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Vienna University of Technology

Energy Economics Group

IEA BIOENERGY – TASK 40

Sustainable International Bioenergy Trade: Securing supply and demand

Country Report: Austria 2011

Authors:

G. Kalt, J. Matzenberger, L. Kranzl

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Vienna University of Technology
Institute of Energy Systems and Electrical Drives – Energy Economics Group
Gusshausstrasse 25-29/370-3, 1040 Vienna, Austria
Tel. +43-(0)1-58801-370363, Fax. +43-(0)1-58801-370397
www.eeg.tuwien.ac.at

Contacts:

Gerald Kalt: kalt@eeg.tuwien.ac.at

Julian Matzenberger: matzenberger@eeg.tuwien.ac.at

Lukas Kranzl: kranzl@eeg.tuwien.ac.at

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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.

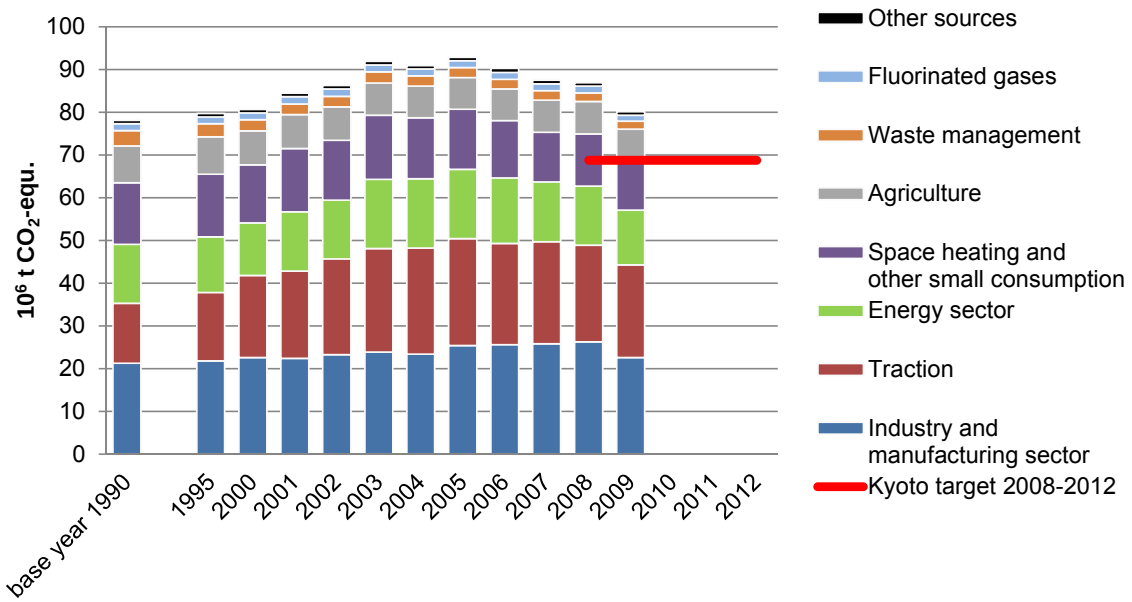


Figure 1. Greenhouse gas emissions from 1990 to 2009 compared to the national Kyoto target.
Source: Schneider et al. (2011)

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.

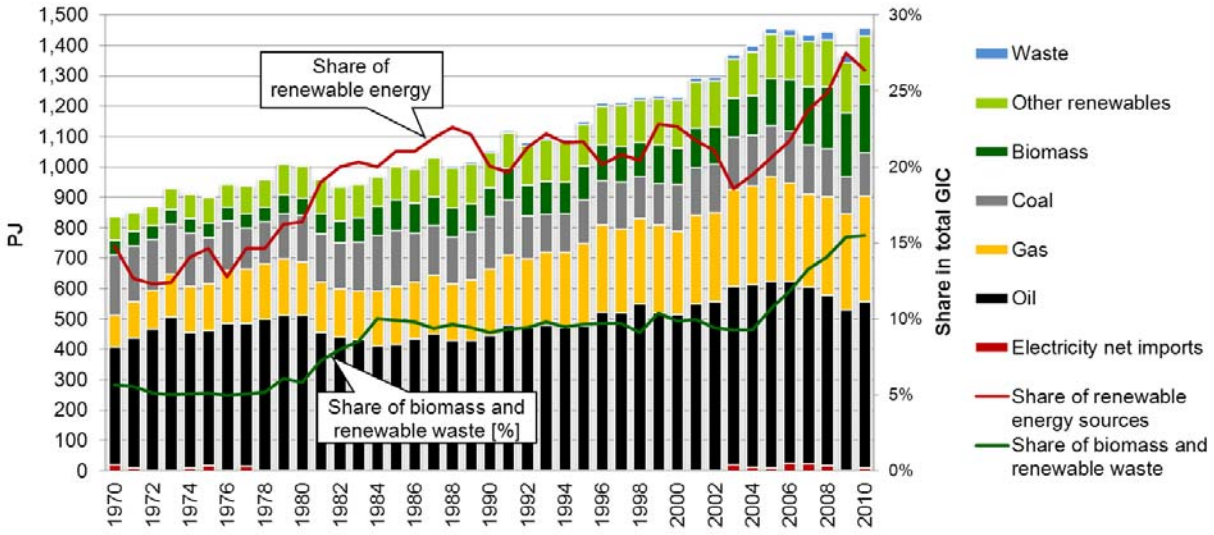


Figure 2. Development of the gross inland consumption of energy in Austria.
(Waste includes renewable as well as non-renewable fractions; other renewables include biomass, renewable waste, hydro power, wind, ambient energy, photovoltaic etc.)
Source: Statistik Austria (2011c)

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.

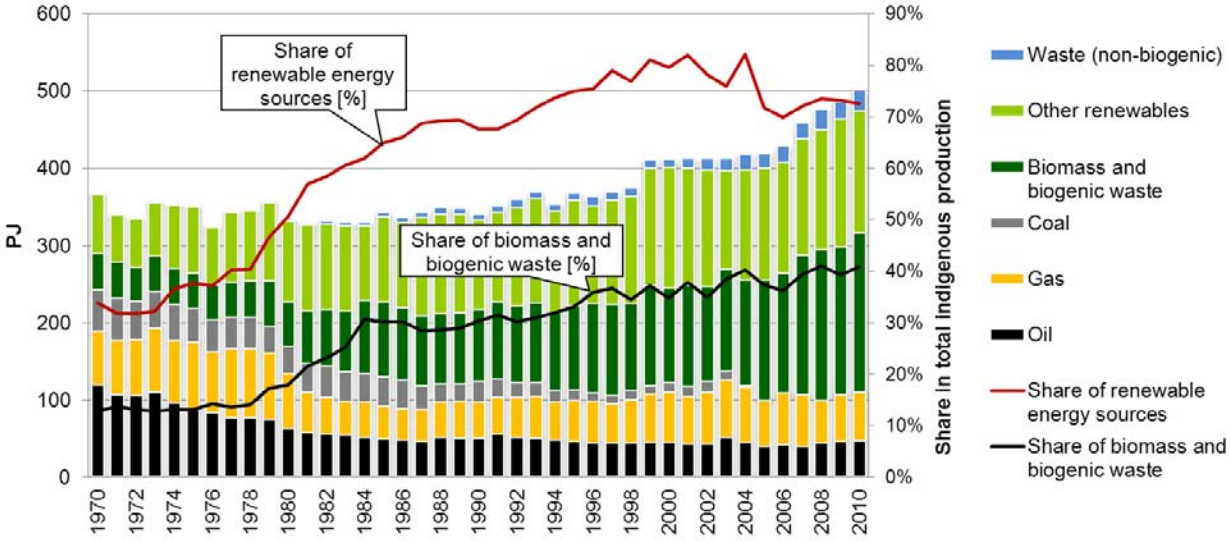


Figure 3. Development of the indigenous primary energy production from 1970 to 2010. Source: Statistik Austria (2011c)

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.

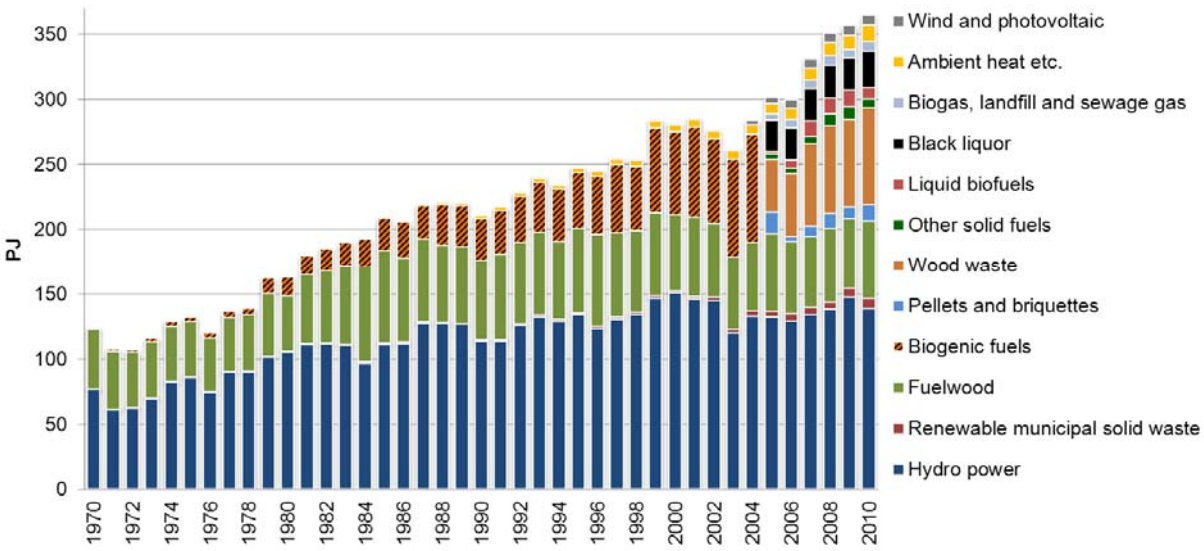


Figure 4. Development of the indigenous production of renewable energy in Austria.
Source: Statistik Austria (2011c)

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.

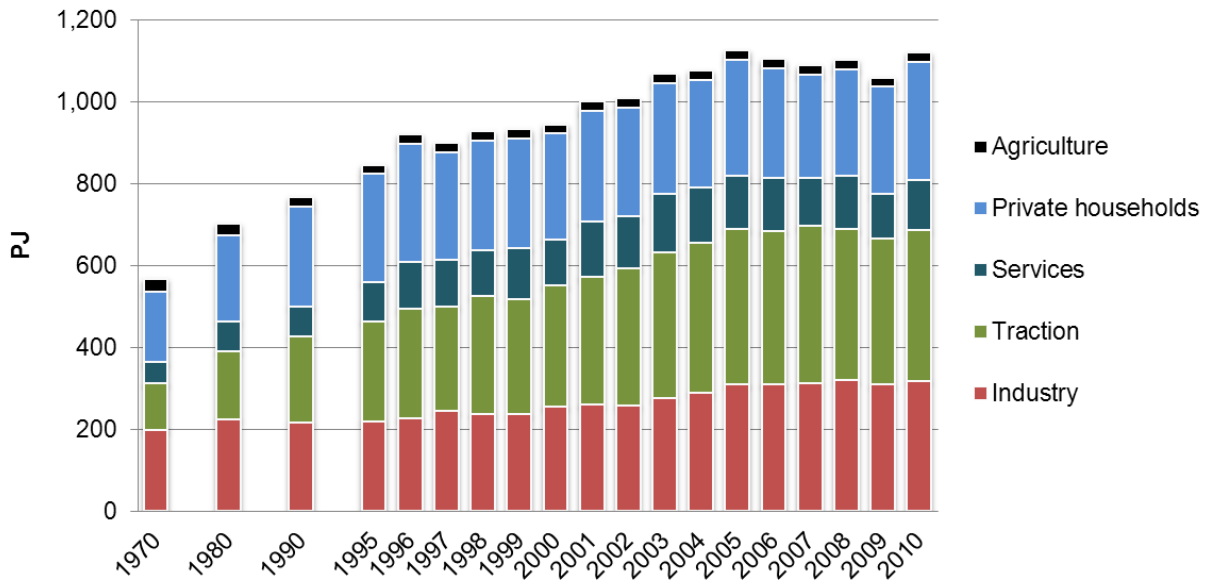


Figure 5. Development of the final energy use broken down by economic sectors.
Source: Statistik Austria (2011c)

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).

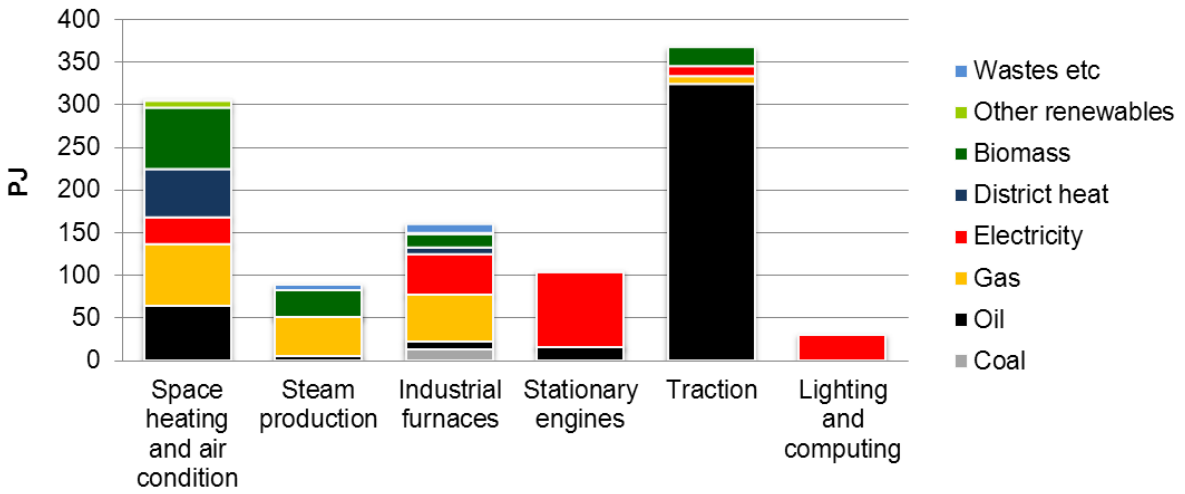


Figure 6. Useful energy consumption in 2009 broken down by energy sources and purposes.
Source: Statistik Austria (2011d)

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.

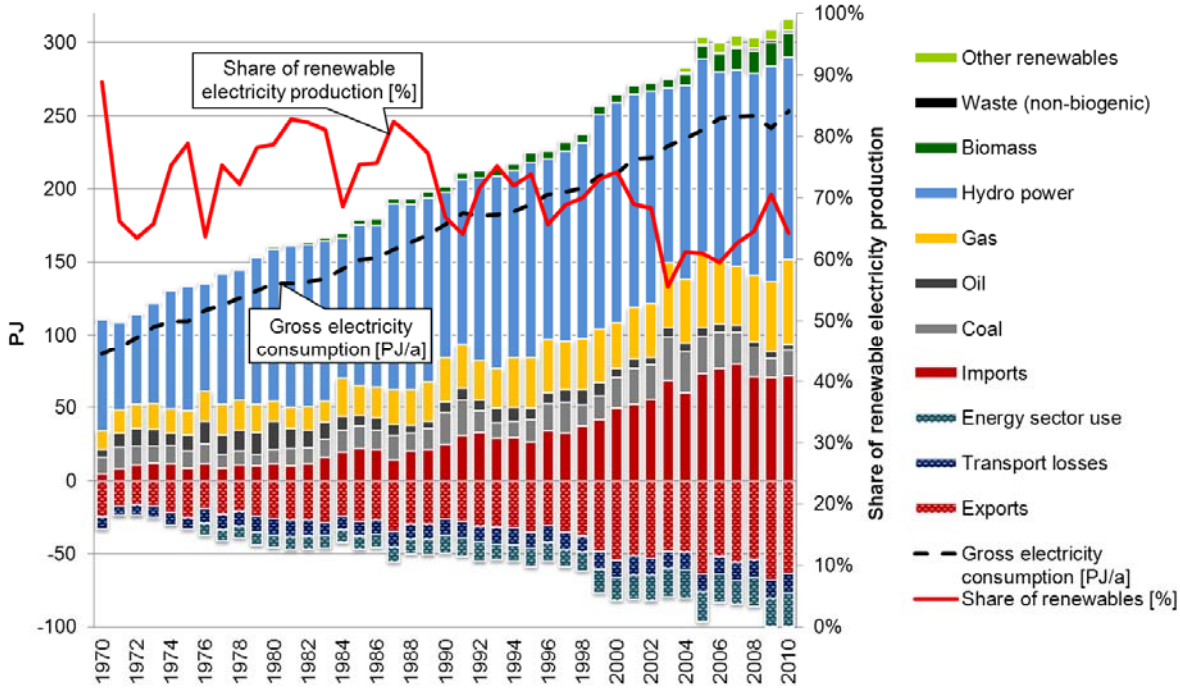


Figure 7. Development of electricity production and consumption and of the share of renewable electricity production.
Source: Statistik Austria (2011c)

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.

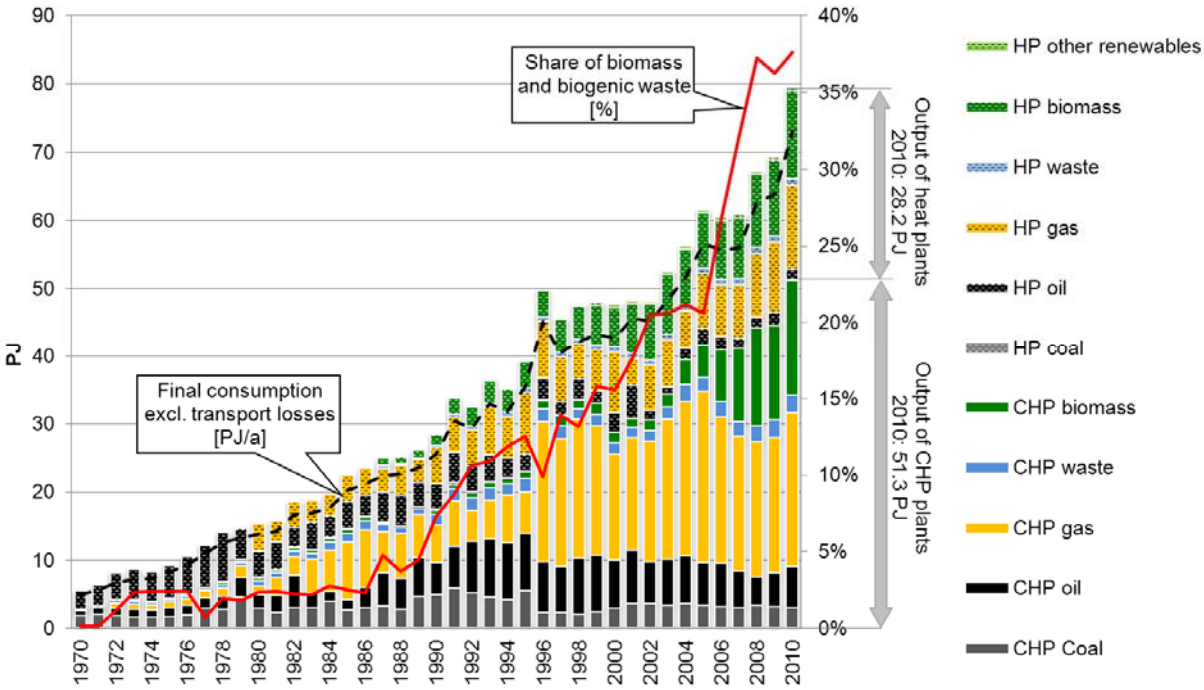


Figure 8. Development of district heat production broken down by CHP- and heat plants (HP) and fuels.
Source: Statistik Austria (2011c)

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.)

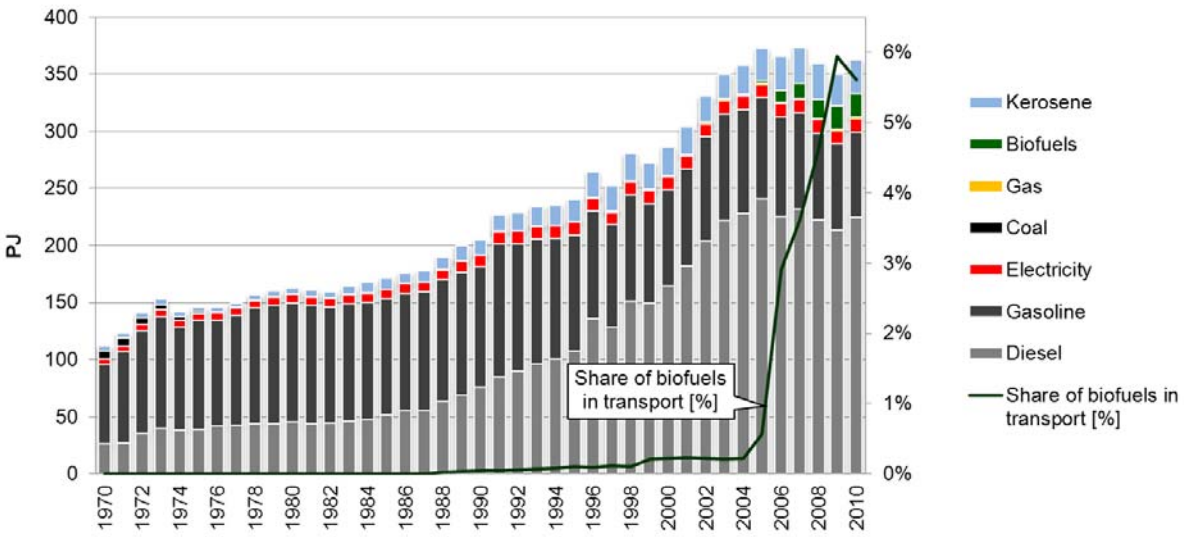


Figure 9. Development of energy consumption for transport and of the share of biofuels.
Source: Statistik Austria (2011c)

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.

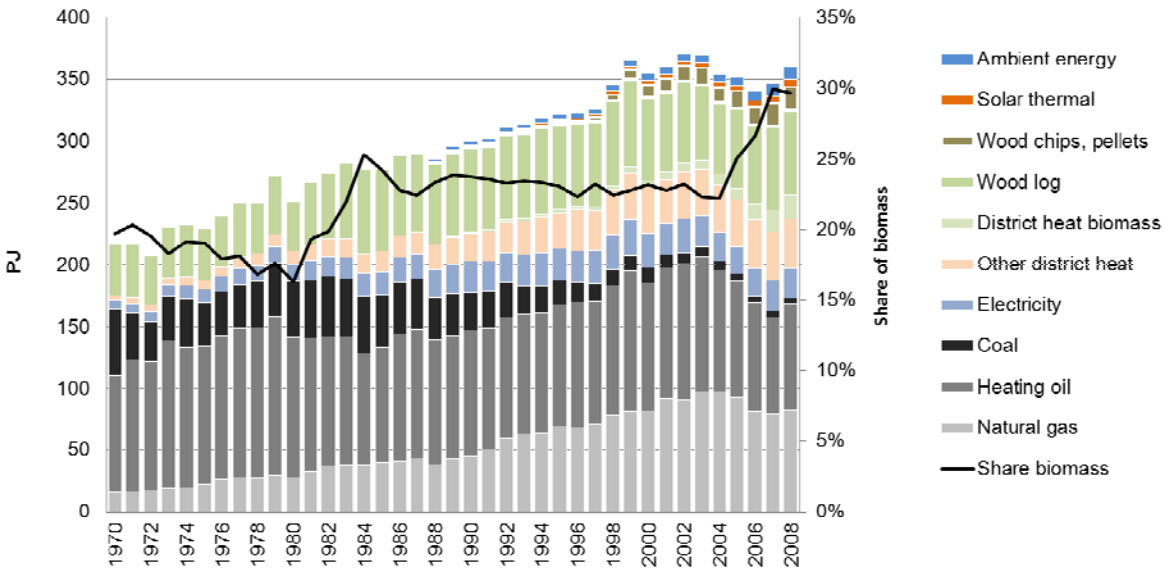


Figure 10. Final energy consumption for space and water heating from 1970 to 2008.
(Data are adjusted for heating degree days)
Source: Müller et al. (2010)

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).

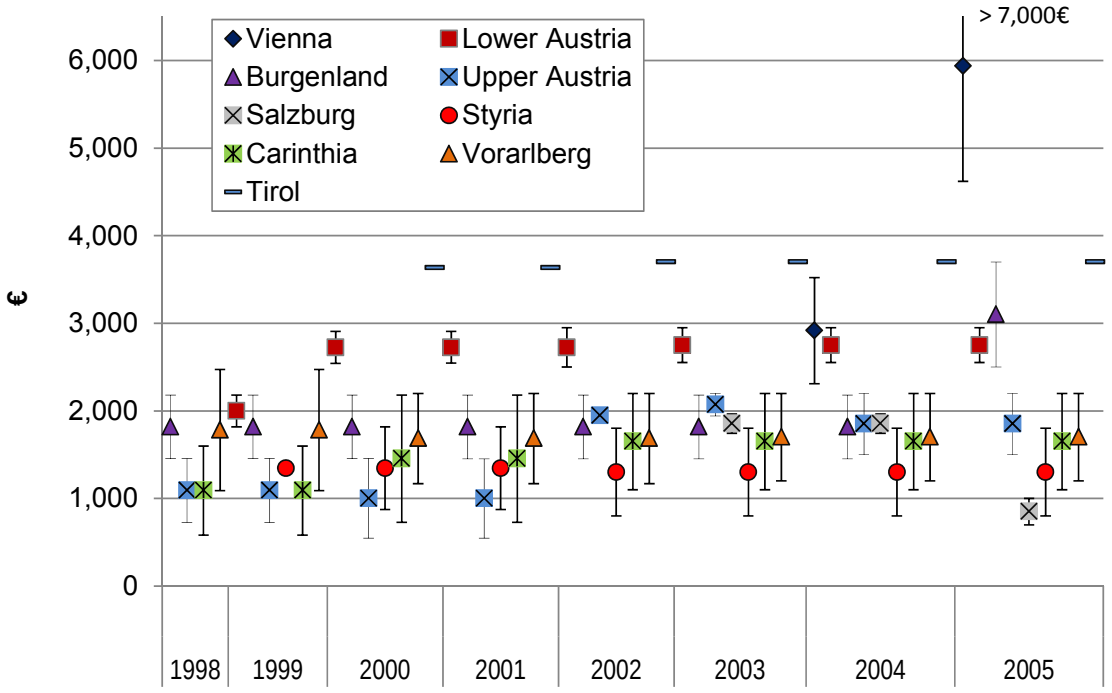


Figure 11. Development of typical/maximum investment subsidies for biomass heating systems.
(Due to the diversity of support schemes and different eligibility criteria a direct comparison between regions is not possible and actual amounts can vary widely. Uncertainty ranges represent the ranges of the 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.

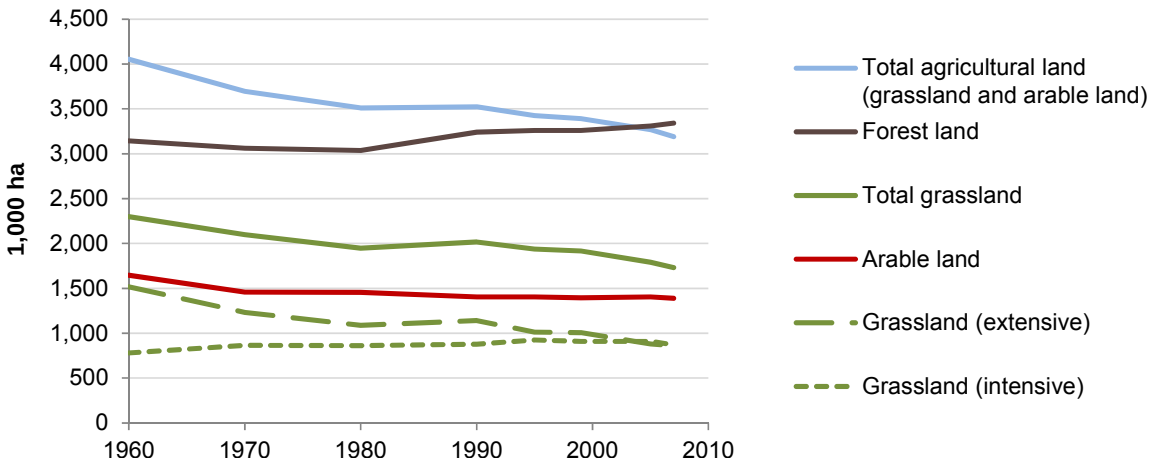


Figure 12. Development of land use in Austria since 1960.
Source: BMLFUW (2011)

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.

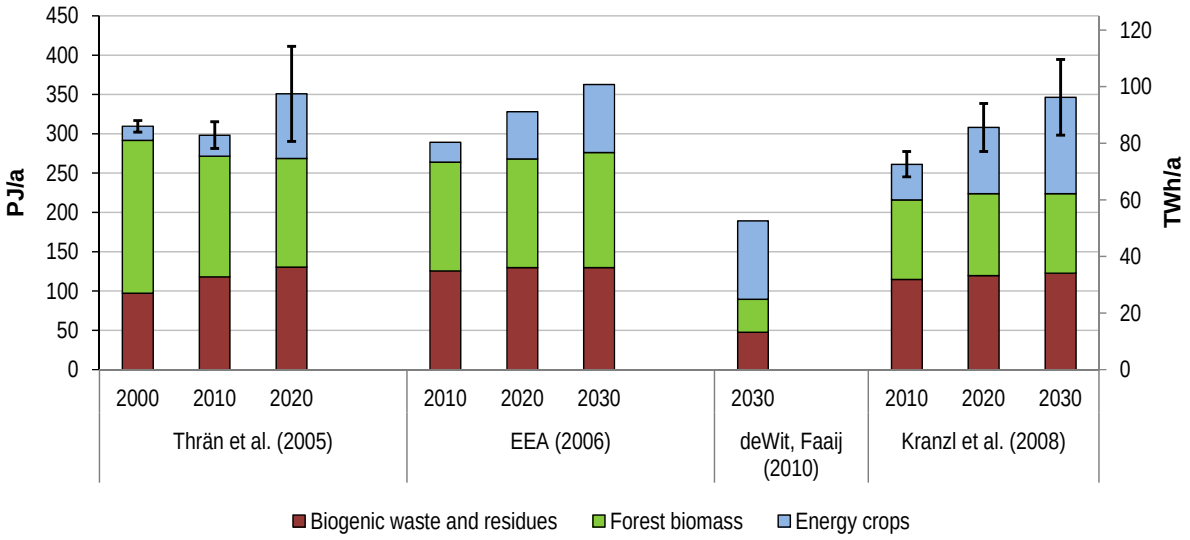


Figure 13. Biomass potentials in Austria.
Sources: Thrän et al. (2005), EEA (2006), de Wit & Faaij (2010), Kranzl et al. (2008)

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.

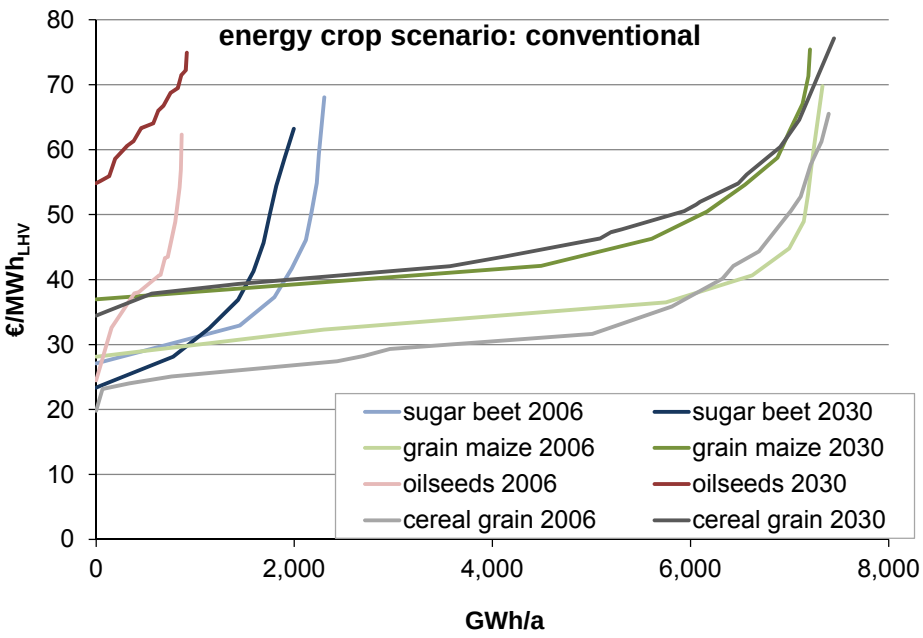


Figure 14. Supply curves in the energy crop scenario "conventional".
Source: Kalt et al. (2010)

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).

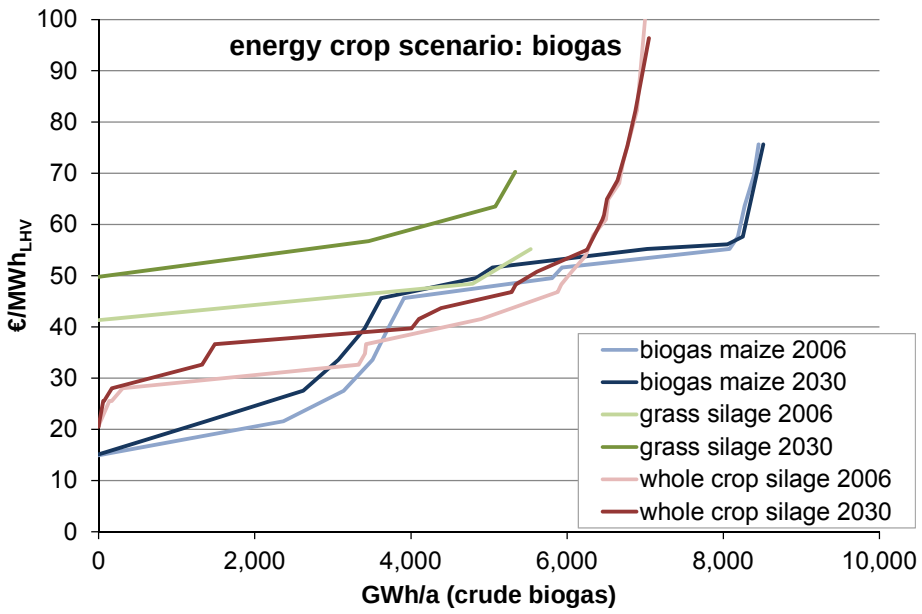


Figure 15. Supply curves in the energy crop scenario "biogas".
(Energy units refer to the lower heating value of the crude biogas yield after co-fermentation with 10% manure.)
Source: Kalt et al. (2010)

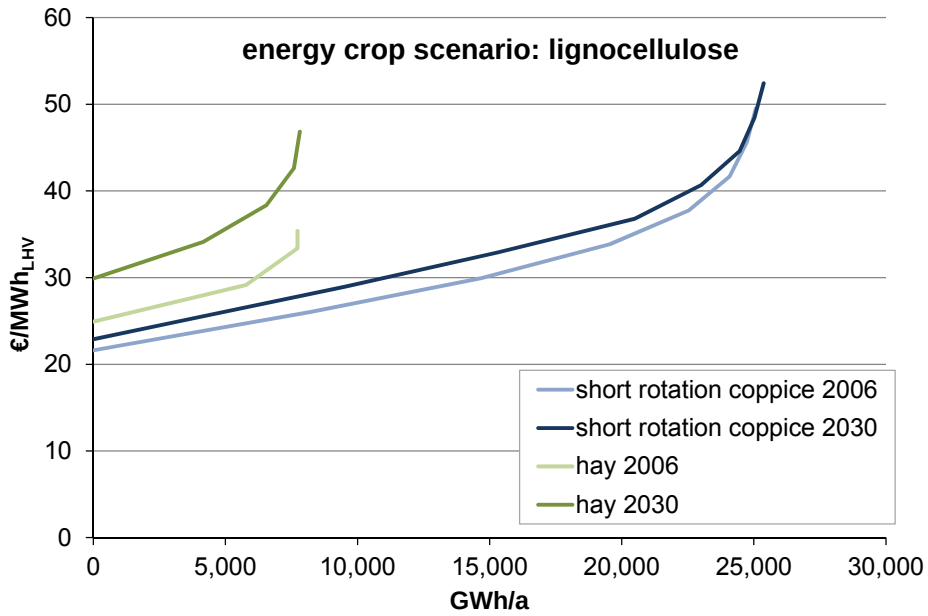


Figure 16. Supply curves in the energy crop scenario "lignocellulose".
Source: Kalt et al. (2010)

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

[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*

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.

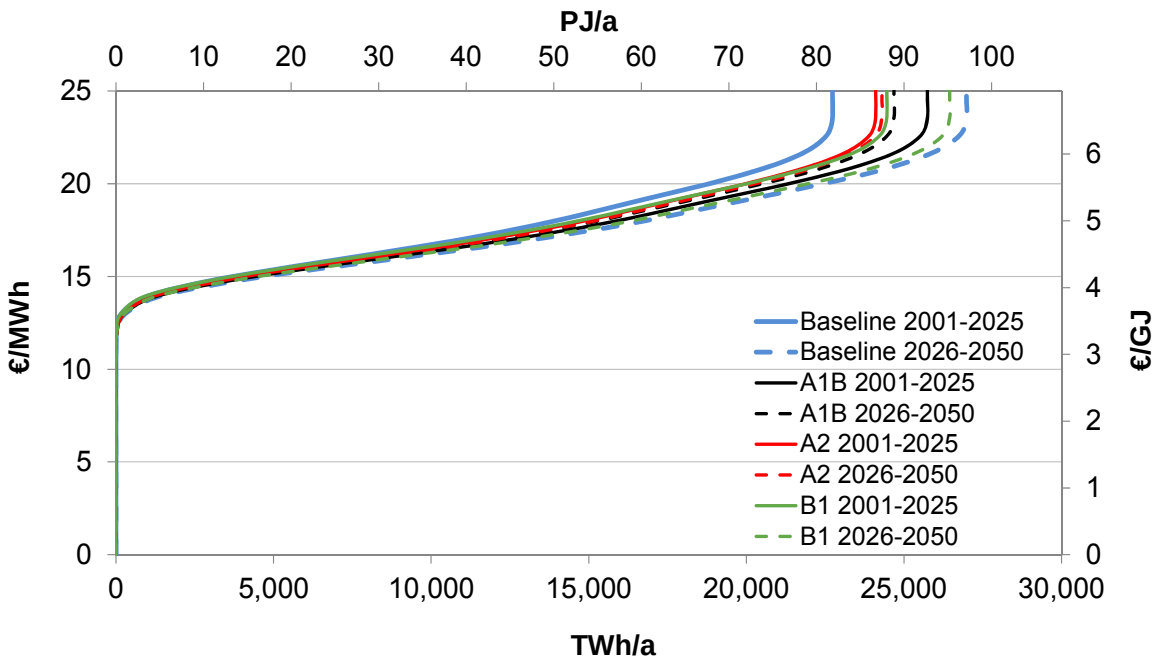


Figure 17. Supply curves for forest biomass for energy use for the different climate scenarios and time periods (averages over 25-year periods).
Source: Kranzl et al. (2010)

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).

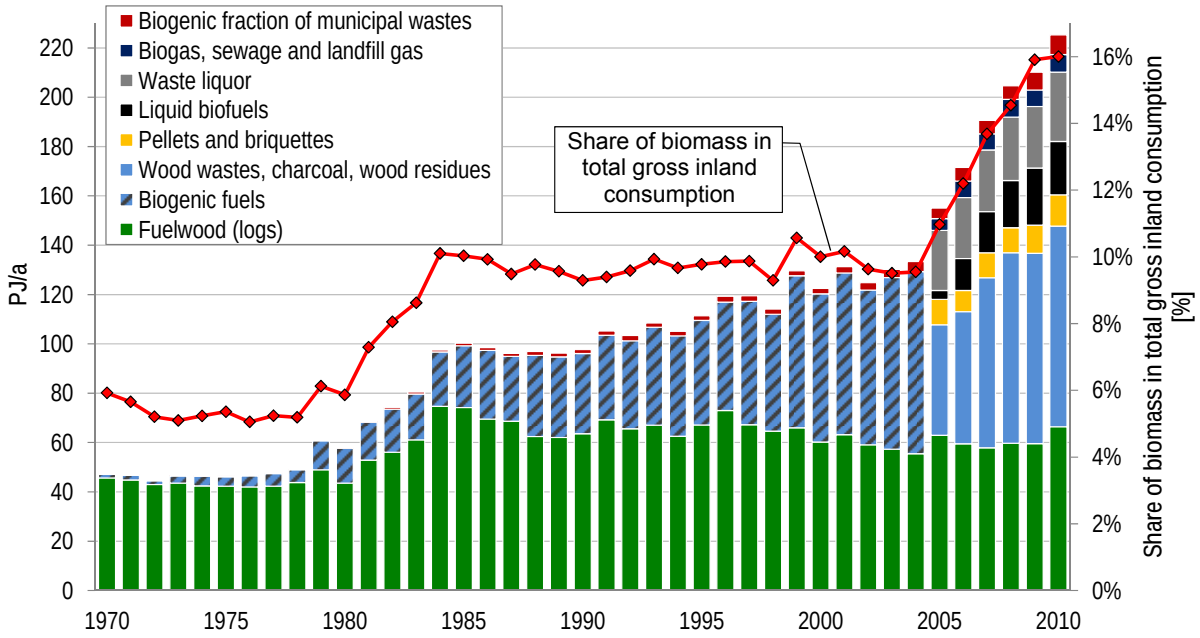


Figure 18. Development of biomass primary energy consumption broken down by biomass types and of the biomass share in the total gross inland consumption from 1970 to 2010. Sources: Statistik Austria (2011c)

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%).

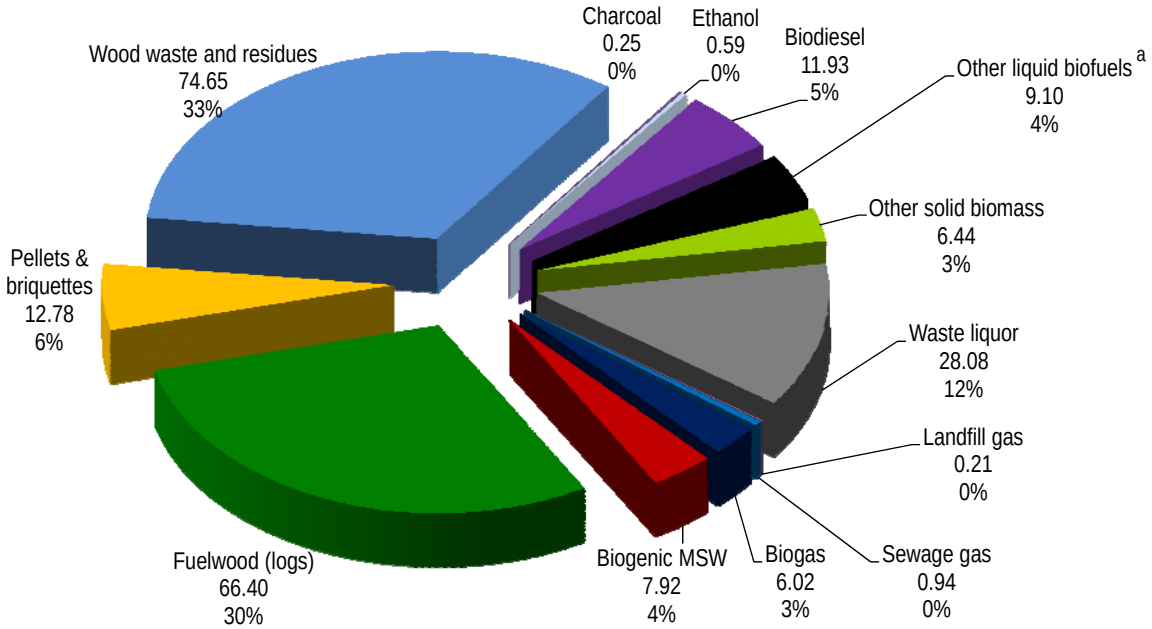


Figure 19. Structure of biomass primary energy consumption by biomass types in 2010.
a) Following Statistik Austria (2011c), pure liquid biofuels (biodiesel, ethanol and vegetable oil) are included in the category “other liquid biofuels”, whereas the categories “biodiesel” and “ethanol” only comprises 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.

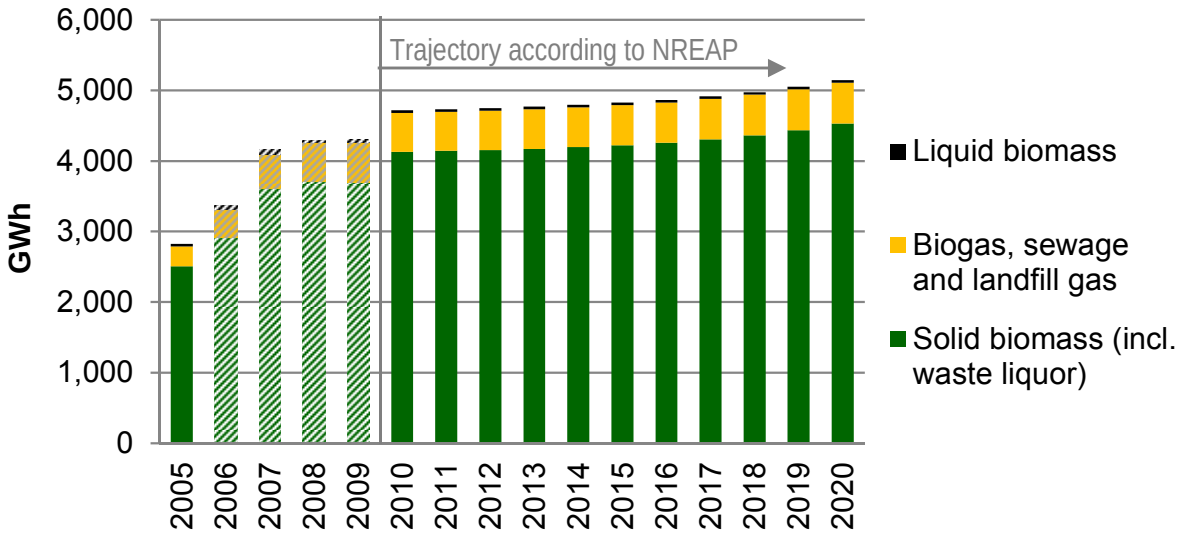


Figure 20. Historic development of electricity generation from biomass and trajectory according to the NREAP.
Sources: Karner et al. (2010), E-control (2011b), Statistik Austria (2011c) (data for the years 2006 to 2009; hatched bars), own calculations and illustration

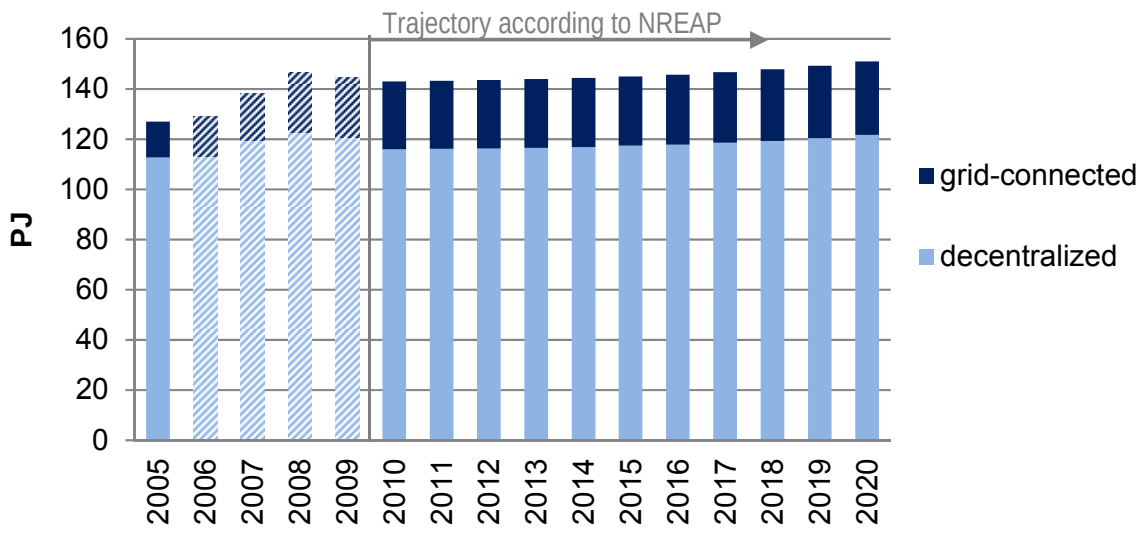


Figure 21. Historic development of final energy consumption of heat from biomass and trajectory according to the NREAP.
Sources: Karner et al. (2010), Statistik Austria (2011c) (data for the years 2006 to 2009; hatched bars), own calculations and illustration

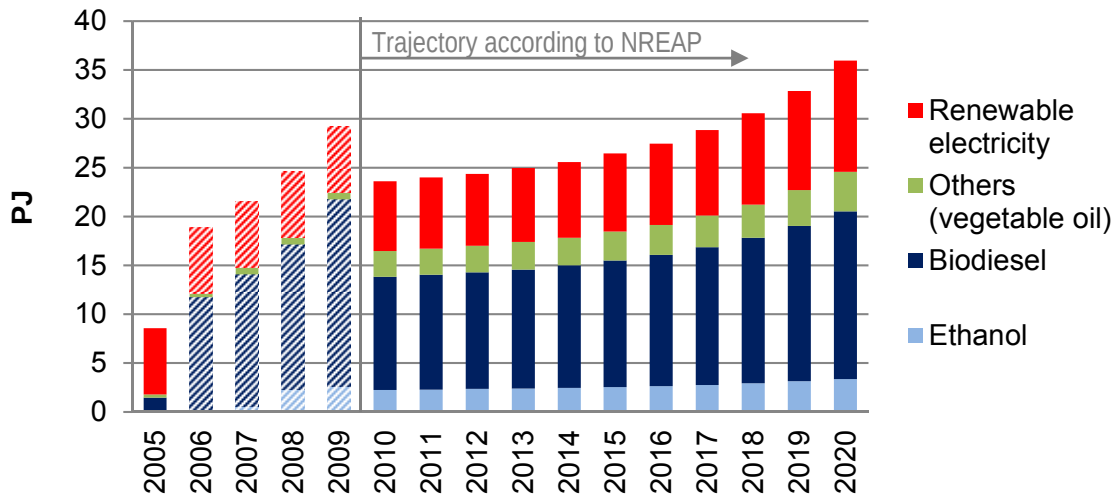


Figure 22. Historic development of biofuel and renewable electricity consumption for transport and trajectory according to the NREAP.
Sources: Karner et al. (2010), Winter (2011) (data for the years 2006 to 2009; hatched bars. As there are no data available on the renewable electricity consumption for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

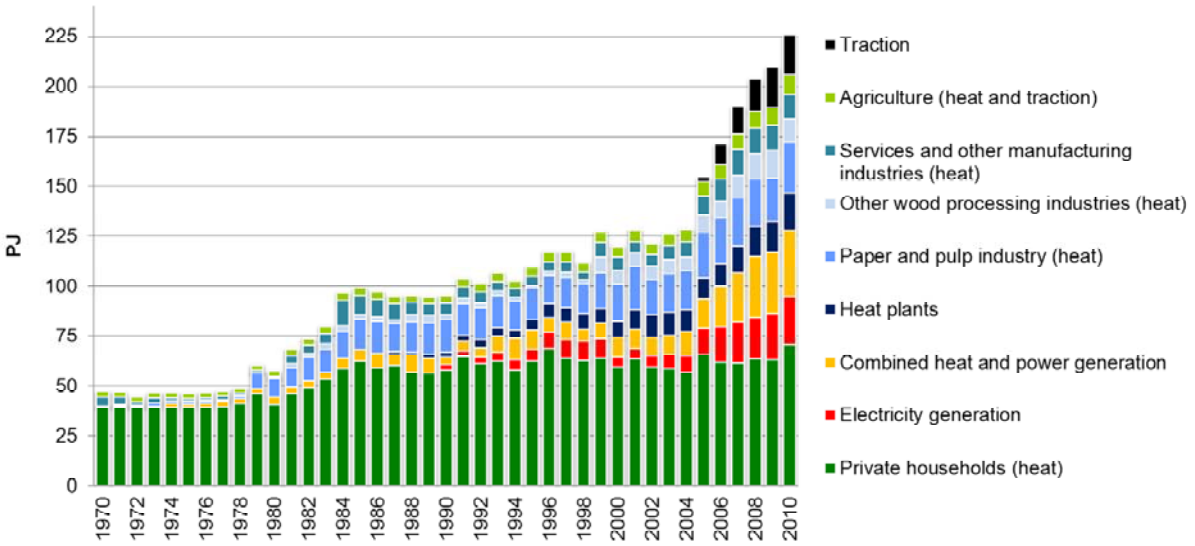


Figure 23. Development of biomass primary energy consumption broken down by utilization type and users.
The categories "CHP" and "electricity generation" also include autoproduction plants in the industry.
Sources: Statistik Austria (2011c)

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.

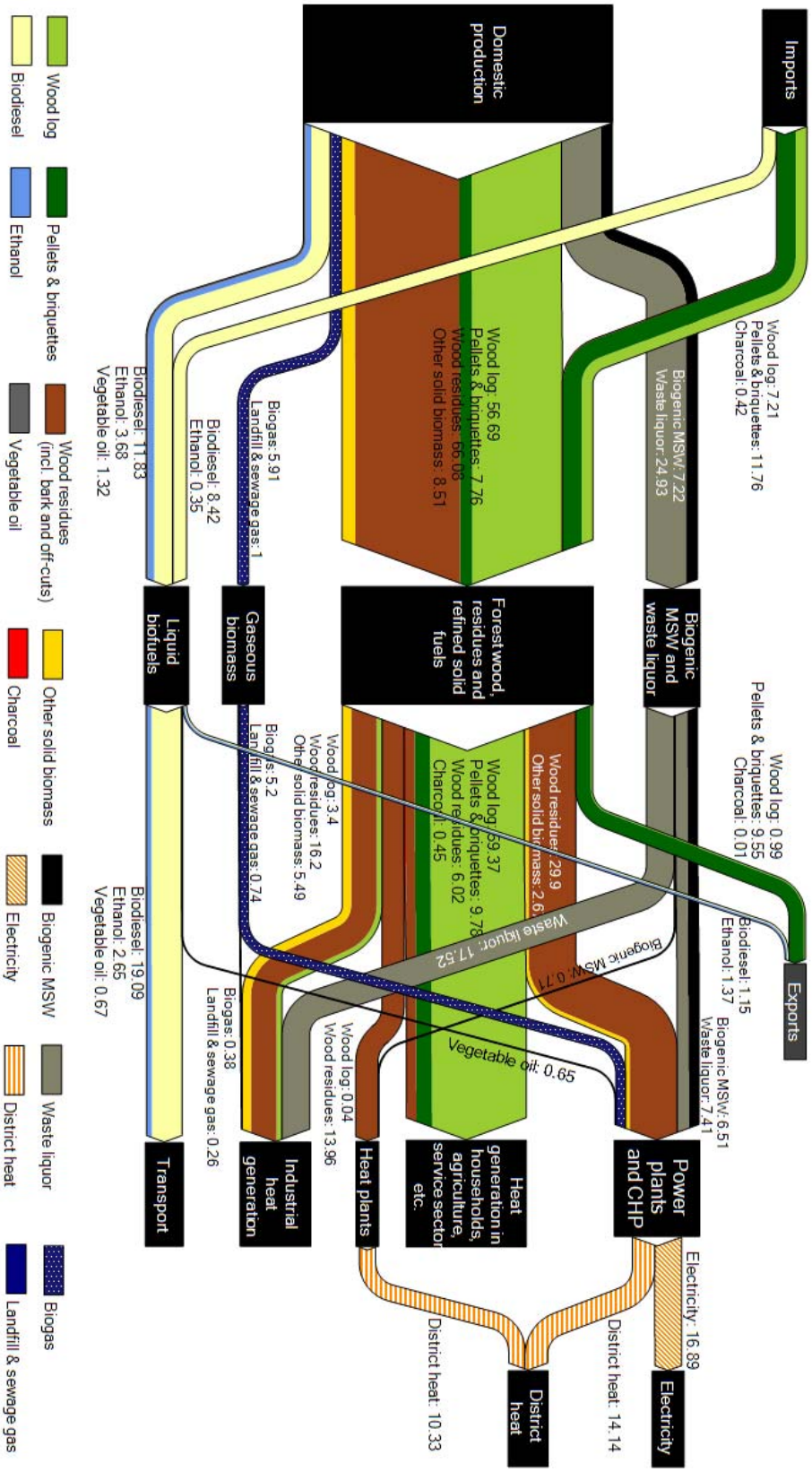


Figure 24. Flow diagram of the Austrian bioenergy sector.
(values in PJ; feedstock imports are stated as equivalents of the refined biofuel; flows of less than 0.5 PJ are partly not displayed for better readability).
Sources: Kalt et Kranzl (2011), based on Statistik Austria (2011c) and Winter (2011),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

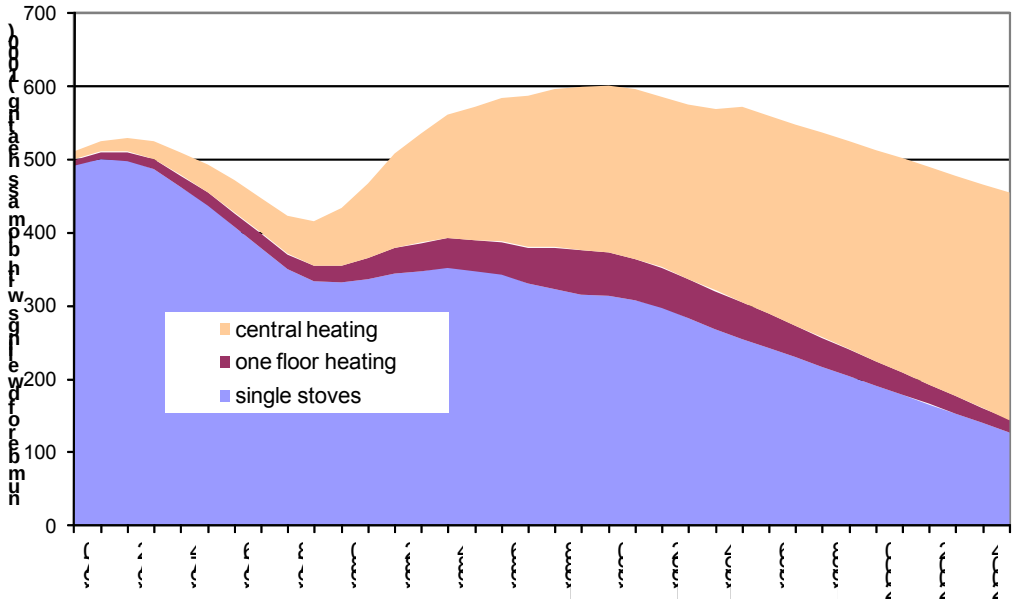


Figure 25. Development of the number of dwellings with biomass heating from 1970 to 2004.
Source: Kranzl et al. (2008)

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.

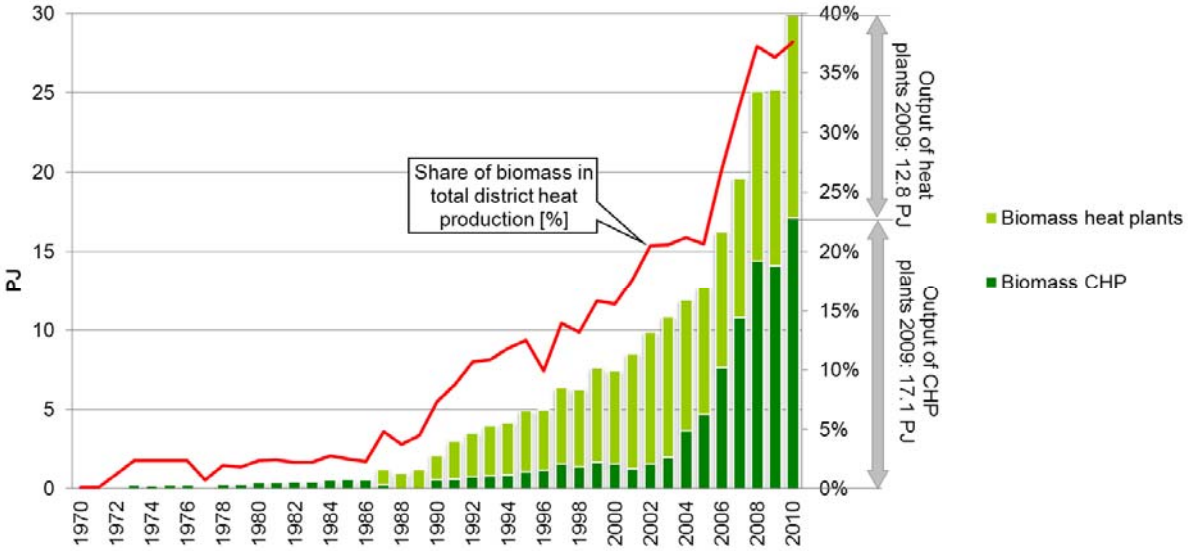


Figure 26. Development of biomass-based district heat generation from 1970 to 2009.
(HP: heat plants, CHP: combined heat and power plants)
Source: Statistik Austria (2011c)

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.

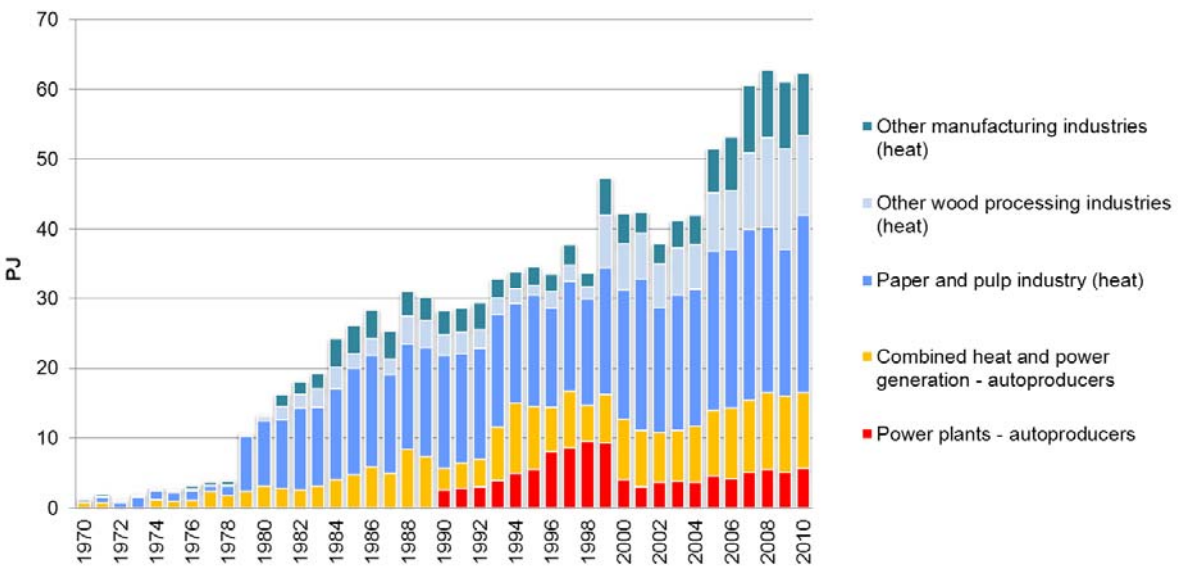


Figure 27. Development of biomass consumption in commerce and industry and the share of biomass in the total final energy consumption of this sector.
Source: Statistik Austria (2011c)

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.

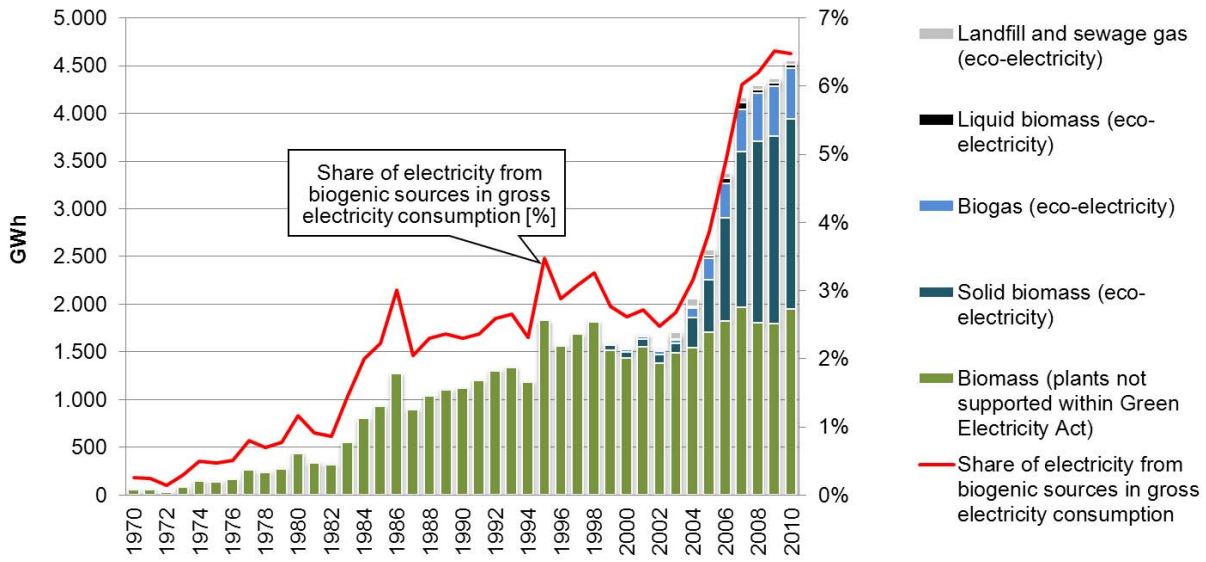


Figure 28. Development of electricity generation from biomass and its share in Austria's gross electricity consumption.
Sources: Statistik Austria (2011c), E-control (2011b)

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).

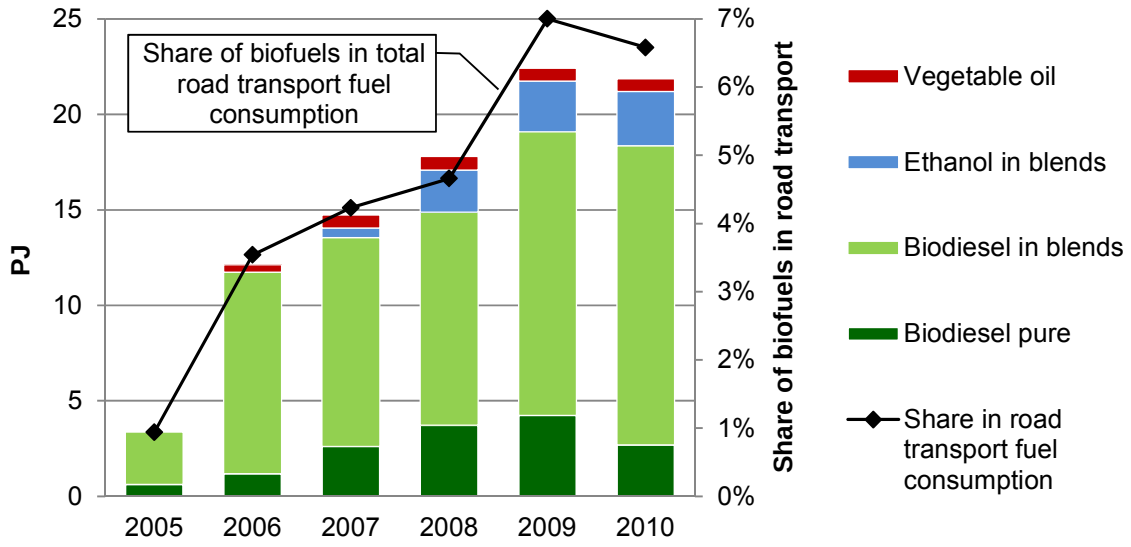


Figure 29. Development of the consumption of biofuels for transport in Austria from 2005 to 2010.
Sources: Winter (2011), Statistik Austria (2011c)

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.

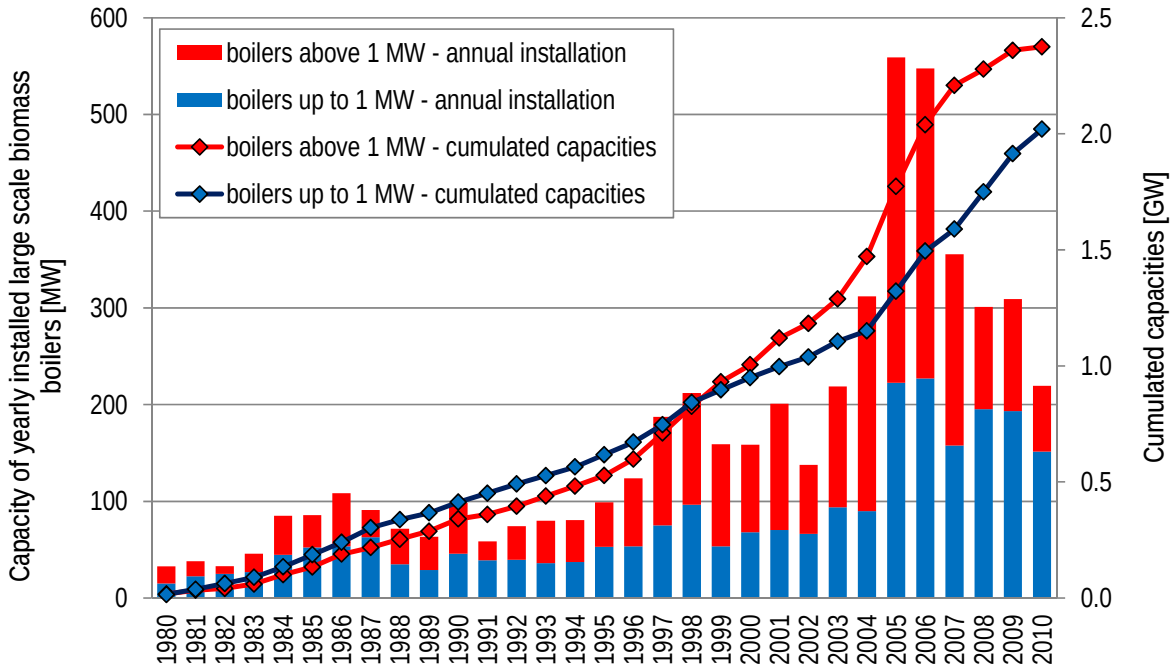


Figure 30. Development of annual installations and cumulated capacities of biomass boilers with a rated power of more than 100 kW.
(Cumulated capacities: calculation based on an assumed lifetime of 20 years; boilers installed before 1980 not taken into account.)
Source: Furtner & Haneder (2011), own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

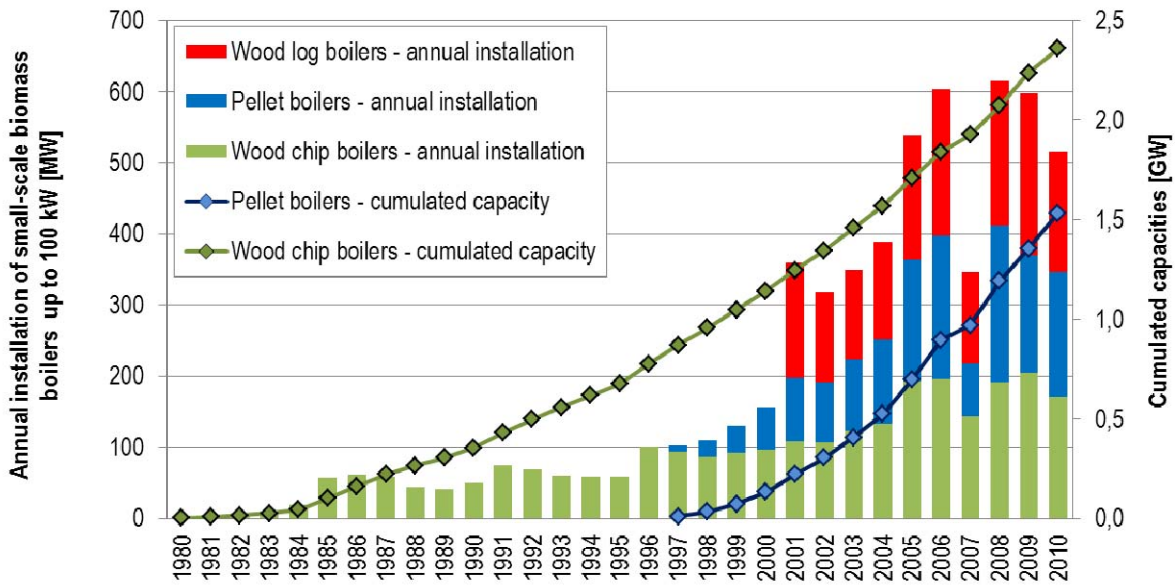


Figure 31. Development of annual installations and cumulated capacities of biomass boilers with a rated power up to 100 kW.
(Cumulated capacities: calculation based on an assumed lifetime of 20 years; wood chip boilers installed before 1980 not taken into account; cumulated capacities of wood log boilers 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}).

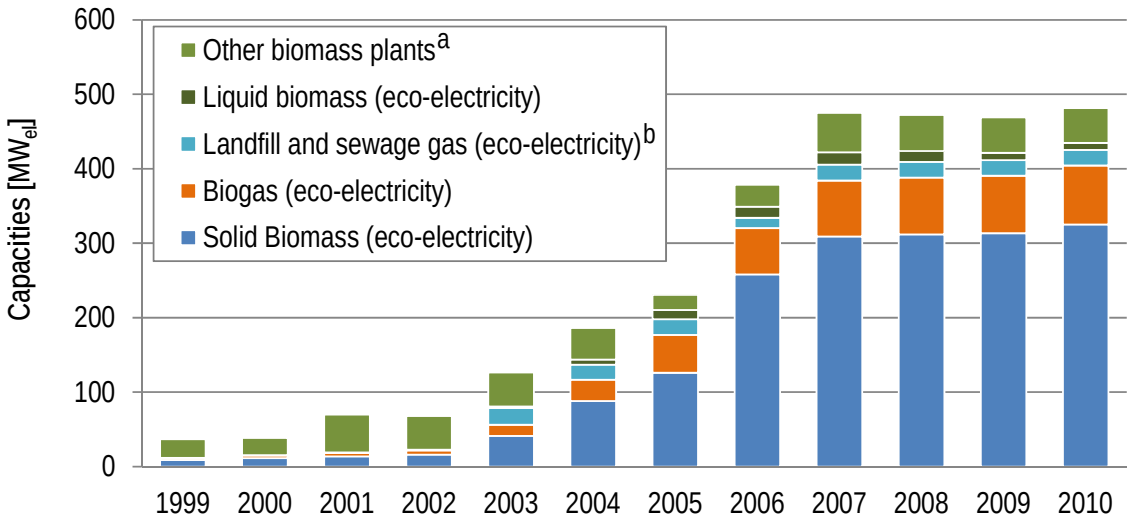


Figure 32. Development of installed capacities for electricity generation from biomass.
a) Bioenergy plants not supported as eco-electricity plants; estimated capacites based on energy balance (6,000 annual full load hours assumed); excluding waste liquor and MSW plants).
b) No data available for the 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).

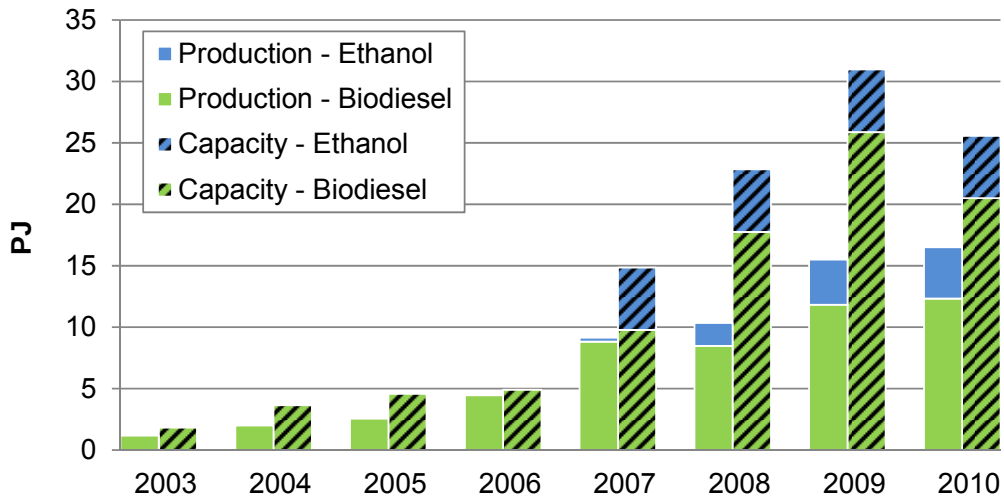


Figure 33. Comparison of the historic development of biodiesel and ethanol production with production capacities in Austria.
Sources: Winter (2011) (production), EBB (2011), ePURE (2011) (production capacities[7])

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.

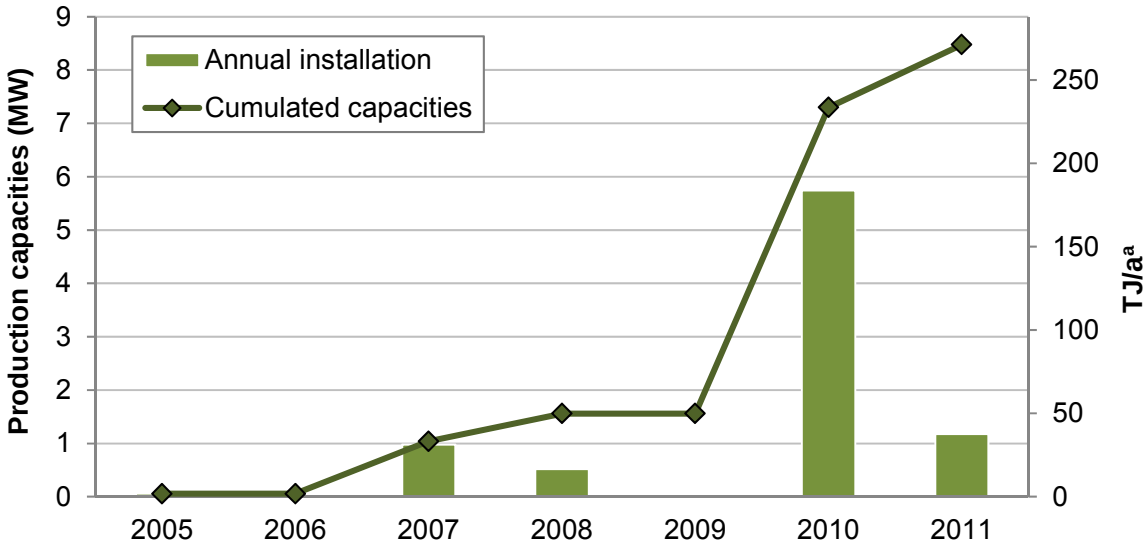


Figure 34. Development of biomethane production capacities.
a) Annual biomethane production capacity at an assumption of 8000 full load hours per year.
Sources: Biogaspartner (2011), Bala et al. (2009).

[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.

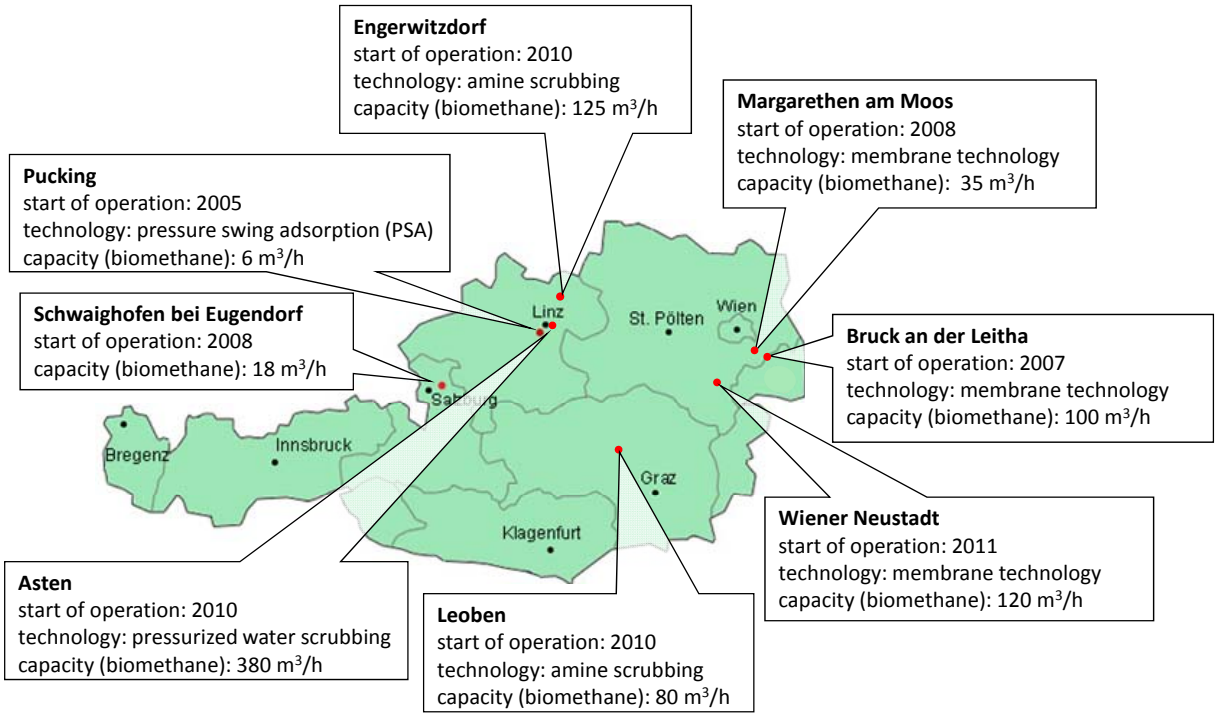


Figure 35. Location and characteristics of biomethane production plants in Austria. Sources: Biogaspartner (2011), Bala et al. (2009).

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.

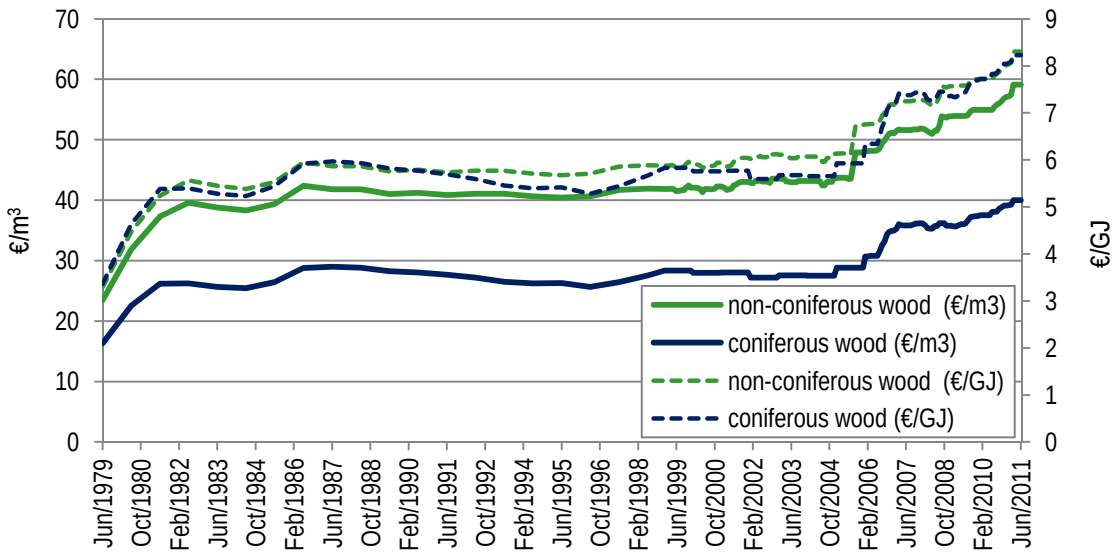


Figure 36. Development of nominal producer prices of fuelwood (coniferous and non coniferous) in Austria, prices are weighted bulk buyer and small consumer prices at forest road excluding VAT and transport cost.
(An average water content of 20% was assumed in the conversion from m^3 to GJ.)
Sources: 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 (€/m^3). 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 m^3 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.

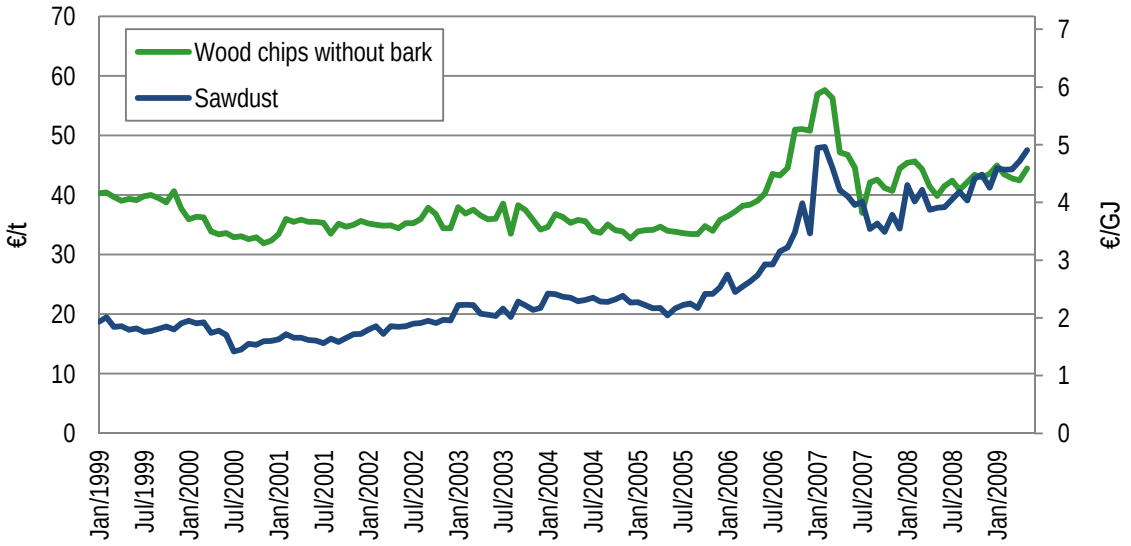


Figure 37. Nominal price development of wood chips without bark and sawdust in Austria. Source: FHP (2010)

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.

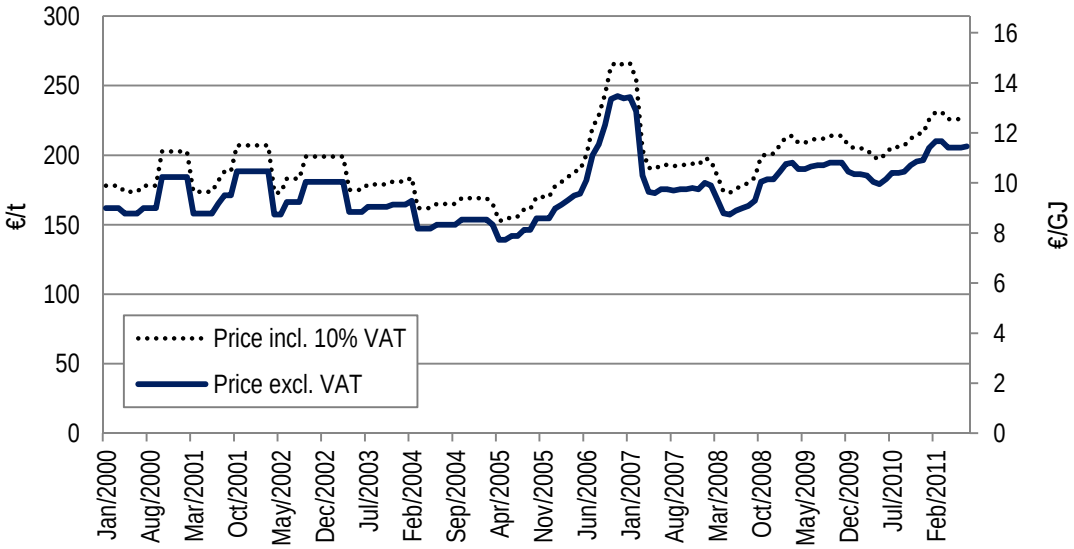


Figure 38. Nominal price development of wood pellets in Austria.
(Weighted average price per tonne delivered as loose; purchase volume of about 5 tonnes; incl. transport of max 50 km; incl. VAT (10%); ÖNORM M 7135)
Sources: ProPellets (2011), Pellet@las (2011)

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.

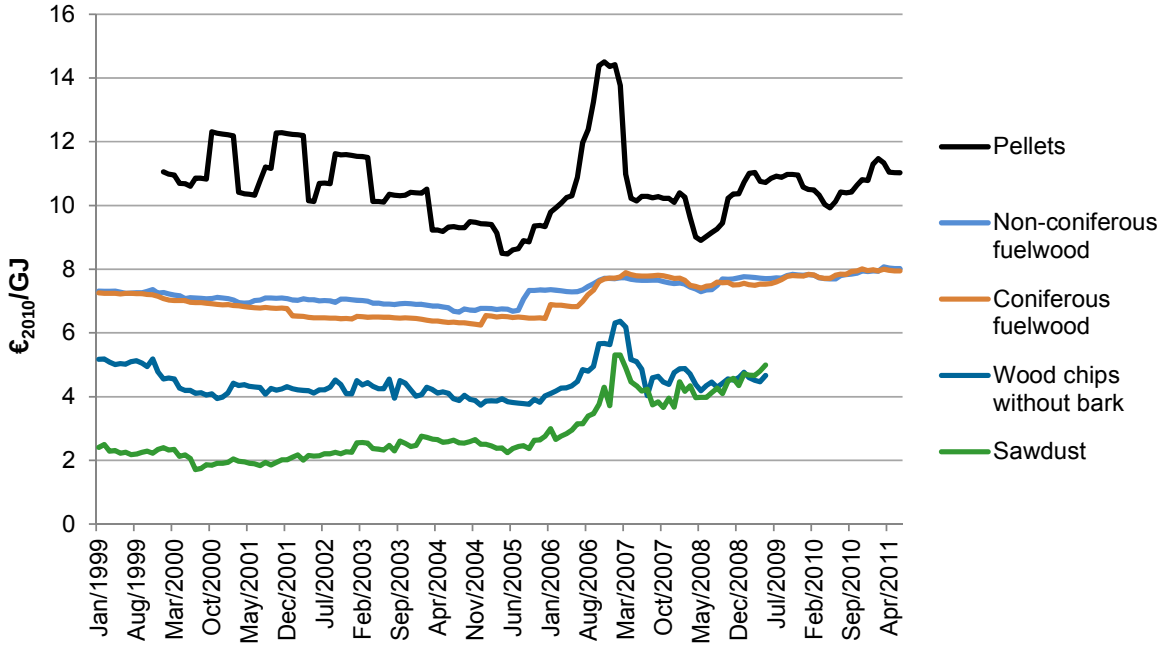


Figure 39. Comparison of real price development of wood fuels.
(in €$_{2010}$ excl. VAT).
Sources: Statistik Austria (2011e), LK-NÖ (2011), FHP (2010), ProPellets (2011), Pellet@las (2011), Statistik Austria (2011f), own calculations

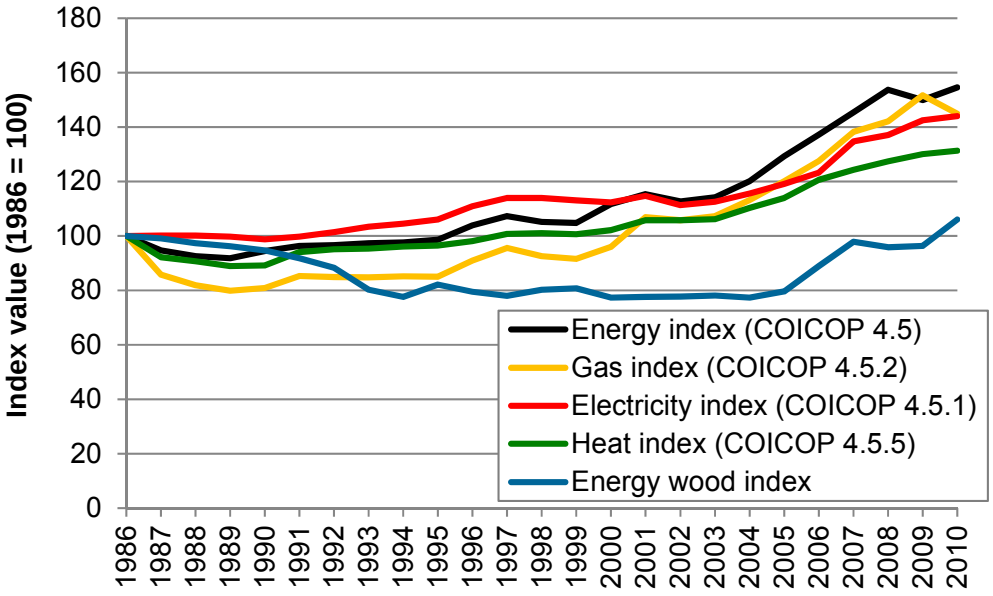


Figure 40. Development of the Austrian energy wood index from 1979 to 2010.
(COICOP: Classification of Individual Consumption According to Purpose; see (UN Statistics Division, 2011); Electricity, heat, gas and energy indices also include associated expenditure such as hire of meters, reading of meters, 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.

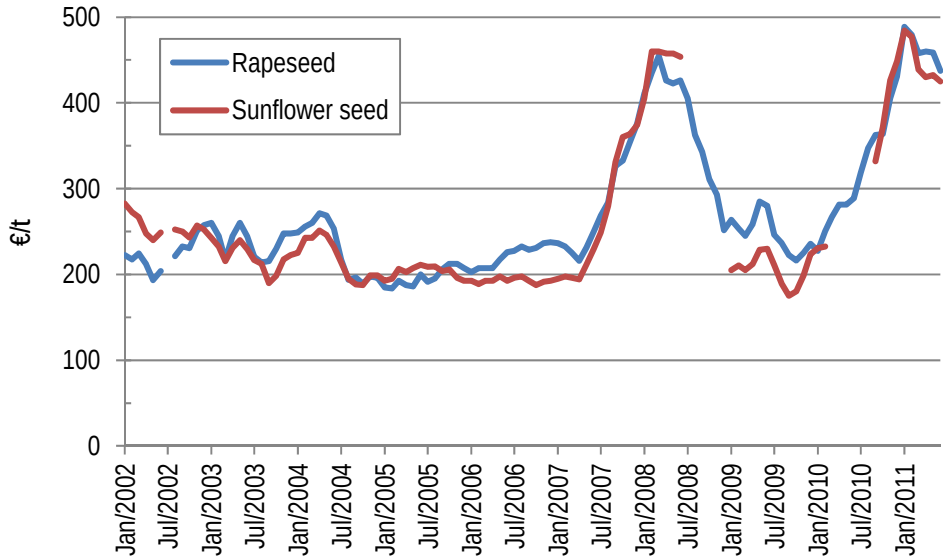


Figure 41. Nominal price developments of oilseeds at the Vienna Agricultural Commodities Market (Börse für landwirtschaftliche Produkte in Wien).
(Monthly average wholesale prices in €/ton, excl. VAT; rapeseed: 40% fat, bulk; sunflower seed: 44% fat, bulk)
Source: Stock market for agricultural products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

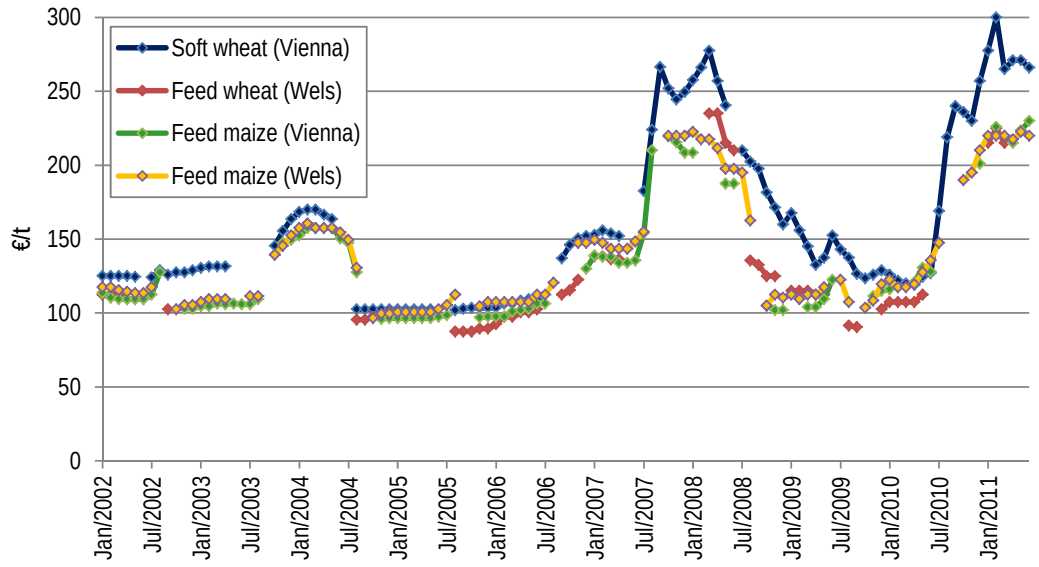


Figure 42. Nominal price developments of wheat and maize at the Agricultural Commodities Markets Vienna and Wels (Börse für landwirtschaftliche Produkte in Wien and Wels).
(Monthly average wholesale prices in €/tonne, excl. VAT)
Source: Stock market for agricultural products Vienna, in AMA (2011)

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.

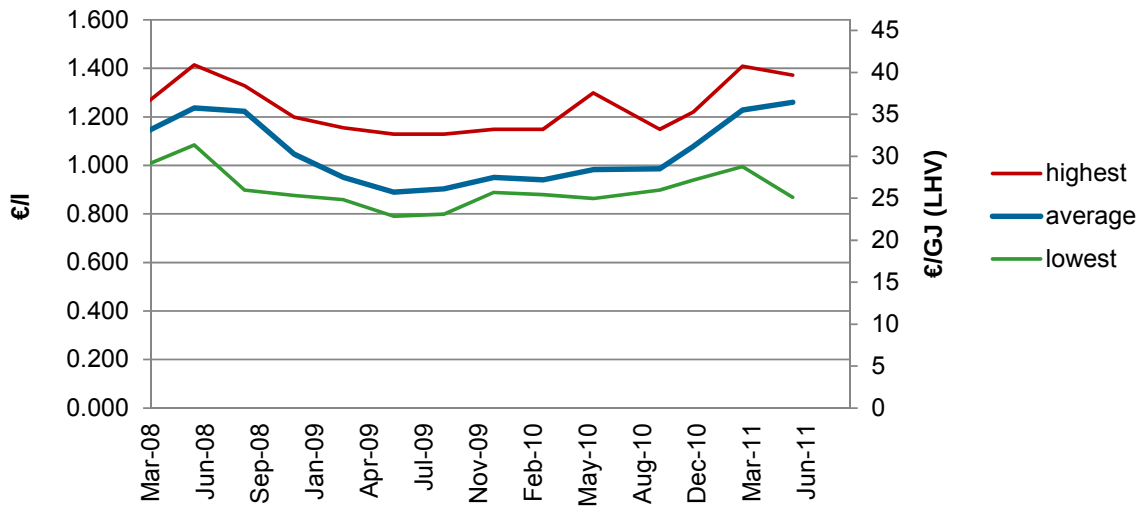


Figure 43. Nominal price development of biodiesel at the pump.
(based on a survey of 1380 petrol stations, 32 of which selling biodiesel)
Source: Arbeiterkammer (2011)

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.

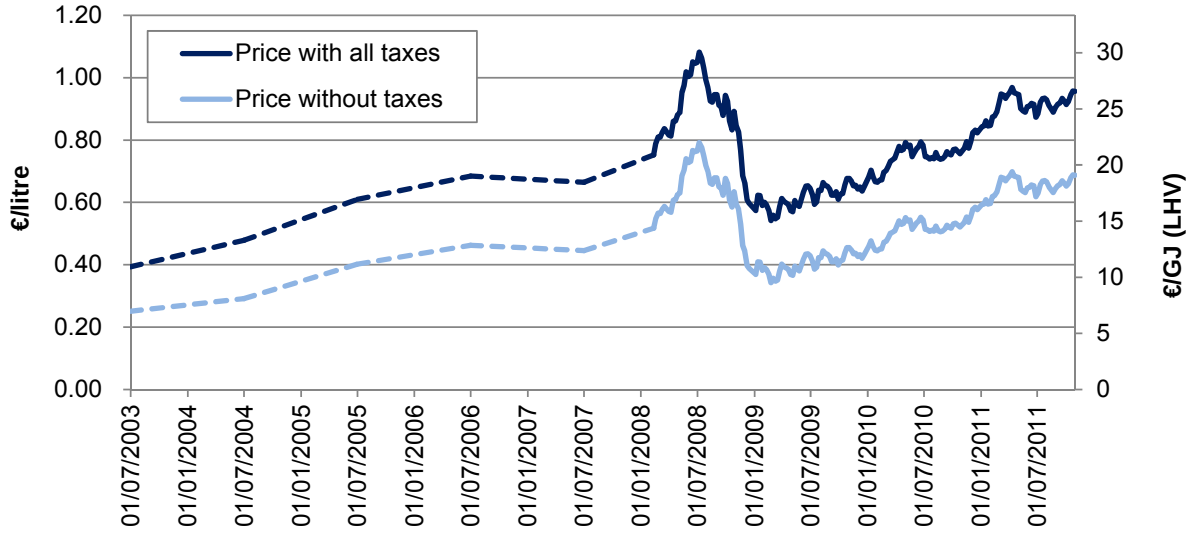


Figure 44. Nominal price development of heating oil.
(Prices refer to a purchase quantity of 2,000 litre; 2003 to 2007: annual averages, from 2008: weekly values)
Sources: Statistik Austria (2011h), BMWFJ (2011)

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”).

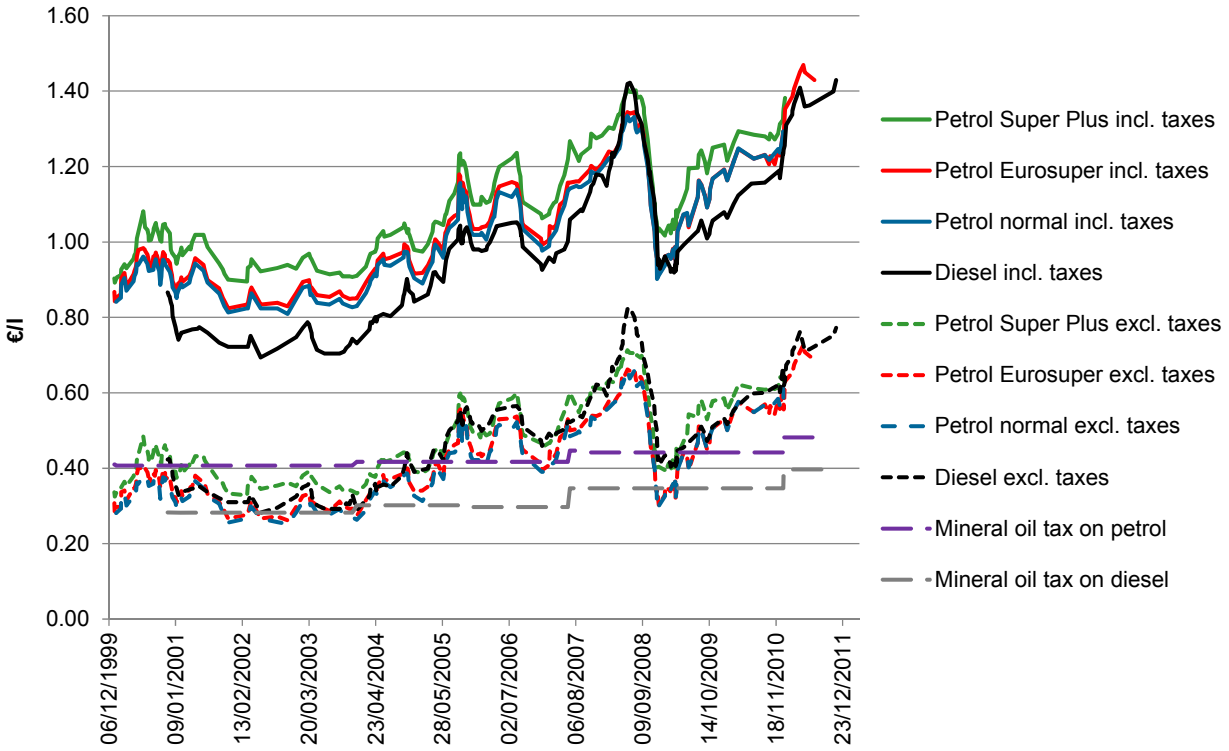


Figure 45. Nominal price development of fossil transport fuels at the pump incl. and excl. VAT and mineral oil taxes.
Source: ÖAMTC (2011), own calculations

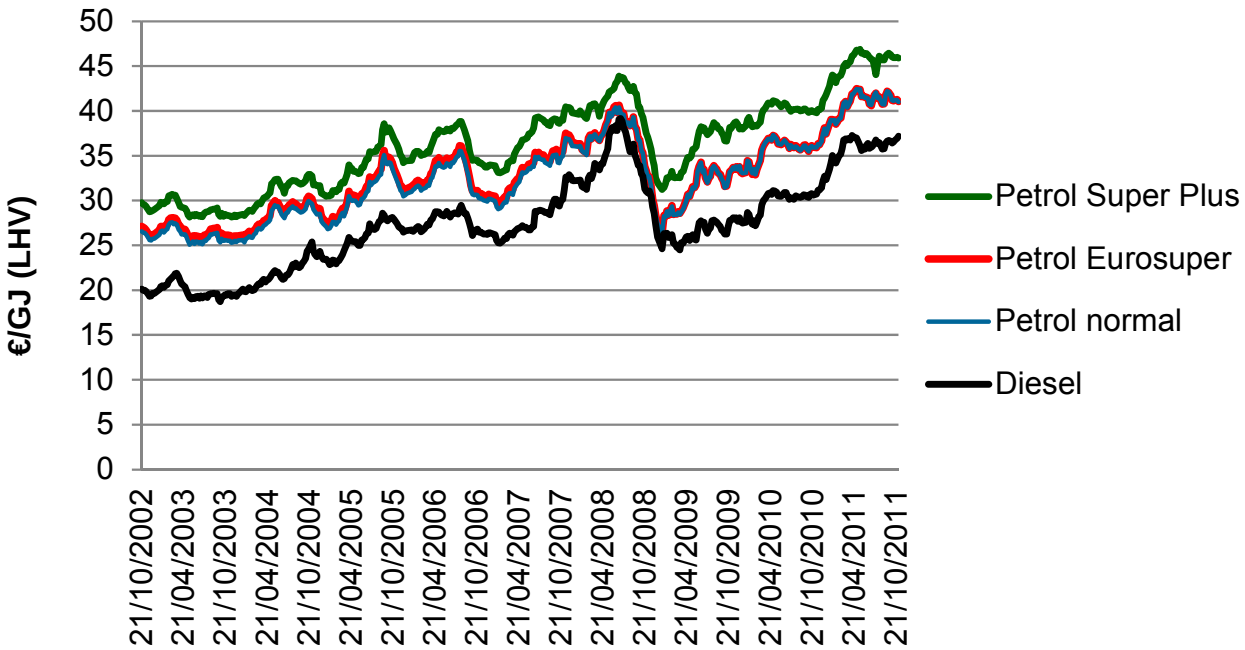


Figure 46. Nominal price development of fossil transport fuels at the pump (incl. taxes).
Sources: BMWFJ (2011)

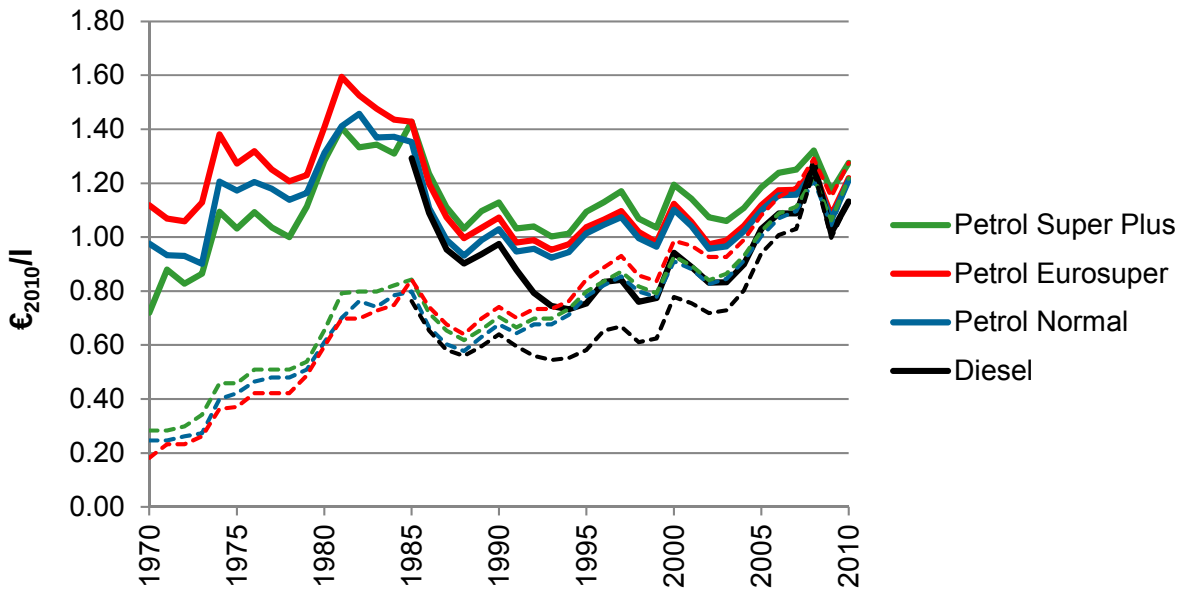


Figure 47. Real and nominal price development of transport fuels from 1970 to 2010 (price at the pump incl. taxes).
(Continuous lines: real prices in €$_{2010}$; dashed lines: nominal prices)
Source: ÖAMTC (2011), own calculations

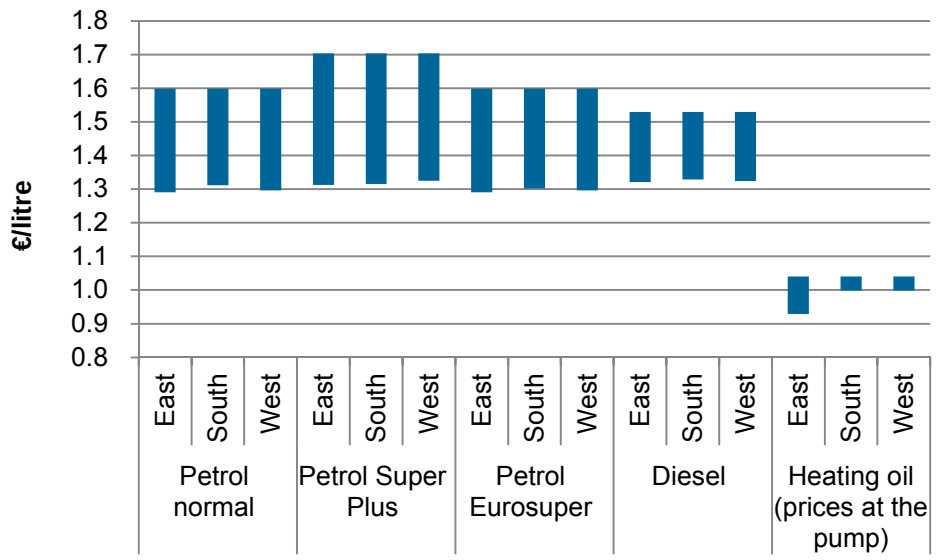


Figure 48. Regional spread of transport fuel prices at the pump as of 11/11/2011.
(East: Upper Austria, Lower Austria, Vienna, North-Burgenland; South: East Tyrol, Carinthia, Styria, South-Burgenland; West: Vorarlberg, North Tyrol, Salzburg)
Source: BMWFJ (2011)

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.

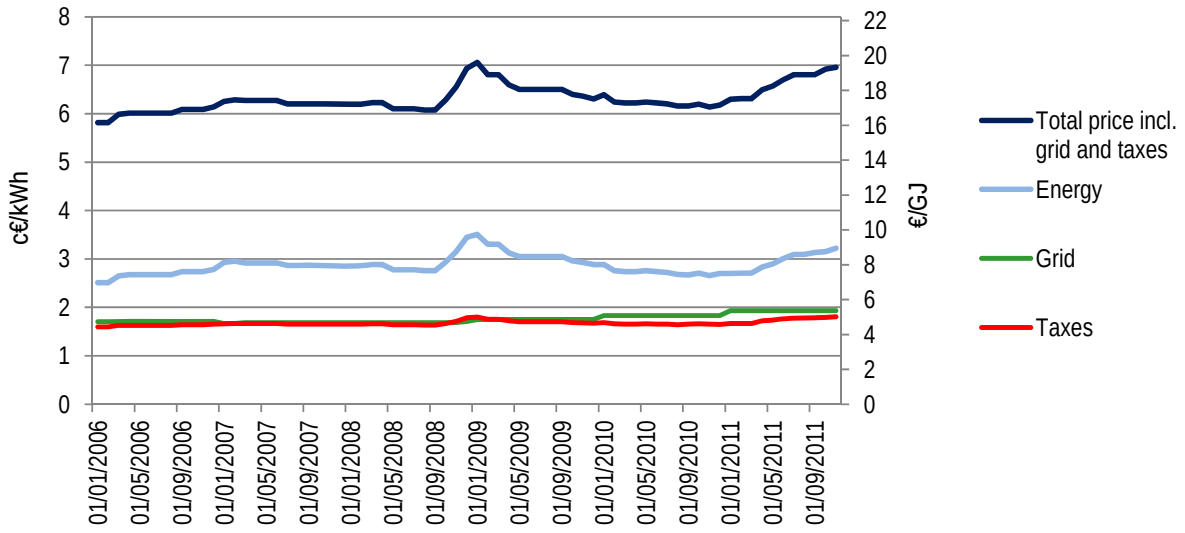


Figure 49. Development of average gas prices (nominal) for households.
(Total end user prices include the energy prices, grid charges and taxes (VAT and energy tax). Prices refer to an annual consumption of 15,000 kWh/a.)
Sources: Statistik Austria (2011h), BMWFJ (2011)

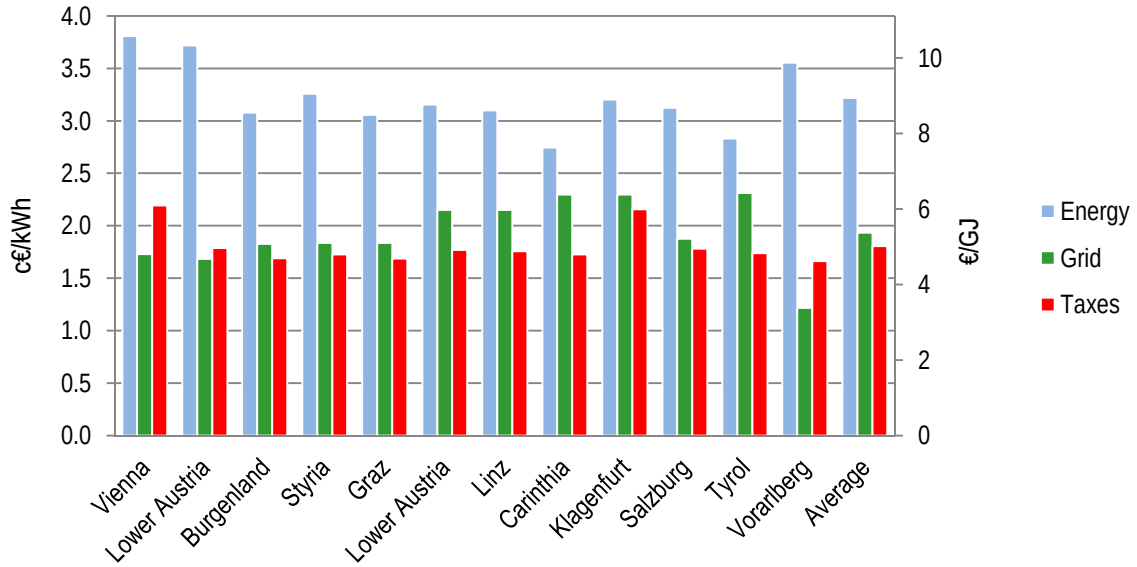


Figure 50. Comparison of gas price for households as of 01/11/2011.
(Prices refer to an annual consumption of 15,000 kWh/a.)
Sources: Statistik Austria (2011h), BMWFJ (2011)

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.

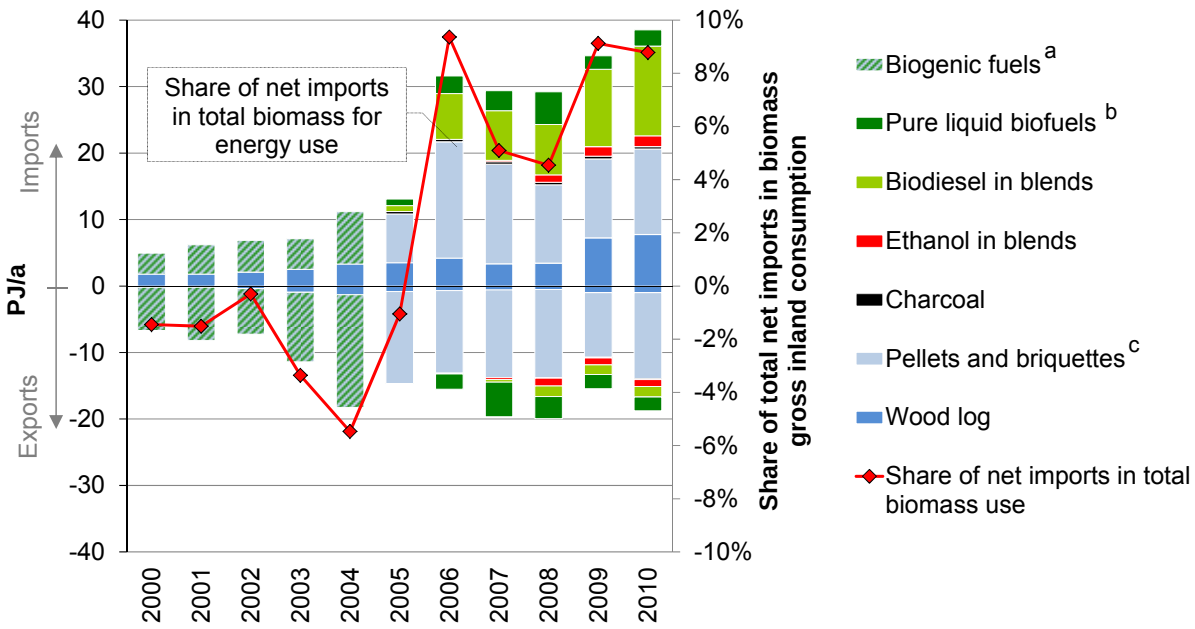


Figure 51. Imports and exports of biogenic energy carriers according to energy statistics of the national statistical authority.
a) Includes all types of biomass except wood log
b) Includes vegetable oil, pure biodiesel and E85
c) A comparison with other trade statistics indicates that the category "pellets 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.

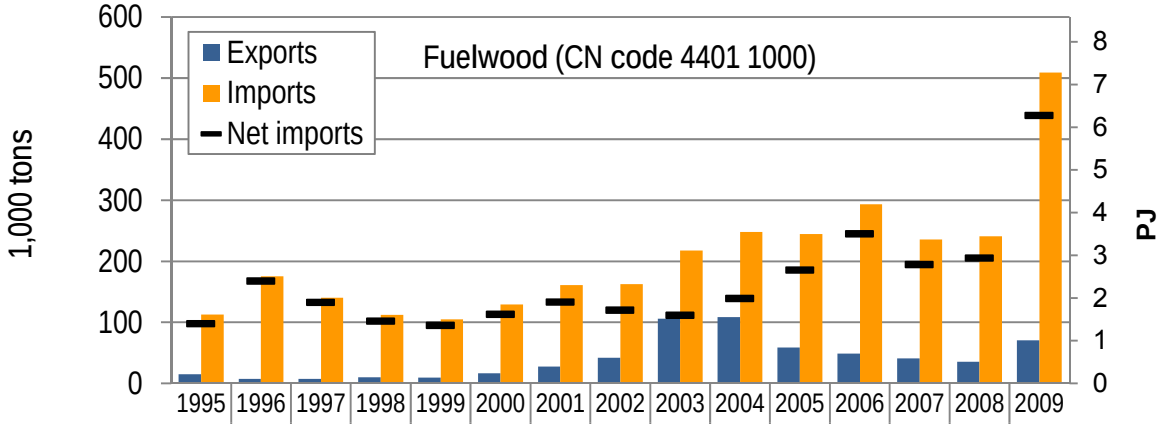
In the following sections, the historic development of Austria's imports and exports of wood fuels are presented. This includes fuelwood, wood chips, wood residues and pellets. Only data reported by Austria are shown, regardless of the fact that the quantities reported by trade partners partly differ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

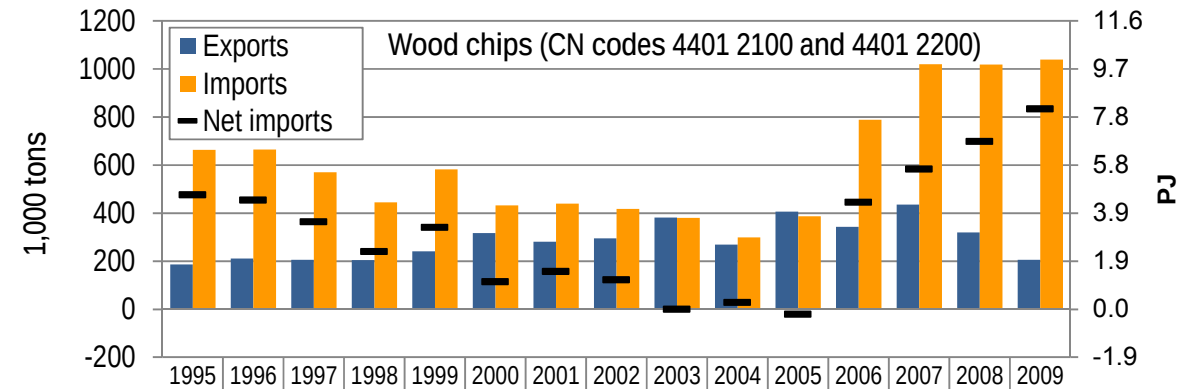


	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exports	15	7	8	10	10	16	28	42	106	109	59	49	41	36	71
Imports	113	175	141	113	105	129	161	162	218	248	245	294	236	241	509
Net imports	98	168	133	102	95	113	133	120	111	139	186	245	195	205	438

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).

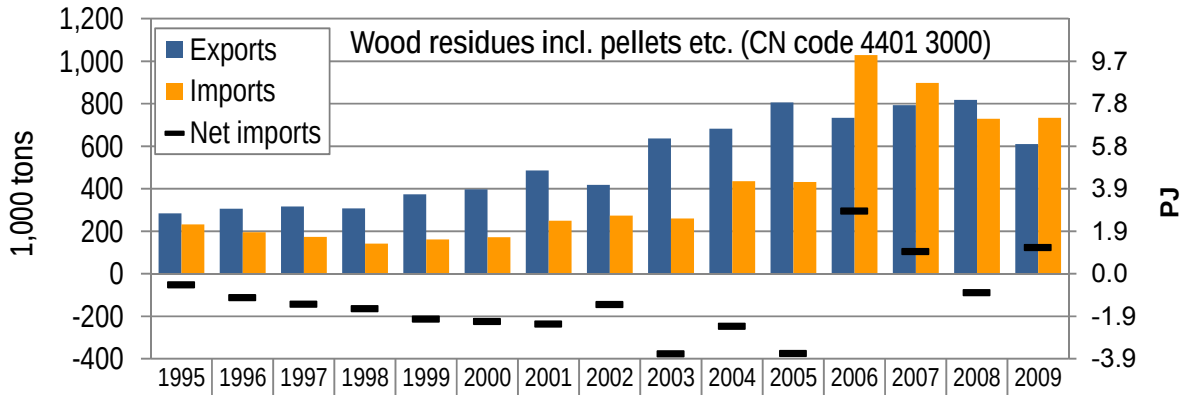


	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exports	187	211	206	204	241	317	282	295	381	270	407	344	436	320	205
Imports	664	665	571	445	582	433	440	418	381	299	387	789	1020	1019	1039
Net imports	476	454	364	241	341	115	158	123	0	29	-20	445	584	699	834

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

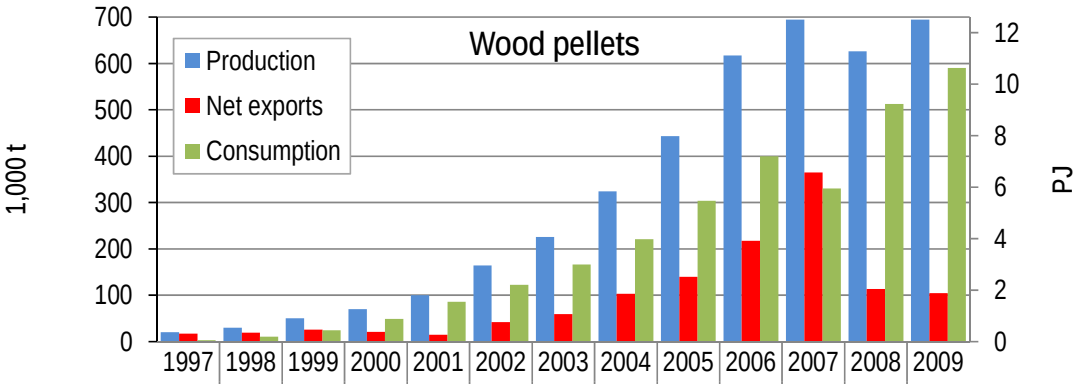
Figure 54. Development of Austria's imports and exports of wood residues (incl. wood pellets) from 1995 to 2009.
Source: Eurostat (2011)

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.

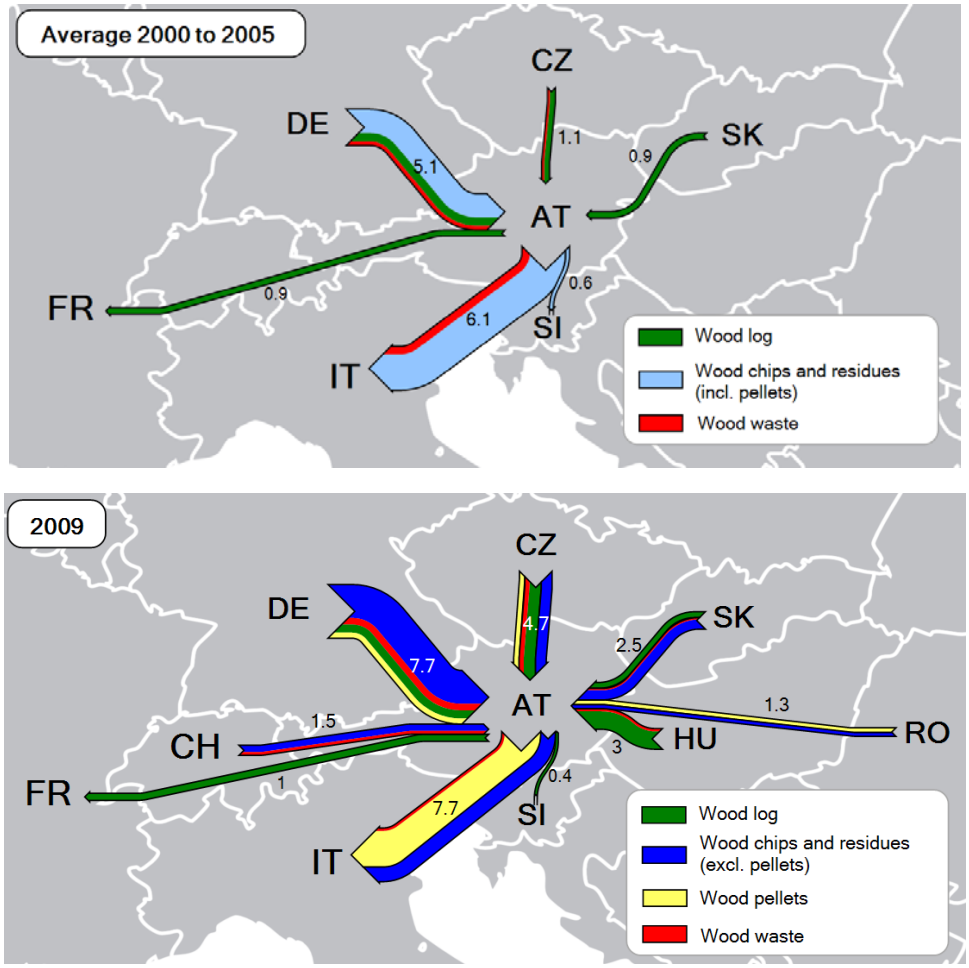


Figure 56. Comparison of the net trade streams with wood log, wood residues, pellets and wood waste in 2009 (bottom) with the annual average during 2000 to 2005 (top).
(values in PJ, only streams above 0.3 PJ are shown)
Sources: Kalt (2011), based on Eurostat (2011)

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.

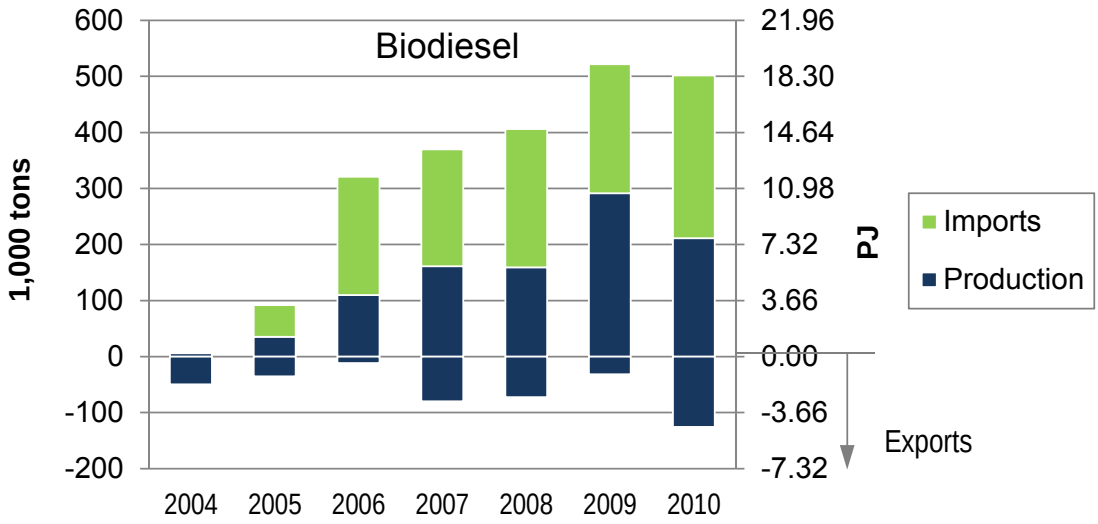


Figure 57. Austrian biodiesel supply from 2004 to 2010 according to the official biofuel report persuant Directive 2003/30/EC.
Sources: Kalt (2011), based on Winter (2011), Statistik Austria (2011c)

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.

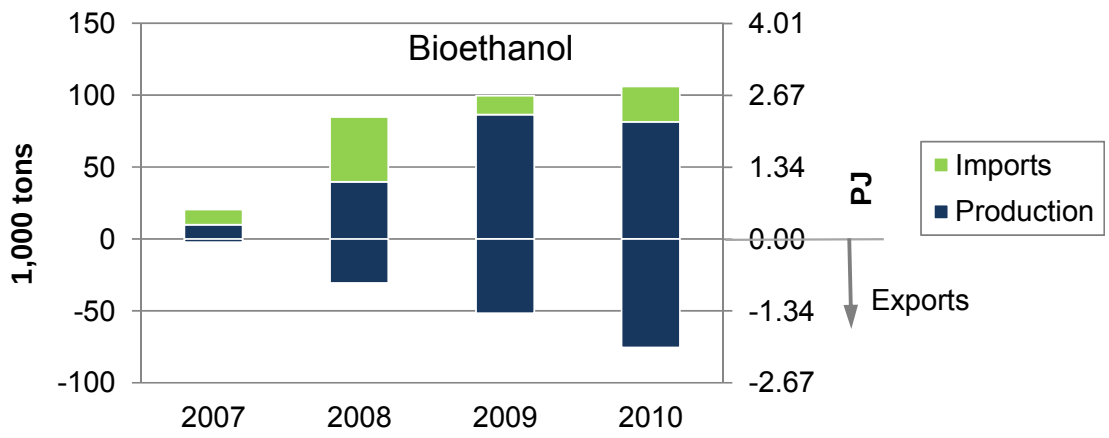


Figure 58. Austrian bioethanol supply from 2007 to 2010 according to the official biofuel report persuant Directive 2003/30/EC.
Sources: Kalt (2011), based on Winter (2011), Statistik Austria (2011c)

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.

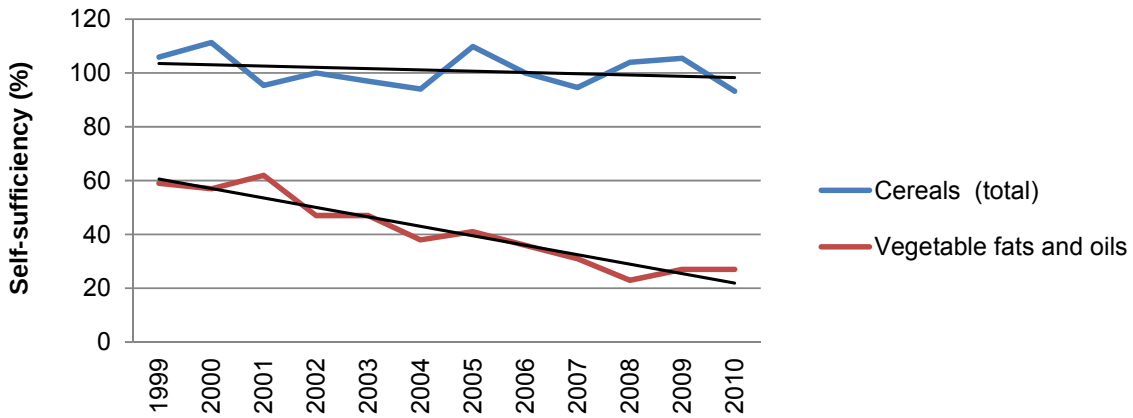


Figure 59. Development of the rate of self-sufficiency with cereals and vegetable fats and oils from 1999 to 2010.
Source: Statistik Austria (2011i)

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.

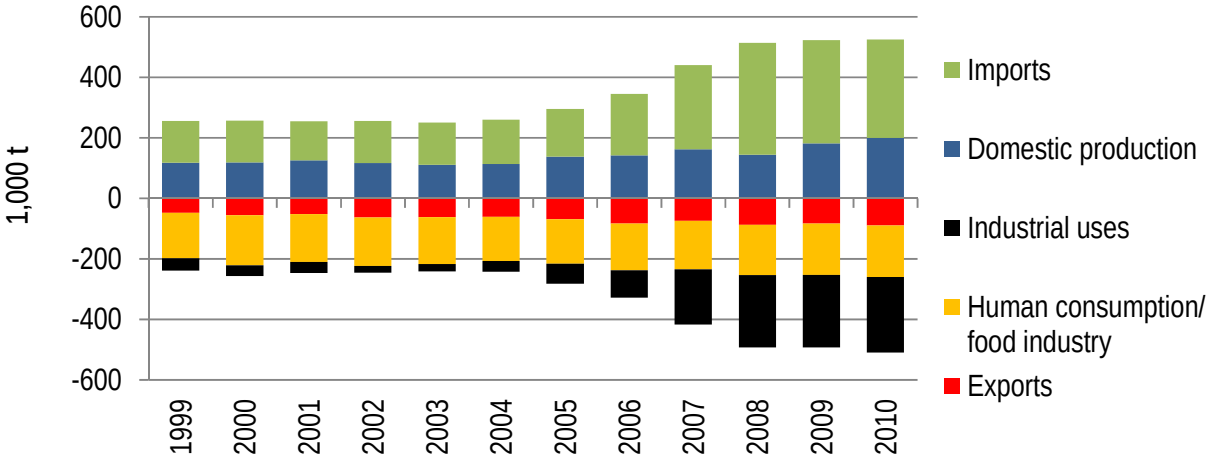


Figure 60. Supply balance for vegetable oil.
(Stockkeeping, consumption for animal feed and losses are not shown due to negligible quantities, "Domestic production" represents to the oil content of the Austrian oilseed production)
Source: Statistik Austria (2011i)

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.

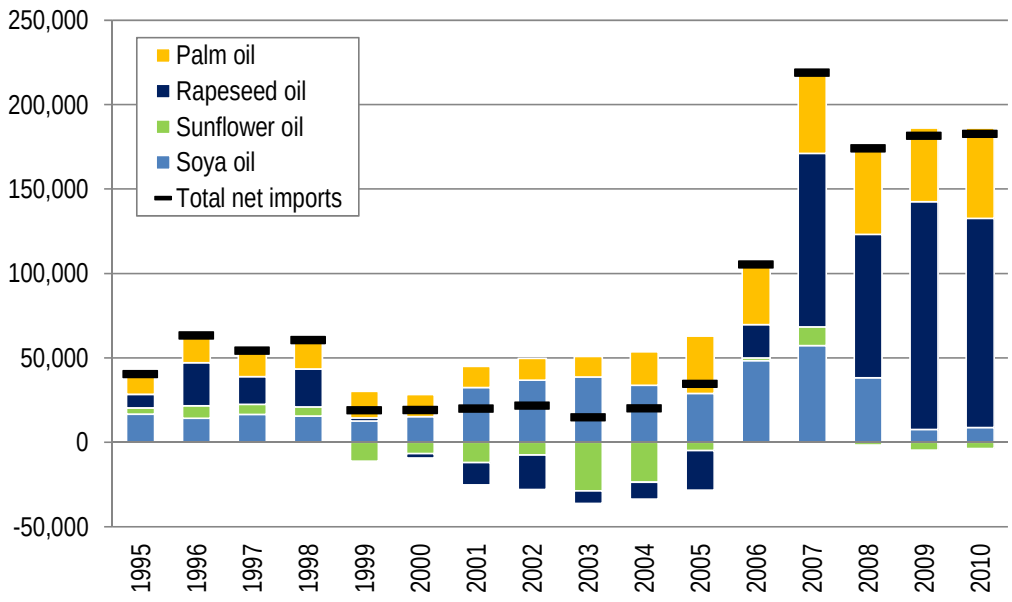


Figure 61. Development of net imports of palm oil, rapeseed oil, sunflower oil and soya oil from 1995 to 2010.
Source: Eurostat (2011)

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.

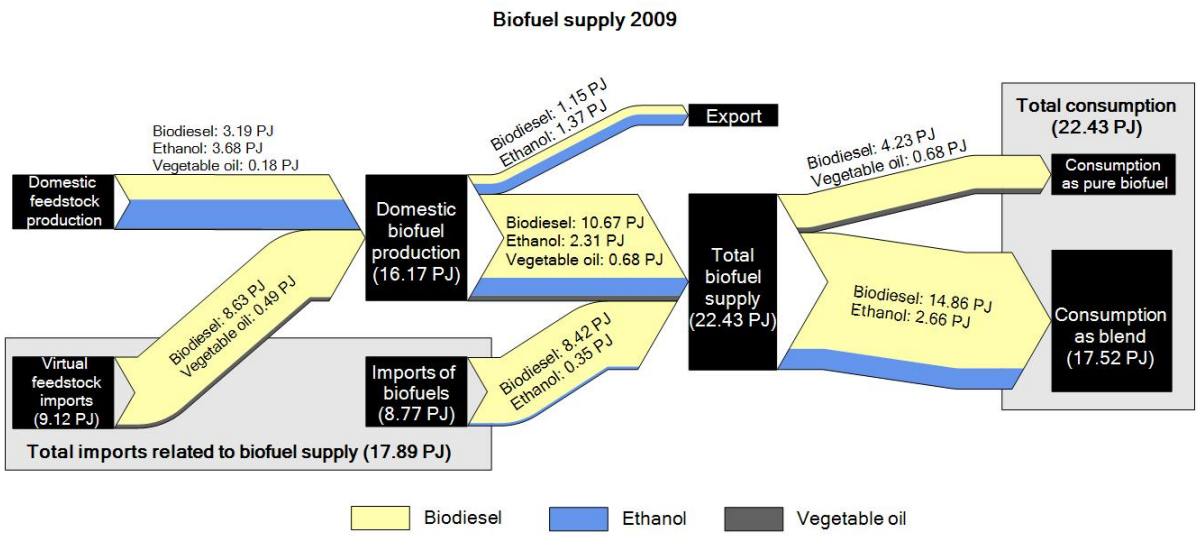


Figure 62. Flow diagram of the Austrian biofuel sector in 2009.
(Feedstock imports are stated as equivalents of the refined biofuel rather than calorific values of the feedstock used; feedstock imports related to biofuel production have been determined based on the self-sufficiency with agricultural 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).

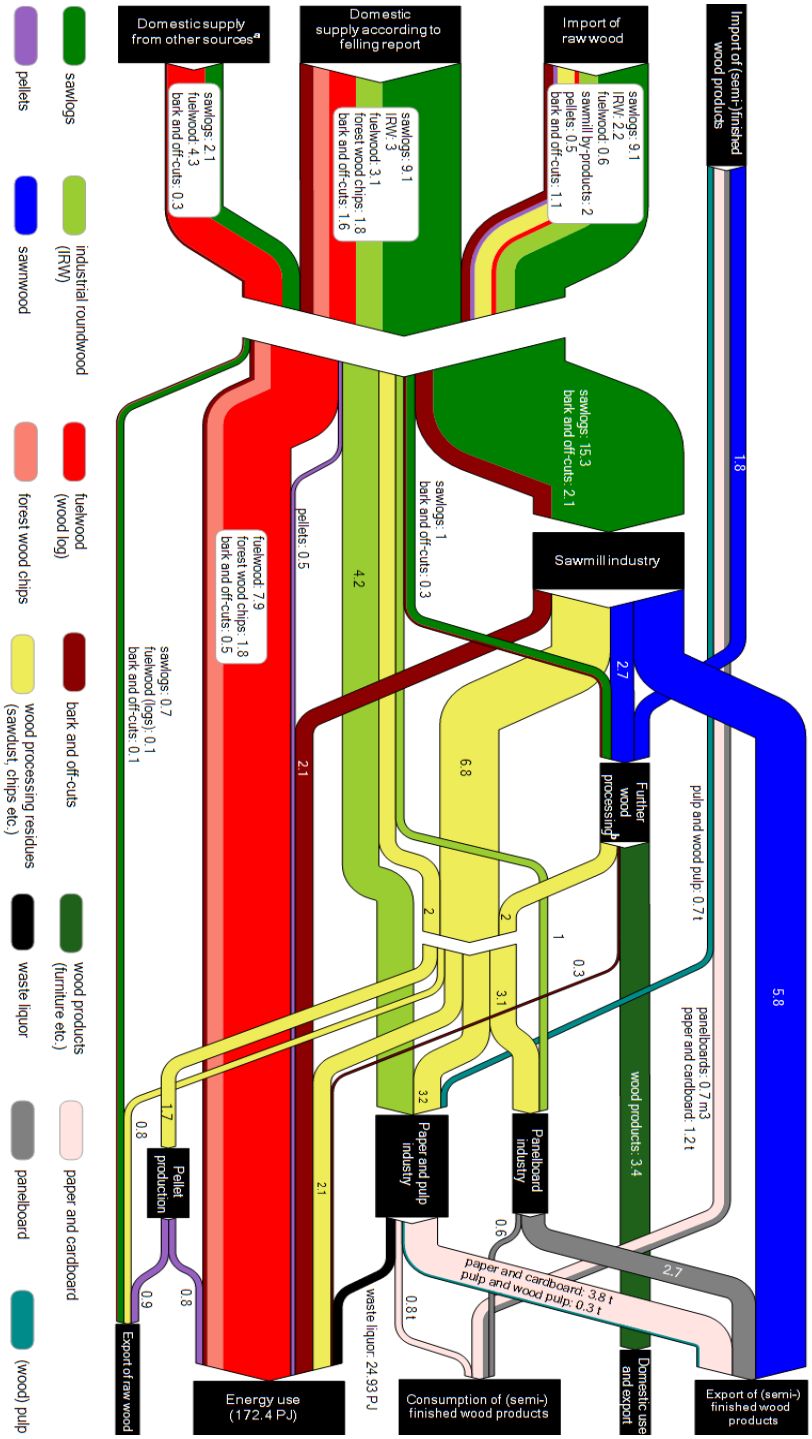


Figure 63. Wood flow diagram for Austria in the year 2009.
(values in solid cubic meters, if not stated otherwise)
a) Domestic supply from other sources: All domestic sources of raw wood not included in the official felling report;
b) Further wood processing: carpentries, furniture plants and veneer 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.

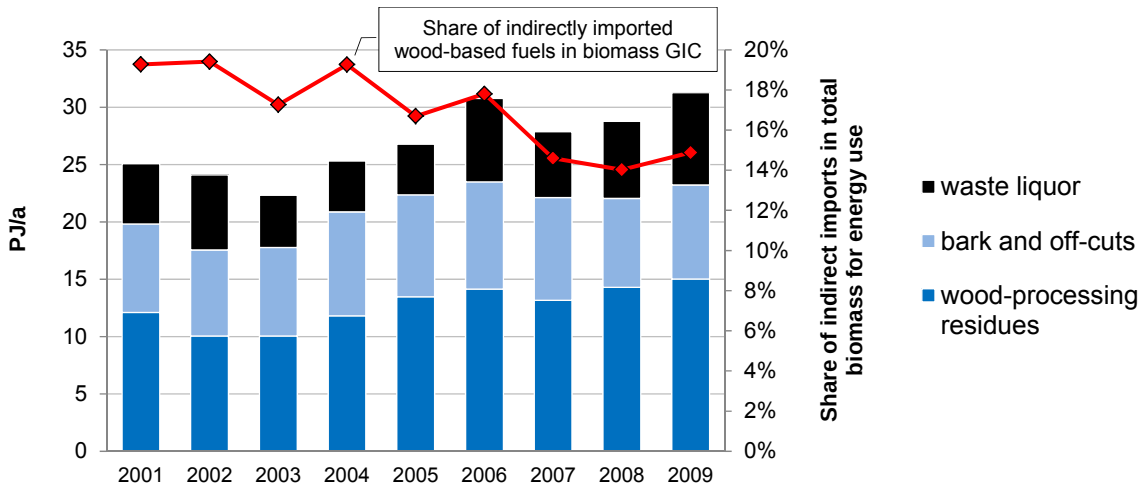


Figure 64. Development of the main indirect import streams for energy use, and the according share in the total biomass consumption.
Source: Kalt & Kranzl (2011)

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).

9 References

Akkerhuis, J., 2010. WP5-report: Incentives to promote Bioethanol in Europe and abroad, BEST (Bioethanol for Sustainable Transport) Deliverable No.5.14, Rotterdam.

Alakangas, E. et al., 2011. Combined Nomenclatures (CN codes) for biomass fuels, EUBIONET 3.

AMA, 2011. Marktinformation - Getreide und Ölsaaten. Available at: http://www.ama.at/Portal.Node/ama/public?gentics.am=PCP&p.contentid=10007.27196 [Accessed August 9, 2011].

Arbeiterkammer, 2011. Treibstoffpreisanalyse der Erhebung von 14. – 15. Juni 2011, Bundeskammer für Arbeiter und Angestellte.

Austropapier, 2011. Statistics of the Austrian paper and pulp industry. Available at: http://www.austropapier.at/index.php?id=81 [Accessed March 15, 2011].

Bala, H. et al., 2009. (BIO) Gas-Inseltankstelle - Integration einer Gasaufbereitung und einer (Bio)-Gastankstelle im Inselbetrieb in eine bestehende Biogasanlage, Vienna.

BFW, 2011. Österreichische Waldinventur 2007-09. Available at: http://bfw.ac.at/rz/wi.home [Accessed July 19, 2011].

Biogaspartner, 2011. Feed-In projects in Austria. Available at: http://www.biogaspartner.de/index.php?id=10275&L=1&fs= [Accessed August 25, 2011].

BMLFUW, 2007. Anpassung der Klimastrategie Österreichs zur Erreichung des Kyoto-Ziels 2008-2013 (Adaptation of the Austrian Climate Strategy for reaching the Kyoto-target 2008-2013). URL http://www.klimastrategie.at/filemanager/download/32772/ [Accessed July 19, 2011], Federal Ministry of Agriculture, Forestry, Environment and Water Management, Vienna

BMLFUW, 2011. Grüner Bericht 2010, Vienna: Federal Ministry of Agriculture, Forestry, Environment and Water Management. Available at: http://www.gruenerbericht.at/ [Accessed November 30, 2011].

BMWFJ & BMLFUW, 2010. EnergieStrategie Österreich (Energy Strategy Austria), Vienna: Federal Ministry of Economy, Family and Youth and Federal Ministry of Agriculture, Forestry, Environment and Water Management. Available at: http://www.energiestrategie.at/ [Accessed November, 2011]

BMWFJ, 2011. Energiepreise. Website of the Federal Ministry of Economy, Family and Youth. Available at: http://www.bmwfj.gv.at/ENERGIEUNDBERGBAU/ENERGIEPREISE/Seiten/default.aspx [Accessed August 11, 2011].

EBB, 2011. Website of European Biodiesel Board - Statistics. Available at: http://www.ebb-eu.org/stats.php# [Accessed July 28, 2011].

E-control, 2011a. Feed-in tariffs for renewable power plants. Available at: http://www.e-control.at/en/market_players/renewables/feed-in-tariffs [Accessed July 19, 2011].

E-control, 2011b. Statistics on electricity, natural gas and green electricity. Available at: http://www.e-control.at/en/statistics [Accessed July 21, 2011].

EEA, 2006. How much bioenergy can Europe produce without harming the environment?, Copenhagen: European Environment Agency.

ePURE, 2011. Website of ePURE - Statistics. Available at: http://www.epure.org/statistics/info/Productioncapacityinstalled [Accessed July 28, 2011].

European Commission, 2003. Directive 2003/30/EC of the European Parliament and the Council on the promotion of the use of biofuels or other renewable fuels for transport.

European Commission, 2009a. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

European Commission, 2009b. "Health Check" of the Common Agricultural Policy, URL http://ec.europa.eu/agriculture/healthcheck/index_en.htm, [Accessed January 2011].

European Commission, 2010. Commission regulation (EU) No 861/2010 of 5 October 2010 amending Annex I to Council Regulation (EEC) No 2658/87 on the tariff and statistical nomenclature and on the Common Customs Tariff.

Eurostat, 2011. Website of Eurostat - External trade. Available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/external_trade/data/database [Accessed March 10, 2011].

FAO, 2011a. Website of ForesSTAT - Forestry statistics of FAOSTAT. Available at: http://faostat.fao.org/site/626/default.aspx#ancor [Accessed March 15, 2011].

FAO, 2011b. Website of FAOSTAT - Forestry Trade Flows. Available at: http://faostat.fao.org/site/628/default.aspx [Accessed May 31, 2011].

FHP, 2010. Website of the Association of the Austrian Wood Industries; Statistical data. Available at: http://www.forstholzpapier.at/index.php?option=com_content&view=article&id=64&Itemid=61 [Accessed November 2011]

Furtner, K. & Haneder, H., 2011. Biomasse-Heizungserhebung 2010, Landwirtschaftskammer Niederösterreich, Abteilung Betriebswirtschaft und Technik.

Haas, R., Knápek, J., Kalt, G., Kranzl, L., Weger, J., 2005. Prospects and impediments for a significant increase in energetic use of commercial solid biomass in Central & Eastern Europe, Final Report for the CZ-AT Research Project, 2005.

Hagauer, D., 2008. Wood Flow Model in Austria - Drawing the bigger picture. In Workshop on National Wood Resource Balances. Geneva, Switzerland. Available at: http://www.google.at/url?sa=t&source=web&cd=2&ved=0CCAQFjAB&url=http%3A%2F%2Fwww.nancy.inra.fr%2Flef%2Fcontent%2Fdownload%2F3220%2F32669%2Fversion%2F2%2Ffile%2F4.2010-Linking%2Bforest%2Bsector%2Band%2Benergy%2Bsector%2Bmodels_final.pdf&rct=j&q=wood%20flow%20austria&ei=x2B_TZq_I8zMswamtfzkBg&usg=AFQjCNECyN4MOQtm0JXimsLNhfPgMVLF6A&sig2=B8yRX7BEGJUEm61zYHLw2w&cad=rja [Accessed March 15, 2011].

Hagauer, D., Nemestothy, K. & Lang, B., 2007. Woodflow Austria 2005, Vienna.

Heinimö, J., 2008. Methodological aspects on international biofuels trade: international streams and trade of solid and liquid biofuels in Finland. Biomass and Bioenergy, 32(8), pp.702–716.

Heinimö, J. & Junginger, M., 2009. Production and trading of biomass for energy-An overview of the global status. Biomass and Bioenergy, 33(9), pp.1310–1320.

IPCC, 2000. Nakicenovic, N., Swart, R. (Eds.). Special Report on Emissions Scenarios, Cambridge University Press.

IPCC, 2006 IPCC Guidelines for National Greenhouse Gas nventories - Volume 2: Energy. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html [Accessed September 8, 2011].

Kalt G, Kranzl L, Adensam H, Schmid E, Stürmer B, Zawichowski M., 2010a. ALPot – Strategies for a sustainable mobilization of agricultural bioenergy potentials, Climate and Energy Fund, Vienna.

Kalt, G., 2011. An assessment of the implications, costs and benefits of bioenergy use based on techno-economic approaches. Thesis: Vienna University of Technology.

Kalt, G., Kranzl, L. & Haas, R., 2011. Bioenergy in Central Europe - Recent developments, international biofuel trade and future prospects. In Energy Resources: Development, Distribution, and Exploitation. Nova Science Publishers.

Kalt, G. & Kranzl, L., 2011. An assessment of international trade related to bioenergy use in Austria – Methodological aspects, recent developments and the relevance of indirect trade. Energy Policy (submitted)

Karner, A. et al., 2010. National Renewable Energy Action Plan 2010 for Austria, KWI Consultants GmbH, Wegener Zentrum für Klima und Globalen Wandel an der Karl-Franzens-Universität Graz, Österreichisches Institut für Wirtschaftsforschung, Johannes Kepler Universität Linz, Technische Universität Wien, Technische Universität Graz.

Kindermann, G., Obersteiner, M., Rametsteiner, E., McCallum, I., 2006. Predicting the deforestation-trend under different carbon-prices. Carbon Balance and Management, 1:15.

Kindermann, G., Obersteiner, M., Sohngen, B., Sathaye, J., Andrasko, K., Rametsteiner, E., Schlamadinger, B., Wunder, S., Beach, R., 2008. Global cost estimates of reducing carbon emissions through avoided deforestation. PNAS, 105/ 30.

Kranzl, L. et al., 2008. Strategien zur optimalen Erschließung der Biomassepotenziale in Österreich bis zum Jahr 2050 mit dem Ziel einer maximalen Reduktion an Treibhausgasemissionen, Vienna: Vienna University of Technology.

Kranzl, L. et al., 2010. KlimAdapt - Ableitung von prioritären Maßnahmen zur Adaption des Energiesystems an den Klimawandel, Vienna: Energy Economics Group, Vienna University of Technology.

Kranzl, L., Kalt, G., Müller, A., Hummel, M., Egger, C., Öhlinger, C., Dell, G., 2011. Renewable energy in the heating sector in Austria with particular reference to the region of Upper Austria. Energy Policy (submitted)

LK-NÖ, 2011. Energieholzindex Österreich (Energy wood index Austria). Landwirtschaftskammer Niederösterreich. personal information by L. Köck, St. Pölten.

Müller, A. et al., 2010. Heizen 2050 - Systeme zur Wärmebereitstellung und Raumklimatisierungim österreichischen Gebäudebestand:Technologische Anforderungen bis zum Jahr 2050, Vienna: TU Wien, Bioenergy 2020+, AEE Intec, TU Graz.

ÖAMTC, 2011. Entwicklung der Kraftstoffpreise. Website of the Austrian automobile club ÖAMTC. Available at: http://www.oeamtc.at/?id=2500%2C1094719%2C%2C [Accessed November 17, 2011].

OECD/FAO, 2008. Organisation for Economic Co-operation and Development, Food and Agriculture Organization of the United Nations, Agricultural Outlook 2008-2017, Paris.

Pellet@las, 2011. Pellet@las - Pellet Market Database. Available at: http://www.pelletsatlas.info/cms/site.aspx?p=9107 [Accessed March 28, 2011].

Prem, J., 2010. Holzeinschlag 2009 - Holzeinschlagsmeldung über das Kalenderjahr 2009, Vienna. Available at: http://www.waldverband-noe.at/download/contribute/Holzeinschlag2009gesamt.pdf [Accessed April, 2011].

ProPellets, 2011. Website of proPellets Austria. Available at: http://www.propellets.at/cms/cms.php [Accessed August 9, 2011].

Rettenmaier, N. et al., 2010. Status of biomass resource assessments. Version 3, Heidelberg: IFEU.

Schmied, A., 2011. personal information by DI Alexander Schmied on the wood consumption of the Austrian wood board industry. Available at: http://www.platte.at/ [Accessed March 15, 2011].

Schneider, J., Anderl, M. & Bednar, W., 2011. Klimaschutzbericht 2011. Available at: http://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0334.pdf.

Schönhart M., Schauppenlehner T., Schmid E., Muhar A., 2010. Integration of bio-physical and economic models to analyze management intensity and landscape structure effects at farm and landscape level, Agricultural Systems 104 (2010) 122-134.

Seidl R., Lexer M.J., Jäger D., Hönninger K. 2005. Evaluating the accuracy and generality of a hybrid patch model. Tree Physiology. 25, 939-951.

Statistik Austria, 2011a. Website of Statistik Austria - Population at Census Day. Available at: http://www.statistik.at/web_en/statistics/population/population_censuses/population_at_census_day/index.html [Accessed July 19, 2011].

Statistik Austria, 2011b. Website of Statistik Austria - Gross Domestic Product and Main Aggregates. Available at: http://www.statistik.at/web_en/statistics/national_accounts/gross_domestic_product/index.html [Accessed July 19, 2011].

Statistik Austria, 2011c. Website of Statistik Austria - Energy balances. Available at: http://www.statistik.at/web_en/statistics/energy_environment/energy/energy_balances/index.html [Accessed March 9, 2011].

Statistik Austria, 2011d. Website of Statistik Austria - Useful Energy Analysis. Available at: http://www.statistik.at/web_en/statistics/energy_environment/energy/useful_energy_analysis/index.html [Accessed July 25, 2011].

Statistik Austria, 2011e. Website of Statistik Austria - Consumer Price Index. Available at: http://www.statistik.at/web_en/statistics/Prices/consumer_price_index_cpi_hcpi/index.html [Accessed November 17, 2011].

Statistik Austria, 2011f. Website of Statistik Austria - Producer prices for agriculture and forestry products. Available at: http://www.statistik.at/web_en/statistics/agriculture_and_forestry/prices_balances/prices_price_indices/index.html [Accessed August 12, 2011].

Statistik Austria, 2011g. Website of Statistik Austria - Special Aggregates. Available at: http://www.statistik.at/web_en/statistics/Prices/consumer_price_index_cpi_hcpi/special_aggregates/index.html [Accessed November 24, 2011].

Statistik Austria, 2011h. Website of Statistik Austria - Energy - Prices, Taxes. Available at: http://www.statistik.at/web_en/statistics/energy_environment/energy/prices_taxes/index.html [Accessed March 15, 2011].

Statistik Austria, 2011i. Website of Statistik Austria - Supply Balance Sheets. Available at: http://www.statistik.at/web_en/statistics/agriculture_and_forestry/prices_balances/supply_balance_sheets/index.html [Accessed March 15, 2011].

Thrän, D. et al., 2005. Nachhaltige Biomassenutzungsstrategien im europäischen Kontext, Leipzig: Institute for Energy and Environment.

UN Statistics Division, 2011. United Nations Statistics Division - Classifications Registry. Available at: http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=5&Lg=1 [Accessed November 24, 2011].

Winter, R., 2010. Biokraftstoffe im Verkehrssektor 2010 - Zusammenfassung der Daten der Republik Österreich gemäß Art. 4, Abs. 1 der Richtlinie 2003/30/EG für das Berichtsjahr 2009. Available at: http://www.ebb-eu.org/legis/MS_7thReport2010/austria_2010_de.pdf [Accessed November 2011].

Winter, R., 2011. Biokraftstoffe im Verkehrssektor 2011 - Zusammenfassung der Daten der Republik Österreich gemäß Art. 4, Abs. 1 der Richtlinie 2003/30/EG für das Berichtsjahr 2010, Vienna: Umweltbundesamt.

de Wit, M. & Faaij, A., 2010. European biomass resource potential and costs. Biomass and Bioenergy, 34(2), pp.188–202.

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