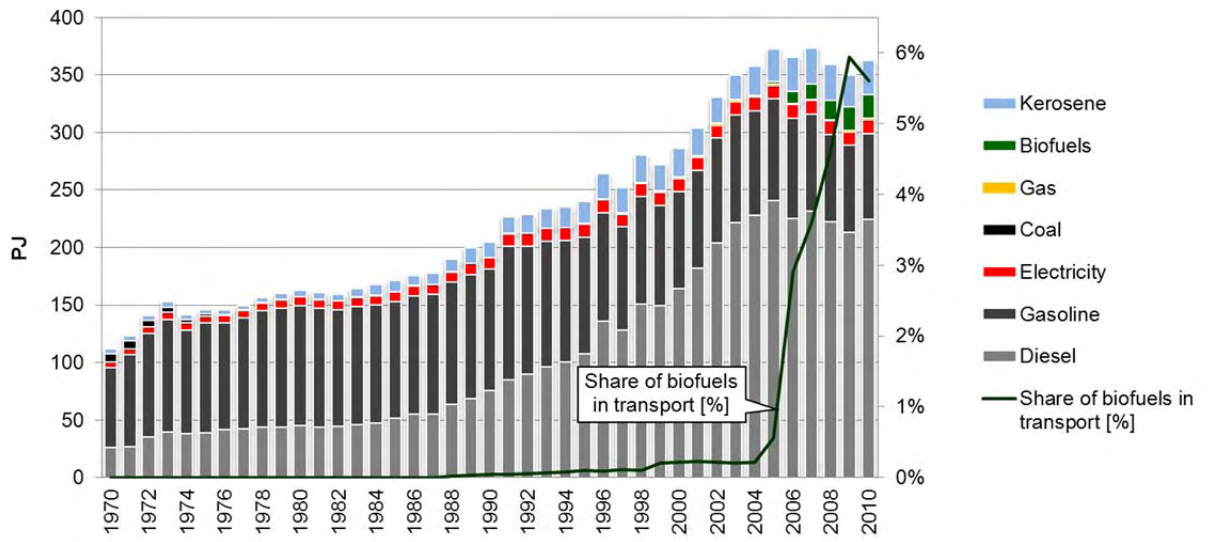


Figure 9. Development of energy consumption for transport and of the share of biofuels.
Source: Statistik Austria (2011c)

1.2.6 Space heat and hot water preparation

Despite highly dynamic developments in the field of biofuels for transport and power generation with biomass in recent years, space heat and hot water preparation is still the most significant form of biomass use in Austria. Fig. 10 shows the development of residential heat generation in Austria from 1970 to 2008.

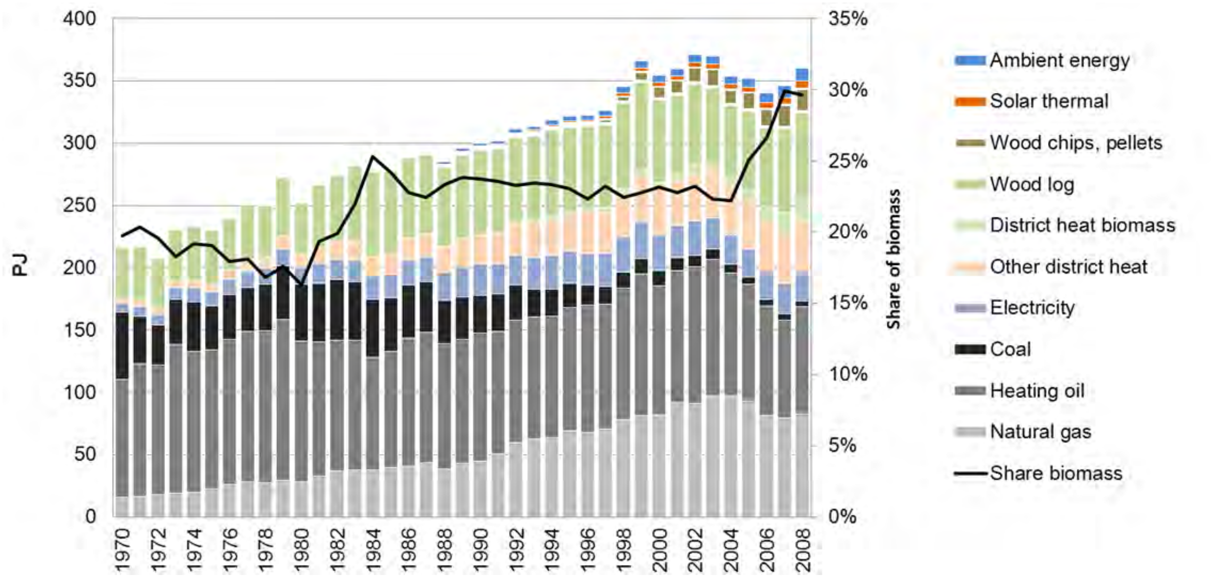


Figure 10. Final energy consumption for space and water heating from 1970 to 2008.
(Data are adjusted for heating degree days)
Source: Müller et al. (2010)

Whereas biomass-based residential heating was traditionally dominated by single stoves, the importance of modern biomass heating systems has been increasing steadily since the 1980ies. During the years 1980 to 1984, the market share of biomass-based heating systems increased from 16 to 25%. From 1985 to 2000, low prices for fossil fuels resulted in an increasing importance of oil and gas systems. However, biomass was increasingly used for district heating during this period (as shown in sections 1.2.4 and 5.3.2). Due to an increasing total consumption, the share of biomass remained relatively stable at about 23% during 1985 to 2004. The following years were characterized by a rapid diffusion of pellet and wood chip heating systems, resulting in a biomass share in this sector of about 30% in 2008.

2 Policy

2.1 National targets and measures to stimulate RES

Due to the “RES directive” (RES: renewable energy sources) (European Commission, 2009a), Austria is obliged to increase its share of renewables on the total gross final energy consumption until 2020 to 34% and at the same time decrease the GHG emissions in those sectors which are not part of the ETS until 2020 by 16%. In the 2005 base year the share of renewables was 24.4% and has increased by 2010 to 30.8%. The implementation of the directive for achieving the renewables target of 34% is a dynamic process, which is mainly determined through the transposition measures of the Energy Strategy Austria (BMWFJ & BMLFUW, 2010) to be implemented by the Austrian Federal Government.

Moreover, of course the European target of 10% RES share in the transport sector also holds for Austria. The RES-E target to be achieved by Austria in 2010 (due to the RES-E directive from 2001 which will be replaced by the RES directive) is 78% of gross electricity consumption.

Table 2. Overview of policies and measures to promote the use of energy from biomass. Source: adopted from Karner et al. (2010)

Name of the measure	Content	Target group	Timeframe	Relevance
Austrian Energy Strategy - proposals for measure	Strategic focus on a future energy and climate policy	Public, Administration	Implementation planned, continuous updating	Overall strategy
Environmental Measures Support Act	Support for operational measures for environmental protection	End-user	since 1993, amended 2009	Regulatory
Environmental support in the inland	Support for renewable energy systems	End-user	since 1993	Most important instrument for environment and climate related investment support
Agreement acc. Art.15a B-VG	Harmonisation between state and counties for renewable energy measures in the building sector	End-user	since 2009	support of renewable energy for domestic heat supply
Austrian Programme for development of rural areas (ÖPUL)	Defines targets, criteria and indicators granting financial support for measures beyond the minimum egal	Landowners, Farmers	2007-2013	A distinction between biomass for energy or other purposes is not made.
Biofuels Directive	Obligation to blend in biofuels	Mineral Oil Industry	Since 2004	stepwise increase in biofuel quota
Law on the taxation of mineral oils	Tax reduction for biogenic fuels	End-user	since 2007	incentive to increase the use of biogenic fuels
5-point action plan for natural and biogas	Fostering biogas as fuel, infrastructure development	End-user	2005-2010	aims to increase biogas use
Green Electricity Act	Support scheme for green electricity	Producer	since 2002, several amendments	Instrument to support specific renewable energy technologies

2.1.1 Energy Strategy Austria

To reach the 2020 targets in June 2009 the Austrian federal ministry of economy, family and youth and the ministry of agriculture, forestry, environment and water management initiated the policy process "Energy Strategy Austria" (BMWFJ & BMLFUW, 2010). The strategy is considered a staring point for a long-term development. Propositions for measures were presented in March 2010.

The objective of the Austrian Energy Strategy is to develop a sustainable energy system which makes energy services available for private consumption as well as for businesses in the future whilst implementing EU rules. Security of supply, environmental compatibility, cost effectiveness, social compatibility and competitiveness have been fixed as core objectives. An important element is the stabilization of final energy consumption at 1,100 PJ/a.

With respect to biomass the strategy aims to further increase electricity and heat co-generation. In accordance with EU directive COM(2008)19, subsidies for domestic heat supply are only to be granted if a minimum conversion efficiency of 85% is reached.

Biogas shall be fostered in all segments of use (electricity generation, biogenic fuel, heat generation) through demand side instruments and investments subsidies.

2.1.2 Environmental Measures Support Act and Environmental Support in the Inland

The Environmental Measures Support Act (Umweltförderungsgesetz) 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; UFI). Specific criteria have to be met in order to apply for investment subsidies for renewable energy systems. Generally up to 30% of investment costs for biomass based systems can be covered.

Support within the scope of the UFI is directed primarily at Austrian companies; individuals may also apply for support if a commercial activity is consistent with the specific application. Kommunalkredit Public Consulting (KPC) is entrusted with the practical development of support programmes. For biomass the technology groups are classified as follows:

- individual biomass units up to 400 kW_{th},
- individual biomass units from 400 kW_{th},
- biomass CHP,
- biomass microgrids,
- local biomass heating.

Individual biomass units up to 400 $kW_{thermal}$

Additional costs (e.g. boiler house, wood chip silos, chipping machine, etc.) are supported for individual biomass units up to 400 kW power, automatically stocked biomass combustion plants or log wood boilers in central heating systems for operational purposes (business, club house, etc.) as well as associated with the measure. Natural and legal persons who are in business and not supported under other support systems, particularly construction and agricultural support, religious bodies and non-profit associations of public authorities in the form of a company with marketdriven practices may apply for this support. The support is calculated with a flat rate of €120 per kW for 0 up to 50 kW and €60 per kW for each additional kW to a maximum of 400 kW. Support is limited to a maximum of 30% of the total environment-relevant investment costs. The support is granted as de minimis aid. A basic prerequisite for the support is that the request be submitted after implementation, however not exceeding six months after accounting.

Individual biomass units from 400 $kW_{thermal}$
Additional costs (e.g. boiler house, wood chip silos, chipping machine, etc.) are supported for the measure supporting individual biomass units up to 400 kW power, automatically stocked biomass combustion plants or log wood boilers in central heating systems for operational purposes (business, club house, etc.) as well as associated with the measure. Natural and legal persons who are in business and not supported under other support systems, particularly construction and agricultural support, religious bodies and non-profit associations of public authorities in the form of a company with market-driven practices may apply for this support. The standard reimbursement rate amounts to 20% of the environment-related investment costs and can be increased through awards (sustainability and gas condensation awards) to a maximum of 30%. The application must take place before the project begins. The environment-related investment costs must amount to a minimum of € 10,000 and limit values for dust and NO_x must always be observed and verified by measuring experts after implementation.

Biomass microgrids
Biomass microgrids for small-scale or internal heat supply are financially supported with this support (i.e. biomass combustion plants, primary heat conduction grid, and heat transfer stations). First and foremost, all natural and legal persons who are in business and not supported under other support systems, particularly housing and agricultural support, religious bodies and non-profit associations of public authorities in the form of a company with market-driven practices, may apply for this support for biomass microgrids. The standard reimbursement rate amounts to 25% of the environment-related investment costs and can be increased through awards (sustainability and gas condensation awards) to a maximum of 30%. In addition, a prerequisite for support is that the application must be made before the project begins and that environment-related investment costs must lie between €10,000 and a maximum of €200,000. Furthermore, the limit value for dust and NO_x must always be observed and verified by experts after implementation.

Local biomass heating
The following measures in particular are supported with the promotion of specific local biomass heating: Central heating including machine installation, storage and heat distribution network for heating supply over a wide area; measures to increase resource efficiency (e.g. fuel drying, gas condensation, buffer storage) and increase energy efficiency for energy production. Natural and legal persons who are in business and not supported under other support systems, particularly agricultural support, religious bodies and non-profit associations of public facilities in the form of a company with market-driven practices may apply for this support. The standard reimbursement rate amounts to 25% of the environment-related investment costs and can be increased through awards (sustainability and gas condensation awards) to a maximum of 30%. A prerequisite is that the application be made before the project begins and that environment-related investment costs amount to a minimum of € 10,000. Milestones I and II of the “QM-Heizwerke” quality management system must, if necessary, be completed before construction begins and the limit values for dust and NO_x, grid losses and heat allocation must be observed.

2.1.3 Agreement under Article 15a B-VG (2009)

While renewable energy measures are promoted in industrial and commercial buildings mainly at federal level through the UFG (environmental measures support act), the development of the legislation and RE measures for residential buildings is largely within the competence of the “Länder” (provinces). Both from a financial and efficiency perspective, the “Länder-specific” investment incentives for private households represent the main support instrument for RE heating and cooling projects in Austria.

The implementation of measures relating to buildings mainly lies in local competence, however the conclusion of the agreement between federal and state government was able to introduce an essential step to the harmonisation and reinforcement of RE measures in the building sector. The federal state governments have for the most part already implemented the obligations agreed on in the Article 15a B-VG Agreement[1] in the respective state-specific housing support laws. A detailed overview of the housing support laws of all federal states can be found in Annex 1 of the NREAP (Karner et al., 2010).

The housing support (Wohnbauförderung; WBF) is the promotional tool with which both the construction of housing as well as the remediation of residential buildings is supported. Since the implementation of building-related measures lies in local competence, the conditions of eligibility in the respective federal states are regulated just as differently as the type and level of housing support. Nevertheless, a few cross-state similarities are determined in the promotion models:

- with the exception of housing remediation in Tyrol (until 31 March 2011, the promotion of residential housing is irrespective of income) the granting of housing support in all federal states is tied to certain income limits. In principle the (statutory) adequate living area is supported at most. The excess living area is excluded from the support;
- compliance with certain minimum requirements for heating a building is deemed to be a condition for the eligibility for WBF (in accordance with the Article 15a B-VG Agreement);
- the use of innovative climate-relevant systems in accordance with the Article 15a B-VG Agreement is supported in all federal states. Particularly strongly supported across the nation are biomass heating installations, solar installations, heat pumps and the connection to local and district heating networks;
- the promotion of RE measures mainly takes place in the form of (one-off, outright) investment grants, however low-interest/base paid interest direct loans are also awarded by the federal state governments as well as annuity subsidies for bank loans or credit.

According to the Austrian Energy Strategy, a further development of the legal specifications as well as the eligibility criteria and instruments in the housing sector will be accelerated in the future. Measures for an enhanced use of solar heat, heat pumps and biomass heating installations in buildings are also planned.

2.1.4 Austrian programme for development of rural areas

ÖPUL 2007-2013 (Austrian programme for development of rural areas; Österreichisches Programm für die Entwicklung des ländlichen Raumes) aims to encourage farmers towards environmentally-friendly land management, species-appropriate livestock management as well as pasture management with low intensity. Through promoting contractual nature conservation, measures to protect and sustain the management of water, soil and ground

[1] Agreement under Article 15a B-VG (2009) between the federal government and states on measures in the building sector for the purpose of reducing the emission of greenhouse gases.

water, as well as other environmentally-sound farming practices, ÖPUL 2007 should provide a significant contribution to agricultural and environment policy and ensure farmers an adequate compensation for the services voluntarily brought into the service of the whole community.

The programme defines comprehensive targets, criteria and indicators granting financial support for measures beyond the minimum legal standards. It is not specifically designed for bioenergy purposes; a distinction between biomass for energy or other purposes is not made. Concerning bioenergy three measures can be considered relevant:

- Environmental measures in agriculture (M214, ÖPUL): About 89% (2004) of the Austrian agricultural areas are covered. Compensation for ecosystem services in the areas of soil protection, Protection of surface and ground water, Air Pollution and Climate Change, Preservation and promotion of biodiversity and Conservation.
- Environmental measures in forestry (M225): Aims to improve ecological value, stability protection function and biodiversity in forests
- Basic services in rural areas (M321): Amongst other targets: Supply of local businesses and consumers with energy from renewable energy sources.

2.1.5 Biofuels Directive

The Biofuels Directive has been implemented into national law within the scope of the Fuel Order Amendment (BGBl. II No 417/2004). It specifies that from 1 October 2005 a 2.5% share of biofuels or other renewable fuels (as measured by total energy content of the binding mineral oil tax introduced in federal territory on petrol and diesel fuels in the transport sector per year) must be introduced under the substitution obligation. This target value rose in October 2007 to 4.3%. From 1 January 2009 the substitution target, depending on the energy content, amounts to 5.75%, measured by the total fossil petrol or diesel introduced or used in the federal territory. To meet the overall target, depending on the energy content, at least a 3.4% share of biofuels or other renewable fuel, measured by the total fossil petrol or diesel introduced or used in the federal territory per year, must be introduced or used under the substitution obligation. In addition, a 6.3% share of biofuel or other renewable fuel, measured by the total fossil diesel introduced or used in the federal territory per year, must be introduced or used under the substitution obligation.

As a key contribution to fulfilling the European target of 10% of renewable energy sources in the transport sector in 2020, E10 and B10[2] should, amongst others, be introduced in Austria from the existence of a European standard (E10 expected in 2012, B10 expected in 2017).

2.1.6 Law on the taxation of mineral oils

In November 2004 the Biofuel Directive (2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport; European Commission, 2003) was transposed into Austrian national law by an amendment to the Fuel Order (Kraftstoffverordnung)

To promote the use of biofuels in the transport sector rates of duty are lower for fossil fuels that are blended with biofuels compared to fossil fuels without blending. By Decision of the National Council of 24 April 2007 the 1995 Mineral Oil Duty Act (Mineralölsteuergesetz)

[2] E10: a blend that contains 10% ethanol and 90% gasoline; B10: a blend that contains 10% biodiesel and 90% fossil diesel.

(BGBl. No 630/1994), as last amended by Federal Act BGBl. I No 180/2004), was amended by means of the 2007 Finance Act (Budgetbegleitgesetz, BBG 2007). The currently valid rates of duty according to the amendment are listed in Table 3.

Table 3. Rates of duty for fossil fuels and biofuels for Austria in 2011.

Fuel type	Specification	rate of duty per 1,000 litres
Petrol	containing at least 44 l of biogenic substances and with a sulphur content of no more than 10 mg/kg	482€
	Other	515€
Diesel	containing at least 44 l of biogenic substances and with a sulphur content of no more than 10 mg/kg	397€
	other	425€
Pure biofuels	completely exempt from mineral oil duty	0€

2.1.7 5-point action plan for natural and biogas

With the five-point action programme – which was launched in June 2006 by the Federal Ministry of Agriculture, Forestry, Environment and Water Management together with the OMV AG – natural and biogas as fuel is encouraged. The programme ended in 2010. According to the Austrian Energy Strategy a comprehensive biogas and biomethane strategy covering the whole product chain is currently being developed.

2.1.8 Green Electricity Act

The support policy for energy from renewable sources in the electricity sector is provided for through the Green Electricity Act. The present legal situation is based on the Green Electricity Act of 2002 and extensions in 2006, 2007, 2008 and 2009.

Under the Green Electricity Act, a technology-specific support of plants producing electric energy on the basis of renewable energy sources (solid, liquid, gaseous biomass, wind power, photovoltaics, landfill and sewage gas, geothermics and small hydropower) is provided by means of fixed feed-in tariffs. In accordance with the current Green Electricity Amendment, investment grants will be awarded in place of feed-in tariffs in the future for plants based on waste liquor of the paper and pulp industry.

Support takes place according to the specific technology and is processed via the processing and administration centre called OeMAG. The electricity delivered to the grid is paid at a tariff determined by OeMAG for a guaranteed period. Since 2006, a cap of the available support contract volume for new eco-electricity plants has been in place, in the course of which a recent increase of additional annual support volume of 17 to 21 million Euro was introduced. The award of supplier contracts between eco-electricity producers and OeMAG takes place on a “first come, first served” basis. To achieve the indicative target of 15% supported green electricity in 2015, an additional creation of 700 MW wind power, 700 MW hydropower (of which 350 MW is supported) as well as 100 MW biomass/biogas (only with raw material available) is aimed at. Table 4 gives an overview on the feed-in tariffs system in 2010.

Table 4. Feed-in tariffs for eco-power plants according to the Ökostrom-Verordnung 2010 (Green Electricity Act 2010).
Source: E-control (2011a)

Fuel-independent technologies (guaranteed for 13 years)		**tariff (cent/kWh)**
Wind		9.70
Photovoltaic (building-integrated)	≤ 5 kW_{peak}	Investment subsidy[b]
	5 kW_{peak} - 20 kW_{peak}	38.00
	> 20 kW_{peak}	33.00
Photovoltaic (non-integrated)	≤ 5 kW_{peak}	Investment subsidy[b]
	5 kW_{peak} - 20 kW_{peak}	35.00
	> 20 kW_{peak}	25.00
Landfill and sewage gas	Sewage gas	6.00
	Landfill gas	5.00
Geothermal		7.50
Fuel-dependent technologies (guaranteed for 15 years)		**tariff (cent/kWh)**
Solid biomass (forest wood chips, straw etc.)[a]	≤ 500 kW	14.98
	500 kW - 1 MW	13.54
	1 MW - 1.5 MW	13.10
	1.5 MW - 2 MW	12.97
	2 MW - 5 MW	12.26
	5 MW - 10 MW	12.06
	> 10 MW	10.00
Wood residues[a]	Bark, sawdust etc.	minus 25%
	Panelboard residues etc.	minus 40%
	Other residues	5.00
Co-firing in thermal power plants[a]	Solid biomass (forest wood chips, straw etc.)	6.12
	Bark, sawdust etc.	minus 20%
	Other residues	minus 30%
Liquid biomass	Base rate	5.80
	Additional premium for "efficient CHP"	2.00
Biogas from agricultural feedstock (e.g. maize, manure)[a]	≤ 250 kW	18.50
	250 kW - 500 kW	16.50
	> 500 kW	13.00
	Co-fermentation with waste	minus 20%
	Additional premium for "efficient CHP"	2.00
	Additional premium for conditioning to natural gas quality	2.00
Fuel-dependent technologies after 15 years		**tariff (cent/kWh)**
Solid biomass (forest wood chips, straw etc.)	≤ 2 MW	8.50
	2 MW - 10 MW	7.50
	> 10 MW	7.00
Biogas from agricultural feedstock (e.g. maize, manure)	≤ 250 kW	9.50
	> 250 kW	8.00
	Co-fermentation with waste	minus 20%

a) mixed fuels: proportional rates; b) Climate and Energy Fund (Klima- und Energiefonds)

2.1.9 Technical Standards

Technologies for the use of renewable energy sources in Austria must meet certain quality standards in order to be able to be entitled to promotion. These quality criteria are established by the Austrian Standards Institute in the form of Ö-Normen (Austrian standards). Some of the most important Austrian standards are listed below.

- directives of the Austrian association of gas and water (ÖVGW)
- in terms of the latest technology, the current version of the harmonised standards for the safety of machines must be observed the list of standards and directives to be applied is indicated in the technical basis for the assessment of biogas plants BMWA 2003 (Chapter 12.0)
- Austrian Standard 12828 Heating installations in buildings – the planning of heating installations
- Austrian Standard 14336 Heating Installations in buildings – installation and approval of water heating installations
- Special field: electrical engineering and energy management ÖVE (Austrian Electrotechnical Association) rules and SNT-Vorschriften (electrotechnical safety regulations on standardisation and typification) (BV: BGBl. II Nr. 222/2002) are legally binding
- Special field: noise restriction
  - Austrian Standard S 5004 – noise emission measurement.
  - Austrian Standard S 5021-1 – sonic principles for the local and supra-local spatial planning and development:
  - ÖAL (Austrian Society for Noise Abatement) Directive No 3, Assessment of noise emissions, noise disturbance in the neighbouring area
- Special field: air quality management
  - technical basis for the assessment of emissions from stationary engines
- Special field: fermentation/waste disposal technology
  - Implementing directive the proper use of biogas wet manure and fermentation
- Residue in farmland and grassland
- Water management
- Austrian Standard B 2506-1: rain water drainage systems for the flow from roof areas and hard usable surfaces, hydraulic design, construction and operation
- Biomass-specific:
  - ÖNORM M 7132: Energy-economical utilisation of wood and bark as fuel – Definitions and properties
  - ÖNORM M 7133: Chipped wood for energetic purposes – Requirements and test specifications
  - ÖNORM M 7135: Compressed wood and compressed bark in natural state – Pellets and briquettes – Requirements and test specifications
  - ÖNORM M 7136: Compressed wood in natural state – Wood pellets – Quality assurance in the field of logistics of transport and storage
  - ÖNORM M 9466: Emission limits for air contaminants of wood incineration plants of a nominal fuel heat output from 50 kW onwards –
  - ÖNORM M 7139 Energy grain - Requirements and test specifications
  - Sustainable production of agricultural products for biogenic fuels (European Commission 2009) is registered and controlled by Agrar Markt Austria (AMA)

2.2 Research and development for renewables

According to an estimate of Statistik Austria, more than 8 billion Euro are expected to be spent on research and experimental development (R&D) in 2011. In comparison to 2010, the total sum of Austrian R&D expenditure will increase by 5.0% to 8.286 billion Euro and hence reach 2.79% of the Gross Domestic Product (GDP). The research intensity for 2010 is estimated to be 2.78%; thus, there will only be a small increase in 2011.

The largest part of total R&D expenditure 2011 (44.6% or 3.70 billion Euro) will be financed by businesses. Funding from the business enterprise sector will rise by 5.9%, after a decrease in 2009 and only a minor increase in 2010. The public sector will contribute 38.7% (approx. 3.21 billion Euro); of this share, the federal government ("Bund") will finance 2.73 billion Euro, the regional governments around 394 million Euro and other public funding from local governments, chambers or social security institutions will be about 87 million Euro. This corresponds to an increase of public sector funding by 4.5% compared to 2010. 16.2% will be financed from abroad and 0.4% (approximately 35 million Euro) by the private non-profit sector. The funds from abroad (about 1.34 billion Euro) originate mostly from international enterprise groups whose domestic affiliates in Austria perform R&D and include backflows from the EU Framework Programmes for Research, Technological Development and Demonstration. Expenditures which can be solely attributed to “Support for production, storage and distribution of energy” amounted to 1.8% of federal expenditures.

A strategy process called “e2050” was launched in 2005 with the aim to develop a long-term strategy for Austrian research on energy technologies. In late 2009 the Ministry for transport, innovation and technology presented the “energy research strategy Austria”. The government has developed different programmes for the energy sector to support R&D in renewable energy and energy efficiency and for market demonstration and deployment. The programme “Energy for the Future” was created in 2007 with a budget of 20 million Euro with the aim to support high-quality technology R&D projects.

2.3 Promotion schemes for RES-Heat

Promotion of solar thermal, heat pumps and biomass heating systems for residential appliances is strongly based on investment subsidies. Since they mainly belong to the authority of the province governments, nine different schemes exist. National policies only exist for large scale plants (e.g. biomass district heating, commercial plants).

Within all provinces, traditionally quite substantial subsidisation schemes for residential building construction (and more recently also for renovation) exist. These schemes since the 1950’s represented the main promotion system for supporting the construction of new residential dwellings. Originally, no energy specific standards were required for receiving these subsidies. However, within the last years, several provinces transformed these systems in promotion schemes for higher thermal quality of building shells as well as for renewable systems (e.g. support is only granted in dwellings with solar thermal or biomass heating systems).

These subsidisation systems on the provincial level (i.e. investment subsidies for RES-H systems and subsidies for residential building construction) clearly represent the main promotion scheme for RES-H systems in Austria.

Besides financial incentives there is a number of awareness campaigns and training programmes from regional energy agencies as well as the federal government (e.g. the "holz:wärme" for biomass and "solar:wärme" for solar thermal within the frame of the programme "klima:aktiv").

2.3.1 Subsidies for biomass systems

Since the beginning of the 80's (after the second oil crisis) the Austrian government forced the use of bioenergy mainly to reduce the dependence of imports of coal and oil. There were a variety of measures to facilitate the marketing of renewable energy sources both at the federal and the provincial level, ranging from fiscal measures and subsidies to emission standards.

With respect to biomass heating systems, investment subsidies are granted in every province but their amounts and conditions are different. In Carinthia and Vorarlberg, fixed amounts are paid out, whereas in other provinces, such as Burgenland or Styria, the subsidies account for certain proportions of the total investment costs. In some provinces there are also additional requirements and restrictions and thus, a comparison between the different support schemes is not straightforward.

In some regions, municipalities also grant subsidies for domestic biomass-fired heating systems and there are also support schemes for the installation of small-scale district and local heating systems in some provinces (e.g. Styria, Upper Austria, Carinthia). Biomass-fired combined heat and power systems and heating systems for agricultural purposes are subsidised both at federal and provincial level (see above).

Austria has been very successful in recent years in developing sustainable energy technologies like solar water heating and biomass heating technologies. One reason for this is the promotion of the use of renewable energy with subsidies. The following figure illustrates the dynamic development of investment subsidies for domestic biomass heating systems in Austrian provinces during the period 1998 to 2005. In 1998, investment subsidies were granted only in Burgenland, Upper Austria, Carinthia and Vorarlberg. There were no direct subsidies in the other provinces but the installation of new heating systems was supported by the granting of soft loans. In the following years, direct investment subsidies were introduced in all provinces and in most of them the amounts were raised significantly. The impact of these measures was the acceleration of substitution of old and inefficient single stoves and boilers with modern low-emission systems (see sections 5.3.1 and 5.4.1).

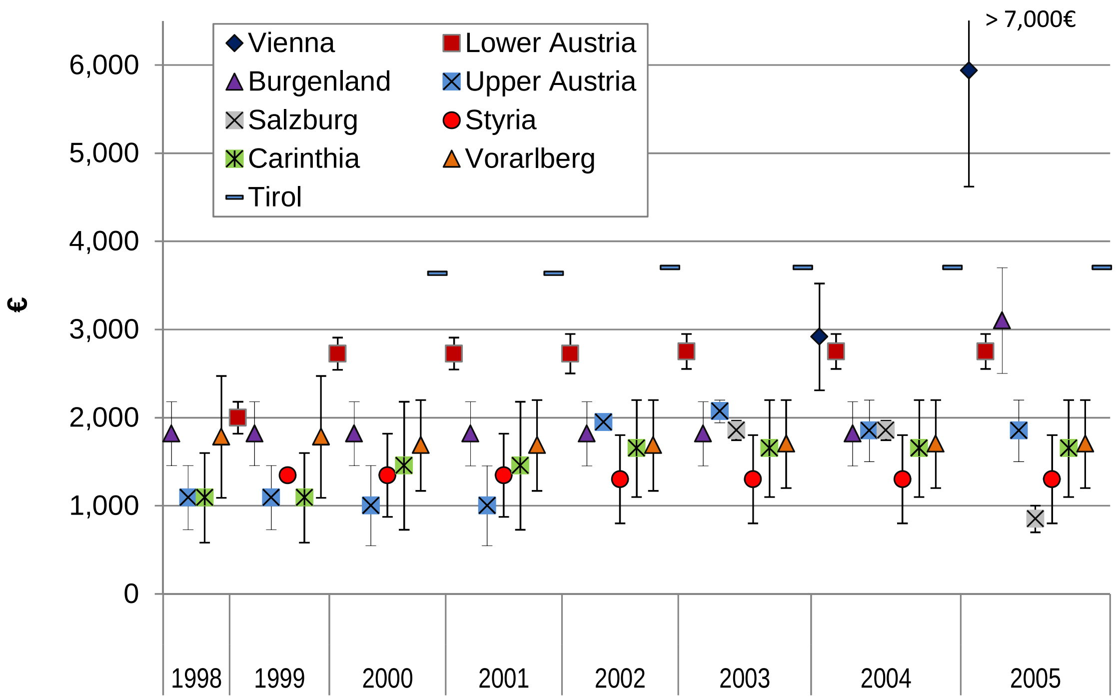


Figure 11. Development of typical/maximum investment subsidies for biomass heating systems.
(Due to the diversity of support schemes and different eligibility criteria a direct comparison between regions is not possible and actual amounts can vary widely. Uncertainty ranges represent the ranges of the maximum/typical values, depending on boiler types, emissions and other criteria.)
Source: Haas et al. (2005) in Kranzl et al. (2011)

2.3.2 Subsidies for solar thermal systems

In general, the provincial subsidies started during the 1980ies and developed strongly during the 1990ies. Roughly speaking, the level of investment subsidies vary for solar thermal systems in the range of 20% to 40% of investment costs (depending on the size of the installation, the type of collector and type of system, e.g. between 600€ to 1,700 € for water heaters, 1,100 € to 3,500 € for combined solar systems).

2.3.3 Subsidies for heat pumps

For heat pumps investment subsidies are in the range of 10% to 30% of investment costs (depending on the type heat source, coefficient of performance etc.). Moreover, for heat pumps several electricity utilities provide additional incentives like investment subsidies or/and reduced electricity tariffs.

2.4 Subsidies for Biofuels

For biofuels the most important support measures are managed by the environmental support act (Umweltförderung im Inland) and the klima:aktiv programme. Biofuels are also subject to tax exemptions (see 2.1.6). The Environmental support act covers

- Pilot or demonstration installations for the introduction for new or greatly improved as technologies as well as projects for testing the application suitability of innovative system components to prove the applicability for large-scale production.

- Operational transport measures: Measures for CO_2 reduction from operational transport. This includes investments for sustainable conversion of transport systems to lower or neutral CO_2 fuels vehicle or fleet conversions internal fuel tank installations for alternative fuels operational investment measures to accelerate public transport, cycling and walking, as well as measures to reduce transport services; mobility services, transport information and logistics systems
- Fuel tank installations for alternative fuels: Investments for the new construction or conversion of fuel tank installations for alternative fuels (plant oil, gas or E85) for vehicles.

The klima:aktiv programme covers: investments in measures and initiatives to prevent or reduce climate-relevant gases (particularly CO_2) for environmentally-friendly sustainable transport development and soft mobility in the field of tourism and leisure transport. Investments are supported for, amongst other things: environment-relevant conversion of transport systems, environment-related logistics systems (e.g. baggage logistics, etc.), environment-related conversion of fleets, systems for the internal provision of alternative fuels, measures to revitalise public transport and measures to promote walking and cycling.

3 Biomass resources

The basic requirement for the production of biomass is land. According to the Austrian Forest Inventory (BFW, 2011), close to 50% of the national territory are covered by forest, making Austria one of the most densely forested countries in Central Europe. The agricultural land includes about 1.4 million hectare (Mha) of arable land, 0.87 Mha of intensively and 0.86 Mha of extensively used grassland (primarily pastures in Alpine regions).

Fig. 12 shows the historic development of forest and agricultural land use in Austria since 1960. It was characterized by a significant decrease of extensive grassland, growing forest land and relatively stable arable land and intensive grassland.

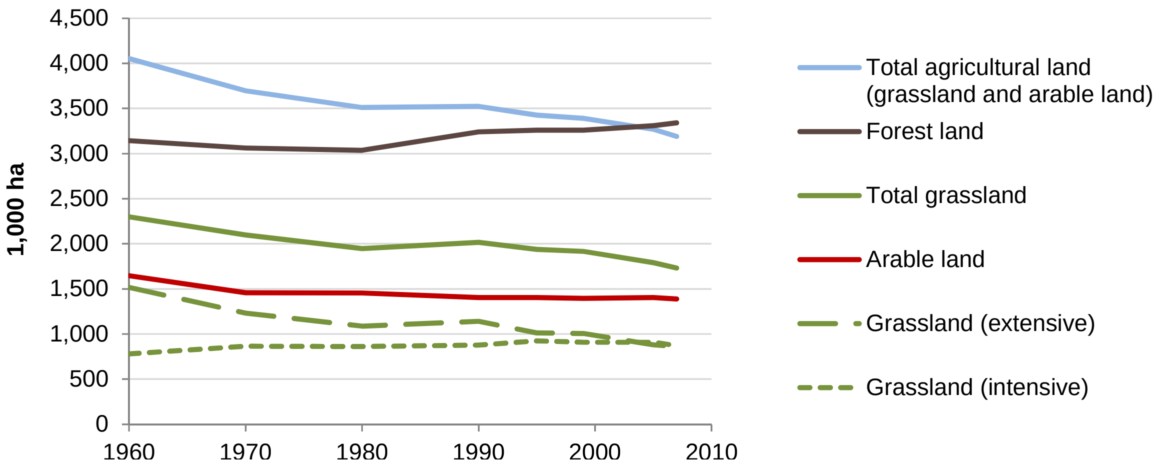


Figure 12. Development of land use in Austria since 1960.
Source: BMLFUW (2011)

The following section provides an overview of biomass potentials in Austria according to different studies. This section has been adopted from Kalt et al. (2010) and Kalt (2011).

3.1 Biomass potentials in Austria

3.1.1 Comparison of literature data

Assessments of biomass potentials are numerous and the results vary widely (see Rettenmaier et al., 2010, for example). There are different concepts of potentials (e.g. theoretical, technical or environmentally compatible potentials). Usually potentials in literature are qualified according to these definitions. Yet methodological approaches, assumptions and constraints of potential assessments differ from study to study, and therefore results are often not directly comparable.

Fig. 13 shows the results of four studies assessing the biomass potentials in Austria. Despite the fact that these studies use different concepts of potentials[3], the methodological

[3] Thrän et al. (2005): technical potential with consideration of structural and ecological restrictions; EEA (2006): technical potential with consideration of environmental criteria (“environmentally-compatible potential”); de Wit & Faaij (2010): “Supply potential” (forest biomass: “sustainable potential”); Kranzl et al. (2008): “sustainable potentials with consideration of ecological restrictions and competing uses”).

approaches are quite similar and a direct comparison of the results is considered reasonable. However, it needs to be taken into account that non-agricultural biogenic wastes and residues are not considered in (de Wit & Faaij, 2010), and that the assessments differ with regard to certain assumptions, some of which have a significant influence on the overall results. These assumptions include the mix of energy crops or the share of residues like straw or sawmill byproducts which can be used energetically under certain constraints.

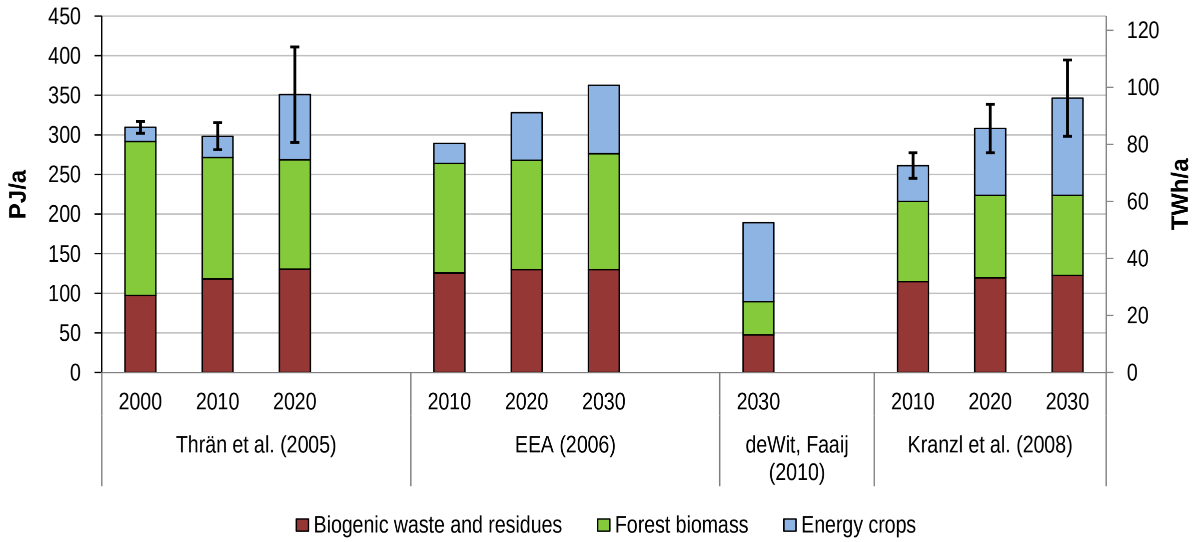


Figure 13. Biomass potentials in Austria.
Sources: Thrän et al. (2005), EEA (2006), de Wit & Faaij (2010), Kranzl et al. (2008)

3.1.2 Biomass supply curves[4]

Supply curves are a common concept used to model the relationship between quantities of commodities that are available on the market at certain prices. Under the assumption of perfect competition, marginal costs (i.e. the costs arising from the production of one more unit of the commodity) determine the supply, as market actors are willing to produce additional output as long as the price they receive is higher than the costs of producing one more unit.

In Kalt et al. (2010), supply curves for agricultural biomass were derived, based on the results of an integrated spatially explicit land use modelling framework (see Schönhart et al., 2010). In this modelling approach, specific focuses on different crop types were assumed ("energy crop scenarios"). Hence, it was assumed that energy crop production in Austria is either focused on conventional crops (oilseeds, common types of cereals, sugar beet etc.), biogas plants (maize silage and other types of silage) or short rotation forestry (primarily poplar). The following figures show the supply curves for these energy crop scenarios, titled "conventional", "biogas" and "lingocellulose". Each figure shows the supply curves for the base year 2006 and 2030. The time dependence of the supply curves result from the underlying scenarios concerning prices for agricultural commodities (OECD/FAO, 2008), agricultural policies[5] and production costs, which are influenced by energy and fuel prices. As

[4] This section has been adopted from Kalt (2011).
[5] The reforms in the Common Agricultural Policy (CAP) which have been agreed on within the "Health Check" in November 2008 and are to be implemented by the EU member states until 2013 include the following: (i) Phasing out of milk quotas until 2015, (ii) "decoupling" of direct aid to farmers from production and increased modulation, (iii) the abolition of set-aside (requirement for farmers to leave

competition between the different types of energy crop types are disregarded with this approach, the quantities shown in the three figures below represent alternative options.

A direct comparison of the potentials shown in the previous section with the supply curves shown below is not reasonable, as there are fundamental differences between the methodological approaches. Whereas the energy crop potentials shown in Fig. 13 are basically the result of certain assumptions concerning arable land available for energy crop production, assumed energy crop mixes etc., the potentials incorporated in the supply curves shown below represent quantities which could be supplied economically at different price levels.

The supply curves basically refer to the energy content (lower heating value) of the energy crops, with the exception of biogas substrates, for which both prices and potentials refer to the energy content of the crude biogas yield after co-fermentation with 10% manure (percentage by energy content). VAT is not included.

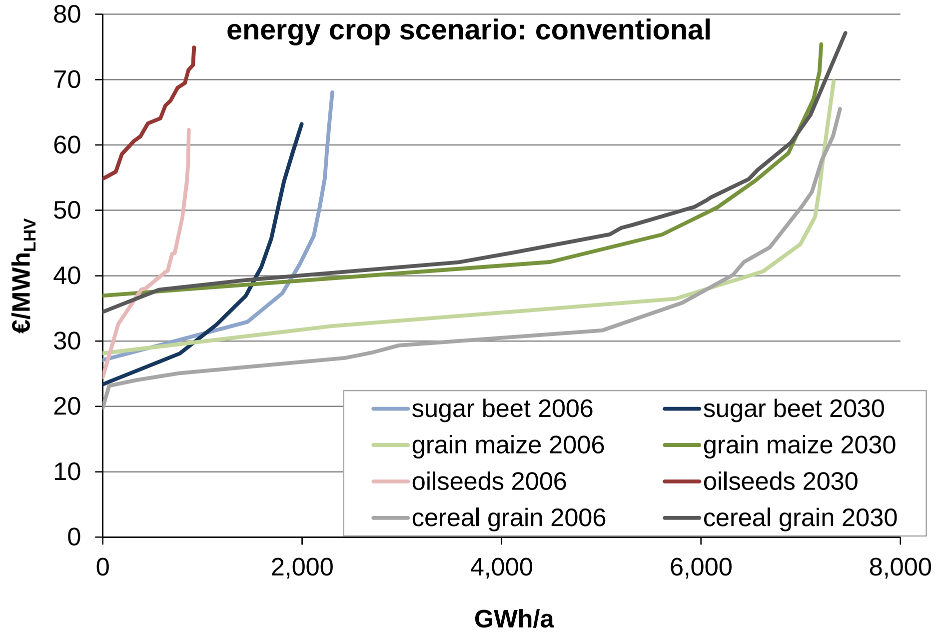


Figure 14. Supply curves in the energy crop scenario "conventional".
Source: Kalt et al. (2010)

10% of their land fallow) and (iv) the introduction of additional support schemes in the field of risk management, animal husbandry and health etc (European Commission, 2009b).

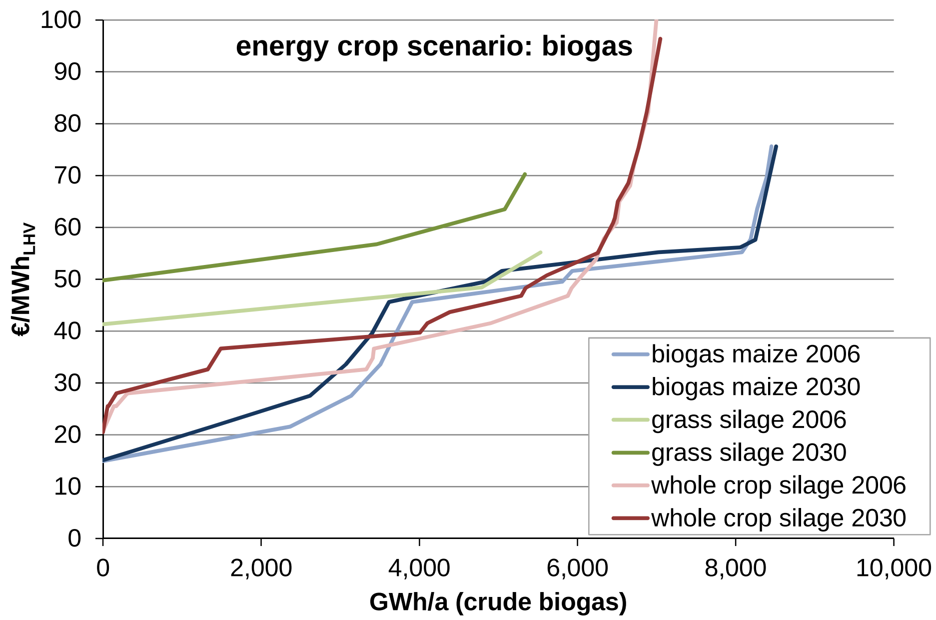


Figure 15. Supply curves in the energy crop scenario "biogas".
(Energy units refer to the lower heating value of the crude biogas yield after co-fermentation with 10% manure.)
Source: Kalt et al. (2010)

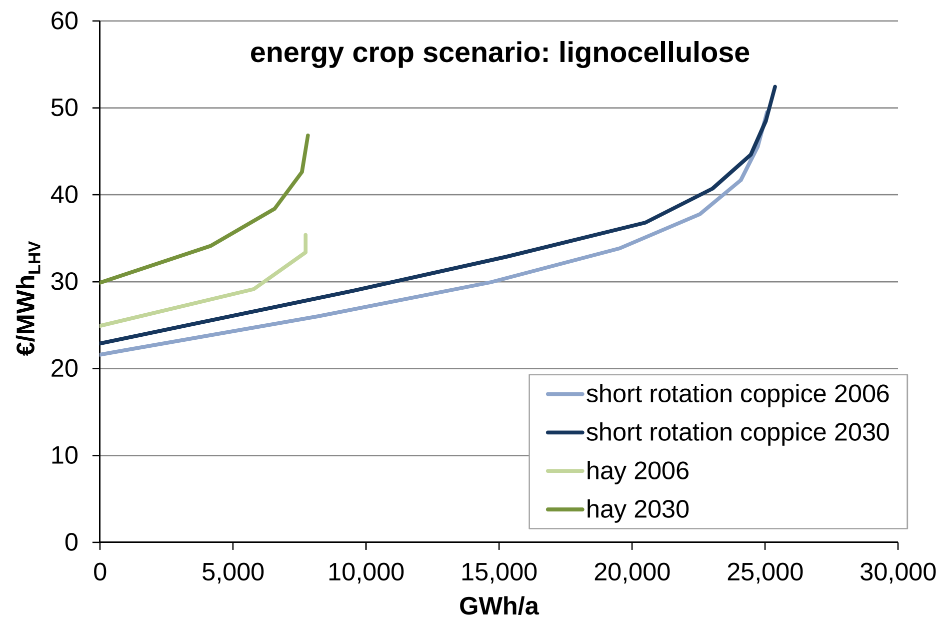


Figure 16. Supply curves in the energy crop scenario "lignocellulose".
Source: Kalt et al. (2010)

In Kranzl et al. (2010) the climate-sensitivity of forest biomass supply potentials in Austria up to 2100 have been assessed based on forest simulation models[6]. The climate-sensitive input data were based on the "SRES-scenarios" *A2*, *A1B* and *B1* (IPCC, 2000) (SRES: Special Report on Emissions Scenarios). The simulated supply potentials are influenced by precipitation, temperature, radiation and other environmental parameters. It was found that the impact of climate change on the dynamics of forest growth highly depends on the characteristics of the respective climate scenarios, and that no clear trend can be identified for the first half of the 21st century. However, on the longer term there is a general trend towards increased growth in alpine regions, whereas in low-lying regions climate change has a negative impact on forest growth. For the whole period 2011 to 2100, the differences in the total supply potential compared to the reference scenario amount to 279,000 t/a (+5.3%) in the *A2*-scenario, 164,000 t/a (+3.1%) in the *A1B*-scenario and 97,000 t/a (+1.9%) in the *B1*-scenario.

Based on the assessment of potentials, climate-sensitive supply curves have been derived in Kranzl et al. (2010) (Fig. 17). The shapes of the curves are determined by the cost of wood extraction, which are influenced by topography, composition of tree species as well as the methods of wood extraction applied. It was found that due to the large time constants of forest growth processes, the shapes of the supply curves do not change substantially during the considered period up to 2050.

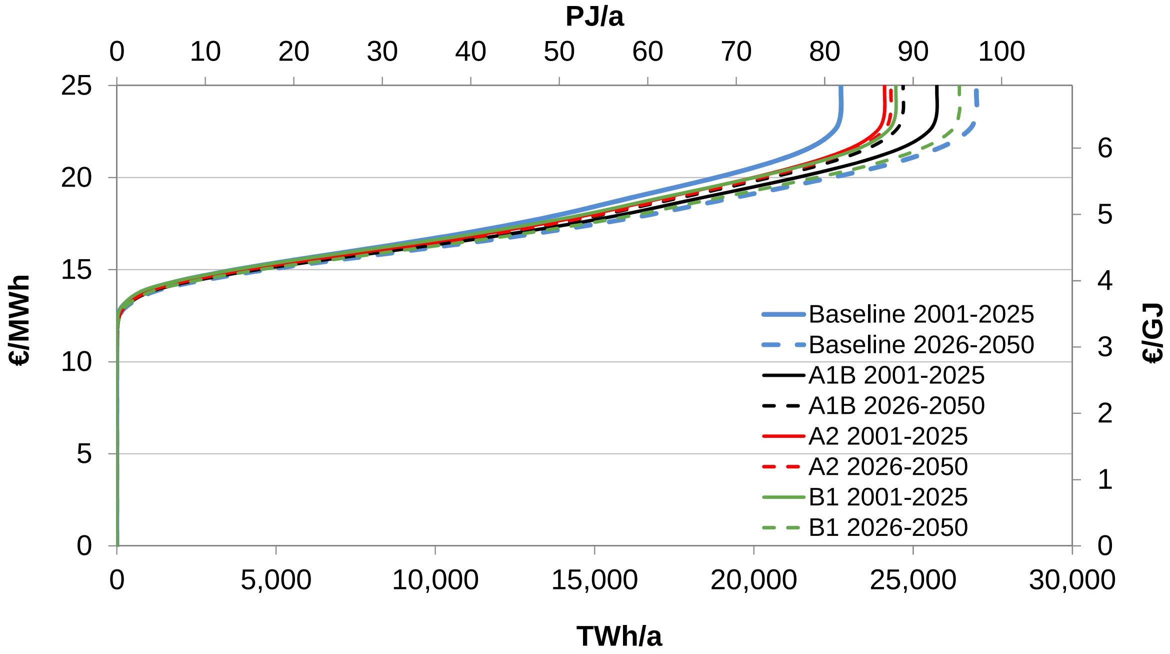


Figure 17. Supply curves for forest biomass for energy use for the different climate scenarios and time periods (averages over 25-year periods).
Source: Kranzl et al. (2010)

[6] More specifically, the approach is based on climate-sensitive simulations of the net primary production, carried out with the forest ecosystem model *PICUS 3G* (an adaptation of the model *PICUS* 1.4; see Seidl et al., 2005) and the model *G4M* – Global Forest Model (Kindermann et al., 2006, Kindermann et al., 2008), which was used to derive supply potentials from the net primary production.

4 Current and expected future energy use of biomass in Austria

This section provides insight into the current importance and structure of biomass use as well as prospects for bioenergy in Austria.

4.1 Current energy use of biomass

Fig. 17 shows the historic development of biomass primary energy consumption broken down by biomass types and of the biomass share in the total gross inland consumption from 1970 to 2009. From 1970 to 2004, biomass statistics differentiated only between the categories “wood log”, “municipal solid wastes” and “other biomass and biofuels”. The latter include all types of liquid biofuels, biogas and wood fuels like wood chips, residues, pellets etc. The data for the biogenic fraction of municipal solid wastes during this period are estimates based on an assumed biogenic share in municipal waste of 20%. More detailed data are available for the years 2005 to 2010. The biogenic share of wastes was in the range of 17 to 24% during this period. In Fig. 17, all liquid biofuels have been summarized to one category, as the original differentiation in energy statistics is considered to be misleading (see comment (a) in Fig. 19).

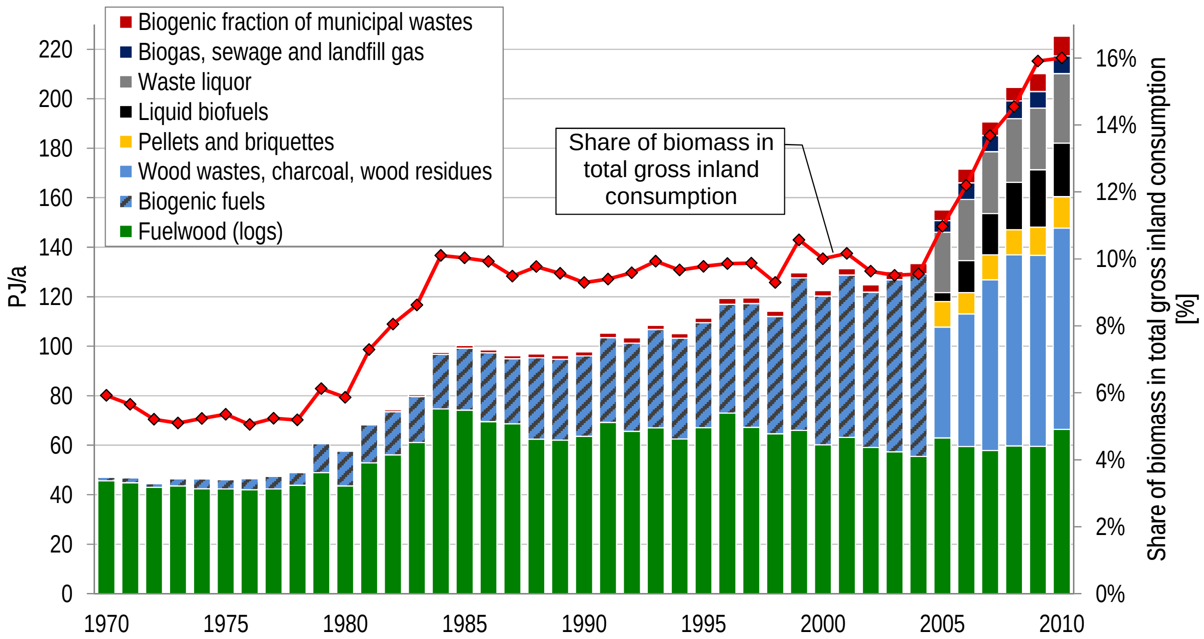


Figure 18. Development of biomass primary energy consumption broken down by biomass types and of the biomass share in the total gross inland consumption from 1970 to 2010.
Sources: Statistik Austria (2011c)

Fig. 18 also shows the share of biomass in the total gross inland consumption, which increased from less than 6% (less than 50 PJ/a) during the 1970ies to 15% (225 PJ) in 2010. The main increase in biomass use took place during the periods 1980 to 1985 and 2004 to 2010. Until the year 1999 the use of wood log for domestic heating accounted for more than 50% of the total biomass use for energy. The rest was primarily wood wastes and sawmill by-products as well as waste liquor of the paper and pulp industry. Especially during the last six years, the different fractions of wood biomass, including forest wood chips, sawmill by-products and other wood wastes as well as liquid and gaseous biomass have become increasingly important, whereas wood log remained relatively constant at about 60 PJ/a.

Fig. 19 shows the structure of biomass primary energy consumption in 2010. The currently most important biomass types are “wood waste and residues” (primarily sawmill by-products) and fuelwood (log wood; 30%), followed by waste liquor (12%).

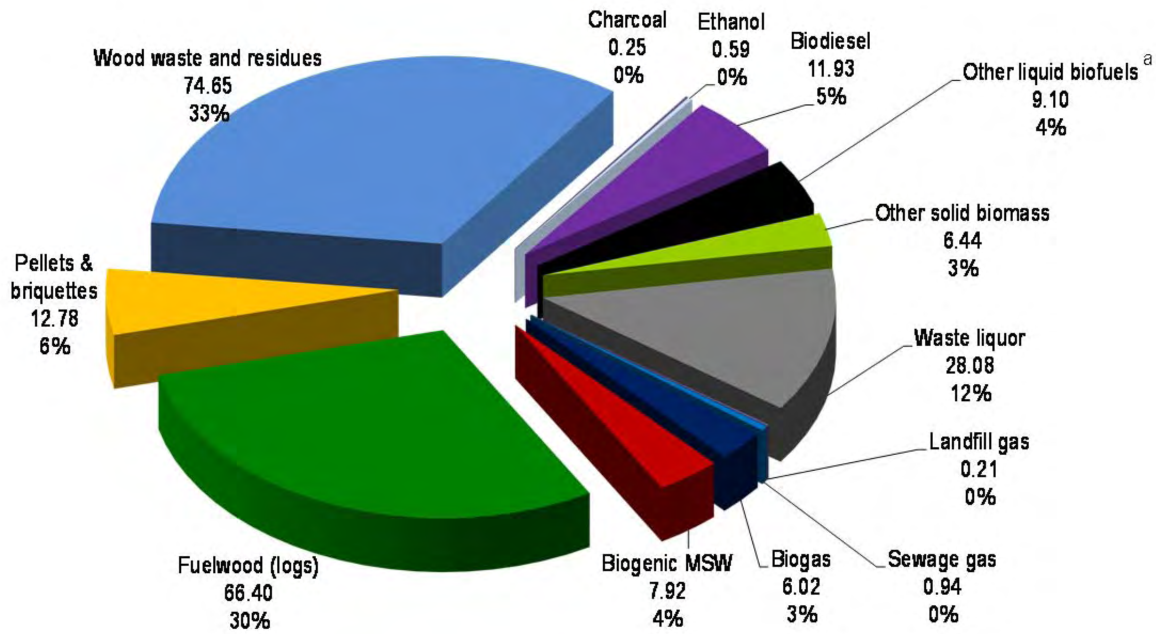


Figure 19. Structure of biomass primary energy consumption by biomass types in 2010.
a) Following Statistik Austria (2011c), pure liquid biofuels (biodiesel, ethanol and vegetable oil) are included in the category “other liquid biofuels”, whereas the categories “biodiesel” and “ethanol” only comprises quantities blended with fossil fuels.
(Data labels: consumption in PJ and share in total biomass consumption)
Source: Statistik Austria (2011c)

4.2 The National Renewable Energy Action Plan

The Renewable Energy Directive (European Commission, 2009a) defines legally binding targets for renewable energy in gross final energy consumption. According to the Directive each Member State is required to provide a National Renewable Energy Action Plan (NREAP) by the end of June 2010.

The following figures show the projections for biomass final energy consumption according to the Austrian NREAP (Karner et al., 2010). Fig. 20 shows the projection for electricity (broken down by solid, gaseous and liquid biomass), Fig. 21 the one for heat (broken down by grid-connected and decentralized heat generation) and Fig. 22 the one for transport fuels (broken down by ethanol, biodiesel, vegetable oil and electricity from renewable sources; not necessarily from biomass). The historic reference values in the NREAP refer to 2005. Compared to this year, the target values appear quite ambitious. However, since 2005 a significant progress in the use of biomass took place, and comparing the target values defined in the Austrian NREAP to the biomass use in 2009 makes it obvious that the targets in the field of bioenergy are far from ambitious. A development as projected in the NREAP would actually mean that apart from plant refurbishment, virtually no new bioenergy plants will be installed in the next decade.

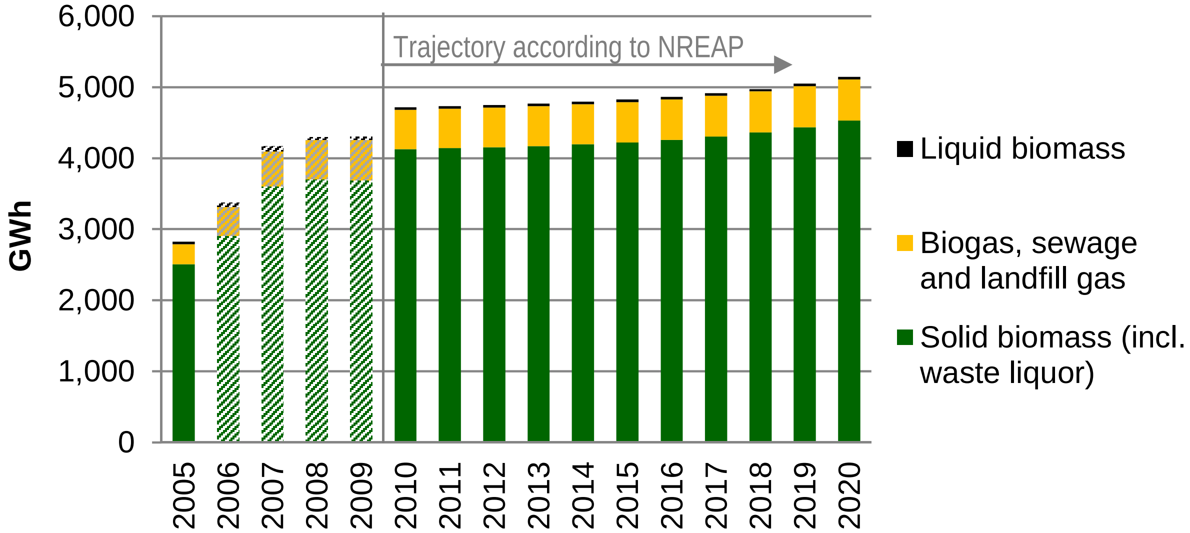


Figure 20. Historic development of electricity generation from biomass and trajectory according to the NREAP.

Sources: Karner et al. (2010), E-control (2011b), Statistik Austria (2011c) (data for the years 2006 to 2009; hatched bars), own calculations and illustration

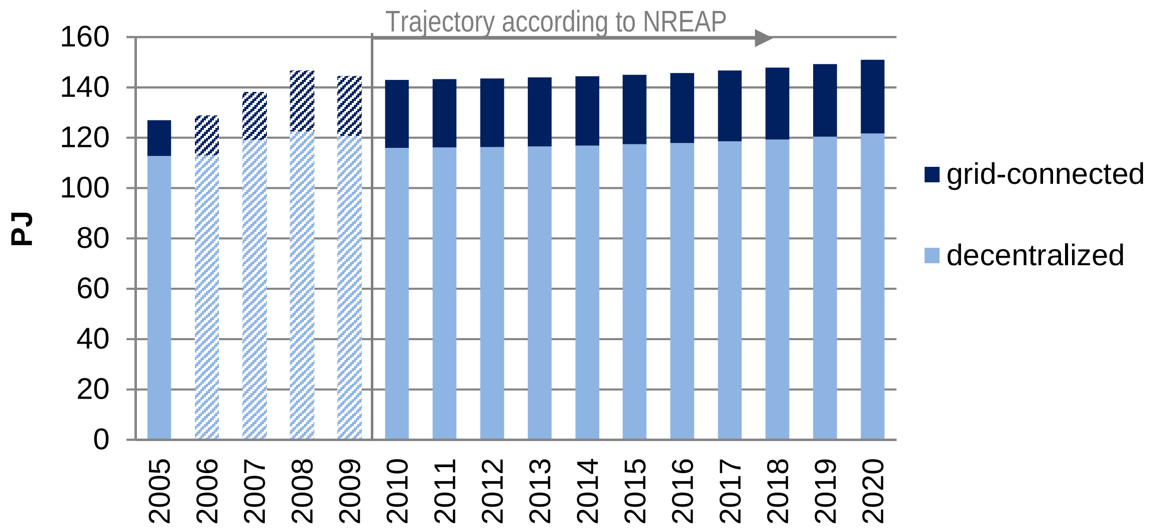


Figure 21. Historic development of final energy consumption of heat from biomass and trajectory according to the NREAP.

Sources: Karner et al. (2010), Statistik Austria (2011c) (data for the years 2006 to 2009; hatched bars), own calculations and illustration

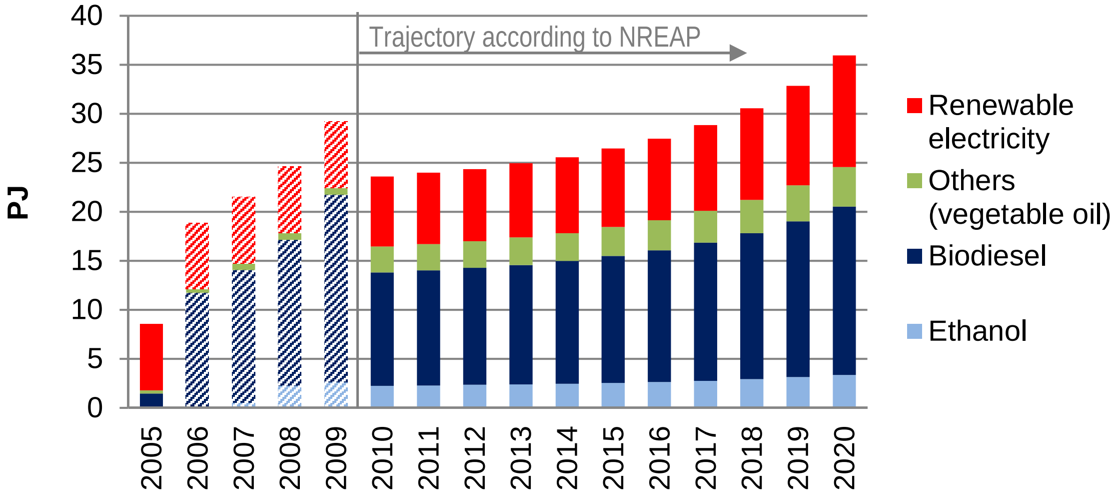


Figure 22. Historic development of biofuel and renewable electricity consumption for transport and trajectory according to the NREAP.
Sources: Karner et al. (2010), Winter (2011) (data for the years 2006 to 2009; hatched bars. As there are no data available on the renewable electricity consumption for transport during 2006 to 2009, the value for 2005 was assumed.), own calculations and illustration

5 Current biomass users

This section provides an overview of the historic development and current state of biomass use with regard to applications and users. In section 5.1 the historic development of biomass consumption broken down by utilization types and users is shown. A flow diagram of the Austrian bioenergy sector is presented in section 5.2, and section provides more detailed information on the development of biomass use for heat production, electricity generation and transport fuel production. Finally, section 5.4 provides data on the historic development of plant capacities (annual installations and/or cumulated capacities).

5.1 Biomass consumption by types of use

The following figure shows the development of the biomass primary energy consumption broken down by types of use. Until the late 1970ies, more than 80% were used for heat generation in private households. During the 1980ies, the biomass use became increasingly diverse, and the consumption for residential heating increased from about 40 PJ per year (PJ/a) to close to 60 PJ/a. During the 1980ies and 1990ies, bioenergy was increasingly used in the industry (first of all the paper and pulp industry). Electricity generation in autoproduction plants also gained some relevance. Biomass use in heat plants gained in importance especially during the 1990ies. After 2004, the use of biofuels for transport increased from less than 1 PJ/a to more than 20 PJ/a, and electricity generation in eco-power plants gained in importance very rapidly.

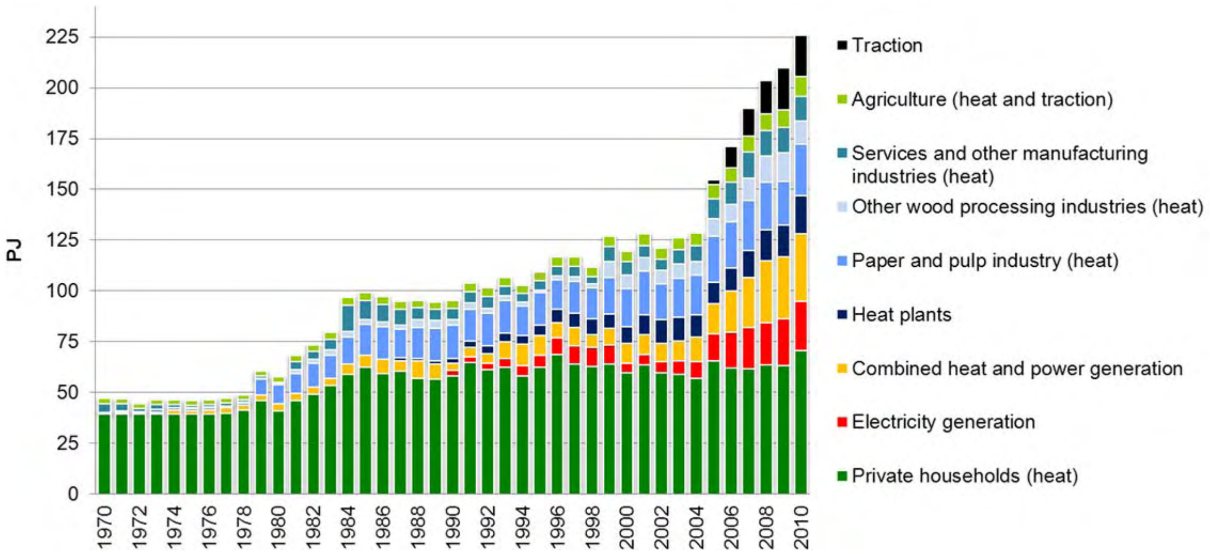


Figure 23. Development of biomass primary energy consumption broken down by utilization type and users.
The categories “CHP” and “electricity generation” also include autoproduction plants in the industry.
Sources: Statistik Austria (2011c)

5.2 Flow diagram of the biomass sector

Fig. 24 shows a flow diagram of the Austrian bioenergy sector in 2009 (adopted from Kalt & Kranzl, 2011). The diagram illustrates which biomass types are used for the different end-uses.

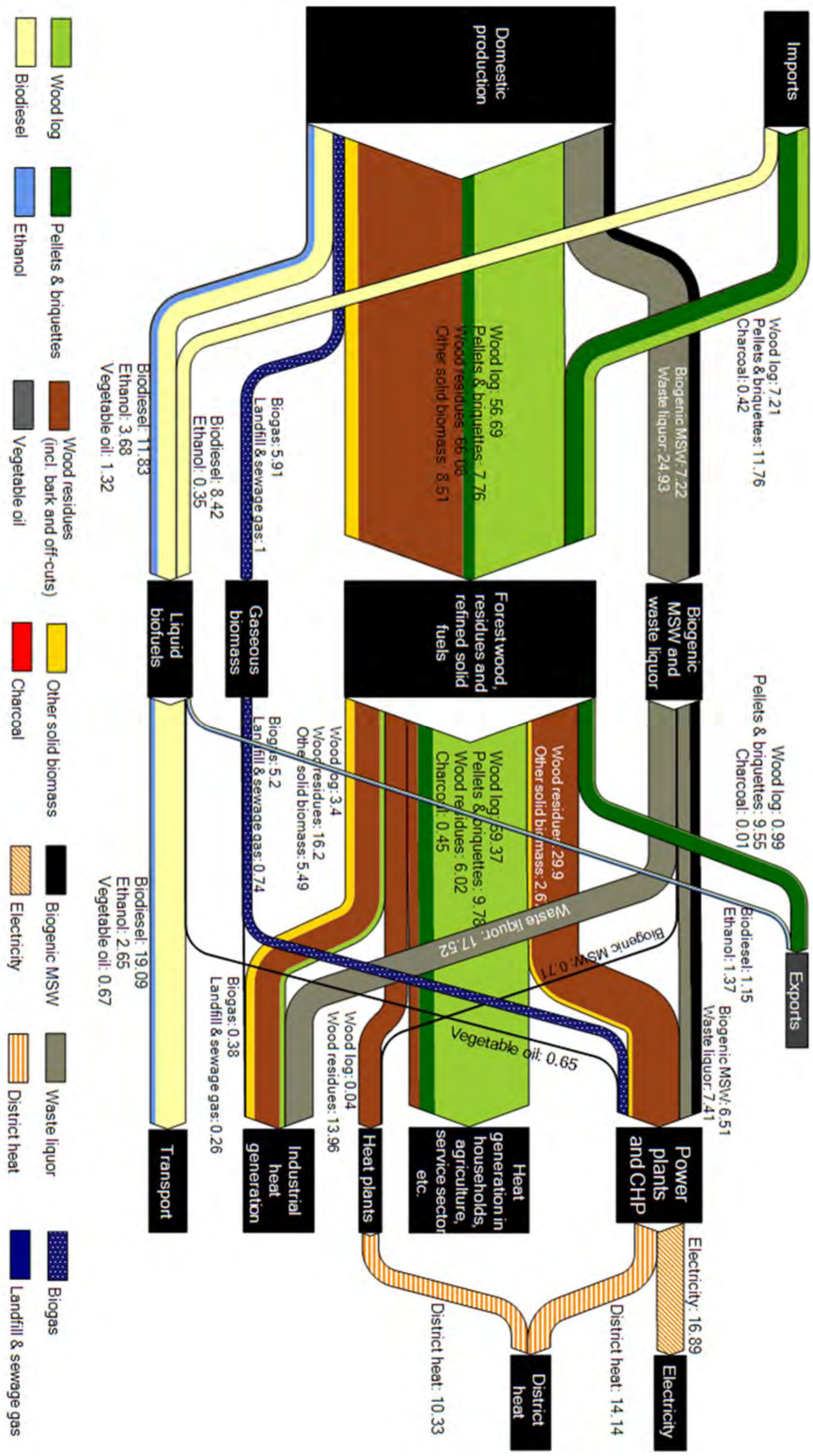


Figure 24. Flow diagram of the Austrian bioenergy sector.
(values in PJ; feedstock imports are stated as equivalents of the refined biofuel; flows of less than 0.5 PJ are partly not displayed for better readability).
Sources: Kalt et Kranzl (2011), based on Statistik Austria (2011c) and Winter (2011), own calculations

5.3 Applications and user types

The following sections provide a more detailed insight into the biomass use for residential and district heating, the consumption in commerce and industry and electricity generation as well as in the transport sector.

5.3.1 Domestic heating

Austria has a long tradition in heating with biomass. Up to 1970, single stoves were dominating domestic heating in Austria. Thereafter, single stoves were increasingly substituted with modern central heating systems. The number of dwellings with biomass heating systems (broken down by single stoves, one floor heating and central heating) is shown in Fig. 25. After the 1970ies, which were characterized by a decreasing number of dwellings equipped with biomass heating systems, there was a strong trend towards biomass-based central heating systems. In 1988 about 21% of all dwellings in Austria were heated with biomass. As a result of declining oil prices, there was a clearly decreasing trend from the beginning of the 1990ies until 2005. Thereafter, sales figures of modern biomass boilers rose significantly (see Fig. 31), resulting in an increasing importance of biomass in domestic heating (cp. section 1.2.6).

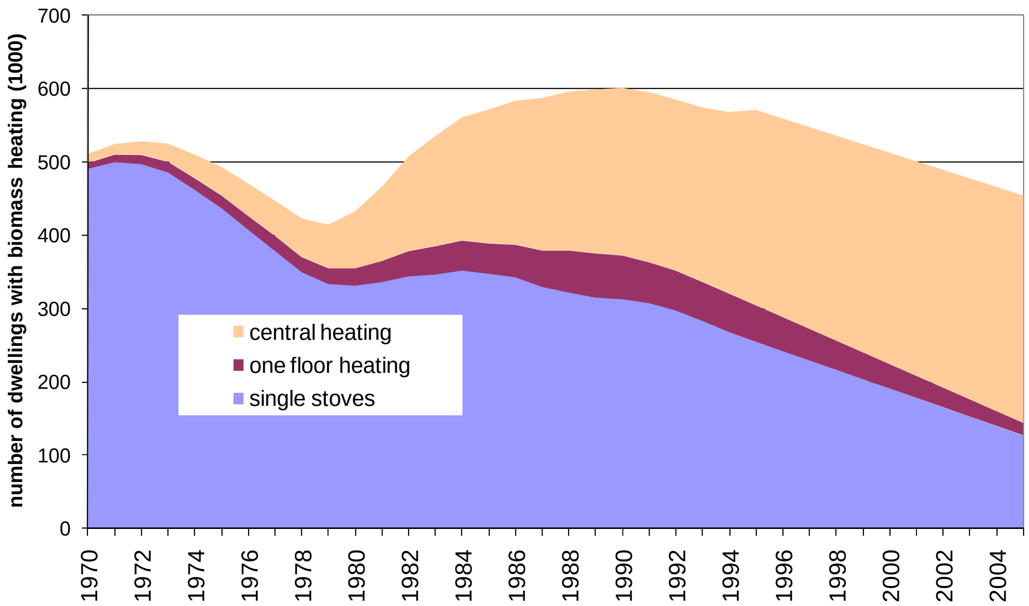


Figure 25. Development of the number of dwellings with biomass heating from 1970 to 2004.
Source: Kranzl et al. (2008)

5.3.2 District heating

Biomass district heating became increasingly popular during the 1990ies, partly due to investment grants of the "Länder" (provinces) and the Ministry of Agriculture. After the 1990ies the deployment of district heating plants declined, but district heat generation in CHP plants rapidly gained in importance. Fig. 26 shows the development of district heat generation broken down by plant types and the share of district heat originating from biomass plants. Since 2008, biomass heat and CHP plants account for more than one third of the total district production in Austria.

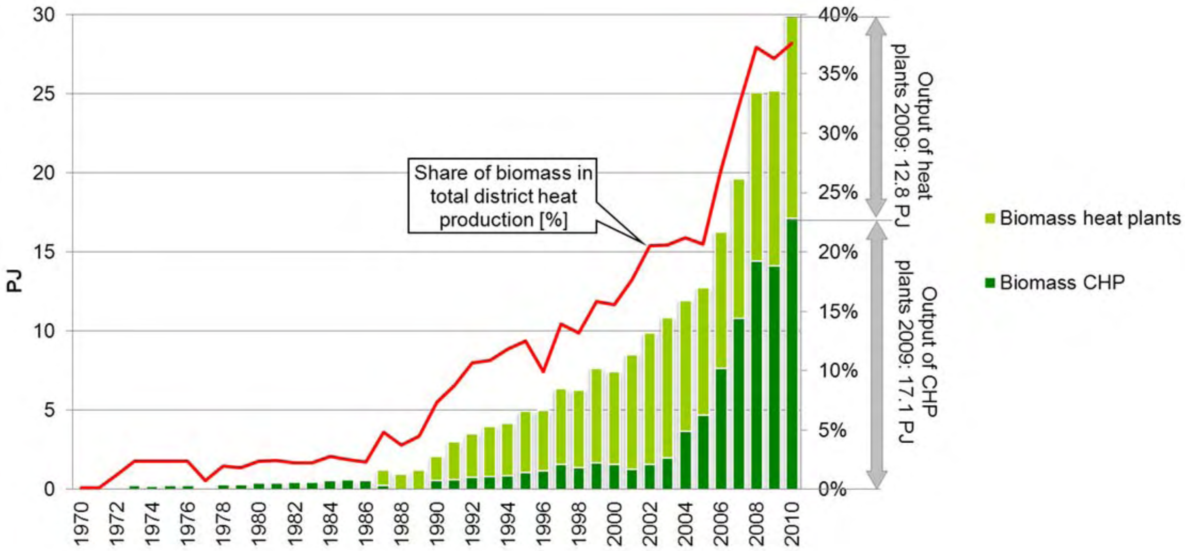


Figure 26. Development of biomass-based district heat generation from 1970 to 2009.
(HP: heat plants, CHP: combined heat and power plants)
Source: Statistik Austria (2011c)

5.3.3 Commerce and industry

The bioenergy use in commerce and industry is dominated by the wood-processing industries, first and foremost the paper and pulp industries (Fig. 27). From the late 1970ies to the early 1990ie the biomass share in the primary energy consumption in commerce and industry increased from about 2% to 16%. In 2010 biomass accounted for about 20% of the final energy consumption. About one fourth is used in CHP and power plants and the rest for heat generation.

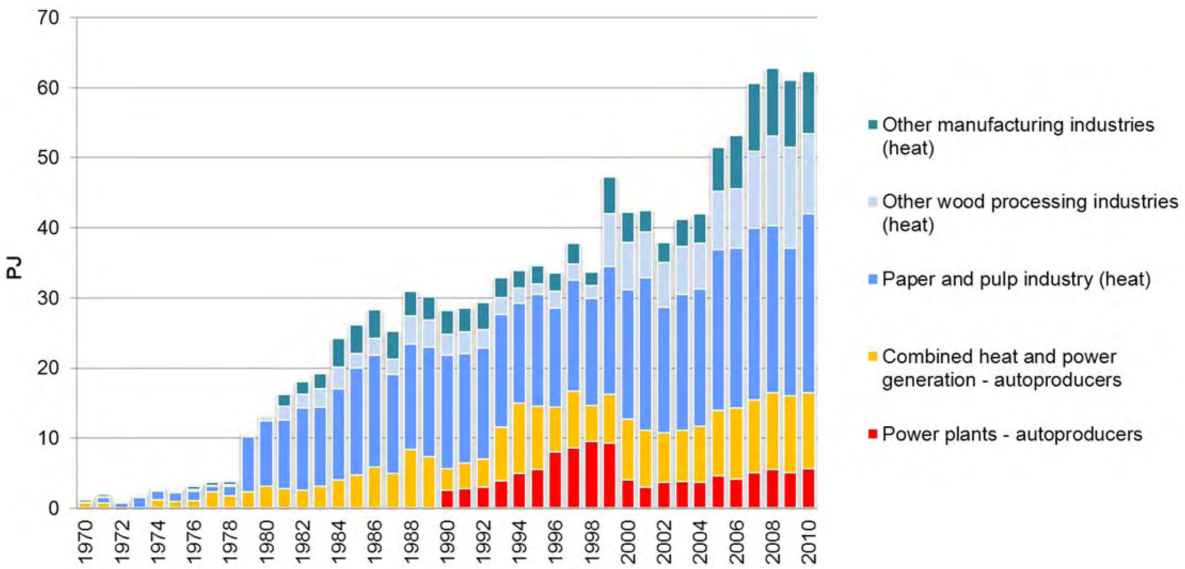


Figure 27. Development of biomass consumption in commerce and industry and the share of biomass in the total final energy consumption of this sector.
Source: Statistik Austria (2011c)

5.3.4 Electricity generation

Fig. 28 shows the development of electricity generation from biomass and biogenic waste. As mentioned before, electricity generation in autoproduction plants of the wood-processing industries gained some importance during the 1980ies and 1990ies. From 1985 to 2004, the biomass-based electricity generation was in a range of 2.5 to 3.5% of Austria's gross electricity consumption. As a consequence favourable of support conditions for eco-electricity plants, a rapid increase occurred during 2003 to 2007. This rapid diffusion virtually came to halt in 2008, primarily due to significant biomass price increases and amendments to the Green Electricity Act (see section 2.1.8). In 2010, biomass-based electricity accounted for about 6.5% of the gross electricity consumption in Austria.

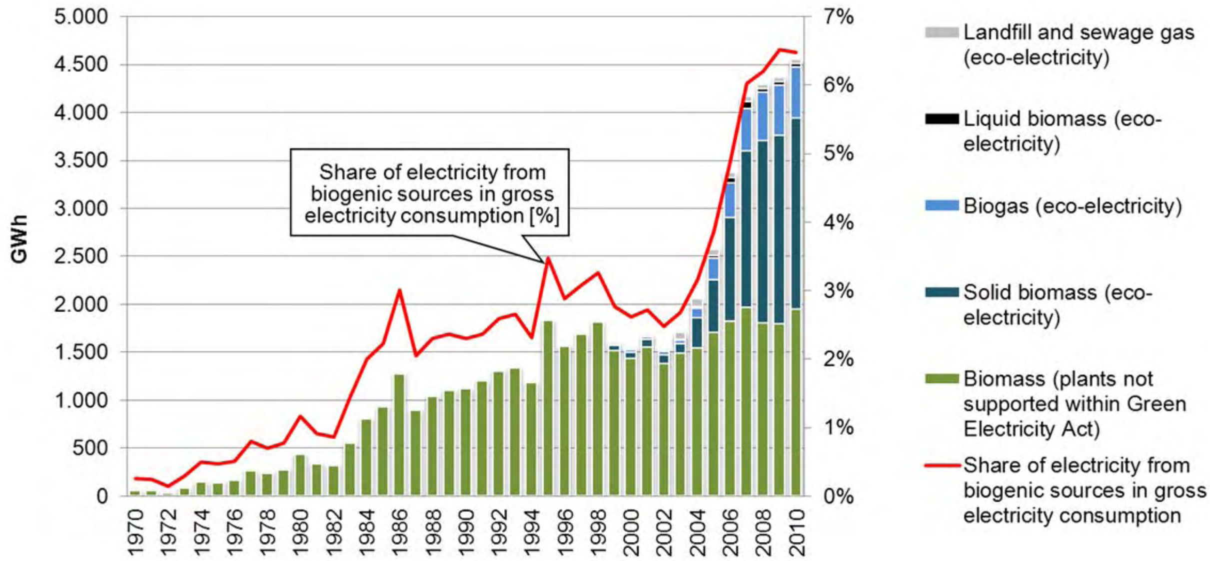


Figure 28. Development of electricity generation from biomass and its share in Austria's gross electricity consumption.
Sources: Statistik Austria (2011c), E-control (2011b)

5.3.5 Transport

The increasing use of biofuels for transport was one of the most dynamic developments in the Austrian bioenergy sector in the last decades. Fig. 29 shows the development of the consumption of biogenic transport fuels broken down by types of biofuels as well as the share in the total fuel consumption in road transport. The figure illustrates that this share increased from about 1% in 2005 to 7% in 2009. From 2009 to 2010, a slight reduction in the consumption of biofuels occurred. The figure also illustrates that the largest contribution comes from biodiesel in blends (66% in 2009), followed by pure biodiesel (19%), ethanol in blends (12%) and vegetable oil (3%). The current use of E85 (a blend that contains 85% ethanol and 15% gasoline) and biomethane (cleaned and conditioned biogas), is negligible (see Winter, 2011).

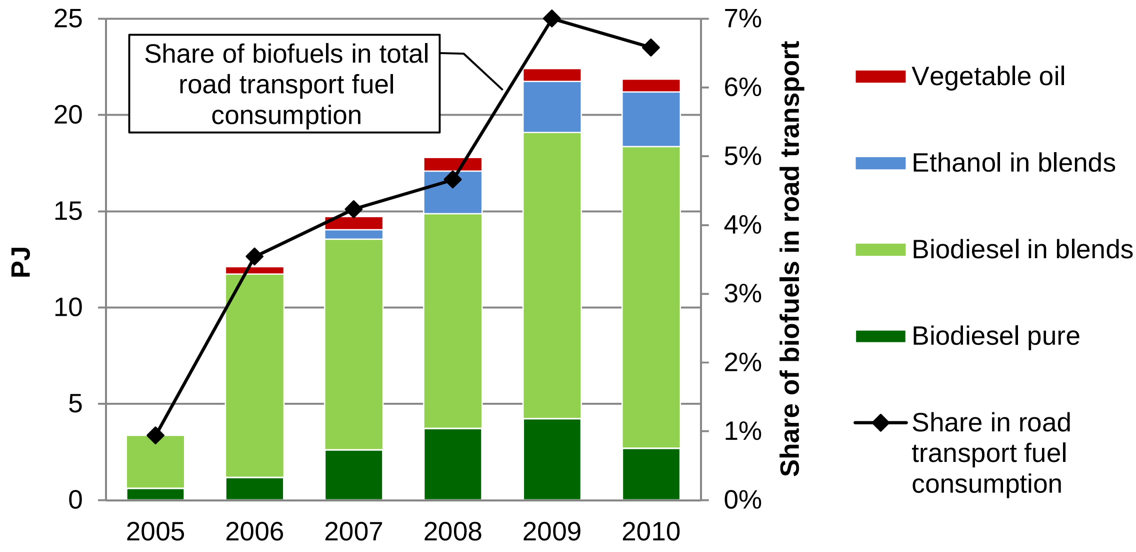


Figure 29. Development of the consumption of biofuels for transport in Austria from 2005 to 2010.
Sources: Winter (2011), Statistik Austria (2011c)

5.4 Plant capacities

This section provides data on currently installed and historic development of bioenergy capacities in Austria, including boiler capacities, capacities for electricity generation and biofuel and biomethane production capacities.

5.4.1 Boiler capacities

Data on biomass boiler capacities are shown in the following figures. Fig. 30, showing the annual installation and cumulated capacities of boilers with a rated power of more than 100 kW, illustrates the rapid deployment in the years 2005 and 2006. Since then, annual deployment rates have been declining, but in 2010 still surpassed the average deployment at the end of the 1990ies and the beginning of the 21st century. Compared to this period, an increasing share of boilers with a rated power of less than 1 MW could be could be observed in recent years. Based on the annual installations, the total installed capacities in 2010 are estimated about 2 GW (boilers up to 1 MW) and 2.4 GW (boilers above 1 MW).

Fig. 31 illustrates the rapidly increasing deployment of small-scale biomass boilers (up to 100 kW) in the last decade. Especially pellet boilers have become increasingly popular during this period. In 2007, the sales figures of pellet boilers declined significantly due to a pellet price peak in 2006/07 (see section 6.1.3), but in 2008 the market had already recovered. The data for 2009 and 2010 show a slight decrease of annual installations, possibly due to the overall economic situation. The cumulated capacities of pellet and wood chip boilers are estimated 1.5 and 2.4 GW, respectively.

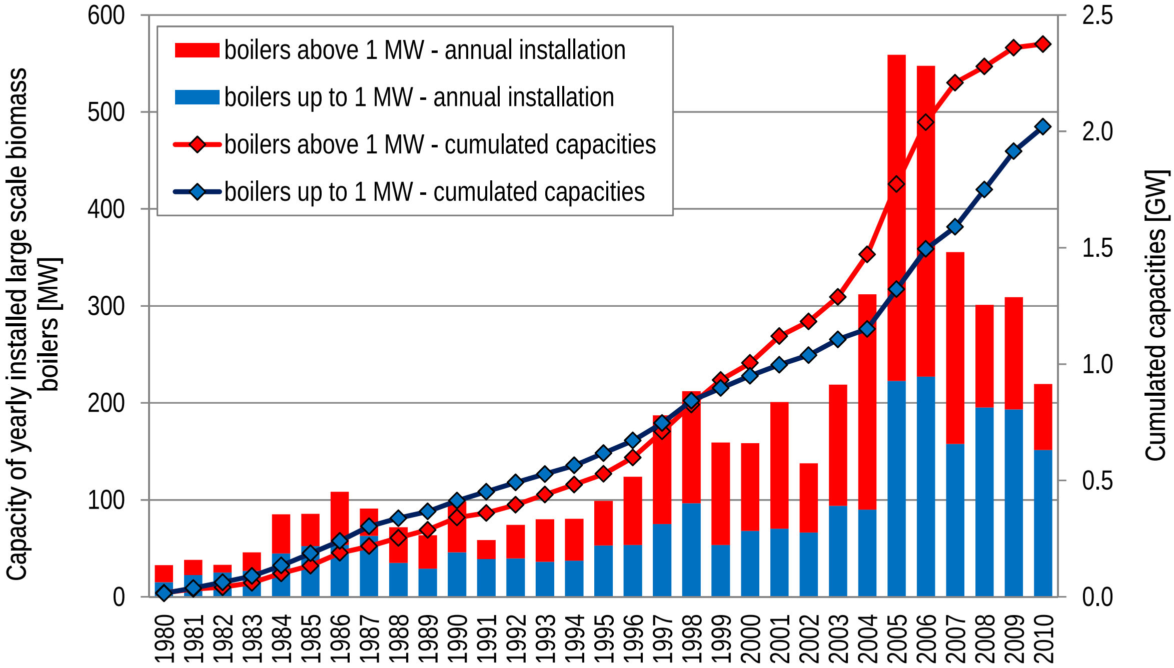


Figure 30. Development of annual installations and cumulated capacities of biomass boilers with a rated power of more than 100 kW.
(Cumulated capacities: calculation based on an assumed lifetime of 20 years; boilers installed before 1980 not taken into account.)
Source: Furtner & Haneder (2011), own calculations

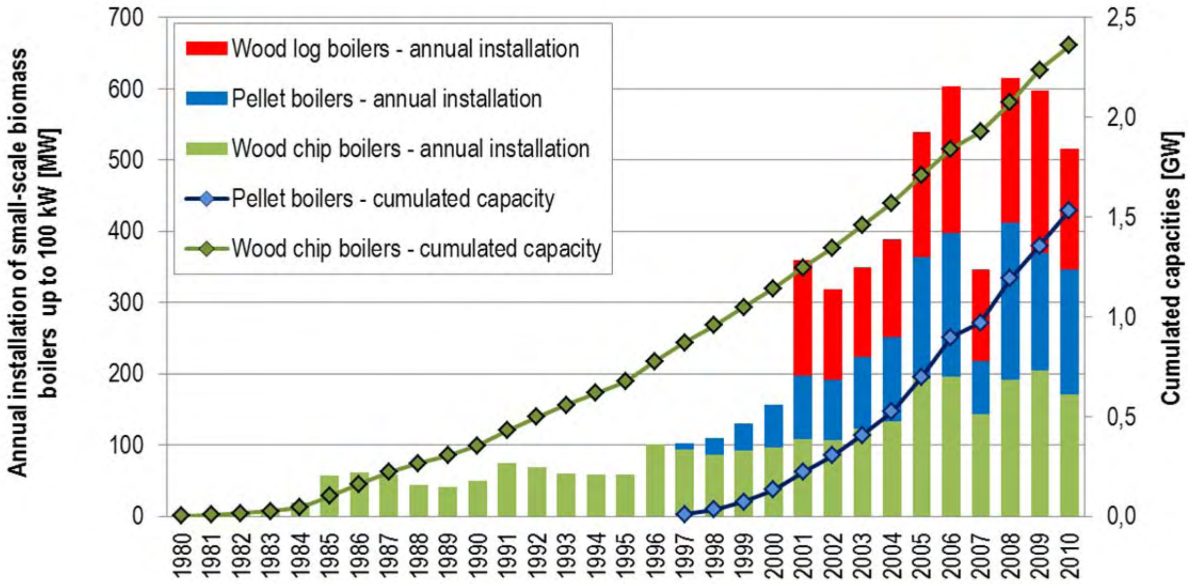


Figure 31. Development of annual installations and cumulated capacities of biomass boilers with a rated power up to 100 kW.
(Cumulated capacities: calculation based on an assumed lifetime of 20 years; wood chip boilers installed before 1980 not taken into account; cumulated capacities of wood log boilers are not shown as data are only available since 2001.)
Source: Furtner & Haneder (2011), own calculations

5.4.2 Capacities for electricity generation

The installed capacities of biomass electricity and CHP plants shown in Fig. 32 are based on official data on eco-electricity plants as well as estimated capacities of plants not supported within the Green Electricity Act (primarily autoproducer plants of the wood processing industries; waste liquor plants are excluded here). The installed capacities of eco-electricity plants using solid biomass exceed 300 MW_{el} and are by far the most important category, followed by biogas plants (about 80 MW_{el}).

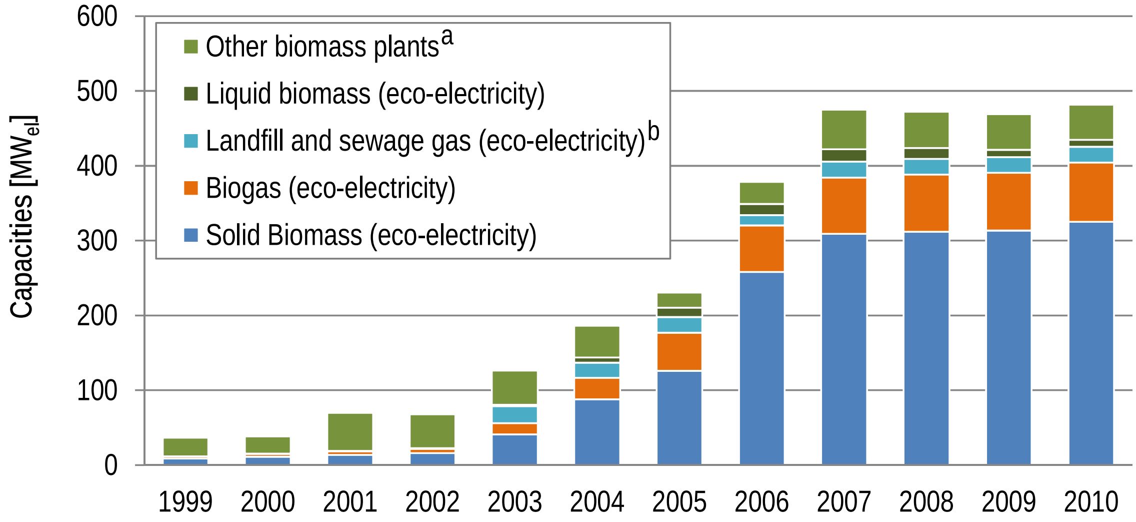


Figure 32. Development of installed capacities for electricity generation from biomass.
a) Bioenergy plants not supported as eco-electricity plants; estimated capacites based on energy balance (6,000 annual full load hours assumed); excluding waste liquor and MSW plants).
b) No data available for the years before 2003
Sources: E-control (2011b), Statistik Austria (2011c), own calculations

5.4.3 Biofuel and biomethane production capacities

Fig. 33 shows a comparison of the biodiesel and ethanol production with the production capacity of Austrian plants in 2003 to 2010. In 2009, there were 14 biodiesel plants and one ethanol plant operating in Austria (Winter, 2011). The total biofuel production capacity of these plants amounted to slightly more than 30 PJ in 2009 (707,000 tons of biodiesel according to EBB (2011) and 190,000 tons of ethanol according to ePURE (2011). A comparison with production data reveals that the biofuel plants in Austria have been operating far below capacity in recent years. In 2008 and 2009, the actual production amounted to approximately 50% of the capacity. According to EBB (2011), the biodiesel production capacities declined by about 5 PJ/a from 2009 to 2010. However, according to the umbrella organization of biofuel producers in Austria, *ARGE Biokraft*, the total production capacity of 14 biodiesel located in Austria accounted for about 650,000 t/a (about 24 PJ/a) in 2009 as well as 2010 (Winter, 2011).

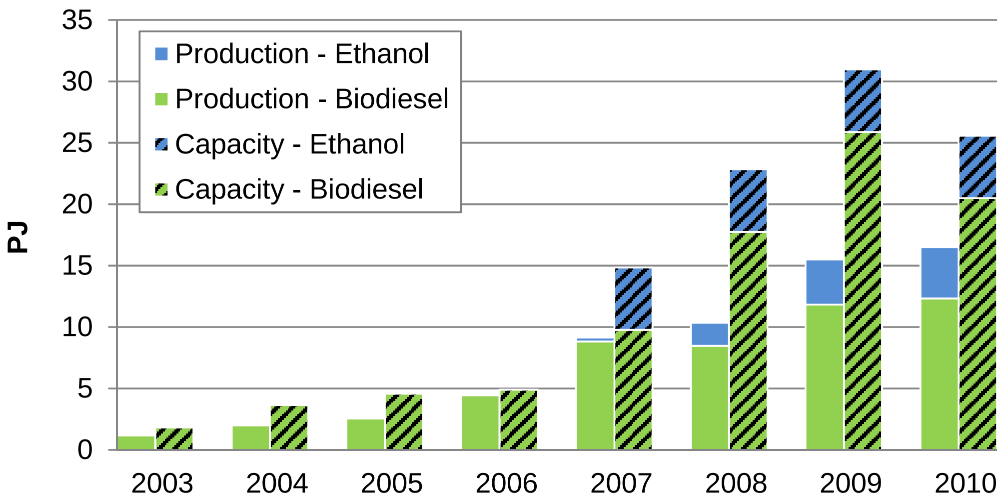


Figure 33. Comparison of the historic development of biodiesel and ethanol production with production capacities in Austria.
Sources: Winter (2011) (production), EBB (2011), ePURE (2011) (production capacities[7])

The following figures provide information on currently installed biomethane[8] plants. With a number of eight plants, and a total capacity of about 8.5 MW, the current relevance of this technology is very limited. Fig. 35 shows the location of these plants and provides information on the capacities and cleaning technologies applied.

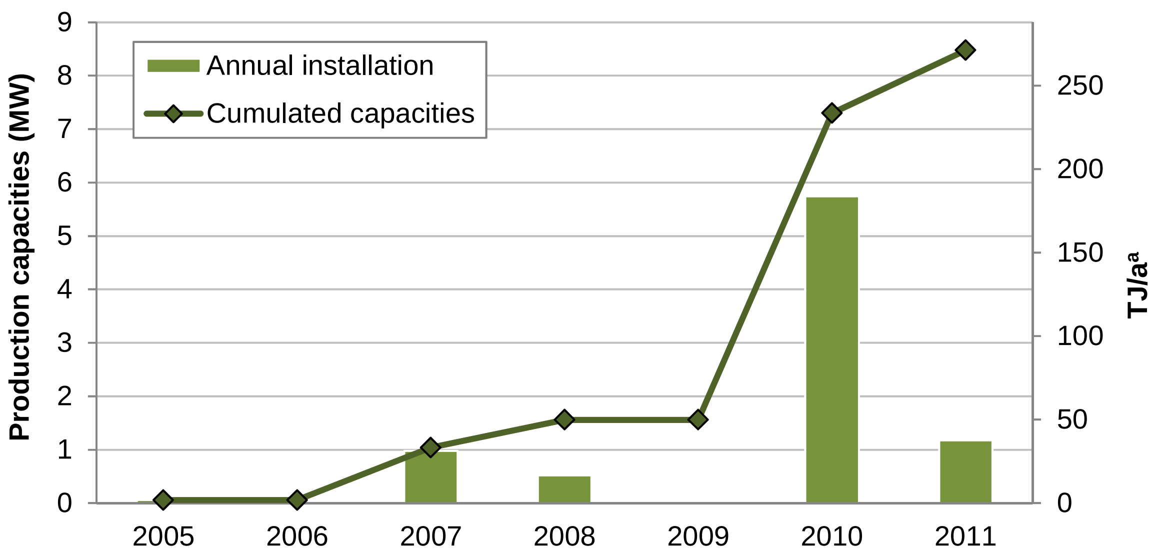


Figure 34. Development of biomethane production capacities.
a) Annual biomethane production capacity at an assumption of 8000 full load hours per year.
Sources: Biogaspartner (2011), Bala et al. (2009).

[7] Following EBB (2011), data on biodiesel production capacities are calculated on the basis of all plants operational in July of the respective year and assuming 330 working days per year.
[8] Biomethane is cleaned and conditioned biogas.

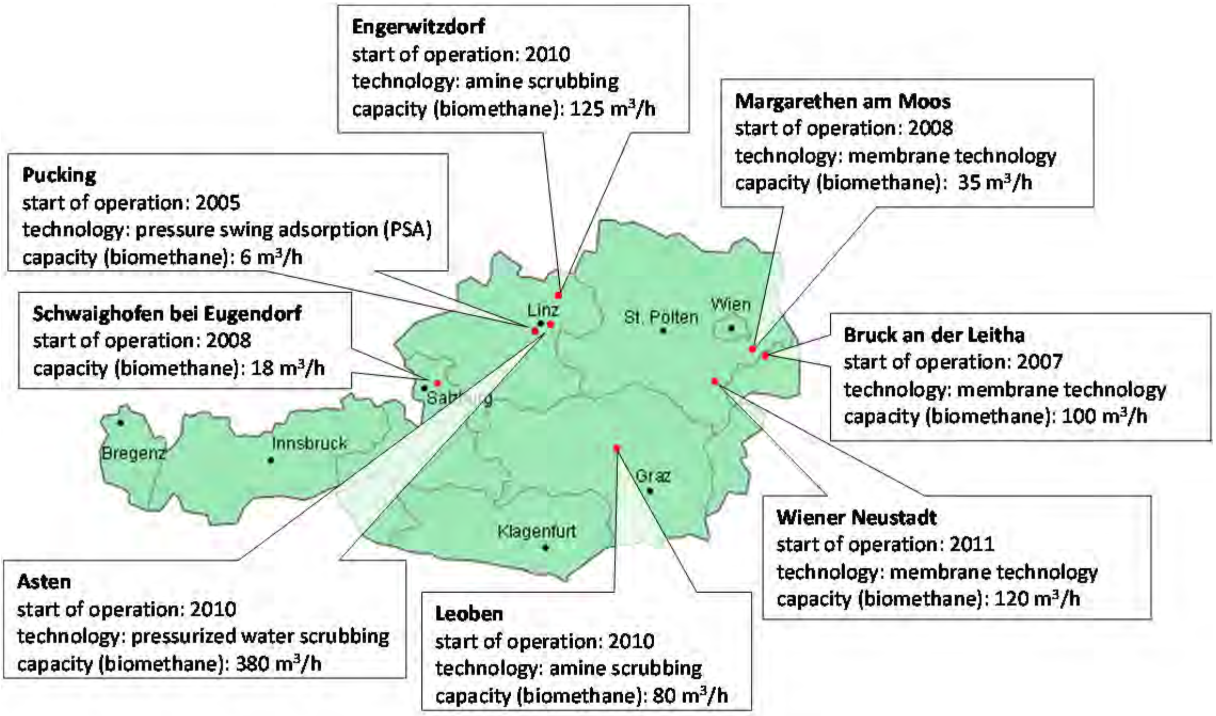


Figure 35. Location and characteristics of biomethane production plants in Austria.
Sources: Biogaspartner (2011), Bala et al. (2009).

6 Price development of biomass and fossil fuels

This section is dedicated to the historic price developments of wood fuels (section 6.1) and agricultural products used for the production of biofuels (6.2). For comparison, price developments of fossil fuels are also shown (6.3).

Biomass prices as well as those of fossil fuels generally depend on the type of consumers or purchase quantities, respectively. All price data stated here refer to specific purchase conditions. Value added tax (VAT) is usually excluded; in some cases prices incl. VAT (accounting for 10% for wood fuels and agricultural commodities and 20% for other fuels) are also stated.

6.1 Wood fuels

In the following sections, price developments of fuelwood (coniferous and non-coniferous), sawmill residues (wood chips and sawdust) and wood pellets are presented.

6.1.1 Fuelwood

As shown in section 4, fuelwood (wood log) accounts for as much as 30% of the total biomass consumption in Austria. Due to largely regional distribution channels, fuelwood prices vary widely and may differ significantly from representative prices in certain regions. Fig. 36 shows the development of representative fuelwood prices according to official national statistics.

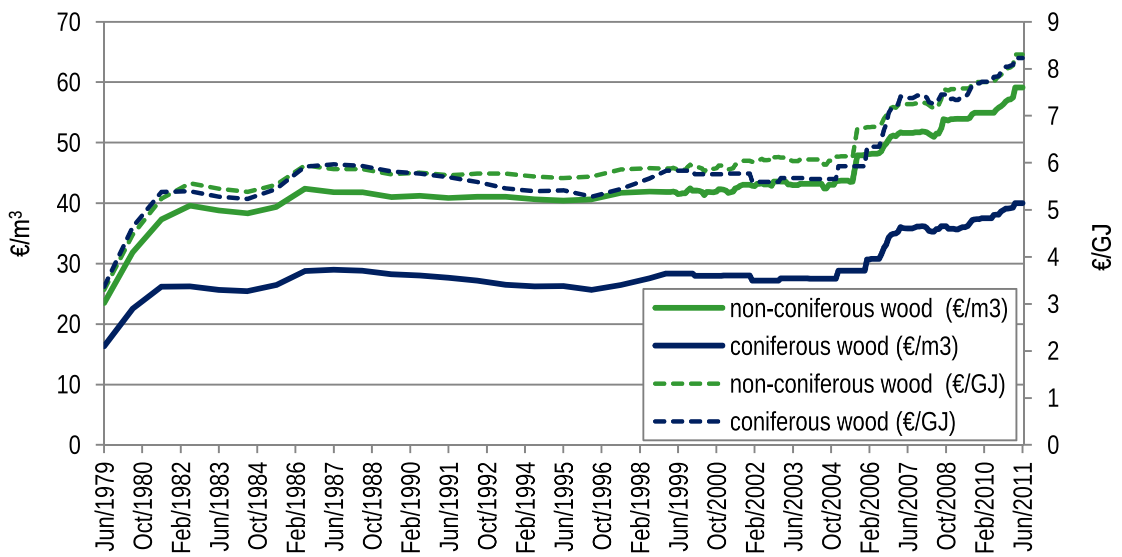


Figure 36. Development of nominal producer prices of fuelwood (coniferous and non coniferous) in Austria, prices are weighted bulk buyer and small consumer prices at forest road excluding VAT and transport cost.
(An average water content of 20% was assumed in the conversion from m^3 to GJ.)
Sources: Statistik Austria (2011e) (monthly values from Jan/1999 to Jun/2011), LK-NÖ (2011) (annual averages from 1979 to 1998), own calculations

The prices shown in Fig. 36 are based on weighted bulk buyer and small consumer prices at the forest road and do not include further transport cost. The original data are stated in € per cubic metre (€/m³). Based on typical calorific values of the most common tree species in Austria and under the assumption of an average water content of 20%, the prices have been converted to €/GJ_{LHV}. Due to a significantly higher specific heating value, the prices of non-coniferous wood per m³ have always been clearly higher than those of coniferous wood. The prices per GJ, however, are almost identical.

Apparently, there have been two periods during the last 32 years which were characterized by rapid fuelwood price increases: Around the beginning of the 1980ies and during the last 6 years. From the mid-1980ies until 2004, the nominal prices remained at an almost constant level of about 6 €/GJ. The price increase in recent years accounted for about 40%.

6.1.2 Wood chips and sawdust

The prices of sawmill by-products (wood chips without bark and sawdust) were relatively constant from the beginning of 1999 to mid-2005, as Fig. 37 shows. Thereafter, the period from mid-2005 until the first quarter of 2007 was characterized by steep price increases. As it was shown in previous chapters, a rapid deployment of biomass CHP plants and a sharp increase in the biomass demand occurred at this time. After a peak in January 2007 the prices decreased by about 30%. Thereafter, wood chips prices have remained relatively stable, whereas the prices for sawdust again showed a rising trend and reached the price level of January 2007 in May 2009. No data are available for 2010 and 2011 could be obtained from FHP (2010). However, data according to LWK (2011) indicate that there were average price increases of about 30% (wood chips) and 22% (sawdust) from 2009 to 2010.

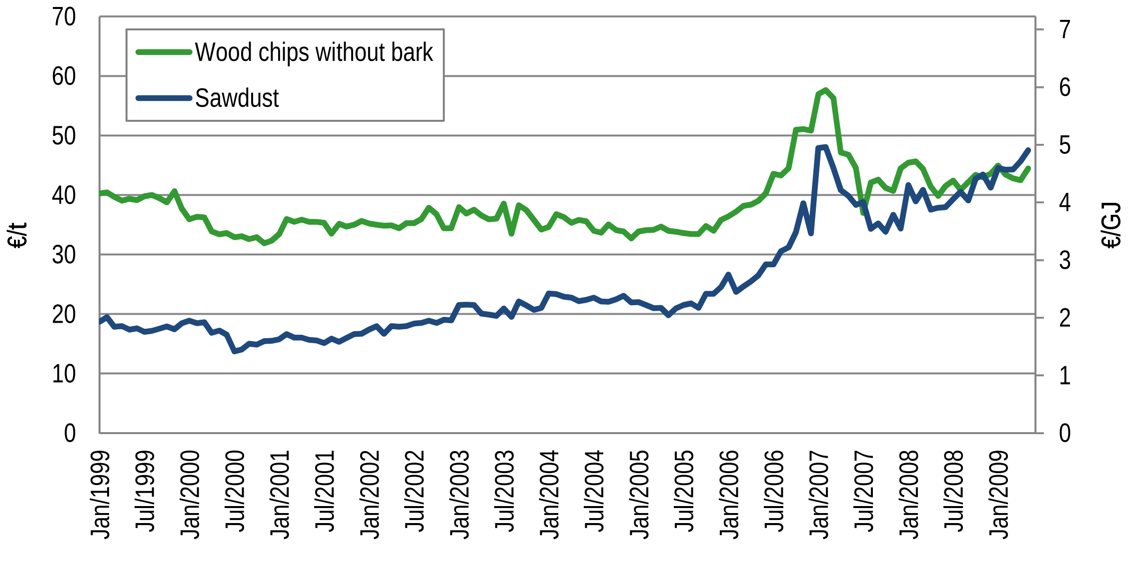


Figure 37. Nominal price development of wood chips without bark and sawdust in Austria. Source: FHP (2010)

6.1.3 Pellets

The prices for wood pellets are subject to pronounced seasonal fluctuations, as Fig. 38 shows. With regard to annual averages, there was a decreasing trend from 2001 to 2005. The price peak in winter 2006/07 was a result of the following events: The preceding winter was exceptionally long with high snowfalls, causing a high demand for wood pellets. Furthermore, wood fellings in 2006 decreased by about 25% due to the weather conditions, resulting in a shortage of roundwood and sawmill residues for pellet production. At the same time, pellet storages needed to be refilled after the long winter 2005/2006 and sales of pellet boilers as well as exports to Italy continued to increase (see section 7.2.4). These events caused the pellet prices to increase by close to 70% compared to April 2005. In spring 2007 prices went back down to less than 200 €/t. Due to windfall caused by the storms "Kyrill", "Paula" and "Emma" in 2007 and 2008, plenty of roundwood was available during these years, and prices remained at a relatively constant level of about 200 €/t. As the pellet price peak in winter 2006/07 caused sales figures of pellet boilers to decline by more than 50% and did serious damage the reputation of the whole pellet industry, it is assumed that producers were also eager to avoid such price peaks in the following years.

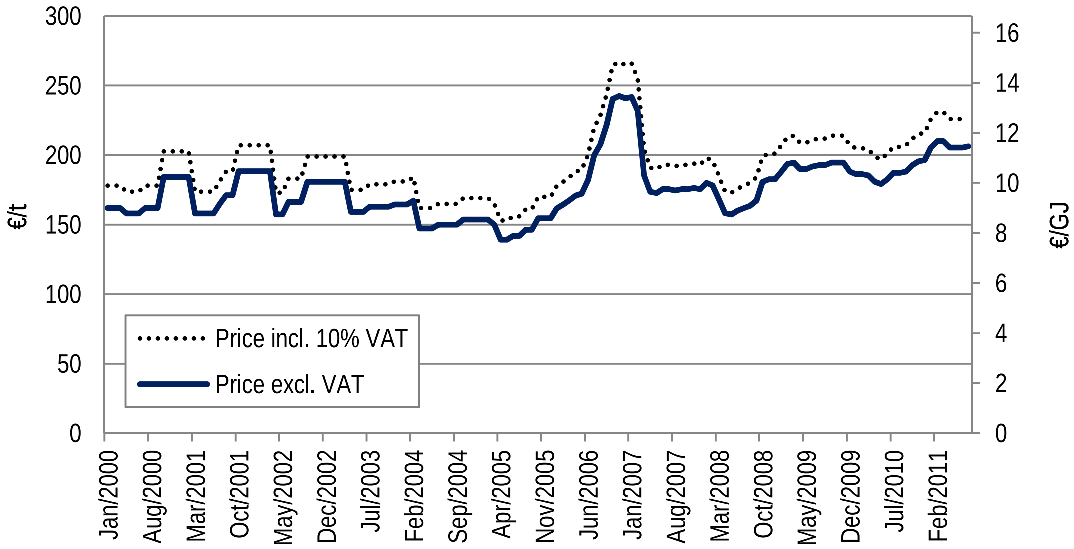


Figure 38. Nominal price development of wood pellets in Austria.
(Weighted average price per tonne delivered as loose; purchase volume of about 5 tonnes; incl. transport of max 50 km; incl. VAT (10%); ÖNORM M 7135)
Sources: ProPellets (2011), Pellet@las (2011)

6.1.4 Summary

The following figure shows a comparison of the real price developments (in $€_{2010}$/GJ) of the wood fuels described above. Unsurprisingly, bulky biomass types primarily used in large scale plants (wood chips and sawdust) are cheapest. The data for fuelwood (wood logs) show the smallest price fluctuations during the considered period from January 1999 to April 2011. However, this might be due to the methodology of data collection and calculation of representative values. Prices for fuelwood are known to vary widely among different regions, and actual price fluctuations in different regions might have been clearly higher compared to what the data in Fig. 39 suggest. Pellets shows clearly more pronounced seasonal price fluctuations than the other biomass types.

The Austrian energy wood index (since 1979 published by the Agricultural Chamber of Lower Austria) is calculated on the basis of the prices for fuelwood, pulpwood, other industrial roundwood, wood chips and sawdust. Fig. 40 shows a comparison of its development since 1986 with other energy indices. Apparently, the energy wood index was clearly more stable than the other indices. In 2010 it reached its first all-time high since 1986.

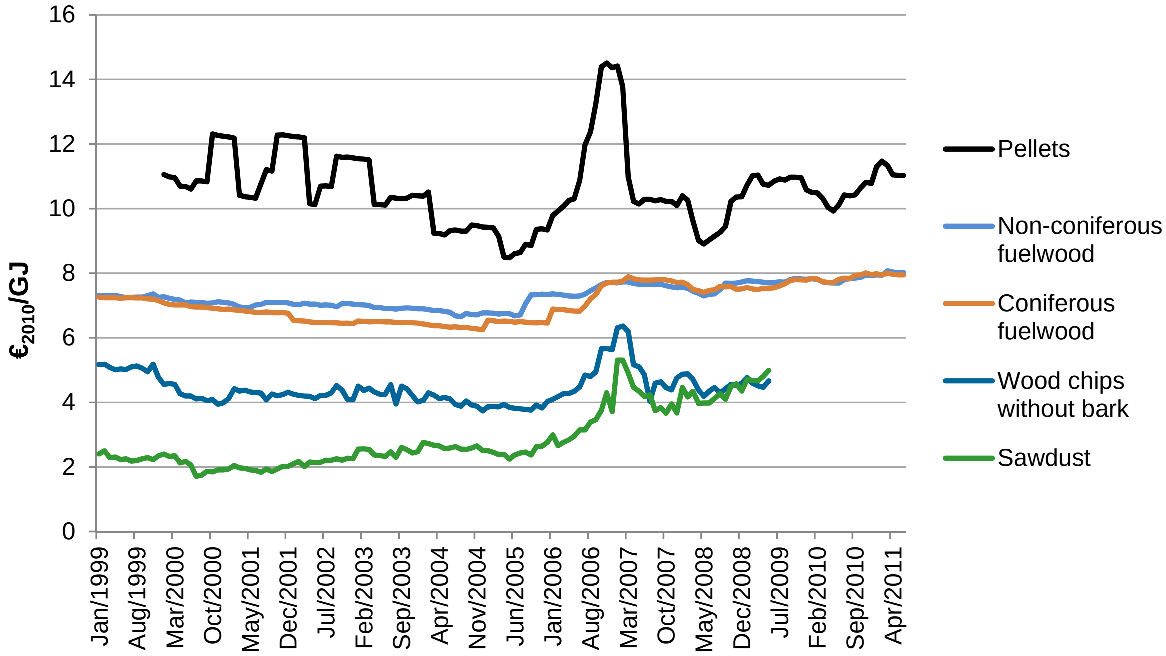


Figure 39. Comparison of real price development of wood fuels.
(in €$_{2010}$ excl. VAT).
Sources: Statistik Austria (2011e), LK-NÖ (2011), FHP (2010), ProPellets (2011), Pellet@las (2011), Statistik Austria (2011f), own calculations

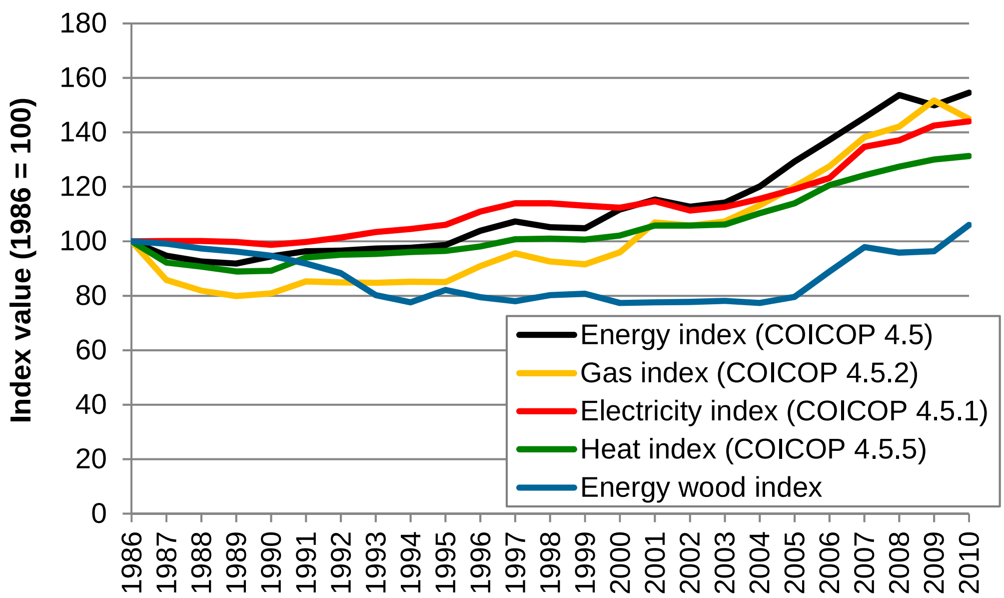


Figure 40. Development of the Austrian energy wood index from 1979 to 2010.
(COICOP: Classification of Individual Consumption According to Purpose; see (UN Statistics Division, 2011); Electricity, heat, gas and energy indices also include associated expenditure such as hire of meters, reading of meters, standing charges etc.; Heat refers to hot water and steam purchased from district heating plants.)
Sources: LK-NÖ (2011), Statistik Austria (2011g)

6.2 Agricultural feedstock and biodiesel

In the following sections price developments of oilseeds (rapeseed and sunflower seed) and feedstock for ethanol production (wheat and maize) are shown.

6.2.1 Oilseeds

The following figure (Fig. 41) shows the price development of the two most important types of oilseeds that are traded at the Vienna Agricultural Commodities Market: rapeseed and sunflower seed. The main feedstock for the production of biodiesel in Austria is rapeseed. The figure shows that the prices for oilseeds remained relatively constant at about 200 €/t from 2004 to 2006. As a consequence of a surge in demand as well as the strong increase in fossil fuel prices from the beginning of 2007, the prices for oilseeds rose to more than 400 €/t. After a decline in mid-2008 and a short stabilization at about original price levels, prices went back up to close to 500 €/t at the end of 2010.

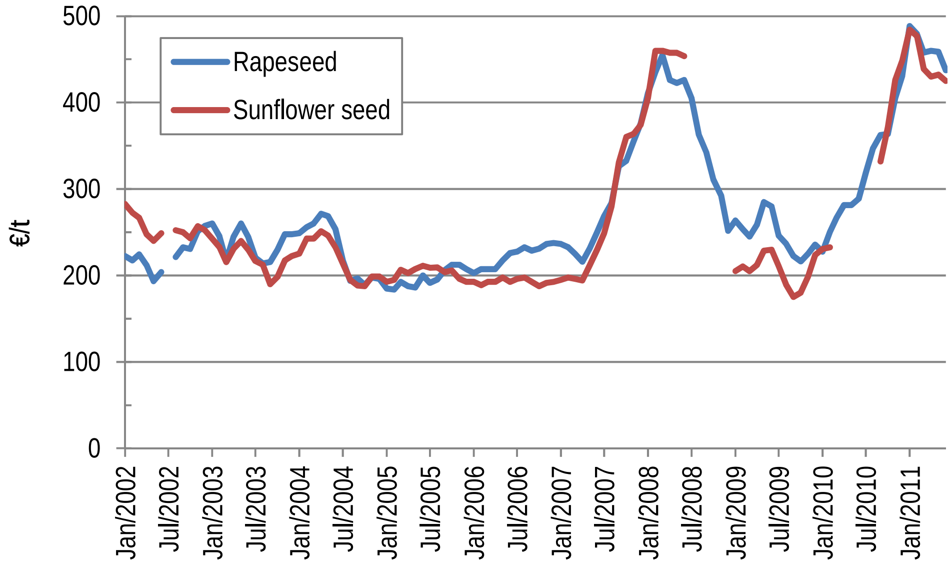


Figure 41. Nominal price developments of oilseeds at the Vienna Agricultural Commodities Market (Börse für landwirtschaftliche Produkte in Wien).
(Monthly average wholesale prices in €/ton, excl. VAT; rapeseed: 40% fat, bulk; sunflower seed: 44% fat, bulk)
Source: Stock market for agricultural products Vienna, in AMA (2011)

6.2.2 Feedstock for ethanol

As mentioned in above, there is one single ethanol plant in Austria with an annual production capacity of 240,000 m³. The following feedstocks are used in this plant: wheat, maize and sugar beet syrup. Wheat accounts for the largest share. Wheat is traded in different qualities; depending on the market situation, different types of wheat are used for ethanol production in Austria.

The following illustration (Fig. 42) shows the price developments of soft wheat, feed wheat and feed maize at the two Agricultural Commodities Markets in Vienna and Wels. There were two periods with exceptionally high prices during the last 10 years: from mid-2007 to mid-2008 and since the last quarter of 2010. The prices for soft wheat showed the highest volatility as well as the highest price peaks.

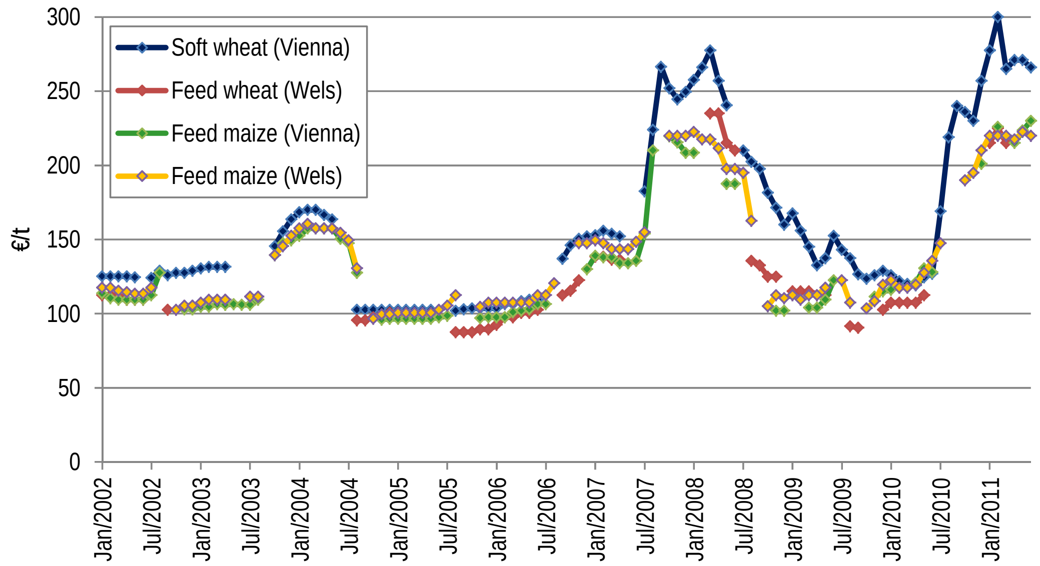


Figure 42. Nominal price developments of wheat and maize at the Agricultural Commodities Markets Vienna and Wels (Börse für landwirtschaftliche Produkte in Wien and Wels).
(Monthly average wholesale prices in €/tonne, excl. VAT)
Source: Stock market for agricultural products Vienna, in AMA (2011)

6.2.3 Biodiesel

Fig. 43 shows the development of average biodiesel prices at the pump from March 2008 to June 2011 as well as highest and lowest registered prices according to a survey of the Arbeiterkammer (Chamber of Labour). According to this survey, biodiesel prices at the pump are strongly coupled to fossil diesel prices and were on average 5.5% lower.

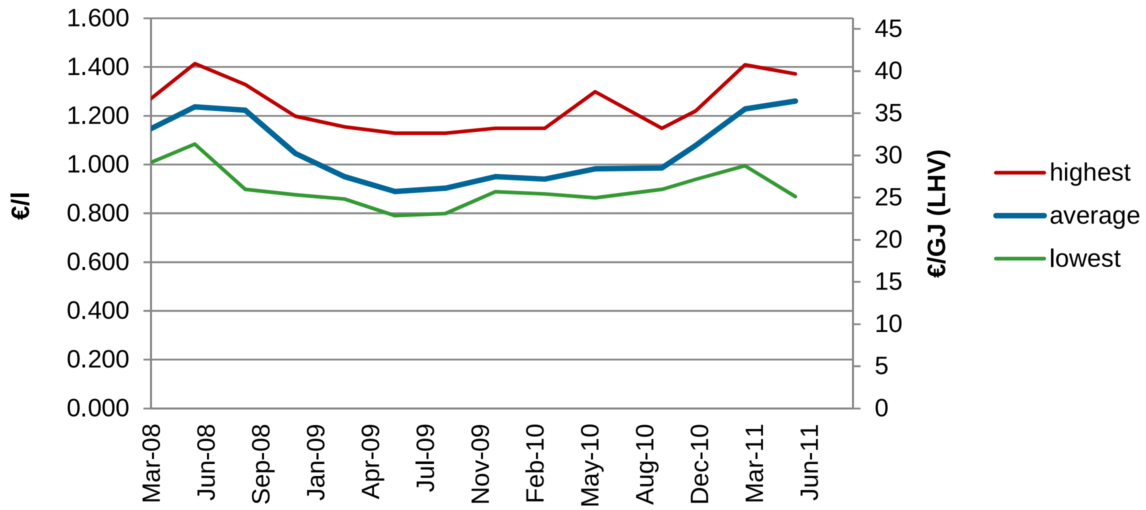


Figure 43. Nominal price development of biodiesel at the pump.
(based on a survey of 1380 petrol stations, 32 of which selling biodiesel)
Source: Arbeiterkammer (2011)

6.3 Fossil fuels

The following figures show the development of fossil fuel prices in recent years. They include prices with and without taxes, prices related to volume and energy units, nominal and real price developments as well as data on regional differences.

6.3.1 Heating oil

The following figure shows the price development of heating oil with and without taxes from mid 2003 to the last quarter of 2011. Apparently, after recovering from the price peak in mid-2008, (nominal) prices with taxes have again increased to close to 1 € per litre.

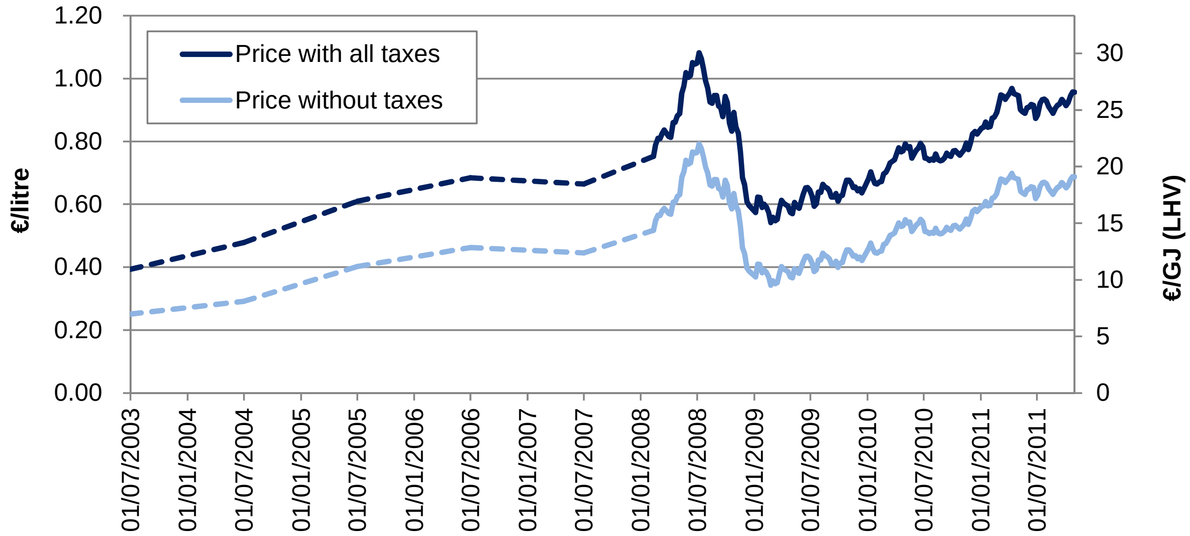


Figure 44. Nominal price development of heating oil.
(Prices refer to a purchase quantity of 2,000 litre; 2003 to 2007: annual averages, from 2008: weekly values)
Sources: Statistik Austria (2011h), BMWFJ (2011)

6.3.2 Transport fuels

Fig. 45 shows the development of nominal diesel and petrol prices at the pump as well as mineral oil taxes. Petrol sorts are distinguished according to their Research Octane Number (RON) into “normal” petrol (RON 91), “Eurosuper” (RON 95) and “Super Plus (RON 98). Prices for diesel and “Eurosuper” including taxes have reached an all-time high in late 2011. The price developments per GJ_{LHV} are shown in Fig. 46. Related to energy content, diesel is still clearly cheaper than petrol.

The historic price development (including nominal and real prices) since 1970 is shown in Fig. 47. It is interesting to note that despite significant price (and also slight tax) increases in recent years, the real prices for transport fuels are still clearly lower than during the early 1980ies.

Fig. 48 illustrates the spread of fuel prices in Austrian regions. Apparently, regional differences are almost negligible compared to the price spread within the regions. Petrol prices show a clearly higher spreads than diesel prices (especially petrol of the type “Super Plus”).

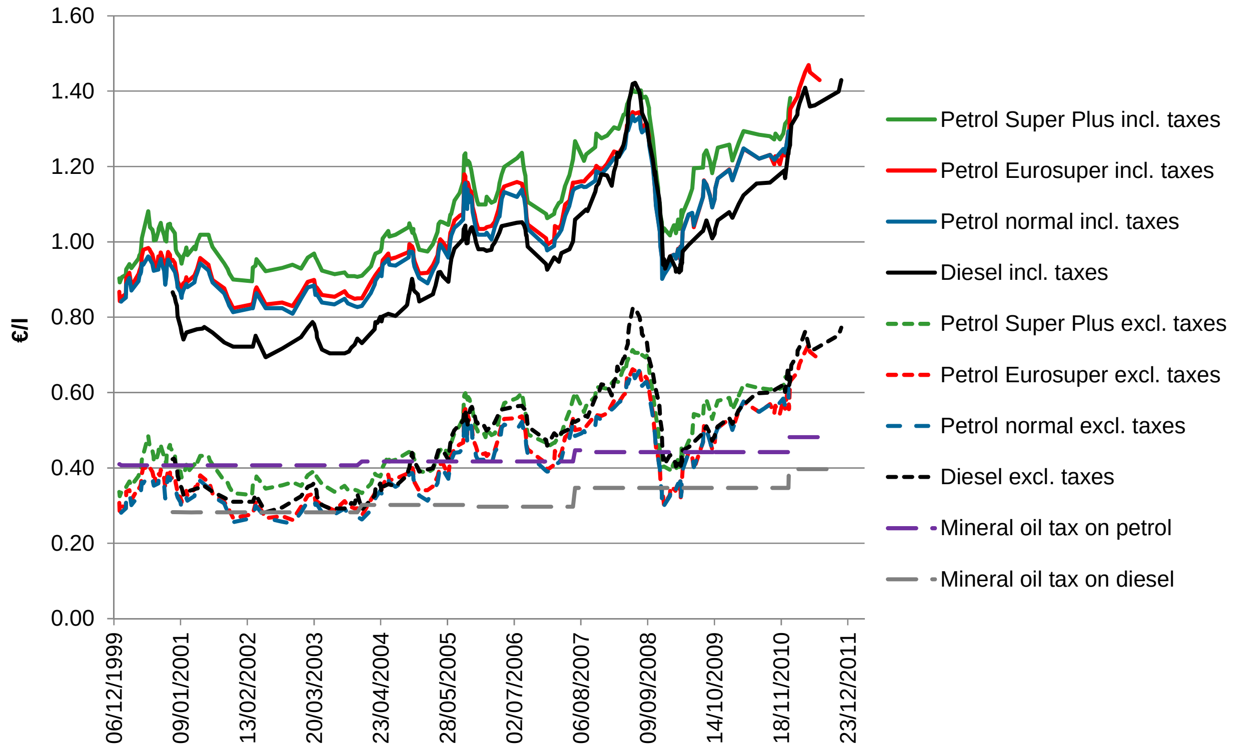


Figure 45. Nominal price development of fossil transport fuels at the pump incl. and excl. VAT and mineral oil taxes.
Source: ÖAMTC (2011), own calculations

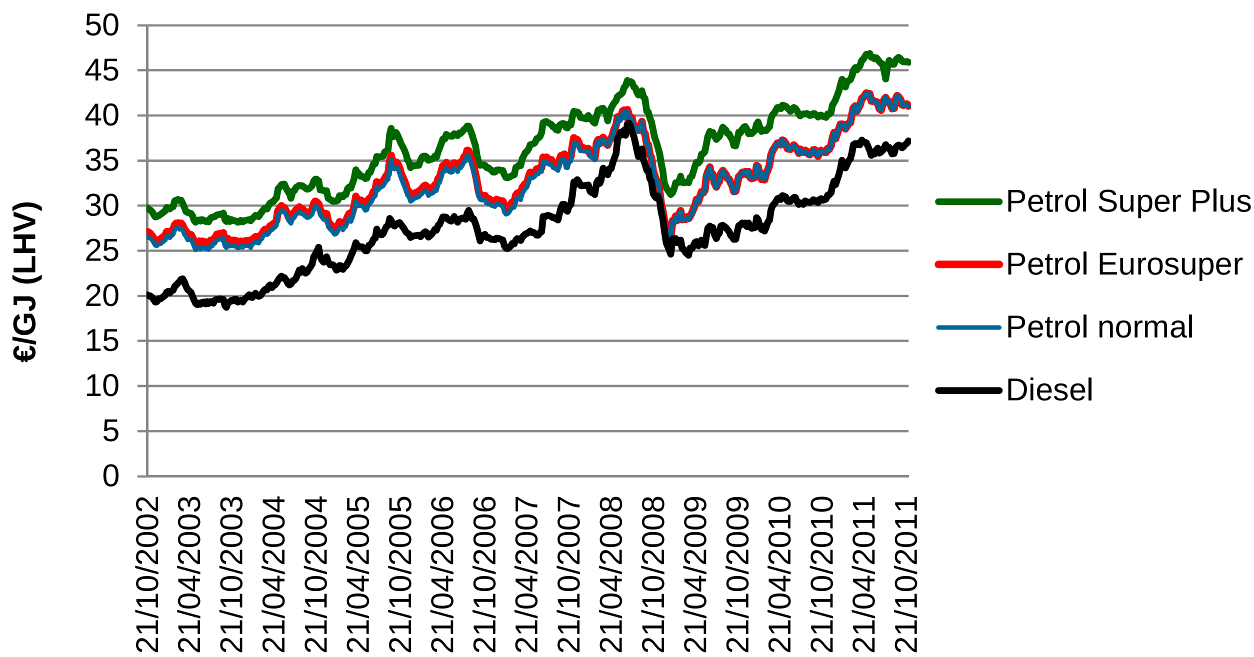


Figure 46. Nominal price development of fossil transport fuels at the pump (incl. taxes).
Sources: BMWFJ (2011)

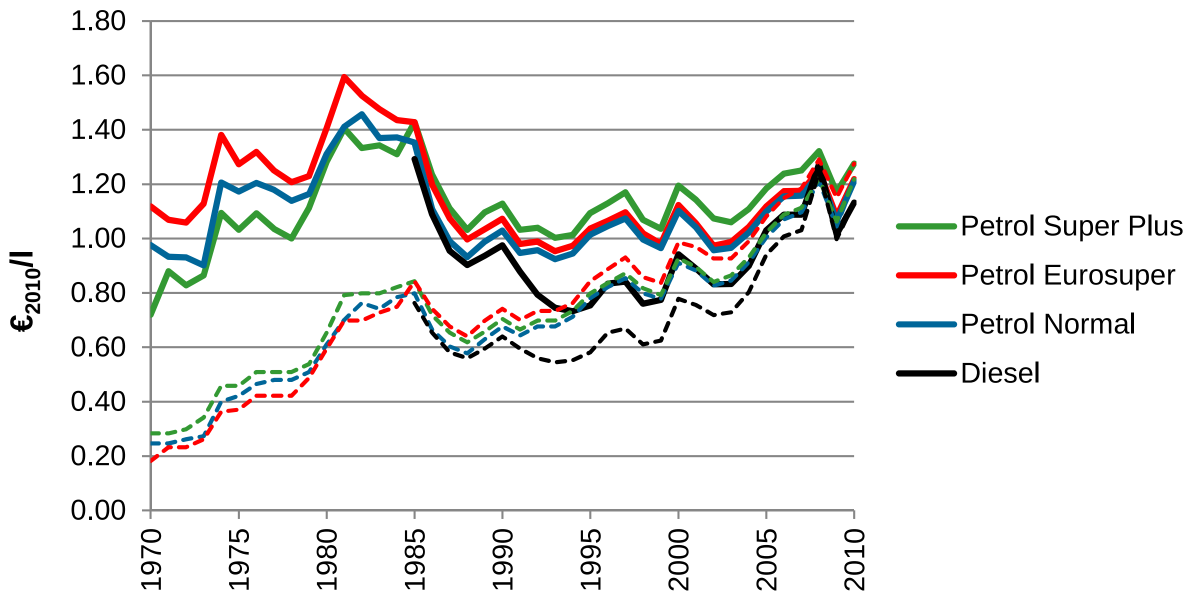


Figure 47. Real and nominal price development of transport fuels from 1970 to 2010 (price at the pump incl. taxes).
(Continuous lines: real prices in €$_{2010}$; dashed lines: nominal prices)
Source: ÖAMTC (2011), own calculations

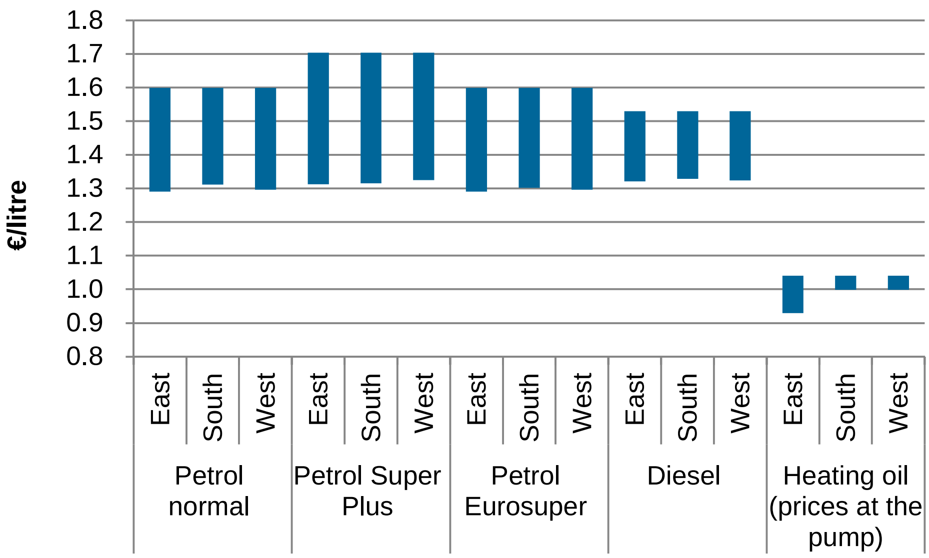


Figure 48. Regional spread of transport fuel prices at the pump as of 11/11/2011.
(East: Upper Austria, Lower Austria, Vienna, North-Burgenland; South: East Tyrol, Carinthia, Styria, South-Burgenland; West: Vorarlberg, North Tyrol, Salzburg)
Source: BMWFJ (2011)

6.3.3 Natural gas

The following figures show the historic development, structure and regional differences of natural gas prices for households. In late 2011, the average prices including grid tariffs and taxes almost reached the maximum price level in January 2009, as Fig. 49 illustrates. Apart from increasing energy prices, increases in grid charges and taxes contributed to this development.

Fig. 50 illustrates that there are significant regional differences in household gas prices. Differing energy prices are the main factor, but grid charges and taxes also differ from region to region. The highest total prices are charged in the capital of Vienna (7.72 c€/kWh in November 2011), followed by the city of Klagenfurt in Carinthia (7.66 c€/kWh). Prices are lowest in the province of Vorarlberg, the westernmost region of Austria.

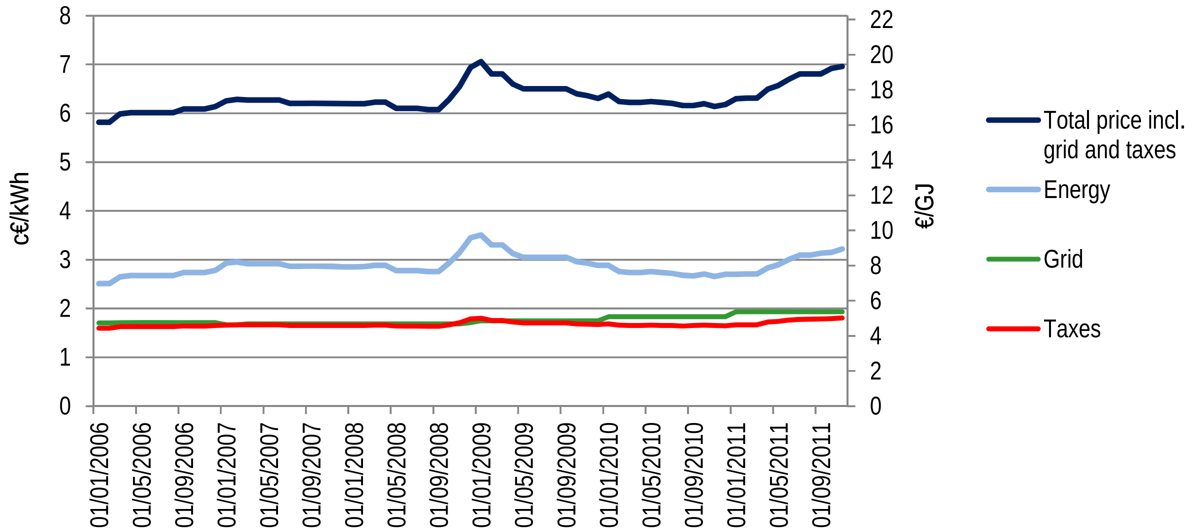


Figure 49. Development of average gas prices (nominal) for households.
(Total end user prices include the energy prices, grid charges and taxes (VAT and energy tax). Prices refer to an annual consumption of 15,000 kWh/a.)
Sources: Statistik Austria (2011h), BMWFJ (2011)

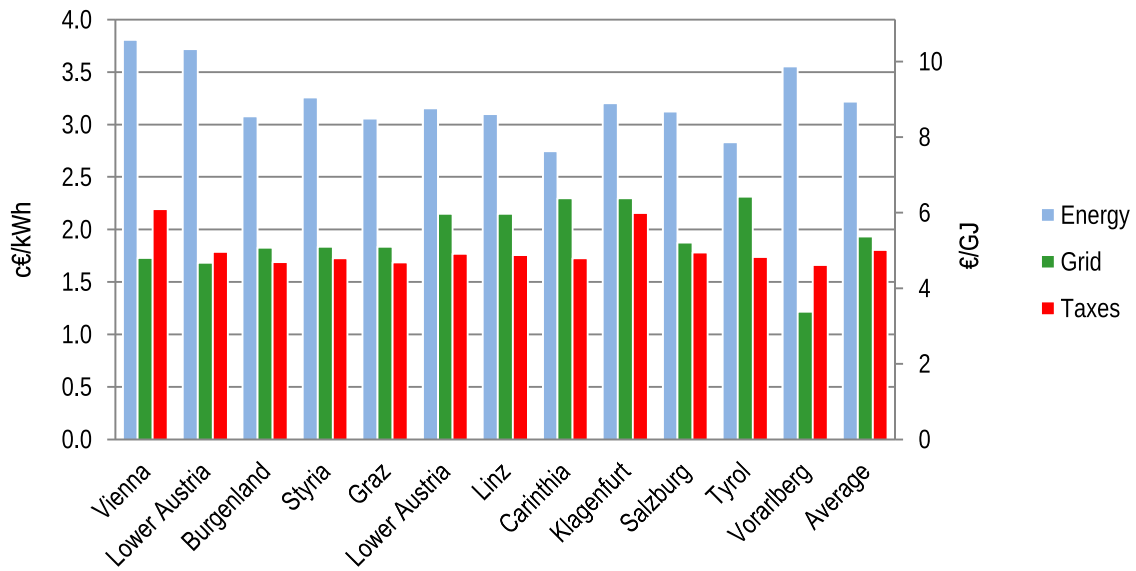


Figure 50. Comparison of gas price for households as of 01/11/2011.
(Prices refer to an annual consumption of 15,000 kWh/a.)
Sources: Statistik Austria (2011h), BMWFJ (2011)

7 International trade of biomass for bioenergy in Austria

This section provides an overview of the international biomass trade related to bioenergy use in Austria. Apart from energy statistics (section 7.1), trade statistics, other databases (e.g. Pellet@las, 2011)) and publications (e.g. the official biofuel report pursuant to Directive 2003/30/EC (Winter, 2011) as well as from the Austrian wood-processing industries and agricultural supply balances are used, in order to provide a comprehensive insight into direct and indirect bioenergy-related trade. The following sections have largely been adopted from Kalt (2011) and Kalt & Kranzl (2011).

The calorific values used for the conversion of data stated in mass (tons; t) or volume (SCM – solid cubic meters) to energy are stated in Table 5. Most are based on the calorific values assumed in the official energy statistics (Statistik Austria, 2011c).

Table 5. CN codes of biomass types used for energy and their definitions according to the nomenclature of trade goods.
Source: based on Statistik Austria (2011c) and own assumptions

	GJ/kg	GJ/SCM[a]
Log wood	14.31[b]	7.20[c]
Wood chips / wood residues	9.69[b]	-
Wood pellets	18.00[b]	-
Biodiesel	36.60[b]	-
Ethanol	26.68[b]	-
Black liquor	8.47[b]	-
Charcoal	31.00[b]	-
Raw wood	-	7.20[c]

a) SCM: solid cubic meters
b) based on Statistik Austria (2011c)
c) assumption; corresponding to coniferous wood with a water content of 20%

7.1 Biomass trade according to energy statistics

Fig. 51 shows the imports and exports of biomass used for energy production in Austria according to energy statistics (Statistik Austria, 2011c). For the period 2005 to 2009, the data are broken down by different types of biofuels, pellets and briquettes, wood log and charcoal. International trade of other biomass types (like wood chips, biogenic municipal solid wastes etc.) is indicated as zero for all years.

The figure illustrates that according to energy statistics, Austria was a net exporter of biomass fuels until 2005. From 2000 to 2004, both imports and exports increased about 2.5-fold, resulting in net exports of 5.6% of the total biomass GIC. In the following years, which were characterized by a rapid increase of biomass use (see section 5), the imports rose to around 30 PJ/a. As a result, the net imports accounted for up to 9% of the total biomass consumption (2006, 2009 and 2010). Both increasing imports of liquid biofuels and wood fuels contributed to this trend.

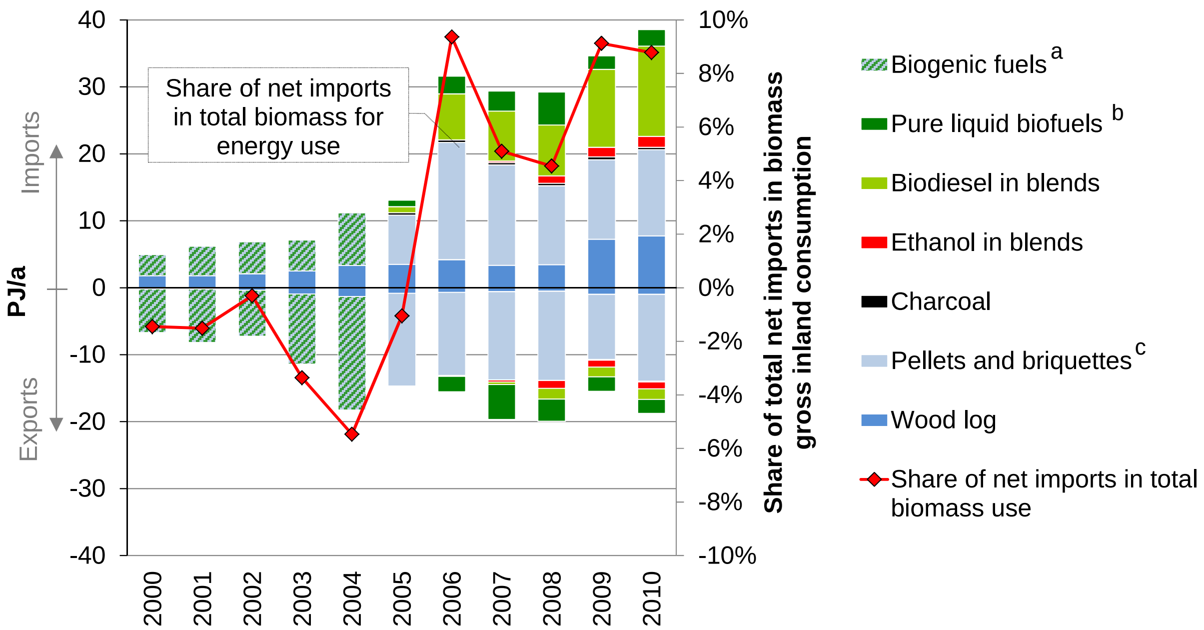


Figure 51. Imports and exports of biogenic energy carriers according to energy statistics of the national statistical authority.

a) Includes all types of biomass except wood log

b) Includes vegetable oil, pure biodiesel and E85

c) A comparison with other trade statistics indicates that the category "pellets and briquettes" also includes unrefined wood fuels.

Sources: Kalt & Kranzl (2011) based on Statistik Austria (2011c)

7.2 Wood fuels in trade statistics

Trade statistics provide data on biomass streams broken down by trade partners. Table 6 provides a list of the most relevant biomass types used for energy in Austria, their definitions and CN codes (see European Commission, 2010). It is stressed that biomass for energy is traded under numerous other codes (e.g. agricultural commodities like oilseeds), and that most codes listed here also include material used for non-energy uses. Apart from wood fuels, the CN codes for the most relevant types of liquid biomass are listed in Table 6.

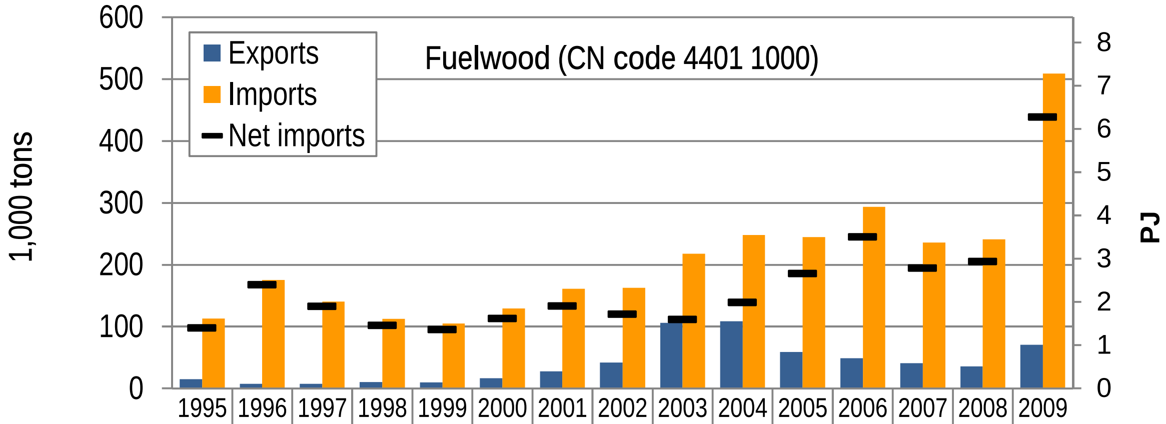
In the following sections, the historic development of Austria's imports and exports of wood fuels are presented. This includes fuelwood, wood chips, wood residues and pellets. Only data reported by Austria are shown, regardless of the fact that the quantities reported by trade partners partly differ significantly.

Table 6. CN codes of biomass types used for energy and their definitions according to the nomenclature of trade goods.
Sources: European Commission (2010), Eurostat (2011), Alakangas et al. (2011), Akkerhuis (2010), Heinimö (2008)

Product (term used in this study)	CN code(s)	Definition(s)
Wood fuels		
Fuelwood	4401 1000	Fuel wood, in logs, in billets, in twigs, in faggots or in similar forms
Wood chips	4401 2100 (coniferous); 4401 2200 (non-coniferous)	Wood in chips or particles
Wood residues (incl. pellets, briquettes etc.)	4401 3000	Sawdust and wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms
Wood pellets	4401 3020	Sawdust and wood waste and scrap, agglomerated in pellets
Sawdust	4401 3040	Sawdust of wood, whether or not agglomerated in logs, briquettes or similar forms (excl. pellets)
Wood waste	4401 3080	Wood waste and scrap, whether or not agglomerated in logs, briquettes or similar forms (excl. sawdust and pellets)
Charcoal	4402 0000	Wood charcoal, incl. shell or nut charcoal, whether or not agglomerated
Liquid biomass		
Rapeseed oil / sunflower oil	1514 / 1512	Rape, colza or mustard oil and fractions thereof / Sunflower-seed, safflower or cotton-seed oil and fractions thereof, whether or not refined, but not chemically modified
Palm oil	1511	Palm oil and its fractions, whether or not refined (excl. chemically modified)
Ethanol	2207 1000; 2207 2000; 3824 9099	Undenatured ethyl alcohol, of actual alcoholic strength of 80%; denatured ethyl alcohol and other spirits of any strength; chemical products and preparations of the chemical or allied industries
Biodiesel	3824 9091	Fatty acid mono-alkyl esters, containing by volume 96,5% or more of esters
Black liquor	3804 0000	Residual lyes from the manufacture of wood pulp, whether or not concentrated, desugared or chemically treated, including lignin sulphonates

7.2.1 Fuelwood

Austria is a net importer of fuelwood, as Fig. 52 illustrates. Until 2004, typical annual net imports were around or slightly above 100,000 t (1.5 to 2 PJ). The annual average of the period 2005 to 2008 was about twice as high, and in 2009 they accounted for more than 400,000 t (more than 6 PJ). This is about one tenth of the total fuelwood consumption. The main trade partners are Hungary, Czech Republic, Slovakia, Germany and France.

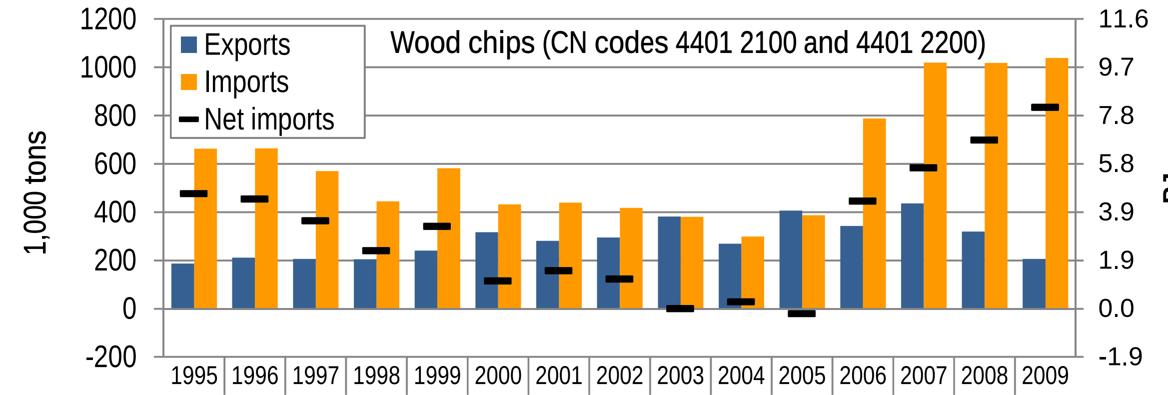


	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exports	15	7	8	10	10	16	28	42	106	109	59	49	41	36	71
Imports	113	175	141	113	105	129	161	162	218	248	245	294	236	241	509
Net imports	98	168	133	102	95	113	133	120	111	139	186	245	195	205	438

Figure 52. Development of Austria's imports and exports of fuelwood from 1995 to 2009.
Source: Eurostat (2011)

7.2.2 Wood chips

Fig. 53 shows the development of wood chips imports and exports. Whereas the years 1995 to 2005 shows a clear trend towards decreasing imports (resulting in net exports of 20,000 t in 2005), there was a remarkable trend reversal in 2006. Until 2009, the net imports to Austria increased to more than 800,000 t (about 8 PJ).

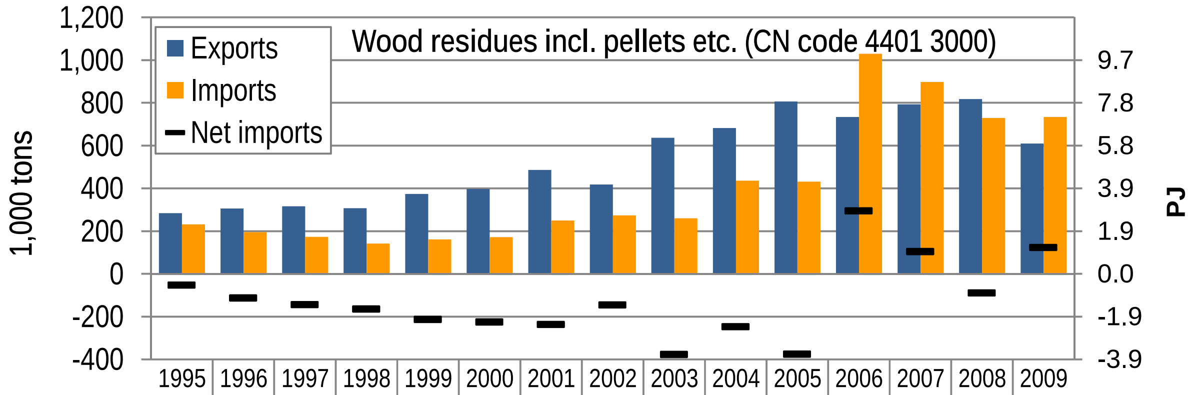


	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exports	187	211	206	204	241	317	282	295	381	270	407	344	436	320	205
Imports	664	665	571	445	582	433	440	418	381	299	387	789	1020	1019	1039
Net imports	476	454	364	241	341	115	158	123	0	29	-20	445	584	699	834

Figure 53. Development of Austria's imports and exports of wood chips from 1995 to 2009.
Source: Eurostat (2011)

7.2.3 Wood residues

The category “wood residues” comprises sawdust and wood waste in different forms, including pellets and briquettes. Fig. 54 shows the development of trade quantities reported under CN code 4401 3000. [9] In contrast to the categories fuelwood and wood chips, the exports of wood residues clearly surpassed the imports until 2005. However, in 2006 the imports increased significantly. In 2009, the net imports accounted for 124,000 t (1.2 PJ).



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exports	284	306	316	307	374	397	487	419	637	682	807	735	793	819	611
Imports	233	195	173	143	161	172	250	274	261	436	432	1,030	898	730	735
Net imports	-52	-112	-143	-164	-213	-225	-237	-145	-376	-246	-375	295	104	-89	124

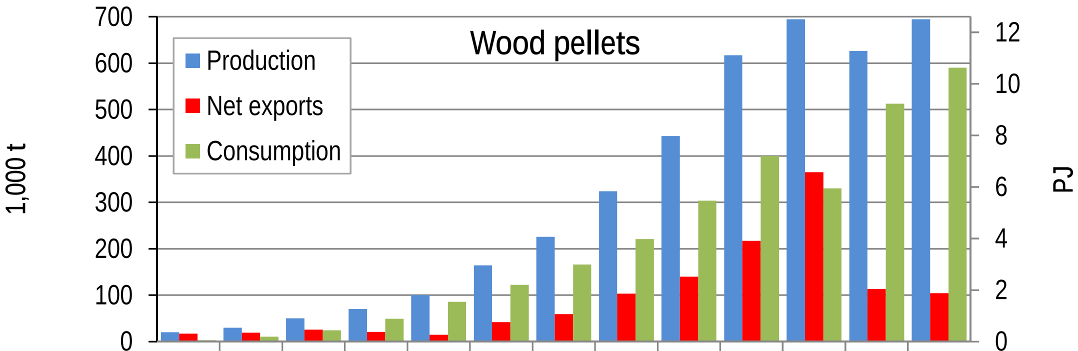
Figure 54. Development of Austria’s imports and exports of wood residues (incl. wood pellets) from 1995 to 2009.
Source: Eurostat (2011)

7.2.4 Pellets

Only since 2009, wood pellets are recorded under a separate CN code (see Table 6). The imports in 2009 accounted for about 200,000 t (3.5 PJ; primarily from Germany, Czech Republic and Romania) and the exports for 360,000 t (6.2 PJ, of which more than 80% to Italy). Hence, Austria was a net exporter of wood pellets (about 160,000 t or 2.7 PJ).

An assessment based on production and consumption statistics according to Pellet@las (2011) result in net exports of slightly more than 100,000 t in 2009 (Fig. 55). Remarkable in the historic development is that the net exports increased from less than 50,000 t in 2002 to 365,000 t in 2007. In the following years, the net exports were clearly lower.

[9] The term “wood residues” used for CN code 4401 3000 was chosen by the authors.



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Production	20	30	50	70	100	165	225	324	443	617	695	626	695
Net exports	17	19	26	21	15	42	59	103	140	217	365	113	105
Consumption	3	11	24	49	85	122	166	221	303	400	330	513	590

Figure 55. Development of production, consumption and net imports of wood pellets.
Source: Pellet@las (2011)

7.2.5 Summary

Trade statistics provide data on biomass streams broken down by trade partners. In order to illustrate the dynamics in recent years, Fig. 56 shows a comparison of the average annual trade volumes during 2000 to 2005 with the streams in 2009. As mentioned above, separate data on wood pellets are available for 2009. In the preceding years, pellets have been recorded together with all kinds of "wood residues".

As mentioned before, it is important to note that trade statistics do not differentiate between end purposes. Therefore, based on trade statistics it is not possible to determine the trade volumes which are actually related to bioenergy use. However, it is assumed that wood log, wood pellets and wood waste are almost exclusively used for energy generation. With regard to wood chips and residues, statistics of the wood processing industries indicate that notable quantities are related to material uses. In 2009, the imports of sawmill by-products of the paper, pulp and wood board industries accounted for an equivalent of 11 PJ (calculation based on Austropapier, 2011 and Schmied, 2011). This corresponds to the total imports according to trade statistics. Hence, it is concluded that at least in 2009, wood residues were only imported for material uses.

Fig. 56 illustrates that especially the net imports from the northern and eastern neighbouring countries have risen significantly in recent years. The total net imports from Czech Republic, Slovakia and Hungary accounted for approximately 2 PJ per year during the period 2000 to 2005. In 2009 they amounted to more than 10 PJ, and an additional 1.3 PJ were imported from Romania. Together, this is equivalent to 5% of the total biomass GIC in Austria in 2009. However, Germany and Italy are still Austria's main trade partners. The net imports from Germany accounted for 7.7 PJ in 2009, compared to an average of 5.1 PJ during 2000 to 2005, and the net exports to Italy increased from 6.1 to 7.7 PJ. With an export quantity of more than 5 PJ in 2009, pellet exports to Italy are by far the most important pellet trade stream and also Austria's main export stream of wood fuels.

Another notable aspect is that Austria's trade streams with neighbouring countries and other European countries shown in the figure comprise more than 90% of the total international trade volumes of wood fuels relevant for Austria. Hence, despite rapidly increasing import activities, Austria's wood fuel trade with more distant countries is still rather negligible.

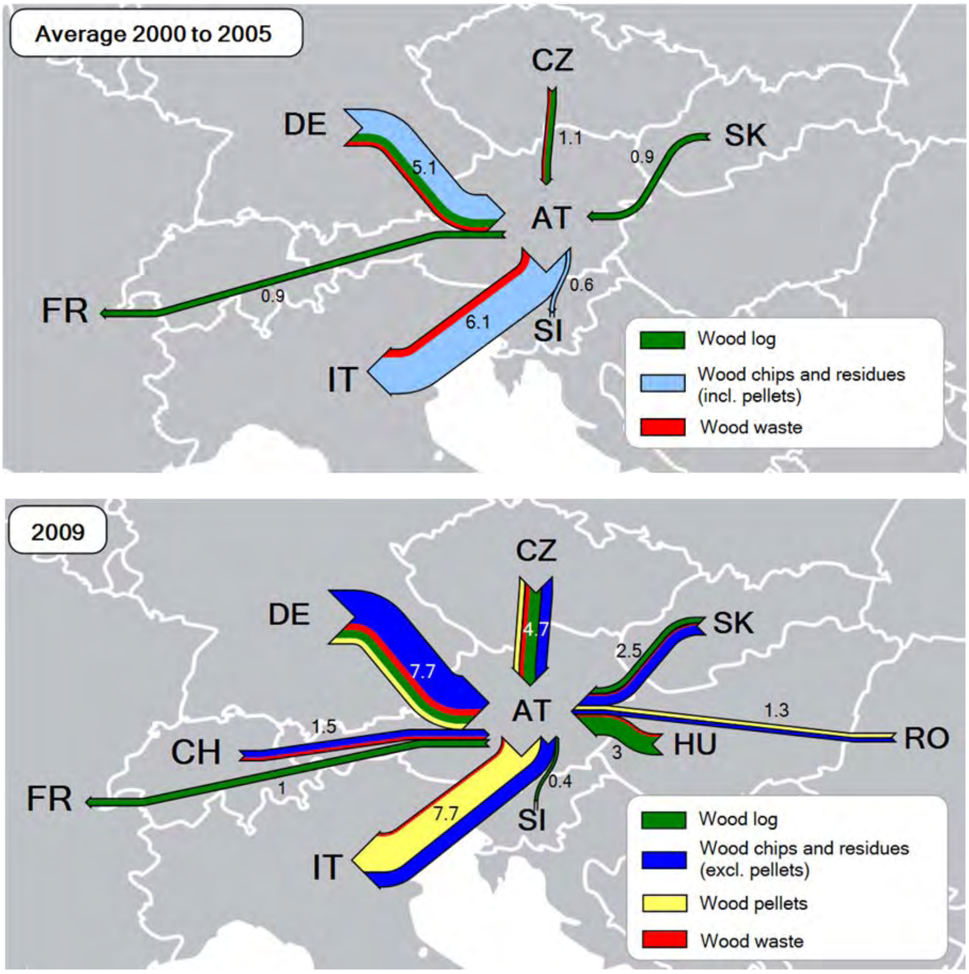


Figure 56. Comparison of the net trade streams with wood log, wood residues, pellets and wood waste in 2009 (bottom) with the annual average during 2000 to 2005 (top).
(values in PJ, only streams above 0.3 PJ are shown)
Sources: Kalt (2011), based on Eurostat (2011)

7.3 Biofuels for transport

The increasing use of biogenic transport fuels (biodiesel, vegetable oil and ethanol) in recent years resulted in a significant increase of cross-border trade. Apart from direct trade with biofuels cross-border trade of feedstock used for biofuel production need to be taken into account.

The following sections are structured as follows: First, data on biofuel production, consumption and trade stated in the official biofuel reports pursuant to Directive 2003/30/EC (Winter 2011) are illustrated and analysed (sections 7.3.1 to 7.3.3). Next, based on supply balances and data on self-sufficiency with agricultural products, conclusions about the impact of biofuel production and consumption on agricultural trade flows is analysed (section 7.3.4). Section 7.3.5 provides a summary.

7.3.1 Biodiesel

Fig. 57 shows the development of biodiesel production and direct imports and exports according to Winter (2011). The figure shows that imports accounted for approximately 50% of the inland consumption during 2005 to 2009. Close to one fourth of the domestic production of biodiesel, which increased from 70,000 t (2005) to more than 320,000 t (2009) was exported.

7.3.2 Vegetable oil

With regard to vegetable oil used for transportation, there are hardly any reliable data, as production volumes in statistics are not differentiated by intended uses and due to largely regional distribution channels. According to Winter (2011), approximately 17,000 to 18,000 t (0.6 to 0.67 PJ) of vegetable oil were used for transportation annually during 2007 to 2009. It is assumed that at least the quantities which are used in agriculture (approximately 2,700 t or 0.1 PJ in the year 2009) originate from domestic production.

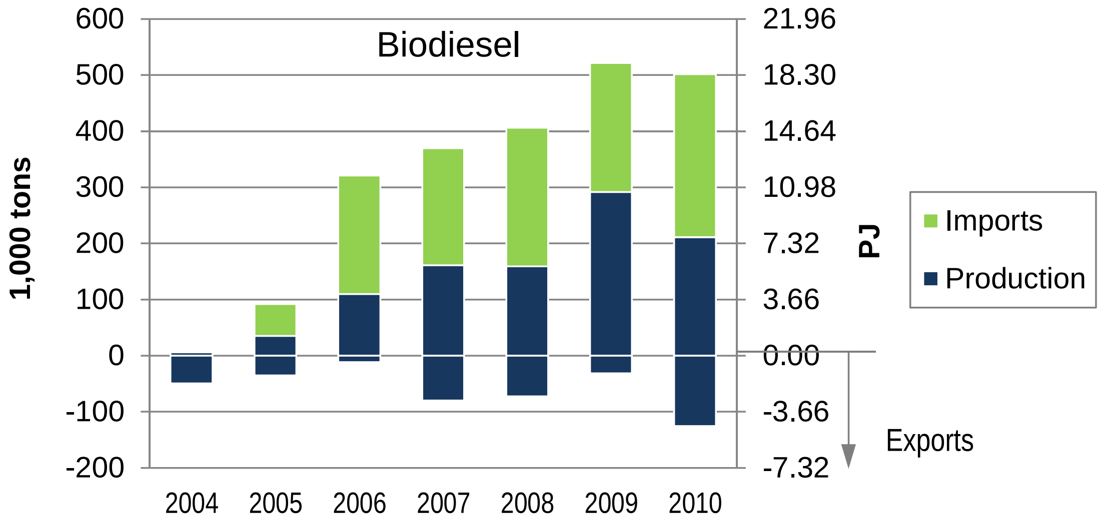


Figure 57. Austrian biodiesel supply from 2004 to 2010 according to the official biofuel report persuant Directive 2003/30/EC.
Sources: Kalt (2011), based on Winter (2011), Statistik Austria (2011c)

7.3.3 Ethanol

The Austrian production of bioethanol used for transportation is limited to one large-scale plant, located in Pischelsdorf in Lower Austria and operated by the AGRANA holding company. The plant became fully operational in mid-2008[10] and has a capacity of approximately 190,000 t/a (5.1 PJ/a). Fig. 58 shows the bioethanol production, imports and exports in Austria from 2007 to 2009. Whereas in 2007 and 2008, Austria was a net importer of bioethanol, the net exports in 2009 amounted to about 28% of the production.

[10] In 2007 a test run was carried out but the final commissioning was postponed due to the high agricultural prices in the second half of 2007 and the first months of the year 2008.

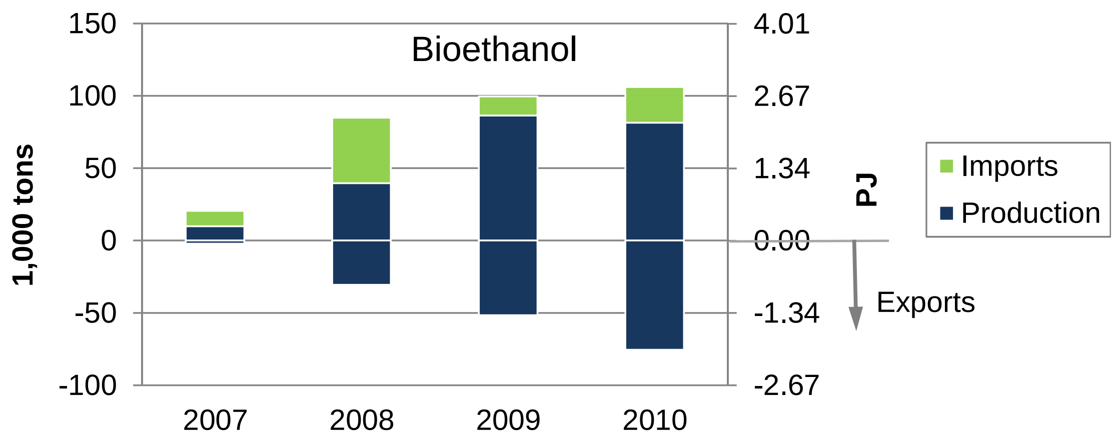


Figure 58. Austrian bioethanol supply from 2007 to 2010 according to the official biofuel report persuant Directive 2003/30/EC.
Sources: Kalt (2011), based on Winter (2011), Statistik Austria (2011c)

7.3.4 Agricultural commodities for biofuel production

There are no data available on the imports of agricultural products intended for biofuel production. However, trends in supply balances and self-sufficiency rates provide some insight into the effects of the increasing biofuel production on foreign trade flows.

Fig. 59 shows the development of the rate of self-sufficiency rate with cereals and vegetable fats and oils. Apparently, Austria is highly dependent on imports in the field of vegetable oils and fats, and the trend in the last 12 years was clearly negative: During 1999 to 2001 the average self-sufficiency (calculated on the basis of the oil yield from domestic oilseed production) was about 60%, whereas during 2008 to 2010 it was less than 30%. In contrast, the self-sufficiency with cereals (including wheat, grain maize, barley, triticale etc.) remained relatively constant at about 100% during the last 12 years.

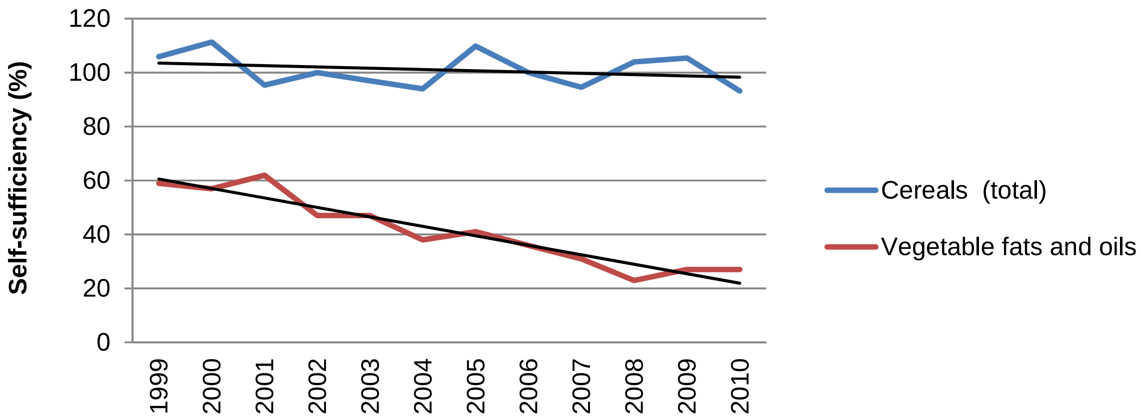


Figure 59. Development of the rate of self-sufficiency with cereals and vegetable fats and oils from 1999 to 2010.
Source: Statistik Austria (2011i)

In order to provide insight into the reasons of the decreasing self-sufficiency with vegetable fats and oils, Fig. 60 depicts the supply balance, showing “sources” (imports and domestic production) as well as “sinks” (processing and human consumption, exports and industrial uses). It is clear to see that the rapidly increasing industrial use of vegetable oils and fats (i.e. primarily biodiesel production) was facilitated by a significant increase in imports, whereas domestic production remained relatively constant. Today industrial uses exceed the quantity used for processing and human consumption in Austria. Hence, the additional demand for energetic uses of vegetable fats and oils was almost exclusively covered with imports.

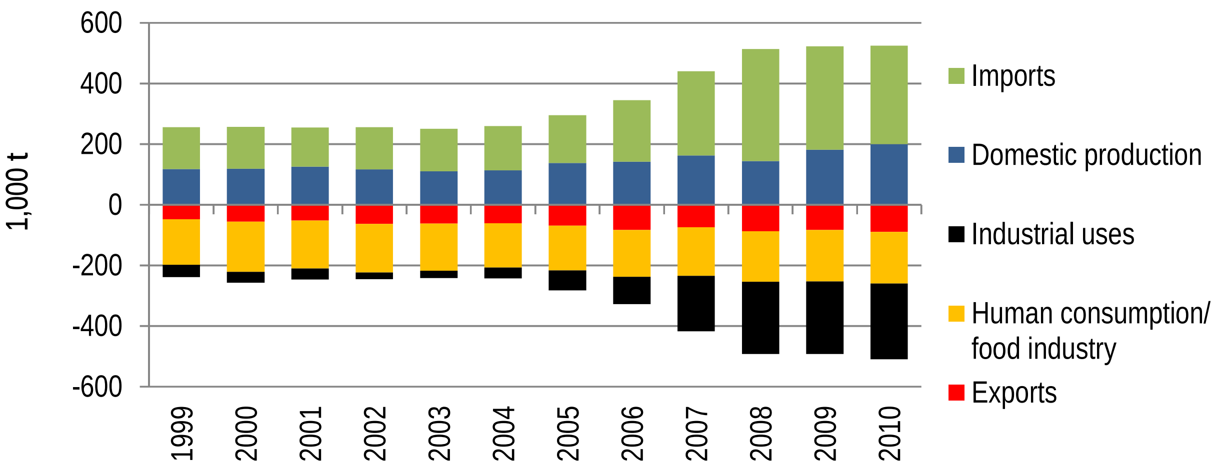


Figure 60. Supply balance for vegetable oil.
(Stockkeeping, consumption for animal feed and losses are not shown due to negligible quantities, "Domestic production" represents to the oil content of the Austrian oilseed production)
Source: Statistik Austria (2011i)

The most important trade streams are imports of rapeseed oil, as Fig. 61 illustrates. These imports primarily originate from Germany. However, imports of palm oil have also become increasingly important for Austria in recent years, although palm oil is not used for biodiesel production in Austria. The net imports rose from slightly more than 10,000 t per year during 2000 to 2003 to an annual average of about 50,000 t during 2007 to 2010 (Eurostat 2011). Palm oil is imported mainly via the Netherlands and Germany from Malaysia and Indonesia and soya oil from Serbia and Germany.

The annual feedstock demand of the ethanol plant at full capacity is reported to account for 620,000 t (75% wheat and triticale, 15% maize and 10% sugar juice). With regard to cereals, the feedstock demand for ethanol production in Austria currently accounts for about 10% of the total domestic consumption. Hence, in contrast to biodiesel production the effect of ethanol production is hardly recognizable in the self-sufficiencies. According to the operator's financial report for the business year 2009/10 (AGRANA, 2010), most of the feedstock originated from domestic production, but there are no profound data available on the feedstock supply of the plant.

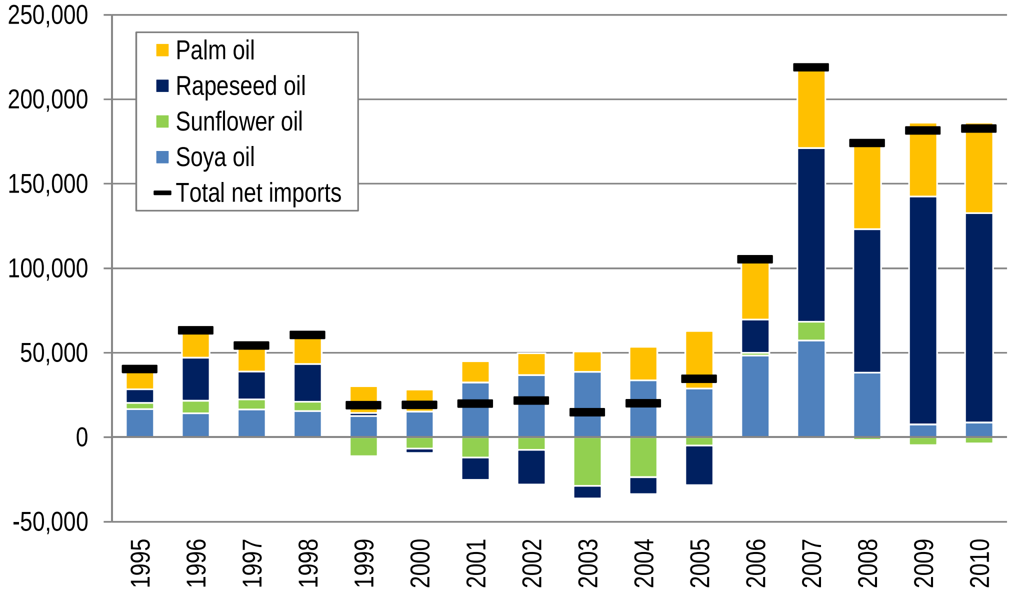


Figure 61. Development of net imports of palm oil, rapeseed oil, sunflower oil and soya oil from 1995 to 2010.
Source: Eurostat (2011)

7.3.5 Summary

Fig. 62 shows a flow diagram for biofuels used in the Austrian transport sector in 2009. The feedstock imports related to biofuel production stated in Fig. 62 have been determined on the basis of the self-sufficiency with agricultural commodities and under the assumption that imports and domestic supply are distributed in equal shares among all end purposes. (see Kalt & Kranzl, 2011). Together, biofuel net imports and feedstock imports accounted for 70% of the total biofuel consumption in Austria in 2009.

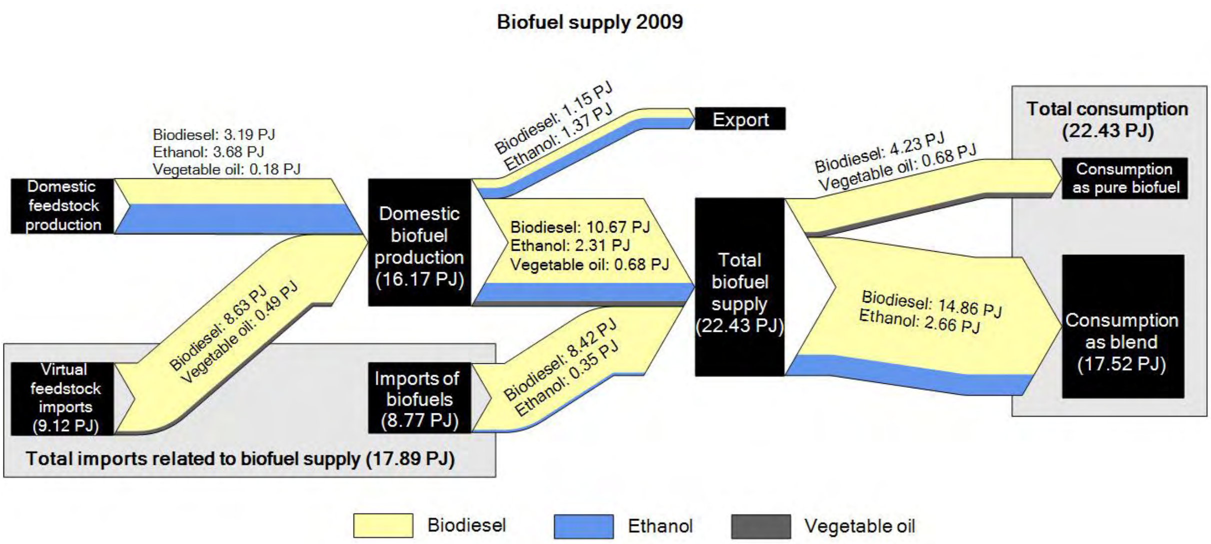


Figure 62. Flow diagram of the Austrian biofuel sector in 2009.
(Feedstock imports are stated as equivalents of the refined biofuel rather than calorific values of the feedstock used; feedstock imports related to biofuel production have been determined based on the self-sufficiency with agricultural commodities, according to an approach described in Kalt & Kranzl, 2011)
Source: Kalt & Kranzl (2011)

7.4 Indirect trade

7.4.1 The concept of indirect trade

The concept of “indirect trade” refers to biomass being traded for material uses, but ultimately ending up in energy generation. According to Heinimö & Junginger (2009), indirect trade of biomass through trading of industrial roundwood and material byproducts comprises the largest proportion of international biomass trade for energy, accounting for approximately two thirds of the total global trade volumes in 2006. Despite a rapid growth in direct biomass trade for energy in recent years, direct trade volumes were clearly less significant in 2006: direct trade with ethanol accounted for about 13% of bioenergy-related trade in 2006, wood pellets for 6.5%, fuel wood for 4.3% and biodiesel for 1.6%.

The following assessments for the case of Austria have been adopted from Kalt & Kranzl (2011).

7.4.2 Wood flows in Austria

In order to assess indirect trade quantities of wood-based fuels (section 5), it is necessary to have a detailed picture of the different utilization paths of the various wood fractions, as well as the flows between the wood processing industries. Fig. 63 shows a diagram of the wood flows in Austria in the year 2009. It is based on production and consumption statistics of the wood-processing industries (sawmill industry: FAO, 2010a; paper and pulp industry: Austropapier, 2011; panelboard industry: Schmied, 2011), Pellet@las (2011), statistical data on wood consumption and trade (FAO, 2010a; FAO, 2010b), previous assessments of the Austrian wood flows (Hagauer et al., 2007; Hagauer, 2008) as well as reports on timber felling (Prem, 2010).

The figure illustrates that the bulk of raw wood is processed to sawnwood by the sawmill industry. The average share of imports in the consumption of the sawmill industry accounted for 43% during the period 2001 to 2009 (between 35% and 52%). Apart from industrial roundwood, the wood supply of the paper and pulp industry and the panelboard industry is based on residues of the sawmill industry (“sawmill by-products”). Therefore, the sawmill industry acts as an important raw material supplier for the other industry segments. The increasing production of the Austrian sawmill industry in the last years and decades provided favourable framework conditions for the growth of the paper and pulp and the wood board industry. However, the import quantities of these industries have also amounted to notable trade streams, as the utilization of wood residues for pellet production and energy generation (and therefore also the competition between material and energy uses) has been growing in recent years.

The flow diagram shows that about one third of the Austrian raw wood supply in 2009 was based on imports. Therefore, a significant share of sawmill by-products, bark and off-cuts being used for energy production in Austria actually originate from foreign countries. On the other hand, large quantities of finished and semi-finished wood products are being exported (sawnwood, paper products and panelboard). Austria’s exports of panelboard and paper products surpass the inland consumption by a factor of about two, and the net exports of sawnwood are in a similar range as the quantity which is consumed domestically (i.e. processed to furniture, construction wood and other end-products).

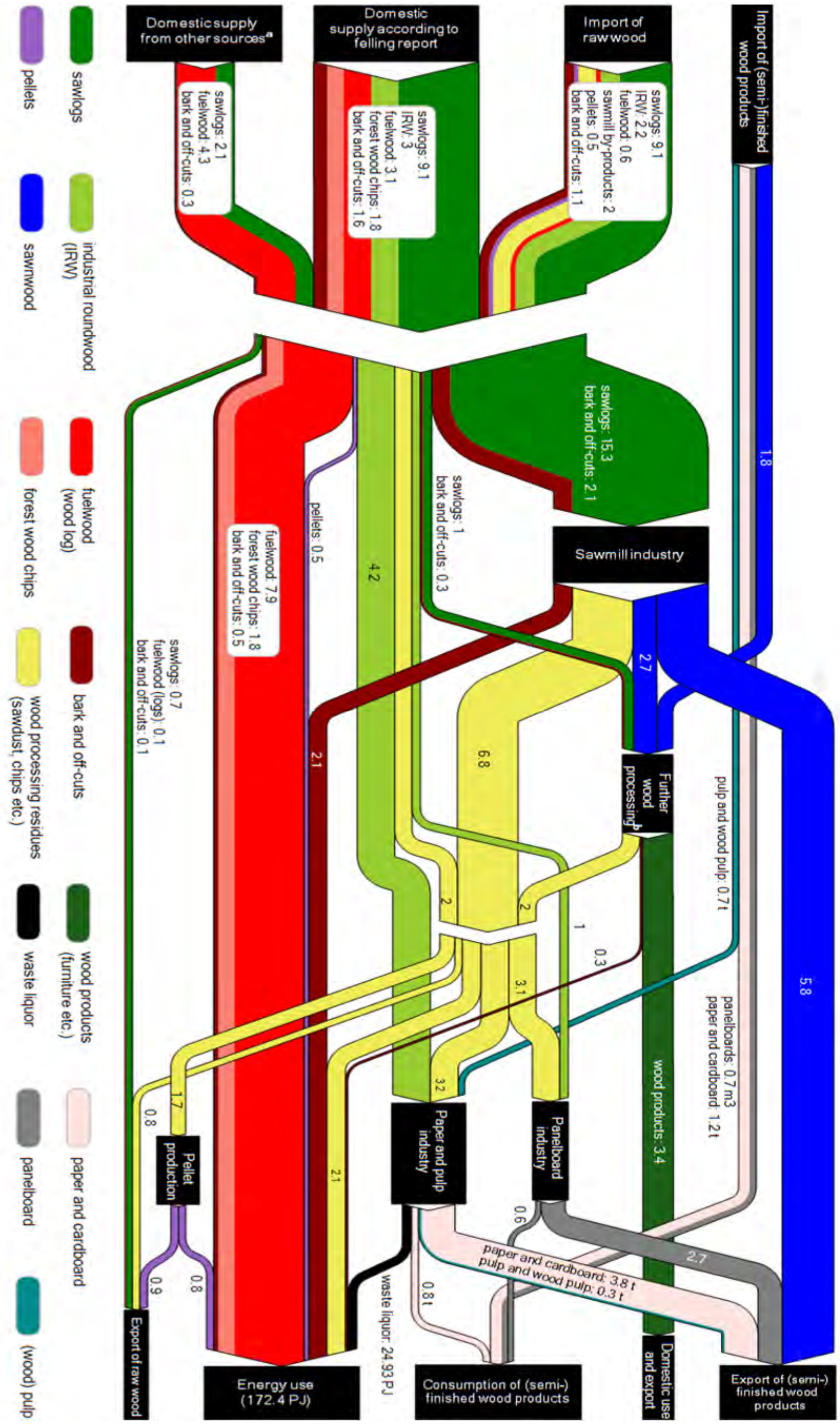


Figure 63. Wood flow diagram for Austria in the year 2009.

(values in solid cubic meters, if not stated otherwise)

a) Domestic supply from other sources: All domestic sources of raw wood not included in the official felling report;

b) Further wood processing: carpentries, furniture plants and veneer plants etc;

Sources: Kalt and Kranzl (2011), based on Prem (2010) (domestic supply according to wood felling report), FAO (2010a) and FAO (2010b) (foreign trade of raw wood and (semi-)finished wood products), Austropapier (2011) (consumption statistics and foreign trade of the paper and pulp industry), Schmied (2011.) (consumption statistics of the panelboard industry), Statistik Austria (2011c) (biomass consumption for energy), Eurostat (2011) (foreign trade of pellets), Hagauer et al. (2007) (general structure of the diagram, estimated values for roundwood consumption and production of by-products in "further wood processing"), own assessments and illustration

7.4.3 Indirect trade of wood-based fuels

Apart from wood chips, bark and other wood fuels, "wood-based fuels" comprise waste liquor of the paper and pulp industry which is usually used for process energy generation. In this section, the quantities of these fuels, which are traded indirectly through sawlogs, industrial roundwood and wood products are assessed. Due to the fact that wood streams are quite complex, not all relevant streams are captured in statistics and statistical data are sometimes inconsistent, it is stressed that the results are associated with some uncertainties and are considered to be best possible estimates.

Based on the wood flow chart in Fig. 63, the following wood streams have been identified as the most significant indirect import streams of biomass for energy:

- Wood-processing residues being imported as sawlogs.
- Bark and off-cuts being imported together with sawlogs and industrial roundwood.
- Industrial roundwood and sawmill by-products being imported by the paper and pulp industry, and ending up as waste liquor used for energy generation.

The indirect trade quantities of these streams according to Kalt & Kranzl (2011) are summarized in Fig. 64. The indirect import streams accounted for an annual average of 27 PJ and between 14 and 20% of the total annual biomass consumption during the considered period. Wood-processing residues accounted for close to 50% of the total quantity (about 13 PJ), and bark and off-cuts for an average of more than 8 PJ per year. With regard to waste liquor, it was found that between 18 and 32% of the total quantity used for energy generation in Austria can be traced back to directly or indirectly imported wood. Hence, the average quantities of indirectly imported waste liquor amounted to about 6 PJ per year during 2001 to 2009.

Compared to direct imports of the bioenergy sector, indirect imports of wood-based fuels were clearly more significant until 2005 (cp. Fig. 51). Only since 2006, direct imports considered in energy statistics are in a similar range. The main reasons for the relatively high fluctuations in indirect and direct imports of wood-based biomass are seen in the weather conditions and storms, which had a significant impact on the wood supply in recent years. Due to large quantities of fallen timber in 2007 and 2008 (caused by the storms "Kyrill" and "Paula"), the total domestic wood supply (including sawlogs, industrial roundwood and fuelwood) was about 25% higher than the average value of 2005, 2006 and 2009 Prem (2010). This explains the comparatively low imports in 2007 and 2008, compared to 2006, 2009 and 2010.

The results of the previous approach indicate that large quantities of wood-based fuels which are used for energy generation in Austria actually originate from imported biomass. On the other hand, it needs to be taken into account that Austria is a net exporter of (semi-) finished wood products. Assuming that wood products and raw wood intended for material uses are usually used for energy generation after their primary uses (either in dedicated bioenergy plants or as biogenic waste in waste treatment plants), these trade flows can also be considered as indirect biomass trade for energy. Due to insufficient data on foreign trade with wood products, as well as methodological difficulties related to recycling rates and time lags between border-crossing and energetic uses, it is considered unfeasible to derive time series of indirect trade related to these streams. However, it is concluded in Kalt & Kranzl (2011) that the high imports with raw wood (which are the reason for the significant indirect imports of wood-based fuels determined in the previous section) are largely balanced by exports of sawnwood and panelboard. Furthermore, with the main trade streams of raw wood and wood products taken into account, the available data indicate that Austria has as least in some years during the last decade been a net exporter of wood-based material.

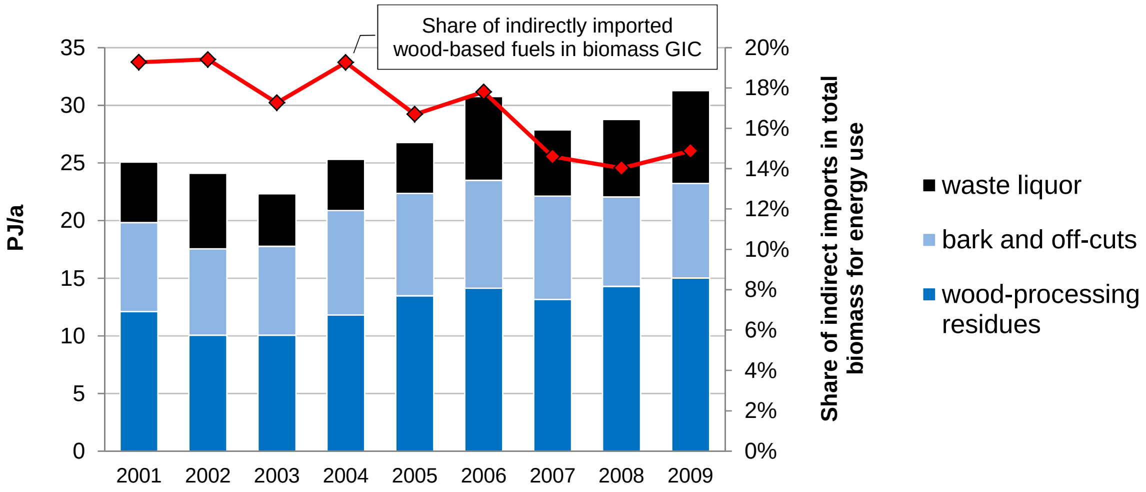


Figure 64. Development of the main indirect import streams for energy use, and the according share in the total biomass consumption.
Source: Kalt & Kranzl (2011)

8 Bioenergy trade: Barriers & opportunities

Regarding the rapid increase in bioenergy use in recent years, it is apparent that biomass imports played a crucial role in covering the additional demand. According to the official energy statistics, biomass trade for energy has increased significantly: Imports have surged from about 5 PJ in 2000 to 38.6 PJ in 2010, and exports from 6.7 to 18.8 PJ during the same period.

Whereas imports are dominated by biodiesel and unrefined wood fuels, wood pellets account for the main proportion of biomass exports. According to energy statistics, 83% of the biomass used for energy originates from domestic production. The self-sufficiency in biomass for energy, defined as the ratio of production to consumption, was 91% in 2010. With indirect trade of wood-based fuels and feedstock imports for biofuel production taken into account (see sections 7.3.5 and 7.4), as much as one third of the total biomass for energy consumption can be traced back to imports (2009). However, it needs to be stressed that while Austria is importing large amounts of raw wood, it is a net exporter of the following wood products: sawnwood, panelboard and paper products (see Kalt & Kranzl, 2011).

In the wood pellet sector Austrian producers were obviously benefiting from the rising foreign demand. Especially the surging exports to Italy (up to 2007) played an important role in this context. It is assumed that the foreign demand created an additional impetus for the development of a mature pellet market in Austria.

Biomass imports are definitely crucial for achieving Austria's energy policy target in the field of biofuels for transport (to achieve a biofuel share of 5.75% in the road transport fuel consumption in 2010). Theoretically[11], about 40 to 50% of all arable land in Austria would be

[11] Disregarding the area suitable for oilseed production and other limiting factors.

required to domestically produce all energy crops consumed in 2010[12] (including energy crops for biodiesel, ethanol, vegetable oil and biogas production as well as solid fuels like Miscanthus and short rotation coppice). Considering the 10%-target for renewable energy in the transport sector in 2020 (see European Commission, 2009a and BMWFJ & BMLFUW, 2010), it is expected that imports will continue to be of crucial importance for the achievement of Austria's energy policy targets.

Despite rising criticism from different stakeholders (environmental organizations, NGOs and partly also independent researchers), who emphasize adverse effects of an increasing (global) energy crop demand, the Austrian government does not depart from promoting its biofuel policy. The rising public concern about the sustainability of biofuels indicates that certification schemes for international bioenergy trade are required to enhance the public acceptance of biofuels and other imported biomass.

As a land-locked country, Austria is in a less favourable condition with regard to international biomass trade than most other European countries. However, international ports like Rotterdam and Hamburg are accessible via the Rhine-Main-Danube Canal. Seasonal fluctuations of the water level may pose a barrier to biomass transport via the Danube.

With regard to woody biomass, Austria's neighbouring countries Germany, Italy, Czech Republic, Slovakia and Hungary are by far the most important trade partners. Hence, it is concluded that despite a rapid growth of biomass cross-border trade in recent years, the largest part of imported and exported fuelwood, wood chips, other wood fuels and also wood pellets is still traded over relatively short transport distances.

Vegetable oil and oilseed imports, which represent a substantial part of Austria's bioenergy-related import streams, primarily originate from the eastern neighbouring countries and Eastern Europe. Nonetheless, Austria's overall supply balance for vegetable oils and fats also indicates an increasing dependence on palm oil imports from overseas.

Until 2020, the EU policy targets for RES in the transport sector will lead to additional demand for plant oil from Eastern European countries. It remains open how this will affect Austria's supply with plant oil.

[12] The fact that there are by-products of biofuel production (DDGS, oil cake etc.) was not taken into account in the calculation of this "gross area requirement". The "net area requirement" roughly amounts to 60% of the gross requirement, i.e. close to 30% of the total arable land (depending on the method of by-product allocation).

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10 Annex

10.1 List of Abbreviations

AMA............................Agrarmarkt Austria
BBG............................Finance Act (Budgetbegleitgesetz)
BGBl............................Federal Act (Bundesgesetzblatt)
CHP............................Combined heat and power (generation)
COICOP......................Classification of Individual Consumption According to Purpose (see (UN Statistics Division 2011)

DDGS .... Dried Distillers Grains with Solubles (ethanol by-product used as livestock feed)
E85 .... fuel blend that contains 85% ethanol and 15% gasoline
EC .... European Commission
(EU) ETS .... European Emission Trading System
GHG .... Greenhouse gas(es)
NREAP .... National Renewable Energy Action Plan
OeMAG .... Green Electricity Settlement Austria (Abwicklungsstelle für Ökostrom AG)
ÖNORM .... Standard published by the Austrian Standards Institute
ÖPUL .... Austrian programme for development of rural areas (Österreichisches Programm für die Entwicklung des ländlichen Raumes)
ÖVE .... Austrian Electrotechnical Association (Österreichischer Verband für Elektrotechnik)
R&D .... Research and development
RE .... Renewable energy
RES(-H/-E/-T) .... Renewable energy sources (for heat/electricity/transport)
RON .... Research Octane Number; a measure of the performance of a motor/aviation fuel
SRES .... Special Report on Emissions Scenarios (see (IPCC 2006)
UFG .... Environmental measures support act (Umweltförderungsgesetz)
VAT .... Value added tax
WBF .... Housing support (Wohnbauförderung)

10.2 List of Figures

10.3 List of Tables

ANHANG B

ENDBERICHT „DEVELOPMENT OF A TOOL TO MODEL EUROPEAN BIOMASS TRADE"

Development of a tool to model European biomass trade

Report for IEA Bioenergy Task 40

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Foreword

This report presents the results of an effort for IEA Bioenergy Task 40 to develop a modelling tool for international biomass trade. Part of this work has also been done in the frame of the RE-Shaping project, and parts of the methodology and the results have also been published as a RE-Shaping deliverable (Hoefnagels, Junginger et al. 2011). In addition, the scenarios for International solid biomass imports were originally developed for the European Commission (Junginger, 2011).

The main aim of this report is to illustrate the approach to include logistic cost of biomass in an energy model and implications to supply and demand of biomass for bioenergy. The costs, as presented in this report, are not intended to and do not always reflect actual (fluctuating) prices of feedstocks, pre-processing and transport of bulk freight.

Contents

Abbreviations

AP	Agricultural products
AR	Agricultural residues
BAU	Business as usual
bbl	Oil barrel (159 l)
BC	British Columbia
CH_4	Methane
CHP	Combined heat and power
CIF	Cost Insurance Freight
CO_2-eq	Carbon dioxide equivalent
CU	Capacity Utilization
EC	European Commission
ECF	Final energy consumption
EU-27	European Union
FOB	Freight on board
FP	Forest products
FR	Forest residues
GHG	Greenhouse gases
GJ	Gigajoule (10^9 joule)
GTAP	Global Trade Analysis Project
h	hour
HFO	Heavy Fuel Oil
IEA	International Energy Agency
JRC	Joint Research Center
KJ	Kilojoule (10^3 joule)
km	kilometer
ktoe	Kilo tonne of oil equivalent (41.868 TJ)
kWh	kilowatt hours
l	Liter
MDO	Marine Diesel Oil
MJ	Megajoule (10^6 joule)
MS	Member states
Mtoe	Million tonne of oil equivalent (41.868 PJ)
N_2O	Nitrous oxide
NOx	Nitrogen oxide
NREAP	National Renewable Action Plan
PJ	Petajoule (10^{15} joule)
PM	Particulate matter (fine dust)
PV	Photovoltaic
RED	Renewable Energy Directive
RES	Renewable energy systems
SNP	Strengthened national support
t	Metric tonne
TJ	Terajoule (10^{12} joule)
tkm	tonne kilometer
UK	United Kingdom
VAT	Value added tax
vh	Vehicle hour
vkm	Vehicle kilometer

1 Introduction

1.1 Background information and problem definition

In the past few years, the European Union has been the centre for solid biomass demand and with concerns regarding security of supply, global climate change and ambitious targets for renewable energy, it is expected that the European and global demand for biomass for energy will increase. The new Renewable Energy Directive (RED) (EC 2010), and the ensuing national Renewable Energy Action Plans (NREAPs) that are published for all EU-27 member states since February 2011, provide insight in the future demand for biomass up to 2020 (ECN 2011) confirming increasing trends of biomass use for bioenergy in Europe.

In the past years, we have seen, that new sources of biomass have been mobilized to meet the European demand, including residue streams (two examples are palm kernel shells shipped from SE Asia to Europe, and wood pellets from sawdust shipped from British Columbia to Europe) and biomass from dedicated plantations (e.g. palm oil from SE Asia, ethanol from Brazil and wood pellets from plantation wood in the SE of the US).However, it is as yet unclear how much of the future demand can be supplied by untapped resources within the EU-27, and how much is likely to be sourced from outside the EU. Policy makers have to deal are faced with this and other uncertainties. Similarly, different industrial sectors are faced with increasing competition, e.g. lignocellulosic feedstocks are already heavily utilized to produce electricity and heat, but in the future may also be a sourced for 2nd generation biofuels production. Next to this, demand by the paper, construction and particleboard industries, is also uncertain (Mantau, Saal et al. 2010).

With the publication of the NREAPs, on-going modelling work and statistical analysis such as the PELLETS@TLAS project (PELLETS@TLAS 2009), REFUEL (REFUEL 2009), GREEN-X (RE-Shaping 2011) and scenario development of future biomass trade (LUT), insight in the current and future demand and supply of biomass for bioenergy is growing. However, no model exists that can even remotely capture on-going biomass energy trade flows, data availability for both current and future supply and demand of biomass is such that efforts can be justified to devise a modelling tool to describe on-going and possible future trade flows.

Such a modelling tool would be very helpful to provide clarification on the role of biomass for meeting renewable energy targets to policy makers. Similarly, such scenario analysis could also be very helpful for the industry to compare these visions with their own global sourcing strategies.

1.2 Aim of this study

The aim of this study is therefore to i) get a comprehensive overview of expected biomass production and demand for the EU-27 member states, and the resulting biomass deficits/surplus which may be covered by international bioenergy trade, and ii) to develop a modelling tool linked to the Green-X model to simulate biomass trade flows in the EU-27 up to 2020.

1.3 Approach

To assess likely trade flows of biomass for bioenergy in context of supply and demand, this study is divided into three parts. Part 1 covers an analysis of the NREAPs, in part 2, an intermodal transport model is developed and in part 3, results of the transport model are integrated in the renewable energy model GREEN-X and scenarios on bioenergy trade are modelled.

The analysis of the NREAPs focuses on final energy produced from biomass that is expected to contribute to the total share of renewables in the NREAPs and the amount of biomass EU MS expected to mobilize from domestic sources and how much is required from import for electricity and heat. The results of the NREAPs for bioenergy are compared with the supply potentials, as available in the GREEN-X model and with existing model projections. Biomass used for transport fuels are beyond the scope of this study. In addition, a detailed analysis on the quality of the NREAPs has been conducted for selected member states (MS).

To model trade flows of solid biomass within Europe, a geospatial explicit intermodal transport model has been developed in the Network Analyst extension of ESRI's ArcGIS (ESRI 2010). The model includes four transport modalities (truck, train, inland ship and short sea shipping) that are connected via transhipment terminals. The origins and destinations of biomass supply and demand regions are connected via lowest cost routes.

The resulted cost and greenhouse gas (GHG) emissions are implemented as origin – destination specific cost and GHG premiums in the renewable energy model GREEN-X and combined with Low Import and High Import scenarios of non-EU biomass. For these scenarios, combined with the EU targets on renewable energy, likely trade flows are modelled in GREEN-X.

This report describes the results of the assessment of the NREAPs (Section 2) and provides a description of the modelling framework developed for Intra-European trade flows (Section 3). Inter-European trade flows, i.e., biomass imported from non-EU regions are described in section 4. Section 5 discusses the model outcomes of GREEN-X, including the implications of biomass trade, and section 6 and 7 ends with the discussion and conclusion respectively.

2 The National Renewable Energy Action Plans and expected supply and demand of biomass for bioenergy

This section discusses the information available in the NREAPs on the planned share of biomass for electricity and heat to meet the binding renewable energy targets of the EC. Although planned to be published in June 2010, all NREAPs were finally available and processed by ECN (2011) by February 2011. Additional answers and clarifications provide by member states to the EC were published in July 2011 on the NREAP website of the EC. This section uses the information available from July 2011 onwards by the EC (2011) and ECN (2011). In addition, detailed information on the NREAPs provided by IEA Bioenergy Task 40 partners for selected member states has been included.

2.1 Electricity and heat from biomass in the NREAPs

Table 2-1 shows the total contribution of RES electricity, RES heating/cooling[1] and RES transport. RES-heat is projected to remain the largest contributor to total renewable energy production in Europe and including mainly heat from biomass (92% in 2005 to 80% in 2020 of total RES-heat). Because RES-electricity from biomass competes with other alternatives such as hydro, wind and PV, the current and future total share of biomass electricity is low compared to heat (6% in 2005 to 8% in 2020 of total renewable energy and 14% in 2005 to 19% in 2020 of total RES-electricity). RES-transport consists almost 90% of ethanol and biodiesel from biomass in 2020 followed by RES-electricity in transport (10%) and others (2%). Transport fuels are not covered in this study.

Table 2-1 Total contribution from renewable energy sources (RES) for all EU-27 member states (ECN, 2011) and contribution of biomass to total RES production.

		Final energy (Mtoe)				Share total renewable energy (%)			
		2005	2010	2015	2020	2005	2010	2015	2020
RES electricity	**Total**	41.1	55.0	76.2	103.1	42%	40%	42%	42%
	Of which biomass	5.9	9.8	14.5	19.9	6%	7%	8%	8%
RES-heating/cooling	**Total**	54.7	67.9	84.8	111.6	55%	50%	47%	46%
	Of which biomass	50.1	59.8	72.3	89.5	51%	44%	40%	37%
RES-transport	**Total**	3.9	15.1	21.3	32.0	4%	11%	12%	13%
Total RES	**Total**	98.7	137.0	180.9	244.5	100%	100%	100%	100%

2.1.1 Electricity from biomass

The amount of electricity from biomass is projected to double between 2010 and 2020. Germany, the UK, France and Italy project the largest absolute growth between 2010 and 2020, but also smaller countries such as Belgium, the Netherlands project significant growth in bioelectricity generation (Figure 2-1). Solid biomass remains the largest feedstock for electricity generation, whereas liquid biomass has the lowest share (Table 2-2). Note that liquid biomass includes mainly electricity generation from black liquor from pulp and paper industries (e.g. in Finland). It is unclear if also other liquid biofuels that might be subject to sustainability issues (e.g. palm oil) are included.

[1] Note that biomass cooling is not used in any of the NREAPs and is therefore only mentioned in table 2-1.

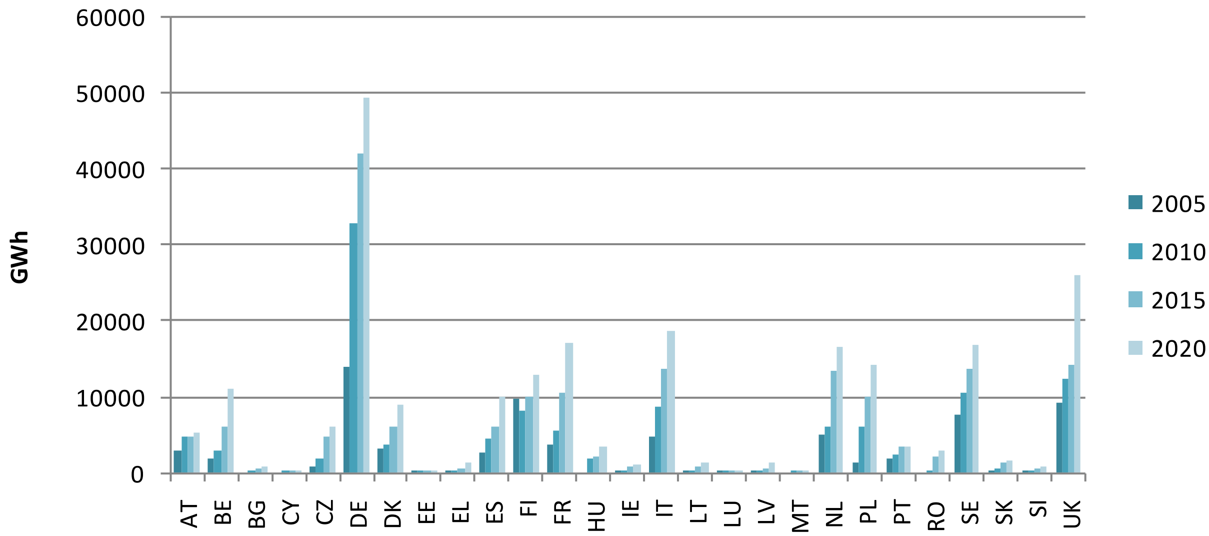

Figure 2-1 Projected total electricity generation from biomass (solid, liquid and biogas) (ECN, 2011)

Table 2-2 Gross electricity generation from biomass (GWh), based on table 10a and 10b from the NREAPs (adjusted from ECN, 2011)

	Biomass electricity generation								Biomass electricity generation per feedstock type											
	Biomass electricity				Of which CHP (%)				Solid biomass				Biogas				Liquid biomass			
Country	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
AT	2823	4720	4826	5147	61%	68%	69%	70%	2507	4131	4223	4530	283	553	567	581	33	36	36	36
BE	1791	3007	5952	11039	NA	NA	NA	NA	1521	2580	5145	9575	235	393	777	1439	35	34	30	25
BG	0	2	656	871	NA	100%	100%	100%	0	0	387	514	0	2	269	357	0	0	0	0
CY	0	30	84	143	NA	NA	NA	NA	NA	NA	NA	NA	0	30	84	143	NA	NA	NA	NA
CZ	721	1930	4819	6165	66%	100%	100%	100%	560	1306	3065	3294	161	624	1754	2871	0	0	0	0
DE	14025	32777	42091	49457	NA	16%	28%	42%	10044	17498	21695	24569	3652	13829	18946	23438	329	1450	1450	1450
DK	3243	3772	6034	8846	100%	100%	100%	100%	2960	3578	5312	6345	283	194	721	2493	0	0	1	8
EE	33	241	346	346	100%	100%	100%	100%	33	241	346	346	NA	NA	NA	NA	NA	NA	NA	NA
EL	94	254	504	1259	NA	29%	14%	12%	NA	73	73	364	94	181	431	895	NA	NA	NA	NA
ES	2652	4518	5962	10017	28%	32%	31%	25%	2029	3719	4660	7400	623	799	1302	2617	0	0	0	0
FI	9660	8090	9880	12910	88%	99%	95%	96%	9640	3930	5300	7860	20	40	50	270	NA	4120	4530	4780
FR	3819	5441	10495	17171	88%	100%	100%	100%	3341	4506	8366	13470	478	935	2129	3701	0	0	0	0
HU	0	1955	2250	3324	NA	6%	32%	90%	NA	1870	1988	2688	NA	85	262	636	NA	NA	NA	NA
IE	116	348	887	1006	11%	11%	7%	56%	8	28	567	687	108	320	320	319	0	0	0	0
IT	4675	8645	13712	18780	51%	31%	31%	31%	3477	4758	6329	7900	1198	2129	4074	6020	0	1758	3309	4860
LT	7	148	761	1223	100%	99%	100%	100%	3	98	533	810	4	50	228	413	0	0	0	0
LU	46	69	200	334	59%	94%	94%	95%	19	25	77	190	27	44	123	144	NA	0	0	0
LV	41	72	664	1226	98%	97%	86%	76%	5	8	271	642	36	64	393	584	NA	NA	NA	NA
MT	0	9	140	135	NA	NA	NA	NA	NA	0	86	86	NA	9	54	50	NA	NA	NA	NA
NL	5041	5975	13350	16639	31%	48%	38%	50%	4758	5103	11189	11975	283	872	2161	4664	0	0	0	0
PL	1451	6028	9893	14218	100%	31%	32%	36%	1340	5700	8950	10200	111	328	943	4018	0	0	0	0
PT	1976	2392	3359	3516	66%	64%	59%	56%	934	1092	1468	1468	34	130	368	525	1008	1170	1523	1523
RO	0	67	2050	2900	NA	101%	100%	100%	0	48	1450	1950	0	19	600	950	0	0	0	0
SE	7570	10631	13692	16753	100%	100%	100%	100%	7452	10513	13574	16635	53	53	53	53	65	65	65	65
SK	32	610	1349	1710	100%	100%	100%	100%	27	540	725	850	5	70	624	860	NA	NA	NA	NA
SI	114	298	623	676	100%	100%	100%	100%	82	150	272	309	32	148	351	367	0	0	NA	NA
UK	9109	12330	14290	26160	NA	0%	6%	7%	4347	5500	7990	20590	4762	6830	6300	5570	NA	NA	NA	NA
EU-27	69039	114359	168869	231971	47%	44%	50%	54%	55087	76995	114041	155246	12482	28731	43884	63978	1470	8633	10944	12747

2.1.2 Heat from biomass

Biomass heat in the EU-27 is projected to increase with almost 50% from 59.8 Mtoe in 2010 to 89.5 Mtoe in 2020. Main contributors to the absolute growth are France (64% growth), Italy (141% growth), the UK (112% growth) and Germany (25% growth) as depicted in Figure 2-2. Especially heat from CHP plants is projected to contribute more in 2020 (32%) compared to 2010 (22%) whereas the absolute contribution of households remains relatively constant (Table 2-3). Although heat from biogas is estimated to grow rapidly (e.g. in Germany) (Table 2-4), in absolute terms, heat from the combustion of solid biomass generation remains the largest (89% in 2020).

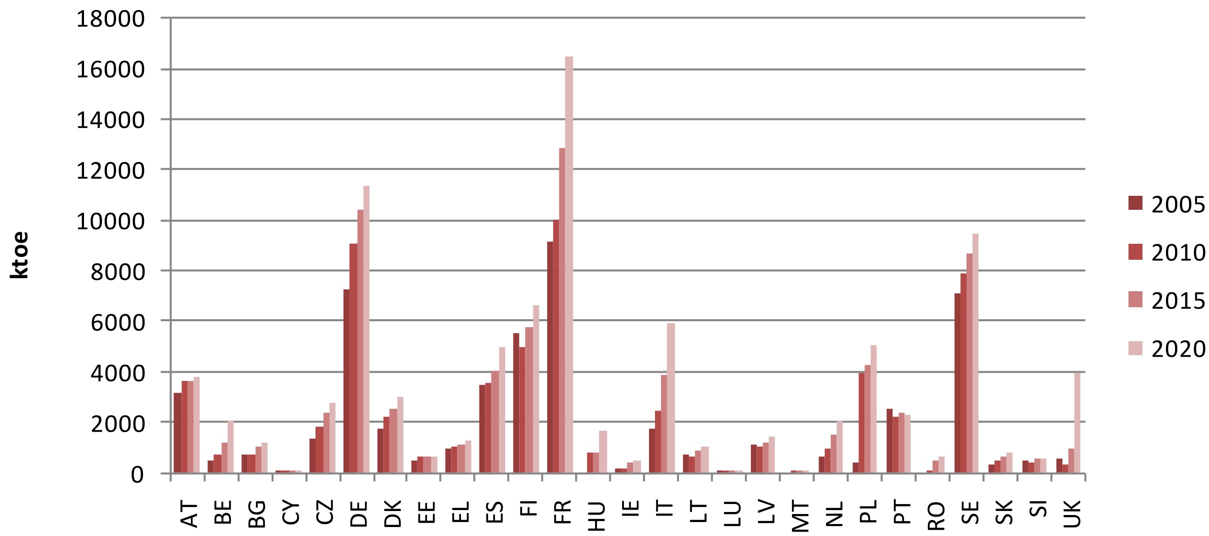

Figure 2-2 Heat generation from biomass including heat from biomass CHP (solid, liquid and biogas) (ECN, 2011)

Table 2-3 Heat generation from biomass per sector (ktoe), based on table 11 from the NREAPs (adjusted from ECN, 2011).

					Of which (%):											
	Total biomass heat generation				Heat from CHP				Stand alone (industrial/residential)				Households			
Country	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
AT	3162	3625	3656	3805	15%	24%	23%	24%	0%	0%	0%	0%	85%	76%	77%	76%
BE	477	682	1178	2034	0%	0%	0%	0%	100%	100%	100%	100%	0%	0%	0%	0%
BG	724	736	1056	1200	0%	0%	14%	16%	0%	0%	0%	0%	100%	100%	86%	84%
CY	4	18	24	30	0%	0%	0%	0%	58%	62%	61%	61%	42%	38%	39%	39%
CZ	1374	1805	2407	2781	9%	26%	46%	47%	27%	14%	3%	4%	64%	61%	51%	49%
DE	7261	9092	10389	11355	0%	13%	25%	38%	39%	26%	19%	9%	61%	61%	56%	53%
DK	1760	2245	2545	2991	51%	46%	61%	68%	9%	11%	1%	0%	40%	43%	38%	32%
EE	505	612	626	607	2%	11%	15%	15%	98%	89%	85%	85%	0%	0%	0%	0%
EL	951	1020	1138	1238	0%	1%	1%	2%	38%	38%	46%	50%	62%	60%	53%	48%
ES	3477	3591	4060	4950	6%	11%	11%	12%	36%	32%	38%	45%	58%	57%	51%	43%
FI	5490	4980	5800	6610	44%	45%	44%	48%	35%	35%	38%	35%	20%	20%	19%	17%
FR	9153	10018	12828	16455	10%	14%	20%	25%	18%	18%	24%	30%	72%	68%	55%	45%
HU	0	813	830	1637	NA	4%	22%	44%	NA	21%	5%	0%	NA	75%	73%	56%
IE	183	198	388	486	1%	3%	4%	26%	90%	85%	90%	69%	9%	12%	6%	5%
IT	1755	2464	3879	5933	35%	27%	26%	22%	0%	13%	15%	17%	65%	60%	60%	61%
LT	686	665	886	1035	0%	5%	20%	26%	91%	86%	75%	70%	8%	9%	5%	4%
LU	22	32	62	103	26%	41%	61%	66%	3%	0%	0%	0%	71%	59%	39%	34%
LV	1119	1023	1191	1409	1%	1%	10%	14%	31%	30%	29%	30%	69%	69%	62%	56%
MT	0	1	2	2	NA	0%	0%	0%	NA	100%	100%	100%	NA	0%	0%	0%
NL	657	961	1487	2071	67%	79%	86%	92%	8%	5%	3%	0%	24%	17%	11%	8%
PL	403	3911	4227	5089	100%	13%	19%	23%	0%	87%	81%	77%	0%	0%	0%	0%
PT	2508	2182	2349	2329	15%	19%	22%	21%	39%	50%	51%	53%	46%	30%	27%	26%
RO	0	16	484	654	NA	100%	100%	100%	NA	0%	0%	0%	NA	0%	0%	0%
SE	7078	7883	8686	9491	31%	38%	43%	46%	55%	49%	44%	41%	15%	14%	13%	12%
SK	358	454	636	759	2%	36%	46%	46%	88%	57%	48%	46%	9%	8%	6%	7%
SI	449	438	549	580	6%	15%	23%	23%	20%	9%	6%	9%	73%	76%	70%	68%
UK	560	323	961	3914	0%	0%	19%	12%	100%	90%	71%	70%	0%	10%	10%	18%
EU-27	50116	59791	72325	89548	18%	22%	29%	32%	33%	33%	31%	32%	49%	45%	40%	36%

Table 2-4 Heat generation from biomass per feedstock type, based on table 11 from the NREAPs (adjusted from ECN, 2011)

Country	Total heat generation per feedstock type: Solid biomass 2005	Solid biomass 2010	Solid biomass 2015	Solid biomass 2020	Liquid biomass 2005	Liquid biomass 2010	Liquid biomass 2015	Liquid biomass 2020	Biogas 2005	Biogas 2010	Biogas 2015	Biogas 2020
AT	3128	3558	3589	3738	6	7	7	7	28	60	60	61
BE	476	669	1138	1947	0	4	14	32	2	9	26	55
BG	724	736	1015	1147	0	0	0	0	0	0	41	54
CY	4	18	24	30	0	0	0	0	0	0	0	0
CZ	1351	1706	2137	2350	0	0	0	0	23	99	270	431
DE	6794	7516	8389	8952	313	664	688	711	154	912	1312	1692
DK	1714	2178	2426	2609	0	8	8	8	46	59	111	374
EE	505	612	626	607	0	0	0	0	0	0	0	0
EL	951	1012	1128	1222	0	0	0	0	0	8	10	16
ES	3441	3550	3997	4850	0	0	0	0	36	41	63	100
FI	5450	2710	3300	3940	0	2240	2470	2610	40	30	30	60
FR	9067	9870	12500	15900	0	0	0	0	86	148	328	555
HU	0	812	800	1552	0	0	0	0	0	1	30	86
IE	176	188	362	453	0	0	0	0	7	10	26	33
IT	1655	2206	3404	5254	0	153	279	397	100	105	196	282
LT	685	657	851	973	0	0	0	0	1	8	35	62
LU	19	25	44	83	0	0	0	0	3	6	18	21
LV	1113	1013	1139	1343	0	0	0	0	6	10	52	66
MT	0	0	0	0	0	0	0	0	0	1	2	2
NL	588	850	1313	1722	0	0	0	0	69	111	174	349
PL	385	3846	3996	4636	0	0	0	0	18	65	231	453
PT	1785	1514	1515	1484	713	655	801	801	10	13	33	44
RO	0	13	392	511	0	0	0	0	0	3	92	143
SE	6992	7800	8607	9415	65	65	65	65	21	18	14	11
SK	357	443	540	630	0	0	0	0	1	11	96	129
SI	401	415	483	497	43	0	12	28	5	23	54	55
UK	493	305	904	3612	0	0	0	0	67	18	57	302
EU-27	48254	54224	64618	79456	1140	3796	4344	4659	723	1771	3363	5434

2.1.3 Biogas injected into the grid

The Netherlands includes also an additional category for biomass injected into the natural gas grid. The Netherlands assumes that this will increase from 31 ktoe in 2010 to 202 ktoe in 2015 and 582 ktoe in 2020. This category has not been included in the estimations of biomass requirements in this study.

2.2 Biomass supply and expected demand

2.2.1 Biomass supply (EU-27 domestic sources)

Figure 2-3 depicts the estimated amount of biomass in the NREAPs (left columns) and the amount of biomass potentially available for energy production used in the Green-X model. It should be noted that the total amount of biomass available in Green-X also includes biomass from expensive resources such as expensive complementary fellings (forestry direct). The price of these biomass types are more expensive than forestry imports from abroad and are therefore likely only used in scenarios with high biomass demand (Figure 2-4).

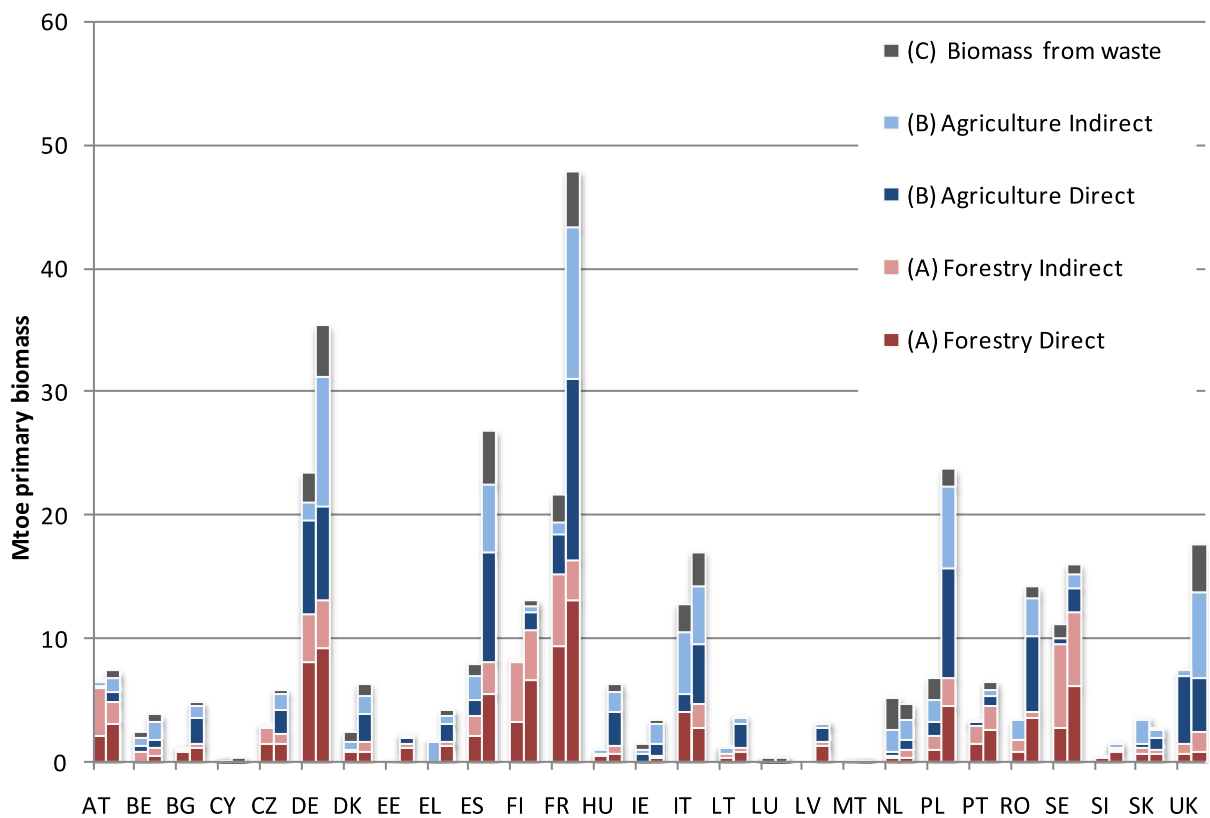

Figure 2-3 Biomass supply in the NREAPS and Green-X for the EU27 from primary, secondary and tertiary resources in 2020. The left columns are based on table 7a of the NREAPS (partly based on ECN 2011), the right columns show the potentials that are used in the Green-X model (Resch 2011).

For most countries that include estimations of biomass in table 7a of the NREAPS for 2020, the supply of primary biomass is higher in the Green-X database than in the NREAPS apart from Slovakia (SK), the UK and the Netherlands (NL). In absolute terms, the largest difference between the NREAPs and Green-X are in the estimated potentials of direct biomass from agriculture in France (FR) and Spain (ES), Poland

(PL), Romania and Germany (DE). The Green-X projections of biomass demand, i.e. the total potential that will be used, for Spain, France and Poland are much lower than the total technical potential and in range with the projected demand and supply of biomass in the NREAPs (Figure 2-4). For Germany, the demand for primary biomass in the NREAPs is in range with Green-X whereas the supply in the NREAPs is significantly lower. This would imply that imports of biomass are required to meet the demand in Germany in 2020.

The main differences between the domestic supply of biomass in the NREAPs and Green-X are found in relatively expensive biomass categories including direct forestry products and direct products from agriculture (mainly energy crops). Expensive complementary fellings, that are included in the potentials of Green-X under direct products from forestry, could explain part of the difference between the NREAPs and Green-X for this category (mainly in Finland, France, Poland and Spain). Energy crops in the NREAPs are significantly lower in France (12 Mtoe), Spain (9 Mtoe), Poland (9 Mtoe), Romania (7 Mtoe) and Italy (4 Mtoe). As shown in Figure 2-4, the potentials in Green-X are not fully used because not all biomass resources will become economically available in the scenarios. Some of these expensive biomass resources might already have been excluded from the NREAP tables.

Indirect products from agriculture in Green-X mainly exists of straw, but excludes biogas from animal manure. For France (11 Mtoe difference), the potential of indirect products from agriculture is linked to the conservative estimates for direct agricultural biomass. Italy includes large potentials for biogas from animal manure in this category.

The exclusion of certain categories in the estimated supply of biomass in the NREAPs for 2015 and 2020 (table 7a), as described below, also explains some of the differences between the NREAPs and Green-X.

2.2.2 Biomass demand

The blue columns in Figure 2-4 show the total potential supply of biomass from the NREAPS, similar to Figure 2-3 and the estimated demand based on the projections of final bioenergy for electricity, heat and transport fuels in the NREAPs from table 10, 11 and 12 in 2020. The red columns show the potential for biomass as implemented in Green-X and projection ranges of demand for 2020 for three scenarios including Business As Usual (BAU), BAU barriers mitigated and Strengthened National Support (SNP). This figure shows that not all of the technical potentials in Green-X are projected to be used for bioenergy as some of these biomass categories are not projected to become economically available in the scenarios. This is in particular true for countries that show large differences between the NREAPs and Green-X (Spain, France and Poland).

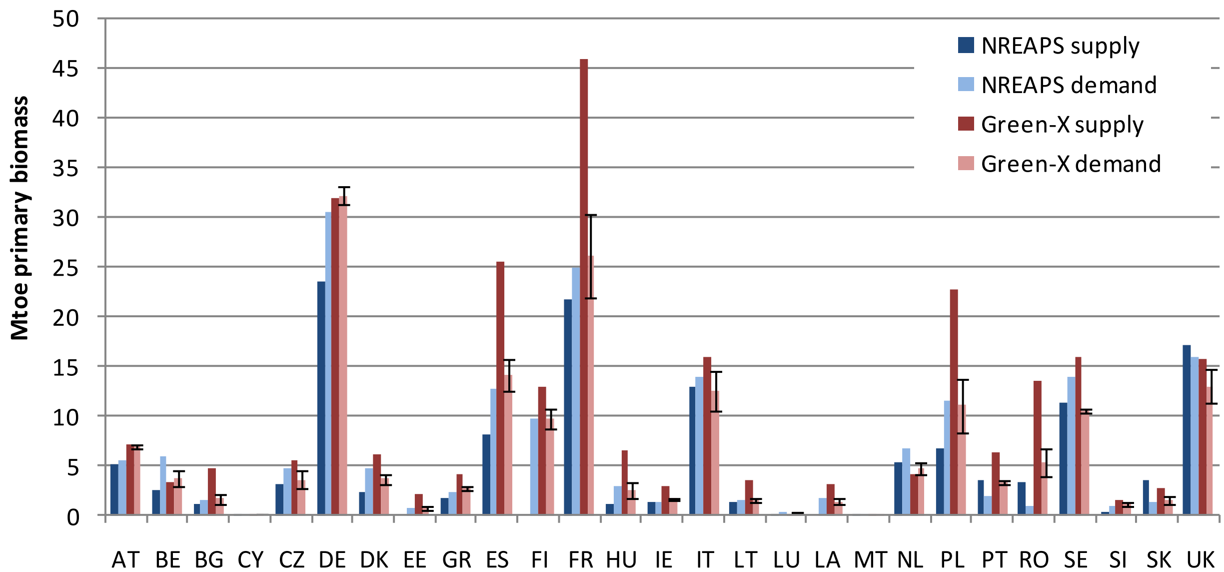

Figure 2-4 Primary biomass supply and demand for electricity, heat and biofuels in the National Renewable Action Plants (table 7a) and Green-X supply and demand ranges for the scenarios Business as Usual (BAU), BAU Mitigated barriers and Strengthened National Support for 2020 (Resch, 2011).

2.3 Issues related to the biomass supply estimates in the NREAPS

This section is mainly based on input from the IEA Bioenergy Task 40 partners in Austria (EEG/TU Wien), Denmark (Technologisk Institut), Finland (Lappeenranta University of Technology) and Germany (Oeko Institute/DBFZ).

2.3.1 Missing data and tables

A major part of the NREAPs do not include all categories of biomass in Table 7 (supply in 2006) and 7a (supply in 2015 and 2020) of biomass from forestry; direct (A1) and indirect (A2), biomass from agriculture: direct (B1) and indirect (B2) and biomass from the biodegradable fraction of waste: MSW (C1), industry (C2) and sewage sludge (C3). Finland and Latvia exclude the expected supply of biomass for 2015 and 2020 whereas Estonia and Greece only provides estimates on direct forestry products (A1) and additional information in text. Note that additional information in appendices or resubmitted NREAPs are now available online. Finland, for example, added the missing tables (7a and 8) in the appendices of the resubmitted NREAP.

Other countries that only include part of the biomass categories in table 7a are Bulgaria (only B1 and 2), Denmark (excludes B1), Estonia (excludes B1, B2 and C1 and C2) and Slovenia (includes only A1 and C2).

2.3.2 Units

The data in table 7 and 7a of the NREAPS are presented in various units of volume m^3, weight (ton wet or dry basis) or calorific value: ktoe, PJ/yr. For data presented in volume (m^3), the main issue is to combine volumes of solid biomass and liquid biomass in category A2 (indirect supply of wood biomass). Black liquor, from the pulp and paper industry, cannot directly be added to solid biomass categories. The liquid volume is different from the solid volume and secondly, the energy density of black liquor (9.0

MJ/kg wb (wet basis)) is lower than most indirect woody biomass sources (e.g. waste wood 15.8 MJ/kg wb) (ECN, Phyllis). Also, it is sometimes unclear if data presented in weight is on wet or dry basis.

In some cases, the specific energy content of the expected amount of domestic resources can be derived from the column primary energy production (ktoe). However, this column is interpreted differently by the MS. The UK, for example, provides the total estimated renewable energy (heat and electricity) produced in this column. Luxembourg considers the total primary production in table 7a to be the total primary demand for biomass and provides the total domestic supply in the column for total primary energy production.

Also inconsistencies were found in the units used. Greece appears to provide biomass from direct agriculture (B1) in Mtoe rather than the reported units (ktoe). A similar error was found for Malta. For Slovenia, it is most likely that the domestic supply of direct forestry should be 333 ktoe instead of 1333 ktoe.

2.3.3 Categories

Also for other categories, adding up volumes or weight units can result in errors and is not always meaningful. Especially when it is unclear what is covered by the biomass categories included (e.g. rapeseed or rapeseed oil). Secondly, some categories are specific to certain conversion systems and have various calorific values such as manure (anaerobic digestion) and straw. Soybean oil could also be problematic as it is a by-product from soybean meal production (feed industry) and should therefore be included in category B2, secondary products.

Furthermore, adding imported refined fuels to primary biomass feedstocks results in balance errors. For example, the NREAP of Austria includes a small consistency in category B (direct biomass from agriculture) of table 7 regarding imported biodiesel that is added to primary feedstocks.

2.3.4 Realisability of the estimated potentials

The future biomass supply potentials that are included in the NREAPs to meet the demand for electricity, heat and transport fuels is uncertain and depends on many factors including competitive use of other sectors or by-products created by other sectors (e.g. pulp and paper industries, biorefineries, sawmill industries). For **Finland** it was assumed that the volume of these industries, based on forestry products, remains at its peak. However, a study by the Finnish forest research institute, has estimated that the production of forest products in Finland will decrease towards 2020.

The NREAP of **Denmark** estimates that the unexploited biomass potential is 130 PJ including municipal solid waste. This potential has been criticized. A report of the Danish Institute of Agricultural Sciences (2008) argues that the unexploited potential of biomass in Denmark is around 90 PJ or more. Some resources require additional development of handling and conversion such as grass, while straw and woody energy crops can be used directly. Still the potential is 40 PJ lower than estimated in the Danish NREAP and according to some Danish experts, even the 90 PJ is too optimistic (Ryberg and Nikolaisen 2009).

The **Netherlands** expect to be able to produce a large share of its renewable energy target from biogas from (co-)digestion of manure which is likely too optimistic.

3 Modelling intermodal transport chains of biomass for bioenergy in Europe

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 has been developed in the ArcGIS Network Analyst extension (ESRI 2011). 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 by transport costs and transhipment costs. Total cost and GHG emissions depend on the routes taken, transport modes used and number of transfers between different transport modes.

3.1.1 The transport network

The transport model uses a hub-spoke method similar to Winebrake, Corbett et al. (2008) that connect different transport nodes via connectors (the spokes) to transhipment hubs. 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 3-1 depicts an example of a transhipment hub in a region including all transport modalities, e.g. Rotterdam. Note that in most regions only road and rail networks are available. Figure 3-2 provides an overview of the destinations used in the model. Network data for road, rail and inland waterways (Figure 3-3) 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.

Because biomass supply potentials in GREEN-X are available on country level, the spatial distribution of energy crops within countries of the EU-27 were derived from the results of the REFUEL project (de Wit and Faaij 2010) that provides the supply potential on NUTS-2 level. 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.

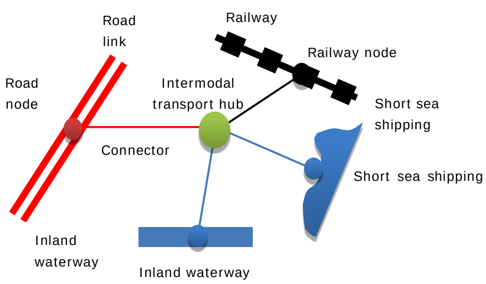

Figure 3-1 the network model approach (hub-spoke) following Winebrake et al. (Winebrake, Corbett et al. 2008; JRC 2009)

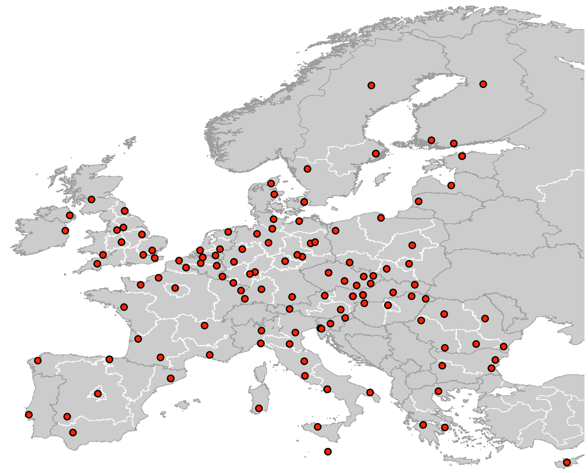

Figure 3-2 EU-27 destinations (largest cities per NUTS-1 region and/or important harbours in the EU-27)

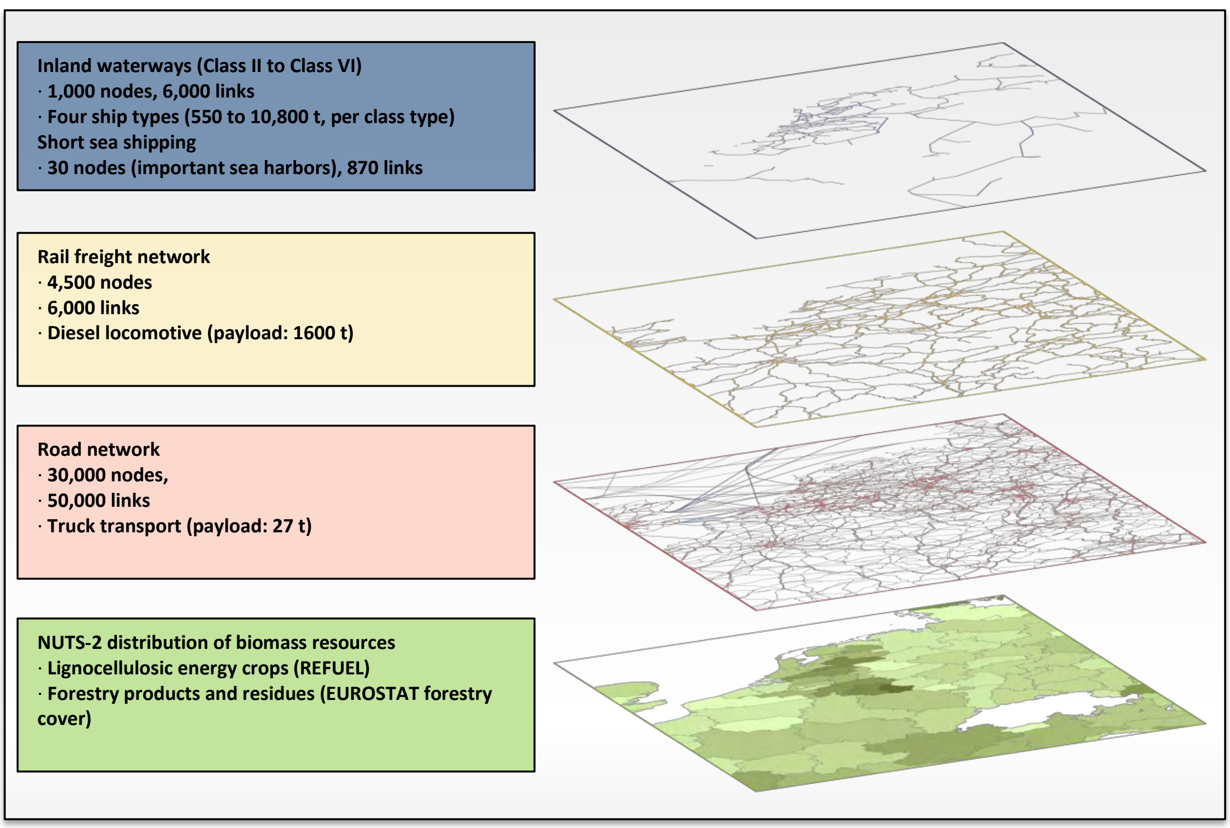

Figure 3-3 depiction of biomass distribution (NUTS-2 level) and network link layers for part of the biomass logistics model.

3.2 Transport modes, cost and performance

For intermodal transport of biomass, four transport modes are available: road (truck), rail, inland navigation or short sea shipping. The cost and environmental performance of these transport modes are covered in this section.

3.2.1 Fuel consumption

Fuel consumption is calculated based on the capacity utilization of each transport mode as follows (Knörr, Seum et al. 2010):

$$ECF = ECF_{empty} + \ EFC_{full} - ECF_{empty} \ * CU$$

In which:

EFC = final energy consumption

ECF_{empty} = final energy consumption empty

EFF_{full} = final energy consumption full load

CU = capacity utilization (weight load / load capacity)

3.2.2 Freight volume (stowage factor)

Wood pellets, but especially wood chips, have relative low densities compared to some other bulk goods that are transported (e.g. iron ore or cement). The amount of volume that a specific type of cargo holds per specific weight (m^3/t) in a ship is called the stowage factor. The stowage factor is the key factor in design optimization of transporting particular cargo (Obernberger and Thek 2010).

In this study, similar transport truck/ship/rail types are assumed for transport of wood pellets and wood chips. The stowage factor of pellets and wood chips is used to correct for the volumetric limitations of the transport modalities.

Stowage factors used (Hamelinck, Suurs et al. 2005):

- Wood chips: 4.17 m^3/t (610 kg/m^3)
- Wood pellets: 1.64 m^3/t (240 kg/m^3)

3.2.3 Transport modes

3.2.3.1 Road transport (truck)

Transport by truck is one of the most used and fasted growing modes for transport of freight (EC 2010). For transport of pellets and other solid biomass, different truck types are being used depending on the end consumer type, region and lose or in bags (Obernberger and Thek 2010; Sikkema, Junginger et al. 2010). The techno-economic performance data for truck transport are based on background data from Smeets et al. (2009) and NEA (NEA 2004). The fuel requirement for trucks is consistent with EcoTransit

(Knörr, Seum et al. 2010) for trucks >24-40 t (0.30 l/vkm) for 50% load and lower than the estimated fuel consumption by JRC for the typical and default values in for truck transport of solid and gaseous biofuels (0.35 l/vkm and assuming empty returns) (EC 2010).

For the future, an annual efficiency improvement of 0.9% was assumed which results in an efficiency improvement of 20% between 2010 and 2030 based on the average efficiency improvement of trucks of 0.8 to 1% per year in the last 40 years. It should be noted however that much of the efficiency gains were made in the 1970s and 1980s and from the 1990s onwards, the improvement rate was much lower, mainly due to strict emission limit values (e.g. NOx, PM) and related measures. Still, the IEA (IEA 2010) expects that trucks can be made 30 to 40% more efficient by 2030 due to improved engines, weight reduction and larger pay loads, tyre improvements and aerodynamics.

Table 3-1 Input parameters for road and rail transport

Parameter	Truck Truck (dry bulk)			Rail	References
	2010	2020	2030		
Load (t)		27		1625	Smeets et al. 2009
Load (m3)		120		4550	
Load factor (during laden trips)		0.93		1.00	NEA 2004
Laden trips of total trips		0.56		0.50	
Fixed cost (excl labour) (€/vh)		18			
Variable cost (excl.fuel) (€/vkm)		0.11			Smeets et al. 2009
Required labour (person/v)		1.00			
Fuel consumption full (l/vkm)	0.37	0.34	0.31		TML 2005, IEA 2009, Smeets et al. 2009, Knörr, Seum et al. 2010
Fuel consumption empty (l/vkm)	0.23	0.21	0.20		
Fuel consumption average (l/vkm)	0.31	0.28	0.26	5.8	
Fuel type		Diesel		Diesel	
Total GHG emissions (g. CO_2-eq/tkm)	68	62	57	22	JEC 2008

3.2.3.2 Rail freight transport

The operation cost and environmental performance of rail transport is difficult to estimate due to various reasons. Due to competitiveness in these sectors, cost data per component is not publicly available. Secondly, the costs are not separated for freight and passenger transport and thirdly, subsidies and country specific rail charges make a significant share of the total transport tariffs (TML 2005). Therefore, we derived the transport tariffs for bulk freight transport by rail from TML (2005) available for 21 countries in Europe. For the other countries, region specific averages were assumed. Based on the energy requirement from bulk transport by diesel freight trains, the fuel fraction was estimated to be 8%. This fraction was used to correct for the fossil fuel prices in the model.

Because the rail network segments in the TransTools model do not include data on electric and non-electrified railway infrastructure in Europe, we assumed all trains to use diesel locomotives. It should be noted that the share of freight transport by diesel locomotives varies significantly per country. In the UK, 90% of freight per tkm are hauled by diesel locomotives (McKinnon 2007), but these figures might be lower in other countries.

In Germany, the average emissions for freight transport by rail were estimated to be 22.6 g. CO_2-eq./tkm for 2009 (DB 2010). These are slightly higher than the estimations in this study for Europe (22.3 g. CO_2-

eq./tkm). The estimations in this study do also include indirect emissions for the production of Diesel and other GHG emissions (CH_4, N_2O) released during the fuel lifecycle.

3.2.3.3 Inland waterways

Inland waterways are subdivided into six classes. In the transport model, Class I waterways, typically suitable for pits-Péniche type of barges, were excluded as they are not cost-effective compared to trucks if biomass is transported. For Class II through Class VI waterways, different suitable barges are included in the model (Table 3-2). Class V and Class VI are combined in the model as they are both possible for large push-convoys that can carry up to 12,000 tonnes. In the model, Class II ships, such as a Kempenaar, can navigate on all waterways (Class II – Class VI), whereas large push-convoys can only navigate on Class V and VI waterways such as the Waal in the Netherlands (UN 2006). The model calculates if it is economically more attractive to use smaller ships or to use larger ships when possible and tranship to smaller ships when required on smaller waterways depending on navigation and transhipment costs.

The techno-economic performance data for inland waterway navigation was derived from Smeets et al. (2009) updated with load factors and laden trip data (empty returns) from NEA (2004). All barges for inland navigation are assumed to use Marine Diesel Oil (MDO) as transport fuel.

Future improvements in cost and performance depend on three important parameters: larger ships or higher load factors (larger ships are more fuel efficient), technological improvements and the use of alternative fuels. For this project, we assumed that the energy requirement of ships remains constant to 2030 as no realistic estimations were found in literature on the improvement potential and substitution rate of existing ship fleets.

Table 3-2 Input parameters for inland navigation

	Inland navigation				
	Class 2	Class 3	Class 4	Class 5/6	
Parameter	Kempenaar	Rhine-Herne Canal ship	Large Rhine ship	Four-barges convoy set	References
Load (t)	550	950	2500	10800	NEA 2004, Smeets et al. 2009
Load (m3)	642	1321	3137	14774	
Load factor (during laden trips)	0.71	0.85	0.77	0.83	NEA 2004
Laden trips of total trips	0.73	0.81	0.75	0.65	
Fixed cost (excl .labour) (€/vh)	10	22	72	214	NEA 2004, Smeets et al. 2009
Variable cost (excl. fuel) (€/vkm)	0.0	0.0	0.7	17.8	
Required labour (person/v)	1.28	1.44	2.62	3.76	
Fuel consumption full (l/vkm)	6.1	8.8	13.1	20.0	NEA 2004, JEC 2008, Smeets et al. 2009
Fuel consumption empty (l/vkm)	4.9	7.6	11.8	18.4	
Fuel consumption average (l/vkm)	5.6	8.4	12.6	19.3	
Fuel type	MDO	MDO	MDO	MDO	
Total GHG emissions (g. CO_2-eq./tkm)	61	40	28	10	JEC 2008

3.2.3.4 Short Sea Shipping

Despite the longer distances, short sea shipping is an attractive alternative to road transport due to the relatively low costs and fuel requirements. However, within Europe, only the Baltic States prefer short sea shipping over road transport at this moment (4000 to 5000 tonnes). The ships used have on board cranes for loading and unloading (Sikkema, Steiner et al. 2011). We assumed ship types for near shore navigation with a load of 5700 ton dry bulk based on NEA (NEA 2004). Note that the environmental performance of these ships is comparable with ships for inland navigation (Class IV). For the future, we assumed that larger ships will be used with an average load of 9600 ton from 2015 onwards. The IEA estimates that maritime transport energy requirements could improve up to 40% by 2030, however some of these measures would limit flexibility and speed (IEA 2009).

Table 3-3 Input parameters for short sea shipping

Parameter	Short Sea Shipping Dry bulk 2010	Short Sea Shipping Dry bulk 2020-2030	References
Load (t)	5700	9600	NEA 2004, Smeets et al. 2009
Load (m3)			
Load factor (during laden trips)	0.79	0.79	NEA 2004
Laden trips of total trips	0.94	0.94	
Fixed cost (excl. labour) (€/vh)	123	225	NEA 2004, Smeets et al. 2009
Variable cost (excl. fuel) (€/vkm)	5.7	11.2	
Required labour (person/v)			
Fuel consumption full (l/vkm)			
Fuel consumption empty (l/vkm)			NEA 2004, JEC 2008, Smeets et al. 2009
Fuel consumption average (l/vkm)	35.3	53.1	
Fuel type	HFO	HFO	
Total GHG emissions (g. CO_2-eq./tkm)	23	20	JEC 2008

3.2.4 Transhipment

The transhipment cost depicted in Table 3-4, are based on estimates from a transhipment firm in Rotterdam, the Netherlands (Smeets, Lewandowski et al. 2009), but corrected for differences in labour cost per country (section 0). Appendix I presents the data for all countries included in the model. The cost for storage are not included here and could add 0.08 €/t*day^{-1}. Prices of storing in ports and loading onto ships were found to be 4.17 €/t to 4.87 €/t including 14 days of storage for the port of Riga (Jong, Tselekis et al. 2010). For Romania, transhipment cost of 2.4 €/t were found (Boer, Cuijpers et al. 2010).

Table 3-4 Transhipment cost (in €/t)

Fuel type	Truck Av.	Truck Range			Rail Av.	Rail Range			Ship Av.	Ship Range		
Loading	1.83	1.14	-	2.74	2.97	1.86	-	4.46	1.83	1.14	-	2.74
Unloading	1.83	1.14	-	2.74	2.97	1.86	-	4.46	1.83	1.14	-	2.74

The energy requirement and related greenhouse gas emissions are based on Ecotransit (Knörr, Seum et al. 2010) based on transhipment of corn (1.3 kWh/t corn). We used this figure for all transhipment options in the model. The required energy was assumed to be generated by diesel generators with an efficiency of 36%, based on the engine efficiency of inland shipping (Schilperoord 2004). Although it is a rough assumption that all modalities have similar (primary) energy requirements and GHG emissions for transhipment, the impact on the total GHG balance of the supply chain is relatively small.

3.2.5 Country specific parameters: fuel, tolls and labour cost

3.2.5.1 Fuel cost

The cost of fuel (diesel, marine diesel, heavy fuel oil) including excise duties and taxes are country specific. To estimate the cost of diesel, the relationship between diesel prices (ARA Spot price FOB) and crude oil prices (EU Brent), excluding excise duty and VAT, were derived from Meerman et al. (2011) with a correlation of $R^2 = 0.96$ and assumed to be similar for all countries. Excise duties and VAT were derived from the EU energy and transport in figures (EC 2010).

All ships for inland navigation were assumed to use marine diesel oil (MDO). Prices of MDO were based on diesel prices, but exclude excise duties. Short Sea Shipping was assumed to use heavy fuel oil (HFO). Prices of heavy fuel oil were based on the correlation between European high sulphur fuel oil and UK Brent blend ($R^2 = 0.94$).

Table 3-5 shows the cost of fuel included in the model. The projections are based on PRIMES crude oil projections increasing from €$_{2008}$46/bbl. in 2005 to €$_{2008}$73/bbl. in 2020. The ranges represent ranges of the minimum and maximum impacts of excise duties and VAT tax in the different countries.

Table 3-5 Fossil fuel prices (€2006), based on PRIMES crude oil price projections, diesel and MDO : (Meerman 2011), excise duties and tax: (EC 2010), HFO: (IEA, 2010).

	2005				2010				2020				2030			
Fuel type	Av.	Range			Av.	Range			Av.	Range			Av.	Range		
Crude fuel (before tax)				0.29				0.32				0.46				0.57
Diesel	0.90	0.73	-	1.13	0.93	0.77	-	1.16	1.16	0.97	-	1.36	1.34	1.13	-	1.52
Marine diesel oil (MDO)	0.46	0.41	-	0.49	0.50	0.44	-	0.53	0.72	0.64	-	0.77	0.90	0.80	-	0.95
Heavy fuel oil (HFO)	0.27	0.26	-	0.28	0.29	0.28	-	0.30	0.42	0.40	-	0.44	0.52	0.50	-	0.54

3.2.5.2 Toll cost

Toll charges include vignette countries and road toll per km and type (e.g. amount axles, weight, environmental performance). For this study, the toll cost charges per road segment for freight transport were derived from the TransTools model. The toll cost charges for freight transport also include ferry costs in the TransTools database. These were also used for this project.

3.2.5.3 Labour cost

Labour cost for transport and storage per country (in €/h) are based on EUROSTAT labour market statistics, for transport and storage 2008 (EUROSTAT 2010a). It should be noted that these data were only available for 17 countries in Europe. For other countries, the regional averages were assumed. For example, Finland was assumed to have similar labour cost to North-West Europe.

4 Scenarios for Inter-European solid biomass trade[2]

4.1 Introduction and aim

In the past decade, the trade of solid biomass has increased strongly, as described in many Task 40 reports, see e.g. (Junginger et al, 2011). Especially the trade of wood pellets for both small-scale heating applications and large scale use for electricity / CHP production has reached a volume of several million metric tonnes per year.

However, the GREEN-X model is unable to endogenously model imports of biomass from third countries. Therefore, imports from outside the EU represent an exogenous input to the modelling exercise. The aim of this chapter is to describe how this input is developed.

4.2 Approach and scope definition

In principle, two approaches are possible to determine the international trade flows of solid biomass. The first one would be to employ macro-economic trade models such as GTAP based models[3]. However, this option was discarded because of several reasons:

- These models are unable to model specific biomass trade flows (e.g. wood pellets)
- The model data is often several years old, thus unable to take into account recent developments. For example, he latest GTAP database (GTAP 7), used in most CGE models, covers 2004 as a base year when international trade of bioenergy commodities was still relatively small.
- Integration of such a model with the Green-X model would have exceeded the available time and resources within this project

Therefore, it was decided to primarily carry out a bottom-up scenario analysis. It was decided to develop two scenarios:

1. A "business as usual / low import" scenario. The main basis for the expected import flows for the short term (2011-2015) are based on **industry expectations** as presented in the first half of 2011 (e.g. Schouwenberg, 2011; de Wolff, 2011), announcement in trade journals (such as Bioenergy International) and on recent literature, such as the latest UNECE Forest products report (UNECE/FAO 2011). These sources already take into account the ongoing investments in e.g. new pellet plants in many parts of the world, and take into account the maximum speed with which wood pellet production and trade can realistically grow in the coming years. In our opinion, they represent the most realistic outlook for the next 4 years. For the period of 2015-2020, potential further development is based on the (projected) availability of woody biomass (e.g. by Pöyry (2010)), and the specific availability of woody biomass in the main sourcing regions (e.g. van den Bos, 2010; De Wit et al. 2011 for Eucalyptus/Brazil, and Gerasimov and Karjalainen (2011) for NW Russia). The assumptions have also been presented to and checked by several experts from Canada and the US.

[2] This section is based on Junginger (2011).

[3] For a full overview of models that are (partially) able to model international bioenergy trade, see e.g. Dornburg et al (200x)

2. An “optimistic / high import” scenario. This scenario basically builds forth on the conservative scenario, but assumes that from 2014 onwards, a number of world regions will use land for energy crops to produce additional wood pellets

Furthermore, we only consider **woody solid biomass imports** towards the EU-27, as we deem solid biomass exports extremely unlikely. This is based on the fact that overall, the EU-27 is projected to have a deficit of solid biomass, as follows by an own internal review of the national renewable energy action plans (Section 2), and is also projected by the recent EUwood study (Mantau, Saal et al. 2010). Even if individual countries may have surpluses, they often cannot compete with the prices of solid biomass imported from other world regions. Possible exceptions are exports to Switzerland and Norway, but it is expected that these trade flows remain marginal (as was the case in 2010 (Eurostat, 2011)).

Also, in all scenarios presented in recent months (and years), (almost) only woody biomass trade is considered. Also currently, no meaningful imports of any agricultural residues for energy use from outside the EU occur to our knowledge. Therefore, we do not consider imports of agricultural biomass for energy. Finally, the preferred type of traded (refined) biomass are wood pellets, as they have a relatively high (volumetric) energy density, are less prone biological activity than e.g. wood chips, and can be blended with coal with less effort than wood chips. As all industry scenarios found only consider wood pellets, this study also assumes that (with one exception) all inter-continental trade will occur as wood pellets[4].

The **available and predominant types of feedstock** (either woody residues such as sawdust, discarded wood, bark, etc.) or roundwood (such as eucalyptus or pine trees from dedicated plantations) will be discussed in more detail in the following sections.

Regarding the expected **prices** CIF[5] Europe, we base our assumptions on observations for the market price for industrial wood pellets delivered CIF Rotterdam, which fluctuated between 2007 and 2010 between 110-140 €/tonne, with a typical average of 120 €/tonne. This price was used as basis for the calculation for the prices across the EU. In addition, we used current prices for short sea shipping to derive prices at other European harbours. For example, if wood pellets would be shipped from St. Petersburg to Stockholm, this price would be lower than 120 €/tonne, as the transport cost would be lower than transporting the pellets to Rotterdam.

Finally, there are a number of important limitations/assumptions to the scenarios:

1. The projected supply of wood pellets in the sourcing regions is **100% dependent on sufficient demand in the EU**. If this demand is not met, no new investments will be made. In the Green-X model, we take this into account by using the following constraint: if in year x the supply potential from a specific supply region is not fully utilized, then the supply in year x+1 will not

[4] Note that inter-European trade may occur in the form of wood chips, especially in the Baltic sea region, mainly due to the shorter transport distances and the ability of many medium-sized end-users to use wood chips as fuel. Furthermore, we do take one specific project of Vattenfall into account, which annually plans to import 1 million bone-dry metric tonnes of wood chips from Liberia to Scandinavia.

[5] Cost, Insurance and Freight, i.e. delivered to a specific destination.

be projected as in the main scenario, but will remain stable, up to the year where the potential is fully utilized. Only then, further growth of the supply potential is possible.

2. The scenarios assumes that **all biomass produced in the sourcing areas is available for the European wood pellet market**. In reality, this does of course not need to be the case. For example, if the US would decide to stimulate the use of wood for co-firing, or (perhaps more likely) 2[nd] generation biofuel technology using lignocellulose as feedstock become commercially available, the amount of resources available for the EU may decline severely. Also, it is quite possible that the South East Asian markets (E.g. Japan and especially South Korea) may boom in the future, and may significantly reduce the imports from especially Western Canada (Murray, 2011)
3. The scenario does **not take into account** ongoing developments in the field of **torrefaction**. Torrefaction technology is currently developed by a large number of individual initiatives, but at the time of writing, not a single, operational large-scale plant has been realized. Nevertheless, it could well be that by e.g. 2015, torrefaction technology is widely commercially available. This could have implications for a) the costs (which may be higher or equal to those of wood pellets), b) the GHG balance (especially for long-distance shipping, torrefied pellets have a lower GHG emission due to the higher energy density), and c) the available potential (as due to the pretreatment step, biomass feedstocks may become available, which were previously 'stranded' (e.g. due to too high transport costs). However, it is still uncertain whether torrefaction technology will break through (and when), and the limited amount of time available, we did not include torrefaction in the analysis.

Based on the above-mentioned scenario, the available biomass potential will be added to the supply curves in Green-X.

4.3 The business as usual / low import scenario

Based on past and current import trends, press releases of individual companies, expert opinions and (especially) on scenario studies by Schouwenberg (2011) and de Wolff (2011), we identified a number of main future sourcing areas. In the following sections, the following data is described for each of the sourcing regions:

a) a short description of the current production capacity and anticipated growth in the next 10 years,
b) the main current feedstocks used for wood pellet production, and an outlook on future feedstock availability
c) a short descriptions of the main modes of transport used for feedstock and wood pellet transport

4.3.1 East and West Canada

The total capacity of the existing 34 wood pellet mills is 2.6 million tonnes (Murray 2011). About 71% of the Canadian capacity is located in the west, mainly British Columbia (BC). There are 16 plants, with an average capacity of 118 ktonnes per year, and the largest is 400 ktonnes/year. The total western capacity is 1 889 000 tons. 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 was estimated that up to 50% of the feedstock used for wood pellet production may be from MPB wood (Murray, 2011). As there are (currently) only two integrated wood pellet mills, also sawdust needs to be transported to the wood pellet mills (on average 100 km by truck). Transport from the mills to the two main ports (Vancouver and St. Rupert) takes places by train. Average transport distances from the BC hinterland (and its main logistic hub Quesnel) tot Vancouver and Prince Rupert are 660 km and 850 km respectively (Verkerk 2008). Pellets are then stored for a short time at the port, loaded onto a dry bulk carrier, and shipped through the Panama Canal to Europe, or over the Pacific Ocean to East Asia.

The eastern part Canada currently contains 29% of the total wood pellet production capacity. The 18 plants have an average of 43 000 tonnes and the largest is 120 000 tonnes (Murray, 2011). The feedstock consists of basically 100% residues from the wood processing industry, and is transported (on average) 100 km from the saw mills to the pellet mills. The wood pellets are transported on average 200 km by truck to the main export harbours of Belledune (New Brunswick) or Halifax (Nova Scotia).

Almost all Canadian production is exported: in 2010, this amounted to about 1.35 Mtonnes to Europe, 0.9 Mtonnes to the US (mainly from the land-locked plants in the centre of Canada), and 60 ktonnes from BC to Japan. Domestic use is about 100 ktonnes (Bradley 2011). For 2011, expectations are that imports will increase to 1,75 MT and 100 ktonnes to the EU and Japan respectively, and will remain stable for the US (Murray, 2011).

Regarding capacity and export developments, Bradley (2011) estimates that production capacity might increase from 2.6 to 3.5 million tonnes in 2014, and to 5.5 million tonnes/year in 2018. An estimated maximum export potential is 4.7 million tonnes, of which about 55% from British Columbia (Western Canada), and the remainder from Central and Eastern Canada. This scenario is based on the expectation that demand in South Korea will grow strongly to allow for the expansion in BC, but in theory, this amount could also become available for Europe, depending on sufficient demand and economic feasibility.

The feedstock base for this expansion is likely partially going to be further residues from sawmills, but possibly also increasingly forest residues (collected at the roadside) and (in BC) also MPB wood, which would require an additional collection effort. Verkerk estimates for BC that in BC alone, a total of 1.3 oven-dry tonnes of sawmill residues may be available, which would in theory suffice to supply roughly half of all wood pellets produced in BC in 2018. The remainder may likely be produced from MPB trees (Murray, 2011). For eastern Canada, we assume that production for export may increase to 920 ktonnes in 2020, but the feedstock source will remain 100% sawdust.

4.3.2 South East USA

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 un(der)utilized in this region.

According to Bioenergy International (2011) the total capacity in this area was about 1.1 Mtonnes at the end of 2010 (Bioenergy International 2011). Capacities of individual plants ranged between a few small ones (<50 ktonnes), several medium sized ones (50-160 ktonnes), and one very large plant (500 ktonnes, GreenCircle, Florida). These plants typically utilize wood residues from the existing saw mills, except for the GreenCircle plant which utilizes roundwood from southern pine. In May 2011, one of the largest wood pellet plants in the world has started operation in Waycross, Georgia, with a capacity of 750 ktonnes per year – solely using SFM-certified southern pine roundwood as feedstock, and utilizing the bark to produce the required heat for drying. Also for the years to come, further plants are planned using southern yellow pine as feedstock, e.g. a 250 ktonnes plant planned to open early in 2012 in Western Alabama, expandable to 500 ktonnes, destined for export and domestic use (Westerveld 2011). Nevertheless, it is also likely that further woody residue streams will be utilized for wood pellet production as well. The US-based consultancy Forisk (Forisk Consulting 2011) estimates that in the coming 5 years, the total demand for wood as raw material for wood pellet production may rise from about 20 million (short & wet) tonnes in 2011 to about 30 million short tonnes in 2015. While the projected demand for 2011 is higher than current capacities, this still supports the projected rapid increase in production as assumed by Schouwenberg (2011) and de Wolff (2011).

Transport distances of the feedstock can be very low or not applicable (in case of integrated sawmill/wood pellet plants), but are probably typically 50 km on average. Wood pellets destined for export are mainly transported by (diesel powered) train to the harbour, in some cases also by boat. For example, the biggest plant in Waycross is about 160 km away from export harbour Savannah, where the pellets are transferred to ocean-going vessels at a dedicated terminal. Similarly, wood pellets are transported approximately 80 kilometres from the GreenCircle plant to the harbour of Panama city (Kortba, 2010). However, it is unlikely that future plants will also be situated so close to export harbours, so on average, a transport distance of 200 km by train is assumed.

4.3.3 North-West Russia[6]:

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 ktonnes per year. The third Russian operative big pellet mill is “STOD” (“Tallion-Terra”) from Tver region, with a production capacity of about 80 ktonnes per year of wood pellets. A number of companies from Karelia, Vologda and Leningrad regions produce each about 20-40 ktonnes per year and export the major part of it. Other pellet producers export less than 20 ktonnes per year and some mills sell only several tons of fuel pellets per year abroad. “Vologdabioexport” from Vologda region was one of the main pellet

[6] Unless indicated otherwise, this section is based on Rakitova (2011).

producers in Russia and one of the biggest pellet exporters from Russia to Europe, but it stopped production in 2010, due to lack of raw materials.

New projects, such as “Swedwood Tikhvin” with a capacity of 75 ktonnes of pellets, are about to launch production in 2011. Also other large projects have been announced in the Leningrad region as well as in other regions. For example, the new company Russian Wood Pellets (RWP) plans to construct several pellet mills with a total capacity of 3 million tons of pellets per year.

For these wood pellet plants, it was assumed that sawdust is the (main) feedstock, that the average transport distance to a port (e.g. St. Petersburg for export to the EU) is 250 km, and that total exports volumes may reach 630 ktonnes before 2020.

However, the biggest plant by far (in fact the biggest plant in the world) is the recently commissioned Vyborgskaya wood pellet plant, situated close to the Finnish border, in the vicinity of St. Petersburg. This plant has a capacity of 900 ktonnes of wood pellets. According to Lesprom (2010), the raw material for pellets consists primarily of logs from Russia and Belarus, which is partly FSC-certified. The timber will be supplied to the plant by rail. The main port for export will be the Port of Vyborg and pellets will be transported the short distance from the factory by rail and truck. The raw material for pellets consists primarily of logs from Russia, and to a very small extent from Belarus, which is partly FSC-certified. The timber will be supplied to the plant by truck (about 50%, average transport distance assumed 250 km) and by barges (also 50%, average transport distance 300 km) (Granath, 2011, Lesprom, 2010). From the plant, the wood pellets can be shipped to the EU over the Baltic Sea.

4.3.4 North-East Brazil

Production capacity and feedstock: Up till 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 (Sultana, Kumar et al. 2010; Suzano 2011), 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. In the state of Alagoas, investments in eucalyptus plantations have been ongoing in recent years. Downey (2011) reports that two more plants may follow in 2018-2019. This is in contrast with the scenario given by de Wolff (2011), which assumes 3 million tonnes of wood pellet production from 2015 onwards. As the plant sites are not clear yet, it is difficult to estimate transport distances. Distances from plantations to the pellet mill are likely 50 km on average. The distance to a port is difficult to estimate, but as the state of Alagoas is not reaching further inland than 300 km and has a well-developed road-network, it seems reasonable to assume that average transport distances will not exceed 200 km.

4.3.5 Liberia

Next to the wood pellet imports described above, we also take into account imports of wood chips from western Africa. 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. The company has estimated that it will need between 7 million and 8 million tons per year of biomass by 2020 to reach the target of a 40 reduction in hard coal usage. Vattenfall has sourced woodchips from Russia and the Baltic States that are primarily pine, but has expressed that the woodchips from the Liberian rubber trees will be more efficient. The company has made an agreement with Buchanan renewables. Buchanan 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 Berlin, Germany, where Vattenfall intends to co-fire them in coal-fired power plants (Vattenfall 2011).

For the import scenarios, we assumed that up until 2020, one million tonnes of wood chips could become available for import to the EU. Based on the distribution of rubber tree plantations, we assumed that the trees are chipped on site, and then transported by truck to the harbour of Buchanan (average transport distance was assumed to be 150 km), and then shipped to the EU using Handy-size vessels. Norden (2011) reports that (part of the) shipping will take place in 24 cargoes of 25,000 tonnes each, with 4, 8 and 12 Handymax cargoes in 2011, 2012 and 2013, respectively.

As can be seen in Figure 4-1, the total potential available for import to the EU under the business as usual scenario may increase drastically from about 42 PJ in 2010 to over 270 PJ in 2020 – under all conditions as stated above. This scenario is based on existing projects, project currently being built and announced projects. Naturally, especially assumptions regarding the 2nd half of the decade become increasingly uncertain. For example, it is very uncertain whether the large-scale production of pellets from eucalyptus in Brazil will occur, and if the anticipated continued growth in wood pellets from pine wood can actually be sustained until 2020.

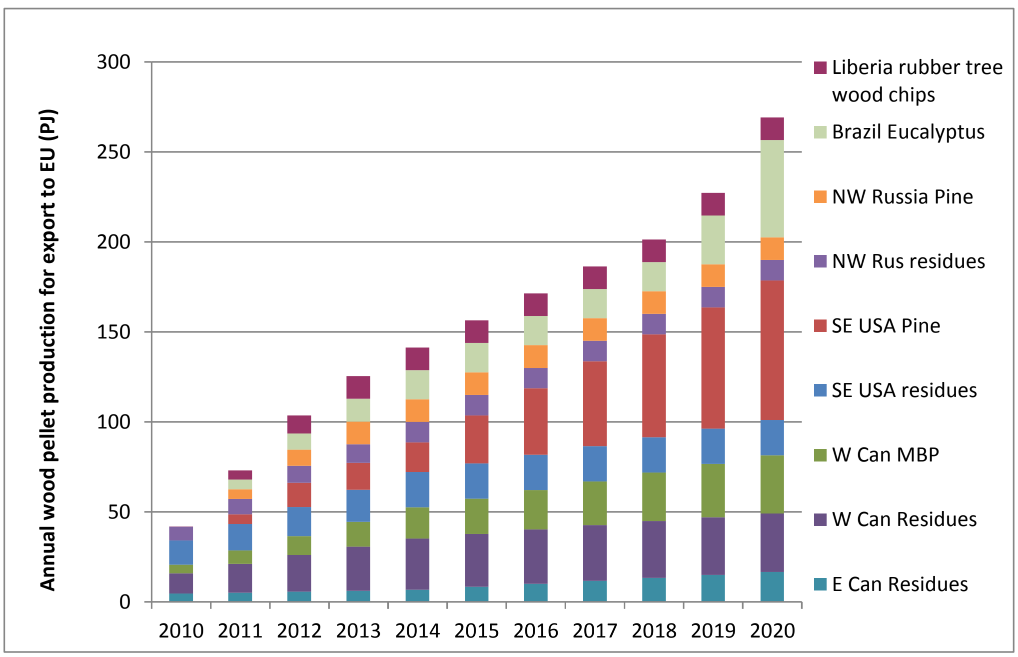

Figure 4-1 anticipated growth in available solid biomass supply from the various sourcing regions. residues = woody industry residues (e.g. sawdust), MPB = Mountain pine beetle affected wood.

4.4 The high import scenario

The scenario developed in the previous section is mainly based on industry expectations. The large utilities, which currently consume and (partially also produce) industrial wood pellets, are either obliged by national laws to adhere to sustainability criteria (e.g. utilities in Belgium, and recently also the UK), or already adhere to voluntary sustainability criteria (e.g. RWE Essent). It can be argued that the scenario described in the previous section is a "Business as Usual" scenario, but it can also be argued that these developments will only happen under the general expectation that mandatory sustainability criteria will be introduced.

In this section, we describe an alternative (or better complementary) high import scenario, in which we assume that demand for wood pellets in the EU and abroad increases rapidly, triggering investments in additional wood pellet plants based on feedstock from new plantations using short rotation crops. We base this high import scenario on the following assumptions:

- We assume that short rotation woody energy crops will likely be established in the same regions as currently pulp plantations are established. Based on the selection criteria mentioned in the previous bullet point, Brazil is by far the country with the largest expanding pulp sector. At the end of 2009, the forecasts expected a capacity expansion of almost 8 million tonnes per year (Pulpmill watch 2011). Other countries would be Uruguay (3 million tonnes/year) and South Africa (almost 600,000 tonnes/year).
- Additionally, it is quite possible that 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 (Johnson 2011), it is deemed reasonable to assume that these countries may also produce woody biomass for export (see also AfricaInvestor (2011)).
- Finally, it is also possible that (given the geographic vicinity) additional roundwood from Russia may be used for energy purpose. Especially under the current export tax system, it is plausible that additional roundwood is harvested for wood pellet production.
- We do not assume any imports from Asia. 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 (Gizot 2010). We furthermore assume 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 East Asia, mainly Japan and Korea (Gizot 2010). Also, according to 2009 statistics, CEPI countries (i.e. 17 EU countries and Norway) exported a net amount of 1.6 million tonnes of pulp (CEPI 2011), so it is deemed rather unlikely that in the future, wood for energy would be traded from South East Asia to the EU.

Based on these assumptions, we postulate the following import flows:

- 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 from eucalyptus plantations.

- In the Western African countries of Liberia, Sierra Leone, Cote d'Ivoire and Ghana, it is assumed that a total of 3 million tonnes of wood pellets will be produced by 2020 from fast growing plantations.
- Finally, it is assumed that up to 3 million tonnes of wood pellets may be sourced from (managed or unmanaged) forests in North-west Russia.

These assumptions lead to an additional amount of 14 million tonnes of wood pellets in 2020, bringing the total to 28 million, i.e. roughly twice as much as assumed in the low-import BaU scenario. Figure 4-2 shows the anticipated growth in available solid biomass supply from the various sourcing regions in the high import scenario from 2010 (1) tot 2020.

Note that the assumptions of the amounts is to some extent arbitrary, but reflects 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. While all developments are not deemed unrealistic, they are *highly speculative*, and would depend amongst others on a strong demand for solid biomass in the EU, and (very) rapid investments in the sourcing areas.

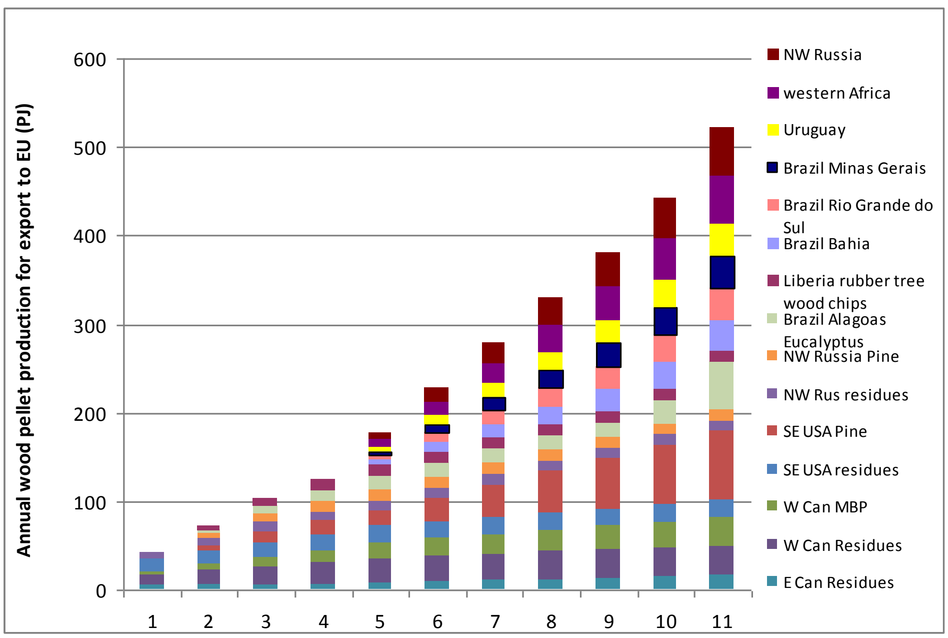

Figure 4-2 Anticipated growth in available solid biomass supply from the various sourcing regions in the high import scenario from 2010 (1) tot 2020 (11).

5 Results

This section covers a discussion of the results of the transport model (0) and the impact of the transport model assumptions and exogenous assumptions on non-EU imports on total inter- and intra-European future trade flows of biomass for bioenergy purposes as projected with GREEN-X (5.2). The emphasis in this section is on biomass trade rather than transport costs because these are already discussed in more detail in the Re-Shaping D12 report (Hoefnagels et al. 2011).

5.1 Transport cost

The results of the biomass logistics model include country to country tables for all 27 EU member states and all tradable solid biomass commodities for every 5 years up to 2030. These results are integrated in the GREEN-X model. To provide an indication of the cost premiums in the GREEN-X model, Table 5-1 shows the averages cost and the ranges for all EU member states. To demonstrate the detailed results of the transport model and the cost implications of biomass pre-treatment and transport, Figure 5-1 through Figure 5-4 show the total supply cost to supply either wood chips or wood pellets from short rotation willow crops for the largest importing countries in the scenarios (Germany, the UK, the Netherlands and Austria) (Figure 5-6).

Cost ranges for tradable, lignocellulosic biomass commodities range from 3 €/GJ for forestry residues transported as wood chips to 24 €/GJ for wood pellets from short rotation coppice (willow) in 2020. These large differences are the result of feedstock cost at farm gate (3 €/GJ for forestry residues in 2010 to 13 €/GJ for SRC willow crops in 2030) and the additional cost for transport over long distances and/or pelletization. The extremely expensive supply chains are, however, unlikely to be used in any scenario.

The results in Table 5-1 and Figure 5-1 and Figure 5-2 show that it is the additional cost for densification of wood chips to pellets, is not economically effective if biomass is transported within Europe. As all biomass imported to the UK has to be transported via sea, most of the additional cost are related to short sea shipping, but also a major part has to be shipped to a sea port first, mainly via road or inland waterways. For Germany, its relatively short distance to large export countries such as Poland result in a less steep cost-supply potential of European resources compared to the UK. Because Austria is a land-locked country, the main transport modes include road and inland waterways (the Danube River) (Figure 5-4). The Netherlands (Figure 5-3) and the UK (Figure 5-2) show similar cost supply curves as both countries are able to import a large quantity via short sea shipping routes.

Table 5-1 Aggregated ranges of the total supply cost (€/GJ) for the EU-27, based on the detailed tables integrated in the GREEN-X model.

Feedstock	Transported as	Year	Feedstock (farm gate)[1]		Transport to CGP (truck) and processing[2]		Transport to destination[3]	
			Av.	Range	Av.	Range	Av.	Range
AP4 (SRC willow..)	Chips	2010	9	8 - 10	0.4	0.2 - 1.4	13	9 - 19
		2020	12	10 - 12	0.5	0.2 - 1.4	16	11 - 22
		2030	13	12 - 14	0.5	0.2 - 1.5	18	13 - 24
	Pellets	2010	9	8 - 10	3.4	3.0 - 4.4	14	10 - 18
		2020	12	10 - 12	3.5	3.1 - 4.6	17	12 - 21
		2030	13	12 - 14	3.6	3.2 - 4.7	19	12 - 24
FP1 (forestry products - current use (wood chips, log wood) and FP2 (forestry products - complementary fellings (moderate))	Chips	2010	6	5 - 7	0.4	0.2 - 1.4	10	6 - 16
		2020	7	6 - 8	0.5	0.2 - 1.4	11	7 - 17
		2030	8	7 - 9	0.5	0.2 - 1.5	12	8 - 18
	Pellets	2010	6	5 - 7	3.4	3.0 - 4.4	11	9 - 15
		2020	7	6 - 8	3.5	3.1 - 4.6	13	10 - 17
		2030	8	7 - 9	3.6	3.2 - 4.7	14	11 - 18
FP3 (forestry products - complementary fellings (expensive))	Chips	2010	9	7 - 9	0.4	0.2 - 1.4	13	9 - 18
		2020	10	9 - 11	0.5	0.2 - 1.4	14	10 - 20
		2030	11	10 - 12	0.5	0.2 - 1.5	16	11 - 21
	Pellets	2010	9	7 - 9	3.4	3.0 - 4.4	14	10 - 18
		2020	10	9 - 11	3.5	3.1 - 4.6	16	12 - 20
		2030	11	10 - 12	3.6	3.2 - 4.7	17	12 - 21
FR2 (forestry residues - current use) and FR3 (forestry residues - additional)	Chips	2010	3	2 - 5	0.4	0.2 - 1.4	7	3 - 14
		2020	4	2 - 6	0.5	0.2 - 1.4	8	3 - 15
		2030	5	3 - 7	0.5	0.2 - 1.5	9	4 - 16
	Pellets	2010	3	2 - 5	3.4	3.0 - 4.4	9	6 - 13
		2020	4	2 - 6	3.5	3.1 - 4.6	9	6 - 15
		2030	5	3 - 7	3.6	3.2 - 4.7	10	7 - 15
FR5 (additional wood processing residues (sawmill, bark)	Pellets[4]	2010	5	4 - 5	2.9	2.5 - 3.9	9	7 - 13
		2020	6	5 - 6	3.1	2.7 - 4.1	10	8 - 14
		2030	6	5 - 7	3.2	2.8 - 4.3	11	9 - 15

1) Farm gate cost including cultivation and harvesting. The feedstock costs vary per country.

2) Processing (chipping and or pelletization) and transport to CGP by truck.

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

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

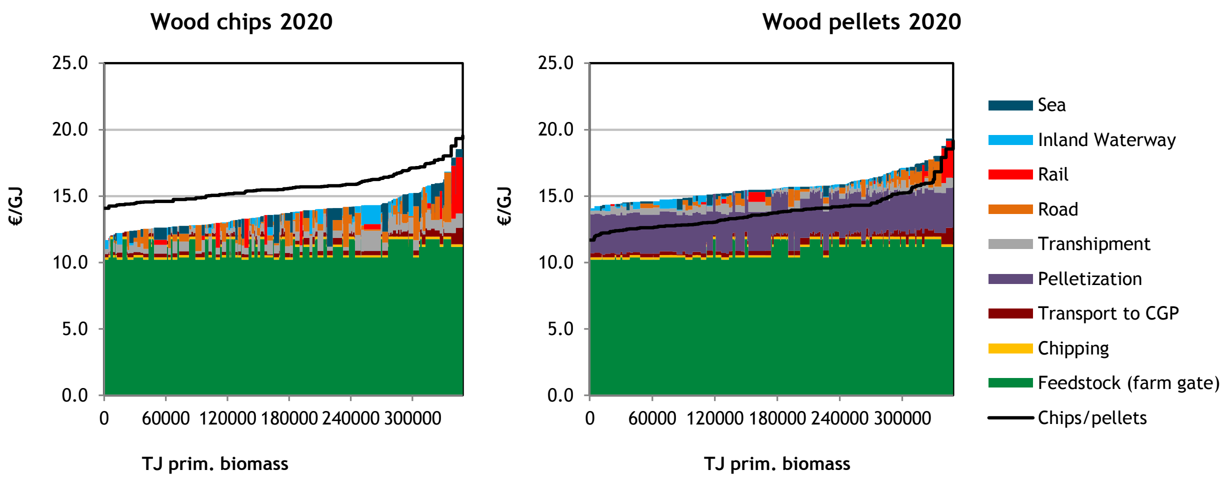

Figure 5-1 Total supply cost of SRC willow crops from EU countries supplied to Germany in 2020.

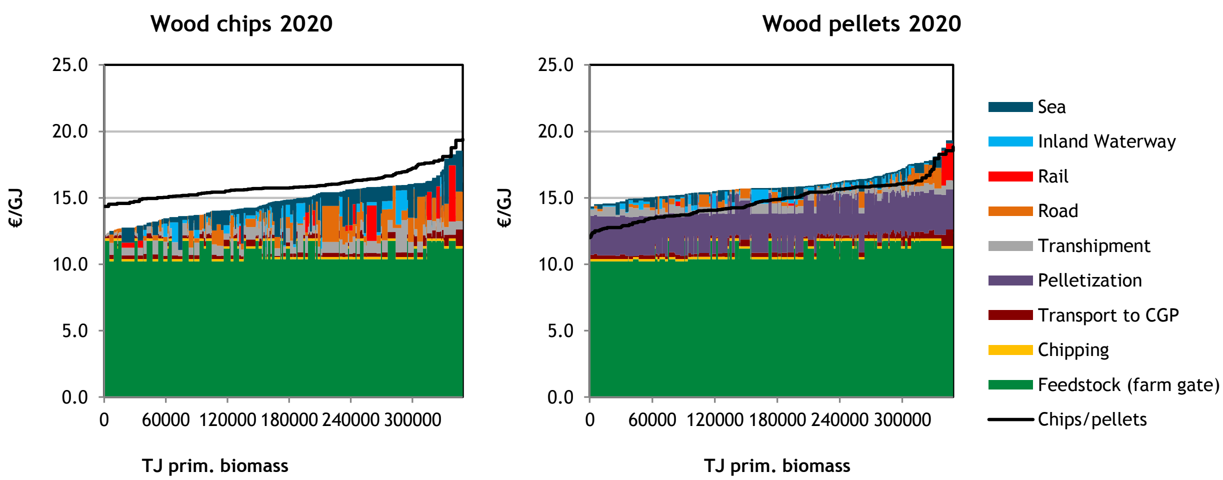

Figure 5-2 Total supply cost of SRC willow crops from EU countries supplied to the United Kingdom in 2020.

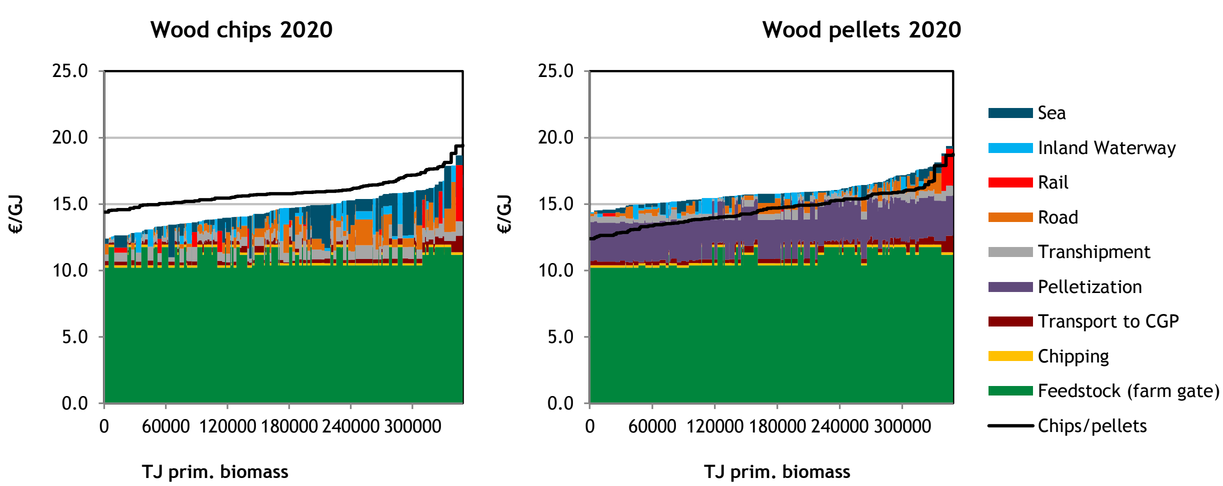

Figure 5-3 Total supply cost of SRC willow crops from EU countries supplied to the Netherlands in 2020.

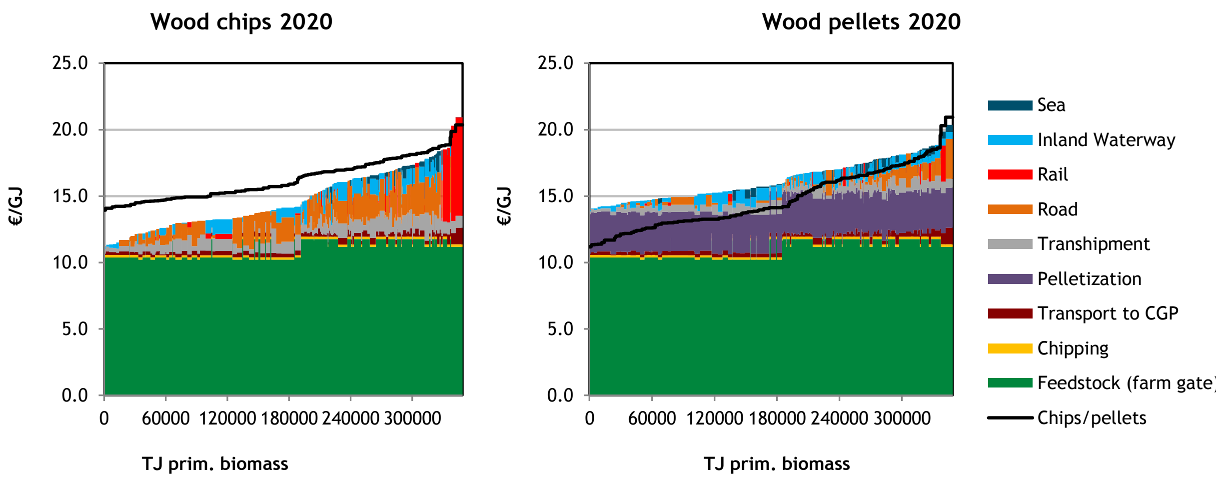

Figure 5-4 Total supply cost of SRC willow crops from EU countries supplied to the Austria in 2020.

5.2 Impact of transport cost on trade flows

Figure 5-5 shows the net domestic consumption and the sources of bioenergy used per country for electricity, heat and biofuels in the Low Import and High Import scenario in 2020 whereas Figure 5-6 shows the same results only for biomass that is traded beyond borders. Exports to other EU-countries are shown as negative bars. Domestic consumption is largest in France (25.9-26.4 Mtoe) followed by Germany (22.7-23.6 Mtoe) and Poland (13.0-13.1 Mtoe). Of these countries, only Poland is a net exporter of bioenergy commodities (2.6 to 2.9 Mtoe in the High Import and Low Import scenario respectively) (Figure 5-6). Other major exporting countries include Estonia (0.6 - 0.8 Mtoe in the High Import and Low Import scenario respectively), Hungary (0.4-0.5 Mtoe) and Slovakia (0.4 Mtoe). Countries with the largest intra-European biomass imports include Germany, the UK, the Netherlands and Austria. Countries with the largest inter-European biomass imports include Germany, followed by Italy, the UK and the Netherlands. In the Low Import scenario, Germany is projected to import 3.8 to 5.2 Mtoe of biomass, of which 47% and 30% is soured from other EU countries in the Low Import and High Import scenario respectively. Despite the reduced import potential of non-EU biomass, domestic production in Germany increases with 14 % relative to the High Import scenario, resulting in an overall increased use of biomass in the Low Import scenario. In countries that have limited domestic potential to compensate for reduced non-EU imports, e.g. the Netherlands or the UK, the total demand for bioenergy decreases relative to the High Import scenario.

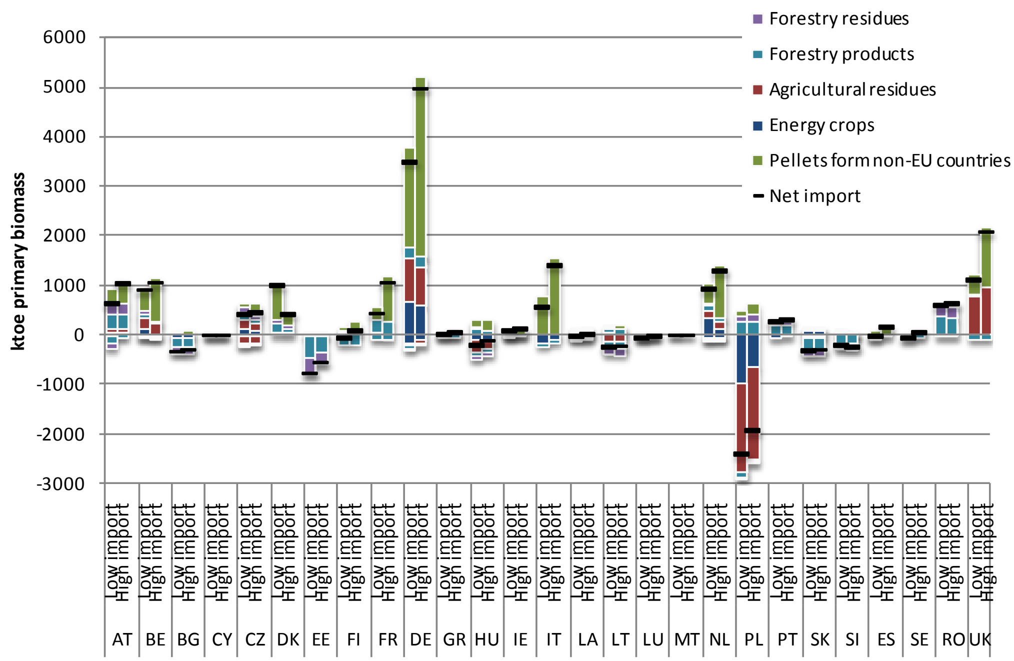

Figure 5-5Net import, export and domestic consumption of biomass for heat, electricity and biofuels in the Low Import and High Import scenario in 2020. Excluding non-tradable commodities (waste, black liquor, biogas). Export is shown as negative.

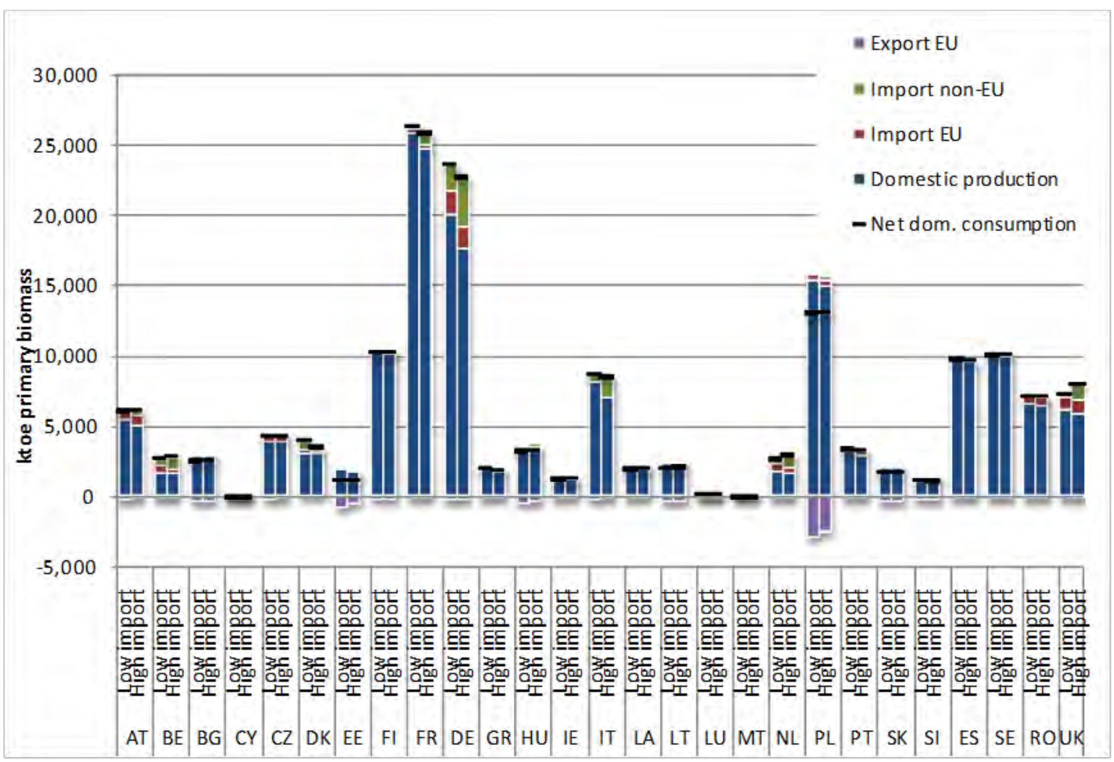

Figure 5-6 Import, export and net import of biomass from EU and non-EU countries in the Low Import and High Import scenario for 2020 per commodity type. Export is shown as negative.

The trade flows of all lignocellulosic biomass commodities in the scenarios are also visualized for the Low Import scenario in Figure 5-7 (2015) and Figure 5-8 (2020). The same graphs are provided for the High Import scenario in Figure 5-9 (2015) and Figure 5-10 (2020). Because Inter-European trade is relatively large compared to intra-European trade flows in these scenarios, the results are also shown for intra-European trade flows only in Figure 5-11 (Low Import, 2020) and Figure 5-12 (High Import, 2020). Note that the absolute size of these trade flows cannot be compared to Figure 5-7 through Figure 5-10 because the absolute amounts of trade are not consistent with the flow sizes in the other figures. For visual reasons, some countries are grouped into trade regions in these figures (Table 5-2).

Table 5-2 Grouped and individual countries in the trade flows depicted in Figure 5-7 to Figure 5-12.

Grouped countries		Individual countries	
1	Austria, Slovenia	12	Finland
2	Baltic States (Estland, Latvia, Lithuania)	13	France
3	Benelux (Belgium, the Netherlands, Luxembourg)	14	Germany
4	Czech Republic, Slovakia	15	Hungary
5	Greece, Cyprus	16	Poland
6	Ireland, United Kingdom		
7	Italy, Malta		
8	Romania, Bulgaria		
9	Spain, Portugal		
10	Sweden, Denmark		
11	non-EU countries (inter-EU imports)		

The results of biomass trade, as depicted in Figure 5-7 to Figure 5-12, show that even in the Low Import scenario, for most countries imports of wood pellets from non-EU imports dominate the trade markets. Nevertheless, there are some major intra-European trade flows in the results of both scenarios. These include exports from Poland to Germany, the UK and the Benelux countries. A significant difference between the Low Import Scenario and the High Import scenario is that Poland will export less biomass to the Benelux in the Low Import scenario, but more biomass to Germany and the UK. Germany, France and Spain, on the other hand, import more biomass to the Benelux countries in the Low Import scenario (Figure 5-11 and Figure 5-12).

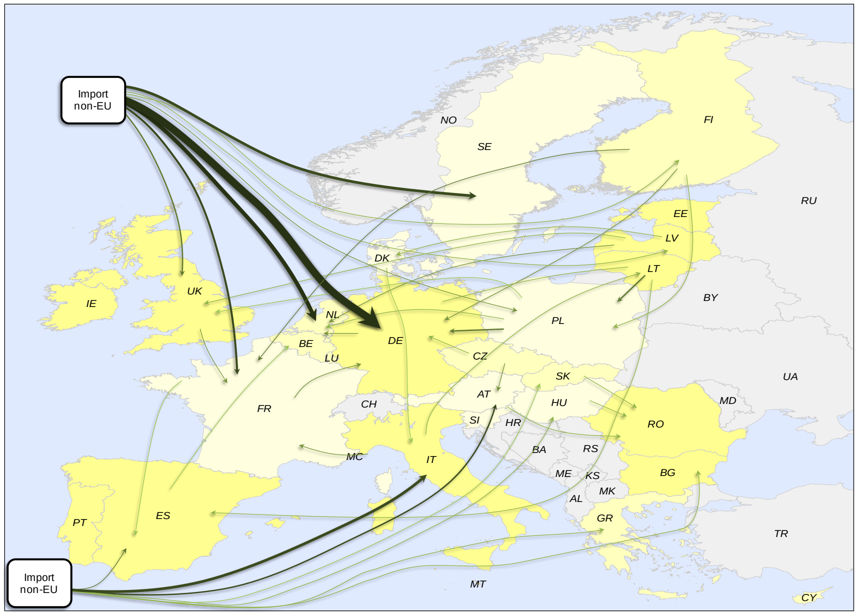

Figure 5-7 Biomass trade flows in the Low Import scenario 2015.

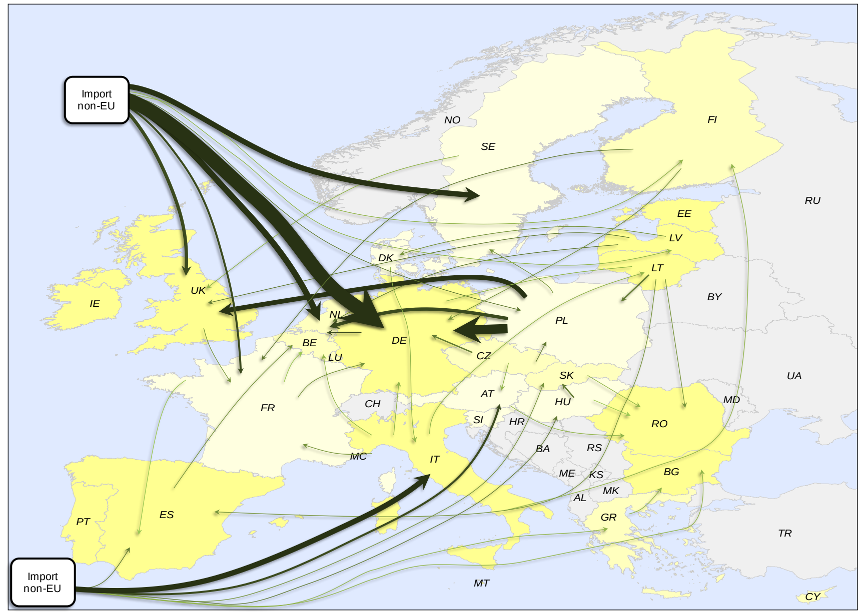

Figure 5-8 Biomass trade flows in the Low Import scenario 2020.

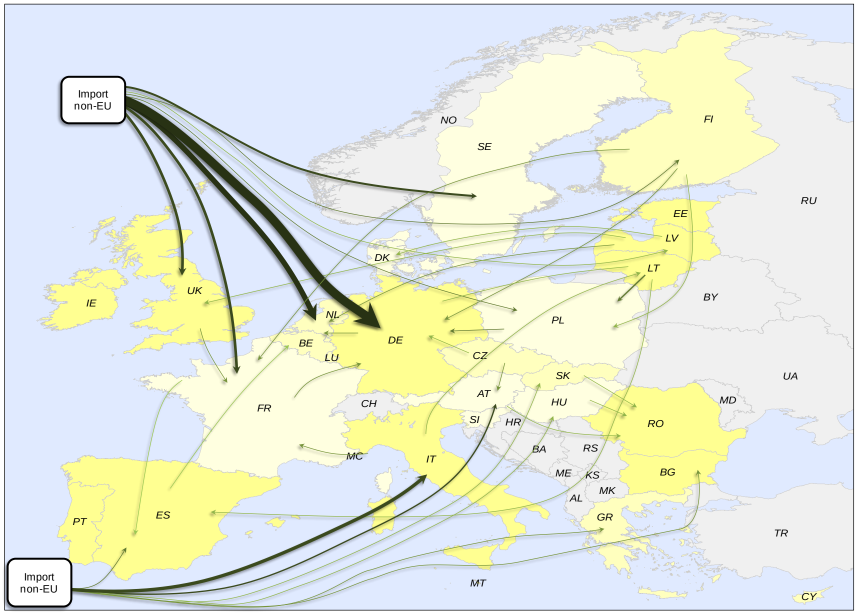

Figure 5-9 Biomass trade flows in the High Import scenario 2015

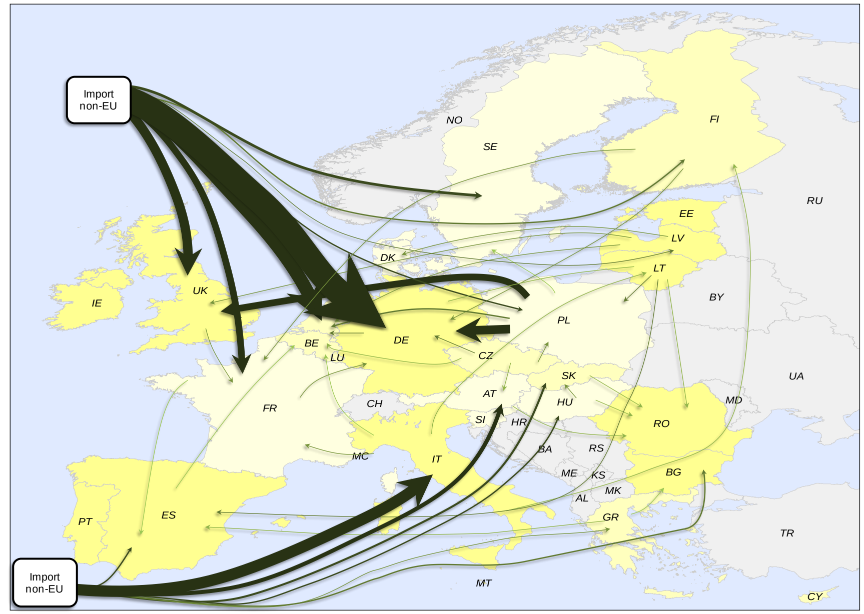

Figure 5-10 Biomass trade flows in the High Import scenario 2020

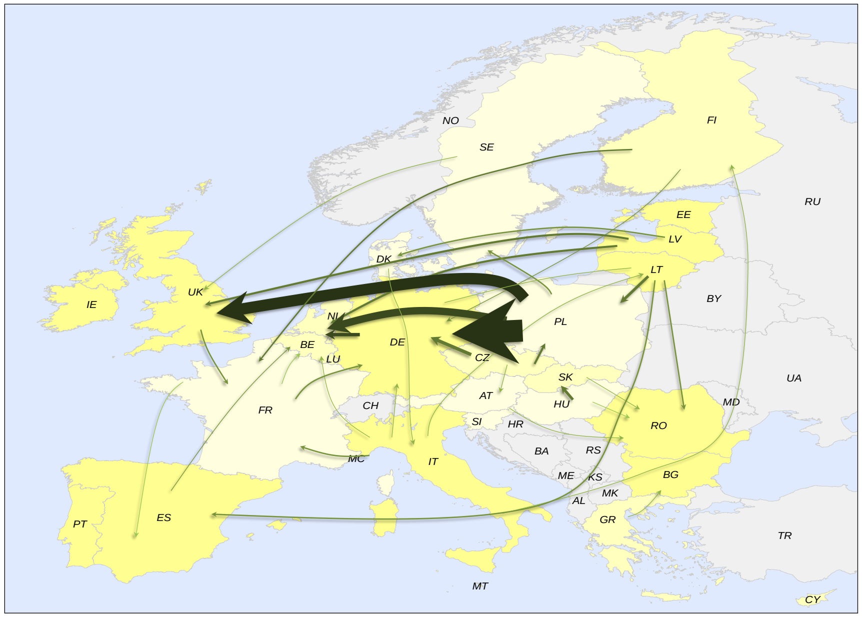

Figure 5-11 Biomass trade flows in the Low Import scenario 2020, only showing intra-European trade flows.

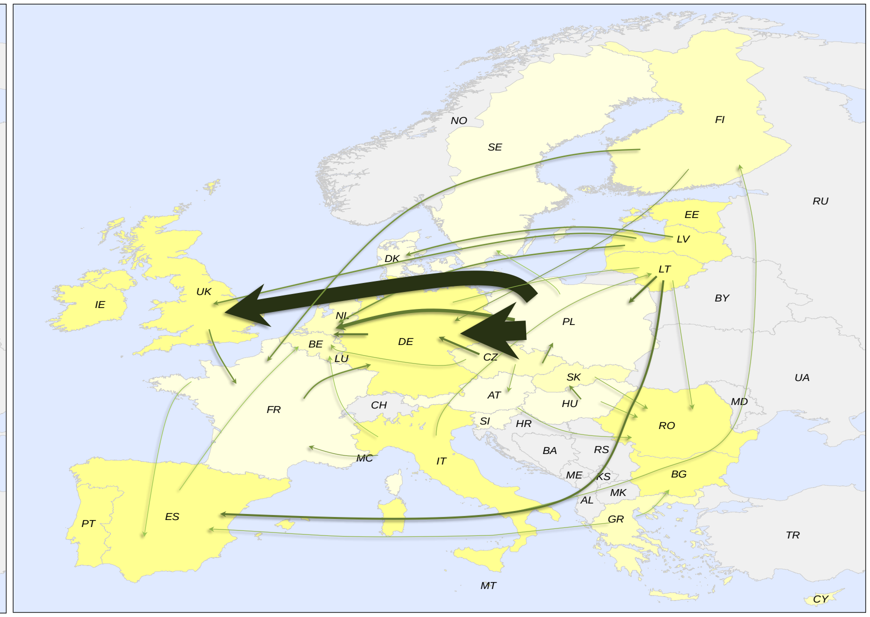

Figure 5-12 Biomass trade flows in the Low Import scenario 2020, only showing intra-European trade flows.

6 Discussion

This report investigated the potential economic implications of logistic supply chains and impact on potential future trade flows for bioenergy including forestry products, forestry residues, short rotation coppice and agricultural residues (straw). This has been done by means of geospatial explicit modelling of intermodal logistic chains in ESRI ArcGIS combined with scenario assumptions on Inter-European imports of wood pellets. The results were integrated in the renewable energy model GREEN-X to assess the impact of biomass supply cost on the potential of biomass for electricity, CHP and heat in context of a competitive renewable energy portfolio including wind, PV and hydropower and the renewable energy targets of the European Commission up to 2020.

The results of this assessment show major increases in trade flows of bioenergy commodities in the scenarios up to 2020. Because most EU member states did not include imported trade flows in their National Renewable Action Plans, it is not possible to compare the results of this study directly to the projections in these documents. If the total demand for bioenergy and the estimated gap between domestic supply and demand (Figure 2-4) are taken as a proxy for biomass imports, key importing countries in the NREAP projections would include countries that are also key importing countries in the Low Import and High Import scenarios of this study such as Belgium, Germany and the Netherlands. Other countries, including the Romania and the UK that are importing countries in the GREEN-X projections, would be able to use domestic biomass for the total demand of biomass for bioenergy. The most important difference between the NREAPs and the GREEN-X scenario projections in this study is the supply potential and estimated demand for Poland. In the GREEN-X scenario projections, Poland is the largest exporting region of biomass within Europe (44-45% of intra-European biomass trade in 2020) including mainly pellets from agricultural residues. In the NREAP of Poland, the demand for bioenergy is higher than the estimated supply potential which would imply that Poland would have to import biomass. Recent unconfirmed market signals in Poland also indicate that it might become a large importing country of wood pellets. The supply potential in the GREEN-X database might therefore be too optimistic.

The trade flows, as projected by the energy model GREEN-X, are mainly determined by the supply cost of bioenergy commodities. These cost estimates are the result of different input assumptions, of which the most important are: feedstock cost, cost and performance of pre-treatment processes (chipping or pelletization), cost of transport and cost of transhipment. The discussion therefore focuses on these parameters, the related impacts on the results and potential improvements to the model.

Feedstock costs in the results of study are derived from the country database of GREEN-X. These cost estimations are, in some cases, higher than projected by other studies for similar feedstock types as discussed in D10 of the RE-Shaping project (Junginger, Hoefnagels et al. 2011). This could result in an overestimation of total supply cost of Intra-European biomass supply. For example, supply of wood pellets for district heating in Sweden (from domestic sources) was estimated to be 12% (of 109 €/t) (Sikkema, Junginger et al. 2010). This study estimates the supply cost of wood pellets from similar feedstocks (wood processing residues) in the EU-27 delivered to Sweden to be 6.9 to 12.5 €/GJ (127 to

235 €/t). If, however, similar feedstock prices would be assumed to Sikkema, Junginger et al. (2010) (37.6 €/t pellets), the supply cost would be in similar ranges (89 to 182 €/t in this study).

Apart from feedstock cost, also fluctuating **currency exchange rates** between e.g. Euros and Canadian or US dollars, Swedish Krona and Russian Rouble result in differences in import prices. These relative variations were not considered in this study because all cost parameters in GREEN-X are expressed in 2006 euros. Note however that recent changes in exchange rates had a major impact on pellet prices and transport cost (Sikkema, Steiner et al. 2011). Extensive sets of sensitivity analysis in the transport model and GREEN-X could provide insight in the impact of exchange rates. This was, however, beyond the scope of this study.

For **pre-treatment** of biomass feedstock, two options for long distance transport were included in the model: wood chips or wood pellets. The advantage of wood pellets over wood chips are the increased calorific value (18 MJ/kg pellets, 12.6 MJ/kg chips), better handling, increased density (610 kg/m^3 pellets, 240 kg/m^3 chips) and lower moisture content (10% pellets, 30% chips). An oversimplified approach was used to calculate the cost of pelletization and chipping. Thek and Obernberger (2004) found differences of pellet production cost of 62 €/t in Sweden to 90 €/t in Austria, mainly due to economies of scale, personal cost, co-generation benefits and electricity prices. This study assumes the same scale for all countries (based on the Swedish case). Furthermore, only fuel cost (diesel and biomass for conditioning and drying) were assumed to be country specific. All other factors, including the GHG performance and cost of electricity supply per country were based on European averages.

Related to **transport**, the assumption whether a truck, train or ship **returns empty** is important to the overall cost balance. In this study, these values were based on empirical data for the Netherlands (NEA 2004). For short distance transport of pellets by **truck**, cost ranges of 12 to 18 €/t (16 €/t for 200 km) were found (Sikkema, Steiner et al. 2011). If the same distance are applied to the model in this study, it results in average cost of 15.3 €/t in 2010 (range: 11.4 – 20.5 €/t) to 16.1 €/t in 2030 (range: 12.3 – 21.3 €/t) excluding toll charges. For long distance transport however, the result of this study are overestimated compared to real cost estimates. The European Transport organization LKW Walter was asked for cost estimates from Warsaw to Rotterdam and from Warsaw to Trieste. They estimated cost of 850 € (Warsaw to Rotterdam) and 1150 € (Warsaw to Trieste) per full load truck (Jong, Tselekis et al. 2010) which would equal 34 and 46 €/t pellets respectively for the same full load factor. If we allow the model to use truck transport only, the cost would be 69 and 59 €/t pellets for Rotterdam and Trieste respectively in 2010. The main reason that cost are higher in this study is the empty return factor used (loaded trips of total trips = 55%). The amount of empty returns for long distance truck transport might therefore be overestimated in this study. Note however, that most transport chains in the result of this study include only short distance transport by truck and a combination of more transport modes. On the other hand, for rail transport, it was found that currently empty **trains** are going from Eastern to Western Europe which could be an opportunity for cost-efficient transport of (solid) biofuels in Europe (Verweij, Zomer et al. 2009; Boer, Cuijpers et al. 2010).

Regional variations including climate were not taken into account in this model, but could influence the results significantly. For St. Petersburg to Denmark, the cost of transport are around 5 €/t more expensive (25 €/t pellets) compared to transport from Riga to Denmark (20 €/t pellets), mainly due to seasonal ice coverage and related cost for icebreakers (Sikkema, Steiner et al. 2011). For routes from the black sea to Western Europe, cost of 29 to 31 €/t were found. For this project, interviews with stakeholders by Jong, Tselekis et al. (2010) resulted in cost ranges of 21 to 23 €/t for transport routes of the Baltic Sea to Western Europe. The bottom-up cost calculations in this study are significantly lower for short distance transport and in range for longer distances. For Riga to Rotterdam, the costs range from 6.1 €/t in 2010 to 7.4 €/t in 2030 (compared to 17.5 €/t pellets found by Jong, Tselekis et al. (2010) for the same route). For Constanta to Rotterdam (6200 km), the costs were, in range with empirical data, estimated to be 23 €/t (2010) to 29 €/t (2030) (excluding stevedoring, unloading and storage).

Apart from assumptions related to transport modes, also further improvements could be made in the model regarding **the network structure** of the different transport modes (road, railways, inland water ways and sea harbour connections). For example, inland waterways such as the Danube river, includes many strategic bottlenecks, as identified by the Inland Transport Committee (UN 2006) that were not all included in the TransTools network database. An update of the network in the ArcGIS database, including current bottlenecks and future developments of the inland waterway network in Europe would therefore improve the model.

7 Conclusion

This report investigated the potential of future intra- and inter-European trade of solid biomass for bioenergy purposes taking country to country specific intermodal transport routes into account and matching supply and demand for energy crops, forestry products and residues and agricultural residues. For this purpose, a geospatial, intermodal biomass transport model was developed in the ArcGIS 10.0 Network Analyst extension. This model has been complemented with data on the cost of shipment using road (truck), water (ocean ships and inland navigation ships) and rail and the cost of transshipment between these modalities. The results of the ArcGIS model were integrated in the transport extended renewable energy model GREEN-X and combined with two scenarios on import potential scenarios of biomass from non-EU countries, a Low Import and High Import scenario.

The approach applied provides useful insights in potential trade routes, key supply regions and key demand regions in Europe and potential cost implications for bioenergy production taking logistic implications of biomass from farm gate to supply destinations into account. Because biomass is becoming a major tradable energy commodity, representing bioenergy trade is of key importance to energy models that include renewable energy as no (European) country is limited to national resources.

Main results of the transport model are:

- Transport cost can add substantially to the total cost balance of supplying solid biofuels to the demand region. The cost for transporting biomass processed into wood chips from the supply region to the final destination could add up to 48% (9 €/GJ) of the total supply cost (19 €/GJ) in the case of SRC crops and up to 75% (9 €/GJ) of the total cost (12 €/GJ) in the case of forestry residues. The cost for transporting biomass processed into pellets from the supply region to the final destination could add up to 52% (7 €/GJ) of the total supply cost (13 €/GJ) in the case of forestry residues and 30% (6 €/GJ out of 17 €/GJ) in the case of SRC crops.
- When only looking at the cost of GJ delivered to the end-user, the cost for pelletization do not pay off against the lower transport cost from increased energy density, lower moisture content and lower stowage factor. It should be noted however that the model does not take possible end-user requirements and preferences into account.

Based on this assessment of the NREAPs for bioenergy production and supply of biomass to meet the required inputs for heat and electricity, we conclude that it was not possible to directly translate the NREAP roadmap data into scenarios for GREEN-X for the following reasons:

- The quality of the NREAPs varies between MS. Whereas MS states provide thorough overview of the roadmap to 2020, some other MS provide too little information or include too many inconsistencies in the data and information provided to translate in modelling scenarios;
- Some of the choices might be political and do not reflect optimal or realistic pathways for the deployment of RES-technologies.

Therefore, supply potentials of biomass were based on the GREEN-X database combined with High Import and Low Import scenarios of non-EU biomass to meet the EU renewable energy targets up to 2020.

With respect to the results of the GREEN-X Low Import and High Import scenario, the main results are:

- Total bioenergy intra-European biomass trade increases to 6,560 ktoe in 2020 in the Low Import scenario and 5,640 ktoe in the High Import scenario. This would be equivalent to 13 to 15 million tonne wood pellets (18 GJ/tonne).
- Inter European imports of wood pellets and wood chips are almost used to their full potential in 2020 with 5,990 ktoe in the Low Import scenario and 11,740 ktoe in the High Import scenario which is more than double the amount of Intra European biomass trade in this scenario and equivalent to 27 million tonne pellets.
- Key exporting regions within Europe are in both scenarios Poland, Estonia, Hungary and Slovakia. Poland is projected to export 2,565 (High Import) to 2,880 ktoe (Low Import) which covers 44 to 45% of total intra-European trade flows in 2020. Estonia (10%-12% of total intra-European trade), Hungary and Slovakia (7-8% of total intra-European trade) export significantly less compared to Poland in both scenarios in 2020. Key importing regions of intra-European biomass trade include Germany, the UK, the Netherlands and Austria. Key importing regions of inter-European biomass trade include Germany, Italy, the UK and the Netherlands.
- The difference between the Low Import and High Import scenario shows the impact of inter-European trade on intra-European trade. If lower imports are assumed, the increased marginal cost of domestic European resources results in increased production of energy crops in Germany and reduced imports. Other countries, such as the UK and Benelux countries, import more biomass from EU countries (mainly Poland).

These results demonstrate the potential of the modelling framework developed to model biomass trade flows. It should be noted however that the two scenarios modelled in this project are for demonstration of the models only and are not sufficient to draw any conclusions on implications of policy processes or export potentials of different countries. Such analysis would at least require a broader set of scenarios and sensitivity runs that were not conducted within this project. It is therefore also not possible to draw reasonable conclusions by comparing the results of this study with the results of the NREAPs.

Finally, it is concluded that further development of the modelling tool is required. These include:

- Improvement of input parameters to the transport model including logistic processes such as transhipment and the amounts of empty returns and capacity loads of transport modalities. For example, trains do return empty from Eastern European countries to Western European countries and could support optimized supply routes for bioenergy (from East to West). More insight is however required in these logistic processes that requires more information on transport sectors and related activities.

- The addition of other biomass commodities such as liquid biofuels (e.g. FT-diesel or ethanol) and other solid biofuels such as torrefied pellets. Torrefied pellets have higher energy densities than wood pellets and could therefore decrease transportation costs, but on the other hand, they require additional process energy for the torrefaction process. Thus, a triple trade-off between wood chips, wood pellets and torrefied pellets could be evaluated. For liquid biofuels, especially 2nd generation biofuels would be interesting to include as they compete with similar biomass sources (e.g. grassy crops or woody biomass) to electricity and heat production.
- The addition of more non-EU supply regions such as North-West Russia (forestry potential) and Ukraine (agricultural biomass potential) and inter-continental linkages to e.g. Canada and the USA. Europe is already importing large amounts of wood pellets for bioenergy production from these regions and it is expected to increase in the future. The model is currently being updated to include long distance maritime shipping and links to other continents (North America). These updates will allow for consistent modelling of both inter and intra-European trade flows.

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Appendix I

Estimation of primary bioenergy requirements based on final energy projections for heat and electricity in the NREAPs

The total primary biomass requirement for electricity and heat is calculated as the sum of solid, gaseous and liquid biomass requirements for electricity, heat and combined heat and power (CHP) (eq. A-1):

$B_{req} = B_e + B_{CHP} + B_H$ eq. A-1

Where:

- B_{req} : total primary biomass requirement (electricity, heat)
- B_e : total primary biomass requirement for electricity plants
- B_{CHP} : total primary biomass requirement for CHP plants (all biomass allocated to electricity generation)
- B_H : total primary biomass requirement for heat plants (district heating, industry and households)

In which the total biomass requirement for electricity from electricity and CHP plants is calculated as follows:

$B_e = E_{e,\,solid} / \eta_{e,\,solid} + E_{e,\,liquid} / \eta_{e,\,liquid} + E_{e,\,biogas} / \eta_{e,\,biogas}$ eq. A-2

$B_{CHP} = E_{CHP,\,solid} / \eta_{CHP,\,solid} + E_{CHP,\,liquid} / \eta_{CHP,\,liquid} + E_{CHP,\,biogas} / \eta_{CHP,\,biogas}$ eq. A-3

Where:

- $E_{e,\,solid}$: gross electricity generation electricity plants (solid, liquid or biogas)
- E_{CHP} : gross electricity generation CHP plants (solid, liquid or biogas)
- η_e : electric efficiency electricity plant (solid, liquid or biogas)
- η_{CHP} : electric efficiency CHP plant (solid, liquid or biogas)

All biomass required for CHP plants is allocated to electricity generation. The amount of heat from CHP plants is calculated as shown below (formulas A-4 to A-6):

$H_{CHP,\,solid} = E_{CHP,\,solid} * \eta_{H,\,CHP,\,solid}$ eq. A-4

$H_{CHP,\,liquid} = + E_{CHP,\,liquid} * \eta_{H,\,CHP,\,liquid}$ eq. A-5

$H_{CHP,\,biogas} = E_{CHP,\,biogas} * \eta_{H,\,CHP,\,biogas}$ eq. A-6

Where:

- H_{CHP} : heat produced from CHP plants (solid, liquid or biogas)
- $\eta_{H,\,CHP}$: heat efficiency CHP plants (solid, liquid or biogas) (unit of heat/unit of primary biomass)

Heat from commercial stand-alone plants (industry and district heating) is calculated with formulas A-7 through A10:

$H_{DH+ind, solid} = H_{gross, solid} - H_{households,} - H_{CHP, Solid}$ eq. A-7

$H_{DH+ind, liquid} = H_{gross, liquid} - H_{CHP, liquid}$ eq. A-8

$H_{DH+ind, biogas} = H_{gross, biogas} - H_{CHP, biogas}$ eq. A-9

If $H_{DH+ind, solid/liquid or biogas} < 0$, $H_{DH+ind, solid/liquid or biogas} = 0$ eq. A-10

Where:

- H_{DH+ind} : heat from district heating and industry (solid, liquid or biogas)
- H_{gross} : gross heat generation (solid, liquid or biogas) (from table 11)
- $H_{households}$: gross heat generation households (assumed all solid biomass) (from table 11)

Biomass required for all stand-alone heat plants (district heating, industry, households) is calculated with formulas A-11 through A-15:

$B_{H, DH+ind, solid} = H_{DH+ind, solid} / \eta_{H, DH+ind, solid}$ eq. A-11

$B_{H, DH+ind, liquid} = H_{DH+ind, liquid} / \eta_{H, DH+ind, liquid}$ eq. A-12

$B_{H, DH+ind, biogas} = H_{DH+ind, biogas} / \eta_{H, DH+ind, biogas}$ eq. A-13

$B_{H, households} = H_{households} / \eta_{H, households}$ eq. A-14

$B_H = B_{H, DH+ind, solid} + B_{H, DH+ind, liquid} + B_{H, DH+ind, biogas} + B_{H, households}$ eq. A-15

Where:

- $B_{H, DH+ind}$: biomass required for district heating and industry (solid, liquid or biogas)
- $B_{H, households}$: biomass required for heating in households (assumed all solid biomass)
- $\eta_{H, DH+ind}$: heat efficiency district heating and industry
- $\eta_{H, households}$: heat efficiency households

The efficiencies assumed in Table 0-1 are based on the efficiency ranges of the technology characterization in GREEN-X. For this report, it was simply assumed that the lower bound of the efficiencies represents 2005 and the highest represents 2020. The efficiencies for 2010 and 2015 are interpolated from the assumed efficiencies of 2005 and 2020. Note that in GREEN-X, the efficiencies of biomass conversion depends on the scenarios and related substitution speed and replacement types of biomass electricity, heat and CHP plants.

Table 0-1 Assumed efficiencies for 2010 - 2020 (based on Green-X technology database)

Year	$\eta_{e\,(stand\,alone),\,solid}$	$\eta_{e\,(stand\,alone),\,biogas}$	$\eta_{e\,(CHP),\,solid}$	$\eta_{e\,(CHP),\,biogas}$	$\eta_{CHP\,solid}$	$\eta_{CHP\,biogas}$	$\eta_{H,DH+ind}$	$\eta_{H,\,households}$
2010	28%	31%	19%	29%	63%	54%	87%	81%
2015	29%	32%	20%	31%	63%	56%	87%	84%
2020	30%	34%	21%	33%	64%	57%	87%	87%

Appendix II

Country specific parameters in the biomass transport model

Table 0-1 Country specific parameters

	Diesel (€/l)				MDO (€/l)				HFO (€/l)				Labour (€/h)	Transhipment cost (€/t fw)		
														Truck	Ship	Rail
Period/country	2005	2010	2020	2030	2005	2010	2020	2030	2005	2010	2020	2030	2005-2030	2005-2030	2005-2030	2005-2030
Crude fuel (before tax)	0.29	0.32	0.46	0.57	0.29	0.32	0.46	0.57	0.29	0.32	0.46	0.57				
Refined fuel before tax	0.39	0.42	0.61	0.76	0.39	0.42	0.61	0.76	0.22	0.24	0.35	0.43				
EU-27																
Austria	0.88	0.92	1.15	1.33	0.47	0.51	0.74	0.92	0.27	0.29	0.42	0.52	28.04	2.48	2.48	4.03
Belgium	0.92	0.96	1.19	1.37	0.47	0.51	0.74	0.92	0.27	0.29	0.42	0.52	28.35	2.49	2.49	4.05
Bulgaria	0.84	0.88	1.10	1.28	0.47	0.51	0.74	0.92	0.27	0.29	0.42	0.52	2.86	1.14	1.14	1.86
Cyprus	0.73	0.77	0.99	1.16	0.45	0.49	0.70	0.88	0.26	0.28	0.40	0.50	7.42	1.38	1.38	2.25
Czech Republic	0.95	0.99	1.21	1.39	0.46	0.50	0.73	0.91	0.27	0.29	0.42	0.52	9.24	1.48	1.48	2.41
Denmark	0.96	1.00	1.24	1.43	0.49	0.53	0.77	0.95	0.28	0.30	0.44	0.54	33.03	2.74	2.74	4.46
Estonia	0.91	0.95	1.18	1.36	0.47	0.51	0.74	0.92	0.27	0.29	0.42	0.52	7.46	1.39	1.39	2.25
Finland	0.95	0.99	1.22	1.41	0.48	0.52	0.75	0.93	0.27	0.30	0.43	0.53	28.04	2.48	2.48	4.03
France	0.98	1.02	1.24	1.42	0.47	0.51	0.73	0.91	0.27	0.29	0.42	0.52	28.04	2.48	2.48	4.03
Germany	1.04	1.08	1.31	1.49	0.46	0.50	0.73	0.91	0.26	0.29	0.41	0.52	26.20	2.38	2.38	3.87
Greece	0.75	0.79	1.00	1.16	0.42	0.46	0.67	0.83	0.27	0.30	0.43	0.53	14.60	1.76	1.76	2.87
Hungary	0.96	1.00	1.23	1.42	0.49	0.53	0.77	0.95	0.28	0.30	0.44	0.54	7.48	1.39	1.39	2.25
Ireland	0.91	0.94	1.16	1.33	0.44	0.48	0.70	0.87	0.27	0.29	0.42	0.52	28.04	2.48	2.48	4.03
Italy	0.98	1.01	1.24	1.42	0.47	0.51	0.74	0.92	0.27	0.29	0.42	0.52	14.60	1.76	1.76	2.87

Table 0-2 Country specific parameters (continued)

	Diesel (€/l)				MDO (€/l)				HFO (€/l)				Labour (€/h)	Transhipment cost (€/t fw)		
														Truck	Ship	Rail
Period/country	2005	2010	2020	2030	2005	2010	2020	2030	2005	2010	2020	2030	2005-2030	2005-2030	2005-2030	2005-2030
Latvia	0.87	0.91	1.14	1.32	0.47	0.51	0.74	0.92	0.27	0.29	0.43	0.53	5.76	1.30	1.30	2.11
Lithuania	0.86	0.90	1.12	1.30	0.46	0.50	0.73	0.91	0.27	0.29	0.42	0.52	6.35	1.33	1.33	2.16
Luxembourg	0.74	0.77	0.97	1.13	0.41	0.45	0.65	0.81	0.26	0.28	0.40	0.50	28.04	2.48	2.48	4.03
Malta	0.87	0.91	1.14	1.32	0.46	0.50	0.72	0.90	0.26	0.28	0.41	0.51	11.17	1.58	1.58	2.57
Netherlands	0.95	0.99	1.22	1.40	0.46	0.50	0.73	0.91	0.26	0.29	0.41	0.52	28.04	2.48	2.48	4.03
Poland	0.89	0.93	1.16	1.34	0.48	0.52	0.75	0.93	0.27	0.30	0.43	0.53	7.75	1.40	1.40	2.28
Portugal	0.79	0.83	1.03	1.18	0.41	0.44	0.64	0.80	0.27	0.30	0.43	0.53	14.60	1.76	1.76	2.87
Romania	0.80	0.84	1.07	1.25	0.46	0.50	0.73	0.91	0.28	0.30	0.43	0.54	4.55	1.23	1.23	2.00
Slovak Republic	1.04	1.07	1.30	1.48	0.46	0.50	0.73	0.91	0.27	0.29	0.42	0.52	7.86	1.41	1.41	2.29
Slovenia	0.99	1.03	1.26	1.44	0.47	0.51	0.74	0.92	0.27	0.29	0.42	0.52	14.86	1.78	1.78	2.89
Spain	0.84	0.87	1.10	1.27	0.45	0.49	0.71	0.89	0.26	0.28	0.41	0.51	18.03	1.95	1.95	3.16
Sweden	1.04	1.09	1.32	1.51	0.49	0.53	0.77	0.95	0.28	0.30	0.44	0.54	28.04	2.48	2.48	4.03
United Kingdom	1.13	1.16	1.36	1.52	0.41	0.44	0.64	0.80	0.27	0.29	0.42	0.52	21.60	2.13	2.13	3.47
Non-EU countries (region)																
South East	0.79	0.83	1.05	1.23	0.46	0.50	0.72	0.90	0.27	0.29	0.42	0.52	7.42	1.38	1.38	2.25
North West	0.96	1.00	1.22	1.40	0.46	0.50	0.72	0.90	0.27	0.29	0.42	0.52	28.04	2.48	2.48	4.03
North East	0.88	0.92	1.15	1.33	0.47	0.51	0.74	0.92	0.27	0.29	0.42	0.52	6.52	1.34	1.34	2.17
Central	0.96	1.00	1.22	1.40	0.46	0.50	0.72	0.90	0.27	0.29	0.42	0.52	28.04	2.48	2.48	4.03

ANHANG C

WORKSHOP AGENDA “DEVELOPMENT OF TORREFACTION TECHNOLOGIES AND IMPACTS ON GLOBAL BIOENERGY USE AND INTERNATIONAL BIOENERGY TRADE

Task 32:
Biomass combustion and co-firing

IEA Bioenergy

Task 40:
Sustainable International Bioenergy trade

Development of torrefaction technologies and impacts on global bioenergy use and international bioenergy trade

Friday January 28th 2011

1.30 p.m. till 6.00 p.m.

within the

Central European Biomass Conference (CEBC), Graz, Austria

Location: Stadthalle Graz

Workshop rationale and aim

Torrefaction is an interesting pre-treatment technology for biomass before pelletisation and/or combustion. It is a thermo-chemical process for the upgrading of biomass that is usually run at temperatures ranging from 200 to more than 300°C under the exclusion of oxygen and at ambient pressure.

This workshop will give a comprehensive overview of fundamentals of torrefaction, the main advantages of and the challenges in producing torrefied biomass. Ongoing R&D activities will be shown, demonstration plants under construction or already in operation will be presented and the latest state-of-science in torrefaction will be discussed.

A major focus of the workshop will also be put on logistic aspects of torrefied biomass and the possible impacts on global international bioenergy trade. International biomass trade of e.g. wood pellets, ethanol or biodiesel has been growing strongly in the past decade, but is still relatively small compared to other commodities. While the technical biomass potential would in theory allow for much larger quantities to be utilized, in practice the use is hampered by a geographical mismatch of supply and demand, and associated high logistical costs. Torrefaction is a pre-treatment technology that may help to overcome this barrier as it might enable the use of so-far unutilized biomass potentials, and may thus play a pivotal role for the future growth of bioenergy trade.

This workshop targets on representatives from industry, policy makers, NGOs and academia. The event takes place as a parallel session within the Central European Biomass Conference 2011 in Graz, Austria.

Registration

As the workshop is an integral part of the Central European Biomass Conference 2011, visitors to the workshop need to register to the conference. It is possible to book one single conference day.

About IEA Bioenergy Task 32 and Task 40

IEA Bioenergy Task 32 (Biomass Combustion and Cofiring) aims to expand cost effective and environmentally sound use of biomass combustion and cofiring technologies by collecting and exchanging knowledge amongst its member countries, using reports, databases, handbooks etc. Currently, 13 member countries participate in the task. Information about the task and its activities can be found at the task 32 website www.ieabioenergytask32.com.

Joint Task 32 / Task 40 workshop, Graz, Austria, 28 January 2011
Final programme

Task 40 under the IEA Bioenergy Agreement entitled: 'Sustainable International Bioenergy trade; securing supply and demand', was initiated in 2004 and currently has thirteen country members and the European Commission. Organisations in Task 40 include government agencies, industries, academia and consultancies. A key element of the work program is to monitor and analyze experiences with the rapidly growing international bioenergy trade in solids and liquid biofuels while simultaneously evaluate opportunities and barriers for the development of a sound international market. Task 40 typically organises 2-3 workshops per year. For more information see www.bioenergytrade.org

Programme

Time	Lecture / speaker
13:30	Welcome address *Martina Ammer, Federal Ministry for Transport, Innovation and Technology, Vienna, Austria*
13:35	Introduction *Chairman: Jaap Koppejan, IEA Bioenergy Task 32, Enschede, The Netherlands*
13:40	Task 40 overview of international developments in torrefaction *Chris Kleinschmidt, KEMA, Arnhem, The Netherlands*
13:50	The ratio behind torrefaction: trade-off between additional investment & energy use vs. logistical & end-use advantages *Michael Wild, EBES AG, Vienna, Austria*
14:10	Fundamentals and basic principles of torrefaction *Martin Englisch, ÖFI, Vienna, Austria*
14:30	Pilot-scale biomass torrefaction - an extensive parametric study *Anders Nordin, Umea University, Umea, Sweden*
14:50	ECN's torrefaction-based BO2-technology – from pilot to demo *Jaap Kiel, ECN, Petten, The Netherlands*
15:10	Presentation of the Torrbed process *Robin Post van der Burg, Topell, The Hague, The Netherlands*
15:30	Presentation of the Torr Coal process *Jan Brouwers, Torr Coal, Sittard, The Netherlands*
15:50	Presentation of the ACB process *Klaus Trattner, Andritz AG, Graz, Austria*
16:10	**Coffee break**
16:30	Regional/global biomass potentials that are currently unutilized and that may be accessed through torrefaction *Hubert Röder, Pöyry, Freising, Germany*
16:50	Possibilities and bottlenecks for long-distance transport and storage of torrefied material *Ger Ostermeijer, Peterson Control Union Group, Rotterdam, The Netherlands*
17:10	Case study: exports of torrefied and non-torrefied biomass from a Latin American country to Rotterdam Comparison of costs and GHG emissions *Andre Faaij, Utrecht University, Utrecht, The Netherlands*
17:30	The technical aspects of the firing and co-firing of torrefied biomass in large pulverised fuel-fired boilers. *William Livingston, Doosan Babcock Energy Limited, Renfrew, UK*
17:50	Closing *Chairman: Martin Junginger, IEA Bioenergy Task 40, Utrecht, The Netherlands*

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ANHANG D

PUBLICATION “AN ASSESSMENT OF INTERNATIONAL TRADE RELATED TO BIOENERGY USE IN AUSTRIA—METHODOLOGICAL ASPECTS, RECENT DEVELOPMENTS AND THE RELEVANCE OF INDIRECT TRADE”

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An assessment of international trade related to bioenergy use in Austria—Methodological aspects, recent developments and the relevance of indirect trade

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Bioenergy

ABSTRACT

Increasing international biomass trade for energy and concerns about sustainability of globally traded biomass have raised interest in assessments of cross-border trade related to bioenergy. Within this paper, approaches to overcome methodological difficulties related to biomass trade are proposed and applied for the case of Austria.

Biomass currently has a share of 15.5% in Austria's primary energy consumption of 1354 PJ (2009). According to energy statistics, the rate of self-sufficiency with biomass for energy (defined as the ratio of domestic production to inland consumption, with both imports and exports taken into account) is 91%. However, feedstock imports for transport fuel production and indirect imports of wood-based fuels (wood processing residues and waste liquor of the paper industry originating from imported wood) are not taken into account in energy statistics, but prove to be of some significance. Imports of agricultural commodities to the amount of 9.7 PJ can be attributed to domestic biofuel production, and indirect imports of wood-based fuels, account for 31 PJ. With these import streams taken into account, the share of domestic fuels in bioenergy use is only 67%, rather than 84%, as official energy statistics suggest. On the other hand, Austria is exporting more than 50% of its production of sawnwood, panelboard and paper products.

1. Introduction and rationale

With a share of about 15% in the primary energy consumption (PEC) in 2009 (Statistik Austria, 2012), biomass is of major importance for the Austrian energy supply. According to energy statistics, 84% of the biomass used for energy production in Austria originates from domestic sources. With biomass exports (primarily wood pellets) taken into account, the rate of self-sufficiency with biomass is 91%. Biomass accounts for 40% of the total primary energy supply of domestic origin. Therefore, biomass is considered to make a significant contribution to energy security and reducing dependence on energy imports, both of which are core objectives of Austria's energy policy (BMWFJ and BMLFUW, 2010).

However, in fact cross-border trade of biomass used for energy generation is often not fully captured in statistics. In energy statistics only biomass fuels which are traded directly for the purpose of energy recovery is taken into account. Some other trade streams which are just as, or even more important than direct biomass trade are not included. Hence, there is evidence that biomass imports are in fact clearly more significant than energy statistics suggest. Previous studies on international biomass trade highlight the importance of the concept of "indirect" biomass trade (e.g., Heinimö and Junginger, 2009). This concept refers to biomass being traded for material uses, but ultimately ending up in energy generation, for example imported wood products ending up in waste utilization plants or large shares of industrial roundwood ending up as wood-processing residues. According to Heinimö and Junginger (2009), indirect trade of biomass through trading of industrial roundwood and material byproducts comprises the largest proportion of international biomass trade for energy, accounting for approximately two thirds of the total global trade volumes in 2006. Despite a rapid growth in direct biomass trade for energy in recent years, direct trade volumes are clearly less significant: direct trade with ethanol accounted for about 13% of bioenergy-related trade in 2006, wood pellets for 6.5%, fuel wood for 4.3% and biodiesel for 1.6%.

Due to the high importance of international trade for the mobilization of global biomass potentials on the one hand, and rising concerns about sustainability issues of globally traded

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biomass on the other, profound knowledge of developments in international biomass trade are considered an essential basis for policy making in the field of bioenergy.

The objective of this study is threefold: First, to contribute to a clarification of methodological challenges of assessing international trade streams. Second, to document recent trends in bioenergy-related trade and interconnections with the wood-processing industries in Austria. And third, to propose methodologies for assessing biomass trade streams not captured in energy statistics, in order to provide insight into the actual import dependence of the Austrian bioenergy sector. This includes indirect imports of wood-based fuels and feedstock imports for the production of biofuels. The latter are of particular interest, as the increasing global demand for energy crops for biofuel production is found to have an impact on food prices (e.g., Schmidhuber, 2007; Mitchell, 2008; Baffes and Haniotis, 2010) and land-use change (Fonseca et al., 2010), which is likely to offset the greenhouse gas savings achieved through substituting fossil fuels (e.g., Searchinger et al., 2008; Havlík et al., 2010). Finally, the results of the assessments are used to derive detailed flow diagrams of the wood streams (including wood for material and energy uses) as well as of the Austrian bioenergy sector, taking into account the above-mentioned trade streams, different biomass types and end uses.

The issue of international biomass trade is considered to be of high interest for policy makers for the following reasons: First, with regard to supply security and import dependence, it is of crucial importance to have a clear picture of energy commodities trade not captured in energy statistics. And second, monitoring global carbon flows has a political dimension in the context of carbon mitigation policies.

The paper is structured as follows: Section 2 gives an introduction into the methodological challenges addressed within this work, as well as an overview of the approaches applied and the data used. In Section 3, a brief summary of the historic development of bioenergy use in Austria is presented. Section 4 is dedicated to direct biomass trade[2]: Imports and exports according to energy statistics are discussed (Section 4.1), trade streams according to trade statistics are mapped (4.2), and trade quantities related to biogenic transport fuels are analyzed (4.3). The topic of Section 5 is indirect trade with wood-based fuels. After an overview of the methodological approach (5.1), the current wood flows in Austria are described (5.2) and the quantities of indirect trade streams are assessed (5.3). In Section 5.4, the concept of indirect trade is extended to wood products. Section 6 includes a synthesis, discussion and conclusions. Explanations of terms and definitions used in this work are provided in Appendix A.

2. Methodological challenges and data

There are numerous challenges related to measurement of internationally traded quantities of biomass for energy generation. The following methodological challenges need to be addressed (cp. Heinimö and Junginger, 2009):

Most biomass types are produced and traded for several applications, including energy purposes as well as material uses. Biomass for energy is often aggregated together with biomass for other purposes in production statistics (e.g., wood chips and residues, which are used for energy generation as well as for the production of paper and panelboard). This is also true for trade statistics, as trade codes according to the Combined Nomenclature (CN codes) (European Commission, 2010) usually aggregate streams intended for different purposes.

- Biomass is often traded for material uses, but ultimately ends up in energy production. Due to large international trade streams of raw wood and (semi-)finished wood products, this is especially relevant for residues from wood processing (sawmill by-products), waste liquor of the paper and pulp industry and other wood wastes which originate from imported material and are ultimately used for energy recovery. These trade streams are referred to as "indirect trade".
  In order to identify the most relevant indirect trade streams, a detailed assessment of the foreign trade with raw wood and wood products, as well as wood flows within Austria is carried out.
- Liquid transport fuels are traded as pure biofuels as well as different blends with fossil fuels. Depending on the form in which they are traded, biofuels are recorded under different trade codes. For example, ethanol can be imported under the CN code 2207 01, 2207 02 and 3824 9099, as well as further codes in the case of low-blend ethanol, together with other types of denaturated or undenaturated ethyl alcohol (Akkerhuis, 2010). Therefore, a complete assessment of international biofuel trade on the basis of trade statistics is considered infeasible (at least with the current set of CN codes).
- An increasing energetic use of a certain commodity may result in displacement effects to other, non-energetic uses. If increasing shares of domestically produced biomass are used for energy generation, larger quantities of the same biomass required for other purposes have to be imported. Due to methodological difficulties in the assessment of such "induced imports", we propose an approach on the basis of self-sufficiency rates (see Section 4.3).
- As physical properties of most biomass types and especially wood vary widely, the conversion of quantities stated in mass units (e.g., in trade statistics) or volume units (solid cubic meters, SCM; e.g., in forestry statistics) to energy quantities is associated with substantial uncertainties. Furthermore, natural and forced drying of wood results in a loss of weight and volume, causing inaccuracies in investigations of wood flows. Disregarding these sources of uncertainty, the conversion factors stated in Table 1 are assumed.

To sum up, investigations of biomass trade streams related to bioenergy are not straightforward, and specific methodologies need to be developed, in order to gain insight into the import dependence of the bioenergy sector or the effect of an increasing bioenergy use on trade flows.

The official national energy statistics according to Statistik Austria (2012) form the starting point of this assessment. With regard to biofuels for transport, the official report pursuant to Directive 2003/30/EC (Winter, 2010) is also used, as it provides more detailed data on the utilization of biogenic transport fuels. This report also contains data on domestic production, imports and exports of liquid biofuels, but it does not provide any information on the origin of feedstock used for biofuel production. National supply statistics for agricultural commodities are used to fill in this data gap (Statistik Austria, 2011).

As there are no data on supply balances and cross-border streams of biogas substrates available (primarily maize is used in Austria; see Kalt et al., 2010), the assessment of import streams of the biogas sector is based on a bottom-up estimate by the umbrella organization of the composting and biogas plants in Austria, "ARGE Kompost & Biogas" (Kirchmeyr, 2011). Data from trade statistics (Eurostat, 2011a) are used to map direct trade streams of the following wood fuels: wood-processing residues,

[2] The quantities referred to as "direct trade" in this study include biomass streams stated in energy statistics as well as feedstock used for the production of biogenic fuels (such as oilseeds and plant oil for the production of biodiesel).

Table 1
Conversion factors for biomass.

	GJ[a]/kg	GJ[a]/SCM[b]
Log wood	14.31[c]	7.20[d]
Wood chips, wood-processing residues, other wood waste	9.69[c]	–
Wood pellets	18.00[c]	–
Biodiesel	36.60[c]	–
Ethanol	26.68[c]	–
Vegetable oil	37.60[c]	
Black liquor	8.47[c]	–
Charcoal	31.00[c]	–
Raw wood	–	7.20[d]

[a] Lower heating value.
[b] SCM: solid cubic meters under bark (i.e., excluding bark).
[c] Based on Statistik Austria (2012).
[d] Assumption corresponding to coniferous wood at 20% moisture content on a wet weight basis.

wood log, wood waste and pellets. Other streams are not mapped due to insufficient differentiation and/or fragmentary data in trade statistics.[3] Table 2 provides an overview of most relevant biomass types used for energy in Austria, their definitions and CN codes. However, it is stressed that biomass for energy is traded under numerous other codes (e.g., agricultural commodities like oilseeds), and that most codes listed here also include material used for non-energy uses. It also needs to be stressed that there are substantial uncertainties related to trade statistics, as frequent discrepancies between data according to the exporting country and corresponding data of the importing country indicate (Kalt et al., 2011a).

In order to assess indirect trade quantities of wood-based fuels (Section 5), it is necessary to have a detailed picture of the different utilization paths of the various wood fractions, as well as the flows between the wood processing industries. The required data are obtained from production and consumption statistics of the wood-processing industries (sawmill industry: FAO, 2011a; paper and pulp industry: Austropapier, 2011; panel-board industry: Schmied, 2011) and Pellet@las (2011), statistical data on wood consumption and trade (FAO, 2011a; FAO, 2011b), previous assessments of the Austrian wood flows (Hagauer et al., 2007; Hagauer, 2008) as well as reports on timber felling (Prem, 2009). These data are used to draw a flow diagram of the main wood streams in Austria. Based on this, the quantities of indirectly traded biomass used for energy generation are assessed.

More detailed descriptions of the methodological approaches have been included in the respective sections for better readability.

3. Bioenergy use in Austria

This section gives a brief overview of the historic development and structure of biomass use in Austria. Fig. 1 shows the development of biomass primary energy consumption broken down by biomass types. From 1970 to 2004, biomass statistics differentiated only between the categories "wood log", "municipal solid wastes" and "other biomass and biofuels". The latter include all types of liquid biofuels, biogas and wood fuels like wood chips, residues, pellets etc. The data for the biogenic fraction of municipal solid wastes during this period are estimates based on an assumed biogenic share in municipal waste of 20%. More detailed data are available for the years 2005–2009. The biogenic share of wastes was in the range of 17–24% during this period. In Fig. 1, all liquid biofuels have been summarized to one category, as the original differentiation in energy statistics is considered to be misleading.[4]

Fig. 1 also shows the share of biomass in the total PEC, which increased from less than 6% (less than 50 PJ/a) during the 1970s to 15% (210 PJ) in 2009. The main increase in biomass use took place during the periods 1980–1985 and 2004–2009. Until the year 1999 the use of wood log for domestic heating accounted for more than 50% of the total biomass use for energy. The rest was primarily wood wastes and sawmill by-products as well as waste liquor of the paper and pulp industry. Especially during the last five years, the different fractions of wood biomass, including forest wood chips, sawmill by-products and other wood wastes as well as liquid and gaseous biomass have become increasingly important, whereas wood log remained relatively constant at about 60 PJ/a. As a result, wood log accounted for only 30% of the total biomass use in 2009.

The final energy consumption of biomass-derived energy is structured as follows (2009): Wood log and other biogenic fuels used for heat generation account for 65.6%, district heat for 13.5%, electrical energy from biomass power plants, including combined heat and power (CHP) plants, for 8.5%, and transport fuels for 12.4% (Statistik Austria, 2012).

The importance of biomass for Austria's energy security is emphasized by its share in the primary energy supply of domestic origin: According to the official data by Statistik Austria (2012), biomass accounted for 40% in 2009, which is more than the share of all other renewable energy sources (33%), as well as of fossil fuels (27%). To what extent this picture changes when it is considered that "domestic production" according to energy statistics actually includes indirectly imported biomass and biofuels produced from imported feedstock is one of the core objectives of this work.

The increasing use of biofuels for transport was one of the most dynamic developments in the Austrian bioenergy sector in the last decades. In order to provide a more detailed insight into this development, which is of special significance with regard to cross-border trade (as will be shown in Section 4.3), Fig. 2 shows the use of biogenic transport fuels broken down by types of biofuels as well as the share in the total fuel consumption in road transport. The figure illustrates that this share increased from about 1% in 2005 to 7% in 2009. The figure also illustrates that the largest contribution comes from biodiesel in blends (66% in 2009), followed by pure biodiesel (19%), ethanol in blends (12%) and vegetable oil (3%). The current use of E85 (a blend that contains 85% ethanol and 15% gasoline) and biomethane (cleaned and conditioned biogas), is negligible (Winter, 2010).

With regard to the 2020-scenario described in Austria's official Renewable Energy Action Plan (Karner et al., 2010), it is not expected that bioenergy use in Austria will continue to grow at the same pace as in recent years. In fact, only very slight increases are projected for energy from biomass until 2020 (see Kalt et al., 2011b), which could (under the assumption of rising efficiency) be achieved without mobilizing or importing additional biomass resources.

4. Direct biomass trade

In this section, direct trade streams related to bioenergy use are analyzed. This includes biomass imports and exports according to

[3] For example, biodiesel trade captured in CN code 3824 9091, which has been established in 2008 (Freshfields Bruckhaus Deringer, 2008), only includes pure biodiesel as well as B99 (a diesel blend that contains 99% biodiesel and 1% fossil diesel), and therefore only an unrepresentatively small fraction of the actual trade streams.

[4] In Statistik Austria (2012) pure liquid biofuels (biodiesel, ethanol and vegetable oil) are included in the category "other liquid biofuels", whereas the categories "biodiesel" and "ethanol" only comprises quantities blended with fossil fuels.

Table 2
CN codes of biomass types used for energy and their definitions according to the nomenclature of trade goods.
Sources: Heinimö (2008), Akkerhuis (2010), European Commission (2010), Alakangas et al. (2011), Eurostat (2011a).

Product (term used in this study)	CN code(s)	Definition(s) according to European Commission (2010)
Wood fuels		
Wood log	4401 1000	Fuel wood, in logs, in billets, in twigs, in faggots or in similar forms
Wood chips	4401 2100 (coniferous); 4401 2200 (non-coniferous)	Wood in chips or particles
Wood-processing residues, refined wood fuels and other wood waste	4401 3000	Sawdust and wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms
Wood pellets	4401 3020	Sawdust and wood waste and scrap, agglomerated in pellets
Sawdust	4401 3040	Sawdust of wood, whether or not agglomerated in logs, briquettes or similar forms (excl. pellets)
Wood waste	4401 3080	Wood waste and scrap, whether or not agglomerated in logs, briquettes or similar forms (excl. sawdust and pellets)
Charcoal	4402 0000	Wood charcoal, incl. shell or nut charcoal, whether or not agglomerated
Liquid biomass		
Rapeseed oil/ sunflower oil	1514/1512	Rape, colza or mustard oil and fractions thereof/sunflower-seed, safflower or cotton-seed oil and fractions thereof, whether or not refined, but not chemically modified
Ethanol	2207 1000; 2207 2000; 3824 9099	Undenatured ethyl alcohol, of actual alcoholic strength of 80%; denatured ethyl alcohol and other spirits of any strength; chemical products and preparations of the chemical or allied industries
Biodiesel	3824 9091	Fatty acid mono-alkyl esters, containing by volume 96.5% or more of esters
Black liquor	3804 0000	Residual lyes from the manufacture of wood pulp, whether or not concentrated, desugared or chemically treated, including lignin sulphonates

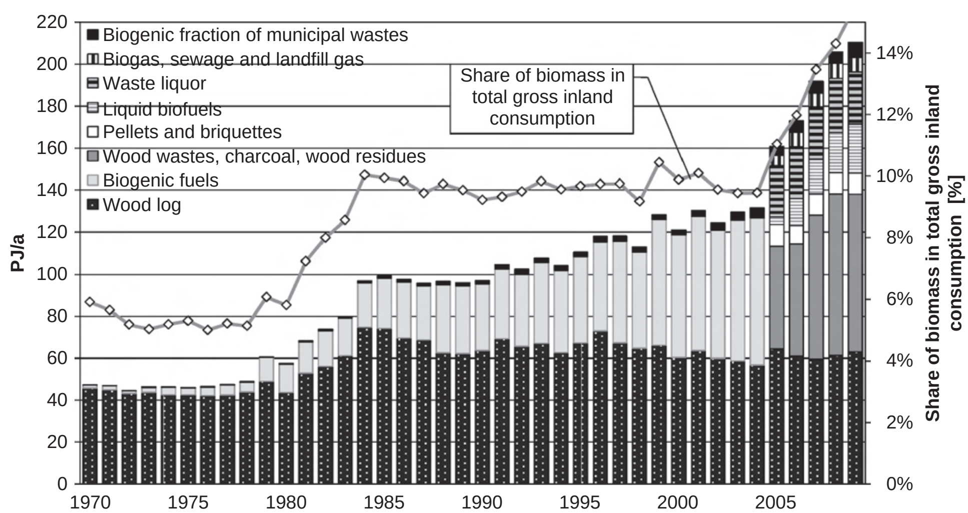

Fig. 1. Biomass primary energy consumption in Austria from 1970 to 2009 and biomass share in total primary energy consumption.
Source: Statistik Austria (2012), own calculations.

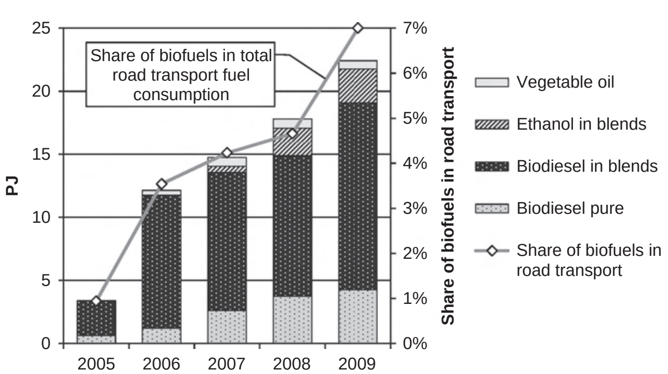

Fig. 2. Development of the consumption of biofuels for transport in Austria from 2005 to 2009.
Source: Winter (2010).

energy statistics, streams of wood fuels according to trade statistics as well as biofuel and feedstock trade related to the use of biofuels in the transport sector.

4.1. Biomass trade according to energy statistics

Fig. 3 shows the imports and exports of biomass used for energy production in Austria according to energy statistics. For the period 2005–2009, the data are broken down by different types of biofuels, pellets and briquettes, wood log and charcoal. International trade of other biomass types (like wood chips, biogenic municipal solid wastes, etc.) is indicated as zero for all years (which is, according to trade statistics, in fact not true for wood chips).

Being a land-locked country with the Alps as a natural barrier, imports to one region and exports from another are often the case in Austria. For some biomass types (e.g. "pure liquid biofuels" and "pellets and briquettes"), these imports and exports are closely matched in most years.

The figure illustrates that according to energy statistics, Austria was a net exporter of biomass fuels until 2005. From 2000 to 2004, both imports and exports increased about 2.5-fold, resulting in net exports of 5.6% of the total biomass PEC. In the following years, which were characterized by a rapid increase of

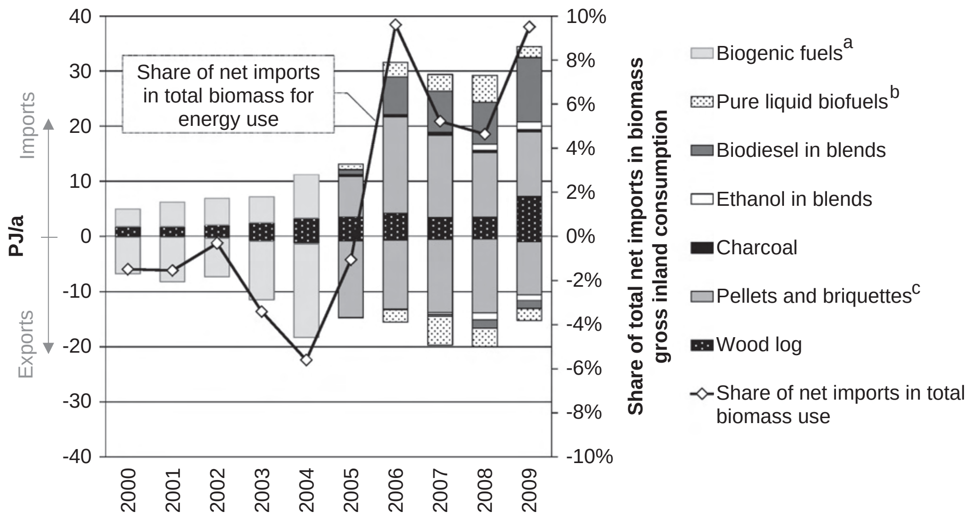

Fig. 3. Imports and exports of biogenic energy carriers according to energy statistics of the national statistical authority. (a) Includes all types of biomass except wood log. (b) Includes vegetable oil, pure biodiesel and E85. (c) A comparison with other trade statistics indicates that the category ''pellets and briquettes'' also includes unrefined wood fuels (wood chips, wood-processing residues, etc.).
Source: Statistik Austria (2012).

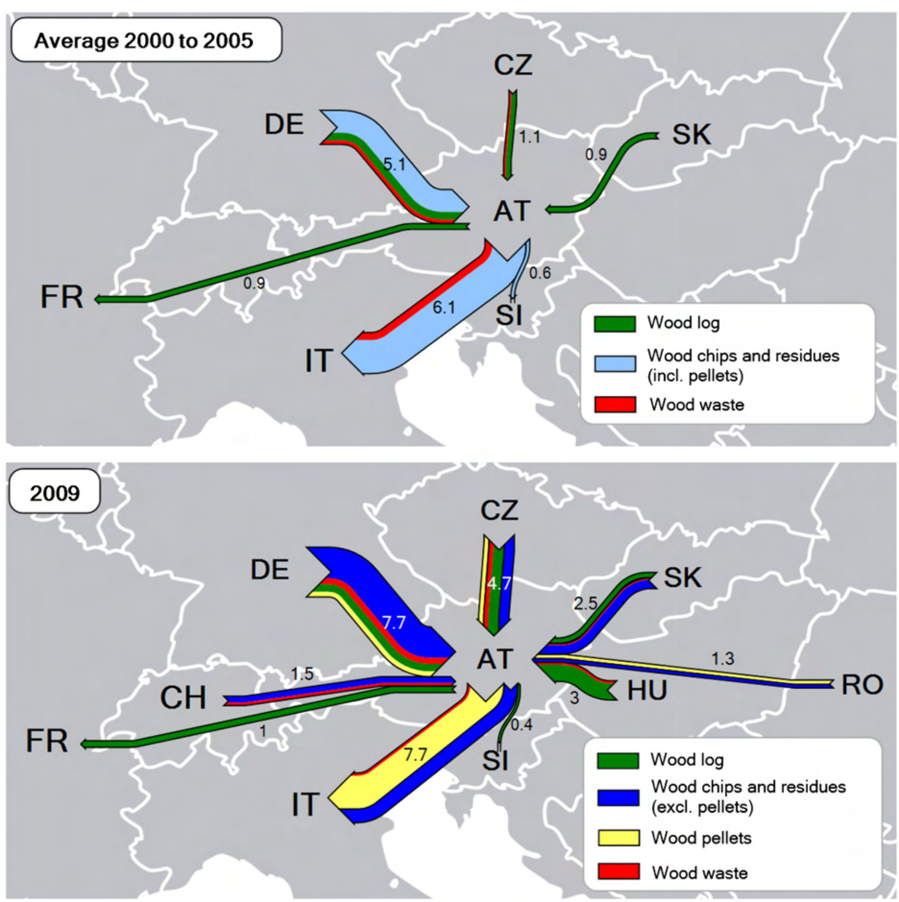

Fig. 4. Comparison of the net trade streams of wood log, wood chips and residues, pellets and wood waste in 2009 (bottom) with the annual average during 2000–2005 (top) (values in PJ; only streams above 0.3 PJ are shown).
Source: Eurostat (2011a), own calculations and illustration.

biomass use (see Fig. 1), the imports rose to around 30 PJ/a. As a result, the net imports accounted for up to 10% of the total biomass consumption (2006 and 2009). Both increasing imports of liquid biofuels and wood fuels contributed to this trend.

4.2. *Wood streams by trade partners*

Trade statistics provide data on biomass streams broken down by trade partners. Fig. 4 shows an illustration of the net trade streams of the following commodities according to Eurostat (2011a): log wood, wood chips, residues, pellets and wood waste.

In order to illustrate the dynamics in recent years, the average annual trade volumes during 2000–2005 are compared to the streams in 2009. For the year 2009, separate data on wood pellet trade are available under CN code 4401 3020. In the preceding years, pellets have been recorded together with sawdust, briquettes and other agglomerated forms of sawdust under CN code 4401 3010 (cf. Table 2).

As mentioned above, it is important to note that trade statistics do not differentiate between end purposes. Therefore, based on trade statistics, it is not possible to determine the trade volumes which are actually related to bioenergy use. However, it is assumed that wood log, wood pellets and wood waste are almost exclusively used for energy generation. With regard to wood chips and residues, statistics of the wood processing industries indicate that notable quantities are related to material uses. In 2009, the imports of sawmill by-products of the paper, pulp and wood board industries accounted for an equivalent of 11 PJ (Austropapier, 2011; Schmied, 2011). This corresponds to the total imports according to trade statistics. Hence, it is concluded that at least in 2009, wood residues were only imported for material uses.

Fig. 4 illustrates that especially the net imports from the northern and eastern neighboring countries have risen significantly in recent years. The total net imports from Czech Republic, Slovakia and Hungary accounted for approximately 2 PJ per year during the period 2000–2005. In 2009 they amounted to more than 10 PJ, and an additional 1.3 PJ were imported from Romania. Together, this is equivalent to 5% of the total biomass PEC in Austria in 2009. However, Germany and Italy are still Austria's main trade partners. The net imports from Germany accounted for 7.7 PJ in 2009, compared to an average of 5.1 PJ during 2000–2005, and the net exports to Italy increased from 6.1 to 7.7 PJ. With an export quantity of more than 5 PJ in 2009, pellet exports to Italy are by far the most important pellet trade stream and also Austria's main export stream of wood fuels.

Another notable aspect is that Austria's trade streams with neighboring countries and other European countries shown in the figure comprise more than 90% of the total international trade volumes of wood fuels relevant for Austria. Hence, despite rapidly increasing import activities, Austria's wood fuel trade with more distant countries is still rather negligible.

4.3. Cross-border trade related to biofuels

The increasing use of the transport fuels biodiesel, ethanol and vegetable oil resulted in a significant rise of related cross-border trade. Apart from trade with refined biofuels, which is documented in the national biofuel report (Winter, 2010), cross-border trade of feedstock used for biofuel production needs to be considered. As there are no data available on the actual import share of the Austrian biofuel industry, the following methodology for calculating "virtual" feedstock imports on the basis of the self-sufficiency of agricultural products is applied: If the self-sufficiency in the respective biofuel feedstock $\sigma_{feedstock}$ is found to be less than 100% ($\sigma_{feedstock} < 1$), the total domestic biofuel production $P_{biofuel}$ is split into production based on domestic feedstock (P_{dom}), and such based on imports (P_{imp}) according to the following formulas:

$$P_{imp} = P_{biofuel}\,(1-\sigma_{feedstock})$$

$$P_{dom} = P_{biofuel} \cdot \sigma_{feedstock}$$

Hence, with this approach it is implicitly assumed that imports and domestic supply of the respective commodity are distributed in equal shares among all end purposes.[5] Next, the virtual feedstock imports together with data on trade streams of refined biofuels are combined to supply balances for biofuels and an according flow diagram.

Biodiesel, being the most important biofuel in Austria, is related to the most significant trade streams. According to Winter (2010), biodiesel imports accounted for approximately 50% of the inland consumption in the period 2005–2009. On the other hand, close to one quarter of the domestic production of biodiesel, which increased from 70,000 t (2005) to more than 320,000 t (2009) during this period, was exported. The self-sufficiency with vegetable oil (calculated on the basis of oilseed production in Austria) has decreased from about 60% around the year 2000 to less than 23% in the marketing year[6] 2007/08 and 27% in 2008/09 and 2009/10 (Statistik Austria, 2011). Fig. 5 shows the supply balance for vegetable oil since 1998/99. With the quantities used in the industry (which is dominated by biodiesel production) increasing by a factor of 7 from 2000/01 to 2009/10, it is apparent that the rapid growth of the Austrian biodiesel industry was the main reason for the increasing import dependence.

Fig. 6 shows the biodiesel supply balance based on Winter (2010) and the methodology described above. While the domestic biodiesel consumption increased from 5500 t in 2005 to 520,000 t in 2009, the production based on domestically produced feedstock only increased from 21,000 t to 87,000 t during the same period, and accounted for no more than 17% of the consumption in 2009. Domestic production based on imported feedstock, on the other hand, accounted for an average of 41% of the consumption during the last five years.

With regard to vegetable oil used for transportation, data are highly uncertain, due to largely regional distribution channels. According to Winter (2010), approximately 17,000–18,000 t (0.6–0.67 PJ) of vegetable oil were used for transportation annually during 2007–2009. It is assumed that at least the quantities which are used in agriculture (approximately 2700 t or 0.1 PJ in the year 2009) originate from domestic production. Based on the self-sufficiency with vegetable oil, the virtual feedstock imports in the years 2007–2009 are calculated to close to 13,000 t (0.5 PJ).

The Austrian production of bioethanol used for transportation is limited to one large-scale plant. The plant became fully operational in mid-2008 and has a capacity of approximately 190,000 t/a (5.1 PJ/a). The annual feedstock demand at full capacity is reported to account for 620,000 t (75% wheat and triticale, 15% maize and 10% sugar juice). According to the operator's financial report for the business year 2009/10, Agrana (2010), "most" of the feedstock used originated from domestic production. However, as the Austrian self-sufficiency with feedstock used for ethanol production was above 100% during the relevant period (Statistik Austria, 2011), the virtual feedstock imports related to ethanol production are zero. The trade streams with ethanol according to Winter (2010) indicate that while Austria was a net importer in 2007 and 2008, the situation changed in 2009, with net exports amounting to 28% of the inland production.

Fig. 7 shows the flow diagram for biofuels used in the transport sector in 2009. Together, biofuel net imports and virtual feedstock imports accounted for 70% of the total biofuel consumption.

5. Indirect trade of wood-based fuels

Apart from wood chips, bark and other wood fuels, "wood-based fuels" comprise waste liquor of the paper and pulp industry

[5] Note that this approach is only applicable if reliable supply balance sheets are available, as it is the case for agricultural commodities but not forest products.

[6] A "marketing year" is a 12-month period, usually starting from a new harvest.

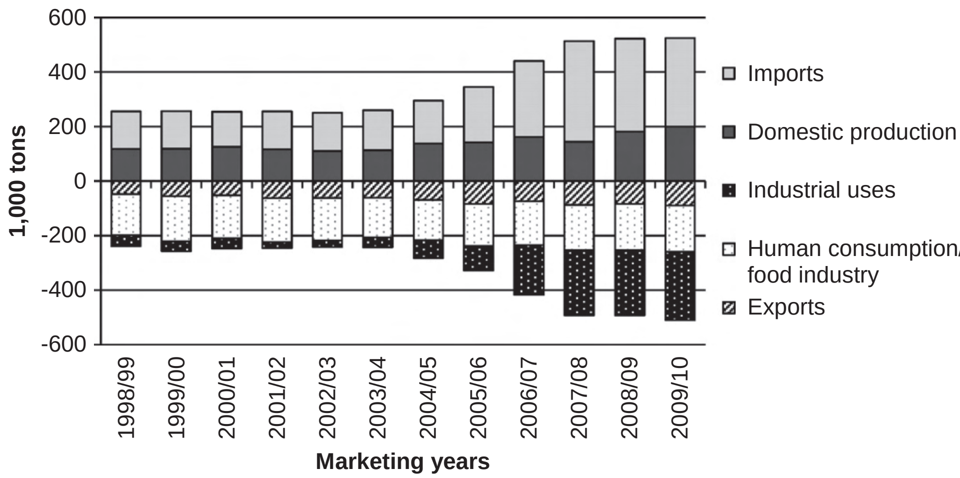

Fig. 5. Supply balance for vegetable oil (Stockkeeping, consumption for animal feed and losses are not shown due to negligible quantities, "Domestic production" also includes imported oilseeds crushed in Austria, whereas the self-sufficiency mentioned in the text is calculated on the basis of oilseed production in Austria.)
Source: Statistik Austria (2011).

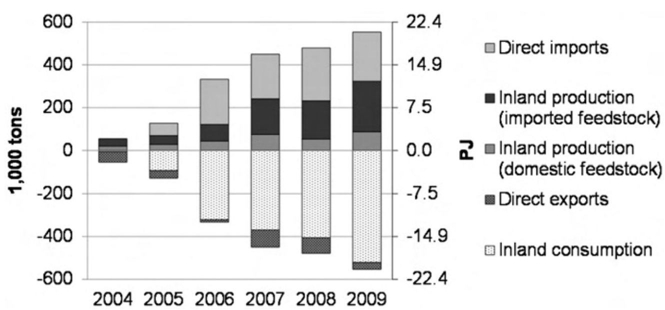

Fig. 6. Supply balance for biodiesel in Austria.
Sources: Winter (2010), Statistik Austria (2011), Statistik Austria (2012), own calculations and illustration.

which is usually used for process energy generation. In this section, the quantities of these fuels, which are traded indirectly through sawlogs, industrial roundwood and wood products are assessed. Due to the fact that wood streams are quite complex, not all relevant streams are captured in statistics and statistical data are sometimes inconsistent, it is stressed that the results are associated with some uncertainties and are considered to be best possible estimates.

5.1. Methodological approach

The methodological approach is based on the following steps: First, fundamental data on cross-border trade as well as production and consumption data are obtained from statistical databases. This data basis is enhanced with data from the wood processing industries (see Section 2), and used to derive a picture of the main wood streams. This includes international trade streams as well as flows between the industry sectors and toward different end uses.

Next, the consistency of the picture is checked, data gaps are filled on the basis of mass balance calculations and estimates in literature (primarily Hagauer et al., 2007), and streams of wood fractions not stated separately in production, consumption and trade statistics (such as bark and off-cuts) are added to the picture, based on typical percentages stated in literature. The biomass consumption according to energy statistics is also taken into account in this step. The final dataset, representing a complete picture of the Austrian wood flows, is displayed graphically as a flow diagram for the most recent year 2009. This diagram is presented and interpreted in the next section.

Next, the historical data are evaluated on the basis of two approaches: Within the first approach (Section 5.3) the main biomass streams, representing indirect imports of wood-based fuels are identified and the according quantities determined on the basis of conversion factors derived from empirical data. This approach is to illustrate the importance of indirectly imported wood-based fuels for the Austrian bioenergy sector. The second approach (Section 5.4) is based on the consideration that it can be assumed that all types of wood products (including panelboard, sawnwood and all types of paper products) ultimately end up in energy generation after their intended uses.[7] All trade streams of wood products can therefore be considered as indirect biomass streams for energy. Within the second approach, the main trade streams of wood products available in statistics are aggregated, in order to quantify the total net imports/exports of wood material.

5.2. Wood streams in Austria

Fig. 8 shows the wood flow diagram for the year 2009. The figure illustrates that the bulk of raw wood is processed to sawnwood by the sawmill industry. The average share of imports in the consumption of the sawmill industry accounted for 43% during the period 2001–2009 (between 35 and 52%). Apart from industrial roundwood, the wood supply of the paper and pulp industry and the panelboard industry is based on residues of the sawmill industry ("sawmill by-products"). Therefore, the sawmill industry acts as an important raw material supplier for the other industry segments. The increasing production of the Austrian sawmill industry in the last years and decades provided favorable framework conditions for the growth of the paper and pulp and the wood board industry. However, the import quantities of these industries have also amounted to notable trade streams, as the utilization of wood residues for pellet production and energy generation (and therefore also the competition between material and energy uses) has been growing in recent years.

[7] According to the Austrian Landfill Ordinance, biogenic wastes may not be landfilled. Therefore, thermal utilization is the usual way of disposing waste wood. In the case of paper and other wood products, one or more recycling loops may occur before the material is used energetically. Still, the final use can be assumed to be for energy generation.

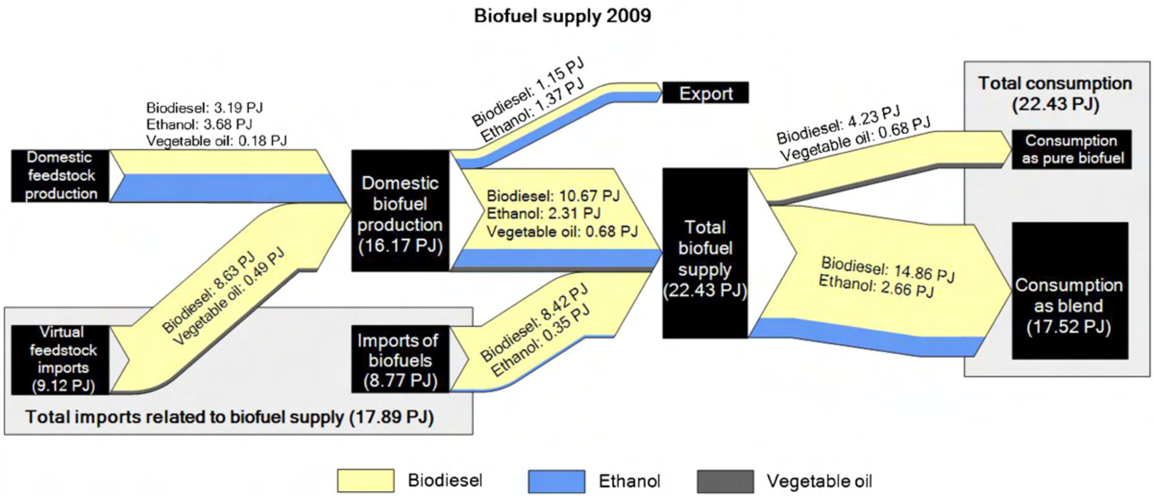

Fig. 7. Flow diagram of the Austrian biofuel sector in 2009. (Feedstock imports are stated as equivalents of the refined biofuel rather than calorific values of the feedstock used.)
Sources: Winter (2010), Statistik Austria (2011), Statistik Austria (2012), own calculations and illustration.

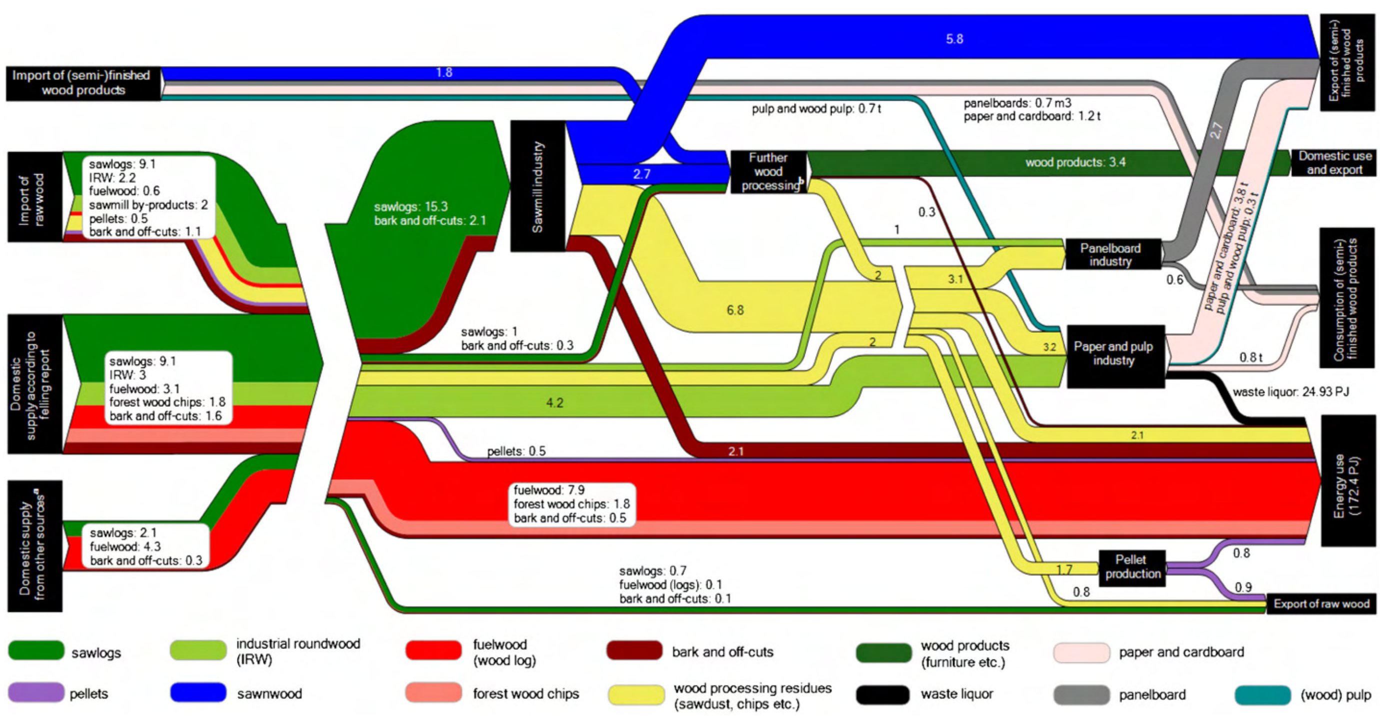

Fig. 8. Wood flow diagram for Austria in the year 2009 (values in millions of solid cubic meters, if not stated otherwise; see Appendix A for further definitions). (a) Domestic supply from other sources: All domestic sources of raw wood not included in the official felling report; primarily fuelwood from privately owned forests and wood from non-forest areas. (b) Further wood processing: carpentries, furniture plants and veneer plants, etc.
Sources: Prem (2009) (domestic supply according to wood felling report), FAO (2011a) (foreign trade of raw wood and (semi-)finished wood products), Austropapier (2011) (consumption statistics and foreign trade of the paper and pulp industry), Schmied (2011) (consumption statistics of the panelboard industry), Statistik Austria (2012) (biomass consumption for energy), Eurostat (2011a) (foreign trade of pellets), Hagauer et al. (2007) (general structure of the diagram, estimated values for roundwood consumption and production of by-products in "further wood processing"), own assessments and illustration.

The flow diagram shows that about one third of the Austrian raw wood supply in 2009 was based on imports. Therefore, a significant share of sawmill by-products, bark and off-cuts being used for energy production in Austria actually originate from foreign countries. On the other hand, large quantities of finished and semi-finished wood products are being exported (sawnwood, paper products and panelboard). Austria's exports of panelboard and paper products are about twice as high as the inland consumption, and the net exports of sawnwood are in a similar range as the quantity which is consumed domestically (i.e., processed to furniture, construction wood and other end-products).

5.3. Indirect imports of wood-based fuels

Based on the wood flow chart in Fig. 8, the following wood streams have been identified as the most significant indirect import streams of biomass for energy:

- Wood-processing residues being imported as sawlogs.

- Bark and off-cuts being imported together with sawlogs and industrial roundwood.
- Industrial roundwood and sawmill by-products being imported by the paper and pulp industry, and ending up as waste liquor used for energy generation.

Hence, the total indirect imports of wood-based fuels (WBF_{indir}) are calculated as the sum of indirectly imported wood-processing residues (WPR_{indir}), bark and off-cuts (BOC_{indir}) and waste liquor (WL_{indir}):

$$WBF_{indir} = WPR_{indir} + BOC_{indir} + WL_{indir}$$

Indirectly imported wood processing residues are calculated according to the following equation, where $\sum_j (WPR_{prod,j})$ denotes the total production of wood processing residues over all relevant industries j (sawmill industry and further wood processing), $\sigma_{import,j}$ the share of imports in the according raw wood supply and α_{energy} the share of wood processing residues which is used energetically in Austria.

$$WPR_{indir} = \alpha_{energy} \sum_j (WPR_{prod,j} \cdot \sigma_{import,j})$$

The indirectly imported quantity of bark and off-cuts is calculated on the basis of the total raw wood imports to Austria RW_{import} and estimated shares of bark p_{bark} and material which ends up as off-cuts $p_{off\text{-}cuts}$ according to the following equation, as bark and off-cuts are not included in wood quantities measured in volume units (Sandler, 2001).

$$BOC_{indir} = RW_{import} \left(\frac{p_{bark} + p_{off\text{-}cuts}}{1 - p_{bark} - p_{off\text{-}cuts}} \right)$$

Based on Hagauer et al. (2007) and Sandler (2001), p_{bark} is generally assumed 10% and $p_{off\text{-}cuts}$ 2.5%.

Indirect imports of waste liquor WL_{indir} are calculated on the basis of the total waste liquor production WL_{prod} and the shares of directly and indirectly imported raw wood (σ_{import} and σ_{indir}) consumed by the paper and pulp industry:

$$WL_{indir} = WL_{prod}(\sigma_{import} + \sigma_{indir})$$

The results of this assessment are summarized in Fig. 9. The indirect import streams accounted for an annual average of 27 PJ and between 14 and 20% of the total annual biomass consumption during the considered period. Wood-processing residues accounted for close to 50% of the total quantity (about 13 PJ), and bark and off-cuts for an average of more than 8 PJ per year. With regard to waste liquor, it was found that between 18 and 32% of the total quantity used for energy generation in Austria can be traced back to directly or indirectly imported wood. Hence, the average quantities of indirectly imported waste liquor amounted to about 6 PJ per year during 2001–2009.

Compared to direct imports of the bioenergy sector, indirect imports of wood-based fuels were clearly more significant until 2005: Direct imports of wood fuels accounted for about 10 PJ and exports for about 15 PJ in 2005, as Fig. 3 shows. Only since 2006, direct imports considered in energy statistics are in a similar range. The main reasons for the relatively high fluctuations in indirect and direct imports of wood-based biomass (Fig. 3 and Fig. 9) are seen in the weather conditions and storms, which had a significant impact on the wood supply in recent years. Due to large quantities of fallen timber in 2007 and 2008 (caused by the storms "Kyrill" and "Paula"), the total domestic wood supply (including sawlogs, industrial roundwood and fuelwood) was about 25% higher than the average value of 2005, 2006 and 2009 (Prem, 2009). This explains the comparatively low imports in 2007 and 2008, compared to 2006 and 2009.

5.4. Cross-border trade with wood products

The results of the previous approach indicate that large quantities of wood-based fuels which are used for energy generation in Austria actually originate from imported biomass. On the other hand, it needs to be taken into account that Austria is a net exporter of (semi-)finished wood products. Assuming that wood products and raw wood intended for material uses are usually used for energy generation after their primary uses (either in dedicated bioenergy plants or as biogenic waste in waste treatment plants), these trade flows can also be considered as indirect biomass trade for energy. Due to insufficient data on foreign trade with wood products, as well as methodological difficulties related to recycling rates and time lags between border-crossing and energetic uses, it is considered not feasible to derive time series of indirect trade related to these streams. However, by aggregating all trade streams related to material wood uses, it is possible to roughly determine whether Austria actually depends on imports, or is in fact a net exporter of wood material.

Fig. 10 shows the aggregated trade streams with wood products and raw wood intended for material uses (in SCM and energy equivalents), and Fig. 11 the aggregated trade streams of the paper and pulp industries (in tons). Apparently, the aggregated wood imports and exports shown in Fig. 10 are in a similar

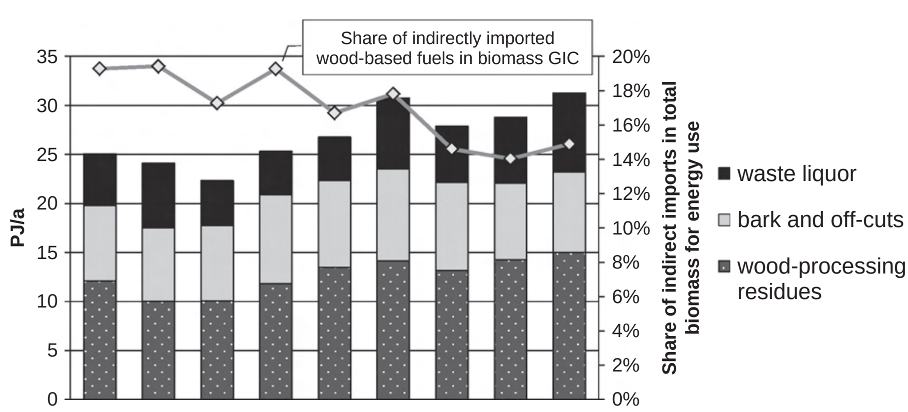

Fig. 9. Development of the main indirect import streams for energy use, and the according share in the total biomass consumption.
Sources: Hagauer et al. (2007), BMWFJ and BMLFUW (2010), Austropapier (2011), FAO (2011a), FAO (2011b), Schmied (2011), Statistik Austria (2012), own calculations and illustration.

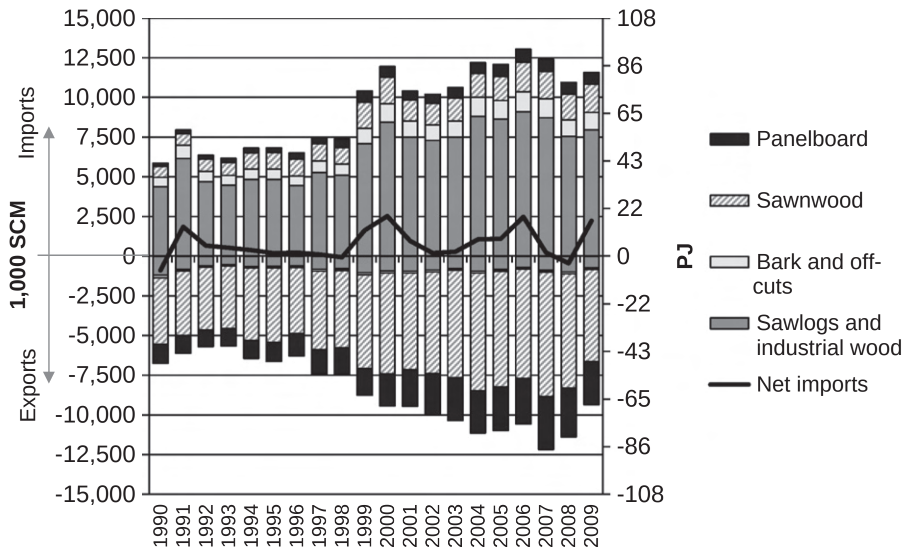

Fig. 10. Aggregated trade streams with wood products and raw wood intended for material uses.
Sources: FAO (2011b), own calculations and illustration.

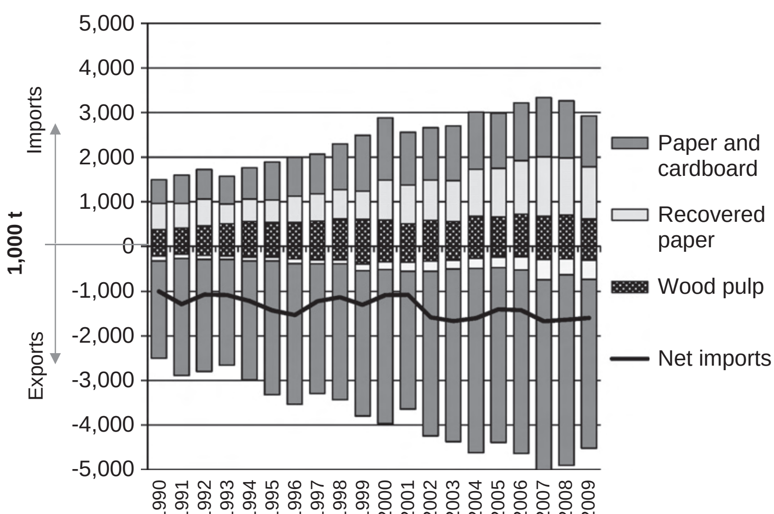

Fig. 11. Aggregated trade streams of paper, cardboard, recovered paper and wood pulp.
Sources: Austropapier (2011), FAO (2011b), own calculations and illustration.

range. The total net imports varied from about −0.9–2.5 million SCM during 1990–2009, but in most years the imports and exports were quite balanced. In contrast, the total net imports of the commodities paper, cardboard, pulp and recovered paper have been clearly negative during the last 20 years. Considering the quantity of wood required to produce this surplus, it is concluded that these net exports are a highly relevant indirect biomass stream. According to statistical data (Austropapier, 2011), an average of more than 1.5 SCM of wood are required to produce 1 t of paper/pulp.

To sum up, this approach indicates that the high imports of raw wood (which are the reason for the significant indirect imports of wood-based fuels determined in the previous section) are largely balanced by exports of sawnwood and panelboard. Furthermore, with the main trade streams of raw wood and wood products taken into account, the available data indicate that Austria has definitely been a net exporter of wood-based material in several years of the considered period (e.g., 2008 and 2007).

6. Synthesis, discussion and conclusions

As a result of the increasing use of bioenergy, global cross-border trade of biomass has grown strongly during the last decade (Junginger et al., 2011). On a global scale, indirect trade through roundwood and wood chips accounts for the most significant trade streams (630 PJ in 2006 according to Heinimö and Junginger (2009)), but direct trade with refined biomass fuels has increased from practically zero in 2000 to an estimated 200 PJ in 2009 (liquid biofuels: 120 to 130 PJ, pellets: 75 PJ according to Junginger et al. (2011)).

Due to several reasons explained in this work, getting insight into international biomass trade related to energy generation is not straightforward. Additional trade codes for specific biomass types can help to facilitate the monitoring of direct trade streams, as experience with recently introduced CN codes (for wood pellets and biodiesel) shows. But in order to quantify displacement effects of an increasing use of bioenergy and to track indirect trade streams, specific methodologies (such as the ones proposed in this work) need to be applied.

6.1. The Austrian bioenergy sector

The official energy statistics for Austria also indicate that biomass trade for energy has recently been increasing significantly: Imports have surged from about 5 PJ in 2000 to 34.5 PJ in 2009, and exports from 6.7 to 15.2 PJ during the same period. Whereas imports are dominated by biodiesel and unrefined wood fuels, wood pellets account for the main proportion of biomass exports. According to energy statistics, 84% of the biomass used for energy originates from domestic production. The self-sufficiency in biomass for energy, defined as the ratio of production to consumption, was 91% in 2009. However, the results of this work indicate that with feedstock for biofuel production and indirect trade of wood-based fuels taken into account, cross-border trade related to bioenergy is clearly more significant than energy statistics suggest. Imports of agricultural commodities which can be attributed to biofuel production (according to the approach proposed in this work, where imports are distributed proportionally between the different end uses) accounted for close to 10 PJ in 2009, which corresponds to about 40% of the total biomass consumption in the transport sector. Assuming that vegetable oil from domestic production is primarily used for human consumption (as it was the case before the rapid growth in biodiesel production in recent years), feedstock imports related to biofuel production might actually be even higher. However, with a self-sufficiency rate of about 30% (according to our approach), the Austrian biofuel sector is highly dependent on imports, and its overall environmental impact highly depends on sustainability issues like agricultural practices and land-use change in exporting countries, or global indirect land-use change, respectively. The far-reaching policy implications of this issue are currently neglected to a large extent.

Despite the rapid growth of the biofuel sector in recent years, it is still of minor importance compared to residential heating and industrial heat/CHP generation, as Fig. 12 illustrates. The figure shows a flow diagram of the Austrian bioenergy sector. It is based on the official energy statistics (Winter, 2010; Statistik Austria, 2012), as well as the results of this work, i.e., data on indirect imports and (virtual) feedstock imports for biofuel production. Furthermore, feedstock imports for biogas production (primarily maize and small quantities of beet), accounting for approximately 1% of the total biogas feedstock used according to an estimate of the ARGE Kompost & Biogas (Kirchmeyr, 2011), are also depicted.

Undoubtedly, a main reason for the relatively high share of biomass in the Austrian energy supply (15.5% in 2009) is the size of the wood processing industry, as it acts as a supplier of cheap wood residues for energy use and covers a large share of its process energy demand with biomass. Apart from that, the high import streams of raw wood for material uses represent significant indirect import streams of wood-processing residues, bark, waste liquor etc. Based on the main fractions, it was found that these import streams were in a range of 30 PJ or 15% of the total biomass primary energy consumption in the last four years. This result emphasizes that there are strong interconnections between the wood processing industry and the bioenergy sector, and that the supply security of the Austrian bioenergy sector highly depends on the import and export activities of this industry branch. As Fig. 12 shows, indirect imports of wood-based fuels are primarily relevant for the supply of CHP, district heat and

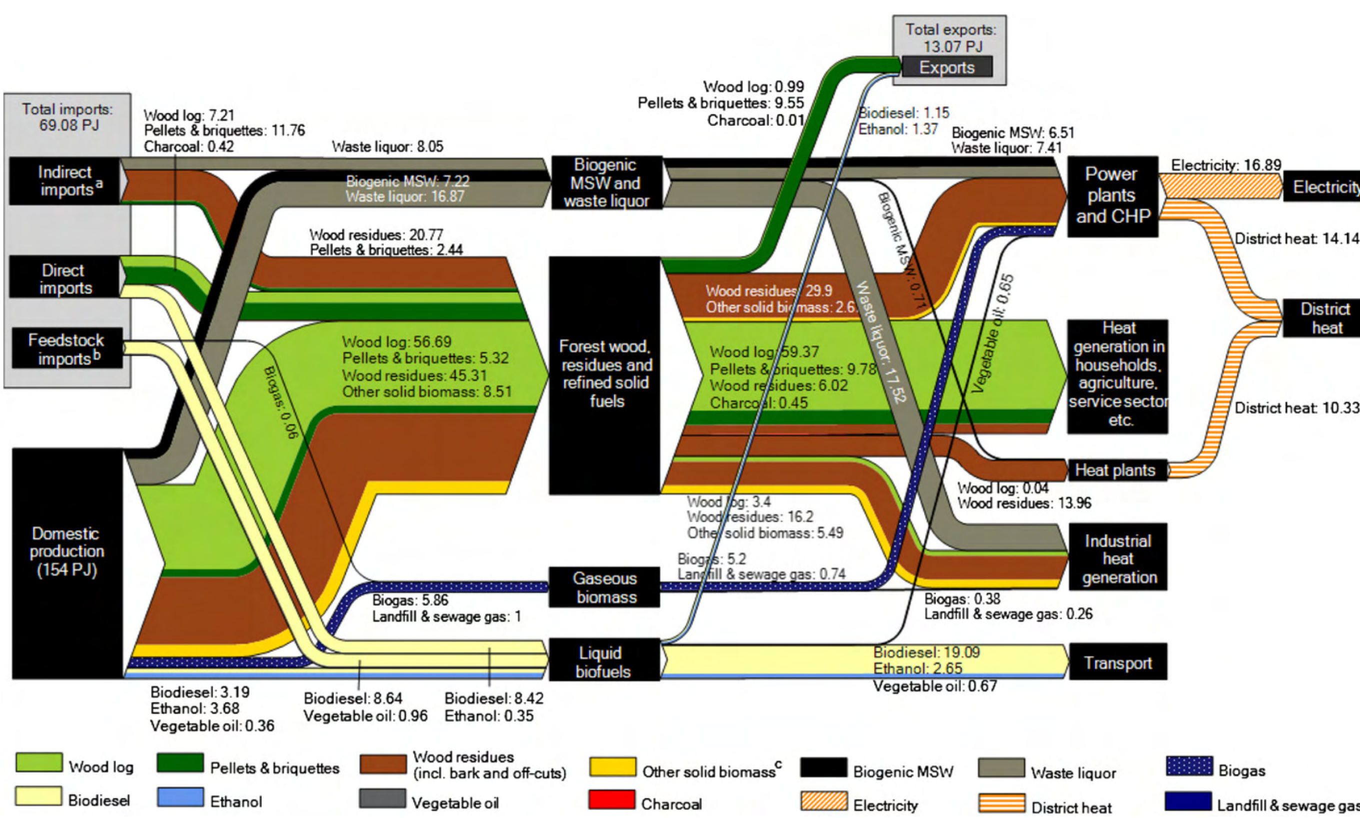

Fig. 12. Flow diagram of the Austrian bioenergy sector (values in PJ; feedstock imports are stated as equivalents of the refined biofuel; flows of less than 0.5 PJ are partly not displayed for better readability). (a) Indirect imports of wood-based fuels (see Section 5.3). (b) Feedstock imports according to the approach described in Section 4.3. (c) "Other solid biomass" comprises wood waste and small quantities of straw.
Sources: Winter (2010), Kirchmeyr (2011), Statistik Austria (2012) (estimate of feedstock imports for biogas production), own assessments and illustration.

industrial heat generation, whereas small-scale heat generation is almost exclusively based on domestic and (to a very limited extent) directly imported biomass.

In total, about one-third of the biomass used for energy in Austria in 2009 can be traced back to imports. Together, indirect imports of wood-based fuels and feedstock imports are clearly more significant than direct imports stated in energy statistics. However, it needs to be stressed that while Austria is importing large amounts of raw wood, it is a net exporter of the wood products sawnwood, panelboard and paper products. Extending the concept of indirect trade to these products is connected with substantial methodological difficulties, and data on trade with finished wood products prove to be insufficient for a full assessment. Our rough approach, which is based on the most significant streams of wood products mentioned above, indicates that Austria's raw wood imports are largely balanced by exports of sawnwood and panelboard. Furthermore, with paper products taken into account, Austria has at least in some years of the last decade been a net exporter of wood-based material. Nonetheless, it is considered noteworthy that a significant fraction of wood-based fuels stated under domestic production in energy statistics actually originates from imports.

6.2. The European perspective

Considering the increasing use of bioenergy in the EU and the importance of bioenergy for achieving the "2020 targets" (Szabó et al., 2011), it is considered crucial to monitor developments in biomass trade on a European level, possibly based on the approaches proposed in this work. Based on a rough investigation, it was found that some developments on the European level are somewhat similar to the situation in Austria: According to energy statistics, the EU is becoming increasingly dependent on biomass imports for energy: From 2006 to 2010, the net biomass imports increased from 0 to 4.5% of the total biomass PEC and accounted for more than 200 PJ in 2010 (Eurostat, 2011b). Increasing imports of both wood fuels and liquid biofuels contributed to this development. Furthermore, the total net imports of vegetable oil used for food, energy and other uses (including oil contained in net imports of oilseeds) have more than doubled during the last 10 years and are now approximately equal to the quantity produced in the EU (FAO, 2012).

Based on a rough investigation of the current state of wood trade in EU countries, it was found that in the following countries the situation is similar to Austria, as they have large imports of roundwood and large exports of sawnwood: Sweden, Finland and Germany (FAO, 2011b). Other countries are net importers (e.g., Italy, the Netherlands, UK) or net exporters of all wood types (e.g., Latvia, Czech Republic, Slovakia). Despite a significant decrease in roundwood imports from Russia since 2007, the EU as a whole is (just like Austria) net importer of roundwood and net exporter of sawnwood, and importing increasing amounts of wood chips, particles, etc.

Acknowledgment

The authors gratefully acknowledge the very valuable comments and suggestions of two anonymous reviewers.

Appendix A. Explanation of terms and definitions used in this study

Biomass: All kinds of biogenic material used for energy or other purposes; biomass used for energy generation is denoted as "biomass for energy" or "biomass fuels".

Biofuels: Biogenic transport fuels (e.g., biodiesel, ethanol).

Raw wood: Includes sawlogs, industrial roundwood, fuelwood, off-cuts and bark.

Sawnwood: Planks, beams and other wood products that have been produced from roundwood.

Sawlogs: Raw wood for sawnwood production.

Industrial roundwood: Includes roundwood consumed by the paper and pulp industry (pulpwood) and such consumed by the panelboard industry.

Panelboard: All kinds of particle board and fiberboard.

Wood-processing residues: Sawmill by-products like sawdust, wood chips and other residues from wood processing (bark and off-cuts not included, if not stated otherwise).

Wood-based fuels: Comprises all types of wood fuels (fuelwood, wood chips, sawdust etc.) as well as waste liquor of the paper and pulp industry (black liquor).

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ANHANG E

WORKSHOP AGENDA UND UNTERLAGEN “BIOENERGIE-TECHNOLOGIEN, RESSOURCEN UND NACHHALTIGKEIT: LOKALE UND GLOBALE HERAUSFORDERUNGEN

Einladung zum Workshop

Bioenergie-Technologien, Ressourcen und Nachhaltigkeit:
lokale und globale Herausforderungen

Donnerstag, 6. Dezember 2012 14:00-16:30

Technische Universität Wien,
EI 06 – Eckart Raum, Altes Elektrotechnik Gebäude, 6. St.

Gusshausstrasse 25-27, 1040 Wien

Die EU hat sich das Ziel gesetzt, die Treibhausgasemissionen bis 2050 um 80% bis 95% gegenüber dem Niveau von 1990 zu senken. Biomasse spielt bei der Schaffung einer Low-carbon economy eine zentrale Rolle. Jedoch stellt sich in Zusammenhang mit der energetischen Biomassenutzung eine Reihe von Fragen, die sowohl technologische Aspekte, als auch die zukünftige Bereitstellung von Biomasse beinhalten. Da für den Einsatz von Bioenergietechnologien die Rohstoffverfügbarkeit ein zentraler Punkt ist, können technologische Aspekte nicht von Fragen der Biomassebereitstellung getrennt werden. Angesichts der globalen Verflechtungen von Biomasse-Märkten (sowohl in energetischer als auch in nicht-energetischer Hinsicht) ist es dabei essenziell, die Frage der Ressourcenverfügbarkeit nicht nur lokal sondern auch überregional und global zu betrachten. Hinsichtlich der Biomassebereitstellung stellt sich daher insbesondere im Kontext globaler Biomasse-Handelsströme die Frage, welche Nachhaltigkeitskriterien erforderlich sind, und wie Zertifizierungssysteme deren Einhaltung sicherstellen können.

Das Ziel des Projektes „**Nachhaltige Bioenergie 2050“** im Auftrag des BMVIT besteht erstens darin, den technologischen Forschungs- und Entwicklungsbedarf aufzuzeigen. Zweitens sollen bestehende Nachhaltigkeitskriterien und Zertifizierungssysteme für Bioenergie einer kritischen Prüfung unterzogen, und Empfehlungen für deren Verbesserung bzw. Weiterentwicklung abgeleitet werden. Mögliche Effekte der Biomasse-Importe aus außereuropäischen Ländern werden anhand afrikanischer Fallbeispiele exemplarisch beleuchtet.

IEA Bioenergy, Task 40 (Sustainable International Bioenergy Trade - Securing Supply and Demand) beschäftigt sich mit der Dynamik von Bioenergiemärkten, internationalem Handel mit Bioenergie und mit den Chancen, sowie möglichen Problemen die mit dem internationalen Handel von Bioenergie einhergehen.

Ausgewählte Ergebnisse aus beiden Projekten werden in diesem Workshop am Do., 6. Dezember 2012, 14:00-16:30 an der TU-Wien präsentiert und diskutiert.

Folgende **Fragen** sollen bei dem Workshop diskutiert werden:

1) Welche Herausforderungen stellen sich für eine nachhaltige Nutzung von Bioenergie angesichts globaler und europäischer Verflechtungen von Biomassemärkten?
2) Bioenergieproduktion in Afrika: „Landgrabbing“ oder notwendige Investitionen in „rückständige“ landwirtschaftliche Strukturen? Welche Grundprinzipien sind zu formulieren, um Risiken zu minimieren und Chancen zu wahren?
3) Welche Zertifizierungssysteme für Bioenergie werden derzeit angewandt bzw. sind derzeit in Entwicklung und welche Empfehlungen für deren Verbesserung bzw. Weiterentwicklung können abgeleitet werden?

Im Anschluss an kurze Impulsreferate erhoffen wir uns eine lebendige Diskussion zu den oben angeführten Themen.

Programm

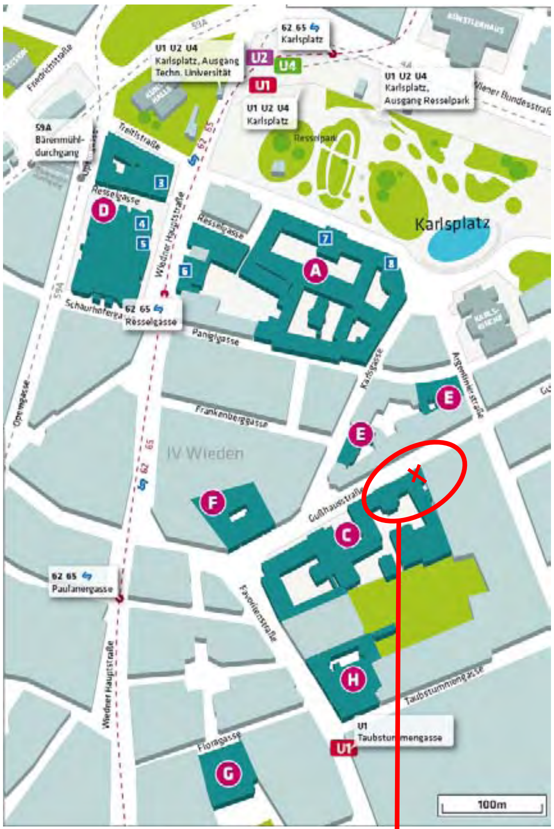
13:45	**Snacks und Eintreffen der TeilnehmerInnen**
14:00	**Begrüßung und Vorstellungsrunde**
	Einführung in das Projekt „Nachhaltige Bioenergie 2050“ und IEA Bioenergy Task 40: International Bioenergy Trade - Vorstellung des Projekts „Nachhaltige Bioenergie 2050“ - Vorstellung von Task 40 „Bioenergy-Trade“ im Rahmen des IEA Implementing Agreements Bioenergy - Ziele und Fragestellungen für diesen Workshop *Lukas Kranzl – Energy Economics Group, TU Wien*
14:30	**Verflechtungen der Biomasse-Nutzung auf der globalen, europäischen und nationalen Ebene** *Lukas Kranzl – Energy Economics Group, TU Wien*
15:00	**Bioenergieproduktion und Landinvestitionen in Westafrika.** **Sierra Leone, ein Beispiel für „Landgrabbing“ oder verantwortungsvolle Investitionen?** *Katharina Zwiauer*
15:30	**Nachhaltigkeitskriterien und Zertifizierung von Biomasse** *Julian Matzenberger –Energy Economics Group, TU-Wien*
16:00	**Diskussion**

Anmeldungen bis spätestens Montag, 30. November 2012 an *matzenberger@eeg.tuwien.ac.at.*

Rückfragen an:

Julian Matzenberger, Lukas Kranzl Energy Economics Group, TU Wien
E-Mail: matzenberger@eeg.tuwien.ac.at, kranzl@eeg.tuwien.ac.at,

Wegbeschreibung:



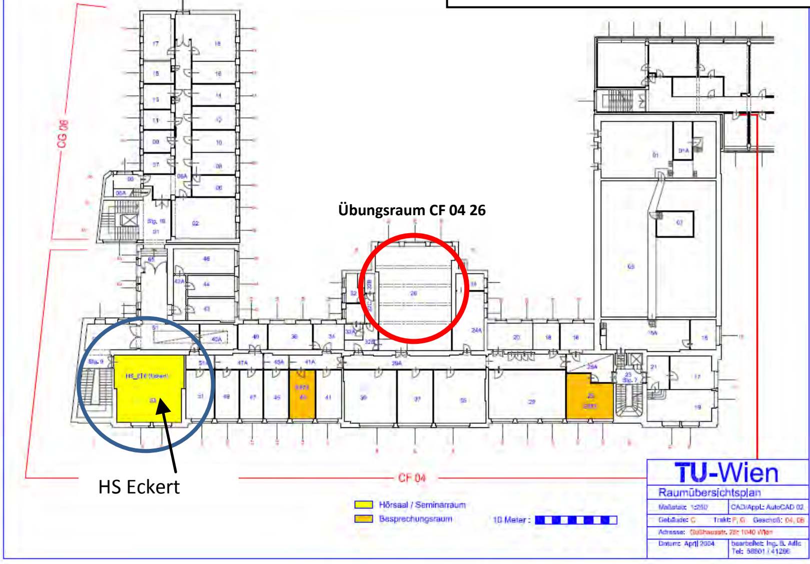
TU-Wien, Raum EI06, 6. Stock

(HS Eckert)

Technische Universität Wien
Institut für Energiesysteme und
Elektrische Antriebe
Gusshausstr. 25-29/370
A-1040 Wien

Zugangsbeschreibung:

Zugang über das alte elektrotechnische Institutsgebäude von der Gusshausstraße kommend, durch das Haupttor des alten Gebäudes, durch die kleine Aula mit einigen Bildschirmen, links halten, durch 2 gläserne Brandschutztüren, rechts durch eine weitere Brandschutztüre, zu einem Aufzug (Stiege 10) und mit diesem in das oberste Geschoß (6.Stock). Im obersten Geschoß, rechter Hand, befindet sich der HS Eckert



TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Energy Economics Group

Bioenergie-Technologien, Ressourcen und Nachhaltigkeit: lokale und globale Herausforderungen

Workshop 6.12.2012, TU-Wien

Lukas Kranzl
Julian Matzenberger
Katharina Zwiauer

Bundesministerium für Verkehr, Innovation und Technologie

FFG

IEA FORSCHUNGSKOOPERATION

TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Energy Economics Group

Technology Gaps bei der Erreichung der Klimaziele 2050:

Bioenergie-Technologien, Ressourcen und Nachhaltigkeit

Lukas Kranzl
Julian Matzenberger
Gerald Kalt
Katharina Zwiauer

bmvit
Bundesministerium
für Verkehr,
Innovation und Technologie

Motivation

- 2050-Ziel der EU
- Bedeutung von Biomasse für ein *low-carbon* Energiesystem
- Technologische Vielfalt
- Technologien im Forschungs- und Entwicklungsstadium
- Fragen der Ressourcenverfügbarkeit
- Abwendung potenzieller Negativ-Effekte (ökologisch, sozial) – Nachhaltigkeitskriterien und Zertifizierung

Fragestellung

- Welche „**Technology gaps**“ gilt es zur Erreichung der langfristigen **klima- und energiepolitischen Zielsetzungen** zu überwinden? Welche Chancen und Perspektiven bieten **innovative Bioenergie-Technologien**?

- Wie können **ökologische und soziale Negativ-Effekte** durch eine **zunehmende globale Produktion von Biomasse** für energetische Zwecke vermieden und Chancen bestmöglich genutzt werden? Welche Rolle kann **Zertifizierungssystemen** zukommen, und welche Aspekte sind bei deren Ausgestaltung zu berücksichtigen?

Untergeordnete Fragestellungen

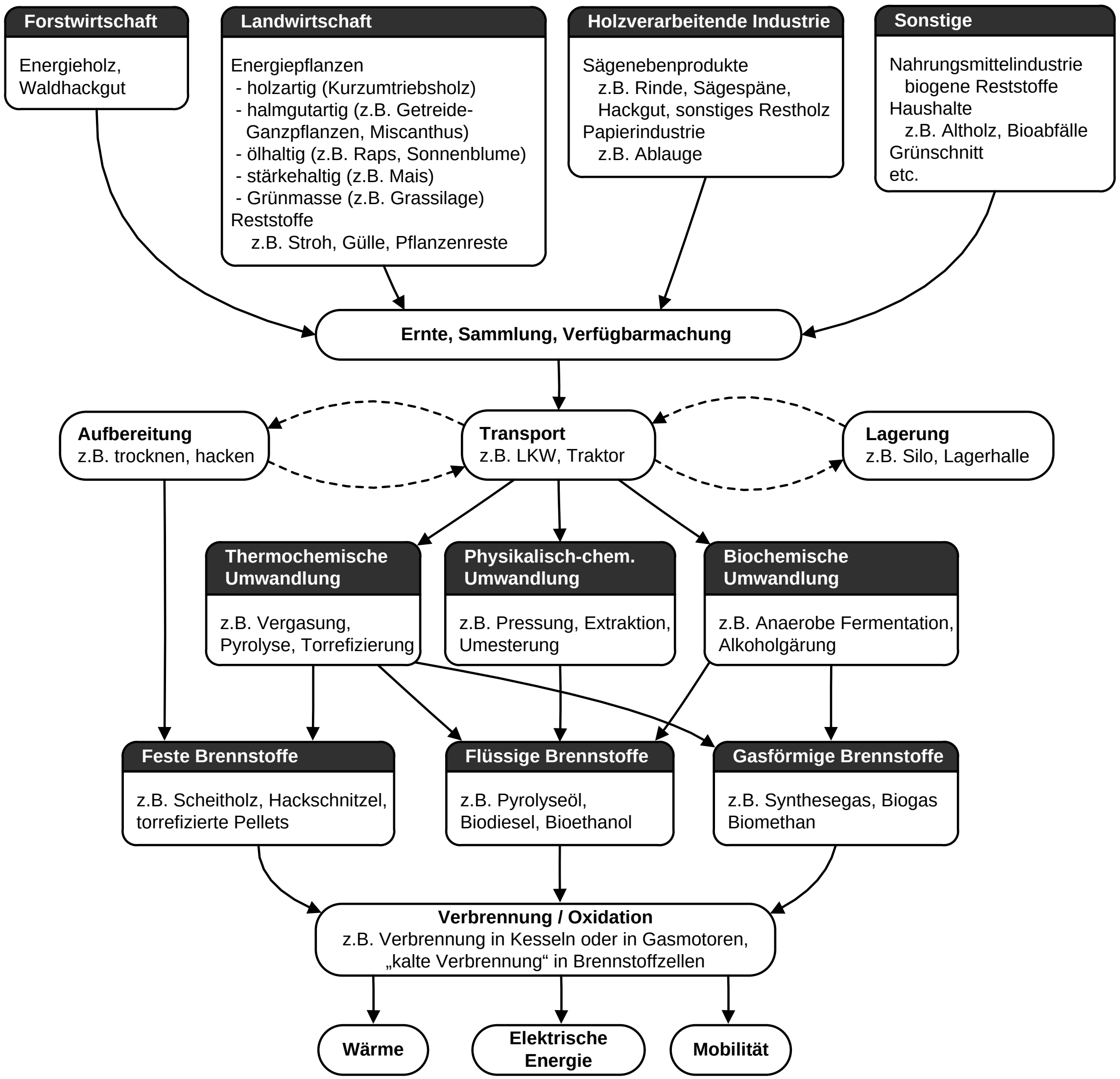
- Welche Rolle kommt **Biomasse** bei der **Erreichung der klima- und energiepolitischen Zielsetzungen** zu?

- Welche **Stärken und Schwächen** weisen verschiedene **Bioenergie-Technologien** auf?

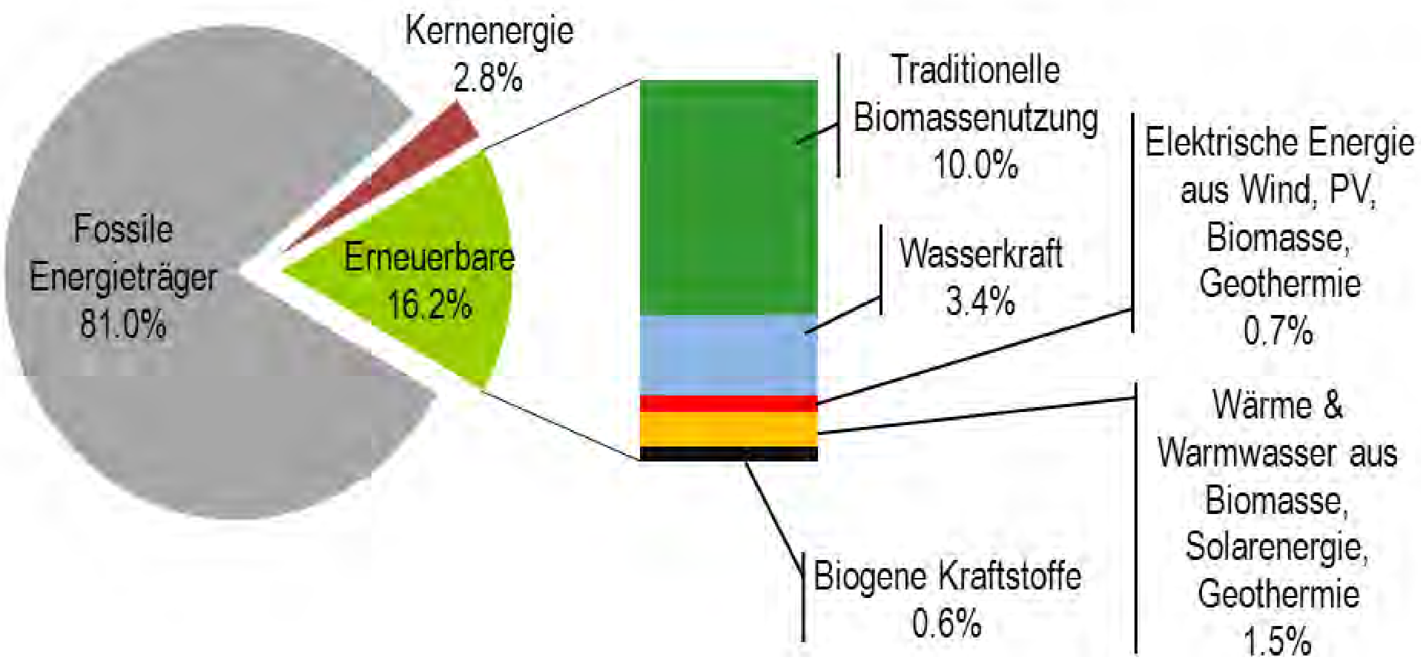
- Welche Praktiken sind bei **transnationalen Landakquisitionen und langfristigen Landverpachtungen in Entwicklungsländern** derzeit zu beobachten?

- Welche potentiellen **sozialen Folgen** bringen diese Entwicklungen bzw. diese Praktiken mit sich?

Bandbreite an Bioenergie-Technologien

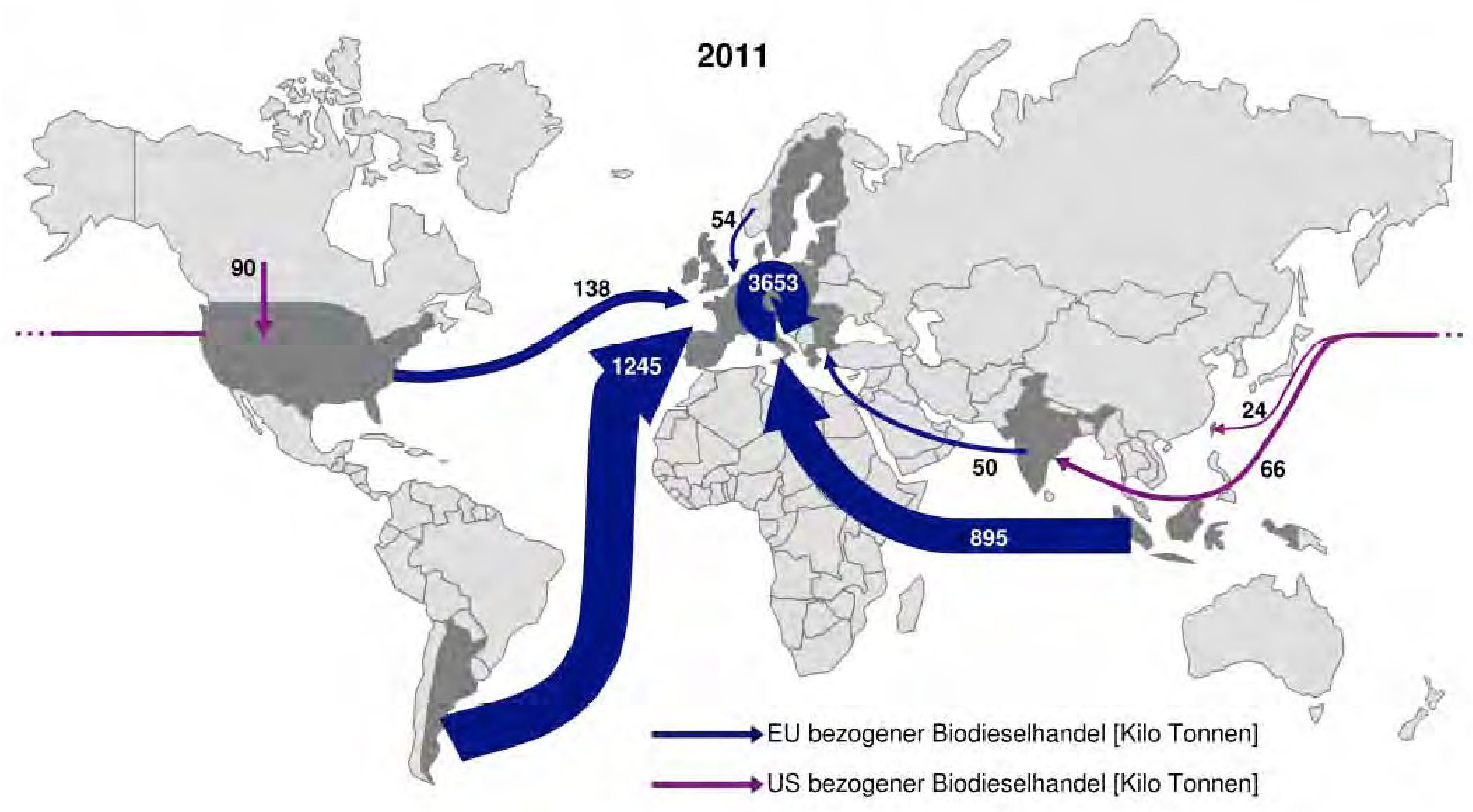


Struktur globaler Endenergieverbrauch, 2009



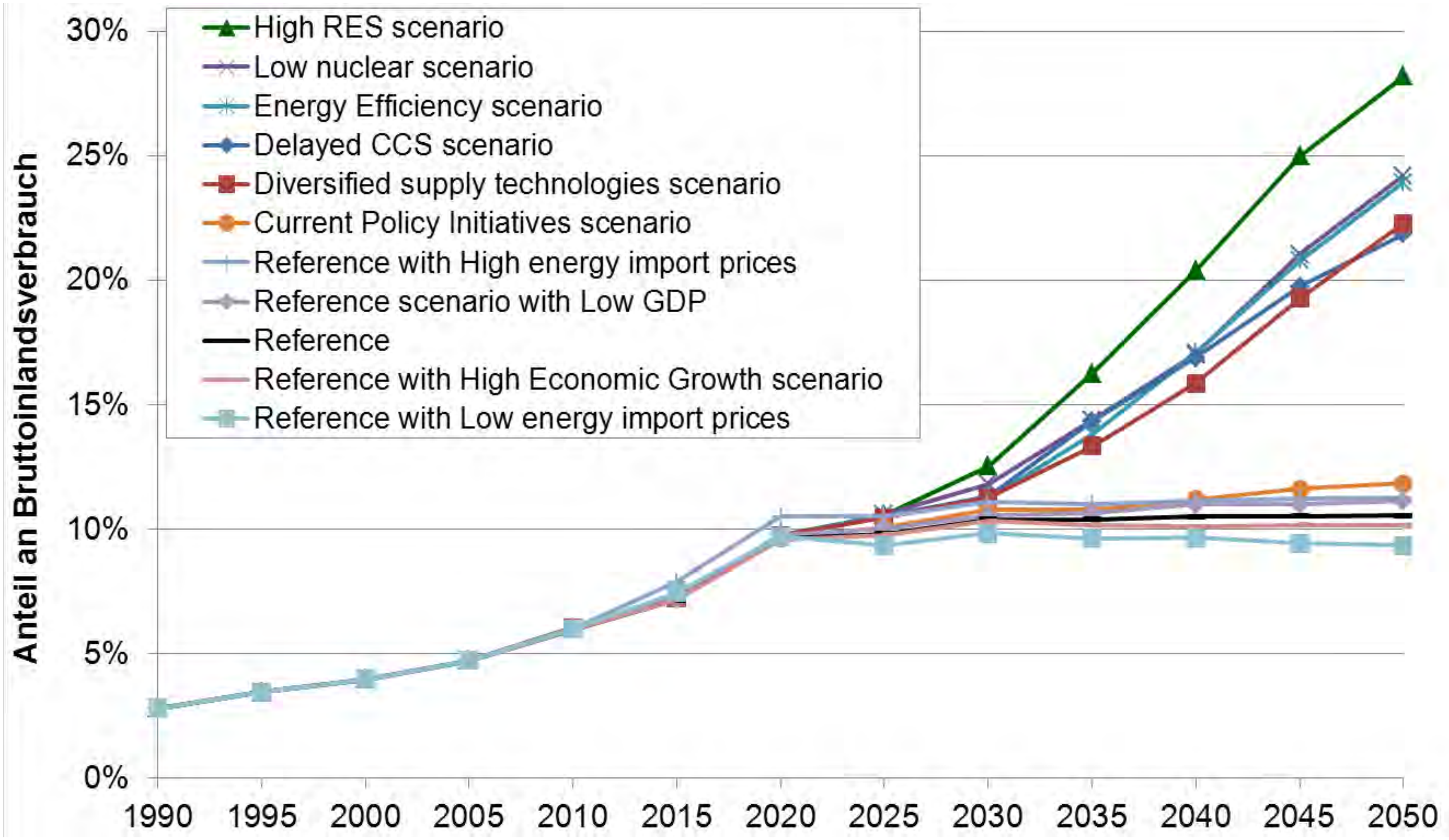
Quelle: REN21 2011, eigene Darstellung

Globale Biodiesel-Handelsströme, 2009



Quelle: Lamers et al 2011

Anteil Biomasse in „Roadmap“ - Szenarien EU-27



Quelle: European Commission 2011a

Arbeitsschritte

- Analyse Bioenergietechnologien: ausgewählte Aspekte zum Stand der Technik innovativer Technologien
- Darstellung und Analyse internationaler Biomasse-Handelsströme
- Fallstudien der Bioenergieproduktion in Afrika für den Export (Sierra Leone, Senegal, Malawi)
- Darstellung und Analyse von Zertifizierungsinstrumenten der Nachhaltigkeit von Biomasse
- Synthese und Schlussfolgerungen

Arbeitspakete & Zeitplan

Arbeitspakete & Tasks / Dauer (Monate)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
AP1: Projektmanagement	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
1.1 Organisation & Kommunikation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
1.2 Projektmeetings	■								■								■	
1.3 Erstellen des Endberichtes																	■	■
AP 2: Bioenergie-Technologien	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
2.1 Technologische Perspektiven der Bioenergie	■	■	■	■	■	■												
2.2 Systemische Aspekte, markt- & nachfrageseitige Potenziale				■	■	■	■	■	■									
2.3 Techno-ökonomische Analysen							■	■	■	■	■	■						
2.4 Multi-kriterielle Bewertung von Biomassenutzungsketten										■	■	■	■	■				
AP 3: Biomassebereitstellung, -handel und Nachhaltigkeit	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
3.1 Nachhaltigkeitskriterien und Zertifizierungssysteme	■	■	■	■	■													
3.2 Bedeutung der Biomassenutzung: Status quo, Szenarien & Klimaziele	■	■	■	■	■	■	■	■	■									
3.3 Internationaler Biomasse-Handel			■	■	■	■	■	■	■	■								
3.4 Perspektiven, Trends und deren Implikationen									■	■	■	■	■	■				
AP 4: Fallbeispiele	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
4.1 Durchsicht relevanter Quellen und Auswahl der Fallbeispiele	■	■	■	■	■													
4.2 Darstellung der unterschiedlichen Landvergabepraktiken			■	■	■	■	■											
4.3 Analyse hinsichtlich möglicher Negativ-Effekte					■	■	■	■	■	■								
4.4 Ansätze zur Förderung nachhaltiger Investitionen im Agrarsektor								■	■	■	■	■	■					
4.5 Aufbereitung der Ergebnisse für Schlussfolgerungen und Empfehlungen														■	■	■		
AP 5: Synthese und Schlussfolgerungen															■	■	■	■
5.1 Perspektiven von Technologien und internationalen Biomasse-Versorgungsketten															■	■	■	
5.2 Anforderungen an Zertifizierungssysteme & Nachhaltigkeitsstandards															■	■	■	
5.3 Schlussfolgerungen & Empfehlungen																	■	■
AP 6: Diskussions- und Verbreitungsprozess	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
6.1 Diskussionsprozess und Expertenworkshop	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
6.2 Verbreitung der Ergebnisse																	■	■
Expertenworkshop																	■	

TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Energy Economics Group

Sustainable bioenergy markets and international trade: Securing Supply and Demand

IEA Bioenergy Task40

Lukas Kranzl
Julian Matzenberger

bmvit
Bundesministerium für Verkehr, Innovation und Technologie
FFG
IEA FORSCHUNGSKOOPERATION

IEA Bioenergy Task 40

Sustainable International Bioenergy Trade: securing an international supply and demand

- **Seit 2004**
- **Task leader:**
  - **Copernicus Institute – Utrecht University, Andre Faaij, Martin Junginger,**
  - **Nidera Handelscompagnie, Peter Paul Schouwenberg**
- **Neben Österreich weiters involviert: Belgien, Brasilien, Kanada, Deutschland, Finnland, Italien, Japan, Niederlande, Norwegen, Schweden, UK, USA**

IEA FORSCHUNGS KOOPERATION

bmvit

IEA Bioenergy Task 40

Zielsetzungen:

- Besseres Verständnis von Bioenergie-Märkten
- Analyse nachhaltiger Biomasse-Produktionsketten
- Analyse von Biomasse-Märkten durch Modellierung und Szenario-Entwicklung
- Evaluierung der politischen, sozialen, ökonomischen und ökologischen Auswirkungen des Biomasse-Handels, insbesondere in Bezug auf Nachhaltigkeitskriterien
- Beitrag zu Zertifizierungs-Vorgängen, Identifikation von Best-Practice-Beispielen

TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Energy Economics Group

Bioenergie-Technologien, Ressourcen und Nachhaltigkeit: lokale und globale Herausforderungen

Workshop 6.12.2012, TU-Wien

Lukas Kranzl

Julian Matzenberger

Katharina Zwiauer

Bundesministerium für Verkehr, Innovation und Technologie

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Agenda

14:00 Begrüßung und Einleitung

- **Vorstellung des Projekts „Nachhaltige Bioenergie 2050“**
- **Vorstellung von Task 40 „Bioenergy-Trade“ im Rahmen des IEA Implementing Agreements Bioenergy**
- **Ziele und Fragestellungen für diesen Workshop**

14:30 Verflechtungen der Biomasse-Nutzung auf der globalen, europäischen und nationalen Ebene

15:00 Bioenergieproduktion und Landinvestitionen in Westafrika. Sierra Leone, ein Beispiel für „Landgrabbing“ oder verantwortungsvolle Investitionen?

15:30 Nachhaltigkeitskriterien und Zertifizierung von Biomasse

16:00 Diskussion

Fragestellungen zum heutigen Workshop

- **Welche Herausforderungen stellen sich für eine nachhaltige Nutzung von Bioenergie angesichts globaler und europäischer Verflechtungen von Biomassemärkten?**
- **Bioenergieproduktion in Afrika: „Landgrabbing“ oder notwendige Investitionen in „rückständige“ landwirtschaftliche Strukturen? Welche Grundprinzipien sind zu formulieren, um Risiken zu minimieren und Chancen zu wahren?**
- **Welche Zertifizierungssysteme für Bioenergie werden derzeit angewandt bzw. sind derzeit in Entwicklung und welche Empfehlungen für deren Verbesserung bzw. Weiterentwicklung können abgeleitet werden?**

Zielsetzung des Workshops

- Austausch mit relevanten AkteurInnen, ExpertInnen
- Berücksichtigung der Ergebnisse anderer, aktuell laufender anderer Arbeiten und Entwicklungen
- Inputs zu den oben formulierten Fragen
- Identifizierung wichtiger weiterer offener Fragen
- Identifizierung wichtiger Herausforderungen einer nachhaltigen Bioenergiebereitstellung
- Qualitätssicherung

Verflechtungen der Biomasse-Nutzung auf der globalen, europäischen und nationalen Ebene

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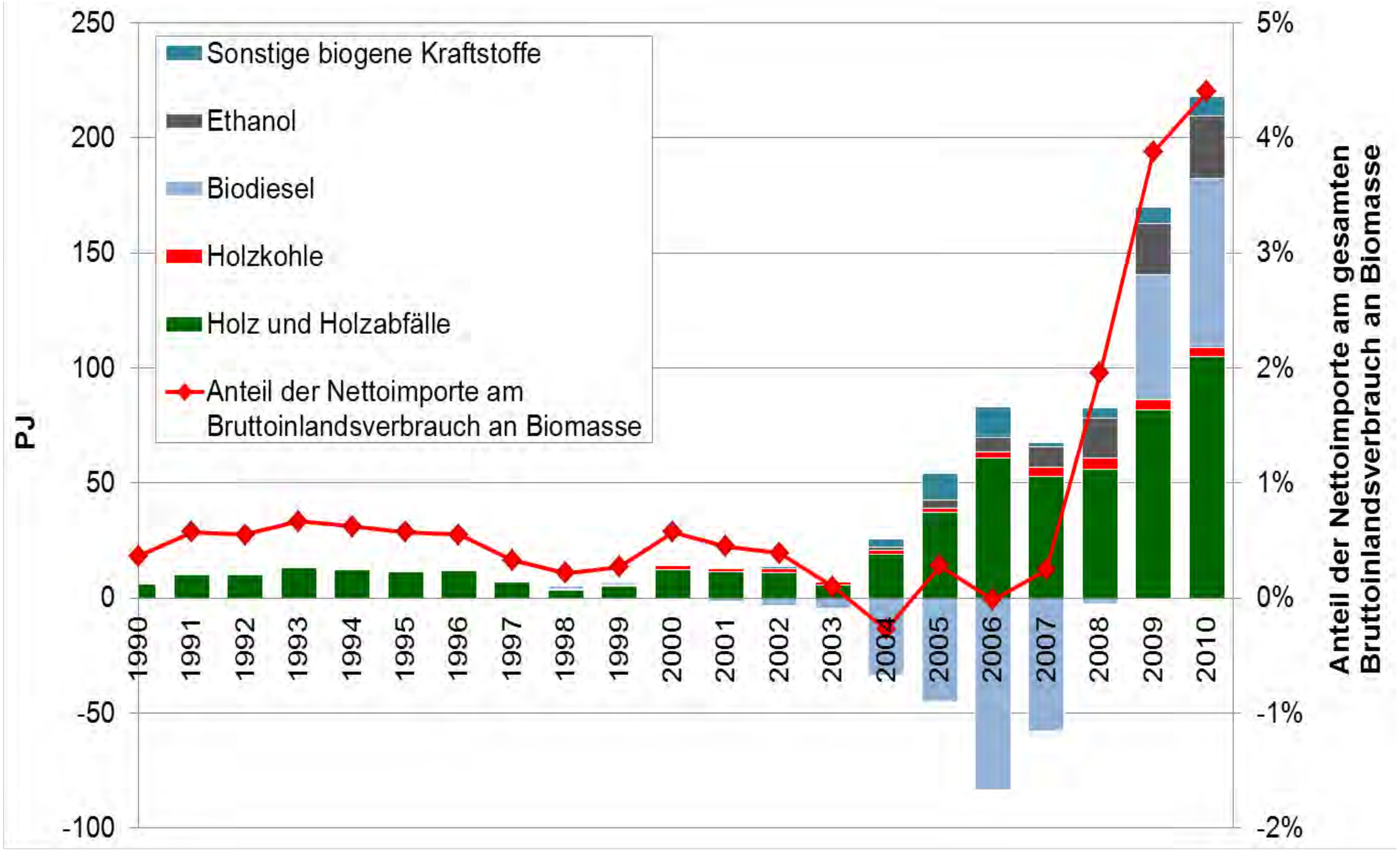
Fragestellungen

- Welche Herausforderungen stellen sich für eine nachhaltige Nutzung von Bioenergie angesichts globaler und europäischer Verflechtungen von Biomassemärkten?
- Wie stellen sich diese Verflechtungen derzeit dar und welche Perspektiven ergeben sich für die Zukunft?

Inhalt

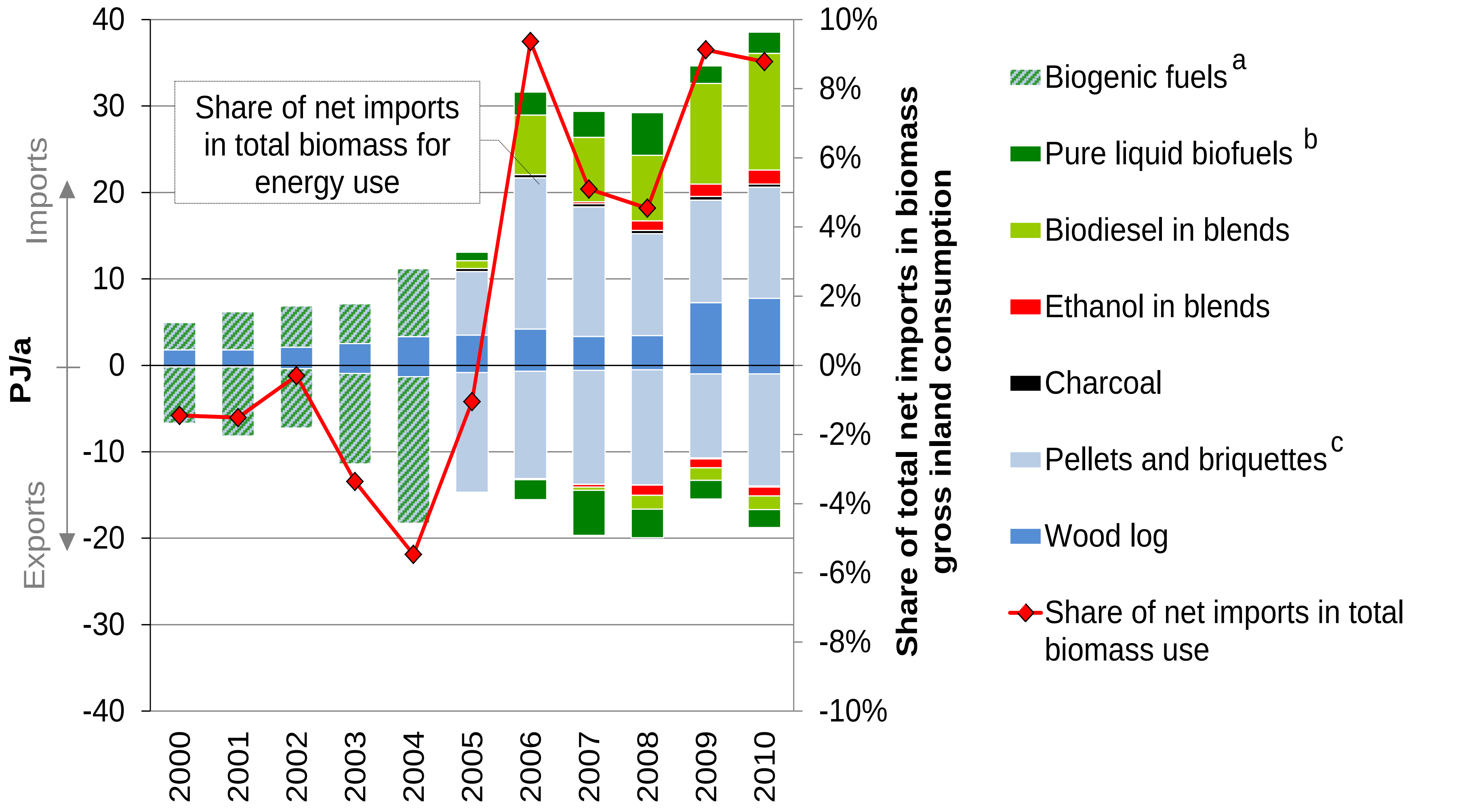
- Internationale Handelsströme Biomasse
  - Global
  - EU
  - Österreich
  - Berücksichtigung energetischer und nicht-energetischer Handelsströme
  - Unterscheidung zwischen fester und flüssiger Biomasse
- Perspektiven, Szenarien

Biomasse-Nettoimporte EU-27 lt. Energiebilanz



Quelle: Eurostat 2011

Bioenergie-Export-Import Bilanz, Österreich



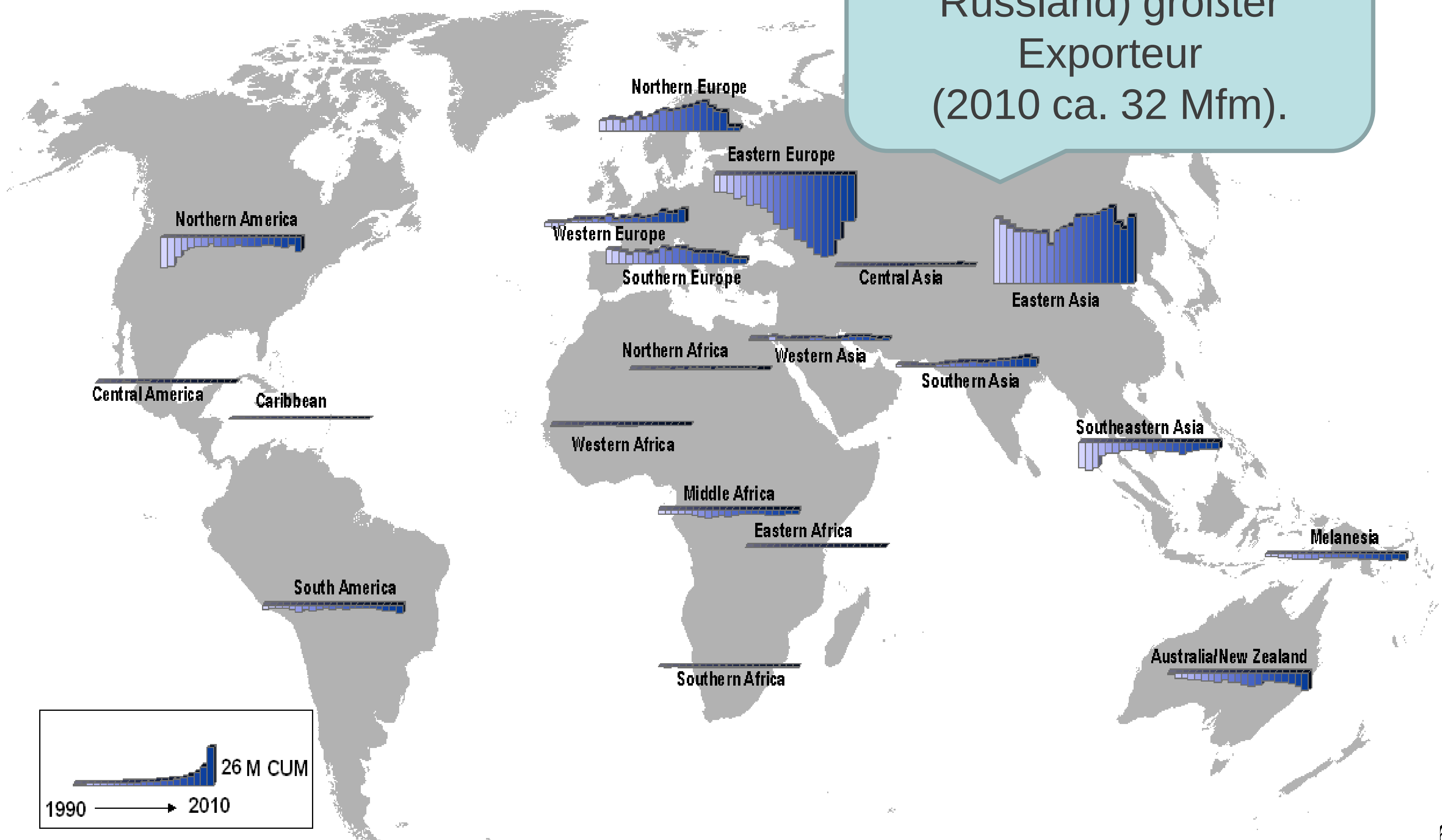
Quelle: Kalt & Kranzl (2011) based on Statistik Austria (2011c)

Biomasse-Ströme (1): Feste Biomasse

- Stark etablierter internationaler Handel mit fester Biomasse für die Holzindustrie
- Global wird der Handel v.a. durch Osteuropa (incl. Russland) und Asien geprägt
- Abhängigkeit von der Position der Holzverarbeitenden Industrie in einem Land
- Abhängigkeit von Konjunktur/Wirtschaftskrise
- Handel mit fester Biomasse für Bioenergie ist vergleichsweise sehr gering
- (Für manche Länder, u.a. Österreich spielt indirekter Biomasse-Import gewisse Rolle)

Rundholz Netto-Importe

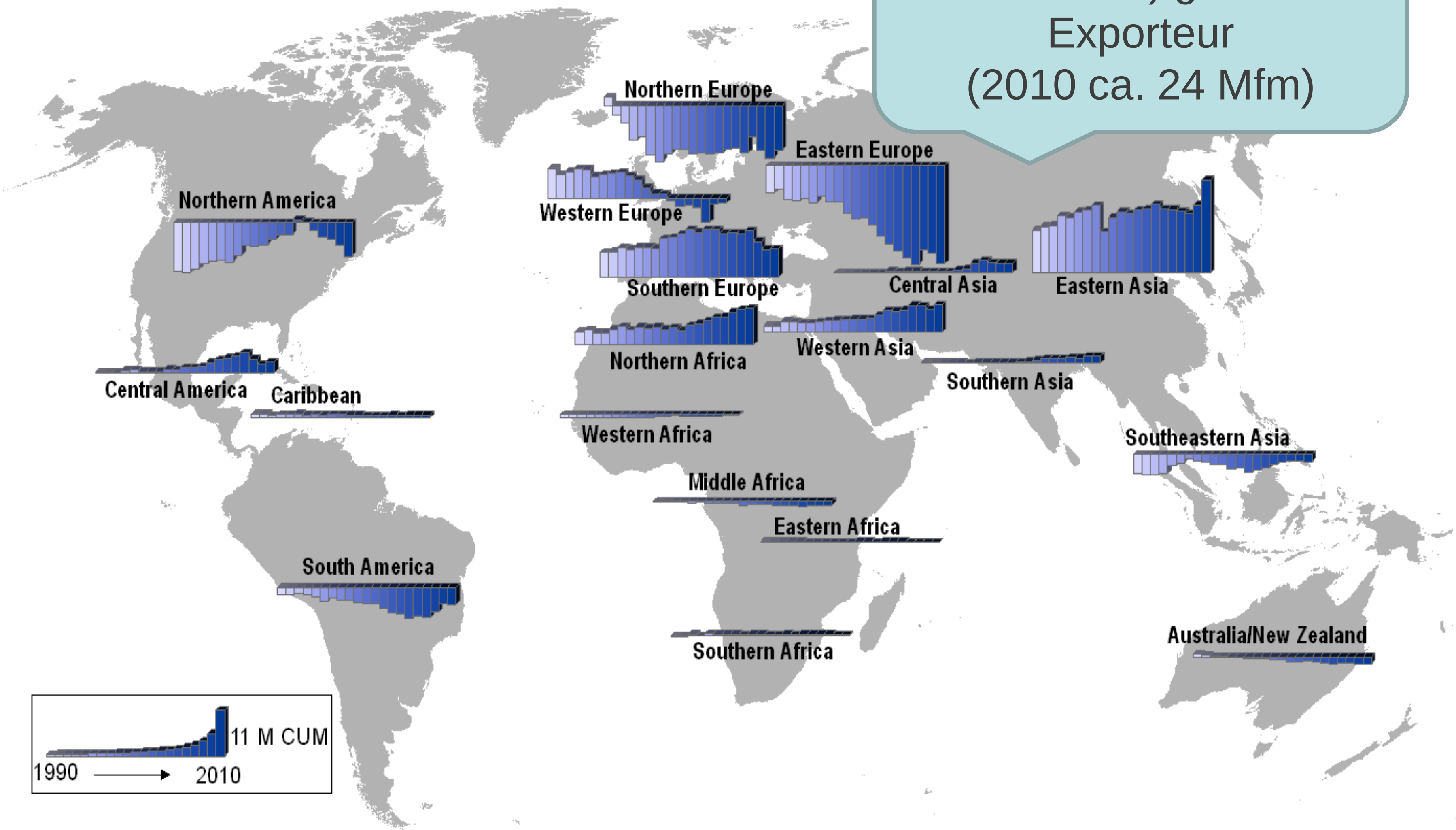
Osteuropa (incl. Russland) größter Exporteur (2010 ca. 32 Mfm).



Quelle: FAO, eigene Berechnungen und Darstellung

Schnittholz Netto-Importe

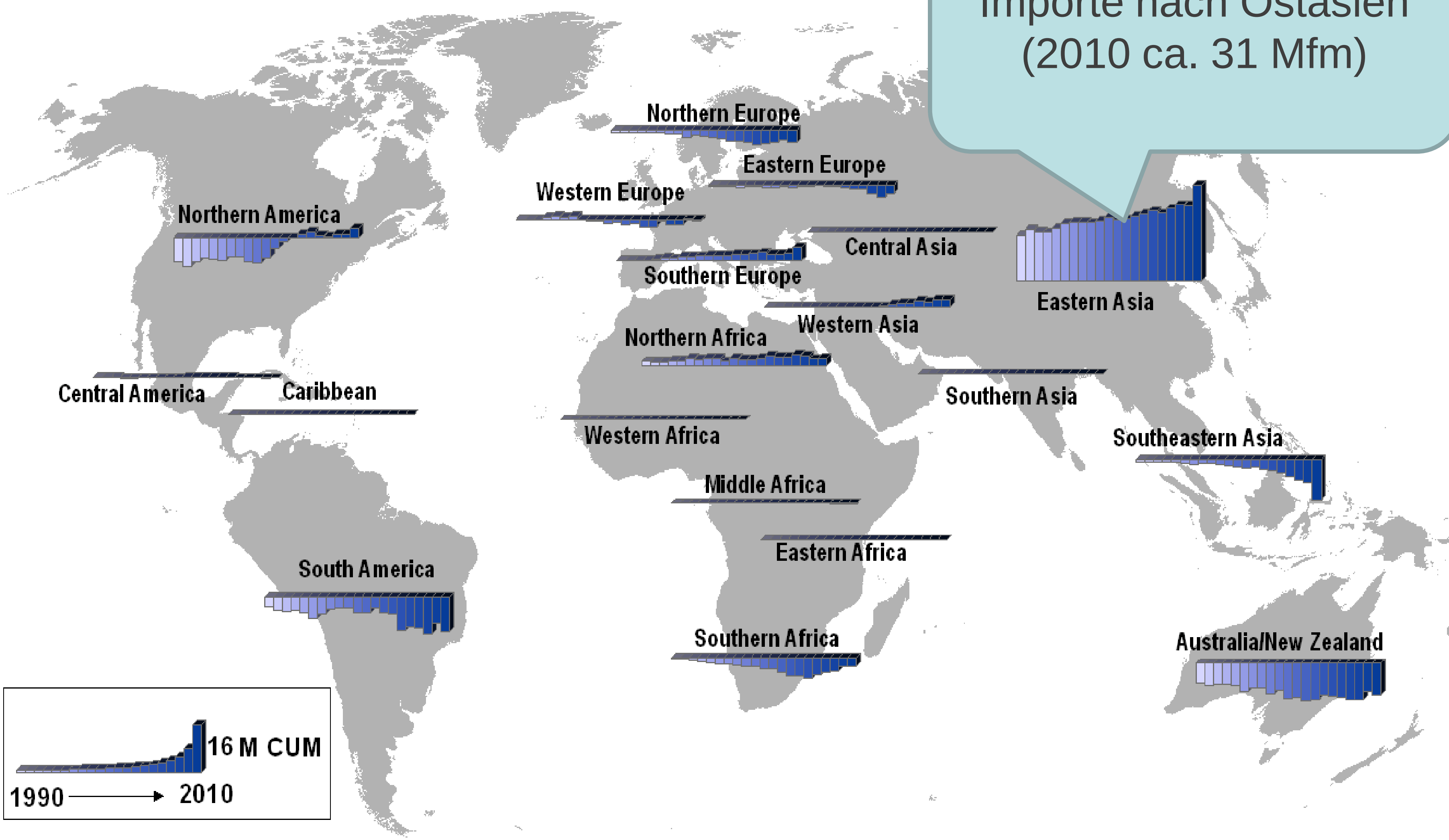
Osteuropa (incl. Russland) größter Exporteur (2010 ca. 24 Mfm)



Quelle: FAO, eigene Berechnungen und Darstellung

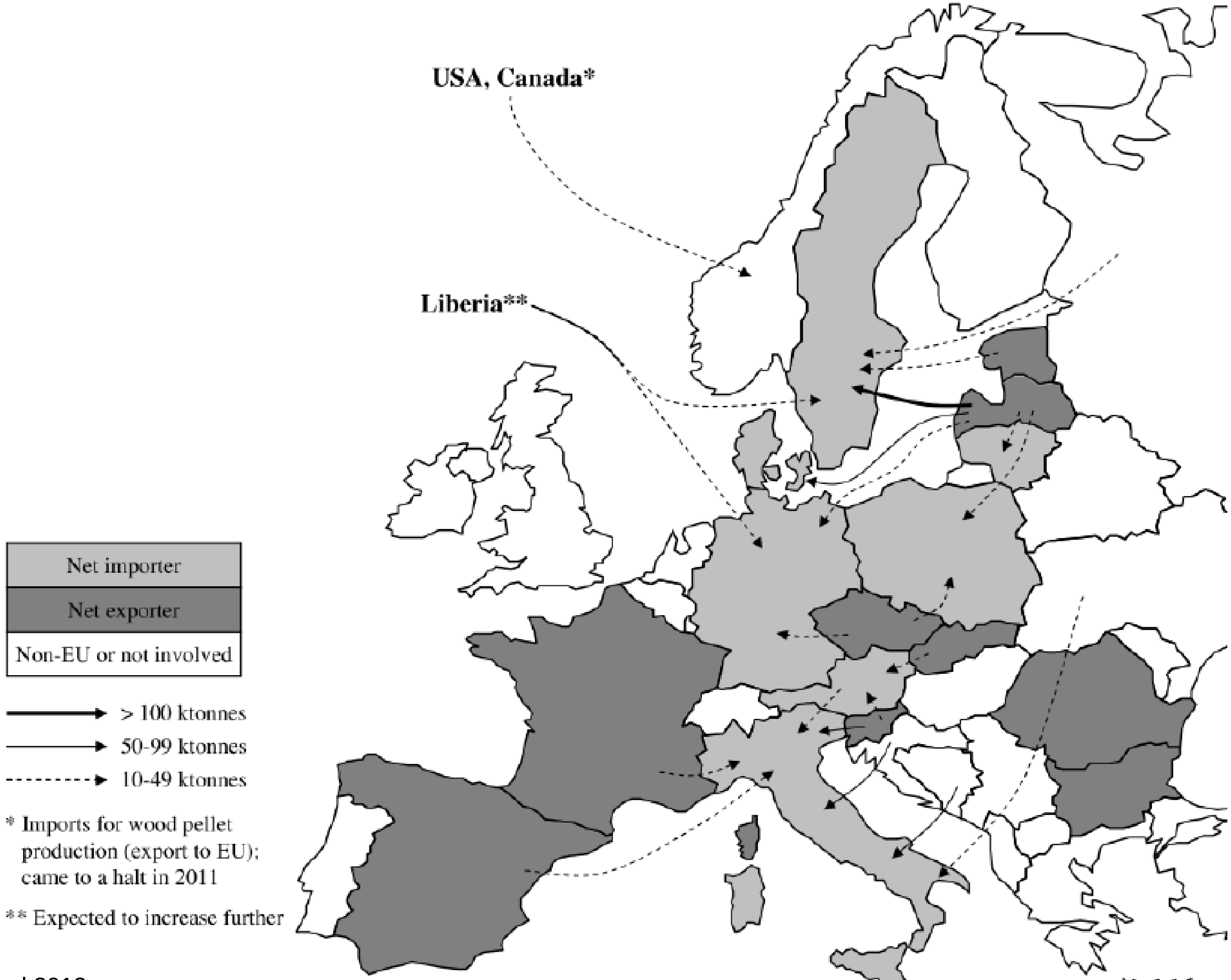
Hackgut Netto-Importe

Importe nach Ostasien
(2010 ca. 31 Mfm)



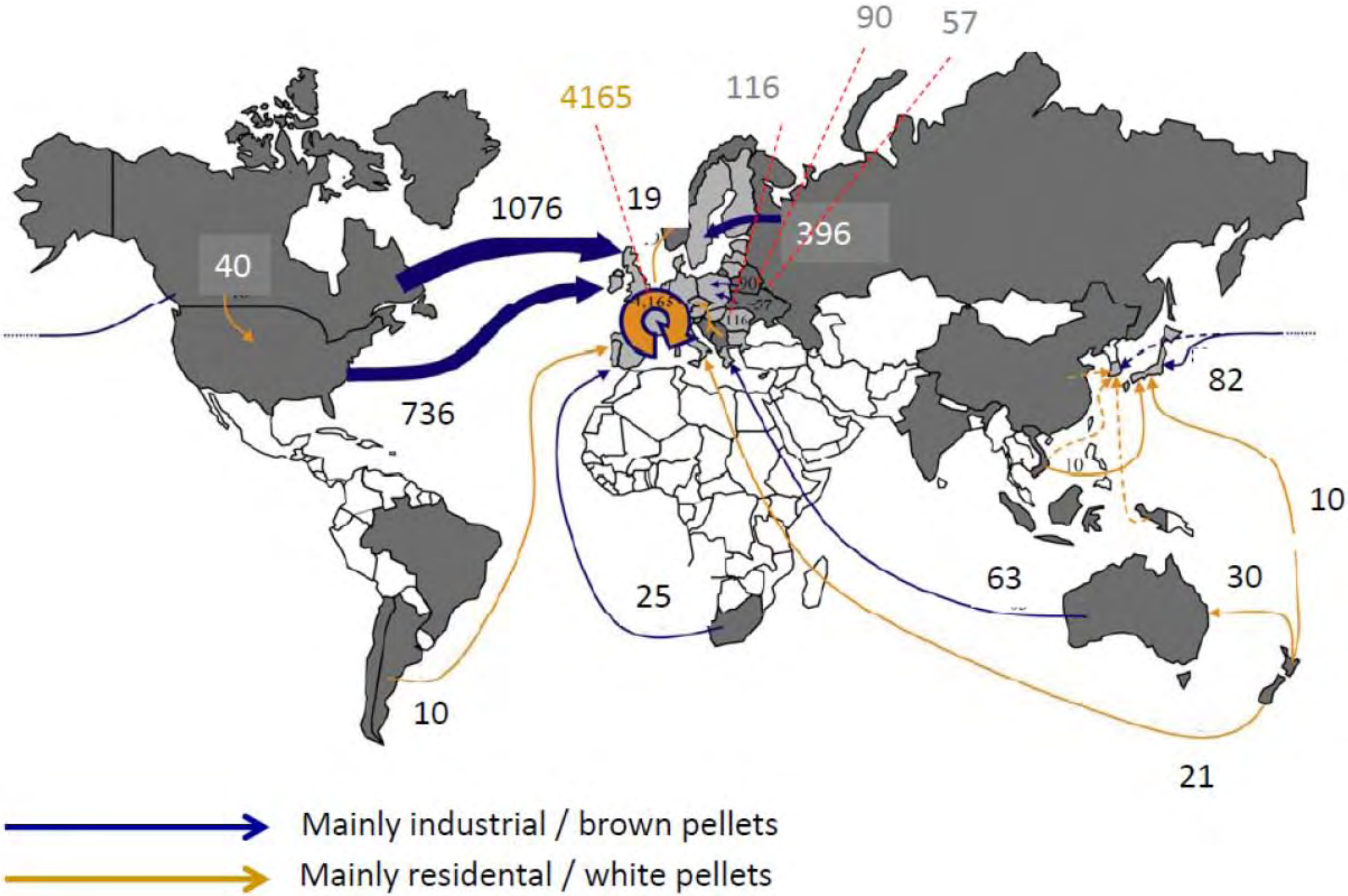
Quelle: FAO, eigene Berechnungen und Darstellung

Bioenergie-Hackgut – Handelsströme EU, 2010



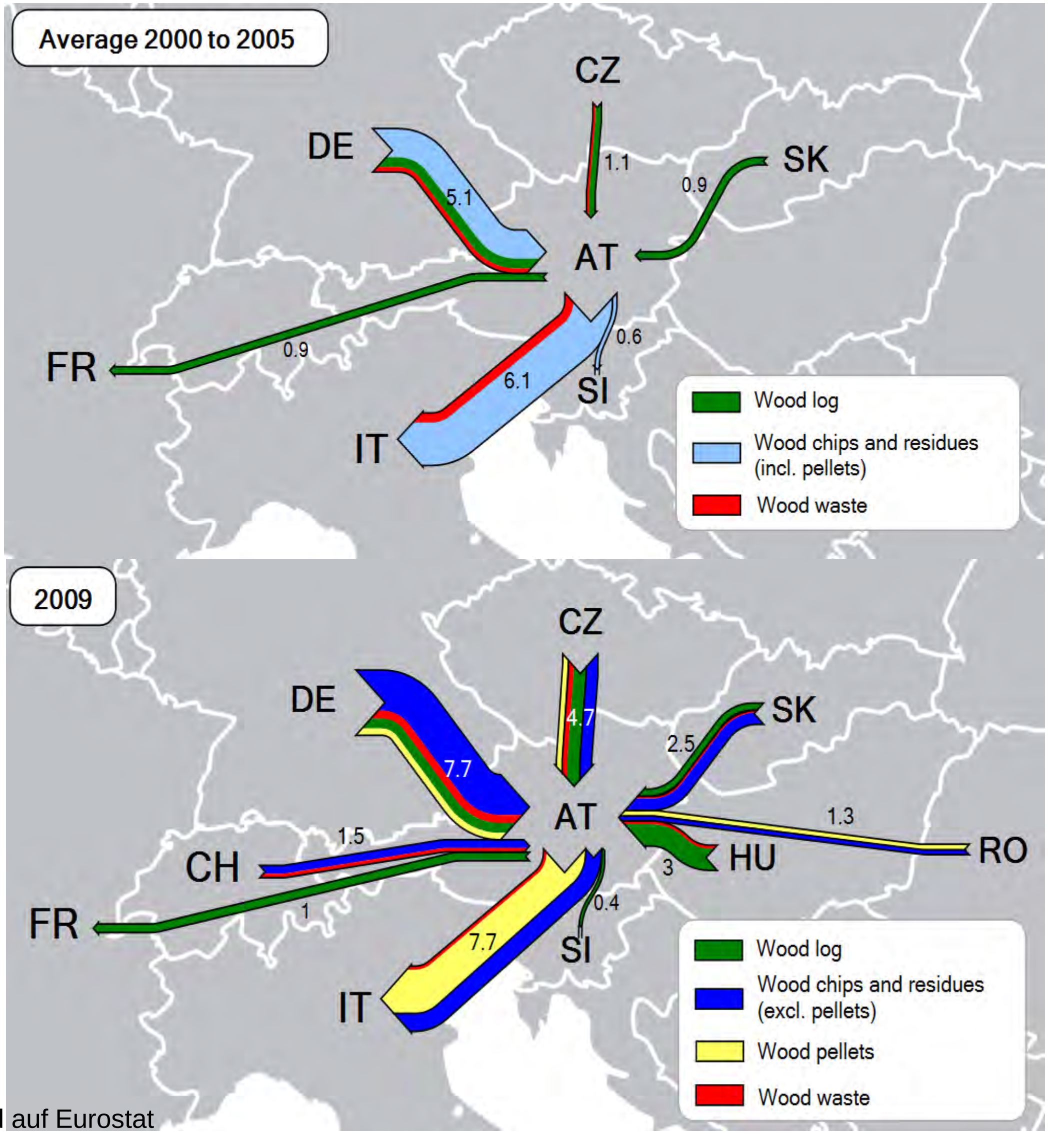
Quelle: Lamers et al 2012

Pellet Handelsströme, 2010 (kt)



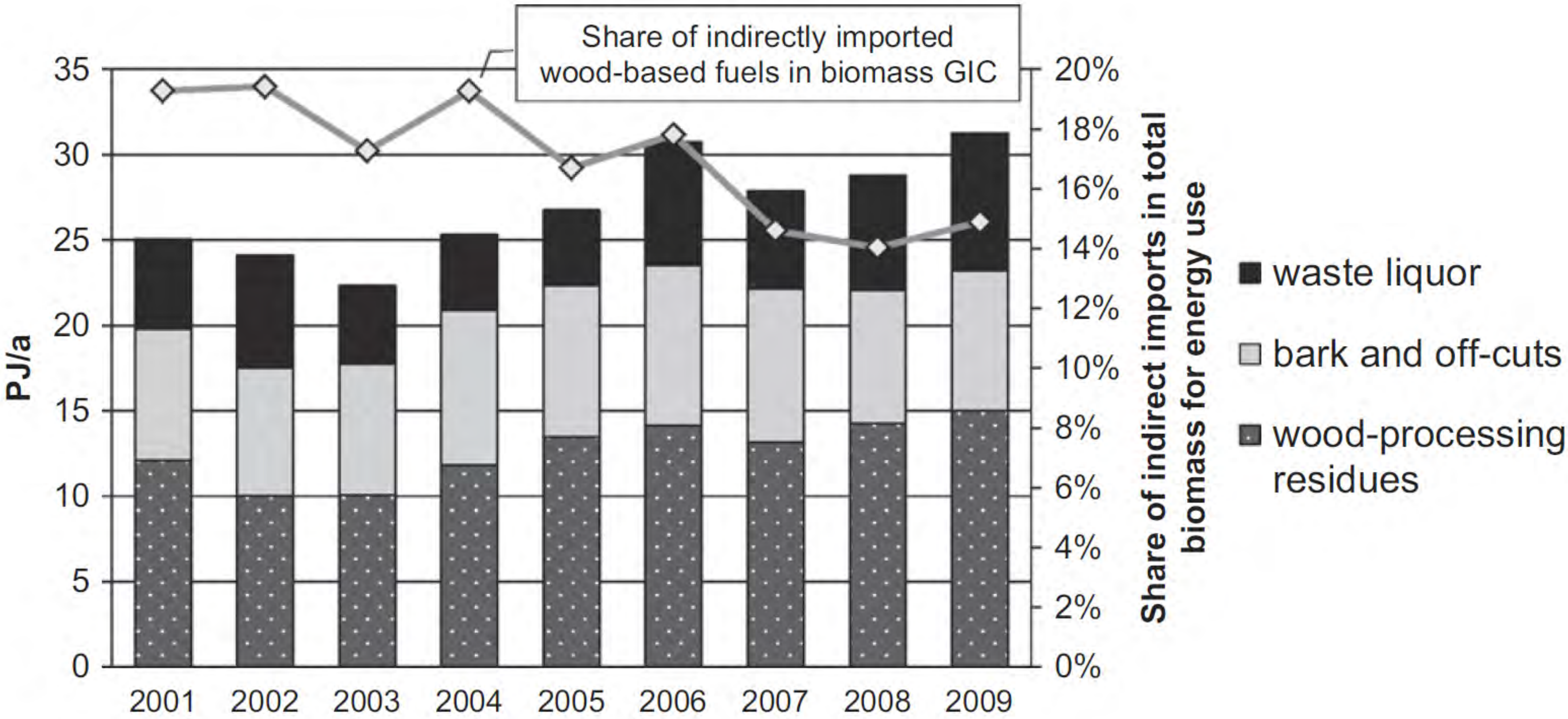
Quelle: Lamers et al 2012

Handelsströme feste Biomasse, Österreich (PJ)



Quelle: Kalt 2011 basierend auf Eurostat

Indirekte Importe an Biomasse am Beispiel Ö



Quelle: Kalt 2012

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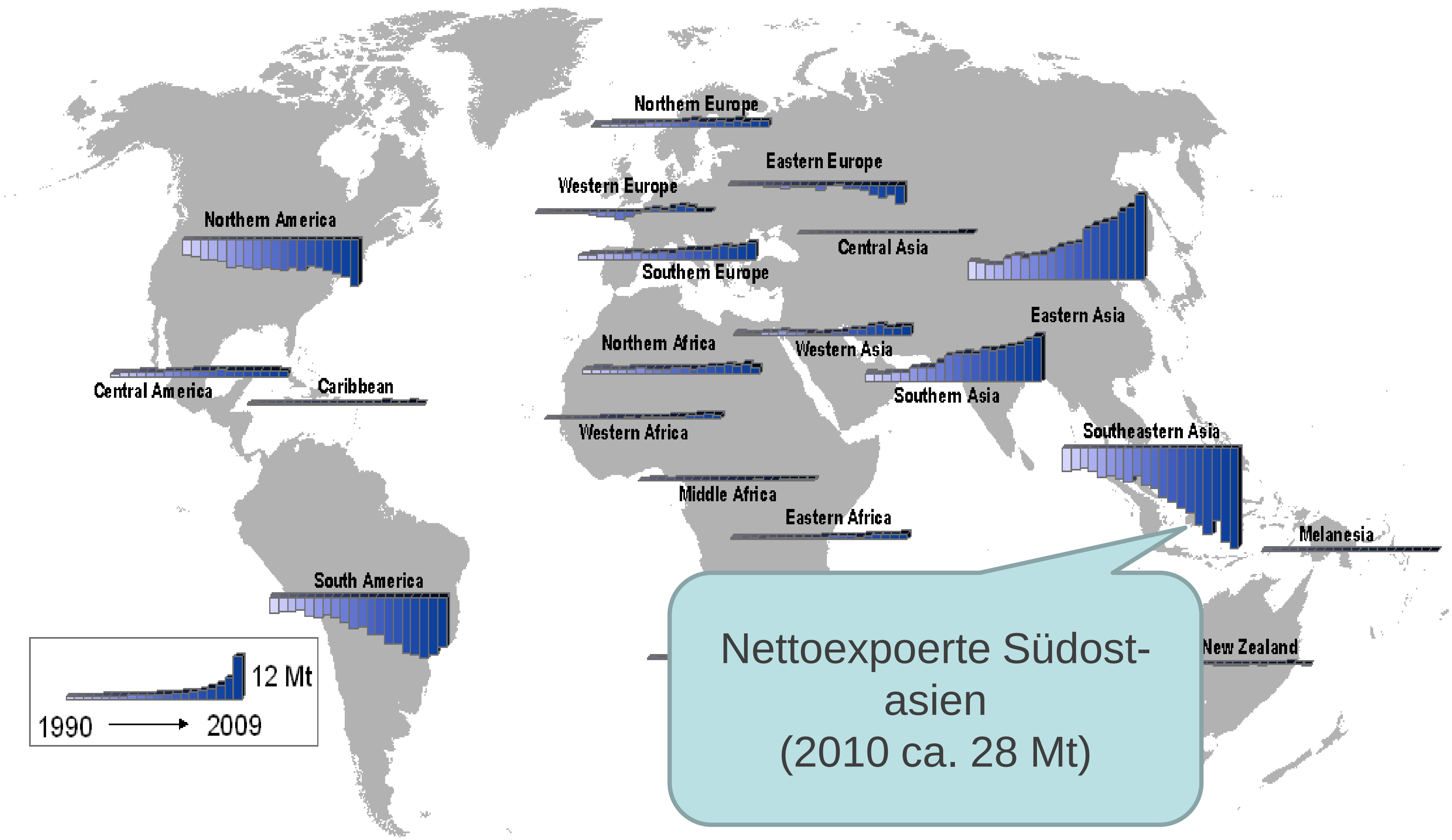
- (Für manche Länder, u.a. Österreich spielt indirekter Biomasse-Import gewisse Rolle)

Biomasse-Ströme (2): Kraftstoffe

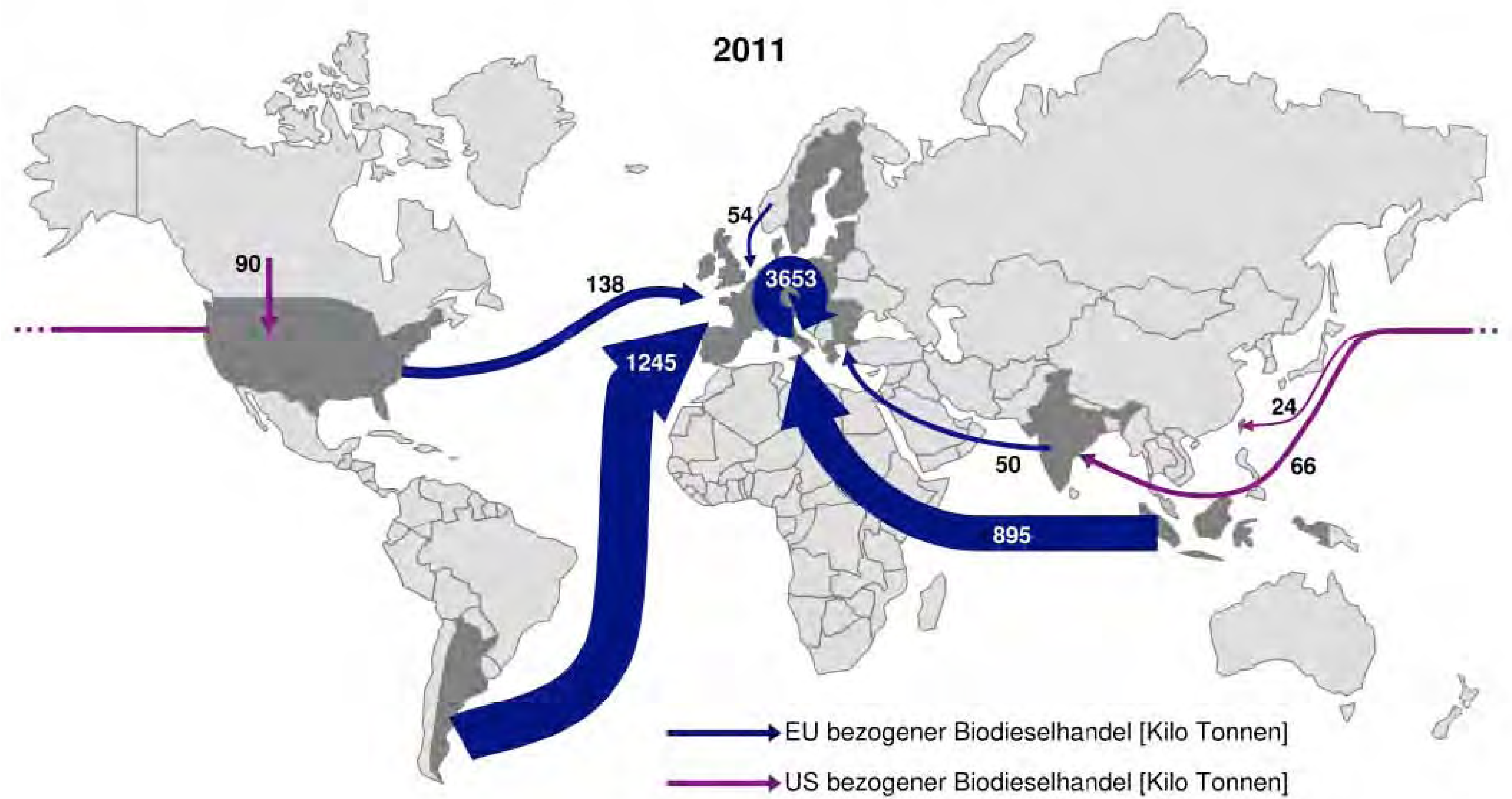
- Pflanzenöl-Markt wird global stark durch S-O-Asien, Brasilien und Nord-Amerika (Exporteure) und Ost- und Südasien (Importeure) geprägt.
- Stark steigende Relevanz des Handels mit Pflanzenöl (sowohl für energetische als auch für nicht-energetisch Zwecke)
- Relativ großer Anteil der Pflanzenölproduktion für energetische Zwecke eingesetzt.
- Steigende Nachfrage nach Biodiesel führte zu deutlicher Verschiebung der Handelsbilanzen, v.a. in Europa.
- Zunehmende Importabhängigkeit Europas bei Biodiesel und Bioethanol
- In Österreich Importabhänigkeit v.a. bei Biodiesel

Pflanzenöl und Ölsaaten Netto-Importe



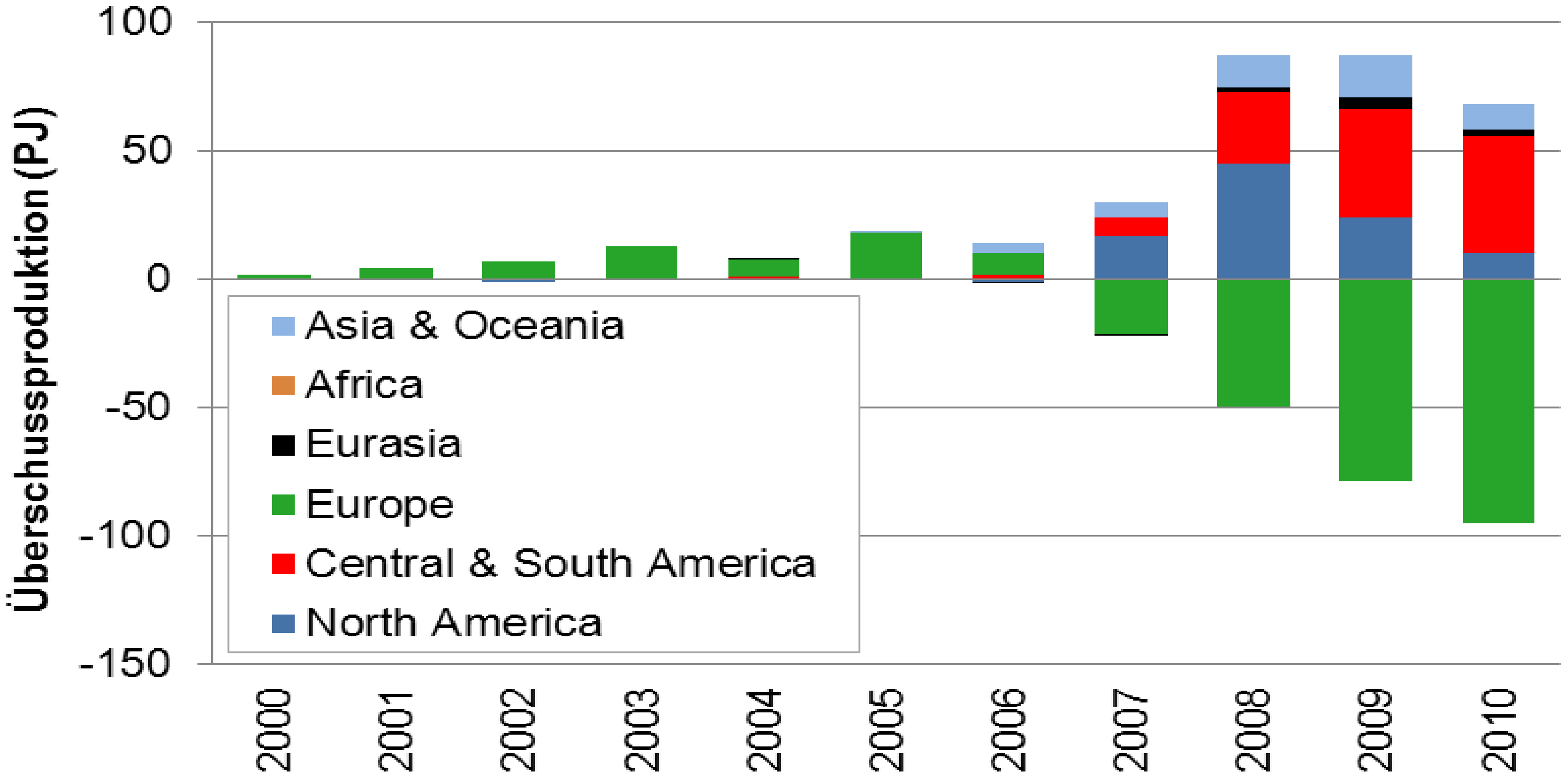
Quelle: FAO, eigene Berechnungen und Darstellung

Globale Biodiesel Handelsströme



Quelle: Lamers, 2011

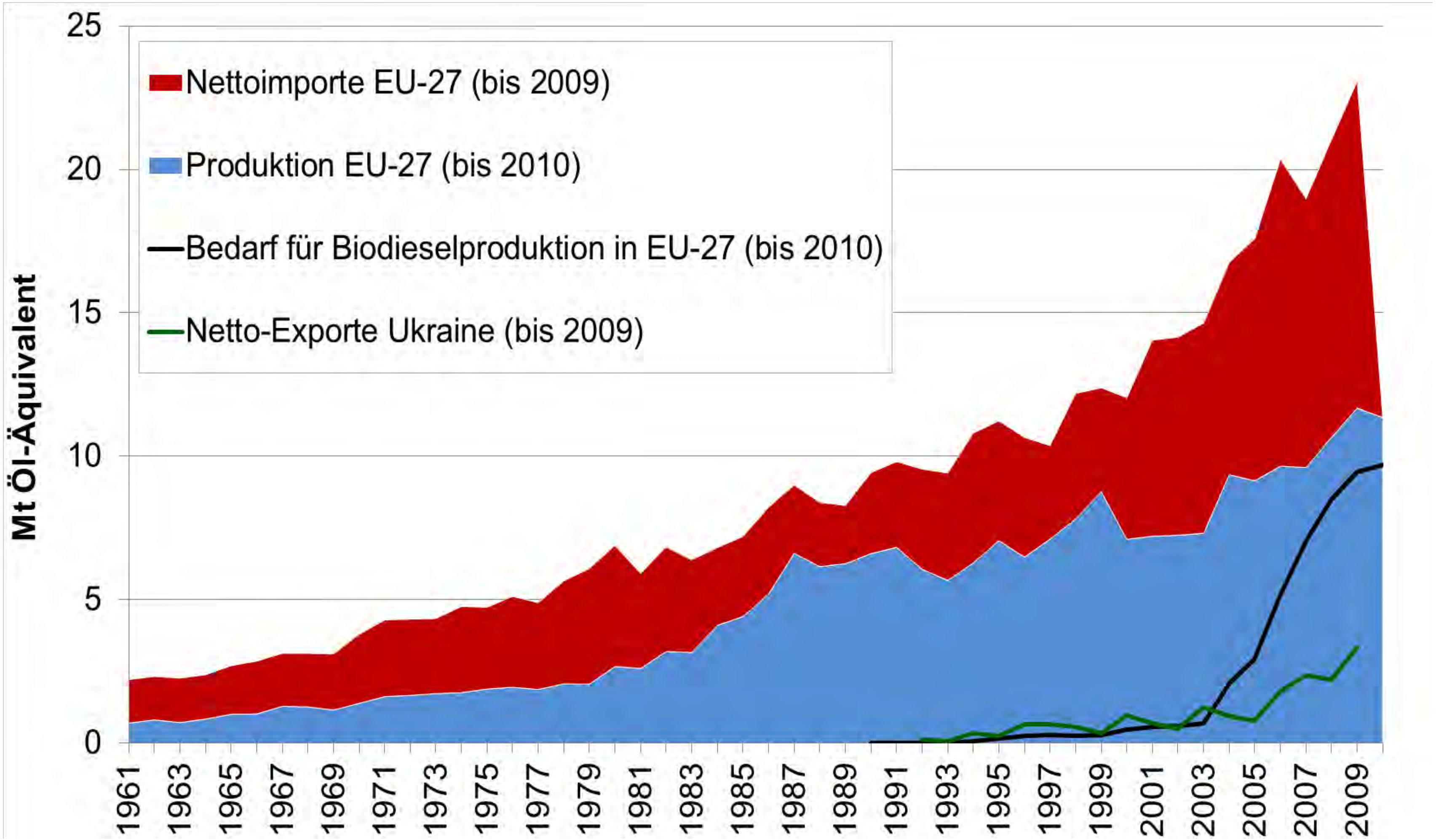
Überschussproduktion Biodiesel



- Überschussproduktion: Produktion minus Verbrauch
- Lagerhaltung nicht berücksichtigt, Verbrauch z.T. ungenau erfasst

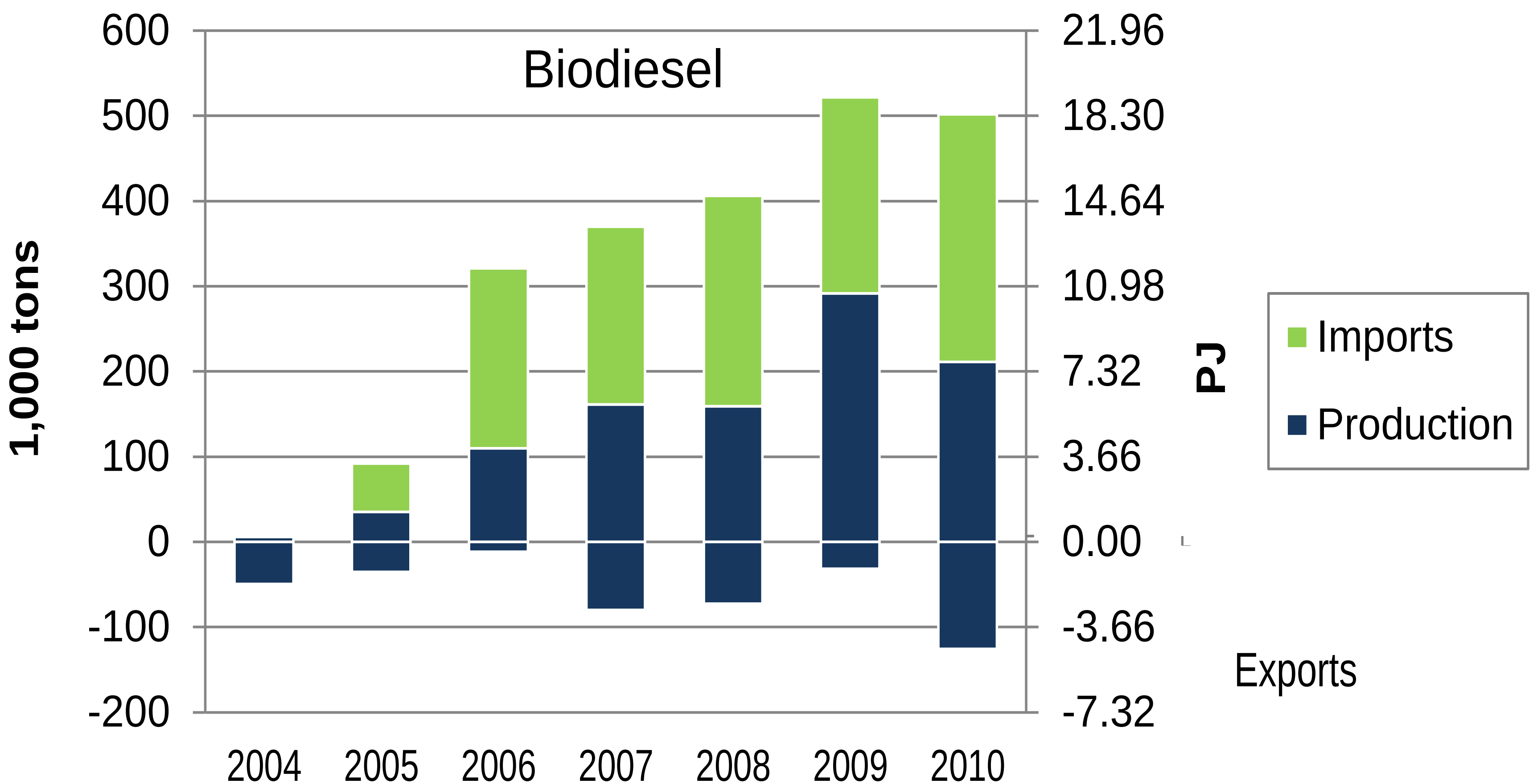
Quelle: EIA 2012

Produktion und Nettoimporte von Ölsaaten und Pflanzenöl EU-27



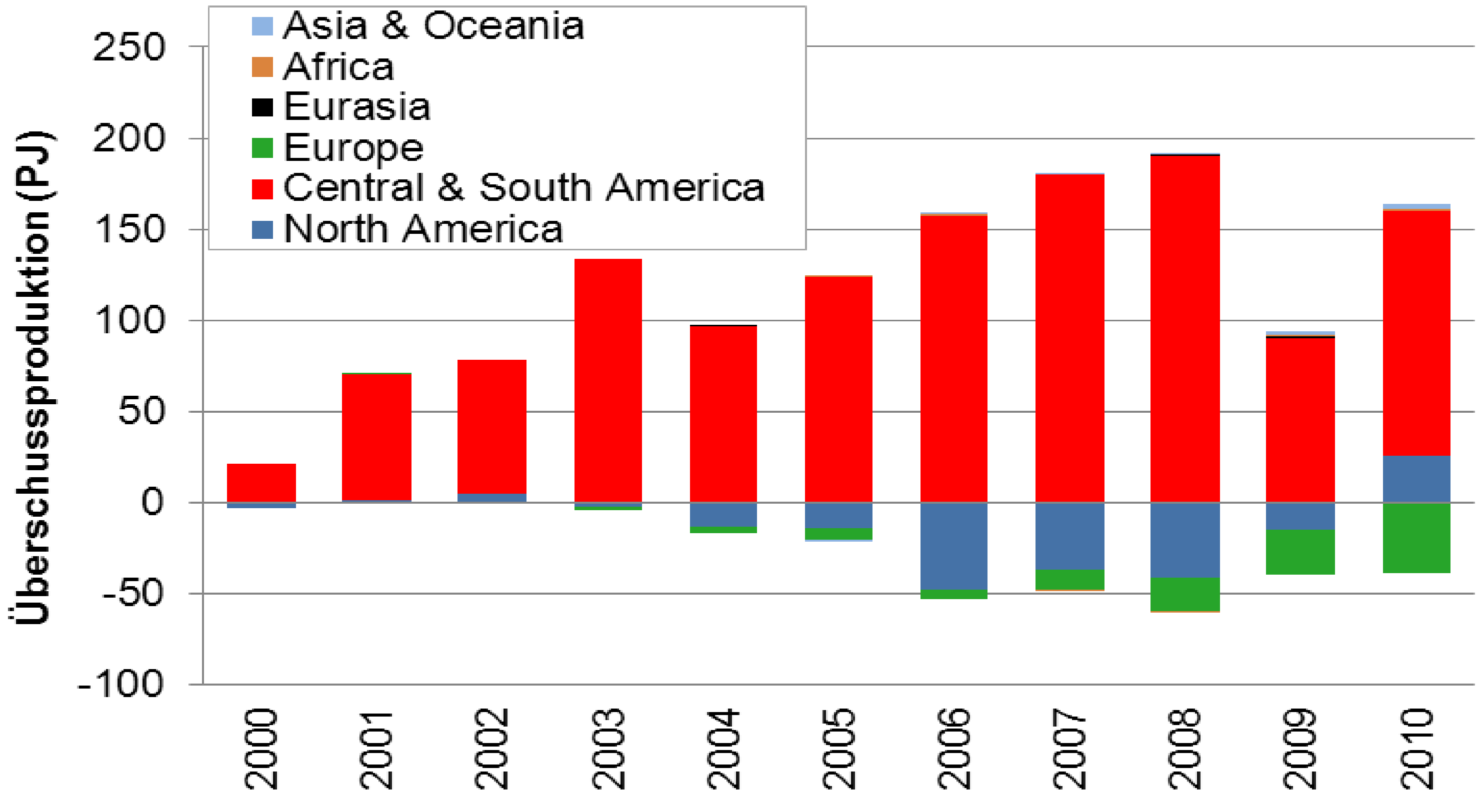
Quelle: Eurostat 2011

Biodiesel Importe und Exporte, Österreich



Quelle: Kalt (2011), based on Winter (2011), Statistik Austria (2011c)

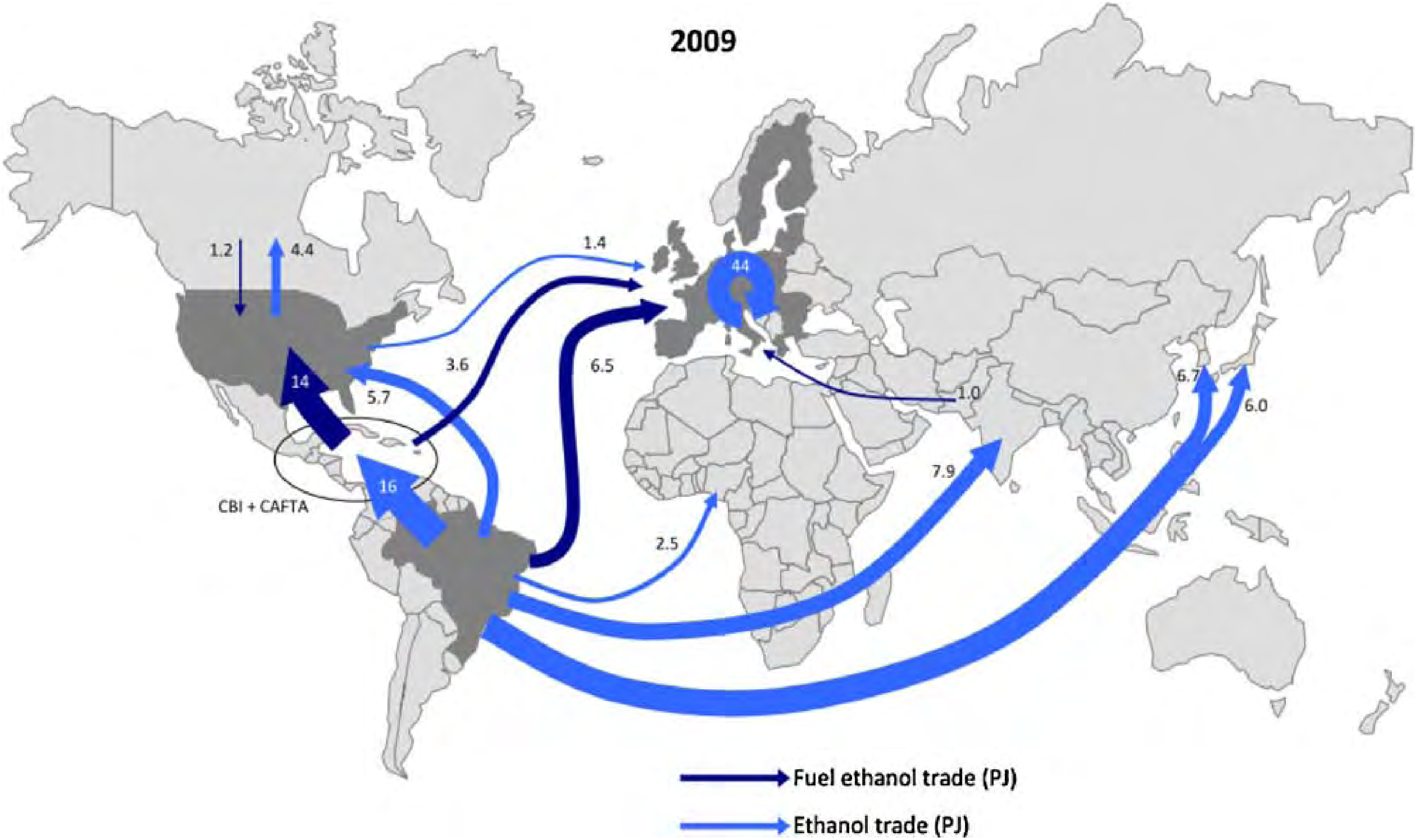
Überschussproduktion Bioethanol



- Überschussproduktion: Produktion minus Verbrauch
- Lagerhaltung nicht berücksichtigt, Verbrauch z.T. ungenau erfasst (v.a. Brasilien)

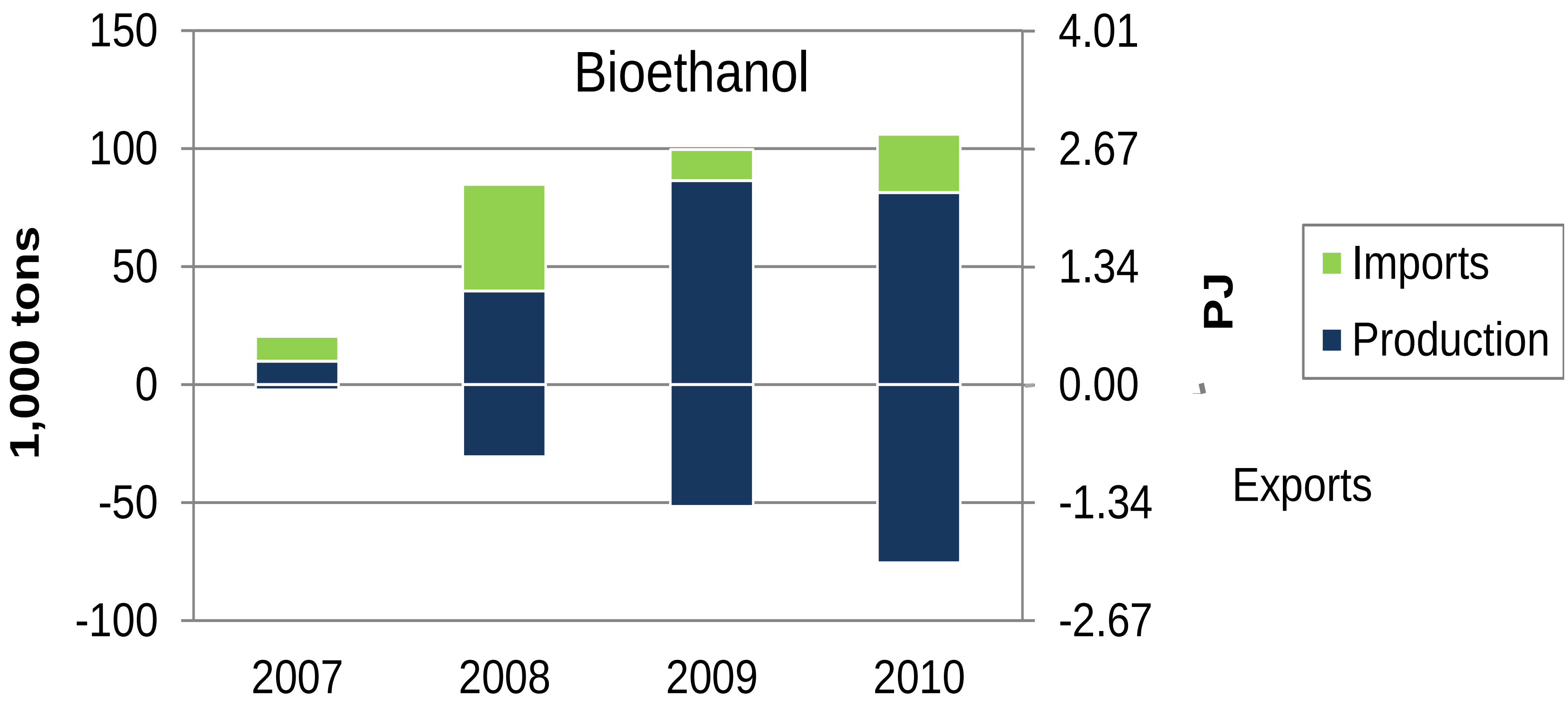
Quelle: EIA 2012

Globale Bioethanol Handelsströme



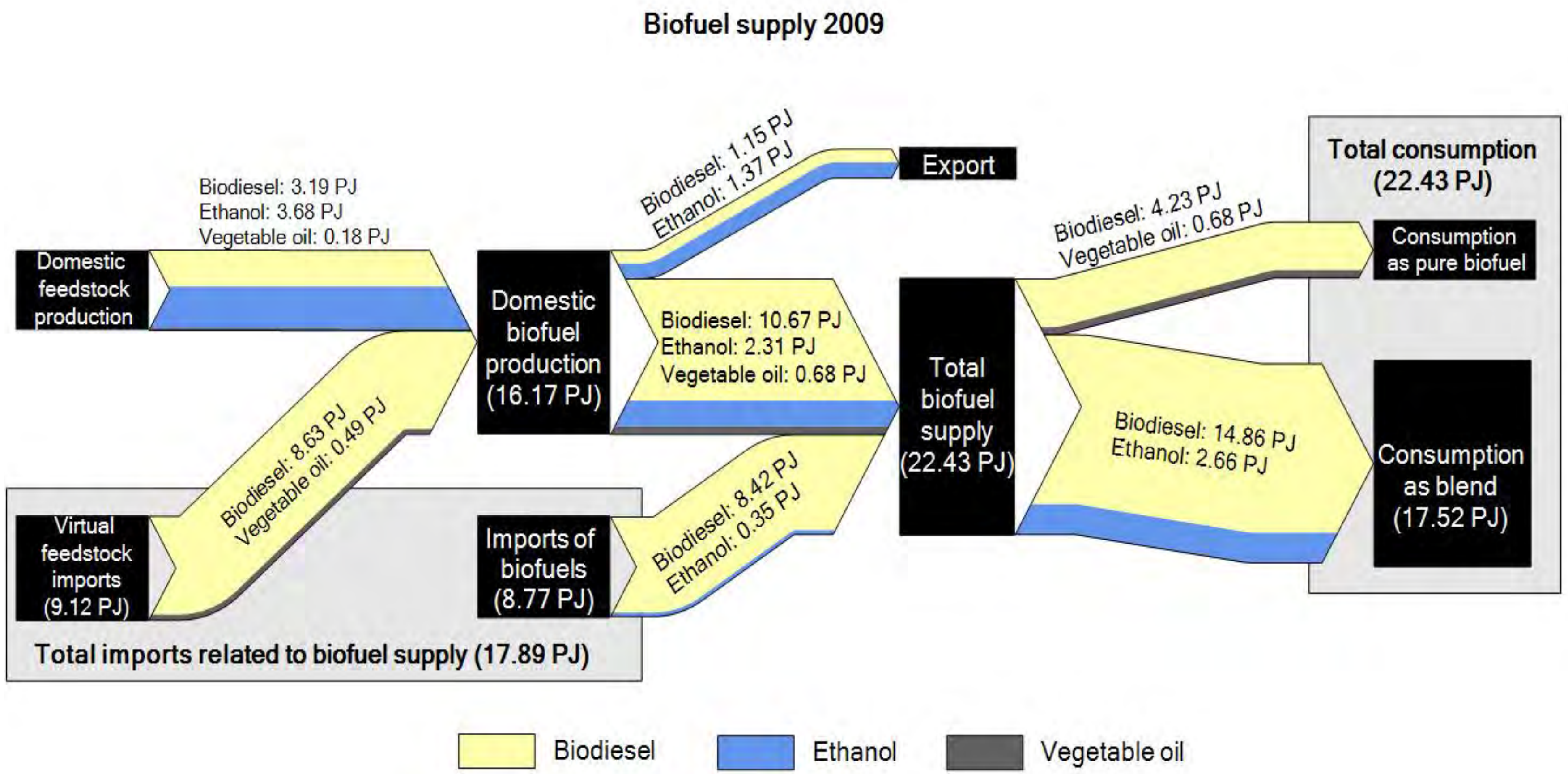
Quelle: Lamers, 2011

Bioethanol Importe und Exporte, Österreich



Quelle: Kalt (2011), based on Winter (2011), Statistik Austria (2011c)

Biofuel Bilanz, Österreich 2009



Quelle: Winter (2010), Statistik Austria(2011), Statistik Austria(2012), eigene Berechnungen und Darstellung

Biomasse-Ströme (2): Kraftstoffe

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- Zunehmende Importabhängigkeit Europas bei Biodiesel und Bioethanol
- In Österreich Importabhänigkeit v.a. bei Biodiesel

Fazit

- Biomasse-Aufbringung und Nutzung weist bereits derzeit z.T. signifikante internationale Verflechtungen auf, sowohl im energetischen als auch nicht-energetischen Bereich.
- Der internationale Handel mit Biomasse für nicht-energetische Zwecke überwiegt deutlich.
- Hohe Steigerungsraten beim Handel mit Bioenergie
- Die Charakteristika und das Verhältnis zu etablierten (nicht-energetischen) Handels-Strömen sind zwischen den verschiedenen Bioenergie-Sektoren sehr unterschiedlich.
- V.a. bei first generation biofuels derzeit schon eine ausgeprägte Importabhängigkeit der EU gegeben.
- Auch Österreich ist bereits derzeit stark in den internationalen Biomasse-Handel eingebunden, v.a. für nicht-energetische Zwecke und zunehmend auch für energetische Zwecke.

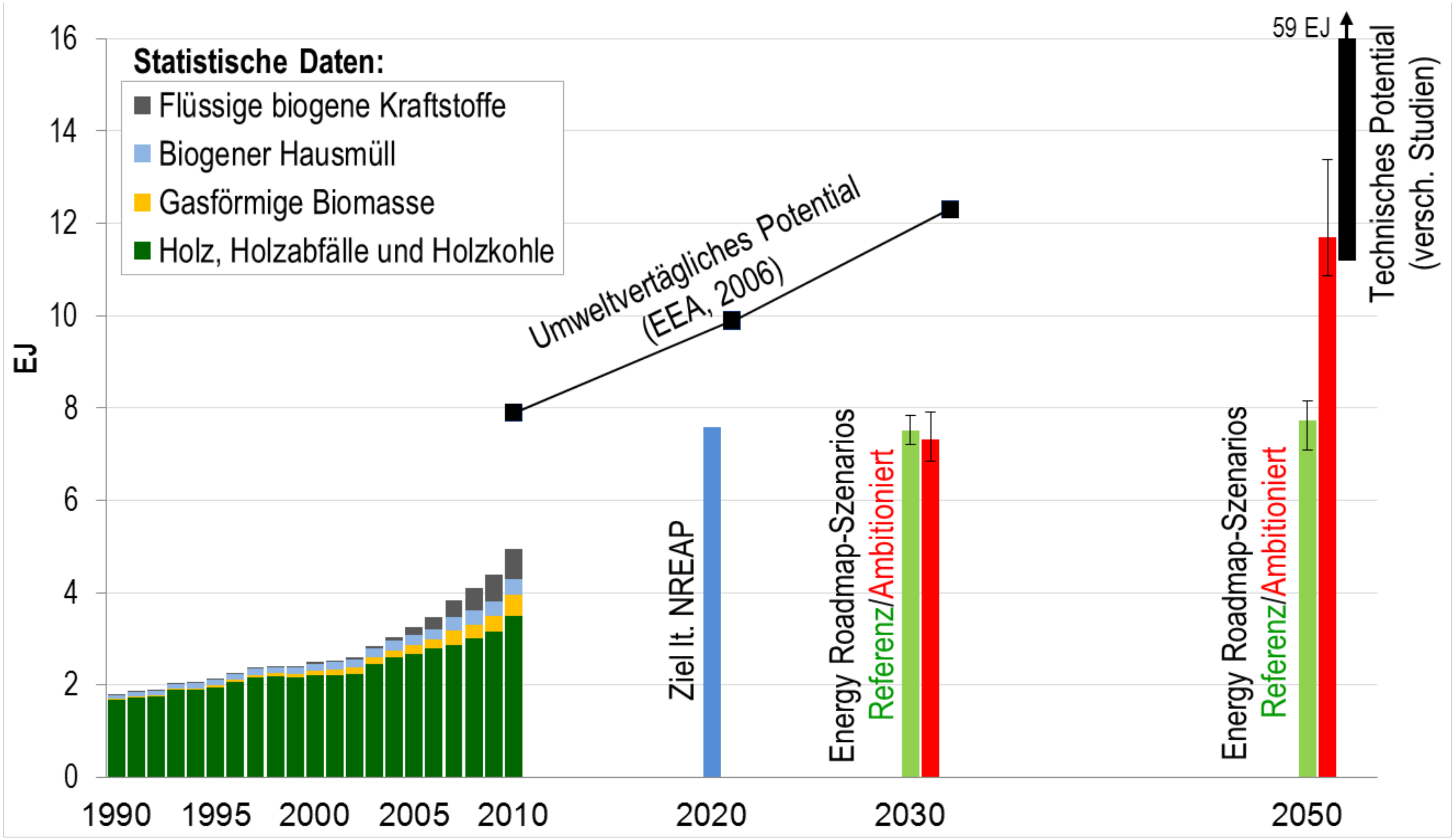
Fragestellungen

- Welche Herausforderungen stellen sich für eine nachhaltige Nutzung von Bioenergie angesichts globaler und europäischer Verflechtungen von Biomassemärkten?

- Wie stellen sich diese Verflechtungen derzeit dar und welche Perspektiven ergeben sich für die Zukunft?

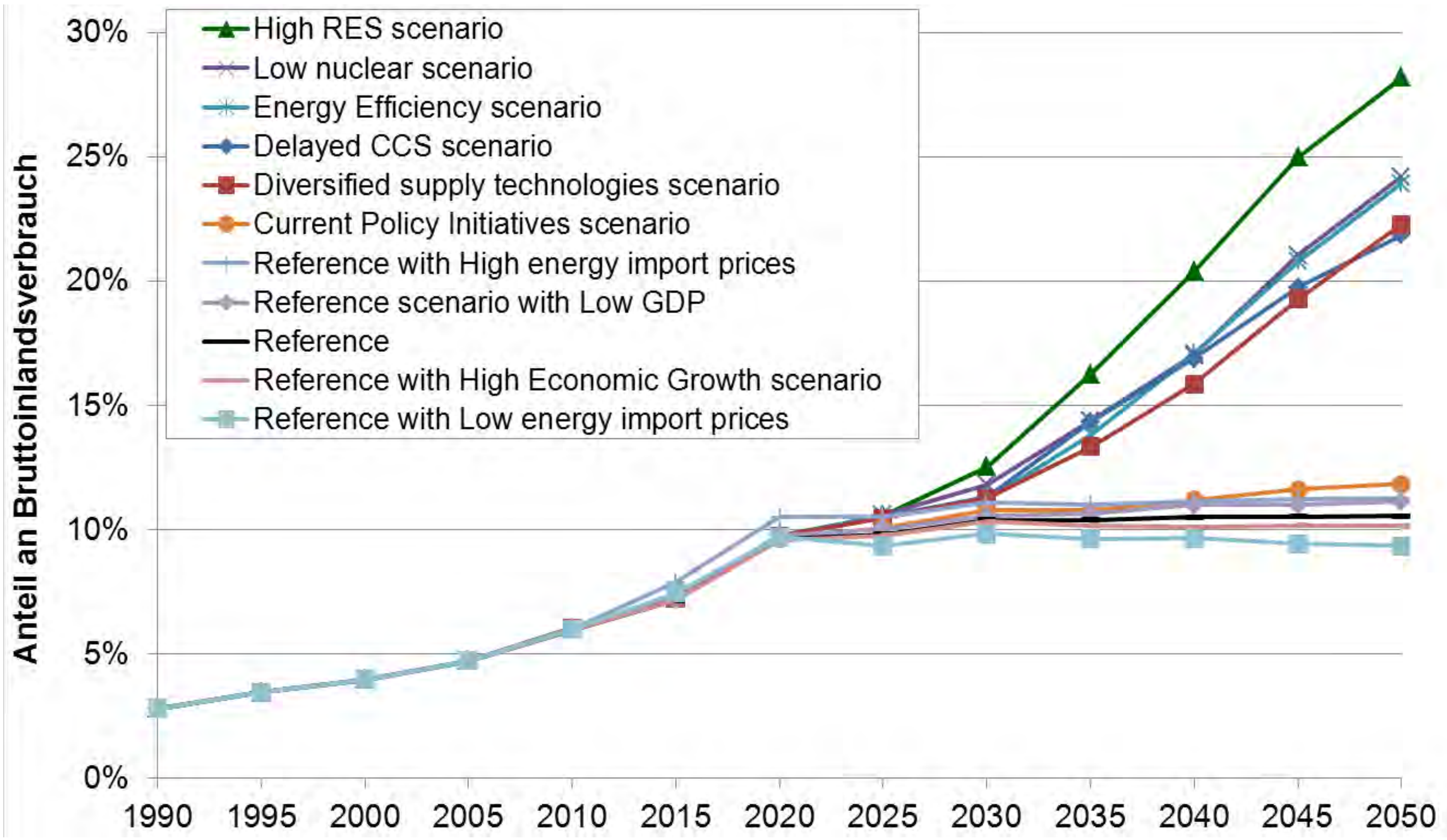
Szenarien

Perspektive der Bioenergie in EU



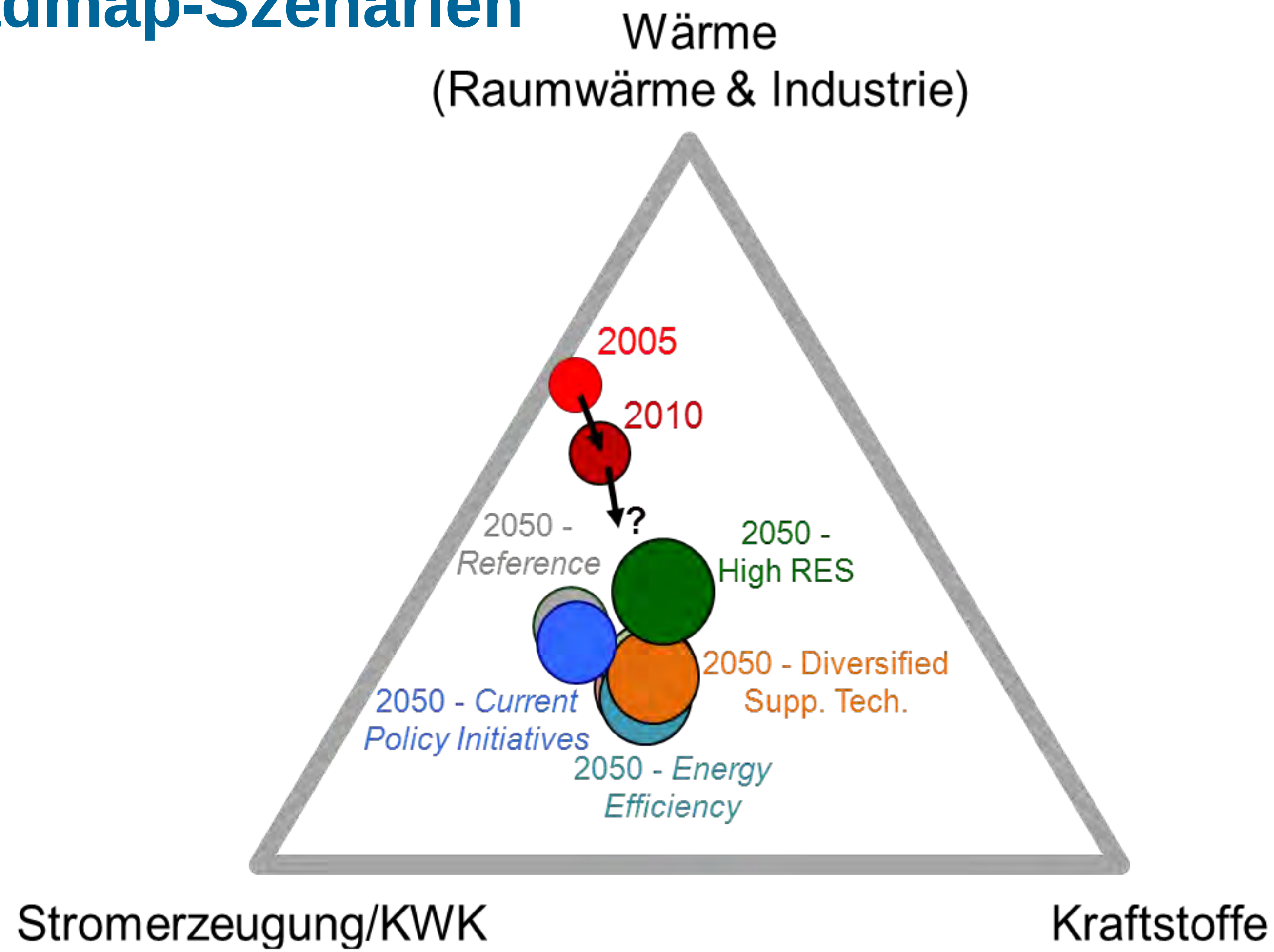
Quelle: Eurostat 2011), (Szabó et al. 2011), (EEA 2006), (European Commission 2011a), (Helmut Haberl et al. 2010), (Smeets et al. 2007), eigene Berechnungen und Darstellung

Anteil Biomasse in „Roadmap“ - Szenarien EU-27



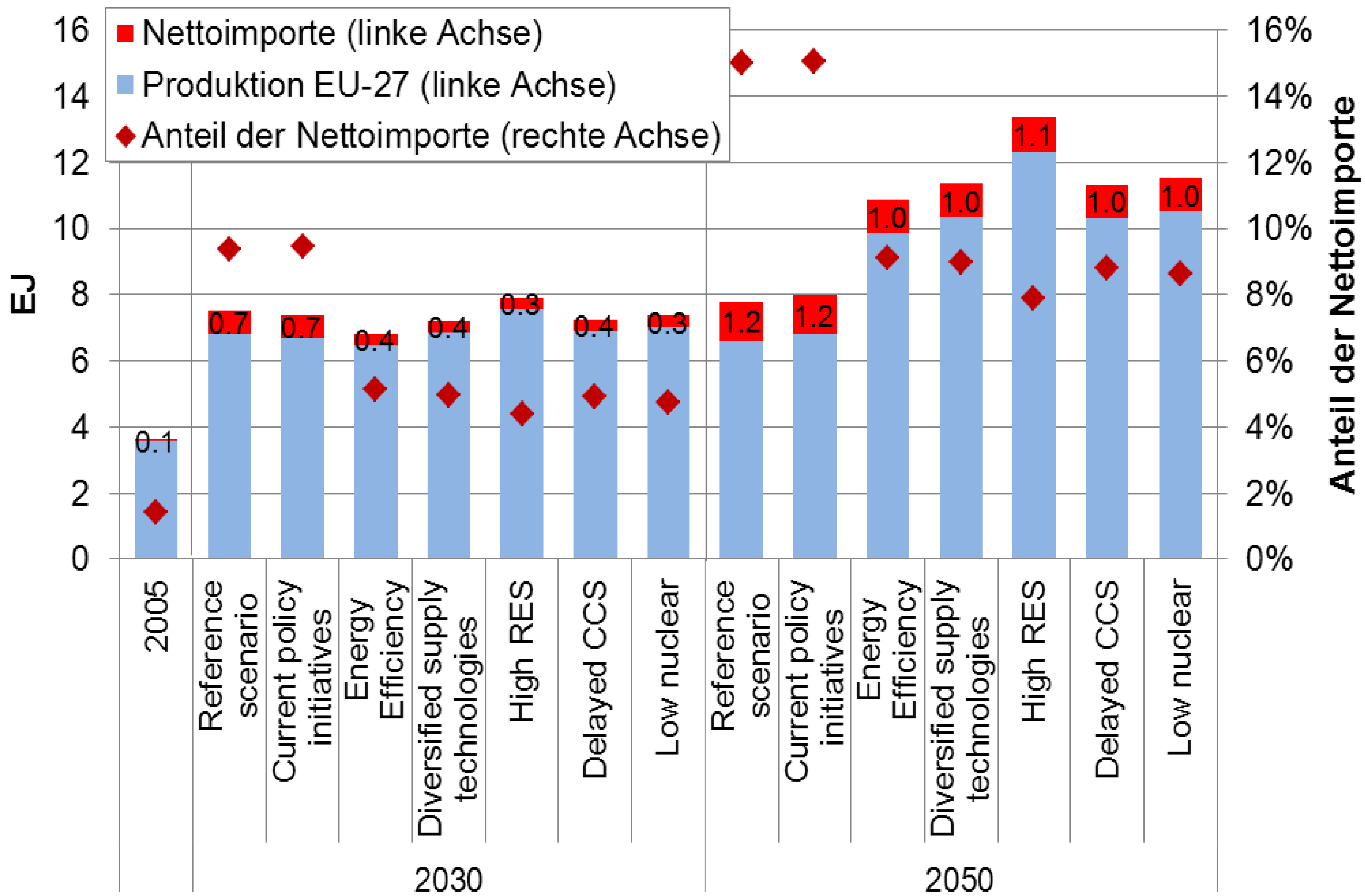
Quelle: European Commission 2011a

Struktur der Biomasse nach Nutzungsarten in Roadmap-Szenarien



Quelle: (Eurostat 2011), (European Commission 2011a), eigene Berechnungen und Darstellung

Biomasse-Aufkommen in Roadmap-Szenarien



Quelle: (European Commission 2011a), eigene Berechnungen und Darstellung

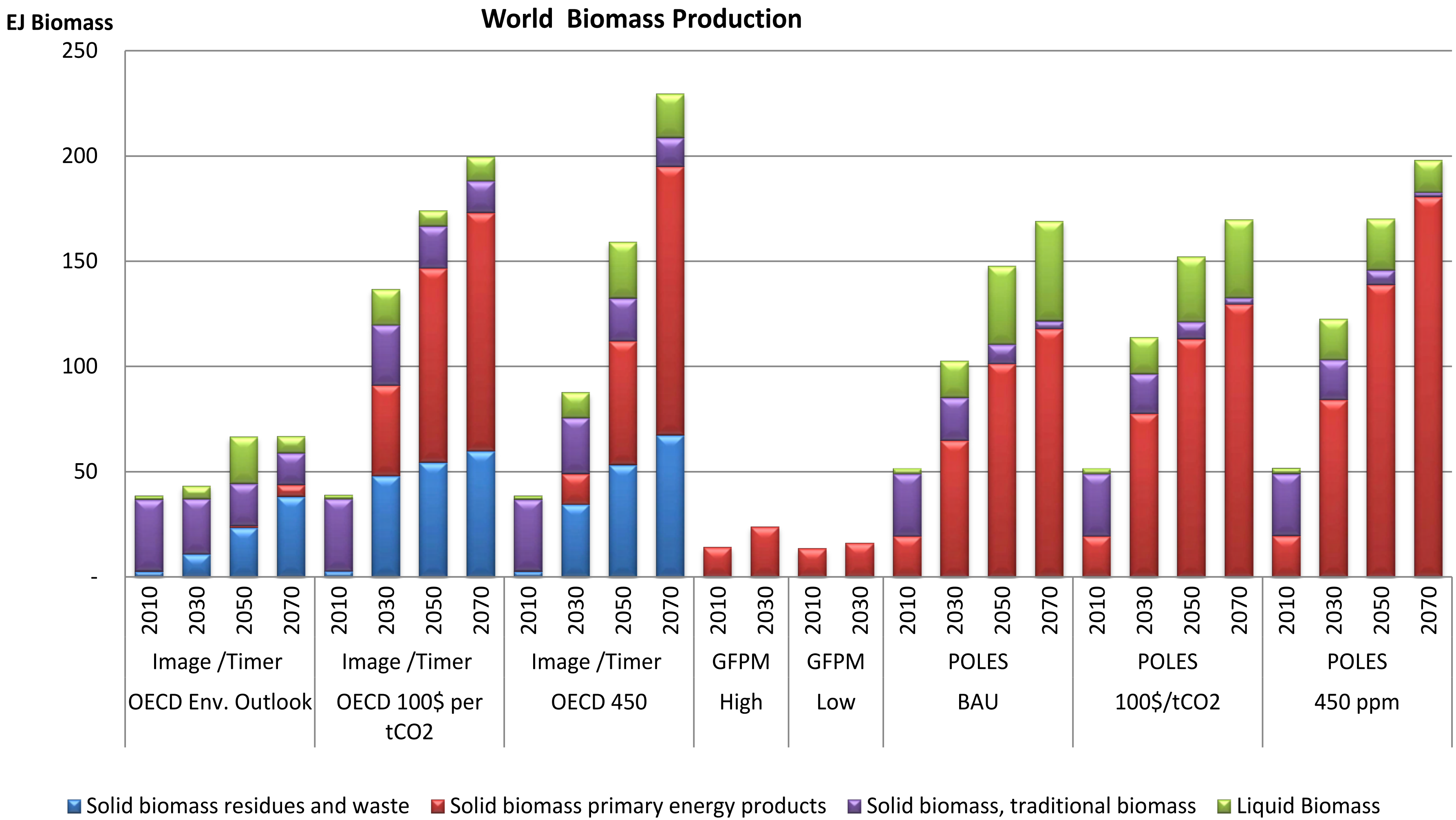
Globale Szenarien Bioenergiehandel

Ausgewählte Szenarien

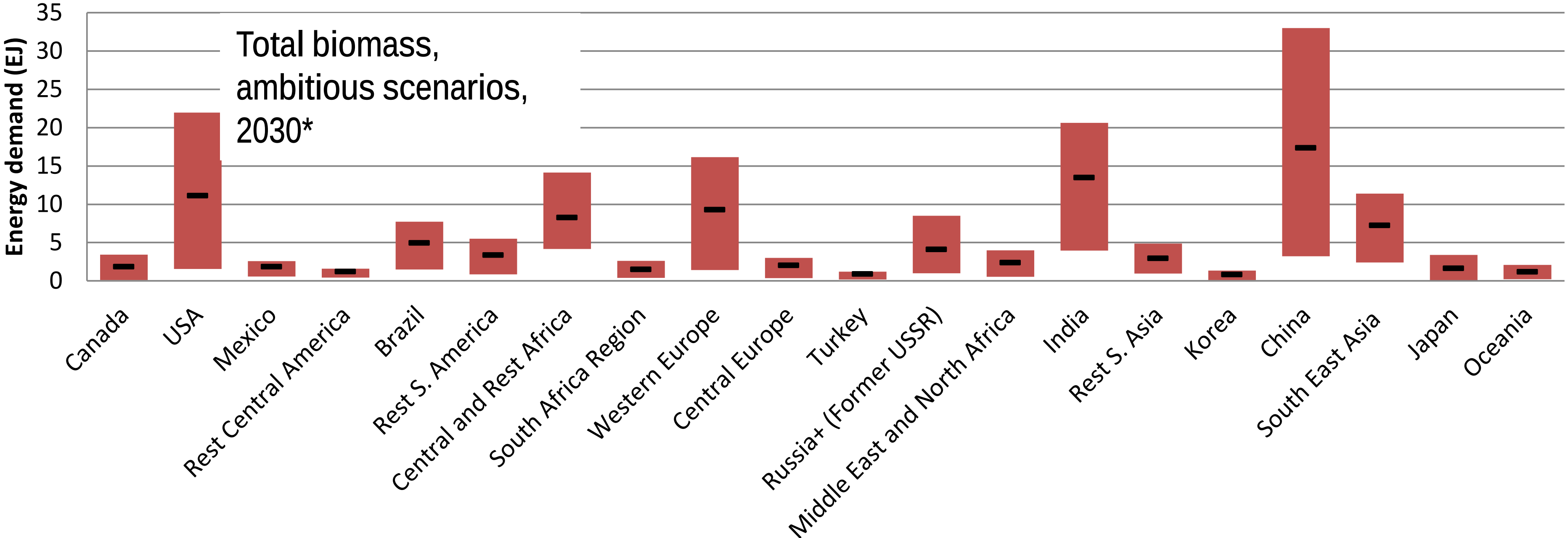
- Ambitionierte Bioenergie-Szenarien
  - TIMER: OECD 450 ppm scenario, OECD 100$ per t CO2 scenario
  - POLES based on EMF scenarios: 450 ppm, 100$ per t CO2
  - GFPM: high

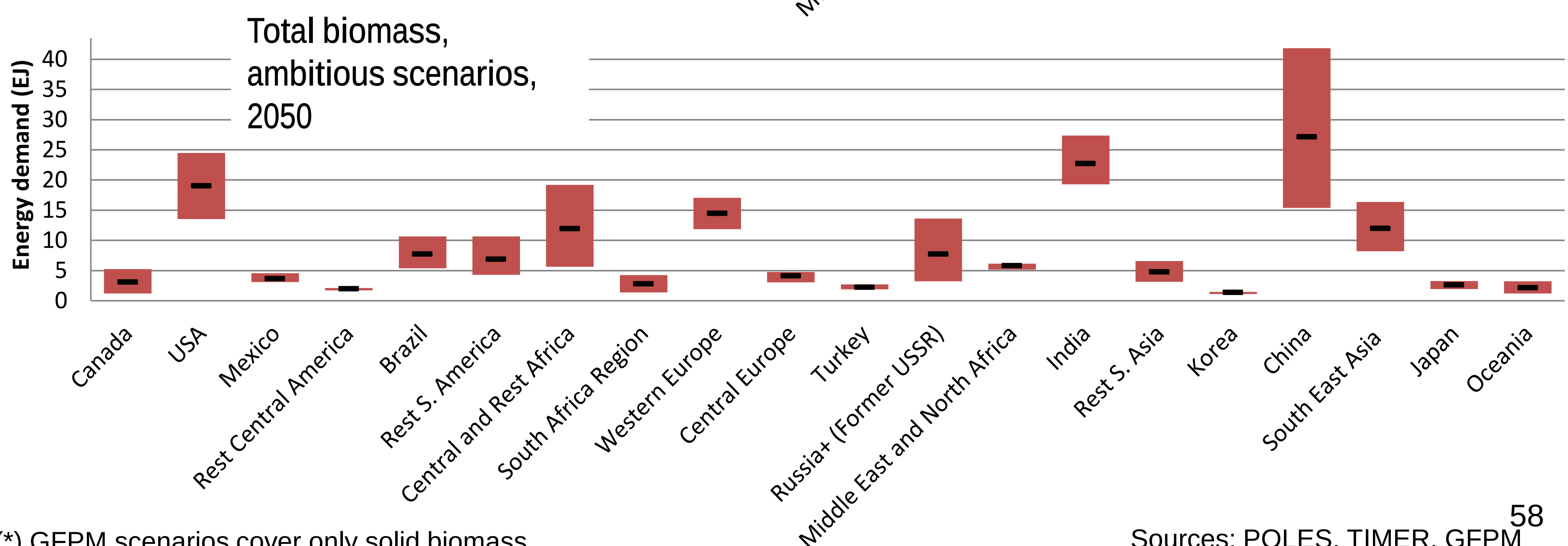
- Moderate Bioenergie-Szenarien
  - TIMER: OECD environmental outlook, OECD EO trade barriers, OECD 650 ppm, OECD 20$ per t CO2
  - POLES: based on EMF scenarios G1 Reference, G4 BAU, BAU+trade barriers, 650 ppm, 20$ per t CO2
  - GFPM: low

Bioenergie Produktion in ausgewählten Szenarien



Bioenergie-Nachfrage





(*) GFPM scenarios cover only solid biomass

Sources: POLES, TIMER, GFPM

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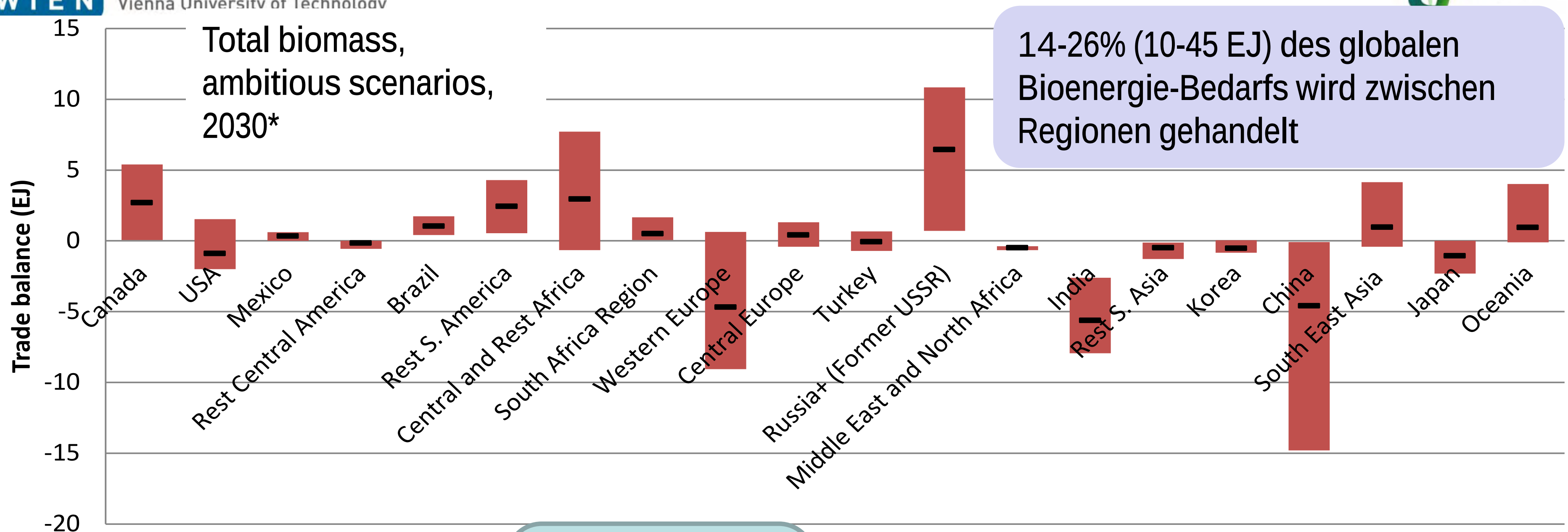
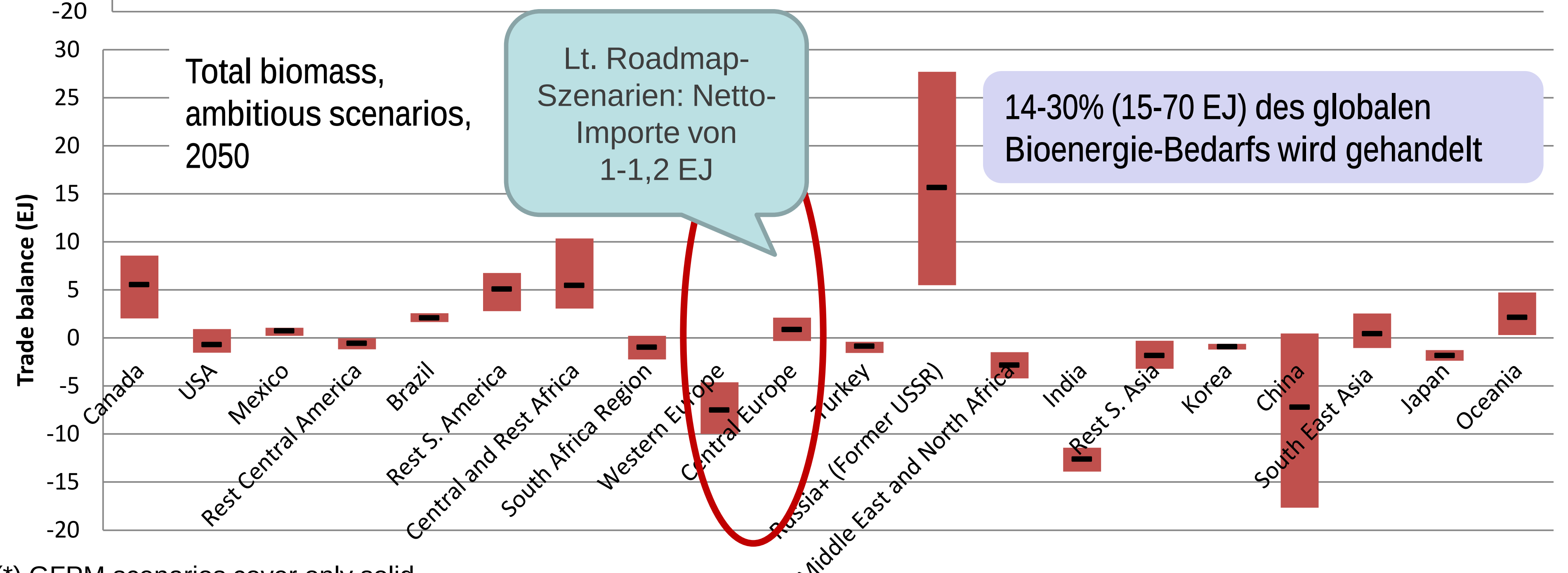
Bioenergie-Handelsbilanz





(*) GFPM scenarios cover only solid

Fazit

- Modelle zeigen deutliche Steigerungsraten von internationalem (und interkontinentalem!) Bioenergie-Strömen, wenn Bioenergie zukünftig höhere Anteil am gesamten Energiebedarf einnehmen soll.
- Die Modellierung des Bioenergiehandels lässt noch viele Fragen offen.
- Zukünftige nachhaltige Bereitstellung von Bioenergie wird zentrale Herausforderung!

Fragestellungen

- Welche Herausforderungen stellen sich für eine nachhaltige Nutzung von Bioenergie angesichts globaler und europäischer Verflechtungen von Biomassemärkten?

- Welche Herausforderungen ergeben sich für eine mögliche zukünftige „bio-based economy“?

Technology Gaps bei der Erreichung der Klimaziele 2050:

Bioenergie-Technologien, Ressourcen und Nachhaltigkeit

Nachhaltigkeitskriterien und Zertifizierung von Biomasse

Lukas Kranzl

Gerald Kalt

Julian Matzenberger

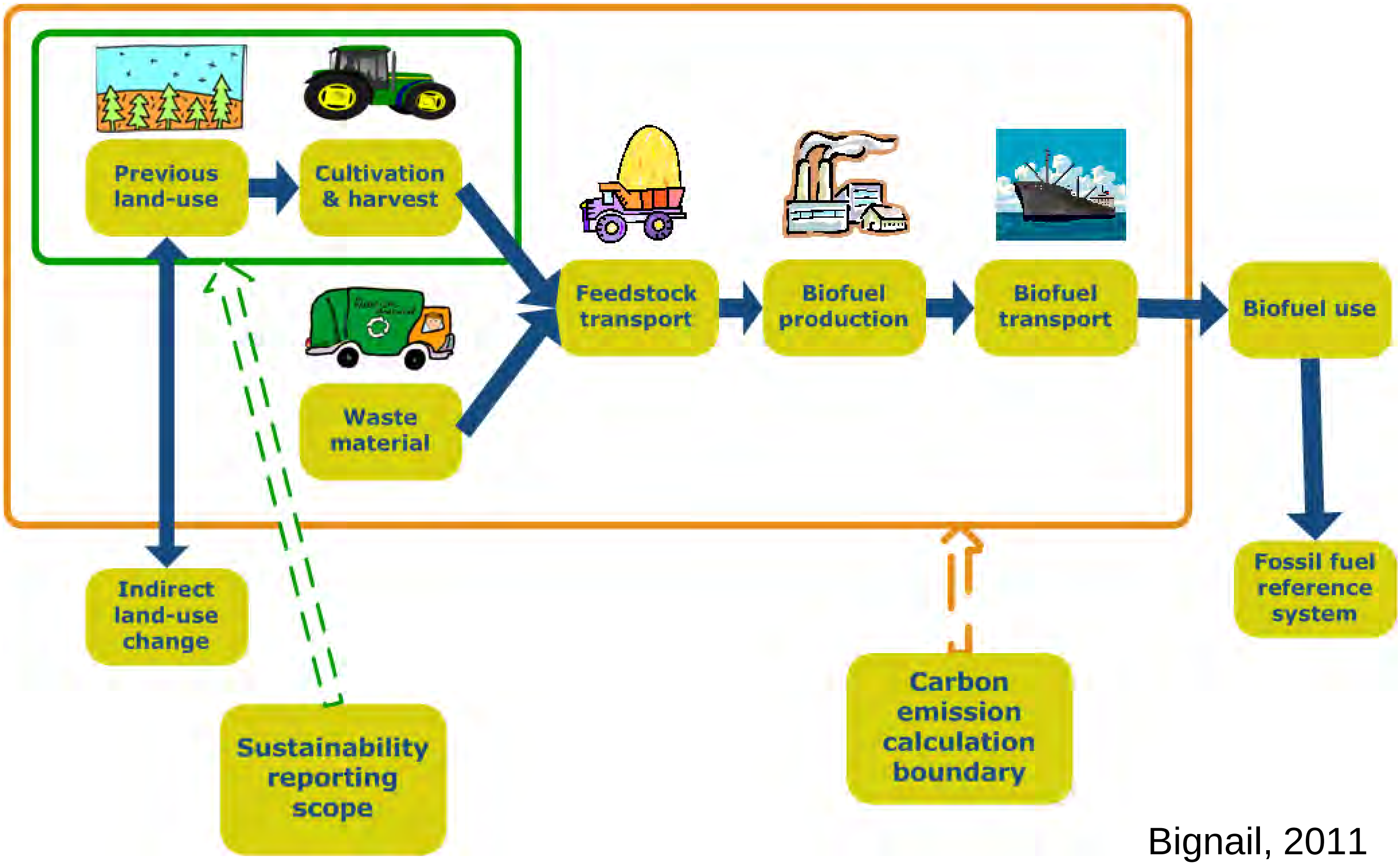
Katharina Zwiauer

Die Erneuerbare Energien Richtline (2009/28/EC)

- Nachhaltigkeitskriterien für „Biobrennstoffe"
  - Reduktion der TGH-Emissionen um 35% (50%-60% von 2017/18) zu berechnen mit einer LCA Methodik
  - Keine Nutzungsänderung von Flächen mit hohem C-Gehalt
  - Keine Rohstoffe von Flächen hoher Biodiversität
  - Rohstoffe aus LaWi Produktion müssen der „guten landwirtschaftlichen Praxis" entsprechen

- Rückverfolgbarkeit der zertifizierten Rohstoffe über die gesamte Lieferkette
  - es muss von den Marktteilnehmern ein Massenbilanzsystem verwendet werden.

Systemgrenzen der Zertifizierung nach RED



Bignail, 2011

Berechnung der THG

E = eec + el + ep + etd + eu – esca – eccs – eccr – eee

E = Gesamtemissionen bei der Verwendung des Kraftstoffs;

eec = Emissionen bei der Gewinnung oder beim Anbau der Rohstoffe;

el = jährliche Emissionen aufgrund von C-bestandsänderungen infolge von LUC

ep = Emissionen bei der Verarbeitung;

etd = Emissionen bei Transport und Vertrieb;

eu = Emissionen bei der Nutzung des Kraftstoffs;

esca= Emissionseinsparung durch Akkumulierung von Kohlenstoff im Boden infolge besserer landwirtschaftlicher Bewirtschaftungspraktiken;

eccs = Emissionseinsparung durch Abscheidung und geologische Speicherung von Kohlendioxid;

eccr = Emissionseinsparung durch Abscheidung und Ersetzung von Kohlendioxid und

eee = Emissionseinsparung durch überschüssige Elektrizität aus KWK

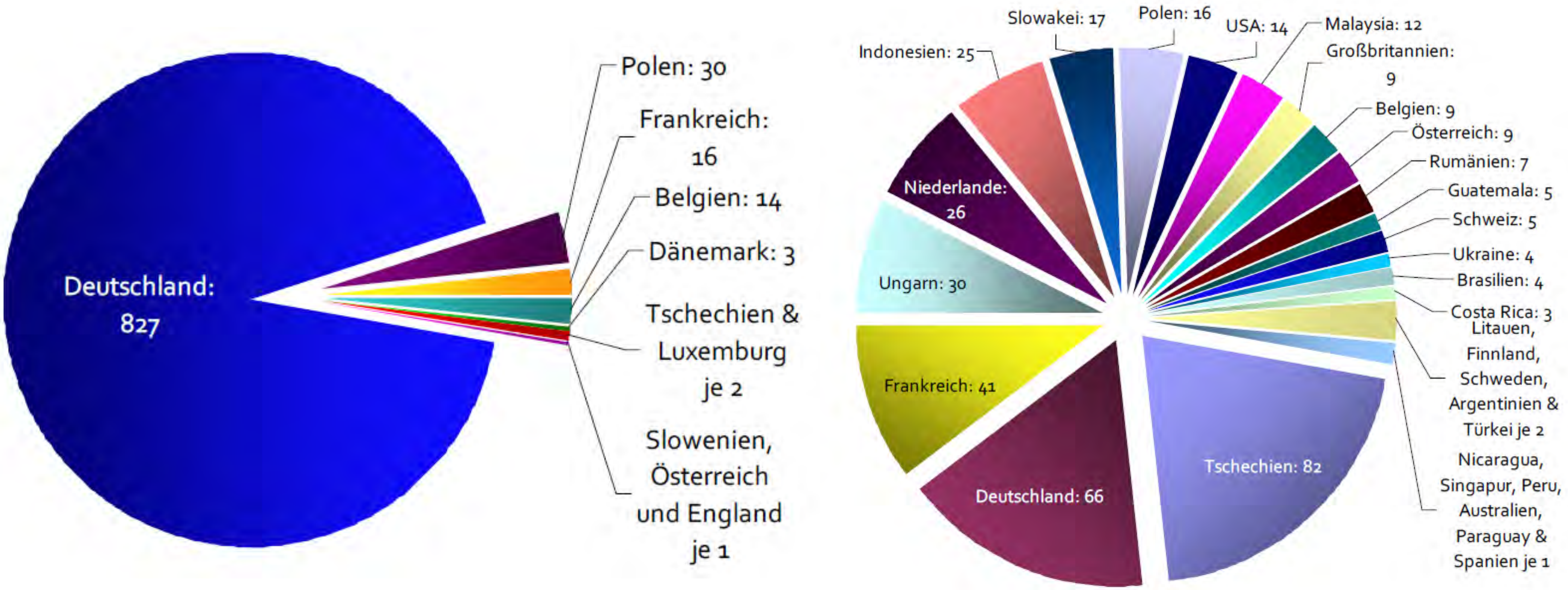
Freiwillige Zertifizierungsysteme („voluntary schemes“)

1. ISCC (Deutsche Initiative, staatlich finanziert, für alle Biotreibstoffe)
2. Bonsucro EU (Roundtable Initiative für Zuckerrohr basierte Biotreibstoffe, mit Fokus auf Brasilien)
3. RTRS EU RED (Roundtable Initiative für Soya-basierte Treibstoffe, Focus auf Argentinien und Brasilien);
4. RSB EU RED (Roundtable Initiative für alle Arten von Biotreibstoffen);
5. 2BSvs (Initiative der französischen Industrie, für alle Arten von Biotreibstoffen);
6. RBSA (Initiative des Unternehmens Abengoa, global, alle Arten)
7. Greenergy (Initiative des Unternehmens Greenergy; für Ethanol aus Zuckerrohr aus Brasilien)
8. Ensus (Initiative des Unternehmens Ensus; für Bioethanol)
9. Red Tractor (britische Initiative, Red Tractor Farm Assurance Combinable Crops & Sugar Beet Initiative)
10. SQC (britische Initiative, Scottish Quality Farm Assured Combinable Crops (SQC) Initiative)
11. Red Cert
12. NTA8080 (niederländische Initiative)
13. RSPO RED (Roundtable on Sustainable Palm Oil RED)

ISCC - Nachhaltigkeitsprinzipien

1. Biomasse wird nicht in artenreichen Gebieten, kohlenstoffreichen Böden oder Torfmooren gewonnen
   - Gebiete mit hohem Naturschutzwert werden geschützt
2. Biomasse wird auf umweltbewusste Weise produziert.
   - Schutz von Boden, Wasser und Luft und die Anwendung einer guten Agrarpraxis (GAP)
3. Sichere Arbeitsbedingungen durch Schulung und Ausbildung, Verwendung von Schutzkleidung und Angemessene und schnelle Hilfeleistung bei Unfällen
4. Die Erzeugung von Biomasse verstößt nicht gegen Menschenrechte, Arbeitsrecht oder Landnutzungsrecht.
   - Die Produktionsweise fördert verantwortungsbewusste Arbeitsbedingungen, Gesundheit, Sicherheit und Wohlstand der Arbeitskräfte und basiert auf guten Beziehungen zur Gesellschaft.
5. Die Erzeugung von Biomasse steht im Einklang mit der regionalen und nationalen Gesetzgebung und entspricht den maßgeblichen internationalen Verträgen
6. Gute Managementpraktiken müssen angewendet werden

Verbreitung REDCert – ISCC



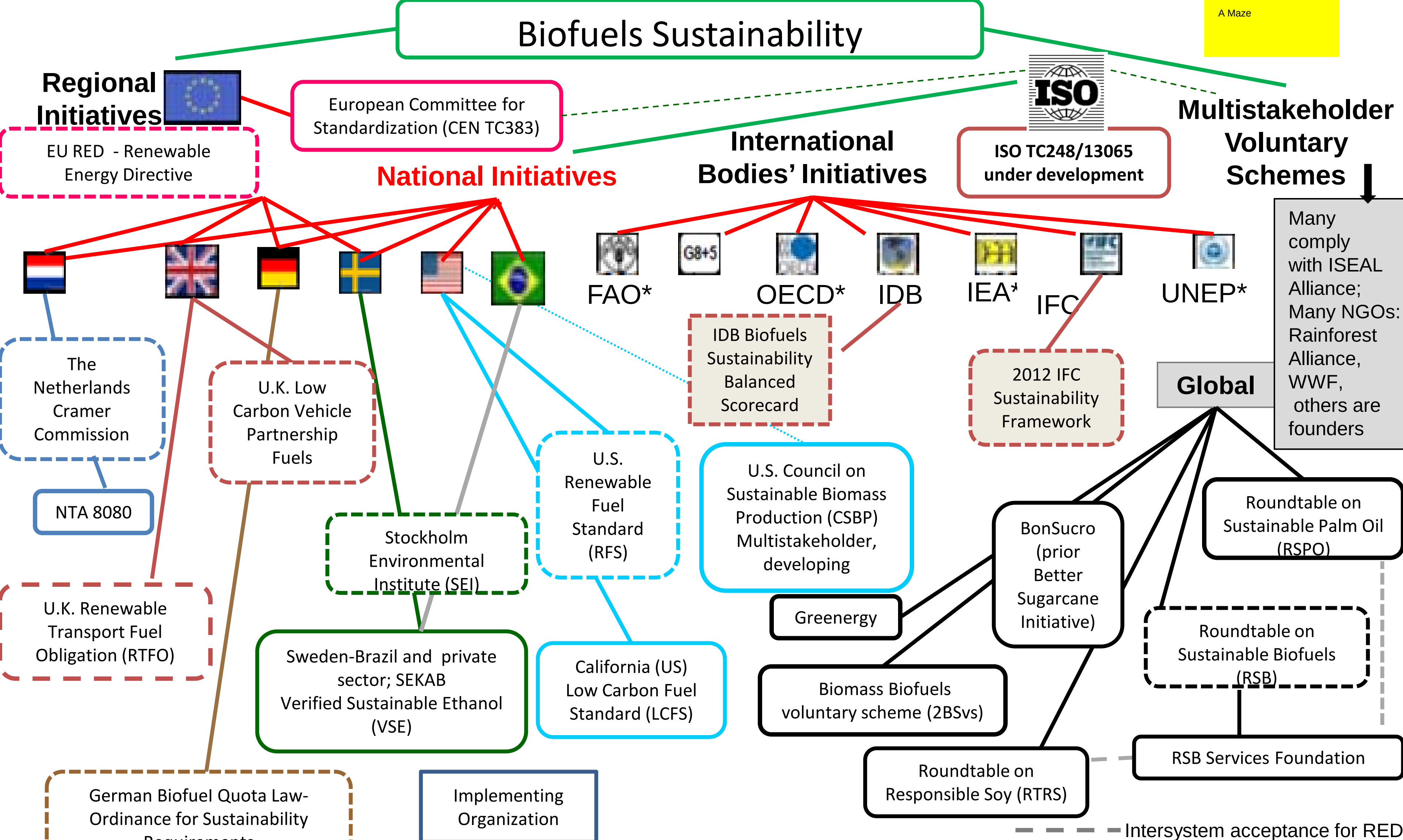
Anzahl der im REDCert (links) und ISCC System (rechts) vergebene Zertifikate und Konformitätsbescheinigungen sortiert nach Ländern (Bücheler, Dez. 2011)

RSB – Nachaltigkeitsprinzipien

1. Legalität
2. Planung, Monitoring und kontinuierliche Verbesserung
3. Treibhausgasemmissionen
4. Menschen- und Arbeitsrechte
5. Ländliche- und Soziale Entwicklung
6. Ernährungssicherheit
7. Umweltschutz
8. Boden
9. Wasser
10. Luft
11. Verwendung von Technlologie, Materialinmut Managementpraktiken
12. Landrechte

GBEP - 24 Indikatoren

INDICATORS		
1. Lifecycle GHG emissions	9. Allocation and tenure of land for new bioenergy production	17. Productivity
2. Soil quality	10. Price and supply of a national food basket	18. Net energy balance
3. Harvest levels of wood resources	11. Change in income	19. Gross value added
4. Emissions of non-GHG air pollutants, including air toxics	12. Jobs in the bioenergy sector	20. Change in consumption of fossil fuels and traditional use of biomass
5. Water use and efficiency	13. Change in unpaid time spent by women and children collecting biomass	21. Training and requalification of the workforce
6. Water quality	14. Bioenergy used to expand access to modern energy services	22. Energy diversity
7. Biological diversity in the landscape	15. Change in mortality and burden of disease attributable to indoor smoke	23. Infrastructure and logistics for distribution of bioenergy
8. Land use and land-use change related to bioenergy feedstock production	16. Incidence of occupational injury, illness and fatalities	24. Capacity and flexibility of use of bioenergy



***Enabling entities**

IEA Bioenergy tasks (multiple countries) LCA methodologies and sustainability expertise

Global Bioenergy Partnership (GBEP) 2011: Sustainability themes and indicators

FAO- Germany: 2012 Bioenergy and Food Security Criteria and Indicators (BEFSCI) tools

* Australia has a Subnational, NSW

Source: NREL (Chum, Warner), UNICA

Zertifizierungsysteme - Nachhaltigkeitsprinzipen

Table 7
Indication of variety of environmental topics included in standards apart from 5.1 to 5.3. • Included as principle, ○ mentioned explicitly in criteria or included as separate criterion, and – not mentioned.

Topics:	EC-RED	US-RFS	NTA 8080	UK-RTFO	RSB	RSPO	RTRS	BSI	ISCC	SAN	Global-GAP	IFOAM	FSC
Good (farming) practices	•	–	○	○	•	•	•	•	–	•	○	•	○
Waste	–[b]	–	○	○	○	○	○	○	–	•	•	○	○
Air	–[b]	–	•	•	•	○	–	○	–	–	○	○	–
Fire	–[b]	–	○	–	○	○	–	–	–	○	○	○	○
GMO	–[b]	–	–	–	○	○	–	○[c]	–	–	○	•	○
Pesticide management	–[b]	–	○	○	○	○	○	○	•	○	•	•	○
No invasive species	–[b]	–	–	–	○	○	–	–	–	–	–	•	○
Hygiene, quality product[a]	–[b]	–	–	–	–	–	–	○[d]	–	–	•	○	–

[a] Not referring to safety and hygienic conditions for employers.
[b] *Note*: regulation on good farming practices refers to EU regulations which include various environmental topics.
[c] To be discussed in mitigation plan.
[d] Criterion: "To continuously improve the quality of sugarcane and products from the sugar mill".

Umsetzung von Nachhaltigkeitskriterien in nationalem Recht von Drittstaaten

	Impacts on protected areas	Clearing of forests	Impacts on threatened species	Conversion of wetlands	Conversion of grasslands	Drainage of peatlands
Asia	+	+	- - -	- - -	- - -	- - -
America	+ + +	+ + +		- - -	- - -	- - -
Africa	+ +			- -	- - -	- - -

Erfassung der RED Nachhaltigkeitskriterien in nationalem Recht – globaler Überblick (Englund et al. 2011)

Umsetzung von Nachhaltigteiskriterien in nationalem Recht von Drittstaaten

	Social sustainability	Land-use	Water	Bio-diversity	Soil	Ecosystem services	Carbon stock	Air	GHG emissions
Asia	+ + +	+ +	+			-	-	- - -	- - -
America	+ + +	+ + +	+ + +	+ +	+		-	-	- - -
Africa	+ + +	+	+ +			-	-	- - -	- - -

Erfassung erweiterter (nicht durch die RED erfasst) Nachhaltigkeitskriterien in nationalem Recht – globaler Überblick (Englund et al. 2011)

Kosten der Zertifizierung

REDcert

Gebührenart	Höhe (in €)	Gebühr fällig für
Grundgebühr 1x p.a.	150	≤ 250t Umsatz/-produktion fester Biomasse
	200	≥ 250t Umsatz/-produktion fester Biomasse
	250	≥ 500t Umsatz/-produktion fester Biomasse
Staffelgebühr nach Standortanzahl	50	1.-3. Standort
	45	4.-10. Standort
	40	11.-20. Standort
	35	21.-50. Standort
	30	51.-100. Standort
	25	ab 101. Standort
Einmalige Registraturgebühr	-	
Zertifikatgebühr	-	
Mengenabhängige Gebühr pro t Biomasse	0,027	Ethanol
	0,035	Pflanzenöl/FAME
	0,05	Biomethan

ISCC

Gebührenart	Höhe (in €)	Gebühr fällig für	
Freiwilliger Mitgliedsbeitrag 1x p.a.	500	< 10 Mio. € Umsatz	
	1.000	10-50 Mio. Umsatz	
	2.000	50-250 Mio. Umsatz	
	3.000	≥ 250 Mio. Umsatz	
Staffelgebühr nach Standortanzahl	-		
Einmalige Registraturgebühr		Ersterfasser (t/a)	Schnittstellen Umsatz (€/a)
	50	< 2.000	< 600.000
	100	< 10.000	< 3.000.000
	150	< 50.000	< 15.000.000
	200	< 100.000	< 30.000.000
	250	< 200.000	< 60.000.000
	300	< 500.000	< 150.000.000
	500	> 500.000	> 150.000.000
Zertifikatgebühr		Ersterfasser (t/a)	Schnittstellen Umsatz (€/a)
	50	< 2.000	< 600.000
	100	< 10.000	< 3.000.000
	150	< 50.000	< 15.000.000
	200	< 100.000	< 30.000.000
	250	< 200.000	< 60.000.000
	300	< 500.000	< 150.000.000
	500	> 500.000	> 150.000.000
Mengenabhängige Gebühr pro t Biomasse	0,02	ISCC Mitglieder	Ersterfasser und Lagerhäuser zahlen keine Mengenabhängige Gebühr
	0,03	Nicht ISCC Mitglieder	

Kosten der Zertifizierung

Klein Unternehmer (Umsatz < 250t feste Biomasse und < 10Mio €)
- erstmalige Registrierung + Überwachung
    - 5.000t Weizen

→ Gesamtkosten der Zertifizierung durch die AMA: 750,-- EUR
→15 ct/t Weizen

Preis Premiumweizen Q4 2012 ~ 260 €/t
~ 0,06% Zertifizierungskosten für Landwirte

Vgl. Smeets & Faaji 2009: „Loose Kriterien“ kein Einfluss auf Produktionskosten
„Strenge Kriterien“ +14% in Ukraine und +42% in Brasilien

Nachhaltigkeitskriterien für feste und gasförmige biogene Energieträger gemäß RED

- Derzeit keine verbindlichen Kriterien, Empfehlungen für:
  - Selbe Anforderungen an Biodiversität und Kohlenstoffgehalt wie für Biotreibstoffe
  - einheitliche THG Berechnungsmethodik, vergleichbar jener von Biotreibstoffen, mit angepassten Standartwerden
  - keine Berechnung der THG für Abfälle
  - Gültigkeit der Kriterien nur für Anlagen >1MW
  - eine Differenzierung von nationalen Förderinstrumenten für Anlagen die höhere Wirkungsgrade erzielen.

  (Inkrafttreten ab Mitte 2014 erwartet, Implementierung ~2016)

- EU Timber Regulation ab März 2013
  - Gegen Illegalen Holzeinschlag, dzt. keine weiteren Kriterien

Handlungsableitungen und Empfehlungen

- Diskriminierung der Nutzung von Biomasse für Biokraftstoffe kann zu einer Beeinträchtigung der Lieferbereitschaft führen
- Klare und übersichtliche Anforderungen an die Nachhaltigkeit nötig. Unsicherheit in den Märkten führt zu Stagnation.
  - Importländer von fester Biomasse haben begonnen eigene Zertifizierungssysteme zu entwickeln
  - Langfistige Verträge, jährliche Evaluierung der Standards
  - Zukünftige Anforderungen unsicher: iLUC , „carbon debt“
- Verwaltungsaufwand gering halten
  - Cross Compliance
  - „One-Stop-Shop“ -> EN oder ISO Norm als gemeinsamer Standard
- Einbeziehung von Endnutzung in die Kriterien

Technology Gaps bei der Erreichung der Klimaziele 2050:

Bioenergie-Technologien, Ressourcen und Nachhaltigkeit

Q & A

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Bioenergieproduktion und Landinvestitionen in Westafrika

Sierra Leone, ein Beispiel für „Landgrabbing“ oder eine verantwortungsvolle Investition?

Katharina Zwiauer

Workshop
Wien, 06. 12. 2012

Übersicht

Landvergaben in Afrika

Sierra Leone im Überblick

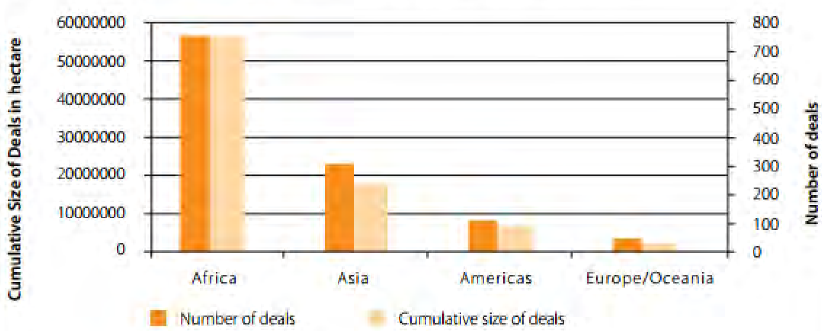
Landvergabepraktiken

„Projekt Addax“: Bioethanolproduktion in SL

Schlussfolgerungen

Landvergaben bis 2012

Figure 2: Land acquisitions by region, number of projects and size

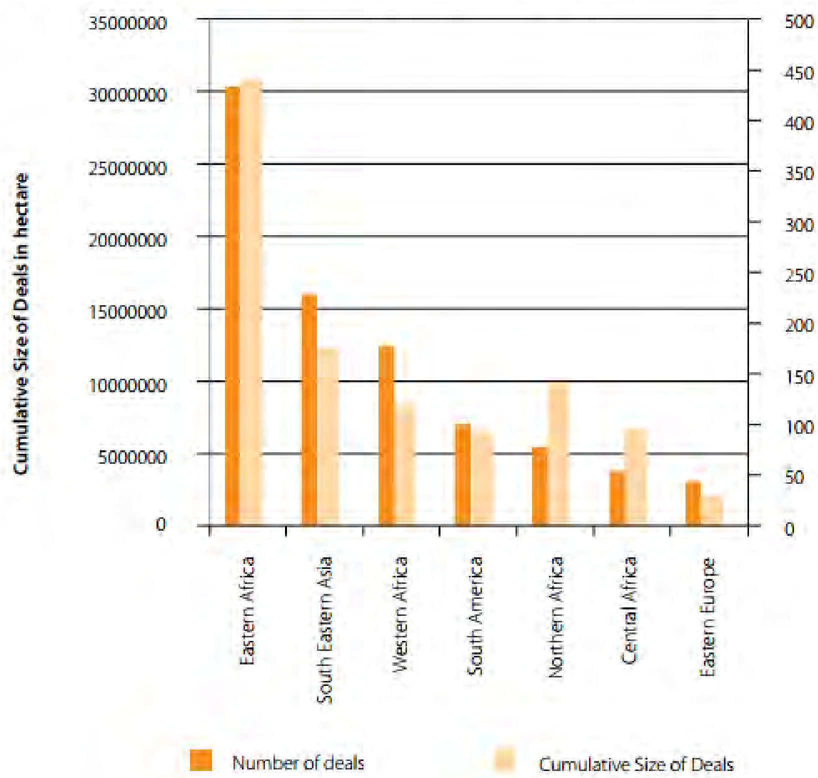


Source: Authors' calculations based on the Land Matrix.

Notes: N = 1217 for number of deals and N = 917 for cumulative size of deals

[2] Source: http://faostat.fao.org/

Figure 3: Land acquisitions by sub-region in Africa, number of projects and size



Quelle: http://landportal.info/landmatrix/media/img/analytical-report.pdf

Fallbeispiel Sierra Leone: Überblick

Politischer Hintergrund:

Kronkolonie und Protektorat
1961 Unabhängigkeit
1991-2002 Bürgerkrieg (Folge: alleinst. Frauen)
Präsidialrepublik

Gesellschaft:

5,7 Mio Einwohner, 9 Ethnien
70 % leben unter der nationalen Armutsgrenze von weniger als 2 US-$
70% der Jungen arbeitslos
64 % Analphabeten
Lebenserwartung: 50 Jahre
hohe Kindersterblichkeit

Diamanten, Gold, Bauxit, Mangan, Platin, Rutil (Titanoxid) Rhodium

Agrarsektor

5,4 Mio ha sind geeignet für landwirtschaftliche Nutzung

1 Mio Ackerland

80% leben von der Landwirtschaft,

Größe der Anbauflächen: 0,5-2ha

Bush fellow system (“slash-and-burn”)

Anbau-Perioden (1-3 y) mit einer 6-jährigen Brache

Fehlende Produktionsmittel:

Düngemittel / Kompost, Subventionen, Zugang zu Krediten, Zugang zu Märkten

Ernährungssicherheit

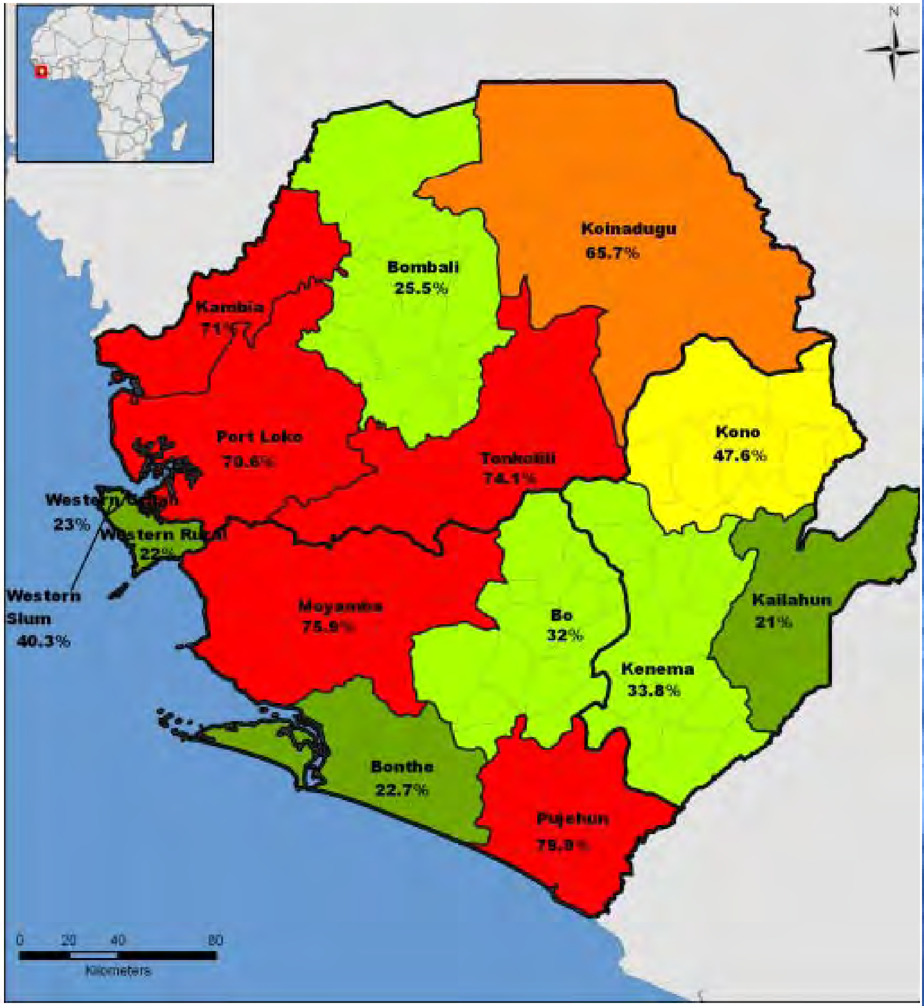
45% haben keinen ausreichenden Zugang zu Nahrungsmitteln

52% leihen regelmäßig Geld, um Lebensmittel zu kaufen

Saisonale Unsicherheiten: Juli/ August durch Überflutungen, **fehlende Transportmittel und Lagermöglichkeiten**

Reisanbau: 659 487 ha

Im D. Bombali werden auf 78311ha Reis angebaut



Quelle: WFP, Unicef

Werben um Ausländische Investitionen

Entscheidungsträger in Afrika

- Hohe Staatsverschuldung
- Stimulation der Landwirtschaft
- Diversifizierung der landwirtschaftlichen Produktion
- Erhöhung der Produktivität, Ernährungssicherheit
- Armutsbekämpfung, Schaffung von Arbeitsplätzen
- Lokale Wertschöpfung
- Verbesserung der Energieversorgung
- Verbesserung der Handelsbilanzen

Investoren

- Verfügbarkeit“ von Land (Mythos)
- Günstige klimatische Bedingungen
- Geringe bis keine Kosten für Landankauf
- Günstige Produktionsbedingungen
  - Niedrige Lohnkosten, schwache Umweltstandards, Steuerfreiheit
- hohe Renditen (risikobereinigt)

“Now is the Time to invest in Sierra Leone”

Steuerbegünstigungen:

- Investment Promotion Act, 2004
- Africa Investment Incentive Act, 2006

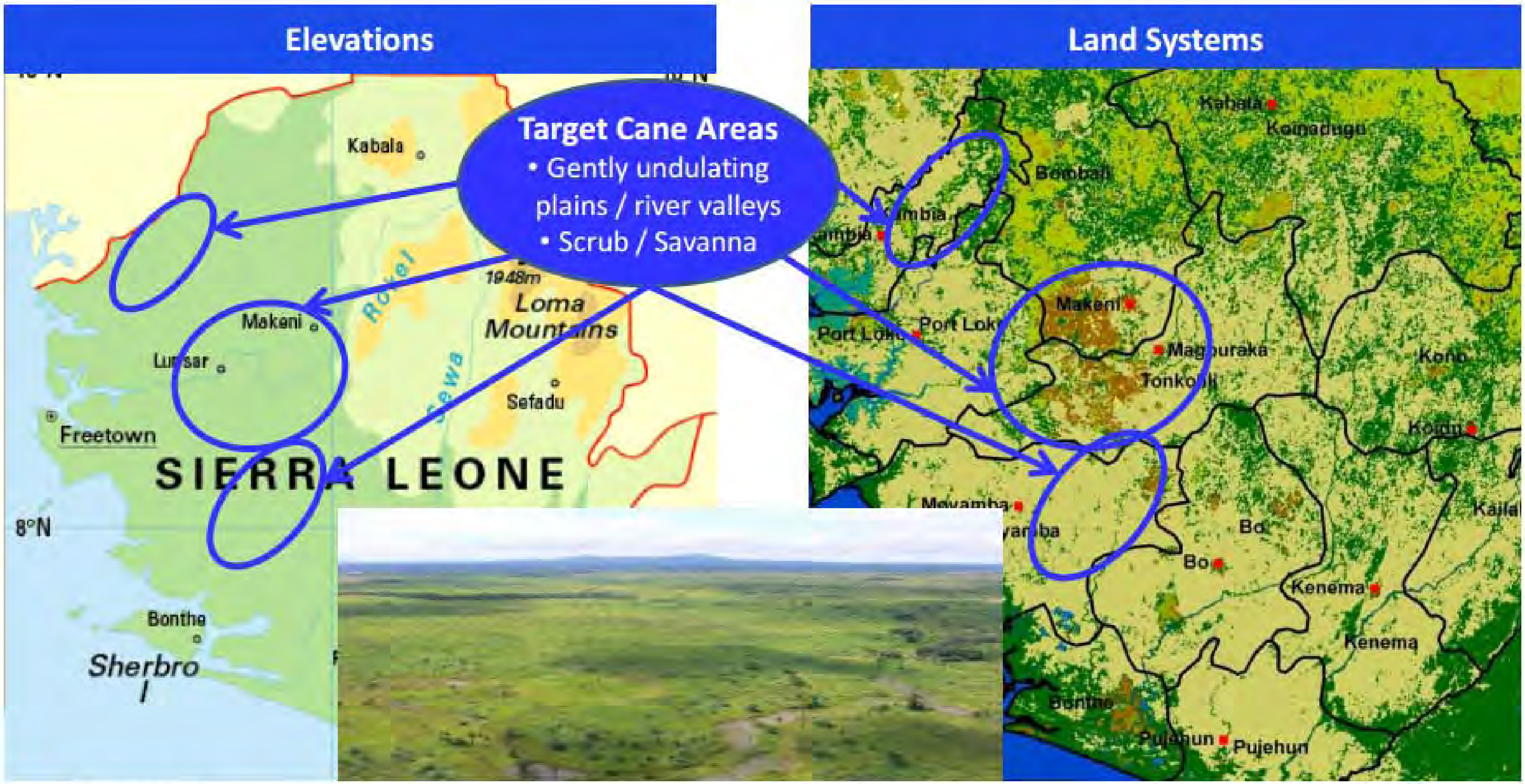
Sierra Leone has a duty-free access to lucrative markets (USA, EU and Asia)

- Foreign residents can easily establish employment in the Republic of Sierra Leone
- “Investors in agriculture also enjoy favourable tax rates: For example, investments in tree crops and rice are exempted from corporate income tax for the first 10 years.”

Produktionskosten:

- Leases on good land range from $5 to $20 per hectare per year; basic labor costs of $2-3 per day;

Target areas for cane have moderate elevations & open land systems



>1,500 M	500 – 1,000 M	Forest	Scrub/Savanna
1,000 – 1,500 M	<500 M	Degraded Forest	Lowland swamps

Source: Oxford Cartographers, SLARI (Sierra Leone Agricultural Research Institute)

20

Akteure einer Landvergabe

- Präsident, Präsidentenberater, Ministerien, Investment and Export Promotion Agencies (SLIEPA)
- Versammlungen der Stammesführer (Chiefdom Councils), Landeigentümer
- Afrikanische und europäische Entwicklungsbanken
- MIGA (Investitions-Garantie-Agentur)
- IFC (International Finance Corporation)
- Zivilgesellschaft, NGOs

Landvergaben in Sierra Leone

Bioenergieproduktion:

Addax Bioenergy (Schweiz)

(57 000 ha)

QIFEL Agribusiness (Portugal)

(126 000 ha)

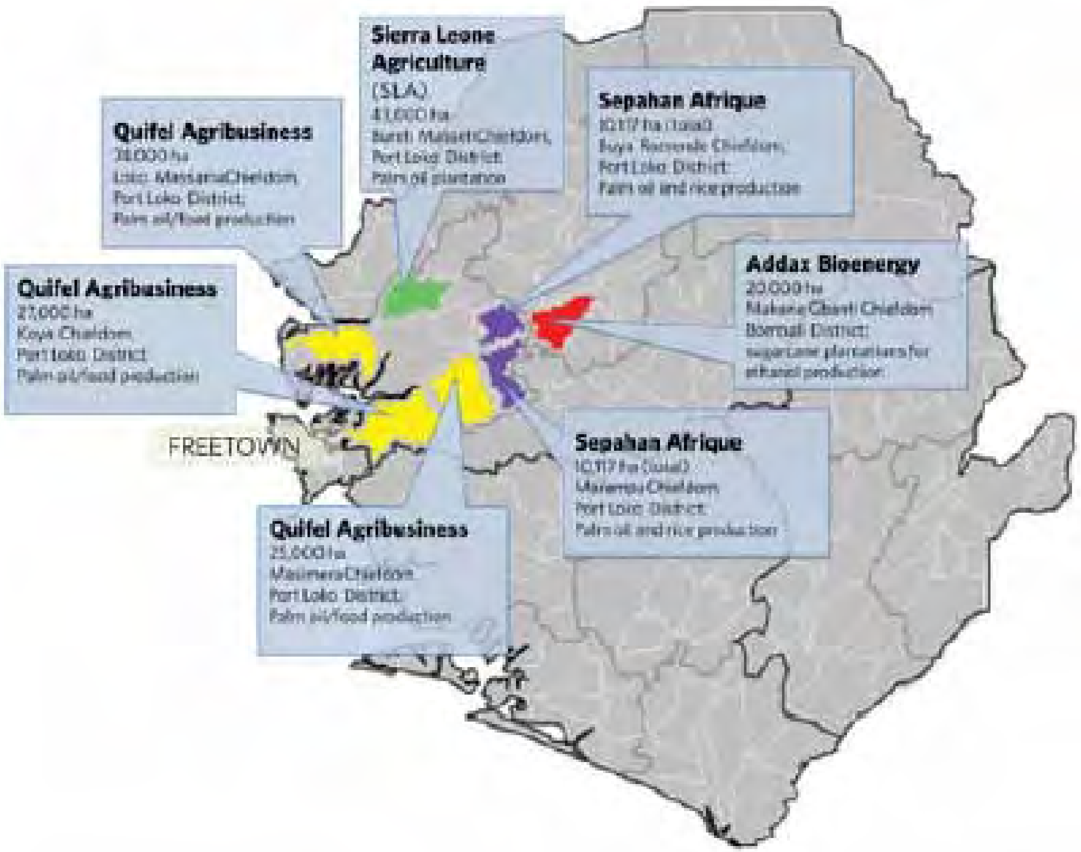
Nahrungsmittel:

Sierra Leone Agriculture (UK)

(43 000 ha)

Sephahan Afrique (Iran)

(10 000 ha)



Addax Bioenergy

Addax Bioenergy S.A. ist eine
Tochtergesellschaft des Schweizer
Energiekonzerns
Addax and Oryx Group Limited (AOG)

1987 gegründet
Rohöl, Goldminen, Bioenergie

Quelle: http://www.addax-oryx.com/uk/index.html

Addax Bioenergy:

The project aims to become a model for sustainable development in Africa, through the respect of strict sustainability standards and the introduction of innovative social solutions. These include extensive and transparent stakeholder dialogue, helping landowners establish deeds of land ownership, enhancing local food security and agricultural productivity, and extensive infrastructure development.

Geldgeber

Netherlands Development Finance Company (FMO)

African Development Bank (AfDB)

UK Emerging Africa infrastructure Fund (EAIF)

Belgian Development Bank (BIO)

German Development Finance Institution, DEG,

South African Industrial Development Corporation (IDC)

and the Cordiant managed ICF Debt Pool

Quelle: Swedfund

Ethanol Projekt in Makeni

Ziel: Integrierter Anbau von Zuckerrohr

Geleaste Fläche: 57 000 ha auf

50 Jahre

- Anbaufläche: 10 000 ha auf

degenerierten Flächen

- Ökologische Korridore,
- keine Abholzungen

Produktionsziel:

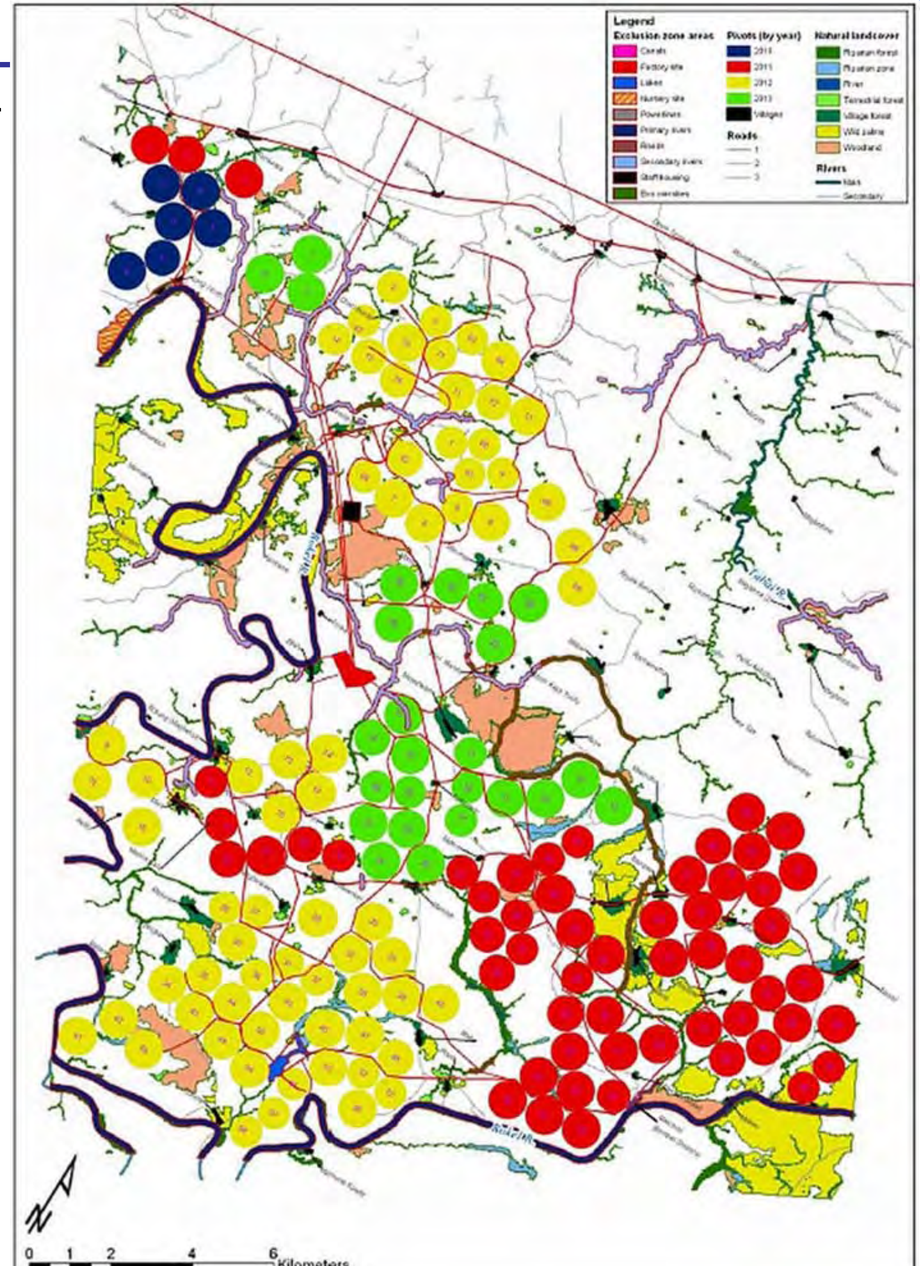
- Bioethanol: 93 000 m³ /J
- 32 MW, davon 15 MW in das

öffentliche Netz

Benefit für die lokalen Bauern:

- 2000 Arbeitsplätze, Gesundheits-

stationen, Schulen, Gemeindezentren



Ethanol Projekt in Makeni -
Nachhaltigkeitskriterien

- **EU Nachhaltigkeitskriterien**

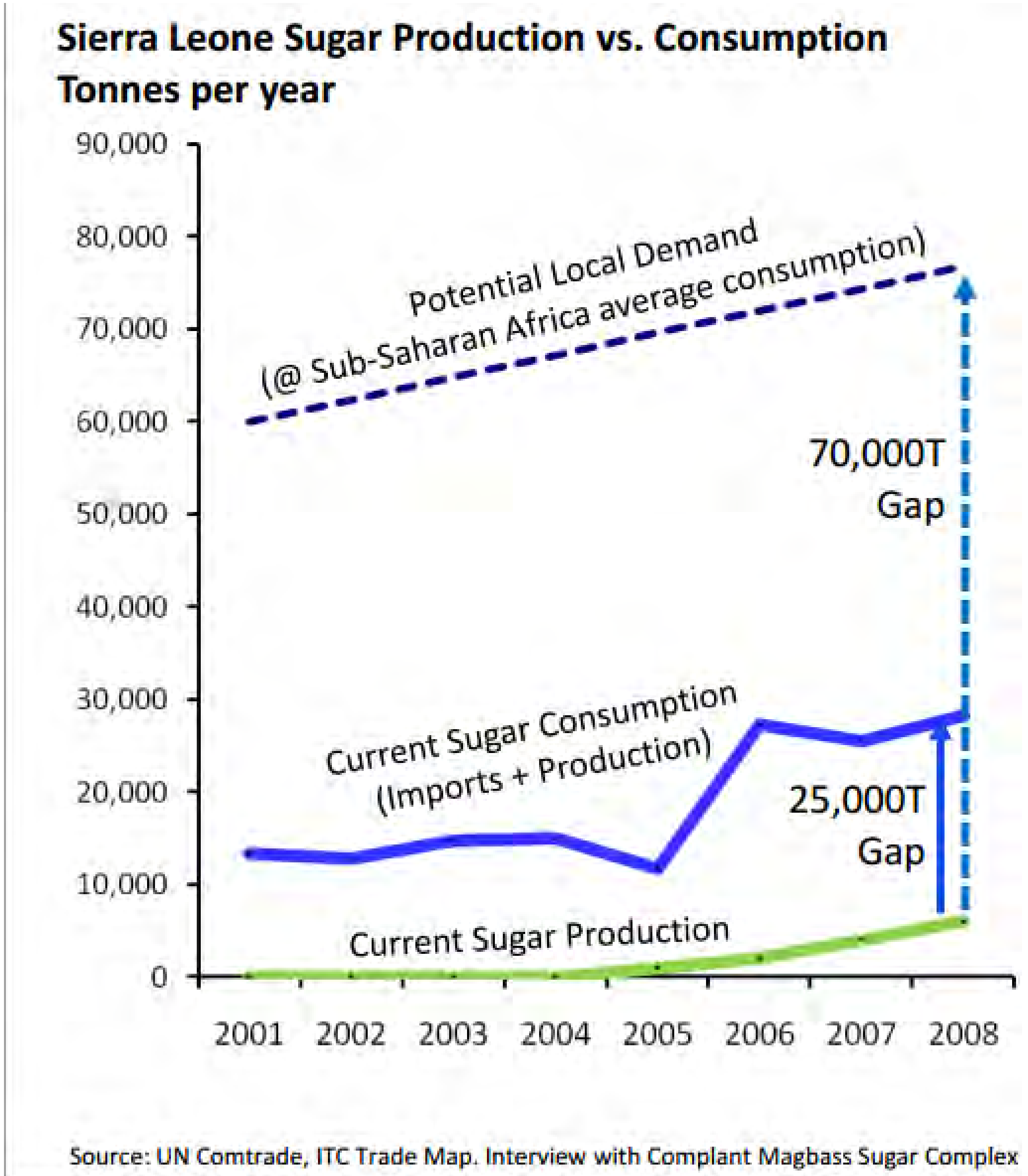
Transparenz bei Landvergaben, Partizipation, Verbote für Flächen mit hoher Biodiversität: Primärwälder, Naturschutzgebiete, Savannen, Flächen mit hohem Kohlenstoffbestand, Respektieren von Land- und Ressourcennutzungsrechten

Sicherstellung der Nahrungsversorgung, Wahrung von Arbeitsrecht, Soziale Nachhaltigkeit, Vermeidung von Umweltbelastungen

- **Roundtable on Sustainable Biofuels (RSB)**
- **Better Sugarcane Initiative (BSI)**
- **National environmental and social legal requirements**
- **Environmental and social policies of its lenders (Entwicklungsbanken)**
- **(IFC) Performance standards and Equator Principles**

  Partizipation

Zuckerproduktion SL



Kritikpunkte von NGOs an Addax Bioenergy

- Gerichtsstand London
- Ökonomische Ungleichheit

Steuerbefreiung, Befreiung von Importzöllen

Addax: 15% Rendite

Addax ist in SL registriert und wird dort versteuern

Einnahmen SL: Water fees of USD 54’000 per year

- Income tax from workers: appr. USD 200’000.
- Dauer des Pachtvertrags (50 J)
- Keine Anstellung länger als 3 Monate
- Zuckerrohr auf fruchtbaren Böden
- Exklusive Wasserrechte

Hunger, food security and large scale land leases for industrial agriculture must be on the political agenda of all parties

Green Scenery challenges all political parties to take a position on large scale land acquisitions of foreign direct investors in agriculture for the 2012 election.

Concerns of civil society organisations and affected land users on Addax Bioenergy

This report by Sierra Leone Network on the Right to Food and Bread for All lays out the major concerns of Civil Society Organisations (CSOs) and affected land users on the Addax Bioenergy project in Sierra Leone as of September 2012.

Quelle: farmlandgrab

Table 2. Sampling of Farmland Lease Fees by Land Deal

Location	Deal	Price $/ha/yr	Lease Terms
Ethiopia	Saudi Star	Free land rent	10,000 ha; 60-year lease
Mali	Malibya	Free land rent	100,000 ha; 50-year lease
Ethiopia	Karuturi	6.75*	300,000 ha; 99-year lease
Sudan	Nile Trading and Development	0.04	600,000 ha at $25,000; 49-year lease
Sierra Leone	Sierra Leone Agriculture	2	43,000 ha; 45-year lease
Sierra Leone	Quifel Agribusiness SL Limited	5	126,000 ha; 49-year lease

Source: Based on Oakland Institute field research, October 2010-June 2011

* Karuturi initially received their land for just $ 1.25/ha (20 birr/ha) but subsequent negotiation with the federal government has raised that price to $ 6.75/ha (111 birr/ha).

Table 3. Sampling of Average Farmland Prices by Country, 2010

Location	Average price $/ha/yr
New Zealand (dairy)	23,000
England (average all land types)	22,000
US (dryland in corn belt)	16,000
Poland	4,550-8,125
Brazil (Mato Grosso dryland)	7,000
Argentina (Central provinces)	5,000-10,000

Source: The Knight Frank Farmland Index 2010

http://www.oaklandinstitute.org/sites/oaklandinstitute.org/files/OI_brief_myth_economic_development_0.pdf

Schlussfolgerungen

Investitionen sind notwendig, aber es braucht verfeinerte / differenziertere Nachhaltigkeitskriterien und entsprechende Gesetze in den einzelnen afrikanischen Staaten

Grundsätze nachhaltiger Investitionen (UNCTAD 2012)

- Ziel investitionspolitischer Strategien ist es Wachstum und nachhaltige Entwicklung zu fördern
- Kohärenz mit nationalen Programmen, Einbeziehung aller Stake-holder
- **Ausgewogenheit zwischen Rechten und Pflichten**
- Jedes Land hat das Recht seine eigenen Regulierungen einzuführen
- Politikregeln **sollten** abgestimmt sein mit nachhaltigen Entwicklungszielen

Schlussfolgerungen

Ergänzende Indikatoren:

- Landvergabepraxis (Transparenz), Entscheidungsfindung
- Eigentumsverhältnisse, wer trägt das Risiko bei Umweltbelastungen (Staat oder Eigentümer)
- Steuereinnahmen
- Kapazitätsentwicklung: wird in die Ausbildung lokaler Arbeitskräfte investiert, wie viele Personen werden ausgebildet
- Qualität und Dauer der Beschäftigung
- Armutsbekämpfung: Zunahme der Personen, die über der Armutsgrenze leben
- Entsteht für Kleinbauern beim Erwerb von Landtiteln eine Benachteiligung , da Land einen ökonomischen Wert erhält

ANHANG F

PRESENTATION HELD AT THE IEA BIOENERGY EXCO MEETING
VIENNA, SCHÖNBRUNN “FUTURE PERSPECTIVES
OF INTERNATIONAL BIOENERGY TRADE”

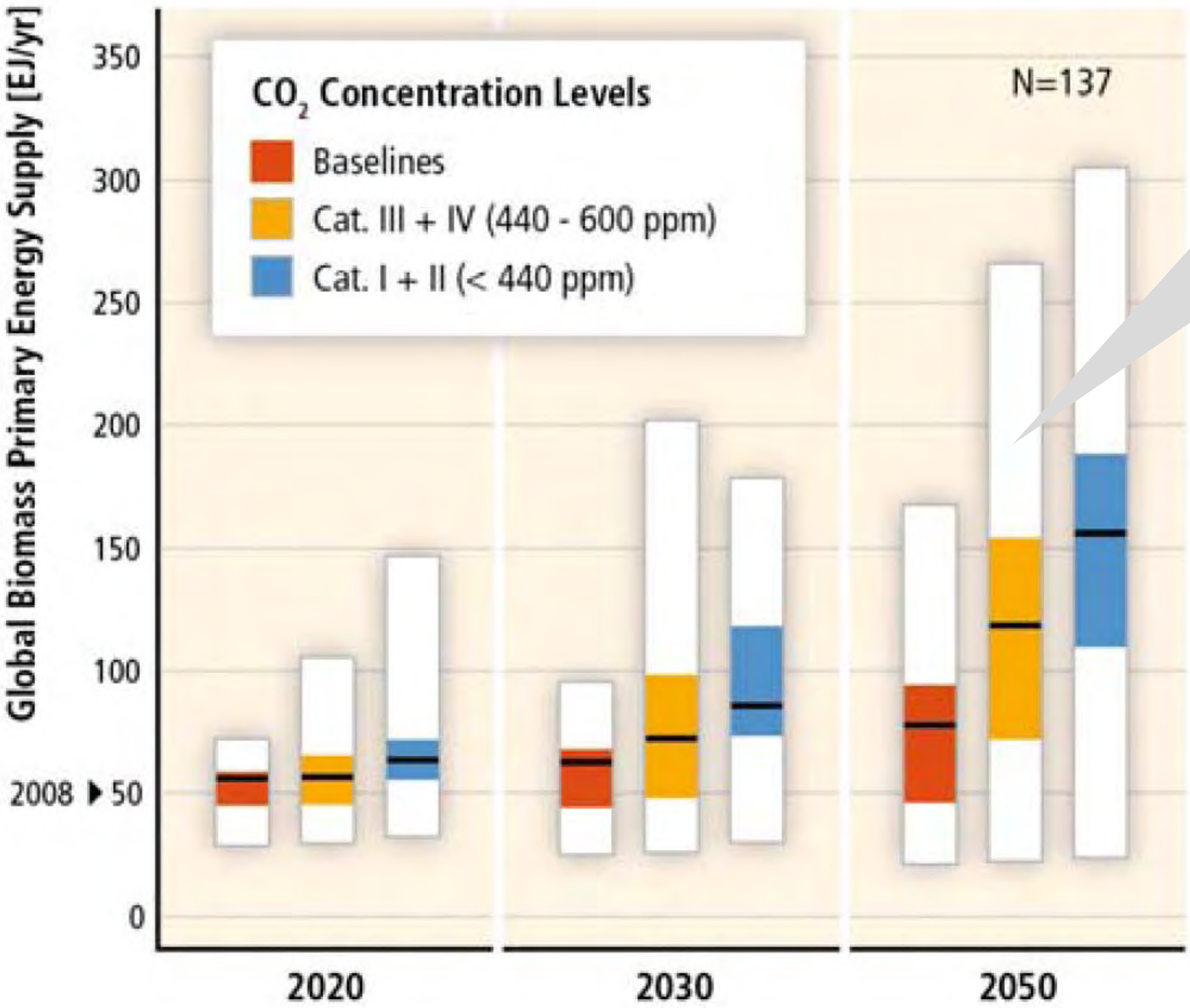
Future perspectives of international bioenergy trade

Lukas Kranzl, Vassilis Daioglou, Martin Junginger, Kimon Keramidas, Julian Matzenberger, Erik Tromborg

IEA Bioenergy Conference 2012,

Vienna, November 2012

Global bioenergy scenarios



Implication of scenarios on future international bioenergy trade?

Source: IPCC SRREN, 2011

Objective

Provide insight into "possible futures" of bioenergy trade and discuss drivers, implications and challenges

Methodological approach

- Investigate to which extent various global energy models and scenarios take into account bioenergy trade
- Compare selected scenario results
- Identify the drivers and implications of different global bioenergy scenarios on bioenergy trade
- Derive conclusions

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Comparison of models and scenarios

- ✓ Screening of existing models and studies
  - ➢ 28 models have been screened in total
  - ➢ Preselection of models
  - ➢ Request (small questionaire) to selected modeling groups

- ✓ Selection of models for further investigation: GFPM, IMAGE/TIMER, POLES

- ✓ Three biomass fractions to be covered:
  - ➢ solid biomass
    - ➢ based on residues and waste
    - ➢ based on primary energy products
  - ➢ liquid biomass distinction of three fractions

- ✓ Regional aggregation level: 20 world regions

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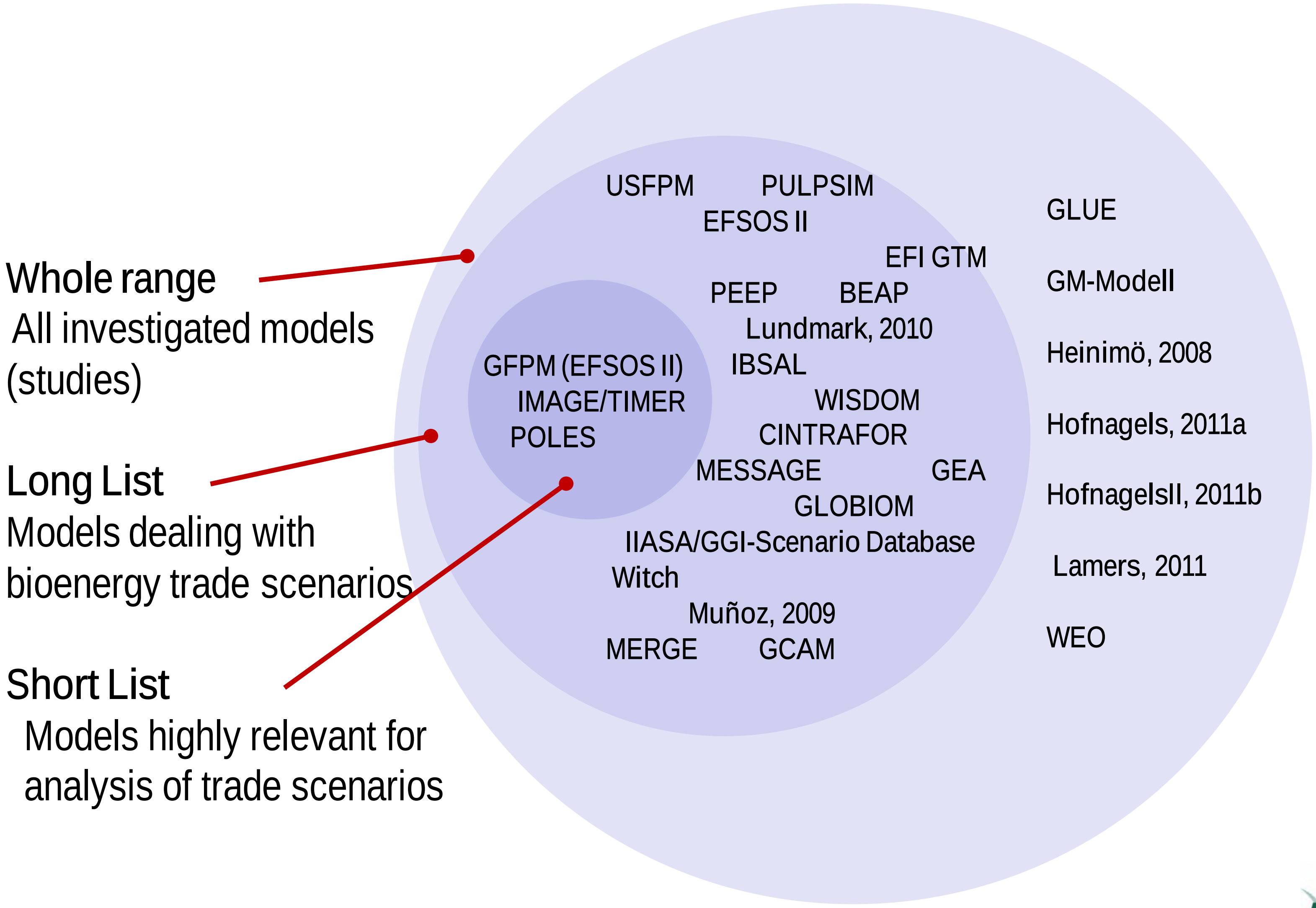
Model selection



Models I – GFPM (EFSOS II)

Short Description: Partial Equilibrium Model

Coverage Biomass Trade: Global - Trade between country and world market rather than between individual countries

Assumptions regarding trade:
- equilibrium calculation determine the direction of change of trade flow
- Institutional and other constraints limit the adjustment that can take place in any given year.
- Effect of tariffs change the cost of transportation.

Sectoral Coverage: Limited to the forest and forest biomass sectors
- covers 14 principal categories of forest products

Regional Aggregation: 180 countries,
- 50 from Africa, 35 from North Central and South America, 50 from Asia and Oceania, and 45 from Europe and former USSR

Scenario Time Frame Up to 2060

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Models II – IMAGE/TIMER

Short Description: Systems dynamic Integrated assessment model

Coverage Biomass Trade: Yes

Assumptions regarding trade: Bilateral trade available
- n regions, n markets. Each region imports from wherever offers the lowest price
- Imports have transport costs, plus a factor determining how "open" they are to that region (i.e. indicating OECD countries or closed economies)

Sectoral Coverage: Traditional biomass (no trade), modern solid biofuel, liquid biofuel

Regional Aggregation global 26 regions

Scenario Time Frame: up tp 2100

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Models III – POLES

Short Description: Partial Equilibrium Model, hybrid, recursive dynamic
Coverage Biomass Trade: Yes; global (imports from one single international market)
Assumptions regarding trade: Competition between domestic supply and imports from international. Competition occurs over part of the demand each year (infrastructure lifetime, trade inertia).

- Internat. solid biomass price: cost curve (biomass use wrt total biomass potential)
- Internat. biofuels price: world avg production costs (explicit technologies)
- Transport costs

Sectoral Coverage: Traditional biomass (no trade); modern solid biomass (consumed as inputs for biofuels, power sector, industry, buildings); liquid biofuels (transport)
Regional Aggregation Global, 57 regions
Scenario Time Frame: up to 2100

Selected scenarios

- **Ambitious bioenergy scenarios**
  - TIMER: OECD 450 ppm scenario, OECD 100$ per t CO2 scenario
  - POLES based on EMF scenarios: 450 ppm, 100$ per t CO2
  - GFPM: high

- **Moderate bioenergy scenarios**
  - TIMER: OECD environmental outlook, OECD EO trade barriers, OECD 650 ppm, OECD 20$ per t CO2
  - POLES: based on EMF scenarios G1 Reference, G4 BAU, BAU+trade barriers, 650 ppm, 20$ per t CO2
  - GFPM: low

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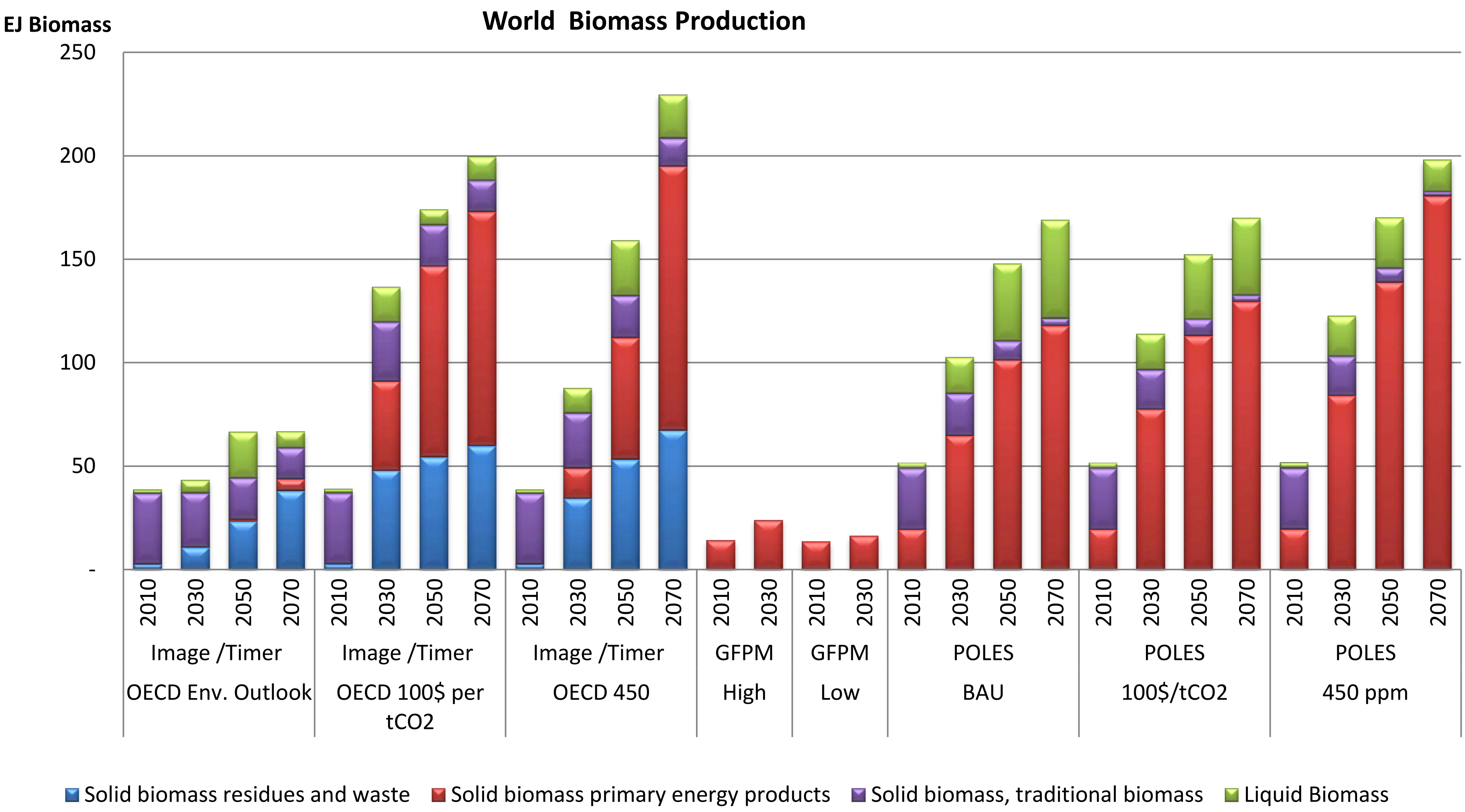
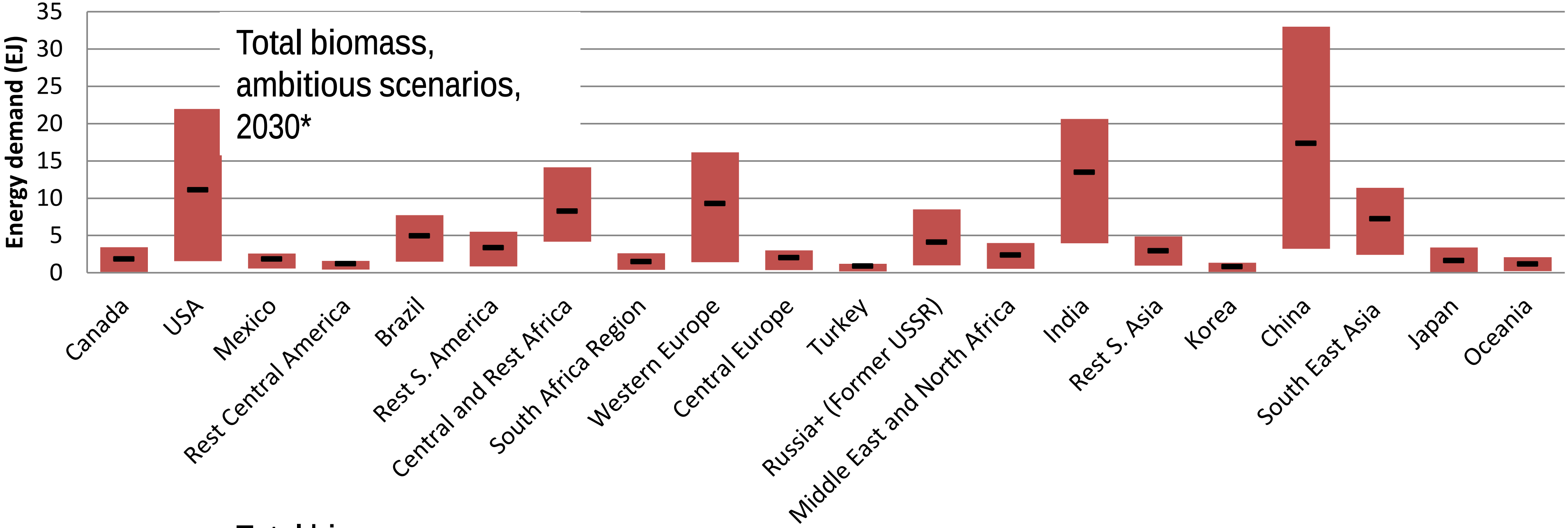
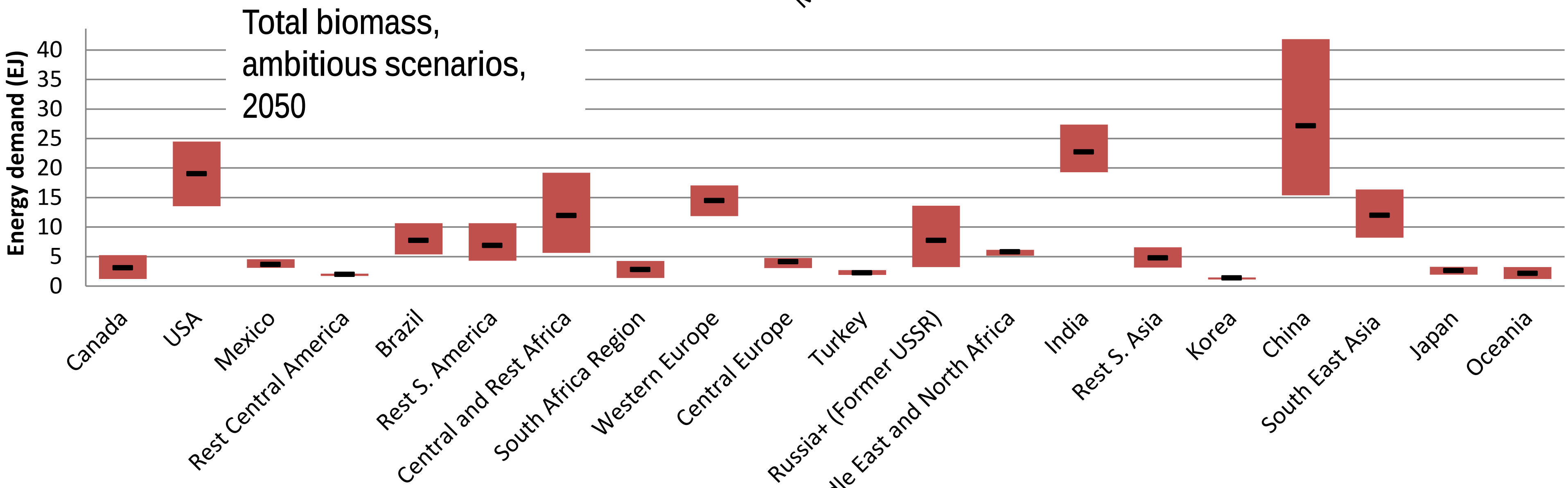
Bioenergy production in selected scenarios



Regional bioenergy demand, selected scenarios

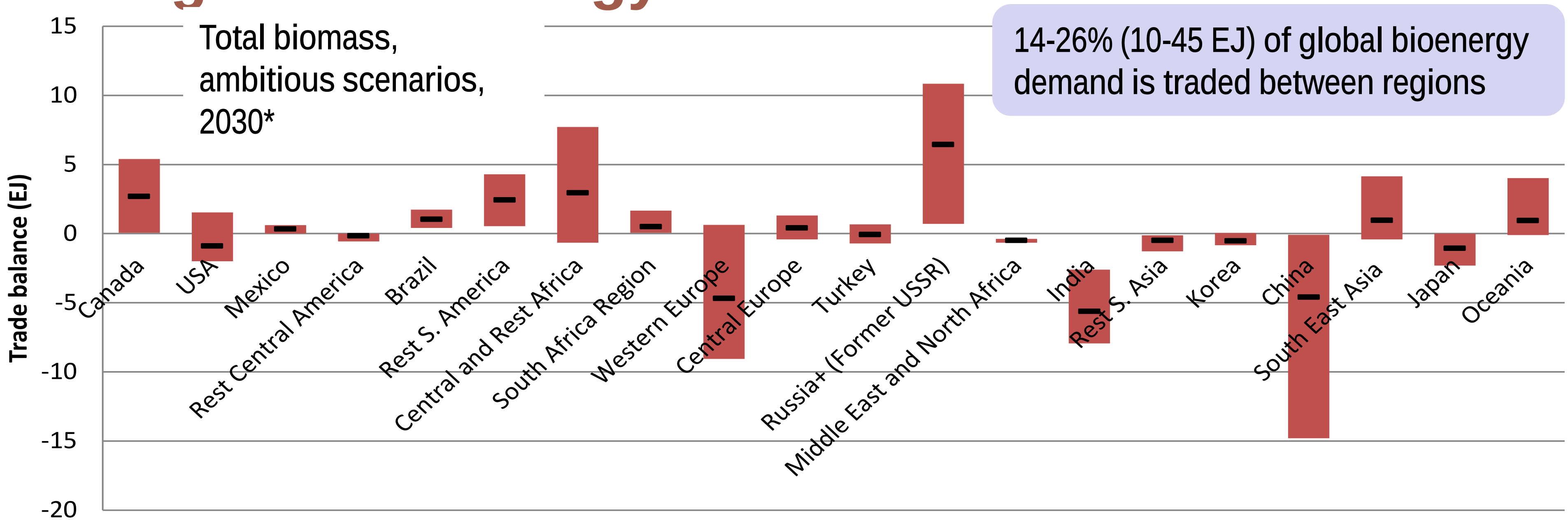


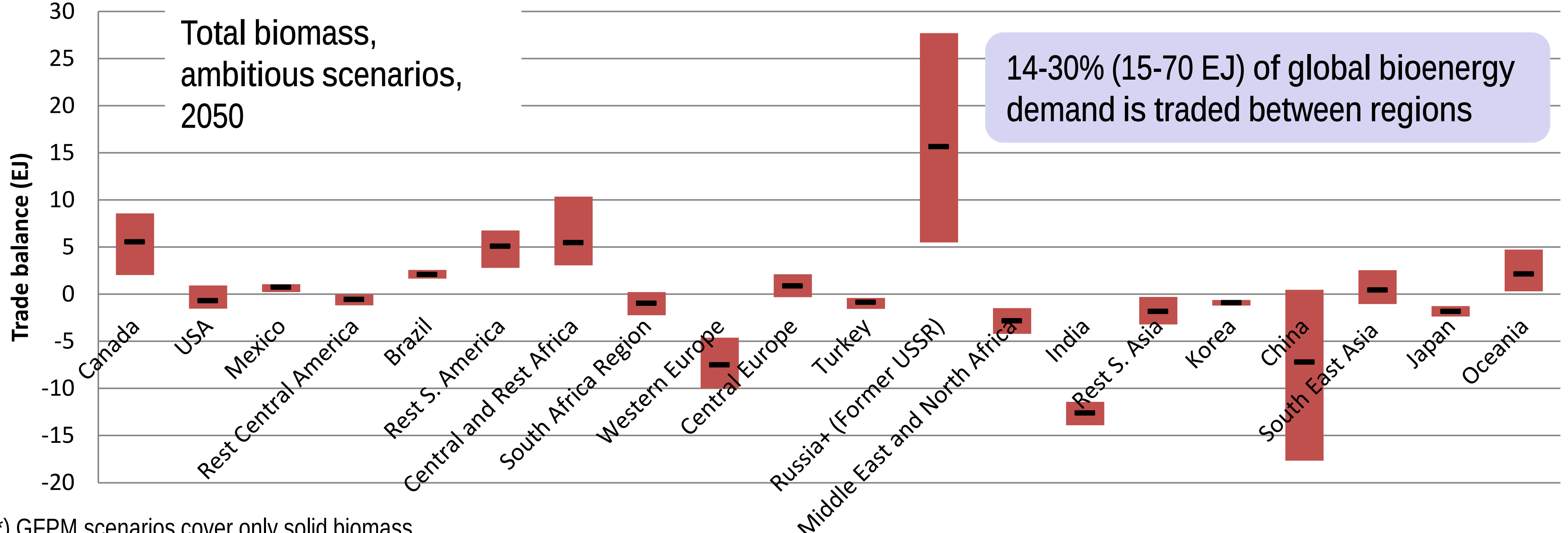


(*) GFPM scenarios cover only solid biomass

Sources: POLES, TIMER, GFPM

Regional bioenergy trade balances





(*) GFPM scenarios cover only solid biomass

Selected drivers

- **Regional balancing of supply and demand**
  - Barriers and drivers of bioenergy demand (in current supply and demand regions): oil price, policies, technological learning, GDP …
  - Barriers and drivers of bioenergy supply
  - Regional development of bio-based industry

- **Barriers and drivers of bioenergy trade**
  - Logistics
  - Trade policies
  - Sustainability requirements
  - …

- **Technological change**
  - Traditional biomass => modern biomass
  - Change in resource base

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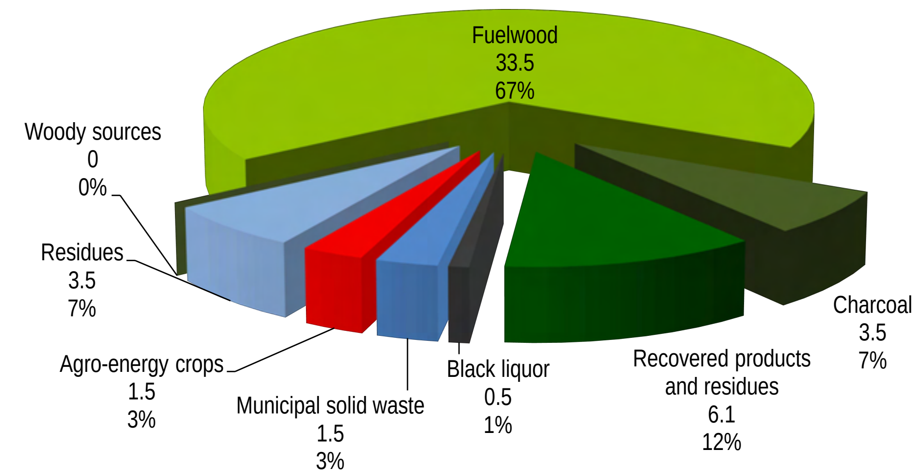
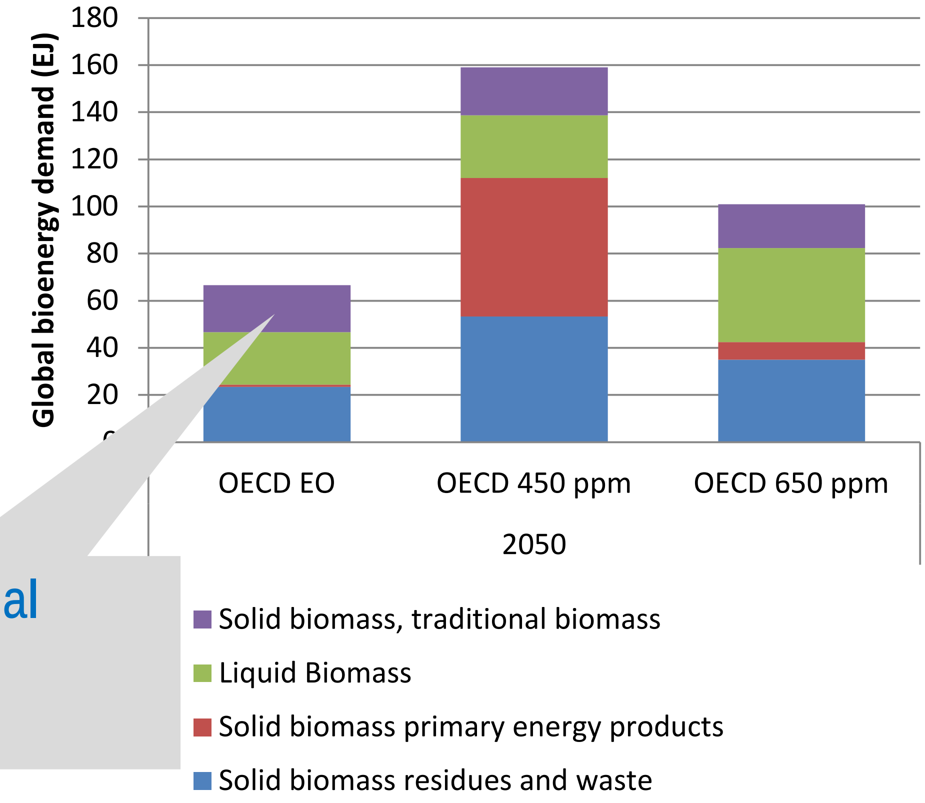
Shift from traditional to modern biomass

Global structure of bioenergy use, 2009



Global structure of bioenergy use according to selected scenario results Image/Timer, 2050



Share of traditional biomass in 2050: 13%-18%

Source: estimation according to FAO 2010

Conclusions (1)

- **Quantities of produced biomass are rising in all investigated scenarios.**
- **All investigated scenarios show a strong increase in total internationally traded biomass (in a range of 20-90 fold increase from 2010 to 2050).**

- **The development of international bioenergy trade will be driven strongly by**
  - Climate policies
  - Regional differences of policies, GDP
  - Supply of biomass resources
  - Technological change and thus shift in the biomass resource base
  - Sustainability requirements
  - Overall global energy demand, GDP, population, …

Conclusions (2): robust results in most scenarios

- **Key potential future bioenergy export regions according to model scenarios in 2050:**
  - Russia + former USSSR (40% of trade, 10% of global demand)*,
  - Canada, South-America, Central and Rest Africa, Oceania (40% of trade, 10% of global demand)*

- **Key future bioenergy import regions in 2050:**
  - India (33% of trade, 8% of global demand)*
  - Western Europe, China (39% of trade, 9% of global demand)*

- USA: relevant importer of liquid biofuels, small exporter (or balanced) for solid biomass
- China: high difference between ambitious and non-ambitious scenarios

(*) values refer to 2050, average of ambitious bioenergy scenarios

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Conclusions (3)

- **Open questions:**
  - Impact of different supply and demand functions in the models
  - Impact of other energy technologies in the scenarios
  - Consideration of bioenergy trade barriers in the models?
  - Impact of trade patterns on future bioenergy scenarios?
  - …
- **Only a few number of global energy models explicitely simulate international bioenergy trade.**
- **Nevertheless, all global energy scenarios need to make an assumption on the future development of bioenergy trade.**
- **A further investigation and integration of international bioenergy trade, barriers and drivers into existing modeling frameworks is highly needed.**

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Further questions:

www.bioenergytrade.org

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