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The emergence of biogenic materials in Austria

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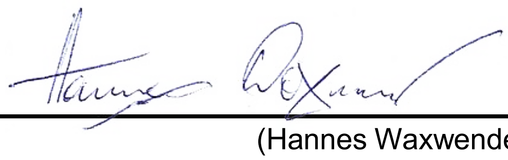

(Hannes Waxwender)

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Abstract

The interdependency between societies and their environment, also known as social metabolism, is a constantly transforming process. Throughout the history of mankind societies adapted to their environment and expanded their social metabolism by the application of before unused materials and new technologies. Some of these adaptations (or application of new technologies and materials) lead, however, to irreversible changes in the social metabolism, also known as socioecological transitions. The first and commonly known transition of the social metabolism, paving the way towards modern societies as we know them today, represents the transition from hunter and gatherer societies to agrarian societies. Biomass, animals and solar power got thereby purposefully applied for the first time in human history, leading to settledness, domestication of animals, the augmentation of population density and probably to the cognitive observation of astronomical tides. Agrarian societies developed in the subsequent centuries, applying new materials and technologies and thus continuously expanding their social metabolism. Nevertheless the primary energy source for mankind continued to be biomass throughout all those centuries – until the second socioecological transition, industrialisation. The application of fossil fuels (first coal then mineral oil) opened the lid of an until then untapped energy pool for humanity, considerably shaping the form of modern societies as we know them today. The energy surplus accessible through the application of fossil fuels enabled a vast development of production, traffic, population density and industrialised communities beyond the capacity constraints of their respective hinterland in the subsequent decades. Fossil fuels are not a part of the biosphere and thus underlie different, in general longer lasting, reproduction and absorption cycles than biomass does. The from the beginning of industrialisation constantly increasing anthropogenic application of fossil fuels, clearly exceeding the pace of the respective natural cycles, lead therefore to an exploitation of the global fossil fuel occurrence and consequently to a steady accumulation of fossil fuel emissions (such as carbon dioxide) in our atmosphere – global problems also known as peak oil and the anthropogenic greenhouse effect today. Due to the exploitation of the global fossil fuel pools, which are the foundation of any industrialised society, and the elimination of our ecosystem through the vast application of fossil fuels and the unreflected and considerably accelerated consumption and economic productivity (leading to augmenting material extractions, losses of biodiversity, etc.) of industrialised societies, claims towards a further (and urgent) socioecological transition of industrialised societies have reached the modern world with the catchword sustainability. If and how the Austrian economy is reacting to these claims and how the European Union's 2020 target on renewable energy is implemented by the Austrian government is analysed within this thesis. By conducting an Economy-wide Material Flow Analysis of biomass for the Austrian economy from 1995 to 2010, the biomass consumption of Austria, as well as the respective development, is evaluated. From 1995 to 2010 domestic biomass consumption in Austria augmented by about 4.85 million tonnes to an overall value of 42.13 million tonnes in 2010. Besides the concerning high level of biomass consumption in Austria a growth of biomass consumption could be observed of on average 0.8% per annum throughout the here considered time span. In the course of the EU 2020 targets Austria agreed inter alia to

augment their renewable energy shares to 34% in 2020. In 2010 the renewable energy share in Austria accounted for, according to the Austrian Ministry of Life (Biermayr P., 2011), 30.8%, hence 3.2% still need to be gained from renewable energy sources. The biggest potential for Austria to achieve this goal is biomass as the characteristics of the Austrian landscape are neither suitable for centrally organized large-scale solar nor wind power that could cover considerable shares of today's excessive energy use in Austria and the benefits of additionally erected hydro-energy plants are in no relation to their (social) costs. The implementation of the EU 2020 target on renewable energy augmented especially imports of energy crops, such as maize, rapeseed, palm oil, soybean, etc. and of wood fuel to Austria in the recent years. Domestic biomass extractions remained on a rather constant level of about 35.57 million tonnes per annum from 1995 to 2010, indicating a fully employment of domestic biomass sources. Nevertheless energy crops, especially maize, experienced vast expansions and thus crowding other crops out. Biomass is a versatile resource, yielding also many residues while harvesting or in their industrial application. Biofuels can also be produced from these residues or even organic waste and residual oil. Wood fuels such as pellets can easily be made out of industrial or harvesting wood residues, adding value to an economy without inducing further extractions. Hence improving cascade use and the recycling streams within the Austrian economy would help achieving the 2020 targets with a long-run perspective. Trying to fulfill ones 2020 commitment by augmenting biomass extractions (at home or abroad via imports) countervails clearly a development towards a sustainable society, which has at its core lowering today's unreflected material consumption – a strategy that is, however and unfortunately, observable for the Austrian economy.

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Abbreviations

BMLFUW	Austrian Ministry of Life
DE	Domestic Extraction
DMI	Direct Material Input
DMC	Domestic Material Consumption
EW-MFA	Economy-wide Material Flow Accounts
Eurostat	Statistics Department of the European Union
EXP	Export
FAOSTAT	Statistics Department of the United Nations Food and Agriculture Organisation
IMP	Import
WRB	Wood Resource Balance

Units

GJ	Gigajoule
GWh	Gigawatt hours
m^3	Cubic meters
t	Metric tonnes

1. Introduction

The social metabolism, describing a society's interdependency to its environment, transformed throughout human history several times. The first irreversible transition represents the cognitive employment of biomass, hence the development from hunter and gatherer societies to agricultural societies. The crucial difference in the social metabolism can be observed in the diverging social energy and material consumption interlinked with these two subsistence forms. Hunter and gatherer societies exhibited an approximate material consumption of 0.5 to a metric tonne per person per year, equaling a daily per capita consumption of 1.5 to 3 kilograms, and required an annual energy input of about 10 to 20 Gigajoule (generated from biomass) per capita (Giljum et al., 2009; Fischer-Kowalski M. and Haberl H., 2007). Agrarian societies, on the other hand, requested an annual personal material consumption of about 3 to 6 tonnes, due to the purposeful employment of biomass and the supply of the domesticated livestock, and demanded an annual energy input of about 65 Gigajoule (generated from biomass) per capita (Giljum et al., 2009; Fischer-Kowalski M. and Haberl H., 2007). Throughout time the augmented application of other materials, such as ores, lead to a further expansion of the social metabolism. The main energy carrier remained, however, biomass until the second irreversible socioecological transition – industrialisation. The application of fossil fuels (at first coal and later mineral oil) made an enormous and by then untapped energy pool accessible to humanity. This paired with technological improvements allowed a vast development of communities beyond their hinterland and triggered a considerable expansion and acceleration of material extractions off. Hence industrialised societies exhibit average annual material extractions of 15 to 25 tonnes per capita, varying considerably amongst industrialised communities – the daily material extraction of a North American citizen was about 68 kilograms, of a European citizen 36 kilograms and in Oceania about 158 kilograms per capita and day in 2000 (Giljum et al., 2009; Fischer-Kowalski M. and Haberl H., 2007). The energy demand of about 250 Gigajoule per capita and year is mainly covered by fossil fuels, to a certain extend biomass and partly by nuclear power and hydro-energy (Fischer-Kowalski M. and Haberl H., 2007). Bearing in mind that the energy surplus connected to the employment of fossil fuels made a vast population growth with population densities ten times higher than in agrarian societies feasible, shows the considerable magnitude of industrialised societies' social metabolisms (Fischer-Kowalski M. and Haberl H., 2007).

Fossil fuels are not part of the biosphere and thus underlie different reproduction and absorption processes exhibiting a different pace than biomass does, which (obviously) is part of the biosphere (Fischer-Kowalski M. and Haberl H., 1997). The anthropogenic use of fossil fuels augments therefore the fraction of fossils entering the biosphere, leading to an overstraining of the biogenic response and absorption system regarding fossils. Hence the human application of fossil fuels contains two main difficulties. First the absorption of fossil fuel emissions takes a considerable amount of time. The accelerated fossil fuel emissions (due to the additional anthropogenic application) exceed the natural absorption capacities and thus lead to remaining fossil fuel emissions, such as carbon dioxide, in our atmosphere. Secondly the reproduction of fossil fuels takes in relation to biomass significantly longer, wherefore an excessive fossil fuel usage, as observable today, leads to emptying the global fossil fuel pools and thus eliminating the applied energy pool allowing industrialisation in the first place. These two main problems, also known as peak oil and the anthropogenic greenhouse effect, let the industrialised world reconsider their material and energy demands and their development path, claiming a development towards a sustainable social metabolism and thus a further socioecological transition.

Reconsidering today's energy consumption and the respective composition (of the industrialised world) can inter alia be observed by the European Union's 2020 targets on renewable energy. The EU is aiming to increase its respective renewable energy supply share to 20%. Austria agreed in the course of the EU 2020 targets to augment their national renewable energy shares to 34% by 2020. The above average renewable energy share goal of Austria is explained by the already today considerable renewable energy fraction in the Austrian energy mix, due to the mountainous landscape of Austria and the utilisation of the thereby connected hydro-energy potential. Therefore Austria exhibited a national renewable energy share of about 30.8% in 2010 of which 39.5% were generated through hydro-energy and 39.4% via biomass – the remaining portions were composed by wind power (2.1%), photovoltaics and solar heat (2%), geothermal energy (0.1%) and others (17%) (Biermayr P., 2011). The renewable energy shares need therefore to augment by another 3.2% in order to obtain the 2020 target. As the Austrian landscape is not significantly exposed to the sun, neither does it possess considerable flat-land or coastal areas, centrally organized large-scale solar or wind power generation only bears small potentials for covering a considerable share of today's excessive energy use in Austria. Hydro-energy, or precisely the kinetic energy of water, represents indeed a renewable energy source. The erection and installation of a hydro-power plant is, however, an irreversible insection into nature wherefore the benefits of constructing further hydro-energy plants are in no relation to their costs. Hence the energetic use of biomass exhibits the biggest potential for Austria to increase their renewable energy shares and thus to obtain their 2020 target. This study is therefore analysing the current Austrian biomass extractions and consumption, focusing on the implementation and effects of the EU 2020 targets on biogenic material flows to the Austrian economy.

Work has already been done in the field of material flow analysis by several scientific and international institutions, distilling an internationally accepted method for estimating material flows into and from an economy – Economy-wide Material Flow Accounts (EW-MFA). Beyond GDP initiatives, attempting to generate appealing indicators such as the GDP but also including environmental and social-aspects of human well-being, boosted the attention assigned to Environmental Accounts, such as EW-MFA and thus made their implementation in traditional statistics, especially within the European Union, possible (Eurostat, 2010). The EU in cooperation with its member states targeted therefore to compile an EW-MFA data set for the entire European Union. Based on EW-MFA work published by several scientific institutions such as the Wuppertal Institute for Climate, Environment and Energy, the Faculty of Interdisciplinary Studies of the University Klagenfurt or the Sustainable Europe Research Institute (SERI) the Eurostat developed an EW-MFA method applicable for all EU member states. Within the framework of an EW-MFA material flows into and from an economy (crossing the system boundary between the analysed economy and its system environment) are recorded. The material flows are monitored in physical units of their respective weights (at a standard moisture content). EW-MFA, such as other

Environmental Accounts, help therefore extending the system of national accounts to environmental issues. Today the Eurostat provides via its homepage an EW-MFA database for all EU member states[1]. For Austria the national statistics department, Statistik Austria, provides as well an online EW-MFA database[2] which, however, exhibits some divergences compared to the by the Eurostat established EW-MFA framework (2012). The accessible data sets do, unfortunately, only provide information on the commodity aggregate level which does not enable insights into single material flows (commodity flows) and thus do not help in distilling the main driving forces of material flows into and from an economy.

Apart from Economy-wide Material Flow Accounts, which make monitoring of any kind of material – ores, biomass, fossil fuels – possible, the detailed analysis of wood flows is drawing the interest of several scientific and international institutions. Wood is a versatile resource and the main input for the paper and pulp industry. Furthermore the application of wood for construction purposes has always been integral and is due to improved processing technologies of wood, yielding for instance cross laminated timber that exhibits high degrees of stability, expected to further augment. Today wood is also on the brink of entering the textile market and expanding its significance for the chemical industry due to improvements of wood plastic components (Mantau U., 2010; Presas T., Mensink M., 2011). Apart from the material use of wood, the resource and especially its residues form a big potential for renewable energy. Especially the market for wood pellets is expected to experience a vast growth (Steirer F., 2009). Hence increases of the pressure on wood supply are anticipated. Therefore studies on the efficiency of wood application are undertaken and of a high information degree, as simply expanding the wood supply by additional fellings is too risky regarding the development of the wood stock and thus sustainable development. Wood fibres and their application contain a high potential of cascade use. If this potential is fully employed and if not, how this potential can be better implemented in wood processing streams needs therefore to be settled first before cutting additional trees for expanding the wood supply. Hence for properly assorting national wood flows, their application(s) within an economy need to be analysed as well and thus has to go beyond the system boundaries established for EW-MFA (which stops to follow material flows after entering the economy). Groundbreaking work in the field of wood flow analysis has already been undertaken by the European Union's wood team, which is a consortium of several scientific institutions – Centre of Wood Science of the University of Hamburg, United Nations Economic Commission for Europe and United Nations Food and Agriculture Organization (UNECE/FAO) Forestry and Timber Section, European Forest Institute (EFI), the Dutch Institute for Forestry and Forest Products (Probos) and the Finnish Forest Research Institute (MELTA) – for the EU 27 and for Austria on behalf of the Austrian Ministry of Traffic, Innovation and Technology in the core of the “Fabrik der Zukunft” (factory of tomorrow) project.

Emanating from the method established by Mantau U. (Centre of Wood Science – University of Hamburg), namely a Wood Resource Balance (WRB), the EUwood team conducted a WRB for the EU 27 for the years 2005 and 2007. A WRB contrasts the supply of wood fibres with their applications. Wood supply is, however, defined in a broader way within the framework of a WRB

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1 http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
2 http://statcube.at/superwebguest/login.do?guest=guest&db=deumwmfa

than in EW-MFA and thus including next to fresh cut wood from the forest also wood from outside the forest (e.g. cuttings and trimmings in parks, along roads, in horticulture, etc.) as well as industrial residues (saw mill by-products, black liquor, etc.) and post-consumer recycled wood which is reapplied. A WRB helps therefore analysing the cascade use factor of an economy by simply relating overall wood use to the respective wood supply from the forest (Mantau U., 2010). Unfortunately WRB data are yet only available for the years 2005 and 2007. In the core of the “Fabrik der Zukunft” project a consortium composed of the University of Technology Graz, the University of Natural Resources and Life Sciences Vienna (BOKU) and the Institute for Industrial Ecology (IIÖ) established a model reproducing the Austrian wood flows and applications serving the calculation of future scenarios on the wood market as well as helping in analysing the efficiency of wood processes in Austria. The findings and the final report, which is brilliant at the in-depth technical accuracy, can be downloaded from www.fabrikderzukunft.at. Unfortunately no access to the established model is provided via the online platform.

The by now already undertaken work in the field of material flow analysis is, however, not sufficient for the within this study targeted results of the extraction and domestic consumption of biomass in Austria, as the Eurostat database as well as the Statistik Austria EW-MFA data set do not provide data on the single commodity level and thus do not allow distilling the main driving commodities of the Austrian biomass consumption. Especially when linking the question of the Austrian biomass consumption to the EU 2020 target on renewable energy, analysing if potential biogenic energy carriers (such as maize, rapeseed, soybeans, palm oil, etc.) experienced a vast increase in their domestic consumption is essential. This identification is, however, only possible if the single commodity flows are known. Work undertaken in the core of the “Fabrik der Zukunft” project or the WRB contain and reveal important information especially on the efficiency of wood applications. The aim of this study is, however, to analyse the extraction and domestic consumption of biomass (in relation to the EU 2020 target). The question of the efficiency in biomass application and the contribution of efficiency gains in lowering biomass extractions without lowering domestic consumption is, however, beyond the scope of the here undertaken study. Nevertheless this question is tackled in a subsequent study established on the here presented findings.

For estimating biomass extraction and consumption in Austria an EW-MFA until the single commodity level is undertaken, so that the central questions regarding the magnitude of domestic biomass extractions, biomass imports, biomass exports and thus domestic biomass consumption can be answered in-depth. Data on the single commodity extractions, imports and exports are gathered from the United Nations Food and Agriculture Statistics Department (FAOSTAT) online database and compiled following the Eurostat's EW-MFA Methodological Guide (2001) and the Eurostat's EW-MFA Compilation Guide (2012). In order to analyse possible effects of the EU 2020 target on renewable energy, an EW-MFA on biomass from 1995 to 2010 is conducted in the core of this survey. Furthermore attention is also assigned to the overall extraction and domestic biomass consumption development path throughout the here considered time interval, indicating whether the above described socioecological transition towards a sustainable social metabolism is already in progress or not.

Chapter 2 presents the applied method, data and the required accounting principles in order to tackle the conceptual difficulties interlinked with executing an EW-MFA. As within an EW-MFA material flows are recorded in their respective weights the moisture content of several material flows will for instance differ wherefore the from the FAOSTAT gathered data needs to be converted for some commodities. Wood, on the other hand, is usually monitored in cubic meters and thus needs to be converted into its respective weight respecting the specific gravity of different tree types. After presenting the applied method and data the resultant biomass extraction quantities and domestic biomass consumption magnitude of Austria from 1995 to 2010 is presented within chapter 3. The EW-MFA category A.1 Biomass is, according to the Eurostat EW-MFA Compilation Guide (2012), separated into four sub-groups – A.1.1 Crops; A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass; A.1.3 Wood and A.1.4 Wild Fish Catch, Aquatic Plants/Animals, Hunting and Gathering (Eurostat, 2012). Sub-group A.1.4 is, however, of lesser interest for the here undertaken study and therefore not included in the here executed EW-MFA survey of biomass. Chapter 3 presents, before discussing overall biomass extractions and consumption, domestic extractions, imports, exports, Domestic Material Input and Domestic Material Consumption of each sub-group (except A.1.4) and shows the main driving commodities of domestic extractions and foreign trade for each sub-group. After discussing the category A.1 Biomass composing sub-groups (except A.1.4) their added up values yielding domestic biomass extraction, foreign trade, direct biomass input and domestic biomass consumption are presented. Before concluding the within this study distilled findings the applied method is revised and modified. EW-MFA experienced a boost in their assigned attention in the recent years, making it a promising tool for expanding indicators of social well-being by environmental aspects. Nevertheless EW-MFA also exhibit shortcomings which have to be pointed out. After revising the here applied method, chapter 4 presents the concluding remarks.

2. Method – Economy-wide Material Flow Accounts

Material Flow Accounting (MFA) is an analytical tool that allows monitoring and rating of a system's metabolism. Within the framework of MFA all material flows that cross the system boundary are recorded, i.e. entering or leaving the analysed system from or to the environment. Internal material flows are therefore not considered in MFA. If however a good is not consumed within an accounting period, it will participate in the net increment of the analysed system's material stock. But as no matter has an eternal duration, it will be emitted into the environment sooner or later. The throughput category serves therefore only as (roughly speaking) a balancing category that allows an accurate estimation of a system's metabolism for a certain accounting period. So that the total material inputs always equal total material outputs plus the net accumulation of materials in a system for each accounting period. This requirement is also known as the material balancing concept (Hinterberger F., Giljum S., Hammer M., 2003).

The analysed material flows are recorded in physical units. This implies that the laws of thermodynamics have to be respected. The above described material balancing concept shows for instance the application of the first law of thermodynamics – conservation of mass – which applies for all kinds of MFA (Hinterberger F., Giljum S., Hammer M., 2003; Moll S., Bringezu S., Schütz H., 2005).

A system's metabolism can be analysed with MFA on different levels and scales, i.e. micro, meso or macro, meaning that the metabolism of a company, community, region or of a whole economy can be monitored by a MFA (Moll S., Bringezu S., Schütz H., 2005; Milota E., Petrovic B., 2012). Besides the system's scale, the analysed materials can also differ. A MFA usually comprises all material flows, i.e. fossil fuels, minerals and biomass. Nevertheless it can be applied to any closer circle of materials. Which type of MFA is applied best, depends therefore always on the interest of the study.

As in this thesis a MFA is applied in order to answer the question of Austria's biomass extraction and consumption, the analysis will be applied on a macro scale. MFA of this scale are also known as economy-wide MFA (EW-MFA). Due to the interest in the extraction of biomass the applied EW-MFA will only cover material flows of biogenic materials (and even within this subgroup not all flows will be analysed, as the extracted quantities of for instance aquaculture are of no significant interest for this thesis). In order to answer the question of Austria's biomass extraction and consumption, a partial EW-MFA is sufficient, meaning that the focus of the EW-MFA survey will be on the input side, as the usage of the extracted materials and not their output to the environment lies in the center of interest in the following steps. Nevertheless biomass export flows from Austria need to be estimated as well, in order to evaluate the domestic biomass consumption of Austria.

The Statistics Department of the European Union (Eurostat) defined within their EW-MFA Methodological Guide “Economy-wide material flow accounts and derived indicators” (2001) a framework for EW-MFA that is applied by the EU-member-states to provide EU-wide consistent material flow data. This guide also forms the foundation for the in this thesis applied EW-MFA survey of Austria's biomass extraction. The Eurostat EW-MFA Methodological Guide (2001) is the most fitting (for a methodological basis) as the EU (together with the United Nations Environmental

Program and the OECD) was one of the first institutions monitoring economy-wide material flows in order to get a step closer towards a sustainable usage of natural resources (Milota E., Petrovic B., 2012). Furthermore the Eurostat in collaboration with the different EU-member-states' national statistics departments have been evaluating their economy-wide material flows ever since 1995. For this evaluation an EW-MFA questionnaire has been developed by the Eurostat and in a peer and review process with the EU-member-states adjusted. The latest updated EW-MFA questionnaire (from July 2012) forms in this thesis the basis for the empirical evaluation of Austria's biomass extraction. But before presenting the calculated data, it is necessary to discuss the components and categories as well as the derivable indicators of an EW-MFA in detail.

Economy-wide MFA

Economy-wide MFA (EW-MFA) is a systematic framework that orders material flow data and thereby provides an overview of a national economy's metabolism (Moll S., Bringezu S., Schütz H., 2005). The analyzed flows are estimated in physical units of metric tonnes and help extending the monetary System of National Accounts.

The material balance concept (as mentioned above) also represents the foundation of EW-MFA (Moll S., Bringezu S., Schütz H., 2005). Within an EW-MFA all material input and output flows that cross the functional border between the environment and the analysed economy are accounted for, as well as all material flows crossing the national (economy's) border – meaning that imports are treated as material flow inputs and exports therefore as outputs (Moll S., Bringezu S., Schütz H., 2005; Milota E., Petrovic B., 2012). This means that theoretically also an economy's water and air in- and output flows are accounted for in EW-MFA. Air and water form without a doubt next to our external energy source – the sun – the basis of life on our planet and should therefore be included in an EW-MFA. The incorporation of air and water would, however, distort, due to their high flow quantities, the of an EW-MFA provided overview of an economy's metabolism, wherefore in practice the in- and output of air and water are usually excluded from EW-MFA surveys – as it is also the case in this thesis. Material flows within the analysed economy are, as already stated above, not part of EW-MFA; they are monitored by Physical Input-Output-Tables (PIOT) (Milota E., Petrovic B., 2012).

2.1. Material flow categories

The material flows in, through and out of an economic system differ in general in their origin and/or destination, as well as in their economic treatment and contribution in the development of an economy's material stock. In the following the material flow categories as elaborated by the Eurostat and provided in the Eurostat EW-MFA Methodological Guide (2001) are presented in the following.

Direct and indirect material flows

Direct material flows only represent the actual weight of the products crossing the system boundary, i.e. entering or leaving an economic system either from or to the environment (domestic extraction or output to nature) or from or to another economy (imports or exports). Therefore direct material flows do not cover the life-cycle dimension of the product chain (Hinterberger F., Giljum S., Hammer M., 2003). Nevertheless the life-cycle dimension in the estimation of domestically extracted goods matters less in EW-MFA, as no material flows within an economic system are taken into account in EW-MFA (this is, as stated above, part of PIOTs) (Eurostat, 2001). For the proper estimation of imported goods, however, the indirect flows required to manufacture the imported product need to be taken into account. Indirect flows comprise both used and unused materials of the production chain necessary to provide a good (Hinterberger F., Giljum S., Hammer M., 2003). Similar to imported goods the indirect flows of exported products need to be taken into account as well, as their up-stream material input flows are not physically exported (Eurostat, 2001).

Used and unused materials

Used materials are extracted or imported resources that enter an economic system for direct consumption or further processing and are therefore value adding. Unused materials on the other hand arise due to the extraction of (used) raw materials but do not enter the economic system. As unused materials are not value adding, they remain mainly hidden from empirical analysis and can be described as physical market externalities (Hinterberger F., Giljum S., Hammer M., 2003). Those externalities occur nationally as well as abroad and also need to be integrated likewise in EW-MFA (Eurostat, 2001). Another common term for unused extractions is “hidden flows”, as the extracted materials do not enter the economic system and are therefore not visible in the monetary economy (Hinterberger F., Gilum S., Hammer M., 2003). Typical examples for unused materials are by-catch in fishery, wood harvesting residues, overburden from mining, etc. (Hinterberger F., Giljum S., Hammer M., 2003).

Origin and destination

Materials can be domestically extracted or imported as well as domestically consumed or exported. Combining the three described material flow categories provides five categories for material inputs, as well as five categories for material outputs for EW-MFA. Table 1 and 2 visualize the relations.

Table 1: Summary of terminology for material input categories

Product-chain	Used or unused	Domestic or ROW	Applied term
Direct	Used	Domestic	Domestic extraction (used)
Not applied	Unused	Domestic	Unused domestic extraction
Direct	Used	ROW	Imports
Indirect	Used	ROW	Indirect (input) flows associated to imports
Indirect	Unused	ROW	

Source: by author based on Eurostat, 2001

Table 2: Summary of terminology for material output categories

Product-chain	Processed or not	Domestic or ROW	Applied term
Direct	Processed	Domestic	Domestic processed output to nature
Not applied	Non-processed	Domestic	Disposal of unused domestic extraction
Direct	Processed	ROW	Exports
Indirect	Processed	ROW	Indirect (output) flows associated to exports
Indirect	Non-processed	ROW	

Source: by author based on Eurostat, 2001

As in this thesis the purpose of applying an EW-MFA is to estimate Austria's biomass extraction and domestic consumption, only material flows entering the Austrian economy are accounted for in this survey. Furthermore only used material flows are included here, as the center of interest lays on Austria's actual, meaning in the economic system physically present, biomass potential and actually consumed biomass amounts. As unused materials do not enter the economic system after they have been extracted, they are of less interest for this survey. Nevertheless unused biogenic materials, especially domestically extracted, form another easily accessible pool of potential biomass that could enter an economic system by adjusting the production processes and thus be domestically consumed. Therefore an estimation of unused material flows is of a high scientific value, but it would go beyond the scope of this thesis to accurately estimate Austria's unused biomass extractions. As EW-MFA is still a young field of study, helpful coefficients that would allow a time- and cost-efficient calculation of unused material flows are still not existing (Eurostat, 2001). Even though several studies focusing on the evaluation of unused material flow coefficients have been published in the last years, none could so far provide a flexible enough set of coefficients that allows an accurate estimation of unused material flows. The main challenge in providing such a set lies within the difference of terrain and vegetation that affect the extraction quantities of unused materials and therefore requires different coefficients for different locations (Eurostat, 2001).

Furthermore only direct material flows entering the Austrian economy are evaluated in this thesis, as (once again) only the in the economic system physically present biomass is in the center of interest. Apart from that indirect material flows are; similar to unused material flows; difficult to estimate, as there is no comprehensive set of coefficients available for calculating them (Eurostat, 2001). Indirect flows on the input-side of an EW-MFA only occur for imported materials, as internal material flows are not recorded by MFA. The indirect flow of an imported good or material can be interpreted as its Ecological Rucksack (Hinterberger F., Giljum S., Hammer M., 2003). This Rucksack obviously changes from country to country due to different production processes and covered transport distances. It is therefore crucial from which country the imported materials stem and by which mean of transport they reached their destination. A set of coefficients flexible enough to estimate the indirect flows of imported materials accurately doesn't exist yet, even though the Eurostat in close collaboration with the Wuppertal Institute and the various national statistics departments of the EU-member-states are working on such a set of coefficients (Eurostat, 2001). As the indirect flows of imported materials are not physically imported and the center of the here applied EW-MFA survey is to estimate Austria's direct biomass input and domestic consumption of this input, they are of less interest for the here executed evaluation and therefore not discussed any further.

To include both unused material extractions and the indirect flows associated to imports would obviously extend the survey and therefore enlarge its delivered picture of the Austrian biomass extraction. The benefits of including those two categories for the in this thesis executed evaluation would be, out of the above mentioned reasons, of a significantly less magnitude than the costs involved by this laborious and time-consuming task. Estimating unused material extractions and indirect material flows is essential for the evaluation of an economy's sustainability, but of less importance for the analysis of the in an economy physically present biogenic materials – as it is the purpose of the here executed EW-MFA (Eurostat, 2001; Bringezu S., Schütz H., 2001). Therefore unused material extractions and indirect material flows are not included in the following estimation of Austria's biomass extractions and consumption.

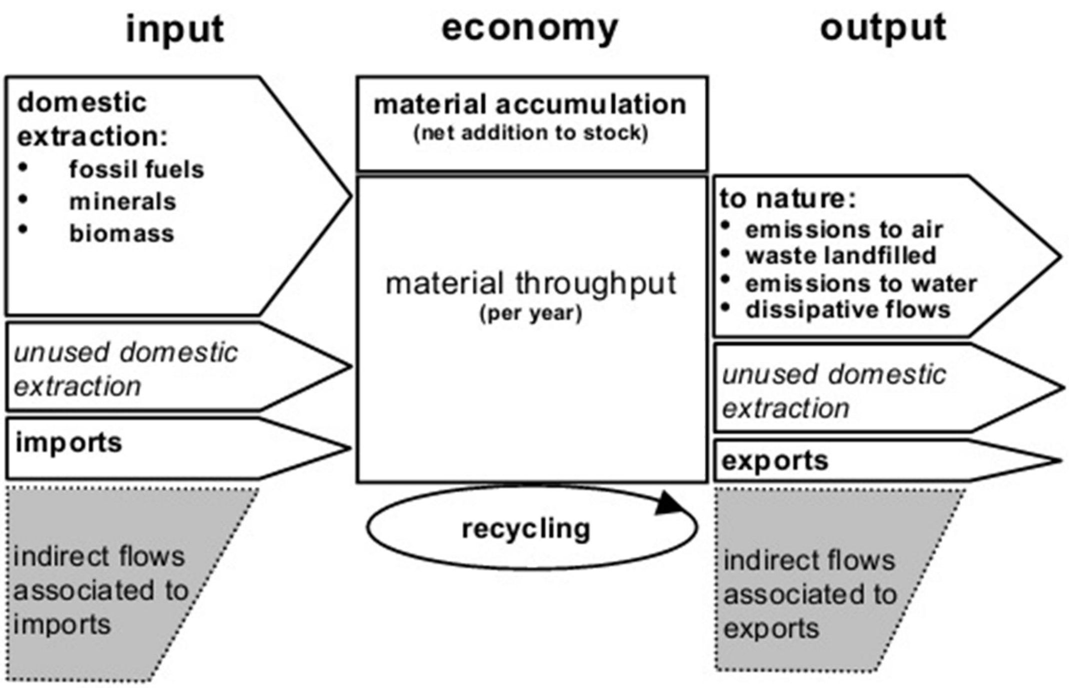
Material stocks and changes

In the context of EW-MFA material stocks mainly comprise man-made fixed assets, i.e. infrastructure, buildings, durable consumption goods (like cars or household equipment) and investment goods (such as machinery) (Eurostat, 2001). Forests and agricultural plants, even though produced by humans, should be interpreted as part of the environment in EW-MFA and the harvest of timber and other plants should therefore be treated as a material input. Considering forests and agricultural plants as a part of the economy would require including the bio-metabolism of trees and plants on the input side of EW-MFA (Eurostat, 2001). As this approach is time-consuming and almost impossible to underpin with actual data, forests and agricultural plants are usually (and as recommended by the Eurostat EW-MFA Methodological Guide (2001)) treated as a part of the environment. This approach is followed in the EW-MFA survey of this thesis.

A similar problem arises including waste deposits in controlled landfills. Even though theory might suggest interpreting controlled landfills as part of the material stock, it is recommended by the Eurostat's EW-MFA Methodological Guide (2001) to treat waste deposits in controlled landfills as outputs of an economic system. If controlled landfills were interpreted as part of the material stock, the emitted substances from the landfills would have to be calculated – which would again be laborious and difficult to underpin with actual data. As the in this thesis applied EW-MFA evaluation rather focuses on the input-side, the problem of waste deposits and controlled landfills does not arise here.

After identifying the several material flow categories, figure 1 presents how material flows are sorted and put into relation within the framework of an EW-MFA. As mentioned before and illustrated in figure 1, material flows are separated in input, throughout and output flows. In the following these three categories and the components composing them are discussed in detail.

Figure 1: EW-MFA scheme excluding water and air



Source: Eurostat. 2001

2.1.1. Material input

Domestic extractions, unused domestic extractions, imports and their indirect material flows compose the material input category of an EW-MFA excluding water and air. In the following those components are discussed in detail and presented how they are applied in this study.

Domestic extraction

The category domestic extraction represents all direct material flows extracted from the domestic environment and entering the economic system. It only records those materials that are value adding to the economic system. Materials used during the production chain do not enter the domestic extraction category, as (mentioned above) the indirect material flows within an economy are not part of EW-MFA.

As indicated in figure 1, the domestically extracted materials are within the framework of an EW-MFA classified into three main material groups: fossil fuels, minerals and biomass. Nevertheless, the main material groups presented here are already aggregated categories. Hence they consist of several sub-groups. As the focus of this paper is, however, on the material flow of biomass, a closer overview of the sub-groups compiling the category biomass, as defined by the Eurostat EW-MFA Questionnaire (2012), is presented in table 3.

Table 3: Sub-groups compiling the category biomass

A.1 Biomass			
	A.1.1 Crops		
		A.1.1.1 Cereals	
		A.1.1.2 Roots, tubers	
		A.1.1.3 Sugar crops	
		A.1.1.4 Pulses	
		A.1.1.5 Nuts	
		A.1.1.6 Oil-bearing crops	
		A.1.1.7 Vegetables	
		A.1.1.8 Fruits	
		A.1.1.9 Fibres	
		A.1.1.10 Other crops n.e.c.	
	A.1.2 Crop residues (used), fodder crops and grazed biomass		
		A.1.2.1 Crop residues (used)	
			A.1.2.1.1 Straw
			A.1.2.1.2 Other crop residues (sugar and fodder beet leaves, other)
		A.1.2.2 Fodder crops and grazed biomass	
			A.1.2.2.1 Fodder crops (incl. biomass harvest from grassland)
			A.1.2.2.2 Grazed biomass
	A.1.3 Wood		
		A.1.3.1 Timber (Industrial roundwood)	
		A.1.3.2 Wood fuel and other extraction	
		M.1.3 Net increment of timber stock	
	A.1.4 Wild fish catch, aquatic plants/animals, hunting and gathering		
		A.1.4.1 Wild fish catch	
		A.1.4.2 All other aquatic animals and plants	
		A.1.4.3 Hunting and gathering	

Source: by author based on Eurostat, 2012

Category A.1 Biomass consists at the two digit level of four sub-groups, i.e. A.1.1 Crops, A.1.2 Crop residues (used), fodder crops and grazed biomass, A.1.3 Wood and A.1.4 Wild fish catch, aquatic plants/ animals, hunting and gathering. The first two sub-groups, A.1.1 and A.1.2, represent the extraction of biomass from agricultural crop and plant cultivation; sub-group A.1.3 covers all biomass extracted from cultivated forests and within sub-group A.1.4 all extractions of non-cultivated (wild) biomass are accounted for (Eurostat, 2012). Together these four sub-groups cover all possible sources of biomass extraction. However, only cultivated biomass extractions (from agricultural crop and plant cultivation or from cultivated forests) are of further relevance for the here undertaken evaluation of the Austrian biomass extraction and actual biomass potential within the Austrian economy. Firstly the in this thesis executed EW-MFA only covers all biogenic materials that are physically present in the Austrian economy, which rules the extraction of wild biomass from hunting and gathering out. Biomass gained from hunting and gathering gets usually extracted for subsistence reasons and is therefore not intended to be used commercially. Secondly the here applied EW-MFA of the Austrian biomass extractions is executed with regard to the European Union's 2020 targets which rules the extraction of wild fish and all other aquatic animals and plants out. Therefore sub-group A.1.4 Wild fish catch, aquatic plants/ animals, hunting and gathering is of no further interest for this study, which leaves A.1.1 Crops (excluding fodder crops), A.1.2 Crop residues (used), fodder crops and grazed biomass and A.1.3 Wood to be discussed in detail and evaluated in the following.

Sub-group A.1.1 Crops (excluding fodder crops) comprises all crops from arable land and permanent cultures (Eurostat, 2012). It therefore covers all staple foods from crop and garden land like roots and tubers, vegetables, cereals or pulses, as well as nuts and fruits from permanent cultures and also industrial crops such as fibre crops or oil bearing crops (Eurostat, 2012).

A.1.2 Crop residues (used), fodder crops and grazed biomass consist as can be seen in table 3 of two further sub-groups: A.1.2.1 Crop residues (used) and A.1.2.2 Fodder crops and grazed biomass. The primary crop harvest is usually only a part of the total plant biomass cultivated (Eurostat, 2012). The residual biomass is, however, used in various ways – either for intra-unit consumption or for commercial reasons (Eurostat, 2012). This used residual biomass is covered by the three digit sub-group A.1.2.1 Crop residues (used), but should not be confused with crop residues that remain on the fields. These extractions are unused and therefore not a part of the domestic extraction category (that covers only used extractions). The main used crop residue is straw gained from cereals (covered by the four digit item A.1.2.1.1 Straw of cereals). Apart from straw the tops and leaves of sugar beets and occasionally sugar cane are typical crop residues in most European countries (covered by A.1.2.1.2 All other crop residues) (Eurostat, 2012). The second three digit sub-group A.1.2.2 Fodder crops and grazed biomass comprises all fodder consumed by the livestock. As no empirical data on the annual fodder uptake of the livestock is available, it has to be estimated through the application of fodder uptake coefficients. The same problem also arises for the evaluation of used crop residues. How these values can still be calculated will be presented and discussed in detail in section.

Sub-group A.1.3 Wood is divided into two groups with regard to its main applications – wood as a source of energy and wood for material use. Item A.1.3.1 Timber (Industrial roundwood) obviously covers all wood produced and extracted for production reasons and item A.1.3.2 Fuel Wood and other extractions represent wood produced and extracted for energy reasons, as well as other forest extractions such as cork (Eurostat, 2012). Item M.1.3 Net Increment of Timber Stock serves as a memorandum item that is important for linking different concepts regarding the output of timber cultivation (Eurostat, 2012). Memorandum items are in general items that help avoiding double counting while executing an EW-MFA (Eurostat, 2001). For the calculation of central EW-MFA indicators such as the Direct Material Input (DMI) or the Direct Material Consumption (DMC) of an economy, only felled timber is of interest as the net increment of the timber stock is no input into the economic system (Eurostat, 2012). As for the evaluation of the Austrian biomass extraction and for the estimation of the Austrian material input and consumption an input approach is sufficient, item M.1.3 Net Increment of Timber Stock won't be discussed any further in this thesis.

Unused domestic extraction

For the extraction of value adding materials, other materials might have to be moved. If those materials do not enter the economic system, they are classified as unused extraction within the MFA framework. Unused domestic extraction therefore comprises all domestic materials that had to be moved during extraction activities, but do not enter the economic system for further purposes (Hinterberger F., Giljum S., Hammer M., 2003). Typical examples for unused extractions on behalf of the extraction of biomass are residues from harvest in agriculture or timber felling residues (Eurostat, 2001; Hinterberger F., Giljum S., Hammer M., 2003).

For the here executed EW-MFA the benefits of including unused domestic extractions are, for the further above mentioned reasons, in no relation to their costs. Unused material extractions are essential for identifying how sustainable an economy is, but rather irrelevant in estimating the Direct Material Input or Domestic Material Consumption (Eurostat, 2001).

Imports

Imports are like domestic extractions direct flows to an economic system. They are, however, not classified by the type of material, but rather by their production state, i.e. raw material, semi-manufactured, finished products and other products (Eurostat, 2001).

As the here carried out survey is focusing on biomass and thereof on primary goods, the calculated imports consist as well only of raw materials. To generate a better overview of the Austrian biomass extraction and to improve linking the direct domestic extraction with the import category, the same sub-groups as for direct domestic extractions are applied for imports, i.e. A.1.1 Crops, A.1.2 Crop residues (used), fodder crops and grazed biomass and A.1.3 Wood. Once again the sub-group A.1.4 Wild fish catch, aquatic plants/ animals, hunting and gathering can be left aside.

Indirect flows associated to imports

Indirect flows associated to imports comprise all used and unused materials during the production chain of an imported product. This means that also the indirectly used materials for the production of the imported good need to be taken into account, as these materials are not physically imported but required to produce and provide the imported good.

For estimating the Austrian Direct Material Input and Domestic Material Consumption, as it is the purpose of the here executed survey, it is sufficient to collect data on the direct material flows. Furthermore evaluating indirect flows associated to imports is time-consuming and only of little value for this study. As there is no comprehensive set of coefficients available, indirect import flows can be evaluated by a Life-Cycle-Analysis (LCA) of each imported good or by an Input-Output Analysis (Hinterberger F., Giljum S,, Hammer M., 2003). These approaches are both laborious and their costs stand in no relation to their benefits for the here executed survey. Therefore indirect flows associated to imports are not included in this study.

2.1.2. Material throughput and stock

Once the materials got extracted or imported they flow (as an input) into the economic system and can then be either accumulated within the economy, consumed domestically within the accounting period (usually one year) or exported to other economies (Hinterberger F., Giljum S., Hammer M., 2003). The accumulation, or the net addition, to the material stock (infrastructure, durable consumption goods, investment goods) is presented by the box “material accumulation” in figure 1. To keep record of the material stock changes allows to describe the annual accumulation of materials within an economic system and therefore to estimate the physical growth of an economy (Hinterberger F., Giljum S, Hammer M., 2003).

Materials, that are consumed within the accounting period (indicated by the material throughput), can either stay in the economic system as recycled goods, leave the economy after their consumption as waste or emissions to the nature or can be exported to other economies (Hinterberger F., Giljum S., Hammer M., 2003). Recycling flows are in general neither counted as inputs to nor as outputs from the environment and therefore not a part of EW-MFA, as the goods stay within the economy. If the recycled material, however, gets exported, adds up to the material stock or is imported from another economy, the recycling flows need to be considered in an EW-MFA survey (Eurostat, 2001). Even though material recycling does not always fulfill the requirements to be included in MFA, it is advisable to take the magnitude of the recycling flows into account, so that double counting is avoided (Eurostat, 2001). To keep track of the (within an economy) recycled materials also allows to relate the recycling flows to the material inputs or outputs (Eurostat, 2001). Despite the advantages of recording material recycling (for a better understanding of the social metabolism), several conceptual difficulties arise when applied. Besides the lack of accurate data, the definition and measurement of recycling flows is difficult and not homogenous throughout the EU (Eurostat, 2001). Due to these conceptual limitations the Eurostat (EW-MFA Methodological Guide 2001) does not recommend to imply material recycling accounts in EW-MFA.

The recycling of biomass would be of a certain interest for this study, as they can be reused several times before emitting them into the environment. It would participate in indicating how efficient biomass is used in Austria and if there is a potential in improving recycling while extracting less new materials. Unfortunately it is difficult to underpin this survey with actual data, wherefore the Eurostat does not recommend including material recycling in EW-MFA. Nevertheless an attempt to measure these recycling flows and to set them into relation with domestic biomass consumption is undertaken in the subsequent paper, for which this thesis forms its foundation.

2.1.3. Material output

Materials that neither contribute to the net addition of the material stock nor are recycled (thus staying in the economic system) within an accounting period, are leaving the economy as an output. The material output can on the first level be distinguished by their main destination, i.e. outputs (back) to the environment and exports to other economies (Eurostat, 2001).

As the here applied EW-MFA is undertaken in order to estimate Direct Material Input and Domestic Material Consumption of biomass in Austria, the output categories of an EW-MFA are of less interest. Nevertheless it is essential to evaluate the material export flows for estimating an economy's Domestic Material Consumption.

Outputs to nature

The category "outputs to nature", as defined by the Eurostat's EW-MFA Methodological Guide (2001), comprises all processed outputs that flow from the economy back into the environment during or after production or consumption processes (Eurostat, 2001). A material entered the environment again, if man loses control over the location and composition of the released material (Eurostat, 2001). The materials are usually released into air, land or water as emissions or waste. Apart from the emission or waste flow to the environment, materials can also be emitted from the economy as a dissipative flow. In general two distinctions of dissipative flows are made by the Eurostat's EW-MFA Methodological Guide (2001), i.e. the dissipative use of products and dissipative losses. Dissipative use of products refers to the material outputs on agricultural land, roads and other purposes, i.e. use of fertilizers, pesticides, seeds and manure on fields or salt and other thawing materials for roads (Eurostat, 2001). On the other hand dissipative losses refer to material outputs due to erosion and corrosion of infrastructures, to abrasion of car tires and to outputs caused by leakages (Eurostat, 2001).

Unused domestic extraction (output side)

On the output side the category unused domestic extractions represents all unprocessed material outputs, i.e. the disposal of all unused domestic extractions (Eurostat, 2001).

Exports

Material exports of an economy are classified the same way as imports to an economy, i.e. as direct flows from an economy to another. This makes the calculation of physical trade balances (imports minus exports) as well as Domestic Material Consumption feasible (Eurostat, 2001).

Indirect flows associated to exports

Indirect flows associated to exports are, like the export category, classified the same way as indirect flows associated to imports and therefore include all used and unused materials as well as the indirect material usage during the production chain. For domestically consumed goods, as mentioned further above, the indirect material flows do not need to be accounted for in MFA, as the material flows within an economy are part of PIOTs (and not MFA). For exported goods the indirect flows during the production process are also within an economic system, which would suggest not taking those material flows into account in MFA. Nevertheless these indirect material flows won't be physically exported, but were still needed to provide the exported product and have therefore to be considered in MFA.

For the estimation of the Austrian Domestic Material Consumption it is, however, sufficient to just account for exports. Indirect flows associated to exports have to be either direct domestic extractions or imports and would need to be subtracted from the material inputs, as they are not physically exported but were still needed to provide the exported good. As the purpose of the here executed EW-MFA is, however, to measure the in the Austrian economy physically consumed biomass, indirect export flows do not need to be accounted for here.

In the following section the respective data sources and accounting principles for executing an EW-MFA are discussed in detail. As the output side of an EW-MFA, except for exports, as well as the material throughput is of less interest here, data sources and accounting principles for the evaluation of domestic biomass extractions, imports and exports are presented in the following.

2.2. Data sources and accounting principles

For evaluating the Austrian biomass extraction, Direct Material Input and Domestic Material Consumption an EW-MFA recording crop, applied crop residues, fodder crops, grazed biomass and wood flows into (and from) the Austrian economy (to other economies) from 1995 to 2010 has been undertaken. Within the here considered time interval changes in the supply of biomass as well as in the trade flows of biogenic materials can be observed and analysed. The from 1995 starting 16 years time interval has been chosen, as it supplies the most updated EW-MFA data feasible and goes along with many nationally and internationally executed EW-MFA, such as the Austrian Statistics Department's (Statistik Austria) or the Eurostat's survey.

The Eurostat as well as Statistik Austria are both providing EW-MFA data of the Austrian economy online. The Austrian Statistics Department presents their evaluated data, however, only until the two digit level – A.1.1 Crops, A.1.2 Crop residues (used), fodder crops and grazed biomass, A.1.3 Wood, A.1.4 Wild fish catch, aquatic plants/ animals, A.1.5 hunting and gathering, A.1.6 Living animals other than A.1.4 and A.1.7 Products mainly from biomass (Statistik Austria EW-MFA database). This means that the data provided by Statistik Austria does not contain any information on the material flows comprising the presented amounts of the two digit level sub-groups. Furthermore the Austrian Statistics Department does not follow the categorisation established and suggested by the Eurostat's EW-MFA Compilation Guide or Questionnaire (2012) (which leaves uncertainties concerning the components included within the different sub-groups, as no proper metadata explanation by Statistik Austria is available). The Eurostat, on the other hand, provides via its homepage[3] economy-wide material flow data for 27 EU-member-states. The EW-MFA data is categorised as recommended by the EUROSTAT's EW-MFA Compilation Guide and Questionnaire (2012), evaluated from 1995 until 2010 and available until the three digit level, which allows an overview of the composition of the two digit level sub-groups. Nevertheless the three digit level categories are as well aggregates of several material flows (namely the actual commodity flows). In order to provide a proper overview of the Austrian biomass extractions and to analyse their driving forces, an EW-MFA including and presenting all individual material flows until the commodity level (the four digit level) has to be undertaken. Therefore another survey, apart from the already existing, is executed within this paper, based on data gathered from the Statistics Department of the United Nations Food and Agriculture Organization (FAOSTAT) database. The EW-MFA data provided by the Eurostat serves (nevertheless) as a reference estimation.

For the evaluation of every single biogenic material that got extracted in, imported to or exported from Austria, the Statistics Department of the United Nations Food and Agriculture Organization (FAOSTAT) provides a comprehensive online data set via its homepage[4]. These data in combination with the by the Eurostat provided EW-MFA Methodological Guide (2001), EW-MFA Compilation Guide (2012) and EW-MFA Questionnaire (2012) allow estimating all material flows of

3 http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/
4 http://faostat.fao.org/site/291/default.aspx

each single material in, from or to Austria. As all single biogenic material flows are evaluated, the various sub-groups recommended by the Eurostat's EW-MFA Compilation Guide (2012) and EW-MFA Questionnaire (2012) can be aggregated again and compared with the respective estimations presented by the Eurostat.

Due to its completeness and information level the FAOSTAT data set forms the main data source for the here executed survey next to the national report of the Austrian forests and wood harvest provided by the Austrian Ministry of Life (BMLFUW) Prem J., Beer R. (2012). Wooded biomass bares a huge potential in its future application wherefore a focus is put on the extractions, imports and exports of wood. Even though it is assumed that nationally evaluated data is more precisely than internationally evaluated data, it will be shown in the following that the FAOSTAT data on forestry do in general not differ from the by the BMLFUW provided data (which is another indicator for the accuracy of the FOASTAT data set).

EW-MFA help, as already mentioned further above, extending the monetary System of National Accounts by expanding it with physical accounts. Therefore the material flows ought to be measured in physical units. The common unit applied for measuring material flows is metric tonnes, which also applies for the here executed EW-MFA survey.

Measuring material flows in metric tonnes means that they are accounted by their respective weight. The weight of materials – especially biogenic materials – can, however, vary due to their moisture content. Furthermore not all materials are statistically recorded in metric tonnes. This is the case for all wood harvested, imported or exported. Wood is commonly recorded in cubic meters and needs therefore to be converted into metric tonnes in order to be included in an EW-MFA. Apart from the conceptual difficulties regarding the measurement of material flows, data on used crop residues and grazed biomass are not available and need therefore to be estimated. How these difficulties can be tackled and dealt with is illustrated and discussed in the subsequent section.

2.2.1. Moisture content

The moisture content of biomass varies across plant parts, vegetation periods and species and can be of more than 95% in the case of fresh living plant biomass (Eurostat, 2012). It is therefore crucial at which moisture content the biomass gets extracted, as in agricultural statistics biomass is accounted for at its weight at the time of harvest (Eurostat, 2012). Crops, like cereals, are commonly harvested at a rather low moisture content of approximately 15%, whereas grasses and fodder crops get usually extracted at rather high moisture contents of 80-95% (Eurostat, 2012; Giljum et al., 2005). It is therefore important to define a standard moisture content for EW-MFA surveys. Otherwise the inconsistencies within the water content would distort the results of an EW-MFA significantly – the Swedish domestic extraction from arable land would for instance be 30 million tonnes if the grass harvest was accounted for at its fresh weight (80-95% moisture content) and only 15 million tonnes if the grass harvest was given in hay weight (15% moisture content) (Eurostat, 2001).

The EUROSTAT recommends therefore to apply a standardised moisture content of 15%, which means that all extracted biomass is integrated air-dried in an EW-MFA (Eurostat, 2001). In the FAOSTAT database all primary crops, apart from grass harvests, are reported air-dried (FAOSTAT, 2013). Therefore all FAOSTAT primary crops categories that can be clearly identified as harvested grass need to be converted to a 15% moisture content, applying the procedure provided in the Eurostat's EW-MFA Compilation Guide (2012), Giljum et al. (2005) and illustrated in equation 1.

Equation 1: Conversion from fresh water content to 15% standard moisture content

$$(1)\ Yield\ (fresh\ weight\text{: } 80\%\ water\ content) * 0.2 * 100/85\ =\ Yield\ (hay\ weight\text{: } 15\%\ water\ content)$$

$$(2)\ Area * Yield\ (15\%\ water\ content)\ =\ Total\ Production\ (revised)$$

Source: by author based on Eurostat, 2012; Giljum et al, 2005

Table 4 illustrates the crops which can be clearly identified as harvested grass and thus have to be converted as shown above. Besides the single commodities, also their respective FAO product codes are presented in table 4.

Table 4: Biogenic materials with 80-95% water content in primary data

Material	FAO product code
Rye Grass, Forage and Silage	638
Grasses nec for Forage and Silage	639
Clover for Forage and Silage	640
Alfalfa for Forage and Silage	641
Leguminous nec for Forage and Silage	643
Mixed Grasses and Legumes	645

Source: by author based on Eurostat, 2012; Giljum et al., 2005

Apart from harvested grass, the material flows of grazed biomass and harvested wood need to be converted as well, so that the standard moisture content of 15% is respected.

2.2.2. Applied crop residues

The primary crop harvest is usually only a part of the total plant biomass cultivated (Eurostat, 2012). The remaining crop residues are, however, used in various ways – either for intra-unit consumption or for commercial reasons (Eurostat, 2012). A good example for this is (cereal) straw which is gained from the remaining residues of the cereal harvest and can be used in various ways – either as a bedding material for the livestock, as feed stuff, as a raw material or even for the generation of energy (Eurostat, 2012). As long as the remaining crop residue is subject to a further economic use, it is considered to be a used domestic extraction and needs therefore to be implied in the here executed EW-MFA survey. If however the crop residue is burnt or ploughed into the field, it is of no further economic use and therefore not to be accounted for a used domestic extraction.

Used crop residues, even if value adding, are usually not monitored by agricultural crop statistics –

as it is also the case for Austria. Nevertheless the magnitude of these residues needs to be evaluated in order to measure an economy's (direct) domestic biomass extractions, direct biomass input and domestic biomass consumption. Therefore an estimation procedure needs to be applied to close this data gap. The Eurostat provides such a procedure along with the necessary coefficients. This procedure is also applied here to close the applied crop residues data gap and is discussed in detail in the following.

The first step for estimating the extraction of used crop residues is to identify those crops which provide residues for further socio-economic use (Eurostat, 2012). These are for the Austrian agriculture all types of cereals, sugar crops and oil bearing crops (EUROSTAT, 2012).

The second step is then to estimate the total available crop residues. As only the primary crop harvest is recorded by agricultural statistics, a coefficient that helps calculating the amount of the total above ground biomass associated to the primary crop harvest needs to be applied. This coefficient is called Harvest Factor and differs obviously from crop to crop. The Eurostat provides in its EW-MFA Compilation Guide (2012) a list of typical Harvest Factors for all the here relevant cereals, sugar and oil bearing crops – which is presented in table 5.

Table 5: Harvest Factors for most common crop residues used

Crop	Harvest Factor
Wheat	1
Barley	1,2
Oats	1,2
Rye	1,2
Maize	1,2
Rice	1,2
All other cereals	1,2
Rape seed	1,9
Soy bean	1,2
Sugar beet	0,7
Sugar cane	0,5

Source: by author based on Eurostat, 2012

To estimate the total available crop residues, the Harvest Factors need to be applied for each crop

Equation 2: Applying the Harvest Factor for calculating available crop residues

$$Available\ crop\ residues\ [tonnes]\ =\ primary\ crop\ harvest\ [tonnes] * Harvest\ Factor$$

Source: by author based on Eurostat, 2012

as illustrated in equation 2.

The various Harvest Factors are calculated out of the Harvest Indices and grain to straw ratios of the different crops (Eurostat, 2012). The Harvest Index is the ratio of primary crop harvest subject to the above ground biomass at maturity and the straw to grain ratio is defined as the ratio of grain yield and above ground biomass at maturity less the grain yield (Huehn M., 1993). These ratios obviously change locally due to the growing seasons and topographical conditions of the cultivated area, as well as temporally due to annual weather conditions (Huehn M., 1993; Kemanian A. et al., 2007). Hence the by the Eurostat EW-MFA Compilation Guide (2012) presented Harvest Factors are only rough coefficients that can only deliver an approximation of the actually available crop residues and therefore of the used crop residues.

The third and final step of estimating the magnitude of used crop residues is to evaluate the of the available crop residues applied fraction (Eurostat, 2012). This fraction can be estimated by applying the recovery rates of each here relevant crop. The recovery rate contains information on the applied shares of the respective crops. Estimating the recovery rates for the in Austria extracted crops would go beyond the scale of this thesis, wherefore the by the Eurostat EW-MFA Compilation Guide (2012) provided recovery rates are applied here – table 6 presents the coefficients.

Table 6: Harvest Factors and recovery rates for most common crop residues used

Crop	Harvest Factor	Recovery Rate
Wheat	1	0,7
Barley	1,2	0,7
Oats	1,2	0,7
Rye	1,2	0,7
Maize	1,2	0,9
Rice	1,2	0,7
All other cereals	1,2	0,7
Rape seed	1,9	0,7
Soy bean	1,2	0,7
Sugar beet	0,7	0,9
Sugar cane	0,5	0,9

Source: by author based on Eurostat, 2012

To estimate the extraction of used crop residues, the recovery rates of each crop need to be applied as illustrated in equation 3.

Equation 3: Applying recover rates for calculating used crop residues

$$Used\ crop\ residues\ [tonnes]\ =\ available\ crop\ residues\ [tonnes] * recovery\ rate$$

Source: by author based on Eurostat, 2012

Similar to the Harvest Factor, the recovery rate can vary locally and over time. Therefore the category used crop residues can only be an approximation to the actual amount of used crop residues. Evaluating these coefficients for Austria would in fact bring the estimation closer to the actual extractions of applied crop residues, however, an evaluation of the Harvest Factor and recovery rate would go beyond the scale of this thesis, hence implementing the by the Eurostat EW-MFA Compilation Guide (2012) provided coefficients is sufficient.

2.2.3. Fodder crops and grazed biomass

Fodder harvested from permanent pastures or directly taken up by ruminants or other grazing animals, is according to the framework of an EW-MFA part of the used direct extraction category (Eurostat, 2001). The sub-group A.1.2.2 Fodder Crops and Grazed Biomass includes all fodder crops, biomass harvested from grassland and biomass directly grazed by the livestock (Eurostat, 2012). Commercial feed crops are, however, not included here as these crops – barley, grain, maize, soy bean, etc. – have already been accounted for in category A.1.1 Crops.

Data on fodder crops and especially on grazed biomass are usually neither recorded by international statistics departments nor by national agricultural statistics, which is also the case for Austria (Eurostat, 2012). Therefore an estimation procedure needs to be applied to fill this data gap.

The Eurostat provides in its EW-MFA Compilation Guide (2012) two approaches for estimating the magnitude of fodder crops and grazed biomass – a supply-side approach and a demand-side approach. Within the supply-side approach the data gap is closed by identifying the production quantities of each fodder crop, whereas the demand-side approach estimates the fodder requirements for the existing livestock (Eurostat, 2012). It is however recommended to apply both approaches and combine them for crosschecking the results (Eurostat, 2012).

Supply-side approach

For evaluating the production quantities of fodder crops, one can consult the FAOSTAT data base as well as the European Environment Agency (EEA). Both institutions present their production data on fodder crops, however, in monetary terms. To avoid recalculating these data into physical units and the thereby involved inaccuracies, the Eurostat EW-MFA data base can be consulted, which estimates data on fodder crops already in physical units of metric tonnes.

For estimating the total theoretical supply of grazed biomass, the grazing potential of an economy needs to be calculated. Evaluating the grazing potential means to multiply the total pasture area (of an economy) with an average yield coefficient (Eurostat, 2012). As pastures differ due to their topographic location and the weather they are exposed to, the average yield also differs between pastures. Therefore applying different average yield coefficients for different pastures is advisable and reduces inaccuracies. Data on pasture areas of each country can be gathered from the FAOSTAT data base, which divides the pastures in several sub-groups. For the before mentioned average yield coefficients, the Eurostat EW-MFA Compilation Guide (2012) can be consulted, which provides such coefficients for three different types of pastures – Rough Grazing, Alpine Pasture, Extensive Pasture and Improved Pasture. The average yield coefficients are measured in tonnes per hectare at the 15 per cent moisture content, so that the calculated grazing potential goes along with the standard moisture content (of 15%) – table 7 presents the coefficients as provided by the Eurostat EW-MFA Compilation Guide (2012).

Table 7: Average area yield of permanent pastures in Central Europe

Pasture type	Average yield coefficient [t at 15%mc / ha]
Rough grazing, alpine pasture	0,5
Extensive pasture	2,5
Improved pasture	7

Source: by author based on Eurostat, 2012

The here presented and by the Eurostat EW-MFA Compilation Guide (2012) provided average yield coefficients are estimates of typical grazing yield potentials of permanent pastures in Central Europe (Eurostat, 2012). The average area yield obviously changes regionally due to different vegetation periods.

Applying now these coefficients to the several pasture type areas adds up to the grazing potential of an economy at the standard moisture content of 15% – equation 4 illustrates the relations.

Equation 4: Applying average yield coefficients for calculating grazing potential

$$Grazing\ potential\ [t\ at\ 15\%mc]\ =\ pasture\ area\ [ha] * average\ yield\ [t\ at\ 15\%mc/ha]$$

Source: by author based on Eurostat, 2012

Calculating the grazing potential of an economy by applying average yield coefficients is a cost-efficient approach that is easy to undertake. Nevertheless this method contains inaccuracies as no average yield coefficient can reproduce the actual grazing potential of an economy. Therefore these estimations should, as recommended by the Eurostat EW-MFA Compilation Guide (2012), be checked with expert knowledge in order to adjust and modify the estimations to the best possible extend (Eurostat, 2012).

After estimating the theoretical grazing potential, the demand by the livestock has to be calculated, in order to evaluate the direct uptake of biomass by ruminants and other grazing animals. For this step the demand-side approach will be needed.

Demand-side approach

Calculating the demand for grazed biomass requires (firstly) information on the magnitude of grazing animals. This data can easily be gathered from national agricultural statistics as well as from the FAOSTAT data base. Secondly information on the annual feed intake of the livestock is required. The annual feed intake can vary due to the weight of an animal, its application (e.g., weight gain, milk yield) and the feeding system, so that the feed intake even differs within one species (Eurostat, 2012). As it is, however, almost impossible or at least laborious to account the feed intake of each animal in detail, average values are applied to calculate the roughage requirement of the livestock. The Eurostat provides in its Compilation Guide (2012) average European factors on roughage requirements for different species. The data on the average roughage uptake are given in air dry weight (15% moisture content) and take a share of market feed between 5% and 20% into account (Eurostat, 2012). Table 8 presents the values.

Table 8: Average annual roughage intake by grazing animals in Europe

Species	Average annual intake [t / head and year]
Cattle (and buffalo)	4,5
Sheep and goats	0,5
Horses	3,7
Mules and asses	2,2

Source: by author based on Eurostat, 2012

Applying these average annual intake factors now to the number of livestock within an economy results in the roughage requirement of the (complete) livestock of an economy – equation 5 shows the relations.

Equation 5: Applying average annual intake factors for calculating roughage requirement

$$Roughage\ requirement\ [t\ at\ 15\%mc]\ =\ livestock * annual\ intake\ [t\ at\ 15\%mc/head]$$

Source: by author based on Eurostat, 2012

To estimate the biomass uptake through grazing, the roughage requirement has to be reduced by fodder crops and the biomass harvests from grassland (item A.1.2.2.1) as the roughage uptake of an animal may also be covered by grass type fodder crops, hay and silage (Eurostat, 2012). Equation 6 presents the relations.

Equation 6: Applying average yield coefficients for calculating grazing potential

$$Demand\ for\ grazed\ biomass\ [t\ 15\%mc] = roughage\ requirement\ [t\ 15\%mc] - fodder\ crops\ [t\ 15\%mc]$$

Source: by author based on Eurostat, 2012

After estimating the demand for grazed biomass, it can be crosschecked with the grazing potential and thus analysed if the demanded grazed biomass is also available. Nevertheless these estimations base on a variety of rough coefficients that may lead to inaccuracies, wherefore the resulting data can only be interpreted as a rough indicator – especially if the by the Eurostat EW-MFA Compilation Guide (2012) recommended revision with expert knowledge is not respected.

For evaluating the fodder and grazed biomass uptake of the Austrian livestock, both approaches as recommended by the Eurostat were applied in this study. Nevertheless the resulting data was misleading and in no way consistent with the by the Eurostat estimated data, presented on the Eurostat EW-MFA data base. Within the Eurostat EW-MFA Compilation Guide (2012) the Eurostat advises to check the grayed biomass estimations with expert knowledge, a step that could not be realised within this study (Eurostat, 2012). Therefore, due to the assumption that the Eurostat has respected this step, the by the Eurostat provided data on the sub-group A.1.2.2 Fodder crops and Grazed biomass are applied in the here executed survey.

2.2.4. Converting harvested wood from cubic meters to metric tonnes

Within an EW-MFA material flows are measured in metric tonnes. Wood is, however, usually recorded in cubic meters. Therefore the harvested and traded wood volumes need to be converted into their respective weights (at a moisture content of 15%). The conversion of volume into weight depends on the density of the extracted wooded biomass, which differs significantly across species and countries (Giljum et al., 2005, Eurostat, 2002). Therefore country- and species-specific conversion factors need to be applied to estimate the harvested wood weight accurately. But as such a data set is still not available, already derived and more general density coefficients are applied within this thesis – as calculating species-specific conversion factors for Austria would clearly go beyond the scope of this paper. The in the following presented data on the weight of harvested wood is therefore only to be interpreted as a rough indicator and serves only for estimating the Austrian direct biomass input and domestic biomass consumption. The extraction volumes (cubic meters) of wood are, however, presented and discussed in chapter before being converted and implemented in the EW-MFA survey of Austrian biomass flows.

For the conversion of wood volume to wood weight the Eurostat EW-MFA Compilation Guide (2012) recommendations are followed here. The by the Eurostat EW-MFA Compilation Guide (2012) presented conversion factors stem from the “Good Practice Guidance for Land Use, Land-Use, Change and Forestry, IPCC National Greenhouse Gas Inventories Programme” (Penman et al. 2003). The by the IPCC provided conversation factors refer, due to their purpose, to oven dry mass of wood. For EW-MFA the wood weight at the standardised 15% moisture content is, however, of interest, wherefore the Eurostat transformed these factors to convert solid cubic meters into metric tonnes at the 15% moisture content (Eurostat, 2012). Furthermore the conversion factors differ between two main groups of wood – coniferous and non-coniferous – in order to approximate the species-specific density of wood. The conversation factors were derived for EU-member-states and are presented in table 9.

Table 9: Conversion factors from cubic meters to metric tonnes for coniferous and non-coniferous wood

Species	Density [t at 15% moisture content / m³]
Coniferous	0,52
Non-coniferous	0,64

Source: by author based on Eurostat, 2012

2.3. Derivable indicators

The GDP is without a doubt the most appealing and applied wealth indicator used in social science or politics. Its shortcomings in illustrating environmental and social-aspects of human well-being raised, however, several concerns and the call for more accurate but still appealing social-wealth indicators. Environmental Accounts such as EW-MFA experienced therefore an expanded attention in the recent years, as within the framework of an EW-MFA several indicators (of material input, consumption or output) can be derived. Domestic Material Consumption and Direct Material Input represent promising alternatives for appealing social-wealth indicators, due to presenting an aggregated picture of a socio-economic metabolism and the availability of the required data. Table 10 lists the by an EW-MFA survey derivable indicators. EW-MFA indicators differ in general between evaluating input or output material flows or the material consumption. Furthermore depending on the different material flow categories respected within an EW-MFA, different indicators can be derived. The column Accounting Rules in Table 10 presents the required information for calculating each EW-MFA indicator. For evaluating the Direct Material Input indicator of an economy, information on direct domestic extractions and imports are necessitated, for instance. Wherefore estimating the Total Material Requirement of an economy, the respective hidden flows associated to the Direct Material Input need to be known.

Table 10: EW-MFA Indicators

Indicator Class	Indicator	Accounting Rule
Input	Direct Material Input (DMI)	DMI = Direct domestic extractions + Imports
	Total Material Requirement (TMR)	TMR = DMI + Hidden Flows
Consumption	Domestic Material Consumption (DMC)	DMC = DMI - Exports
	Total Material Consumption (TMC)	TMC = TMR – Exports (including indirect flows associated to exports)
Output	Domestic Processed Output (DPO)	DPO = emissions + waste
	Direct Material Output (DMO)	DMO = DPO + Exports

Source: by author based on Eurostat, 2001

As in this paper the focus is on the extraction, imports and exports of biogenic materials, output indicators are of less interest here. The only difference within input and consumption indicators is, as illustrated above, whether hidden flows are included in their calculation or not. As in this thesis only direct flows are evaluated and analysed the Direct Material Input (DMI) and the Domestic Material Consumption (DMC) indicators will be applied here to deliver an aggregated picture of the Austrian socio-economic metabolism and are therefore, unlike the remaining EW-MFA indicators, briefly discussed below.

Direct Material Input (DMI): DMI consists of all material inputs into the analysed economy which are of economic value and directly used in production and consumption processes (Moll S., Bringezu S., Schütz H., 2005; Eurostat; 2001; Hinterberger F., Giljum S., Hammer M., 2003). DMI equals as shown in table 10 all domestic extractions plus imports, hence representing the overall material input into the analysed economy.

Domestic Material Consumption (DMC): DMC is the amount of materials directly used in a national economy (excluding indirect flows) and consumed domestically (Moll S., Bringezu S., Schütz H., 2005; EUROSTAT; 2001; Hinterberger F., Giljum S., Hammer M., 2003). DMC equals therefore DMI minus exports and thus represents, roughly speaking, the domestic material supply applied within the analysed economy.

3. Results

Applying the by the FAOSTAT (and partly the BMLFUW) provided data on the extraction and trade of the for this survey relevant biogenic materials entering (from the environment and other economies) and leaving (to other economies) the Austrian economy according to the before presented EW-MFA scheme established by the Eurostat (EW-MFA Methodological Guide, 2001 and EW-MFA Compilation Guide, 2012) yields the physical magnitudes of all here relevant biomass flows entering and leaving the Austrian economy from 1995 to 2010. The annual Austrian biomass consumption (DMC of biomass) accounted on average for about 39.66 million tonnes, varying between 45.19 million tonnes (2008) and 36.13 million tonnes (2003). On average about 40.9% of the annual Austrian biomass consumption was composed by applied crop residues, fodder crops and grazed biomass, 31.1% by domestically removed and imported wood fibres and 28% by harvested or imported crops throughout the here considered time span. Domestic biomass consumption of Austria developed with an average growth rate of 0.8% per annum and augmented by approximately 4.85 million tonnes from 1995 (37.28 million tonnes) to 2010 (42.13 million tonnes).

Before discussing, however, total biomass flows from and to Austria, the two digit level sub-groups – A.1.1 Crops; A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass; A.1.3 Wood – composing overall biomass flows are analysed in detail. As already mentioned further above, extraction and trade data provided by the FAOSTAT contains rather precise information and thus supplying the respective extraction, import and export quantities of each single biogenic material to and from Austria. This allows identifying the main driving forces of crop, applied crop residues, fodder crops, grazed biomass and wood flows and consequently the main driving commodities of overall biomass flows (which is undertaken in the following). After presenting and analysing the domestic extractions, imports and exports as well as the DMI and DMC of each two digit level sub-group, their added up domestic extraction, import and export values representing total biomass flows, as well as the thereof derivable EW-MFA indicators – direct biomass input and domestic biomass consumption – are presented and discussed subsequently.

3.1 A.1.1 Crops

The two digit level sub-group A.1.1 Crops comprises, according to the Eurostat EW-MFA Methodological Guide (2001) and Eurostat EW-MFA Compilation Guide (2012) various further aggregates on the three digit level, such as cereals, sugar crops, oil bearing crops, fruits, nuts, vegetables, fibre crops, roots and tubers, pulses, etc.. These (three digit) aggregates are composed by single commodity flows of for instance wheat, maize, apples, sugar beet, etc.. The Eurostat provides within its EW-MFA database only information until the three digit level aggregates, whereas the FAOSTAT provides extraction and foreign trade data of each single commodity – wherefore the FAOSTAT database represents the main data source for the here undertaken EW-MFA survey of the Austrian economy. In order to generate a proper overview of the tow digit sub-group A.1.1 Crops, the composition of all crop flow accounts as established by the Eurostat (EW-MFA Methodological Guide, 2001 and EW-MFA Compilation Guide, 2012) is presented in table 11.

Table 11: Composition of two digit level sub-group A.1.1 Cereals

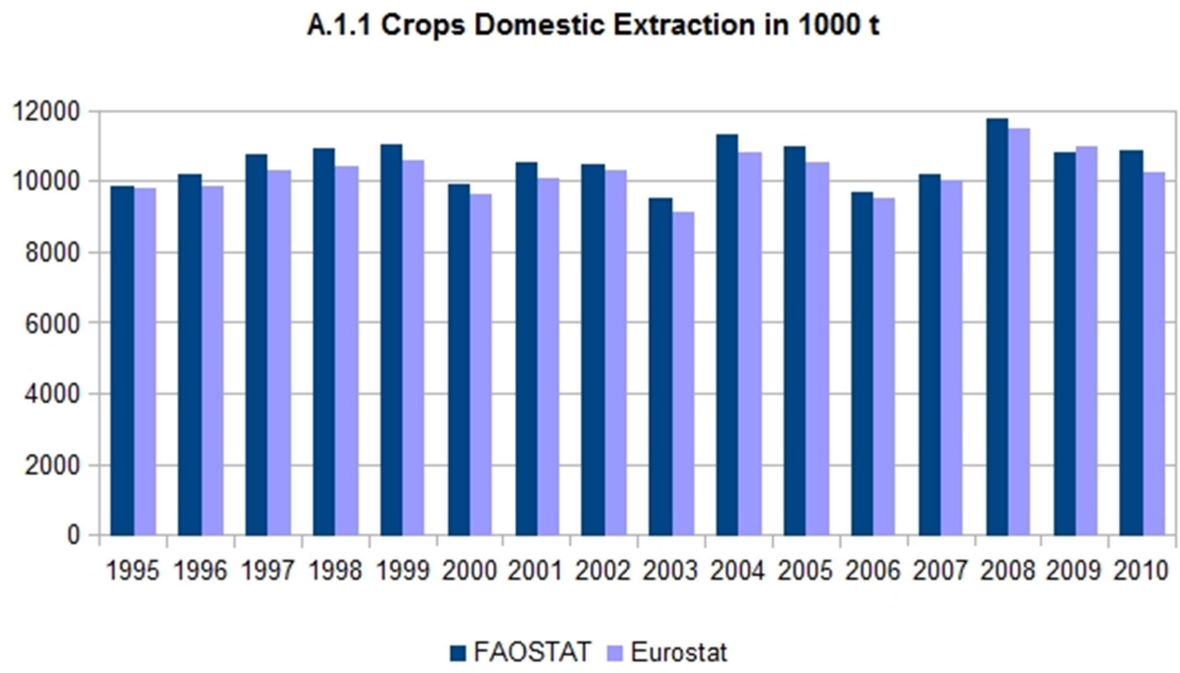
A.1.1 Crops				
A.1.1.1 Cereals	**A.1.1.5 Nuts**	**A.1.1.7 Vegetables**	**A.1.1.8 Fruits**	**A.1.1.9 Fibres**
Barley	Almonds, with shell	Artichokes	Apples	Agave Fibres Nes
Buckwheat	Arecanuts	Asparagus	Apricots	Cotton lint
Canary seed	Brazil nuts, with shell	Beans, green	Avocados	Fibre Crops Nes
Cereals, nes	Cashew nuts, with shell	Cabbages and other brassicas	Bananas	Flax fibre and tow
Fonio	Chestnuts	Carrots and turnips	Berries Nes	Hemp Tow Waste
Maize	Hazelnuts, with shell	Cassava leaves	Blueberries	Jute
Millet	Kolanuts	Cauliflowers and broccoli	Carobs	Kapok Fruit
Mixed grain	Nuts, nes	Chillies and peppers, green	Cashewapple	Manila Fibre (Abaca)
Oats	Pistachios	Cucumbers and gherkins	Cherries	Other Bastfibres
Popcorn	Walnuts, with shell	Eggplants (aubergines)	Citrus fruit, nes	Ramie
Quinoa	**A.1.1.6 Oil Crops**	Garlic	Cranberries	Seed cotton
Rice, paddy	Castor oil seed	Leeks, other alliaceous veg	Currants	Sisal
Rye	Coconuts	Leguminous vegetables, nes	Dates	**A.1.1.10 Other Crops**
Sorghum	Cottonseed	Lettuce and chicory	Figs	Anise, badian, fennel, corian.
Triticale	Groundnuts, with shell	Maize, green	Fruit Fresh Nes	Carobs
Wheat	Hempseed	Mushrooms and truffles	Fruit, tropical fresh nes	Chicory roots
A.1.1.2 Roots and Tubres	Jojoba Seeds	Okra	Gooseberries	Chillies and peppers, dry
Cassava	Kapok Fruit	Onions (inc. shallots), green	Grapefruit (inc. pomelos)	Cinnamon (canella)
Potatoes	Karite Nuts (Sheanuts)	Onions, dry	Grapes	Cloves
Roots and Tubers, nes	Linseed	Peas, green	Kiwi fruit	Cocoa beans
Sweet potatoes	Melonseed	Pumpkins, squash and gourds	Lemons and limes	Coffee, green
Taro (cocoyam)	Mustard seed	Spinach	Mangoes, mangosteens, guavas	Ginger
Yams	Oil palm fruit	String beans	Oranges	Hops
Yautia (cocoyam)	Oilseeds, Nes	Tomatoes	Other melons (inc.cantaloupes)	Maté
A.1.1.3 Sugar Crops	Olives	Vegetables fresh nes	Papayas	Natural rubber
Sugar beet	Palm kernels		Peaches and nectarines	Nutmeg, mace and cardamoms
Sugar cane	Palm oil		Pears	Pepper (Piper spp.)
Sugar crops, nes	Poppy seed		Persimmons	Peppermint
A.1.1.4 Pulses	Rapeseed		Pineapples	Pyrethrum,Dried
Bambara beans	Safflower seed		Plantains	Spices, nes
Beans, dry	Seed cotton		Plums and sloes	Tea
Broad beans, horse beans, dry	Sesame seed		Pome fruit, nes	Tobacco, unmanufactured
Chick peas	Soybeans		Quinces	Vanilla
Cow peas, dry	Sunflower seed		Raspberries	
Lentils	Tallowtree Seeds		Sour cherries	
Lupins	Tung Nuts		Stone fruit, nes	
Peas, dry			Strawberries	
Pigeon peas			Tangerines, mandarins, clem.	
Pulses, nes			Watermelons	
Vetches				

Source: by author based on Eurostat, 2012

3.1.1. A.1.1 Crops – Domestic Extraction

For estimating the annual crop extractions in Austria from 1995 to 2010, data provided by the FAOSTAT database on crop extractions were applied for the in this thesis executed EW-MFA. As already mentioned above, the FAOSTAT database provides extraction data on the commodity level, allowing a precise analysis of the main driving forces for crop extractions in Austria and hence offering data with higher information content than the Eurostat EW-MFA database (which does not break the aggregates up into the commodities composing them). Nevertheless the within this thesis undertaken estimation on domestic crop extractions are compared to the by the Eurostat's EW-MFA database provided empirical information – Figure 2 presents the comparison for each year. As indicated in figure 2, the estimations on domestic crop extractions based on information of the FAOSTAT database are slightly higher than the by the Eurostat calculated extractions. The difference is, however, linear which leads to the assumption of a systematic error – due to following the Eurostat EW-MFA Compilation Guide (2012) as well as applying the Eurostat EW-MFA Questionnaire (2012) for the here undertaken EW-MFA survey and therefore applying the same method as the Eurostat should have for evaluating the in Austria extracted crop quantities. Hence an over reporting of the FAOSTAT or an under reporting of the Eurostat is likely. As traditional statistics record data only from a certain magnitude on, it is more advisable for the here executed survey to use data that tempt to over report in order to draw an accurate picture of the actual crop extractions, which is in this case the by the FAOSTAT database provided information.

Figure 2: Domestic extractions of crops in Austria from 1995 to 2010, in 1000 t; comparison of own estimation based on FAOSTAT and Eurostat EW-MFA data

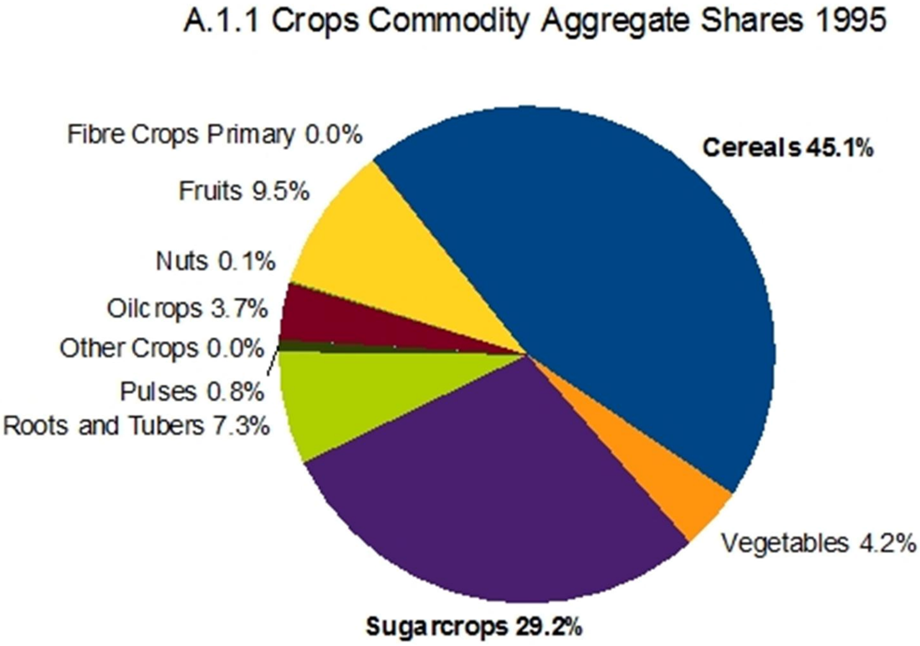


Source: by author based on FAOSTAT; Eurostat EW-MFA database; Eurostat, 2012

The in figure 2 illustrated domestic crop extractions are presented in thousands of tonnes. In 2008 Austrian crop extractions were peaking (regardless the data source) with an overall extraction volume of approximately 11.8 million tonnes (respectively 11.5 million tonnes according to the Eurostat's EW-MFA database estimation) for the here considered time interval. Between 1995 and 2010 the year 2003 exhibited (regardless the data source) the lowest extraction levels with approximately 9.5 million tonnes (or 9.2 million tonnes according to the Eurostat's EW-MFA database) of extracted crops. On average about 10.6 million tonnes of crops got annually extracted within the borders of the Austrian economy and besides the years 2000, 2003, 2006 and 2009 the domestic crop volumes entering the economic system were steadily rising. Any decline in crop extractions was, however, followed by a rather harsh increase of the extraction volumes in the subsequent years (augmenting extraction quantities back on their average levels) – as can be seen in figure 2. Natural causes like flooding, aridity, etc. are supposable reasons for these declines as the production quantities of the subsequent years always augmented back to the average level which indicates a rather stable industry. How these declines affected the Austrian economy and therefore the DMC will be analysed after presenting data on foreign trade. It is, however, possible that the domestic consumption of crops did not change at all during those years, due to an increase of imported crops.

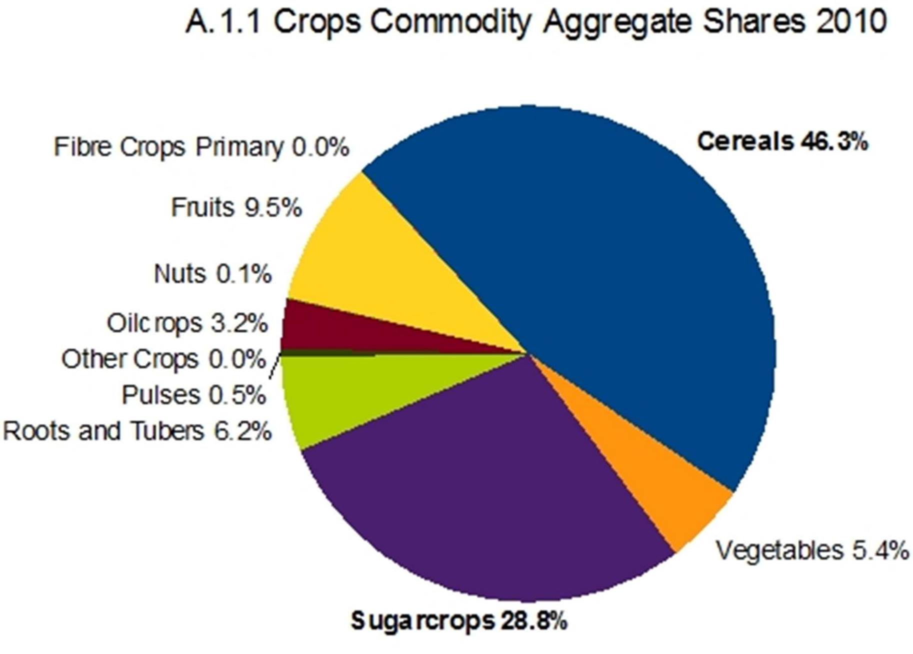
In 1995 the main driving forces for crop extractions in Austria were the commodity aggregates cereals and sugar crops – as illustrated in figure 3. Together the two aggregates comprised almost three quarters (74.3%) of the overall domestic crop extraction in 1995. Amongst the two commodity aggregates, cereals counted with a total extraction quantity of 4.46 million tonnes (45.1%) for almost half of the overall crop extractions (9.88 million tonnes) in 1995, whereas sugar crops accounted for 2.89 million tonnes (29.2%). This means that in 1995 a sugar crop or cereal needed to be extracted three times before another crop (from the remaining commodity aggregates) entered the Austrian economy. In 2010 the composition of domestically extracted crops did not change significantly from 1995 – as presented in figure 4. Cereals and sugar crops with an accumulated share of 75% (of which 46.3% cereals and 28.8% sugar crops) were also the main driving forces for crop extractions in 2010. Their significance even increased slightly from 1995 to 2010. The total extraction of sugar crops increased during the analysed time interval augmenting to 3.13 million tonnes, as well as cereals of which 5.04 million tonnes were extracted in 2010. Even though the harvesting of both aggregates increased, the overall extraction of crops also augmented to 10.89 million tonnes in 2010 leading to a decrease in the commodity shares of sugar crops (29.2% in 1995 and 28.8% in 2010) and thus indicating a slower development of sugar crop extractions in comparison to overall crop extractions. Nevertheless cereal extractions increased during the analysed time interval by 0.58 million tonnes, counting for more than half of the overall crop extraction growth of 1.01 million tonnes (from 1995 to 2010) and thus augmenting the extraction shares of cereals and sugar crops to 75% in 2010.

Figure 4: Shares of crop extractions by commodity aggregates for Austria, 1995



Source: by author based on FAOSTAT; Eurostat, 2012

Figure 3: Shares of crop extractions by commodity aggregates for Austria, 2010



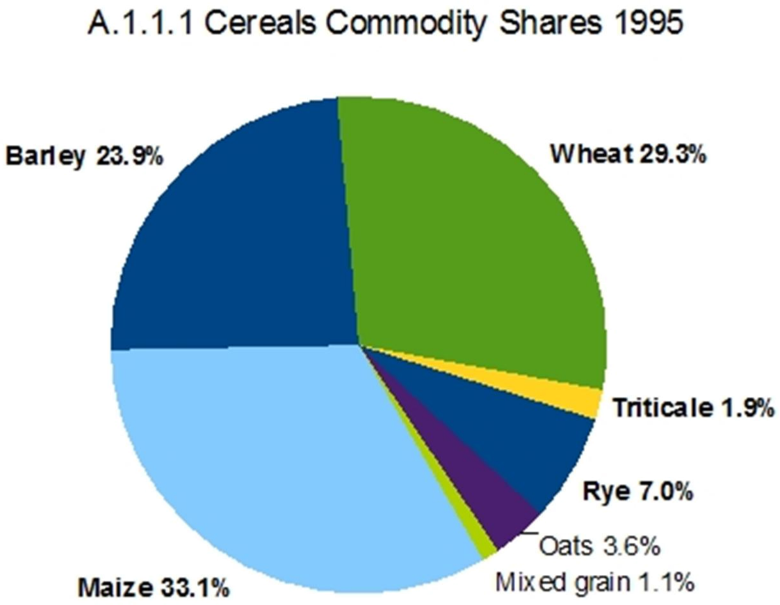
Source: by author based on FAOSTAT; Eurostat, 2012

Data provided by the FAOSTAT database contain information about the commodities compiling the commodity aggregates discussed before. As cereals and sugar crops proved to be the main driving forces for crop extractions, a closer look at these commodity aggregates and the commodities compiling them is undertaken in the following.

The aggregate A.1.1.1 Cereals consists of the commodities wheat, rice, barley, maize, popcorn, rye, oats, millet, sorghum, buckwheat, quinoa, fonio, triticale, canary seed, mixed grains and other cereals (Eurostat, 2001; Eurostat EW-MFA Questionnaire, 2012). Obviously not all of these commodities are harvested in Austria or even enter the Austrian economy. Nevertheless a closer look at the commodities compiling A.1.1.1 Cereals already clarifies the significance of this commodity aggregate, as main resources for the food processing industry are cereals. Moreover due to the increasing attention of biofuels pressure on crop extractions grew. Therefore domestic crop extractions exhibited a significant growth throughout the here considered time interval, representing with an augmentation of 0.58 million tonnes more than half of the overall crop extraction growth from 1995 to 2010. Especially maize extractions experienced a harsh increase and thus forming the main driving force of cereal extractions and also the main accelerator of further crop extractions, as the commodity is a major input for the food processing industry but serves as well for energy generating purposes – the rising significance of the commodity is presented in figures 5 and 6. In 1995 maize extractions took the biggest share amongst cereals, closely followed by wheat and barley. Fifteen years later maize extractions augmented in its share by another 10% so that the commodity counted for almost half of the overall cereal extractions (43.1%) – meaning that nearly every other cereal extracted in Austria was maize in 2010. Bearing in mind that cereal extractions were as well growing throughout the here considered time span indicates that maize extractions were augmenting above the aggregate average and with an overall share in cereal aggregates of 43.1%, the commodity represents as mentioned before the main driving force of cereal extractions and their further expansion. The domestic extractions of wheat on the other hand remained in relative terms almost constant throughout the here considered time interval (29.3% in 1995 and 30.1% in 2010) and thus developing at the average pace of cereal extractions. Hence wheat accounted also for a significant share of cereals but did not accelerate the growth of cereal extractions to the same degree as maize did from 1995 to 2010.

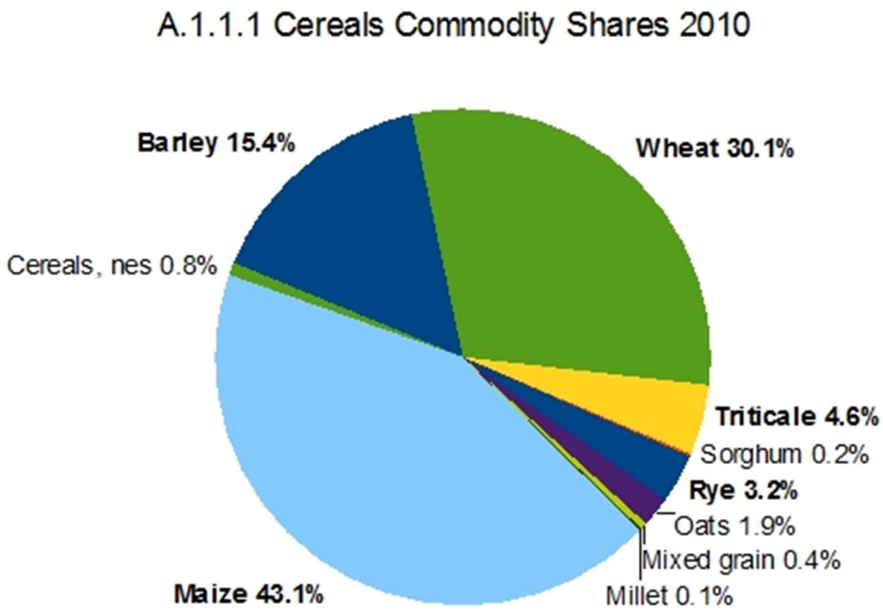
Developed and accessible arable land can be interpreted as a scarce resource in Austria in the short run, wherefore an increase in maize production needs to be compensated by a decrease in the cultivation of any other cereal so that (new) sources of arable land for the production of maize are getting available. (The conversion of arable land from one cereal crop to another is self-evident due to similar vegetation requirements) Figure 6 presents the described conversion process. For the growth of maize production in Austria especially the cultivation of barley was reduced (by 8.5%) in order to “make space”. The reduction does, however, not totally compensate for the augmentation of maize production and as wheat extractions remained more or less constant from 1995 to 2010 (in relative terms), the remaining harvested cereals (i.e. rye, oats and mixed grains) needed to be cultivated less intensively. Primarily rye but also oats were harvested at significant lower levels in 2010 than in 1995. The reduction of rye was, however, compensated by a harsh increase in triticale. Triticale is an anthropogenic generated cereal type developed throughout the last century (Schuchert W., 2011). It is a crossing between wheat and rye, combining the productivity and quality of wheat and the resistance and modesty of rye – hence yielding similar harvesting rates as wheat under good circumstances and higher crops than wheat under bad circumstances (Schuchert W., 2011). Triticale serve as a resource for bakery products, feedstuff or beer and is therefore a substitute for wheat, rye and barley (Schuchert W., 2011). Moreover the starch content of triticale allows also its application for the generation of biofuels (Umweltbundesamt Austria, 2013a).

Figure 6: Cereals commodity shares for Austria, 1995



Source: by author based on FAOSTAT; Eurostat, 2012

Figure 5: Cereals commodity shares for Austria, 2010



Source: by author based on FAOSTAT; Eurostat, 2012

The aggregate A.1.1.9 Sugar Crops consists of sugar cane, sugar beet and other sugar crops (including sugar maple, sweet sorghum and sugar palm) (Eurostat, 2001; Eurostat EW-MFA Questionnaire, 2012; FAOSTAT). In Austria only sugar beet was, however, cultivated throughout the analysed time interval and it is to be assumed that this does not represent an exception (due to vegetation circumstances). Sugar beet (and thus sugar crop) extractions in Austria varied between 2.49 million tonnes (2006) and 3.31 million tonnes (1998) during the analysed time interval. The cultivation of sugar beet is rather demanding requiring good soil quality with a big share of humus, distinct fertilizers, good irrigation and a well temperate summer (Lebensministerium Austria, 2011; Liebhard P., 1997). If these requirements are not met, the harvest quantities as well as their quality (sugar content) are affected negatively (Liebhard P., 1997). Sugar beet serves primarily for the production of sugar which is applied in various ways within the food processing industry but also in other branches like the chemical industry which demands glucose originating from sugar beet (Lebensministerium Austria, 2011; Umweltbundesamt Austria, 2013a; Liebhard P., 1997). While harvesting and processing sugar beet many residues accrue such as sugar beet leaves, cooked sugar beet chips and molasses which is a nutritious and to a certain extend sugar containing syrup accruing while processing sugar beet for sugar production. Sugar beet leaves and the residual sugar beet chips from cooking serve as animal fodder, while the molasses is further applied for the production of industrial alcohol and other biotechnological products (Lebensministerium Austria, 2011, Liebhard P. 1997). The starch and sugar content of sugar beet residues makes their application for energy and heat generation (biofuels) possible (Umweltbundesamt Austria, 2013a).

3.1.2. A.1.1 Crops – Foreign trade

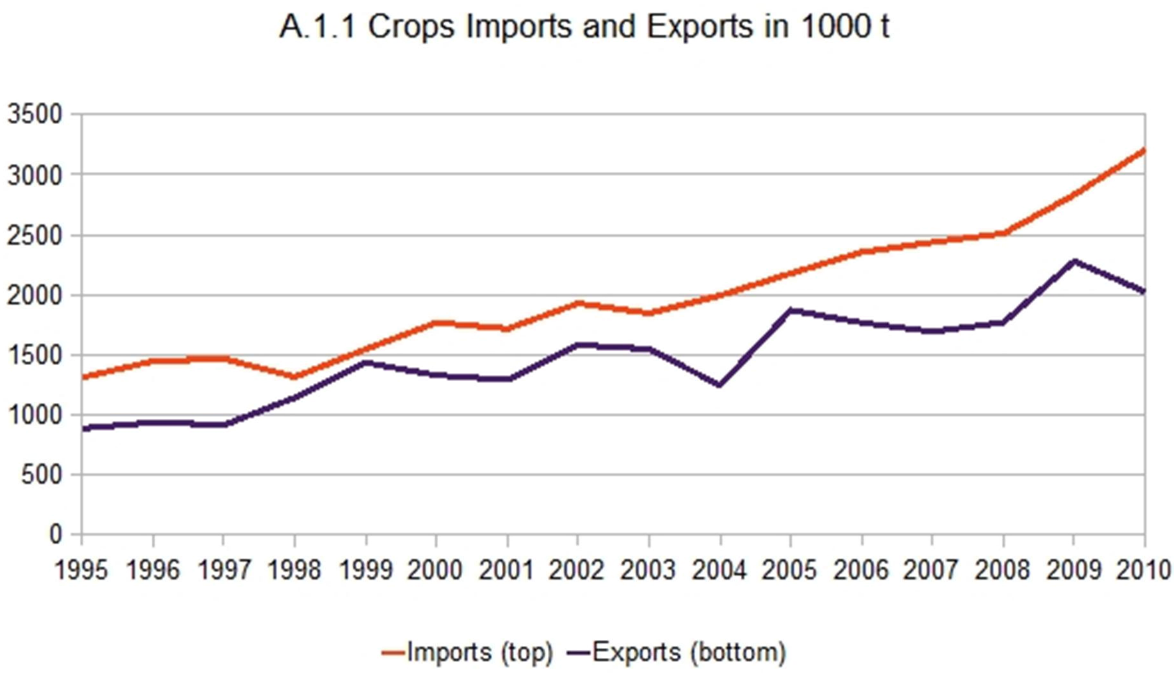
Data on the foreign trade of crops from and to Austria was gathered from the FAOSTAT database. The FAOSTAT provides, as for domestic extractions, trade quantities for each commodity which allows an analysis of the main import and export flows from and to Austria. Summing the individual crop trade flows according to the Eurostat EW-MFA Compilation Guide (2012) and the Eurostat EW-MFA Questionnaire (2012) up, yields total import and export rates of crops from and to Austria for the in this thesis considered time span. Figure 7 illustrates the results in thousands of tonnes. Imports are represented by the orange (top) line and exported crop quantities by the purple (bottom) line. It can be easily seen in figure 7 that the magnitude of crop foreign trade is significantly lower than the scale of domestic crop extractions. Whereas traded crop quantities were between one million and 3.5 million tonnes, domestic crop extractions varied approximately between 9 and 12 million tonnes from 1995 to 2010.

Adding each imported crop up and setting the result into relation with the respective summed up export quantities shows that Austria was a net-importer of crops for the here considered time interval. Figure 7 illustrates the relation as the graph representing crop import quantities is higher than the purple (bottom) export line, meaning that import quantities exceeded export quantities in each year (from 1995 to 2010). In 1998 and 1999 the foreign trade of crops from and to Austria was, however, almost balanced. Import quantities were dropping to their 1995 level in 1998, before augmenting significantly again from 1999 on. At the same time exports were peaking, until they dropped again in 2000 and 2001. In 1998 and 1999 domestic crop extractions were rather high (around 11 million tonnes) which probably made a balanced physical trade of crops possible in those years – a hypothesis that is, however, discussed in the following section analysing the DMI and DMC of Austria in detail.

Besides the drop in 1998 and some minor decreases in 2001 and 2003, crop imports were growing each year, leading to an overall augmentation from 1995 to 2010 of 1.9 million tonnes. Bearing in mind that imported crop quantities accounted for 1.3 million tonnes in 1995, shows that crop import quantities more than doubled within the here considered time span. Especially from 2008 on the gradient of the import rate graph in figure 7 augmented significantly, indicating a rapid growth trend of crop import quantities in the upcoming years whereas export quantities were decreasing from 2009 on. The harsh augmentation of imported crop quantities can, however, be set in relation to the European Union's 2020 targets on renewable energy. Energy generated from biomass represents Austria's main prospective source of renewable energy, wherefore a higher demand and pressure on biogenic materials like crops is the consequence. As long as no action regarding the improvement of cascade use and recycling of crops is undertaken, the increased demand on crops (due to their application for energetic purposes) needs to be satisfied by domestic extractions and imports. As the energetic use of crops should not be in conflict with the material use of crops, higher domestic crop extraction and import quantities will be the logical consequence. Hence the EU's 2020 targets, not implemented with a proper long run perspective, countervail the development towards a sustainable economy, as they can trigger additional biogenic material extractions off.

Besides the European Union's 2020 targets on renewable energy, resolutions concerning food safety (especially on beef) due to the chronic wasting disease incidents in 2000 affected the market on meat, livestock and consequently fodder crops (EU Regulation (EC) No. 1760/2000, 2000). Demand on locally produced beef was increasing (due to the aversion to foreign beef) by the customers, as well as by the venders, as they wanted to re-build their customer's confidence. An increase in domestically raised cattle goes along with an increase in domestically consumed fodder crops, which can also be set in relation to the rapid growth of crop imports from 2003 on – as commercial feed stuff is included within sub-group A.1.1 Crops. Additionally to the chronic wasting disease incidents in 2000, bird flu and swine flu raised further concerns regarding food safety, which were responded by identification and labeling regulations for pork, mutton, goat meat and poultry in 2011 (EU Regulation (EC) No. 1169/2011, 2011).

Figure 7: Imports and Exports of Crops for Austria from 1995 to 2010, in 1000 t



Source: by author based on FAOSTAT; Eurostat, 2012

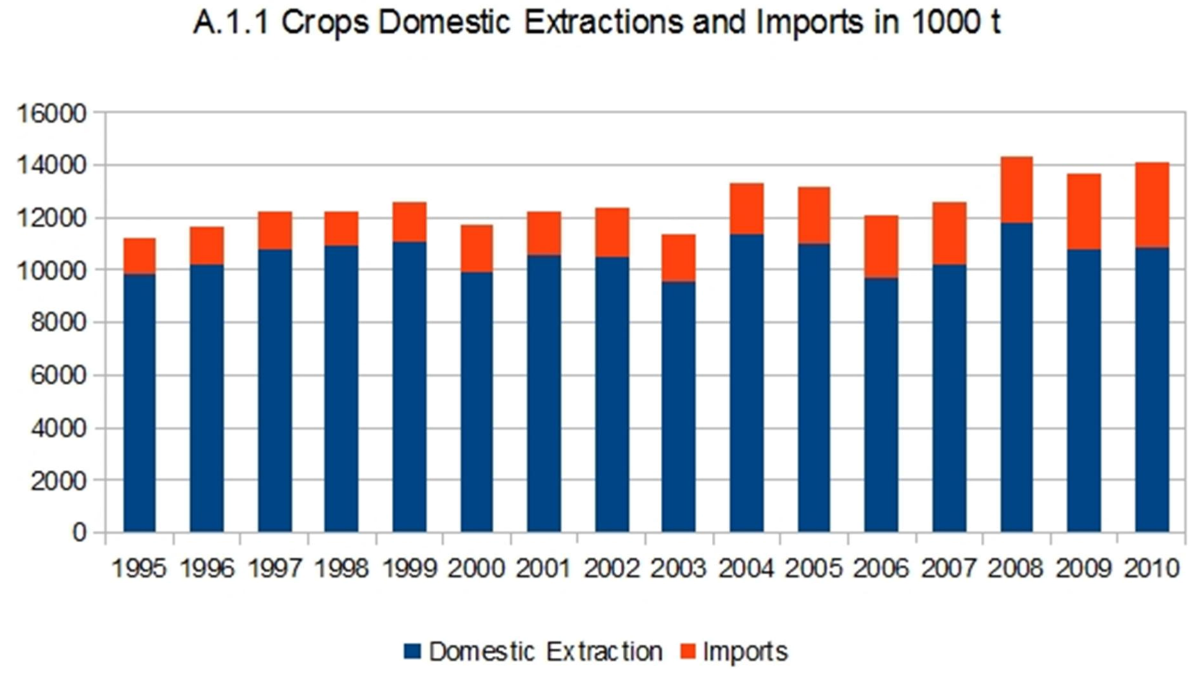
Exports on the other hand were not as constantly increasing as imported crop quantities, as can be seen in figure 7. In 2004 export shares dropped significantly as in 2003 domestic crop extractions reached its lowest value within the here considered time span. From 2005 to 2009 crop exports were augmenting again, but only moderately in comparison to crop imports wherefore the physical trade balance drifted more than ever (between 1995 and 2010) apart. The harsh drop of crop exports at the end of the here considered time interval paired with the significant increase of crop imports indicates a further rise of the physical trade imbalance in the upcoming years.

Imports

Between 1995 and 2010 crop imports were, except view minor drops in 1998, 2001 and 2003, rapidly increasing. Comparing the imported crop quantities, however, with domestic crop extraction volumes – as undertaken in figure 8 – shows that imports are of a significantly smaller magnitude than domestically harvested crop amounts. No concrete relation between the two values can be found, as crop imports seem to grow unaffectedly by the respective domestic extraction quantities. Hence crop imports do not serve compensating low domestic crop harvest rates, as suggested at the beginning of this chapter. In 2006, for instance, domestic crop extractions were rather low with a total weight of 9.7 million tonnes. In the same year imports accounted for about 2.4 million tonnes. In 2008 domestic crop extractions peaked with an overall amount of 11.8 million tonnes. Imports were, however, still rising and accounted for 2.5 million tonnes in 2008.

Nevertheless crop imports experienced a harsh increase from 2008 on. This steep augmentation, which continued steadily until 2010, suggests a further growth and raising importance of crop imports for the Austrian economy in the near future. Paired with moderately developing or even decreasing, as the 2010 situation suggests, export rates, the Austrian economy will become considerably dependent on imported crops for stimulating its domestic crop consumption. Keeping the EU 2020 targets in mind, shows that the progressive displacement of crop extractions makes the Austrian economy piece by piece more dependent on purchases of commodities that are expected to play a central role in the near future.

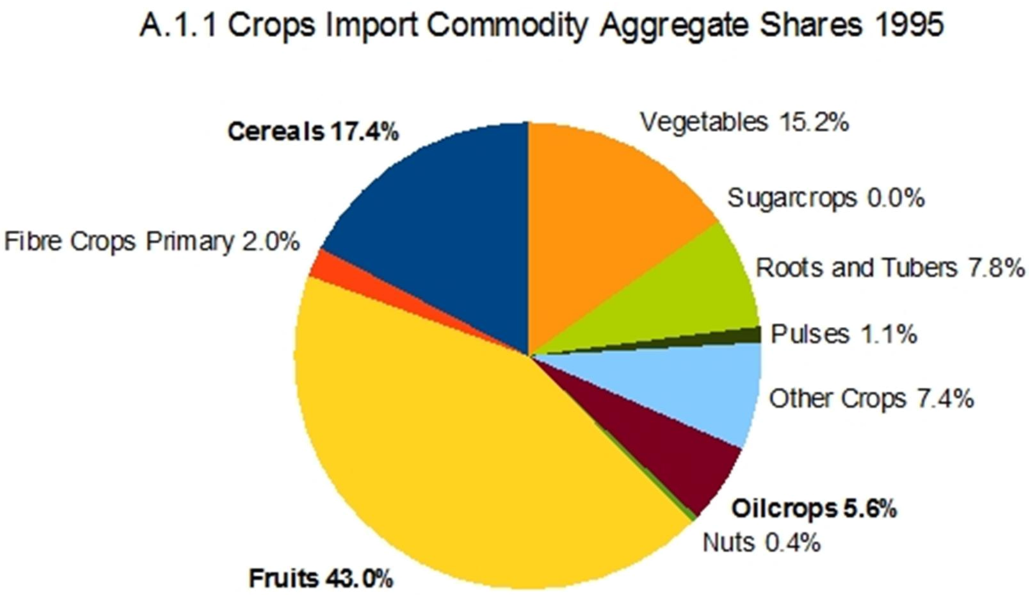
Figure 8: Domestic extractions and imports of crops for Austria, in 1000 t



Source: by author based on FAOSTAT; Eurostat, 2012

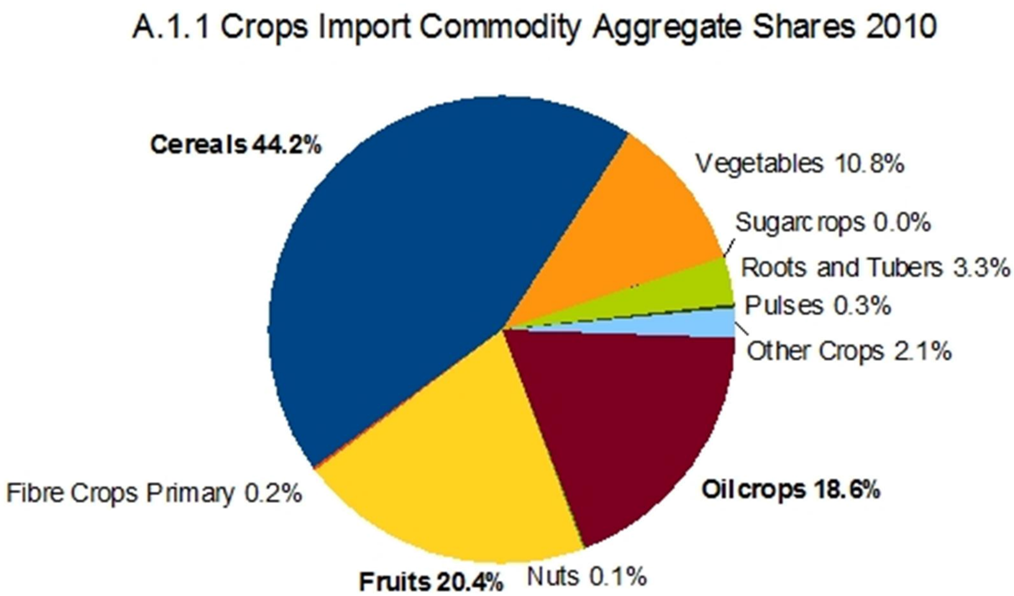
In order to identify the mainspring(s) of the rapidly increasing crop import quantities, commodity aggregate shares of imported crops for the time interval boundaries (1995 and 2010) are analysed firstly. After identifying the most significant aggregates, a closer look is taken into these aggregates, analysing the commodities composing them. Figures 9 and 10 are illustrating the 1995 and 2010 import commodity aggregate compositions.

Figure 10: Commodity aggregate shares of crop imports to Austria in 1995



Source: by author based on FAOSTAT; Eurostat, 2012

Figure 9: Commodity aggregate shares of crop imports to Austria in 2010



Source: by author based on FAOSTAT; Eurostat, 2012

In 1995 imports of fruits represented the main driving force of crop imports to Austria, which is comprehensible for the Austrian economy. In 2010 the situation changed, however. Import quantities more than doubled from 1995 to 2010. The magnitude of fruit imports did, however, not change much, in absolute terms, within the here considered time span. In 1995 about 0.6 million tonnes of fruits were imported to Austria and in 2010 0.7 million tonnes. This growth was, however, significantly lower than the average development of crop imports from 1995 to 2010, wherefore fruit imports cannot be identified as the main driving force of the harsh crop imports augmentation – even though these imports have without a doubt considerable importance for the Austrian economy.

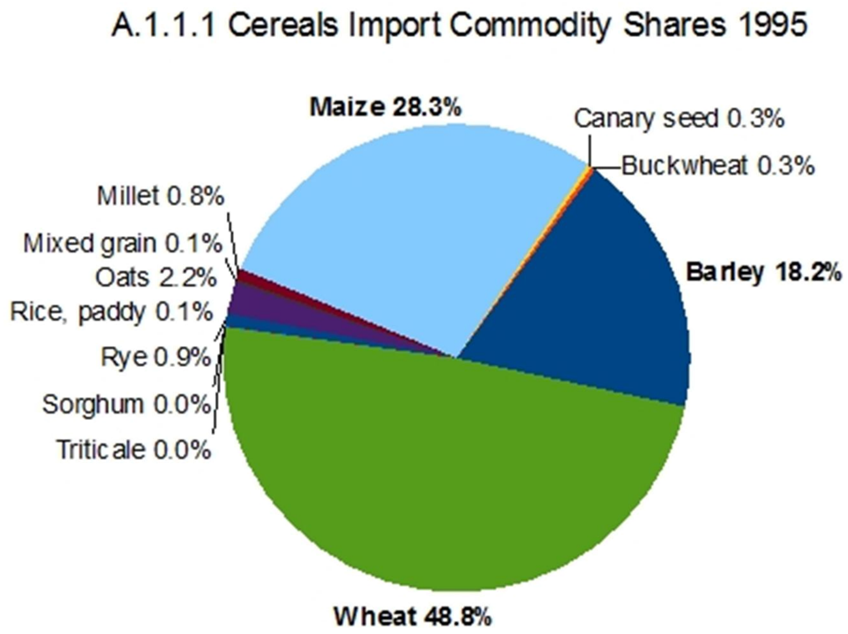
In 2010 the import situation changed – as can be seen in figure 10. Cereal imports which not even accounted for a fifth of the overall imported volume in 1995 experienced a harsh increase and thus made up a considerable share of the 2010 crop imports. In 1995 about 0.2 million tonnes of cereals were imported to Austria whereas in 2010 1.4 million tonnes were purchased from other economies (which is double of the fruit imports in 2010). Cereal imports septuplet from 1995 to 2010 representing a growth rate clearly above the average crop imports development path and hence identifies the commodity aggregate cereals as a main driving force for the harsh expansion of imported crop quantities to Austria.

Besides cereals, oil crop imports experienced as well a significance gain, according to the import shares, from 1995 to 2010. In 1995 oil crop imports only accounted for approximately 6% of total crop imports. In 2010 and at a more than doubled import volume, oil crops made almost a fifth of overall crop imports up. In numbers oil crop imports to Austria almost ten folded from 0.07 million tonnes in 1995 to 0.6 million tonnes in 2010 which makes also the commodity aggregate oil crops a main driving force of the harsh expansion of crop imports.

As a next step, these two commodity aggregates (cereals and oil crops) are broken down into the individual commodities composing them for the years 1995 and 2010. Figures 11 and 12 present the commodity shares for cereals and figures 13 and 14 the respective shares of oil crops, so that the central commodities driving and pressing crop imports to Austria can be identified. This analysis, to underline it once more, is only feasible due to the information provided by the FAOSTAT data.

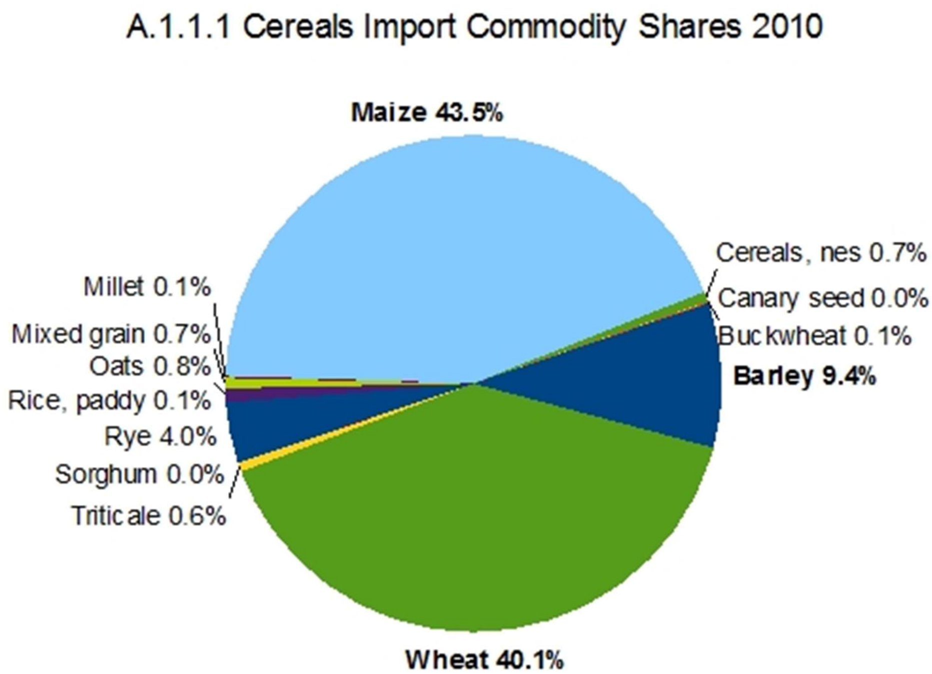
In 1995 cereal imports mainly consisted of wheat (49%), maize (28%) and barely (18%) – as presented in figure 11. In 2010 the situation changed significantly. Import shares of wheat dropped, but keeping in mind that the overall import quantities of cereals septuplet from 1995 to 2010, wheat imports were with a total weight of about 0.6 million tonnes (in 2010) alone three times higher than overall cereal imports in 1995 (or accounting for the import quantity of the commodity aggregate fruits in 1995). Maize imports made, however, the biggest share of cereal imports up in 2010 – 43.5% or about 620 000 tonnes. Import shares of barely, on the other hand, bisected from 1995 to 2010, even though in absolute terms barely imports augmented more than threefold – which was, however, still lower than the average cereal import growth.

Figure 12: Commodity shares of cereal imports to Austria in 1995



Source: by author based on FAOSTAT; Eurostat, 2012

Figure 11: Commodity shares of cereal imports for Austria in 2010



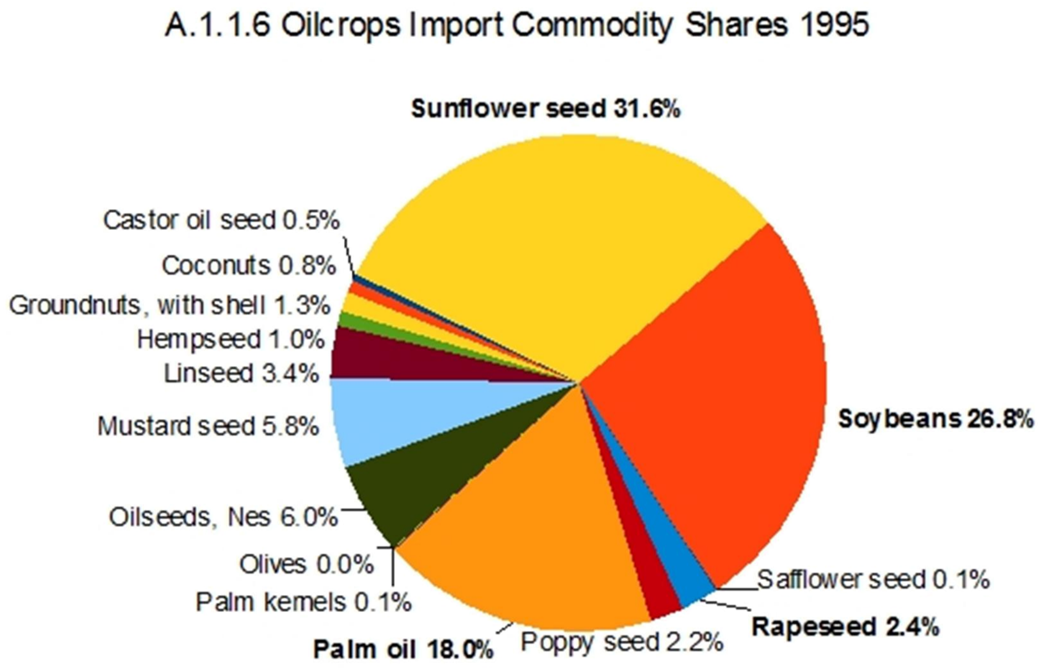
Source: by author based on FAOSTAT; Eurostat, 2012

Focusing on the two driving powers of cereal imports to Austria and bearing the EU 2020 targets on renewable energy as well as the before discussed food safety issues in mind, shows that the two commodities maize and wheat fit perfectly in the requirements of both issues. Maize is a well-known fodder crop and as customers' awareness of the purchased meat's origin was rising due to chronic wasting disease incidents, swine flu or bird flu, demand on locally produced meat increased and hence triggered a higher demand on fodder crops off. A demand which was at least partly satisfied by augmented maize imports. On the other hand maize can, due to its starch content, be applied as an energy crop generating bioethanol (Lichtblau G., Pölz W., Stix S., Winter R., 2012; Umweltbundesamt Austria, 2013b). Apart from serving the production of bioethanol, maize can also be applied for generating biogas (Lichtblau G., Pölz W., Stix S., Winter R., 2012; Umweltbundesamt Austria, 2013b). As biogas is gained through fermenting maize (or other applicable resources) the whole plant can be used (Lichtblau G., Pölz W., Stix S., Winter R., 2012; Umweltbundesamt Austria, 2013b). Nevertheless biogas as well as bioethanol can also be generated from liquid manure or other organic waste (biogas) and from straw or wood residues (bioethanol) (Lichtblau G., Pölz W., Stix S., Winter R., 2012; Umweltbundesamt Austria, 2013b). Hence biological energy carriers can also be generated from commodities which are interpreted as waste nowadays. Improvements of the recycling stream – expanding the shares of re-entered commodities – could therefore help stabilizing or even reducing domestic extractions and imports of cereals without adversely affecting the Domestic Material Consumption and therefore contribute in establishing a sustainable economy.

The same also applies for wheat which is firstly a central input of our nutrition system and also applicable for the production of bioethanol (Lichtblau G., Pölz W., Stix S., Winter R., 2012; Umweltbundesamt Austria, 2013b). If burning, however, an integral component of our nutrition for the generation of energy is advisable, should be out of question. Observing recent global wheat prices suggests, at least economically, that this is not an advisable strategy.

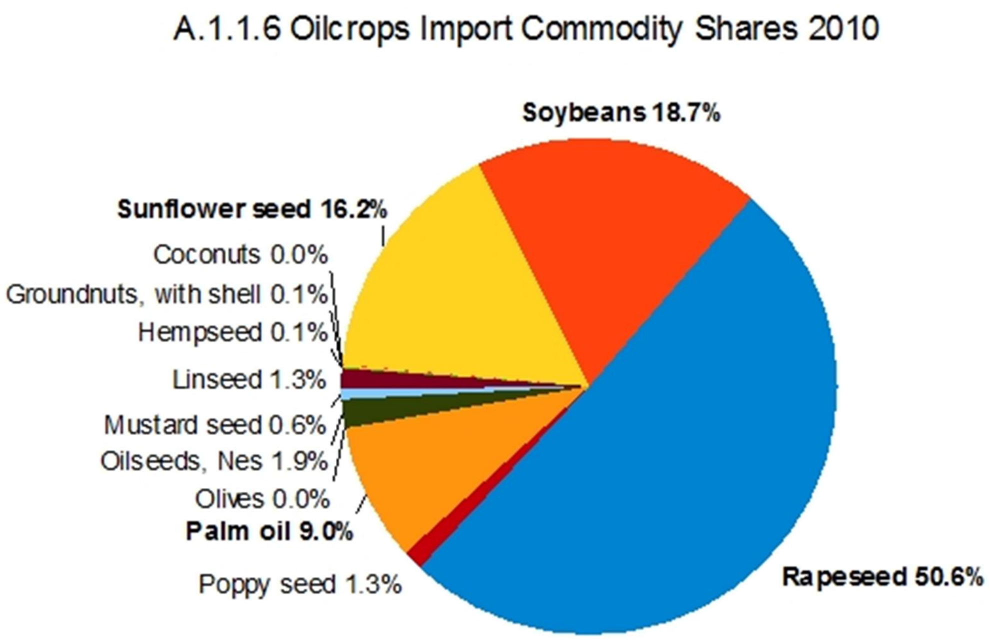
Besides cereals, oil crop imports were also augmenting significantly between 1995 and 2010, so that every fifth imported crop was some kind of oil crop in 2010. In absolute terms oil crop imports almost decupled from 0.07 million tonnes in 1995 to 0.6 million tonnes in 2010 and thus representing an even steeper increase than cereal imports did. Figures 13 and 14 break the commodity aggregate oil crops up into the individual crops composing the aggregate. Identifying the main driving forces for the considerable acceleration of oil crop imports from 1995 to 2010 seems rather obvious. Rapeseed imports accounted for 1 776 tonnes in 1995 and increased by 1700% (or 170-fold) to 0.3 million tonnes in 2010. Apart from rapeseed imports every other oil crop experienced a decrease in its commodity shares from 1995 to 2010. This observation is, however, misleading, as oil crop imports almost decupled within the here considered time span. Thus import quantities of, for instance, sunflower seeds, soybeans or palm oil were still considerably rising from 1995 to 2010, but at a slower pace than the oil crop aggregate exhibited (due to the harsh increase in rapeseed imports). Sunflower seed as well as palm oil imports more than quadrupled (sunflower seeds: 0.023 million tonnes in 1995, 0.096 million tonnes in 2010; palm oil: 0.013 million tonnes in 1995, 0.054 million tonnes in 2010) and soybean imports were almost increasing six fold (0.02 million tonnes in 1995 and 0.1 million tonnes in 2010) within the here considered time interval.

Figure 14: Commodity shares of oil crop imports to Austria in 1995



Source: by author based on FAOSTAT; Eurostat, 2012

Figure 13: Commodity shares of oil crop imports to Austria in 2010



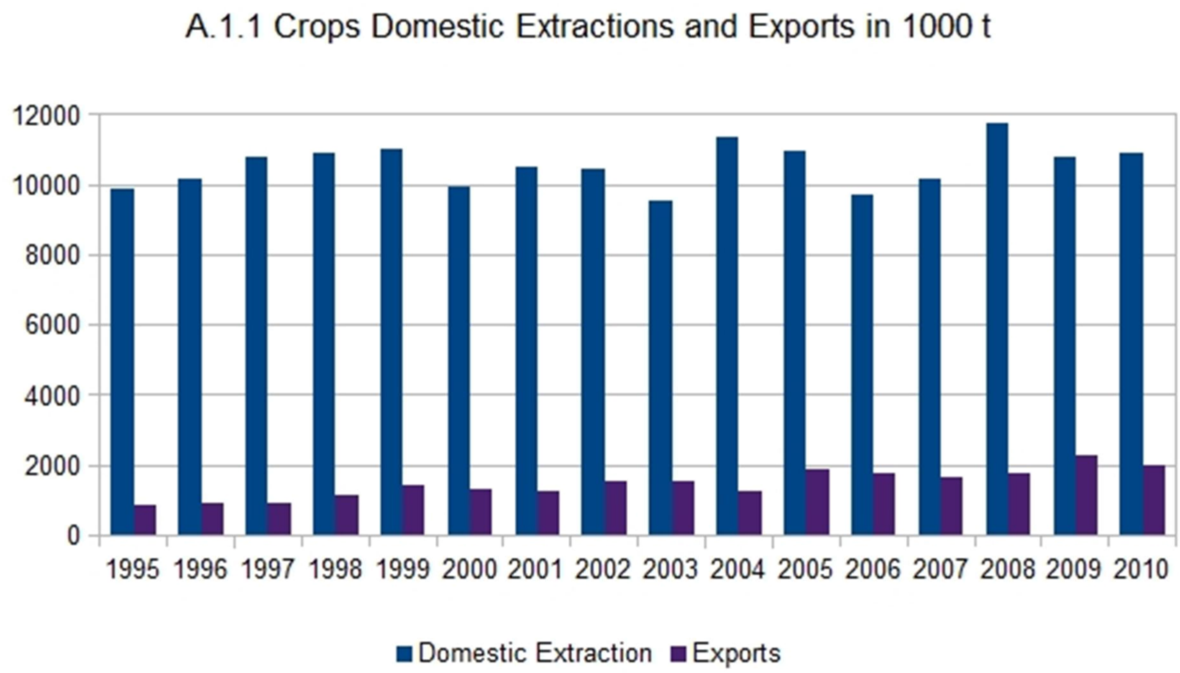
Source: by author based on FAOSTAT; Eurostat, 2012

Bearing the European Union's 2020 targets on renewable energy in mind, as well as the Austrian contribution to reach this ambitious goal, delivers quickly a reasonable explanation for the harsh growth of oil crop imports. The Austrian government committed itself to increase the energy supply share of renewable energy sources to 34% in 2020 (Mantau U., Steirer F., 2007). In 2010 the overall share of renewable energy sources in the Austrian energy generating system accounted for 30.8% of which 39.5% (39 237 GWh) originated from hydro-power plants and 39.4% (39 117 GWh) from biomass (Biermayr P., 2011). Due to the characteristics of the Austrian landscape (not suitable for centrally organized large-scale wind or solar power generation) and the considerably unbalanced cost-benefit ratio of the erection of additional hydro-power plants, biomass represents the main renewable energy carrier for Austria in the near future and thus the most promising source for achieving its 2020 shares. As cereals are already applied for producing bioethanol or biogas, oil bearing crops can and are also used for the generation of liquid fuels. Due to their oil content, oil crops can be applied in the production of biodiesel (Lichtblau G., Pölz W., Stix S., Winter R., 2012; Umweltbundesamt Austria, 2013b). Nevertheless biodiesel can also be gained from edible oil residues, wherefore the same as stated above in the discussion of cereal imports and bioethanol and biogas from fresh cut crops applies here as well (Lichtblau G., Pölz W., Stix S., Winter R., 2012; Umweltbundesamt Austria, 2013b). Thus increasing oil bearing crop extractions and imports in order to reach the EU's 2020 targets without implementing improved recycling systems for residual oil and oil crop residues, will in the long-run only expand our total material extraction (either locally or abroad through imports) and therefore countervail the intentional idea of improving sustainability by augmenting the renewable energy shares in our energy system.

Exports

Crop exports from Austria are to a certain extend connected to domestic crop extractions. As can be seen in figure 15, the magnitude of domestic crop harvests in one year affects export quantities of the subsequent year. In 2003, for instance, domestic crop extractions reached their minimum for the here considered time span whereas crop exports remained on a rather constant level of 1.5 million tonnes in 2003. In the following year crop exports from Austria dropped, however, significantly by 0.3 million tonnes even though domestic extractions augmented considerably by about 1.8 million tonnes. In 2008, on the other hand, domestic crop extractions were peaking (for the here considered time interval) whereas crop exports (once again) remained at a rather constant level – 1.69 million tonnes in 2007 and 1.77 in 2008. In the subsequent year (of 2009) crop exports increased, however, significantly reaching their maximum (between 1995 and 2010) of 2.28 million tonnes, whereas domestic extractions were already diminishing by almost a million tonne. Hence a by a year lagged correlation of domestic crop extractions and their exports can be identified for the Austrian economy between 1995 and 2010.

Figure 15: Domestic crop extractions and crop exports from Austria, in 1000 t



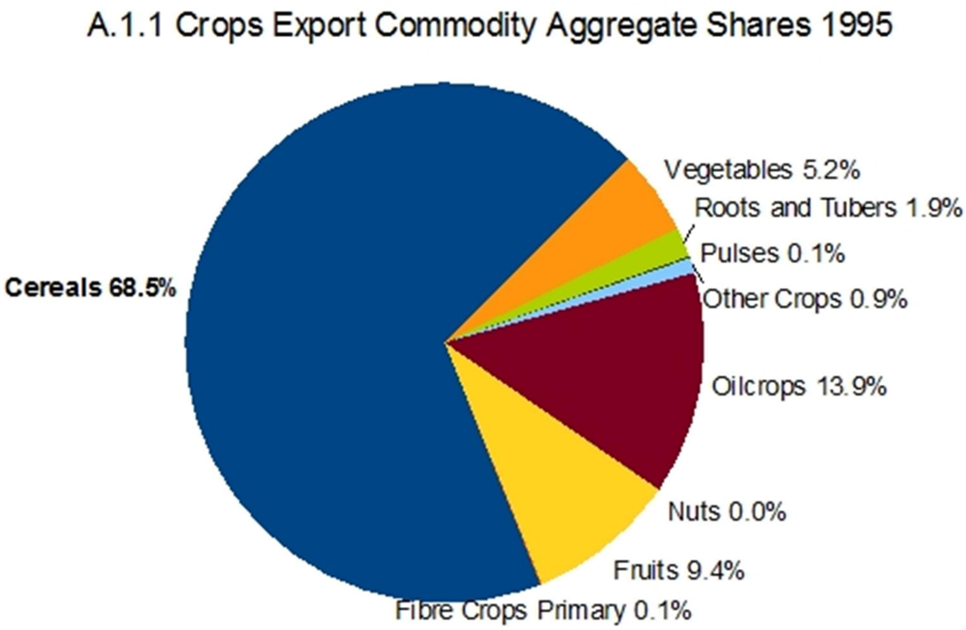
Source: by author based on FAOSTAT; Eurostat, 2012

Crop exports more than doubled from 0.89 million tonnes in 1995 to 2.02 million tonnes in 2010. Export rates varied, however, within the here analysed time interval between 2.28 million tonnes (in 2009) and 0.89 million tonnes (in 1995). Hence crop exports exhibited a less constant growth than crop imports did at the same time. Taking therefore a closer look at the main driving forces of crop exports, offers conclusions regarding this rather unstable development. Figures 16 and 17 illustrate the commodity aggregate shares of crop exports from Austria for the time interval boundaries 1995 and 2010. Cereals form, as can be seen in the subsequent figures, the main force of crop exports exhibiting shares of 69% in 1995 and 58% (of a more than doubled export volume) in 2010. Hence export rates of certain cereals influence overall crop exports significantly.

From 1995 to 2010 the commodity aggregate sugar crops appeared in the Austrian crop export statistics. From 1995 to 1998 no single sugar crop was exported according to the FAOSTAT database. From 1999 on the respective export rates were developing on a rather low level, exhibiting several drops until the year 2009 when sugar crop exports peaked significantly and hence contributed to the crop export rate maximum of 2009, before dropping again in 2010.

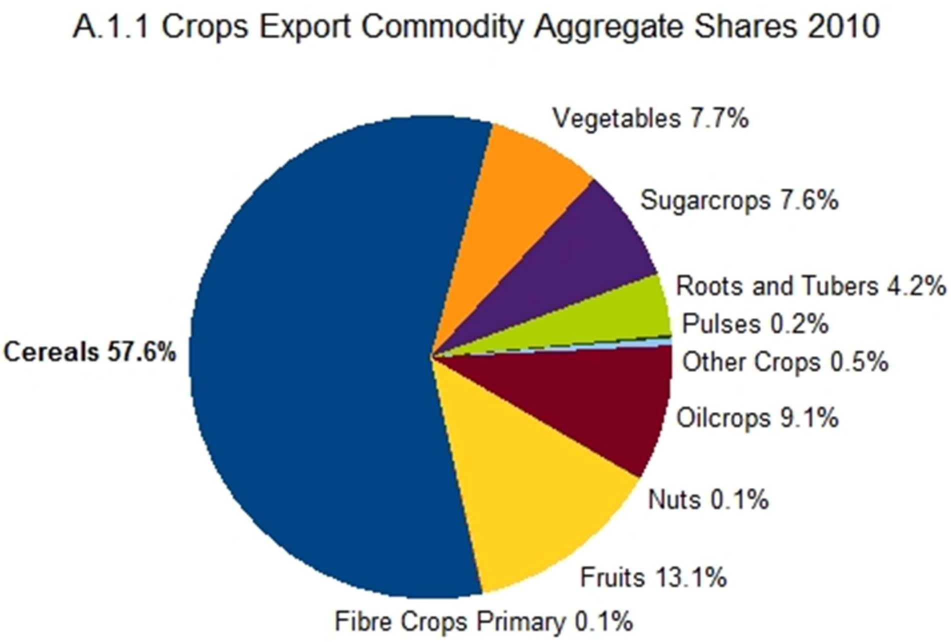
Oil crop exports on the other hand experienced a decrease in their commodity aggregate shares by about a third. Crop exports were, however, more than doubling from 1995 to 2010 wherefore oil crop exports still augmented in absolute terms within the here considered time interval.

Figure 16: Crop export commodity shares from Austria, 1995



Source: by author based on FAOSTAT; Eurostat, 2012

Figure 17: Crop export commodity shares from Austria, 2010

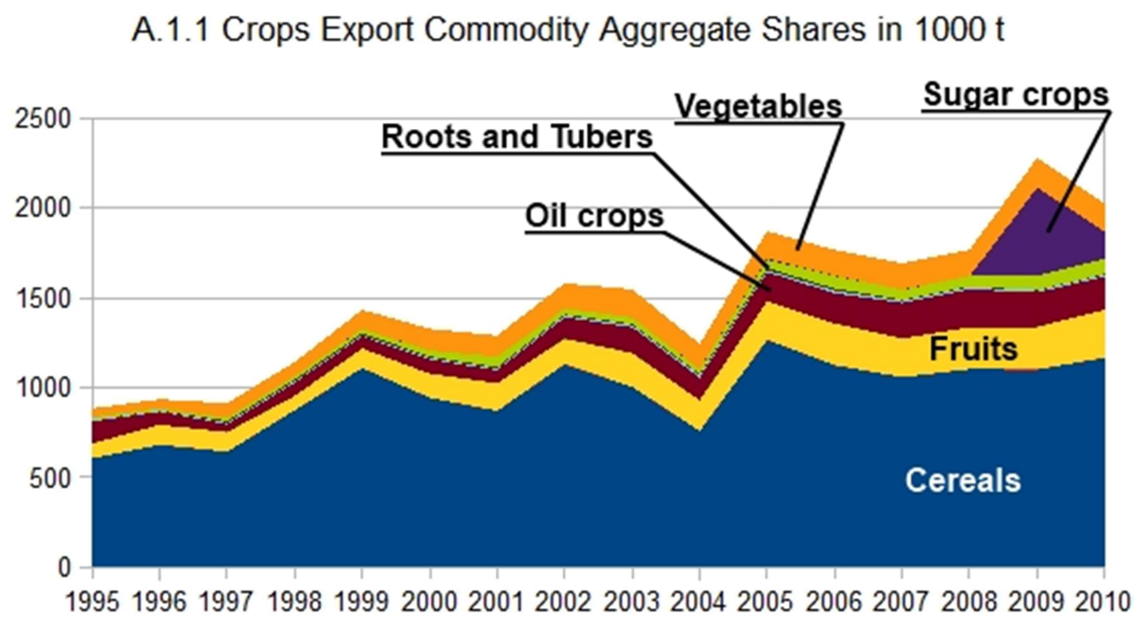


Source: by author based on FAOSTAT; Eurostat, 2012

Nevertheless crop exports were, as stated before, varying considerably throughout the here considered time interval wherefore a single examination of the time span boundaries is not sufficient in order to analyse the prominent drops and boosts of crop exports from the Austrian economy. Figure 18 presents therefore the respective commodity aggregate shares in absolute terms (thousands of tonnes) from 1995 to 2010.

From 1999 to 2001 cereal exports were dropping steeper than oil crop, fruit, vegetable or roots and tubers exports, thus absorbing the harsh cereal export decreases and catching overall export rates. The significant drop of crop exports in 2004 was, as can be seen in figure 18, induced by a rather homogenous reduction of all commodity aggregate export rates. From 2004 to 2005 cereal exports were, however, increasing less steep than oil crop, fruit, vegetables and roots and tubers exports and thus reducing the commodity aggregate share of cereals. The crop export peak of 2009 was, as illustrated in figure 18, not triggered off by expanded cereal exports, neither augmented export quantities of oil crops, fruits, vegetables or roots and tubers, but induced by a until 2008 not even considered commodity aggregate – sugar crops. Thus the additionally exported sugar crops augmented the crop export rate significantly. Before 2009 only about 728 tonnes of sugar crops were on average exported annually. In 2009, however, almost half a million tonne of sugar crops was exported from the Austrian economy, before dropping again by about 0.3 million tonnes in 2010.

Figure 18: Crop export commodity aggregate amounts for Austria from 1995 to 2010, in 1000 t

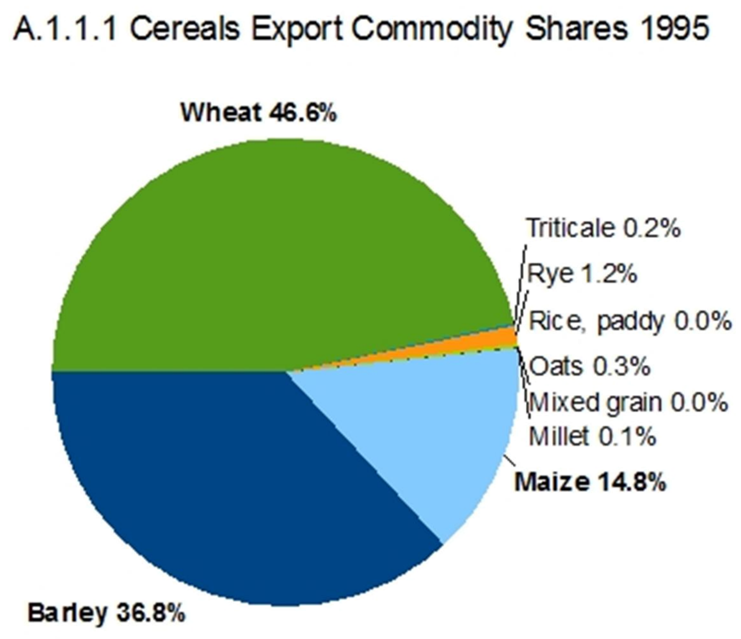


Source: by author based on FAOSTAT; Eurostat, 2012

Sugar crop exports consist only of exported sugar beet, as no other sugar crop is extracted in Austria (and neither imported). Hence sugar beet exports lead, inter alia, to a peak of total crop exports from Austria in 2009. Throughout the here considered time interval, cereals were, however, representing the main driving force of crop exports and thus significantly influencing crop exports from the Austrian economy between 1995 and 2010. Therefore a closer look at the commodities composing the aggregate cereals and their respective export shares are discussed in the following and presented by figures 19 and 20.

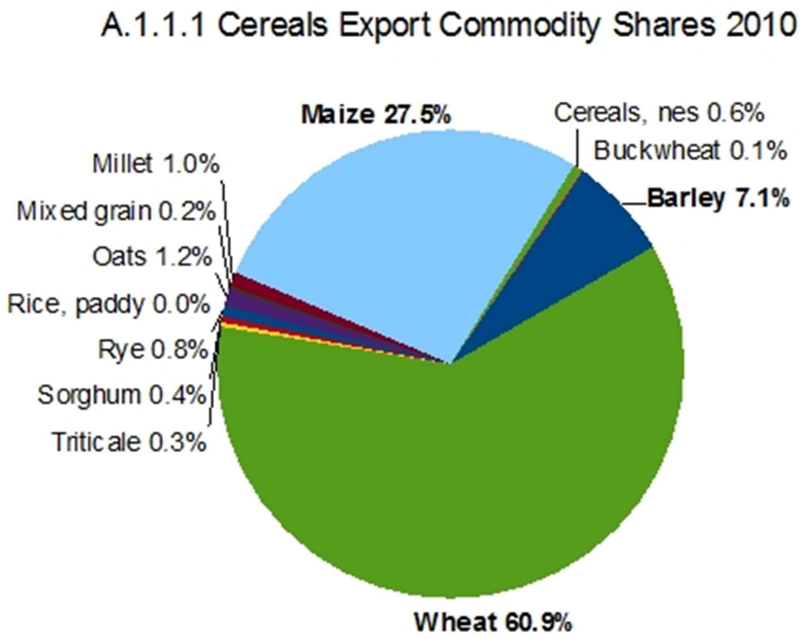
Wheat, maize and barely accounted for the biggest shares in cereal exports in 1995 as well as in 2010, even though the significance of barely diminished considerably throughout the here analysed time interval. But not only in relative terms did barely exports drop from 1995 to 2010. In 1995 about 0.22 million tonnes of barely were sold to foreign economies whereas in 2010 only 0.08 million tonnes got exported. On the other hand maize exports were increasing stronger than cereal exports on average, hence expanding their shares by about 13%. In absolute terms maize exports augmented by about 0.23 million tonnes from 0.09 million tonnes in 1995 to 0.32 tonnes in 2010. Wheat exports more than doubled from 1995 to 2010 and thus experiencing a further increase in their commodity shares (as average cereal exports only doubled from 1995 to 2010), so that in 2010 more than every other exported cereal was wheat. In absolute terms wheat exports grew by approximately 0.43 million tonnes from 0.28 million tonnes in 1995 to 0.71 million tonnes in 2010. Thus wheat and maize represent the main driving forces of cereal and thus crop exports from Austria for the here considered time span.

Figure 19: Cereal export commoditiy shares from Austria in 1995



Source: by author based on FAOSTAT; Eurostat, 2012

Figure 20: Cereal export commoditiy shares from Austria in 2010



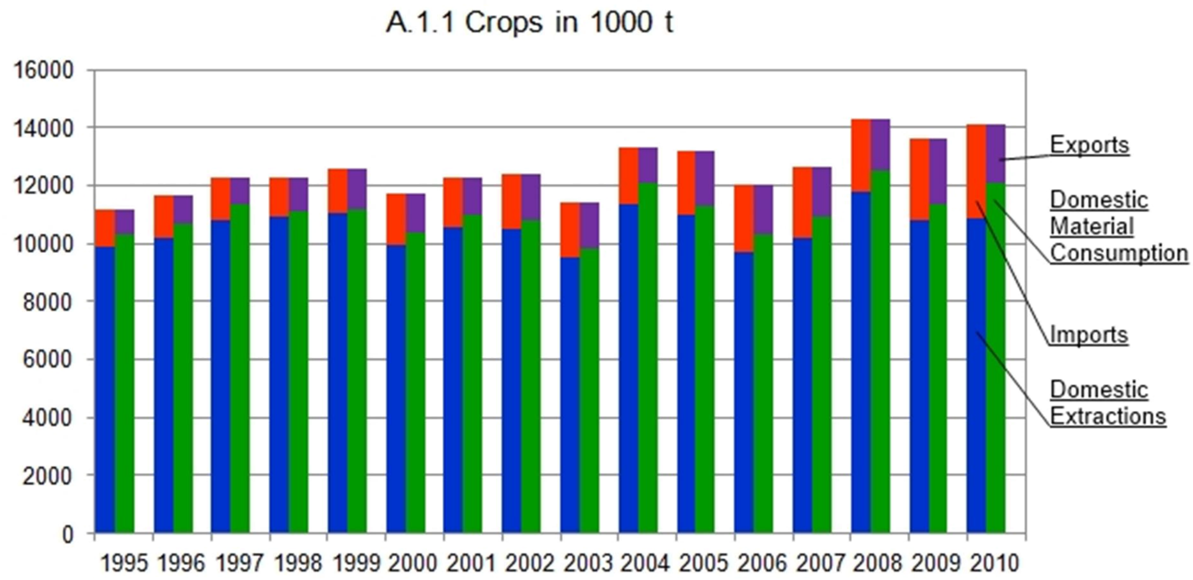
Source: by author based on FAOSTAT; Eurostat, 2012

3.1.3. A.1.1 Crops – Direct Material Input and Domestic Material Consumption

After evaluating the direct crop flows to and (partly) from the Austrian economy (domestic crop extractions, imports and exports) the EW-MFA indicators presenting the Direct Material Input (DMI) and Domestic Material Consumption (DMC) of crops are derived for the Austrian economy between 1995 and 2010. DMI equals the sum of domestic crop extractions and the respective imports and hence represents the overall crop input into the Austrian economy, but not necessarily the Austrian crop consumption as a certain fraction of the DMI gets exported (and thus not domestically consumed). Subtracting the exported crop quantities from the DMI yields therefore the DMC.

Figure 21 presents direct crop input and domestic crop consumption of the Austrian economy between 1995 and 2010. Furthermore the EW-MFA indicators composing factors – domestic extractions, imports and exports – are presented in figure 21. The stacked bars on the left hand side of each year in figure 21 represent the Austrian direct crop input and thus consist of domestic crop harvests and imports – as indicated in figure 21. The right hand bars of each time interval in figure 21 are composed by domestic crop consumption and exports (as illustrated in figure 21) and thus equal direct biomass input in each year, as DMC equals DMI minus exports. From 1995 to 2010 the Austrian crop consumption exceeded domestic extractions, a gap which is considerably increasing towards the end of the here analysed time span (2010). Overall the direct crop input of the Austrian economy augmented by about 2.9 million tonnes from 1995 to 2010. Due to the lower expansion of domestic crop harvests, crop import flows were accelerated wherefore in 2010 almost

Figure 21: Direct Material Input and Domestic Material Consumption (and composing factors) of crops for Austria from 1995 to 2010, in 1000 t



Source: by author based on FAOSTAT; Eurostat, 2012

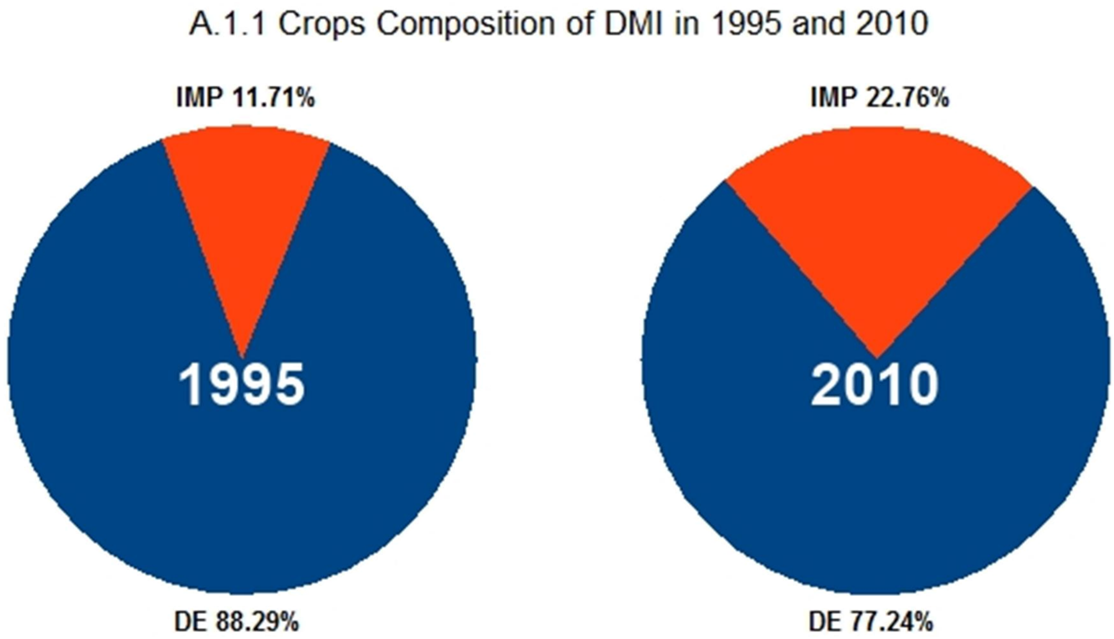
23% of the Austrian DMI of crops was composed by crop imports – in 1995 not even 12% of the DMI were imported. Simultaneously domestic crop consumption augmented significantly and at a higher pace than domestic crop harvests, hence expanding the difference between crop consumption and harvests in Austria. Crop exports, on the other hand, were growing as well, but at a smaller scale than imports and thus leading to a considerable physical crop trade imbalance of Austria in 2010. In the following the DMI and DMC of crops as well as their physical trade are discussed in detail.

As can be seen in figure 21, domestic crop extractions formed clearly the main composing factor of direct crop input, especially for the first half of the here considered time interval. Therefore DMI and domestic crop harvests peaked simultaneously – 1999, 2004 and 2008 – and also exhibited synchronal minima – 2000, 2003 and 2006. For the first third of the here analysed time span direct crop inputs were only slightly higher than domestic crop extractions and thus representing low import volumes from 1995 to 1999. In the year 2000 Austrian crop harvests dropped, however, by about 1.1 million tonnes from 11 million tonnes in 1999 to 9.9 million tonnes in 2000. In order to counterbalance this drop of crop supply, crop imports into the Austrian economy were increasing simultaneously by about 0.2 million tonnes. Additionally the relatively high crop export rates from the Austrian economy were also decreasing by about 0.1 million tonnes from 1999 to 2000, so that the drop in direct crop inputs was absorbed by about 0.3 million tonnes wherefore the DMI decreased not as much as domestic crop extractions by about 0.8 million tonnes from 1999 to 2000. From then on a constant growth of crop imports can be observed, which can also be easily seen by the steady expansion of the direct crop input in relation to domestic crop harvest quantities in figure 21.

From 2008 on crop imports to Austria experienced an additional acceleration. Crop harvests in

Austria were on the other hand considerably decreasing from about 11.8 million tonnes in 2008 to 10.8 million tonnes in 2009. This harsh drop of about a million tonnes (of domestically extracted crops) was, however, counterbalanced by crop imports wherefore the DMI was only decreasing by approximately 0.6 million tonnes from 2008 to 2009. In 2010 overall direct crop inputs into the Austrian economy were again augmenting by about half a million tonne, due to the rapidly increasing crop imports to Austria, as domestic crop extractions remained at a rather constant level from 2009 to 2010. Hence crop imports expanded their shares in the Austrian DMI and therefore their significance for the Austrian economy throughout the here analysed time span considerably – as can be seen in figure 22.

Figure 22: Composition of Austrian direct crop input, 1995 and 2010



Source: by author based on FAOSTAT; Eurostat, 2012

Figure 22 illustrates the composing factors of the Austrian direct crop input and their respective shares for the time span boundaries 1995 and 2010. The before mentioned increased importance of crop imports for the Austrian economy throughout the here considered time interval can easily be seen in figure 22. In 1995 about every eight crop was imported, hence domestic crop extractions were composing about 88% of the direct crop input of Austria. Fifteen years later the situation changed considerably. Almost every fourth crop was purchased from foreign economies in 2010. Thus domestic crop extractions only made 77% of the Austrian direct crop input up in 2010. Crop imports were therefore almost doubling their DMI shares. Bearing in mind that the DMI was increasing, as can be seen in figure 21, from 1995 to 2010, crop imports expanded significantly in absolute terms – by about 1.9 million tonnes.

Direct crop inputs into the Austrian economy augmented from approximately 11.2 million tonnes in 1995 to 14.1 million tonnes in 2010 – hence growing by about 2.9 million tonnes. On average the annual Austrian DMI of crops accounted for about 12.6 million tonnes between 1995 and 2010, with its overall maximum in 2008 (14.3 million tonnes) and minimum in 1995 (11.2 million tonnes). This represents a rather constant increase of the Austrian direct crop input with an average annual growth rate of about 1.5%.

Subtracting exported crop quantities from the direct crop input yields the domestic crop consumption (or Domestic Material Consumption of crops). Between 1995 and 2010 the average annual Austrian crop consumption was about 11.1 million tonnes. From 1995 to 2010 the Austrian DMC of crops augmented by about 1.8 million tonnes and developed with an average annual growth rate of about 1%. Austrian Crop consumption reached its minimum with an overall weight of 9.8 million tonnes in 2003, due to a harsh drop in domestic extractions and no adaptation of import or export quantities regarding the crop shortfalls in 2003. In the subsequent year of 2004 Austrian crop harvests were considerably growing again, as can be seen in figure 21. Crop exports were, however due to the shortcomings in the previous year, reduced. Imports, on the other hand, continued growing steadily, wherefore the DMC of crops significantly exceeded domestic crop extractions for the first time within the here considered time span in 2004. In the following year of 2005 crop exports were, due to the domestic high-yields in the previous year, augmenting again. Domestic crop harvests were, however, not as fruitful in 2005 as they were in 2004 – as can be seen in figure 21. Hence domestic crop consumption dropped and almost equaled domestic extractions once again. In 2008 domestic crop consumption exceeded domestic harvest quantities again and also peaked with an overall consumption of 12.5 million tonnes in the same year and thus indicating high physical trade imbalances of crops in 2008, even though the highest crop yields were achieved in 2008 (throughout the here considered time span).

Domestic crop extractions and their consumption in Austria were rather balanced until the year 2003 – as illustrated in figure 21 – and thus indicating a rather balanced physical trade of crops from 1995 to 2003. If domestically harvested crop quantities equal domestic consumption quantities of crops, the DMC can theoretically be covered only by domestic extractions. Theoretically because not all kinds of crops are and can (at least economically) be grown in Austria – such as certain fruits or vegetables. Therefore these crops need to be imported. On the other hand, vegetation characteristics of the Austrian landscape are suitable for other crops (such as wheat) which can therefore be produced above domestic demand levels and thus serve foreign markets.

As can be seen in figure 21, the domestic crop consumption of the Austrian economy exceeded domestic extraction quantities in each year from 2003 on. The arising gap is consequently filled by crop imports, thus imports were augmenting from 2003 on – as can be seen in the constant acceleration of crop imports in figure 21. From 2009 on DMC and domestic extractions of crops exhibited a tendency to drift more and more apart, thus additionally increasing the acceleration of crop imports, making the Austrian economy a clear net-importer of crops in 2010. The physical trade imbalances can be extracted from the difference in the crop import and export magnitudes in figure 21.

Due to the vegetation characteristics in Austria not all crops can, at least economically, be grown and harvested in Austria, such as certain kinds of fruits or vegetables. Thus the harsh increase in crop imports could have been triggered off by an expansion of these, in Austria not producible. In combination with domestic crop short fallings (such as in 2000, 2003, 2006 and 2009) and consequently reduced export quantities, physical trade imbalances of crops and domestic crop consumption above domestic crop extraction levels would be reasonable.

Analysing the main driving forces of crop imports to Austria, as undertaken in the import section of chapter 3.1.2. A.1.1 Crops – Foreign trade, showed, however, that imports of fruits and vegetables were developing below the average growth of crop imports. Crop imports of maize, wheat, rapeseed, soybeans and palm oil were on the other hand boosting, hence considerably accelerating crop imports to Austria. Except for palm oil and soybeans, vegetation characteristics are, however, rather suitable for the production of wheat, maize and rapeseed in Austria. Furthermore these crops are applicable for the generation of energy and heat, but are still central ingredients for our nutrition system – whereas biofuels and biogas can also be gained from crop residues or organic waste (Lichtblau G., Pölz W., Stix S., Winter R., 2012; Umweltbundesamt Austria, 2013b).

Simultaneously crop exports were not augmenting to the same quantitative levels, exhibiting a less constant growth than crop imports did, especially from 2003 on. These several drops in crop exports and their slow growth in comparison to crop imports contributed to the further development of imbalanced physical crop trade from 2003 on. Despite the slow paced development of crop exports, wheat exports were augmenting significantly from 1995 to 2010 and even exceeding wheat imports in 2010 by 0.14 million tonnes. Consulting the FAOSTAT's detailed trade matrix shows that Austria was importing about 0.57 million tonnes of wheat from other economies in 2010. Wheat purchases from Hungary (186 000 tonnes; 32.7%), Slovakia (137 000 tonnes; 24%), the Czech Republic (129 000 tonnes; 22.6%) and Germany (94 000 tonnes; 16.5%) formed more than 95% of the overall imported wheat volume in 2010 (FAOSTAT detailed trade matrix). On the other hand the Austrian economy sold about 0.71 million tonnes of wheat to foreign economies, of which exports to Italy were forming a clear majority of 70.2% (499 000 tonnes) (FAOSTAT detailed trade matrix). Besides Italy, Germany (88 000 tonnes; 12.3%), the Switzerland (43 000 tonnes; 6%), the Netherlands (16 000 tonnes; 2.1%), Greece (12 000 tonnes; 1.8%) and Bulgaria (12 000 tonnes; 1.8%) were also buying considerable amounts of Austrian wheat – accounting together for almost 95% of the overall exported wheat volume from Austria in 2010 (FAOSTAT detailed trade matrix). Wheat represents, however, an exception amongst the here discussed crops.

Austria decided within the European Union's 2020 renewable energy targets to expand their renewable energy share to 34% (Mantau U., Steirer F., 2007). In 2010 30.8% (99 315 GWh) of the total Austrian energy supply were already generated from renewable energy sources (Biermayr P., 2011). Hydro-power composed 39.5% (39 237 GWh) and biomass accounted for 39.4% (39 117 GWh) of the overall renewable energy supply (99 315 GWh) (Biermayr P., 2011). Together these two sources formed about 80% of the energy generated from renewable energy carriers and sources in Austria in 2010 (Biermayr P., 2011). The remaining 20% were composed by smaller fractions of energy generated from wind power (2 035 GWh; 2.1%), photovoltaics and solar heat (1 993 GWh; 2%), geothermal energy (90 GWh; 0.1%) and others such as leach, renewable shares of community heating and ambient heat (16 843 GWh; 17%) (Biermayr P., 2011). As the Austrian landscape is rather unsuitable for centrally organized large scale energy generation from solar or wind power (that can cover considerable shares of today’s excessive energy use), and as the benefits of any further erected hydro-energy plant is in no relation to its costs (especially its social-costs), biomass and hence crops, next to woody biomass, represent for Austria the most promising energy carrier for achieving the targeted renewable energy share expansion of almost 4%.

The importance of energy-crops for the Austrian economy can also be derived from the augmented extraction quantities and shares of maize, wheat and sugar beet – as presented in chapter 3.1.1. A.1.1 Crops – Domestic Extraction – as well as from the rapid growth of energy-crop imports such as wheat, maize, rapeseed, soybeans and palm oil – as presented in chapter 3.1.2. A.1.1 Crops – Foreign trade. The here observed strategy of Austria to achieve their 2020 targets exhibits, however, a rather short-term perspective, as augmented imports without being absorbed by expanded export quantities increase the dependence on elementary commodities. Furthermore increasing import quantities and domestic extractions in order to meet the EU's 2020 targets leads to expanded material extractions either nationally or abroad. Hence trying to achieve the 2020 targets with a short-term perspective, as observed for Austria, clearly countervails a development towards a sustainable economy. The current path of Austria towards the 2020 goals can therefore be interpreted as a simple assurance of individually affordable energy for the near future and simultaneously accepting the high global social-costs connected to this kind of behaviour. Energy-crops such as wheat, maize, rapeseed, soybeans or sugar beet are also central commodities in our nutrition system, hence their additional application for energy generating purposes increases the pressure and prices of these commodities and thus adversely affects non-subsidised economies.

As mentioned before in this chapter, each biofuel or biogas can also be produced out of crop residues or organic waste (Lichtblau G., Pölz W., Stix S., Winter R., 2012). Hence improving the recycling stream for augmenting biofuel and biogas production would contribute in sustainably meeting the EU's 2020 targets. Estimating the overall amount of residues accruing from applied crops (not only their used fractions) as well as the net-increment of organic waste would offer insights in the energetic potential of crop residues and organic waste. This is, however, not part of an EW-MFA and of this paper. However, this thesis serves as a groundwork for the evaluation of biomass application in Austria which is, subsequently to this thesis, undertaken.

3.2. A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass

As for A.1.1 Crops, the two digit level sub-group A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass is composed by further aggregates on the three and even four digit level. The name of sub-group A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass already suggests its further aggregates – A.1.2.1 Crop Residues (used) and A.1.2.2 Fodder Crops and Grazed Biomass. The three digit level categories are, however, once again separated into A.1.2.1.1 Straw, A.1.2.1.2 Other Crop Residues, A.1.2.2.1 Fodder Crops and Biomass Harvested from Grassland and A.1.2.2.2 Grazed Biomass. Table 12 illustrates the various aggregates and the materials composing them. As already discussed above – in chapters 2.2.2. Applied crop residues and 2.2.3. Fodder crops and grazed biomass – data on applied crop residues, fodder crops (excluding commercial feeding stuff) and grazed biomass are not provided by the FAOSTAT, Statistik Austria, the BMLFUW or any other traditional statistics. Hence their respective extraction and trade quantities need to be estimated applying the scheme and coefficients provided by the Eurostat EW-MFA Compilation Guide (2012) and EW-MFA Methodological Guide (2001). Nevertheless the resulting estimations from applying the FAOSTAT data and Eurostat method were rather misleading – as discussed in detail in the following – wherefore data on sub-group A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass was gathered from the Eurostat EW-MFA database. Even though the Eurostat provides within its EW-MFA database less detailed data than the FAOSTAT does, for the sub-group A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass the Eurostat EW-MFA database reaches, however, the four digit aggregate level, which is sufficient for the here analysed sub-group.

Table 12: Composition of sub-group A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass

A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass	
A.1.2.1 Crop Residues (used)	**A.1.2.2 Fodder Crops and Grazed Biomass**
A.1.2.1.1 Straw (from)	*A.1.2.2.1 Fodder Crops (incl. Biomass Harvest from Grassland)*
Wheat	Fodder beet
Barley	Fodder kale
Oats	Swedes
Rye	Carrots for stockfeeding
Maize	Turnips for stockfeeding
Rice	Annual green fodder
All other cereals	Clover and mixtures
A.1.2.1.2 Other Crop Residues	Lucerne
Rape seed	Other legumes (sainfoin, sweet clover)
Soy bean	Temporary grasses
Sugar beet	Permanent meadows
Sugar cane	*A.1.2.2.2 Grazed Biomass*
	Temporary grazings
	Grassland
	Common pasture, heathland and rough grazings

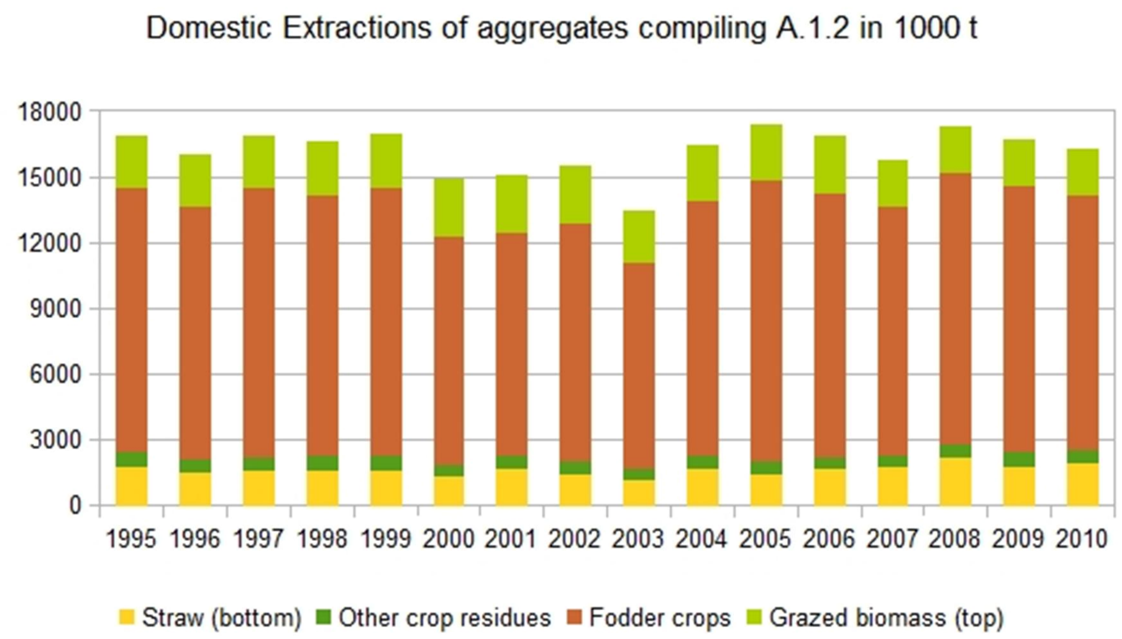
Source: by author based on Eurostat, 2012

3.2.1. A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass – Domestic Extraction

The category A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass is segmented into the two sub-groups A.1.2.1 Crop Residues (used) and A.1.2.2 Fodder Crops and Grazed Biomass. Applied crop residues (A.1.2.1) comprise the volume of straw (A.1.2.1.1) entering the economy as well as of other crop residues (A.1.2.1.2) such as sugar and fodder beet leaves. Crop residues are a fraction of the harvested crops (but not the prime motivation of cultivating those crops) which possess a certain economic value. Crop residues are in general applied within the (harvested) unit and serve as bedding material for the livestock or fodder, even though straw can also be applied for energy or heat generation (Eurostat, 2012). Data on the application of crop residues are, however, not available wherefore the used fraction of crop residues needs to be estimated from the primary crop harvest by applying region- or country-specific conversion factors – as already discussed in chapter 2.2.4. Converting harvested wood from cubic meters to metric tonnes. For the estimation of used crop residues in Austria from 1995 to 2010 empirical information on primary crop harvests was gathered from the FAOSTAT database. Conversion factors for calculating the applied fraction of the accruing crop residues were taken from the Eurostat EW-MFA Compilation Guide (2012) as well as the Eurostat EW-MFA Questionnaire (2012). The resulting data, however, proved to be misleading and way out of proportion with the by the Eurostat provided EW-MFA data on applied crop residues. The Eurostat points in their EW-MFA Compilation Guide (2012) clearly out that the calculations based on the by the Eurostat provided conversion factors need to be cross-checked with expert knowledge, a task that could not be respected to the same degree in this thesis as the Eurostat requires it and supposedly undertook it for their EW-MFA estimations provided via the Eurostat EW-MFA database. Therefore the by the Eurostat's EW-MFA database provided empirical information on sub-group A.1.2.1 is applied here, as it is assumed that the Eurostat included a broader range of expert knowledge in their estimations than possible within the here executed study.

The sub-group A.1.2.2 Fodder crops and grazed biomass comprises any kind of fodder crops except commercial fodder (already included in A.1.1 Crops) and biomass uptake by the livestock on pastures. Data on grazed biomass is not provided by traditional statistics and needs therefore to be estimated as presented in chapter 2.2.3. Fodder crops and grazed biomass. Both approaches (demand-side and supply-side estimation) were undertaken for the here executed survey applying data on pastures provided by the FAOSTAT and information on the amount of livestock from the Statistik Austria. Combining the data with their respective conversion factors taken from the Eurostat EW-MFA Compilation Guide (2012) and Eurostat EW-MFA Questionnaire (2012) yielded the quantitative volume of biomass uptake from pastures by the livestock. The resulting data was, however, once again out of proportion as the by the Eurostat recommended cross-checking with expert knowledge could not be undertaken to a satisfying level, wherefore the by the Eurostat provided data on grazed biomass were applied in this thesis. As the amount of biomass uptake from pastures depends on the magnitude of provided fodder crops, it seemed advisable to apply the by the Eurostat EW-MFA database provided quantities on fodder crops for Austria as well. Figure 23 shows the extracted volumes of category A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass as well as the annual extractions of each sub-group compiling A.1.2 for Austria from 1995 to 2010 as provided by the Eurostat EW-MFA database.

Figure 23: Domestic extractions of applied crop residues, fodder crops and grazed biomass for Austria from 1995 to 2010, in 1000 t



Source: by author based on Eurostat EW-MFA database

Extraction weights of category A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass exceeded the harvested weight of primary crops (category A.1.1) on average by about 5.7 million tonnes in each year (from 1995 to 2010). On average about 16.2 million tonnes of crop residues, fodder crops and grazed biomass were entering the Austrian economy per annum. In 2005 domestic extractions of category A.1.2 peaked with an overall weight of 17.4 million tonnes. Similar to primary crop harvests, crop residues, fodder crops and grazed biomass extractions exhibited their lowest extraction value of 13.4 million tonnes in 2003. Harvests of straw and other crop residues, which are directly connected to the extracted crop amounts, were, however, less affected by the decrease in domestic crop extractions, whereas fodder crop extractions and grazed biomass were dropping significantly and thus inducing the minimum value of category A.1.2 in 2003 – as presented in figure 23. From 1995 to 2010 applied crop residues, fodder crops and grazed biomass weights were developing with an average annual growth rate of -0.2%, hence exhibiting a slight decline.

Figure 23 presents besides the overall domestic extraction weights of category A.1.2 the harvested quantities of each sub-group compiling category A.1.2. Amongst those sub-groups fodder crop extractions represent with annual average domestic harvests of 11.6 million tonnes (average share in total A.1.2 extractions of 71%) the main driving force of crop residues, fodder crops and grazed biomass extractions. The commodity aggregate fodder crops comprises roots and tubers such as fodder beet, fodder kale, swedes, carrots (for stock feeding) and turnips (for stock feeding) and biomass harvested from grasslands such as lucerne, clover, harvested green fodder, harvested temporary grasses and other legumes such as sweet clover and sainfoin (Eurostat, 2012; Eurostat EW-MFA Questionnaire, 2012). Commercial fodder crops such as maize or soya are already included in category A.1.1 crops and thus not accounted for within the sub-group A.1.2.2.1 Fodder Crops (Eurostat, 2012). Unfortunately the Eurostat database, unlike the FAOSTAT database, does not provide extraction quantities on the commodity level, hence a further analysis of the driving commodity extractions composing the four digit sub-group fodder crops cannot be undertaken.

Besides fodder crop extractions, direct biomass uptake from the livestock through grazing exhibits as well considerable weights of on average 2.4 million tonnes per year and thus forming a relevant share in the domestic extraction weights of category A.1.2 of on average 15% per annum between 1995 and 2010. Grazed biomass quantities are, however, estimated through the evaluation of fodder crop amounts, as biomass uptake from the livestock on grasslands is not monitored by traditional statistics (Eurostat, 2012). Therefore grazed biomass quantities are developing similar to fodder crop extraction volumes – as can be observed in figure 23.

Straw and other applied crop residues are of a significant smaller magnitude than fodder crops and grazed biomass. Together the commodity aggregates account for an annual average extraction quantity of 2.2 million tonnes and exhibit an average share in domestic extractions of about 14%. Straw and other applied crop residues result from any extracted crop which provides residues with further socio-economic use (Eurostat, 2012). In general these crops are any kind of cereals such as wheat, rye, barley, oats and maize (Eurostat, 2012; Eurostat EW-MFA Questionnaire, 2012). Apart from cereals, sugar crops such as sugar beet or sugar cane as well as oil bearing crops like rapeseed and soybeans provide residues with further socio-economic use (Eurostat, 2012;

Eurostat EW-MFA Questionnaire, 2012). Amongst the applied crop residues straw exhibits clearly bigger shares and quantities than other crop residues. From 1995 to 2010 about 1.6 million tonnes of straw entered the Austrian economy (from domestic extractions) on average in each year, which exceeded average extractions and application of other crop residues by about a million tonne per annum between 1995 and 2010.

3.2.2. A.1.2 Crop residues (used), Fodder Crops and Grazed Biomass – Foreign trade

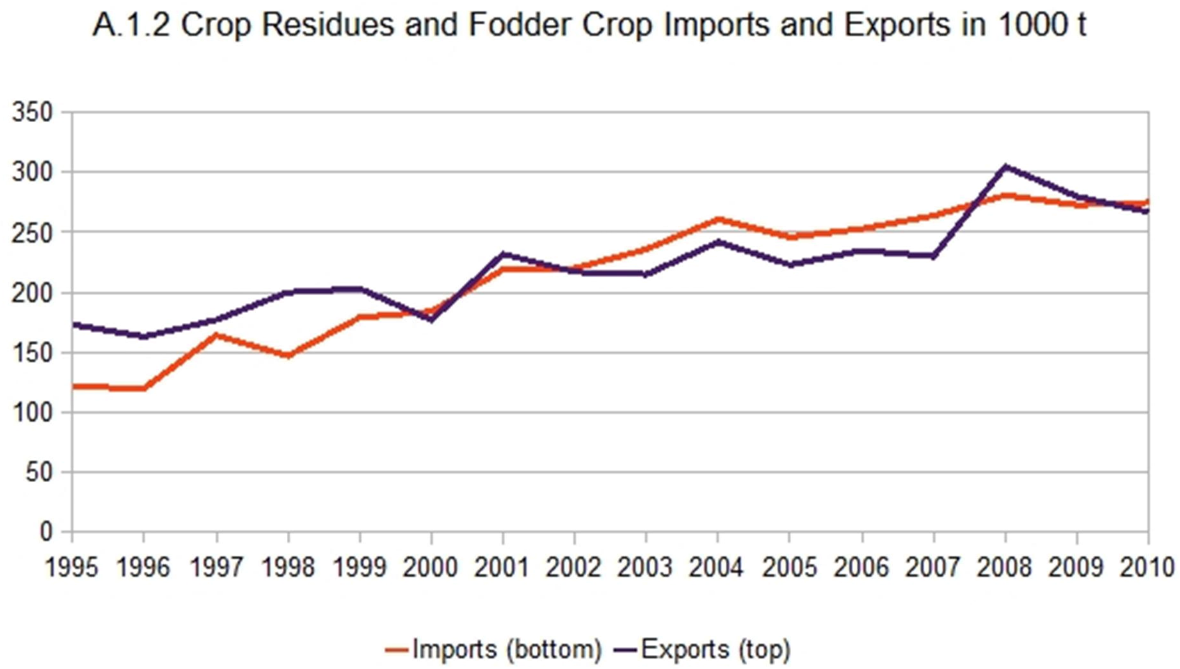
Due to the same conceptual difficulties as described in the previous section, data on the foreign trade of applied crop residues, fodder crops and grazed biomass was gathered from the Eurostat EW_MFA database. Hence an analysis of the single commodity trade flows cannot be undertaken.

Figure 24 illustrates the imported as well as the exported quantities of the category applied crop residues, fodder crops and grazed biomass. Foreign trade of grazed biomass is rather unlikely to happen and the by the Eurostat provided trade data underpin this assumption as no grazed biomass trade flows were recorded from or to Austria between 1995 and 2010 and are not expected to happen. Hence sub-group grazed biomass is excluded from the further analysis of applied crop residues and fodder crop trade flows.

Crop residues and fodder crop trade flows are, as can be easily seen in figure 24, of a significant smaller magnitude than domestic extractions of category A.1.2. Developing between 0.1 and approximately 0.3 million tonnes, foreign trade of crop residues and fodder crops are only forming a small fraction of the Direct Material Input and Domestic Material Consumption of category A.1.2 – as discussed and underpinned with empirical information in the following section 3.2.3. A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass – Direct Material Input and Domestic Material Consumption – hence representing an insignificant share of the overall crop residues (used), fodder crops and grazed biomass supply and consumption in Austria between 1995 and 2010. Nevertheless crop residues and fodder crop imports doubled from 121 000 tonnes in 1995 to 275 000 tonnes in 2010. Crop residues and fodder crop exports developed likewise and augmented by 94 000 tonnes from 173 000 tonnes in 1995 to 267 000 tonnes in 2010.

The Austrian economy exhibited a rather balanced physical trade of crop residues and fodder crops between 1995 and 2010 – as presented in figure 24. From 1995 to 1999 crop residues and fodder crop exports from Austria were exceeding the respective imports. In 2000 exports were dropping slightly below import levels before increasing again and exceeding imports in the subsequent year of 2001. From 2002 to 2007 crop residues and fodder crop imports were, however, augmenting more than exported quantities, hence making the Austrian economy a net-importer of crop residues and fodder crops between 2002 and 2007. In 2008 export quantities of crop residues and fodder crops experienced a harsh growth, thus exceeding the respective import quantities significantly, before exports were dropping again below the import level in 2010. Austria was therefore a net-exporter as well as a net-importer of crop residues and fodder crops within the here considered time interval. The years in which exports were higher than imports exceed, however, the years in which Austria was importing more crop residues and fodder crops than exporting them.

Figure 24: Imports and exports of applied crop residues and fodder crops to and from Austria between 1995 and 2010, in 1000 t



Source: by author based on Eurostat EW-MFA database

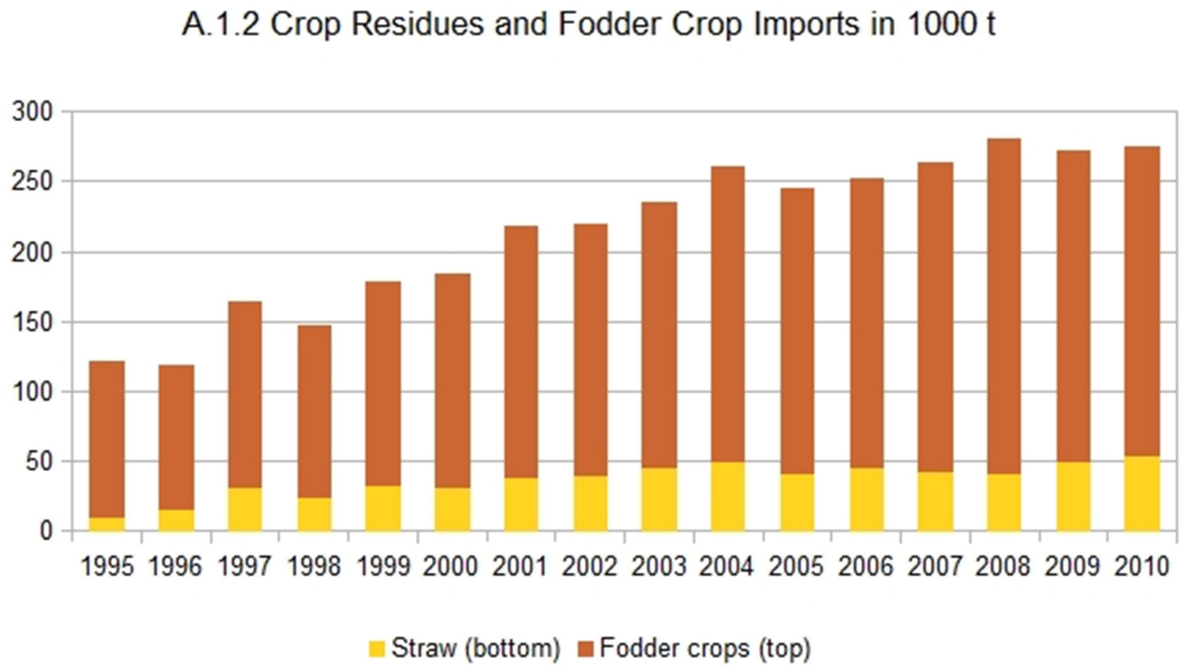
Imports

Figure 25 presents the imported quantities of the single sub-groups composing category A.1.2. As already mentioned before, data from the Eurostat's EW-MFA database was applied in order to analyse crop residues and fodder crop imports (and exports) to (and from) the Austrian economy – hence a survey of the single commodities' import quantities composing the respective aggregates cannot be undertaken here.

Biomass uptake by the livestock (grazed biomass) is obviously rather hard to import, thus not quantitatively appearing in the Eurostat's EW-MFA database and therefore also not illustrated in figure 25. Besides grazed biomass, other crop residues, such as sugar beet leaves, were also not imported even though it would be physically possible. Other crop residues differ, however, in their composition from farm to farm, depending on the planted crops. Hence do not represent a homogenous commodity which makes trading it difficult, as no trade data is presented on other crop residues by the Eurostat EW-MFA database.

Ruling grazed biomass and other crop residues out only leaves fodder crops and straw to be imported – as can be seen in figure 25. Fodder crops form clearly the main driving force of straw and fodder crop imports. In 1995 fodder crop imports accounted for about 112 000 tonnes, thus representing 92.5% of the overall straw and fodder crop imports. In 2010 fodder crop imports augmented by 110 000 tonnes to 222 000 tonnes, representing 80.8% of the overall respective imports. The remaining import quantities were filled by straw imports which experienced a rather harsh increase in relative terms from 1995 to 2010. Straw imports to Austria were more than quintupling within the here considered time span from 10 000 tonnes in 1995 to 53 000 tonnes in 2010 and thus taking up a (relatively) bigger share in total crop residues and fodder crop imports in 2010. The rapid growth of straw imports can be connected to the possible application of straw for heat and energy generation (Eurostat, 2012).

Figure 25: Imports of applied crop residues and fodder crops to Austria from 1995 to 2010, in 1000 t

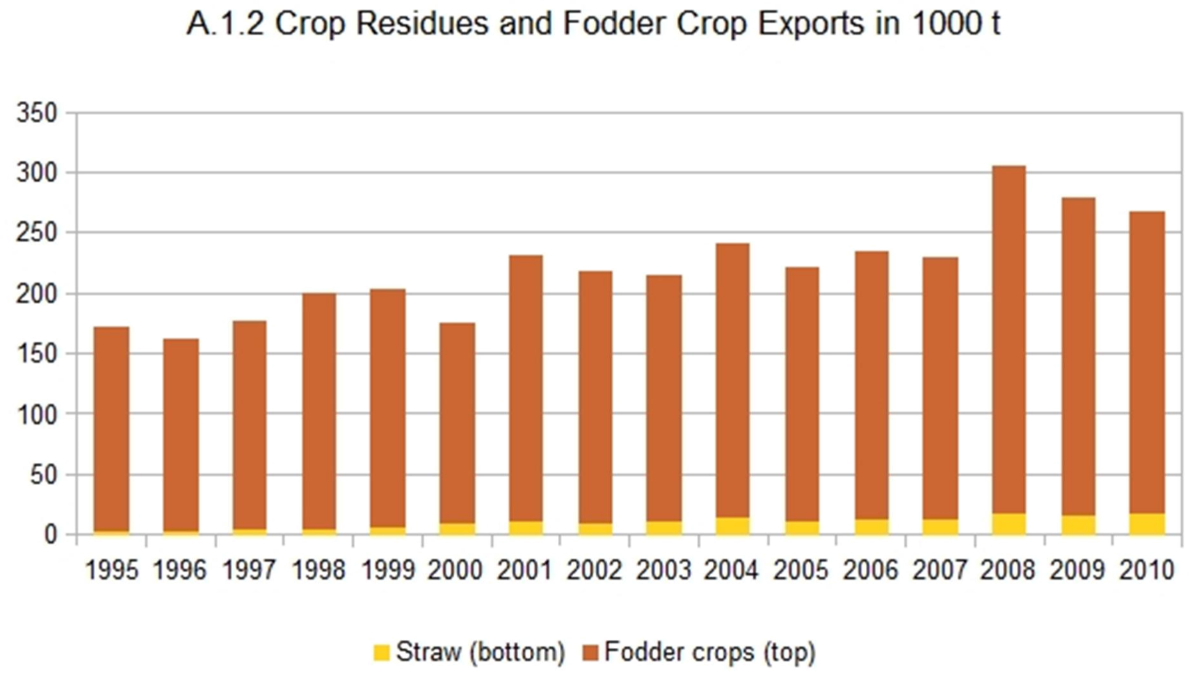


Source: by author based on Eurostat EW-MFA database

Exports

Straw and fodder crops are also the only commodities of category A.1.2 that got exported from Austria. The exported quantities of straw and fodder crops together exhibit similar magnitudes as imports do – thus exhibiting a rather balanced physical trade (as already discussed further above). Fodder crop exports formed as well the main driving force of crop residues and fodder crop exports between 1995 and 2010 – as presented in figure 26. The respective shares in overall crop residues and fodder crop exports accounted with an export quantity of 171 000 tonnes for 99.8% in 1995. Straw exports increased, in absolute terms, on a rather small scale, wherefore fodder crop exports also represented the main driving force of crop residues and fodder crop exports in 2010 (249 000 tonnes, 93.3% of overall exports). Straw on the other hand exhibited with 2 000 tonnes almost no trade flows to other economies in 1995. In 2010 18 000 tonnes of straw were, however, sold to foreign economies, representing a significant augmentation in relative terms.

Figure 26: Exports of applied crop residues and fodder crops from Austria between 1995 and 2010, in 1000 t

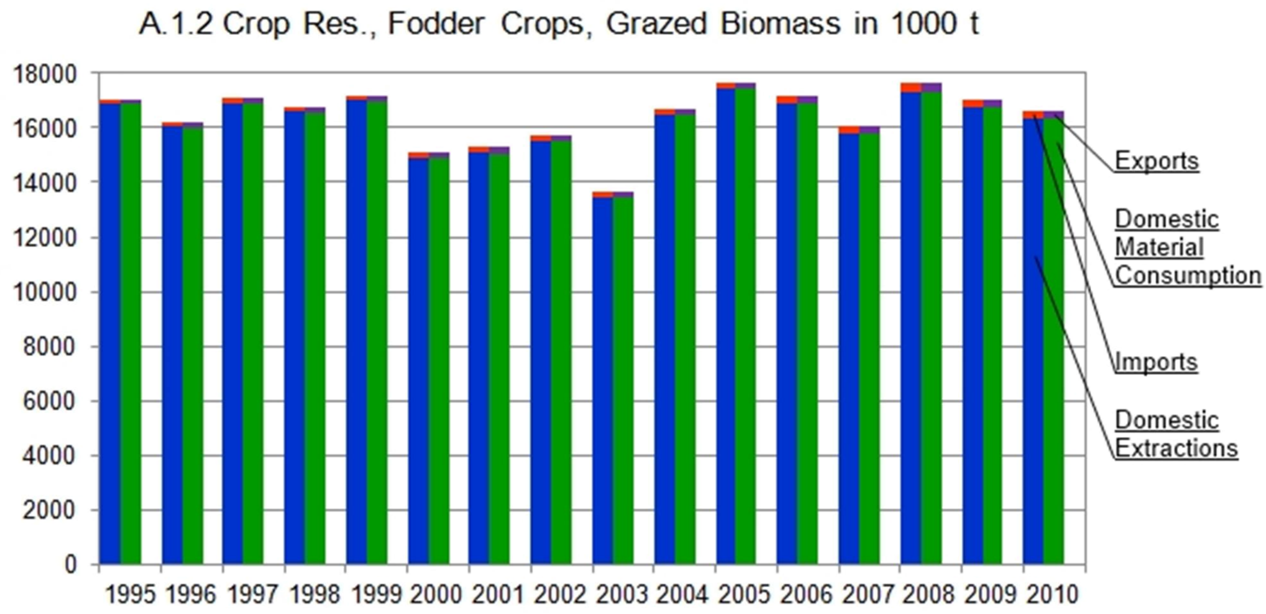


Source: by author based on Eurostat EW-MFA database

3.2.3. A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass – Direct Material Input and Domestic Material Consumption

Setting domestic extraction as well as import and export quantities of applied crop residues, fodder crops and grazed biomass in relation (as presented in chapter 2.3. Derivable indicators) yields the Direct Material Input (DMI) and the Domestic Material Consumption (DMC) of crop residues, fodder crops and grazed biomass. Figure 27 presents the annual magnitudes of the DMI and DMC of Austria for category A.1.2 from 1995 to 2010. Furthermore the EW-MFA indicators composing factors – domestic extractions, imports and exports of biomass – are also presented in figure 27. The stacked bars on the left hand side of each year in figure 27 represent the Austrian Direct Material Input of applied crop residues, fodder crops and grazed biomass and thus consist of the respective domestic extractions and imports – as indicated in figure 27. The right bars of each time interval in figure 27 are composed by domestic crop residues, fodder crops and grazed biomass consumption and exports (as illustrated in figure 27) and thus equal the DMI in each year, as DMC equals DMI minus exports. From 1995 to 2010 the Austrian crop residue, fodder crop and grazed biomass consumption exceeded domestic extractions only slightly, indicating therefore a rather balanced physical trade of category A.1.2. Nevertheless foreign trade of crop residues and fodder crops exhibited rather insignificant volumes between 1995 and 2010, wherefore the DMI and DMC of crop residues, fodder crops and grazed biomass developed accordingly to the respective annual domestic extraction quantities – as can be seen in figure 27. In the following the DMI and DMC of applied crop residues, fodder crops and grazed biomass are discussed in detail.

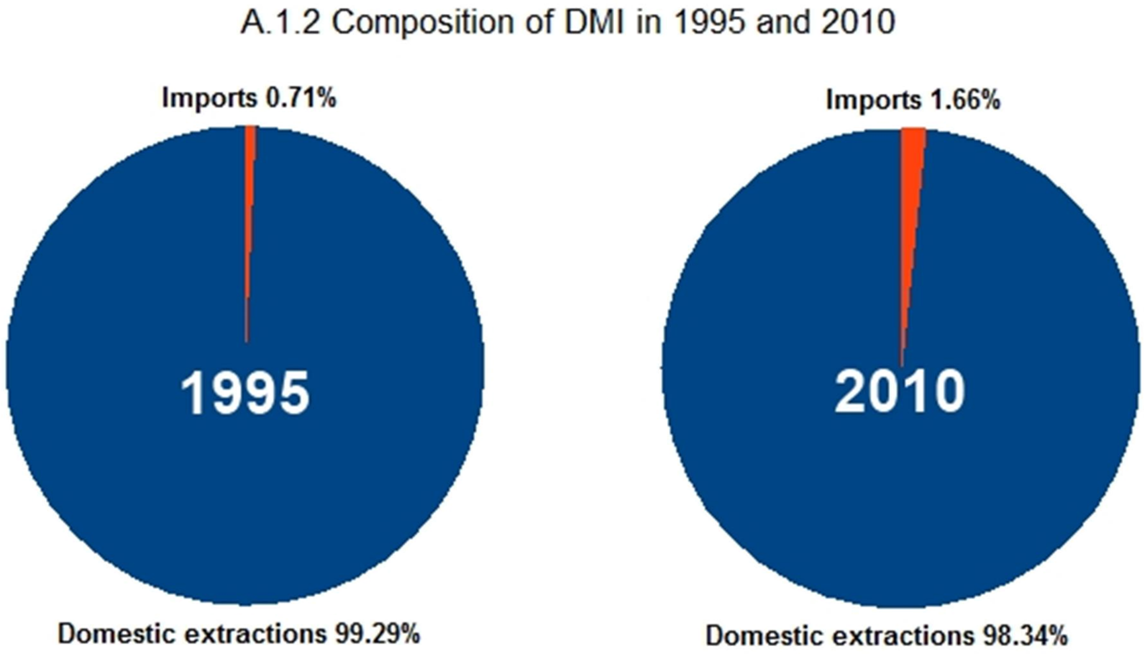
Figure 27: Direct Material Input and Domestic Material Consumption (and composing factors) of crop residues, fodder crops and grazed biomass for Austria from 1995 to 2010, in 1000 t



Source: by author based on Eurostat EW-MFA database

DMI of crop residues, fodder crops and grazed biomass peaked with an overall weight of approximately 17.7 million tonnes in 2005 and reached its minimum with a material input of 13.7 million tonnes in 2003 between 1995 and 2010. DMI and domestic extractions of sub-group A.1.2 exhibit therefore the same maximum and minimum – as can be seen in figure 27. On average DMI of crop residues, fodder crops and grazed biomass exceeded the respective domestic extraction quantities by about 215 000 tonnes per year between 1995 and 2010, representing the annual average import quantities. Analysing the annual average growth rate of direct crop residue, fodder crop and grazed biomass input shows, however, smaller decreases in the DMI than in domestic extractions of crop residues, fodder crops and grazed biomass from 1995 to 2010. Domestic extraction quantities were falling on average by -0.2% per year within the here considered time span. Direct material input developed, however, with a decrease of on average -0.1% per annum. Hence the decrease in domestically extracted crop residues, fodder crops and grazed biomass was absorbed by the indeed low but nevertheless rapidly increasing import quantities of straw and fodder crops – which more than doubled from 1995 to 2010. The significant increase in straw and fodder crop imports can also be observed in the respective DMI shares – as presented in figure 28.

Figure 28: Composition of direct crop residues, fodder crops and grazed biomass input of Austria, 1995 and 2010



Source: by author based on Eurostat EW-MFA database

In 1995 only about 0.7% of the Austrian crop residues, fodder crops and grazed biomass DMI were composed by straw and fodder crop imports (as no other commodities got imported). Hence domestic extractions were forming about 99.3% of the Austrian DMI of sub-group A.1.2 in 1995. The situation did not change much in 2010. Domestically harvested crop residues, fodder crops and grazed biomass were still forming with a share of 98.3% the clear majority of the DMI. Straw and fodder crop imports were, however, increasing significantly (from 0.7% in 1995 to about 1.7% in 2010) even though remaining on a rather low level compared to domestic extractions. Whilst domestic extractions of crop residues, fodder crops and grazed biomass were decreasing, imports were augmenting considerably but still represent only a small fraction of the Austrian DMI.

Subtracting the exported straw and fodder crop quantities (no other commodities belonging to category A.1.2 got exported) from the direct crop residues, fodder crops and grazed biomass input yields the Domestic Material Consumption (DMC) of crop residues, fodder crops and grazed biomass. Straw and fodder crop exports and imports exhibited similar quantities between 1995 and 2010, representing a rather balanced physical trade of straw and fodder crops. Therefore reducing the DMI by the respective annual export weights in order to calculate the DMC of crop residues, fodder crops and grazed biomass, brings the DMC close to the respective domestic extraction quantities (as domestic extractions are expanded by import quantities in order to estimate the DMI).

On average domestically harvested crop residues, fodder crops and grazed biomass exceeded the respective DMC by 6 000 tonnes per year from 1995 to 2010. This remote aberration indicates that the Austrian economy was a net-exporter of straw and fodder crops for the here considered time span, as on average the DMC is lower than domestic extractions for sub-group A.1.2.

Domestic crop residues, fodder crops and grazed biomass consumption peaked simultaneously to DMI and domestic extractions with an overall weight of 17.4 million tonnes in 2005 and reached its minimum with 13.7 million tonnes in 2003 – as can be seen in figure 27. The DMC dropped from 16.9 million tonnes in 1995 to 16.3 million tonnes in 2010, hence exhibiting a negative average development of -0.2% per year from 1995 to 2010. As presented in figure 27 domestic extractions cover in general the respective DMC, as the domestic extraction fraction of the left hand side bars equal the DMC share of the right hand side bars in figure 27. The Austrian economy is therefore not depending on imports to satisfy the domestic crop residues, fodder crops and grazed biomass consumption. Category A.1.2 is, however, bound to the respective domestic extractions as not all commodities of category A.1.2 applied crop residues, fodder crops and grazed biomass are and can be imported.

3.3. A.1.3 Wood

Data on wood harvesting as well as on wood trade is usually recorded in cubic meters. Within an EW-MFA material flows are, however, monitored in metric tonnes. Therefore factors for converting wood volumes into wood weight, respecting the standard moisture content of 15%, need to be applied. As the density and thereby the weight of harvested or traded wood varies due to the species characteristics as well as the vegetation circumstances, species and country specific conversion factors need to be applied in order to monitor the respective wood weights entering or leaving an economy. Unfortunately such a complete set of conversion factors is yet not available – as already discussed in chapter 2.2. Data sources and accounting principles – wherefore the by the Eurostat EW-MFA Compilation Guide (2012) provided conversion factors are applied in the here undertaken estimation. The factors are based on the IPCC National Greenhouse Gas Inventory Programme (Penman et al., 2003) and differ between coniferous and non-coniferous wood species (respecting the standard moisture content of 15%). Variability of vegetation circumstances are, however, not taken into account, yielding two conversion factors – 0.52 (t/m³) for coniferous wood and 0.64 (t/m³) for non-coniferous wood (Eurostat, 2012).

Empirical information on annual wood harvests in Austria from 1995 to 2010 is taken from the FAOSTAT database. The Eurostat points in their EW-MFA Methodological Guide (2001) as well as in their EW-MFA Compilation Guide (2012) out that it is advisable to use nationally derived data on wood production (Eurostat, 2001; Eurostat, 2012). Therefore the from the FAOSAT gathered volumes were cross-checked with data provided in the National Report on Austrian Forests and Wood Harvests (Prem J., Beer R., 2012) published by the Austrian Ministry of Life (BMLFUW) and proved to be accurate as no or only slight differences could be identified between the two data sets. The BMLFUW data set does, however, not always follow the categorisation suggested by the Eurostat EW-MFA Questionnaire (2012) which leads to conceptual difficulties in the further application of the BMLFUW data. The from the FAOSTAT gathered data matches, however, the BMLFUW data set without exhibiting the mentioned conceptual difficulties.

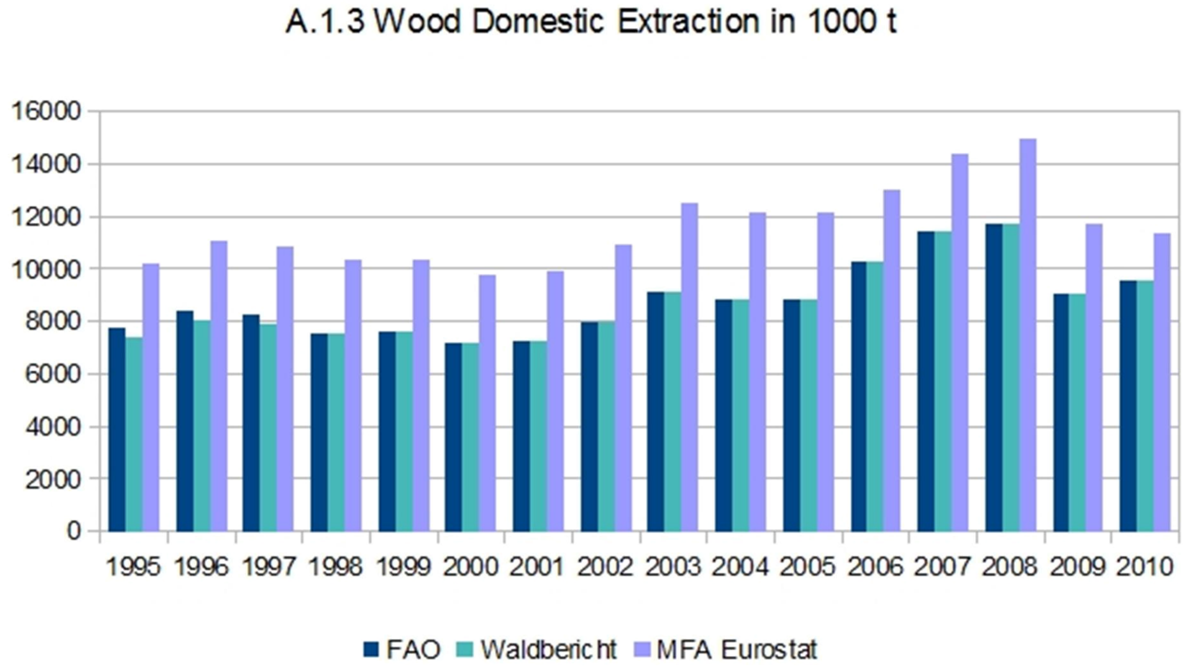
Converting the harvested wood volumes into harvested wood weight (at the standard moisture content) allows comparing the data to the EW-MFA wood harvest data provided by the Eurostat – as can be seen in figure 29. While the nationally recorded data and the FAOSTAT values are generally equal throughout the here considered time interval, the Eurostat estimates significantly higher wood harvests for Austria for each single year. This rather big difference can either be explained by including flows of industrial wood residues (even though wood residues are to be interpreted as material stock within the framework of an EW-MFA) or adding a certain value for unregistered fellings. An inclusion of wood residues by the Eurostat is rather unlikely as these flows are not crossing the system boundary, hence already entered the economy. Furthermore the in figure 29 shown differences between the Eurostat and the FAOSTAT respectively the BMLFUW data is too linear as to represent actual wood flows. The linearity rather suggests the application of a fixed value, such as for unregistered fellings.

Due to these disparities a fourth data source was consulted in order to assess the data on wood harvests and trade properly. The within the EU active conglomerate – EUwood team – composed by members of the University of Hamburg Centre of Wood Science (Mantau U., Saal U.), UNECE/

FAO forestry timber section (Prins K., Steirer F.), European Forest Institute (Lindner M., Verkerk H.), the Dutch Institute for Forestry and Forest Products Probos (Leek N., Oldenburg J.) and the Finnish Forest Research Institute MELTA (Asikainen A., Anttila P.) published Wood Resource Balances for the EU 27 for the years 2005 and 2007. A Wood Resource Balance is an attempt to contrast wood supply with their respective application – also respecting cascade use and hence exhibiting a broader interpretation of wood supply than applied within the framework of an EW-MFA. Cross-checking the in figure 29 presented wood harvesting data with estimates by the EUwood team on wood supply from forests (fresh cut wood fibres originating from forests) in Austria shows that the data gathered from the FAOSTAT database matches precisely the EUwood team estimates for their available years of 2005 and 2007. As the EUwood task force presents its Wood Resource Balance data in cubic meters, conceptual difficulties arise in their comparison with Eurostat EW-MFA data as the Eurostat does not provide any information on coniferous and non-coniferous wood extraction shares within their EW-MFA database. Applying average conversion factors, however, shows that the estimations of the Eurostat are way off the EUwood team results, even taking values for unregistered cuttings into account.

Due to matching the EUwood data on wood supply from forests and their information content as well as their consistency in separating coniferous and non-coniferous wood (except for traded wood fuels), data provided by the FAOSTAT database are applied for the here executed survey of wood harvests in Austria from 1995 to 2010. Furthermore empirical information on wood trade and trade partners (for industrial roundwood) are also provided by the FAOSTAT wherefore the analysis on traded wood is also based on FAOSTAT data.

Figure 29: Domestic extractions of wood in Austria from 1995 to 2010, in 1000 t; comparison of FAOSTAT, BMLFUW and Eurostat EW-MFA data



Source: by author based on FAOSTAT, BMLFUW, Eurostat EW-MFA database

The EW-MFA category A.1.3 Wood consists of coniferous and non-coniferous industrial roundwood (A.1.3.1) and wood fuel (A.1.3.2). Whereas wood fuels are only further separated into coniferous and non-coniferous wood fuels, the sub-group A.1.3.1 Industrial Roundwood comprises all kind of wood serving as saw logs and veneer logs, round and split pulpwood as well as other industrial roundwood differentiated due to their respective species – table 13 illustrates the aggregates as well as their composing material flows.

Table 13: Compostition of sub-group A.1.3 Wood

A.1.3 Wood			
A.1.3.1	Industrial Rouondwood	A.1.3.2	Wood Fuel
	(coniferous and non-coniferous)		(coniferous and non-coniferous)
	Sawlogs and Veneer Logs		Wood Fuel
	Pulpwood (round and split)		
	Other Industria Roundwood		

Source: by author based on Eurostat, 2012

Before discussing the total extractions, trade and domestic consumption of wood in detail, a close look is taken at the commodity aggregates compiling the category A.1.3 Wood. As there is no comprehensive volume to weight conversion set for wood yet, converting the reported quantities (of cubic meters) into metric tonnes leads to inaccuracies. The commodity aggregates as well as the category A.1.3 are therefore first analysed in cubic meters before converting the results into metric tonnes for implementing them into the here undertaken EW-MFA biomass survey for Austria.

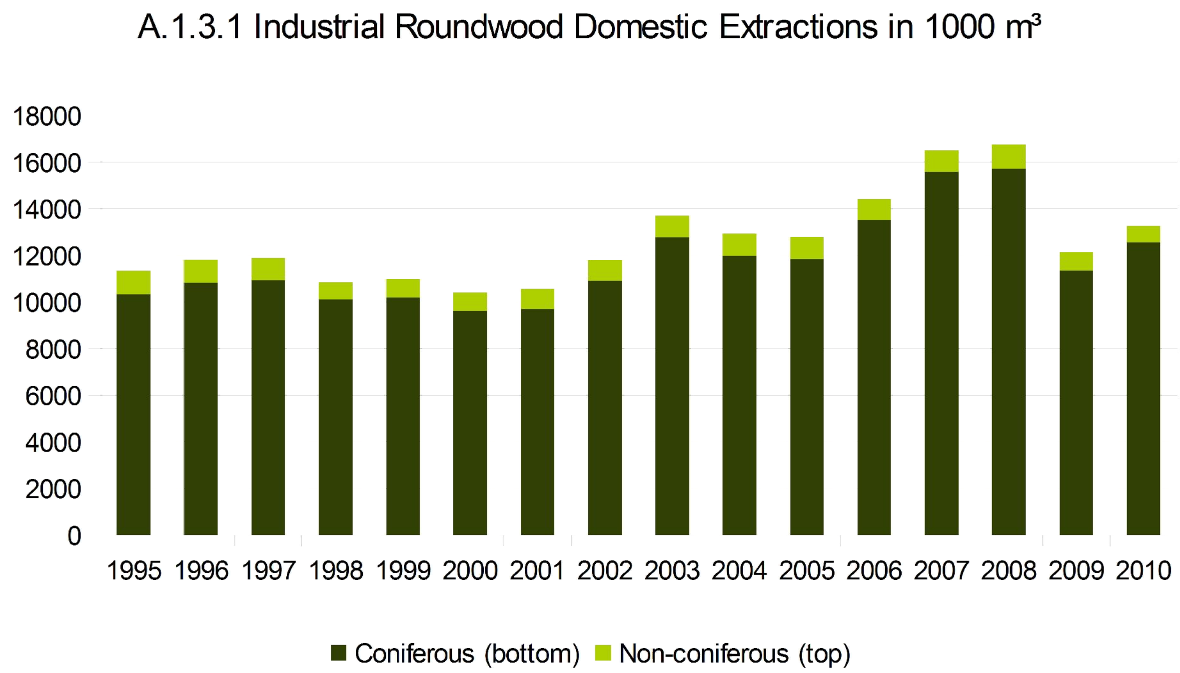
3.3.1 A.1.3.1 Industrial roundwood

Industrial roundwood is in general separated into coniferous and non-coniferous sources of roundwood which allows applying specific volume to weight conversion factors. Industrial roundwood is any kind of wood, except for wood fuel, extracted within an accounting period (FAOSTAT Joint Forest Questionnaire, 2013). As already presented in table 13 the production quantities of industrial roundwood are segmented due to their cause of extraction (i.e. their form of application). Wood harvests counted as saw logs or veneer logs comprise all removals for the production of sawn wood or veneer (FAOSTAT Joint Forest Questionnaire, 2013). Pulpwood (round or split) is any kind of wood or wood chip that is applied for manufacturing fibreboards or particleboards or will enter the pulping industry (FAOSTAT Joint Forest Questionnaire, 2013). Within the remaining sub-group Other Industrial Roundwood all wood extractions not serving neither as saw logs or veneer logs nor as pulpwood are recorded. Due to the versatile application possibilities of wood, the desire of the wood extraction can differ significantly from one to another. Nevertheless fellings for poles, fences or piling posts are popular representatives of other industrial roundwood applications (FAOSTAT Joint Forest Questionnaire, 2013).

3.3.2. A.1.3.1 Industrial roundwood – Domestic extraction

The annual domestic wood extractions of Austria from 1995 to 2010 are presented in figure 30 in thousands of cubic meters. The values are already split up into coniferous (bottom) and non-coniferous (top) wood sources. It can be easily seen in figure 30 that coniferous wood extractions form a clear majority of wood removals in Austria. On average only each tenth wood extraction originates from cutting a non-coniferous tree, which means that about 90% of the overall annual industrial roundwood harvest is coniferous wood. The year 2000 represents with overall cuttings of 10.42 million cubic meters the year with the lowest extraction quantities, whereas in 2008 a maximum of 16.77 million cubic meters felled industrial roundwood was reached for the analysed time interval. Due to the cascade use potential of wood applied for material use (i.e. industrial roundwood) the once extracted wood fibres can stay longer within an economy as they re-enter the supply stream several times (according to their application). An extensive harvested wood volume in one year affects therefore the wood supply positively and hence can reduce the wood extractions of the following years, depending on the material efficiency of the respective economy. The rather harsh drop of wood fellings after the peak of 2008 can be interpreted as an evidence for this relation. Going further back in time a similar incident can be observed. In 1990 another peak of wood extractions was reached (14.16 million m^3) which was then followed by rather low extraction rates of even less than 10 million cubic meters in 1992 (9.86 million m^3) and 1993 (9.71 million m^3). Nevertheless lower domestic extraction volumes can still be compensated by higher import quantities or a reduction in exports, wherefore the here stated hypothesis is picked up in the following section presenting foreign trade data of industrial roundwood.

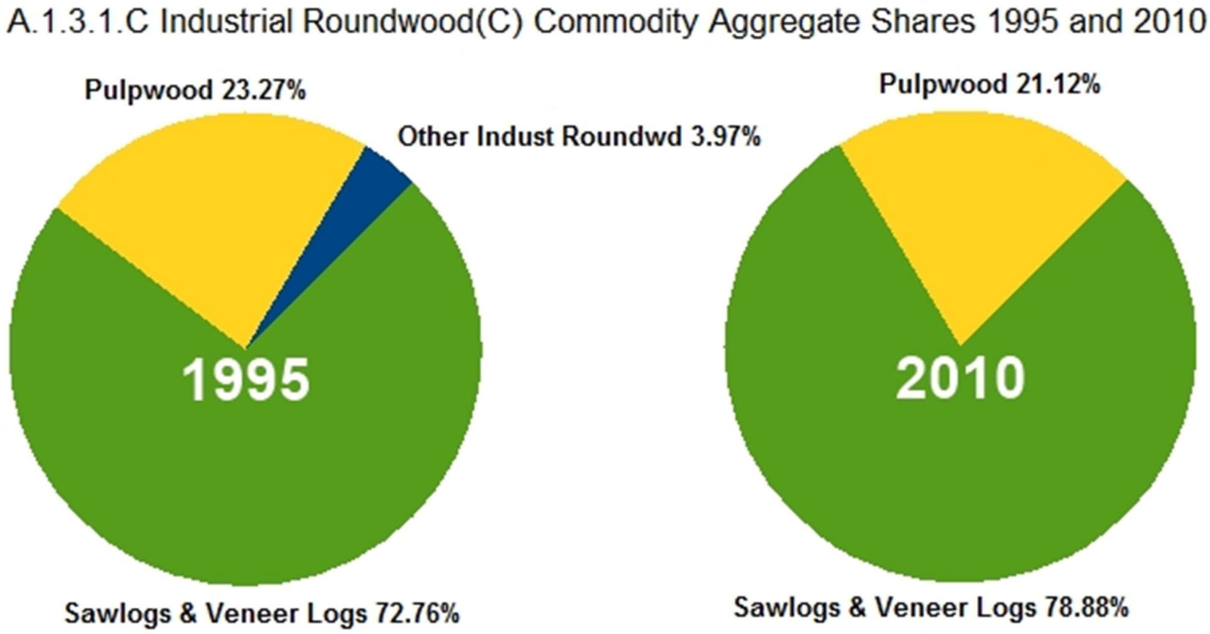
Figure 30: Domestic extractions of industrial roundwood differentiated by species in Austria from 1995 to 2010, in 1000 m³



Source: by author based on FAOSTAT

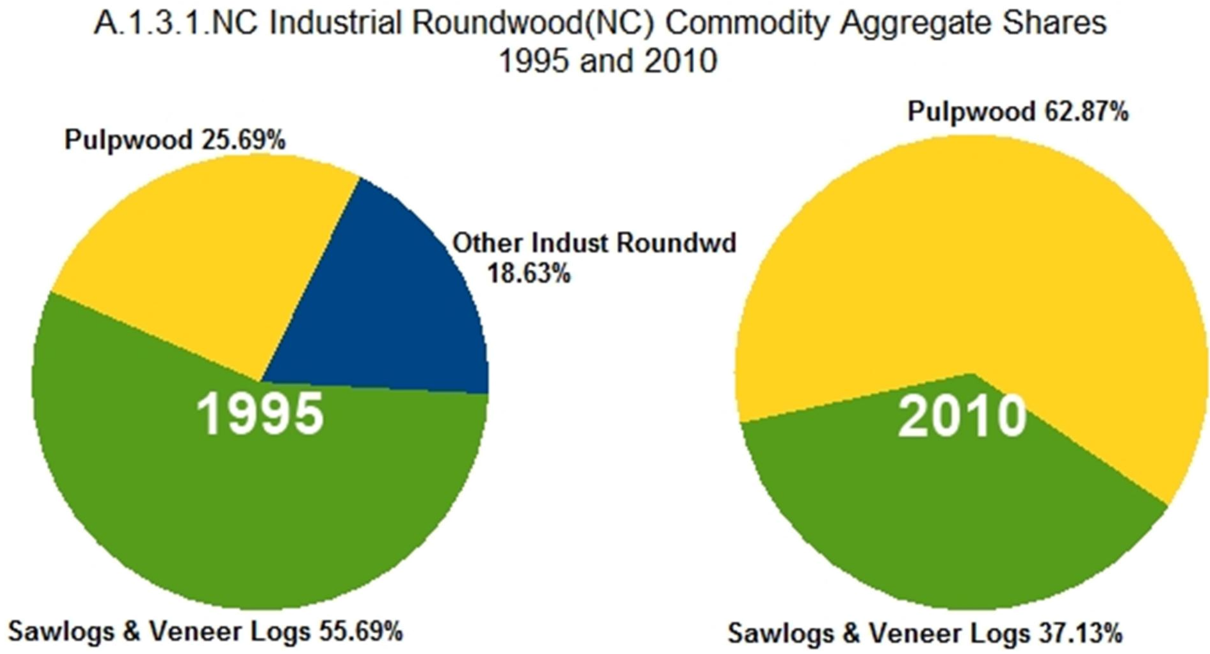
Before focusing on foreign trade a swift glance is thrown at the commodity shares compiling coniferous and non-coniferous domestic industrial roundwood extractions for the time interval boundaries 1995 and 2010. Removals of coniferous wood is mainly driven by the demand on saw logs and veneer logs as they counted for more than half of the respective extractions in 1995 as well as in 2010 – as can be seen in figure 31. Their significance even grew throughout the analysed time span by 6% up to almost 80%. On the other hand the shares of coniferous wood harvests for pulpwood decreased by about 2% from 1995 to 2010, even though the extracted pulpwood volumes increased by approximately 250 000 cubic meters during the same time period – indicating a slower growth than average. As illustrated in figure 31 cuttings for other industrial roundwood disappeared in 2010. Taking a closer look at the FAOSTAT wood production data shows that until 1998 other industrial roundwood extractions counted for a fixed amount of 410 000 cubic meters coniferous wood before being reported as zero from then on. The same can also be observed for non-coniferous extractions. The commodity shares of non-coniferous industrial roundwood fellings are presented in figure 32. As can be seen in the subsequent figure, saw logs and veneer logs were forming the main driving force for non-coniferous wood removals in 1995. Throughout the here considered time interval the situation, however, changed as the shares on non-coniferous pulpwood extractions were increasing and hence forming the majority of non-coniferous wood extractions in 2010. In numbers the removals for particleboards, fibreboards or pulp augmented from 262 000 cubic meters (1995) up to 464 737 cubic meters (2010) representing a similar growth to coniferous pulpwood extractions. Keeping, however, the overall production quantities from coniferous and non-coniferous wood, as well as their overall shares, in mind, the increase of non-coniferous pulpwood extractions can be interpreted as a rather harsh increase.

Figure 32: Commodity aggregate shares of coniferous industrial roundwood extractions for Austria in 1995 and 2010



Source: by author based on FAOSTAT

Figure 31: Commodity aggregate shares of non-coniferous industrial roundwood extractions for Austria in 1995 and 2010



Source: by author based on FAOSTAT

As already mentioned before, recordings of other industrial roundwood extractions seem to stop in 1998 for both coniferous and non-coniferous wood. This can either mean that no more extractions for other industrial roundwood were necessary from 1998 on, implying a high level of material efficiency in Austria, or that other industrial roundwood is recorded within the remaining categories due to changes in classifications. From 1997 to 1998 total roundwood cuttings dropped, however, meaning that both saw logs and veneer logs as well as pulpwood extraction volumes decreased, which makes identifying if the constant shares of other industrial roundwood fellings were added to the remaining aggregates or not rather hard.

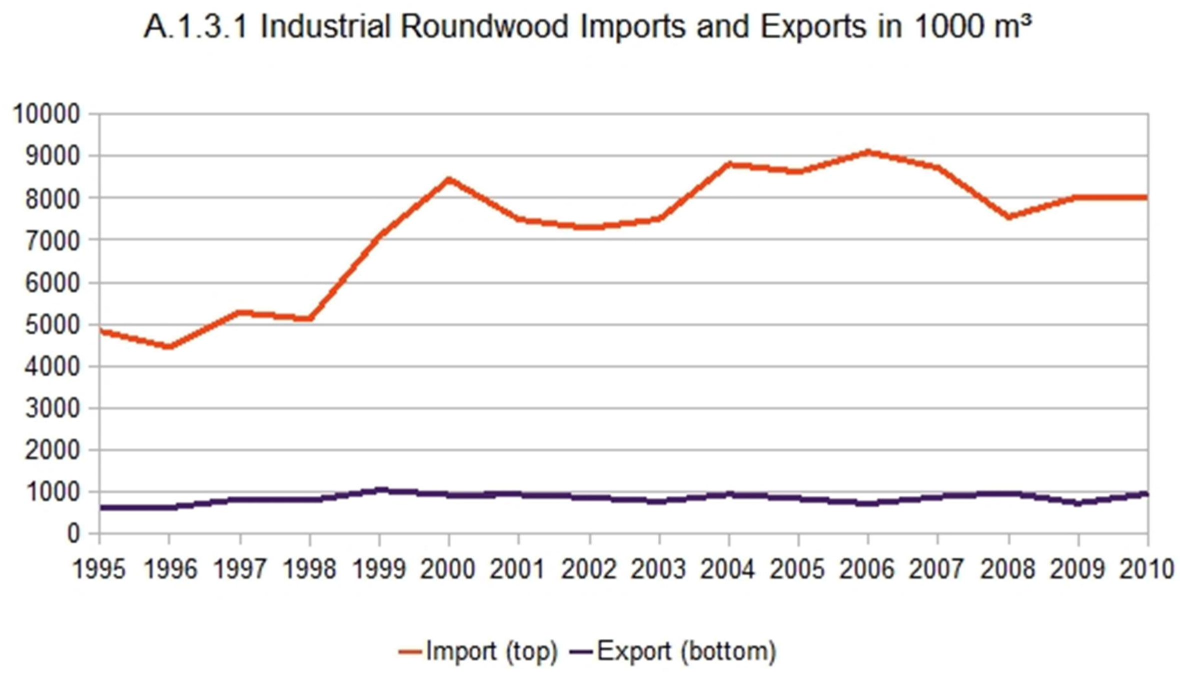
3.3.3. A.1.3.1 Industrial roundwood – Foreign trade

Data on industrial roundwood imports and exports was gathered from the FAOSTAT forestry production and trade database. Due to customs classifications a further segmentation of industrial roundwood into their respective end-user categories (saw logs and veneer logs, pulpwood and other industrial roundwood) as undertaken for domestic extractions could, however, not been executed by the FAO (FAOSTAT Joint Forest Questionnaire, 2013).

Analysing industrial roundwood trade of Austria shows quite significantly that Austria was a net-importer of international roundwood fibres between 1995 and 2010. As illustrated in figure 33, import quantities exceeded the roundwood volumes exported extensively in each year. Timber exports from Austria were rather constant throughout the past years, ranging between 600 000 and 1 050 00 cubic meters, and in relation to roundwood imports developing on a rather low level. Timber imports on the other hand varied considerably (between 4.5 million and 9.1 million cubic meters) during the analysed time span. The augmentation and decrease of roundwood imports developed accordingly to domestic cuttings, hence reflecting the Austrian extraction volumes inversely.

In 2006 Austria imported with a volume of 9.1 million cubic meters the highest quantities of industrial roundwood between 1995 and 2010, in absolute terms. Setting this value in relation to the direct timber input (DMI of timber) of 2006 shows that the imported roundwood volume accounted for approximately 40%, meaning that almost every other wood fibre serving the Austrian timber input was imported. As the import shares of an economy depend on its domestic extractions, the already considerably high shares of 2006 have already been excelled six years before due to the low domestic extraction rate of timber in Austria in 2000 (lowest within the analysed time span). With a DMI share of approximately 45% Austria relied significantly on its imported timber quantities (8.5 million cubic meters) which were only about 1.9 million cubic meters less than the domestically extracted volumes (10.4 million cubic meters) or accounted for more than three quarters of the in Austria cut timber. Industrial roundwood exports on the other hand were, as already mentioned, rather low. Timber removals for trading purposes ranged between 5% and almost 10% of the domestic roundwood harvest peaking in 1999 (9.5%).

Figure 33: Industrial roundwood exports and imports from and to Austria, in 1000 m³

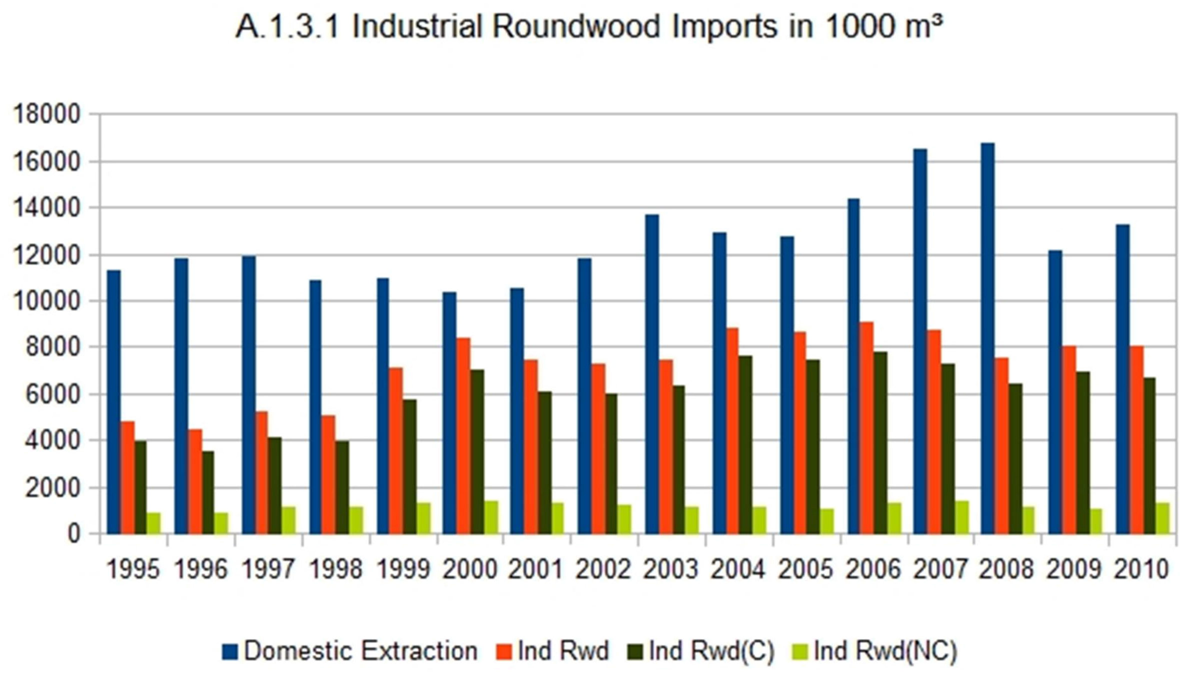


Source: by author based on FAOSTAT

Imports

The annual timber import volumes reflect the Austrian roundwood harvest inversely – as can be seen in figure 34. After the first domestic extraction peak in 1996 timber imports augmented steadily until the year 2000 when imported roundwood volumes almost equaled the domestically cut quantities. After the domestic extraction minimum of 2000, roundwood removals in Austria augmented again thus leading to a decrease of imported timber quantities. This development continued until the second domestic extraction peak of 2003, followed by a decrease in domestic fellings and rising import quantities. From 2005 on domestic timber cuttings were once again expanded triggering a decrease in imported roundwood off which was stopped and reversed by the domestic extraction peak of 2008.

Figure 34: Industrial roundwood imports and domestic extractions for Austria, in 1000 m³



Source: by author based on FAOSTAT

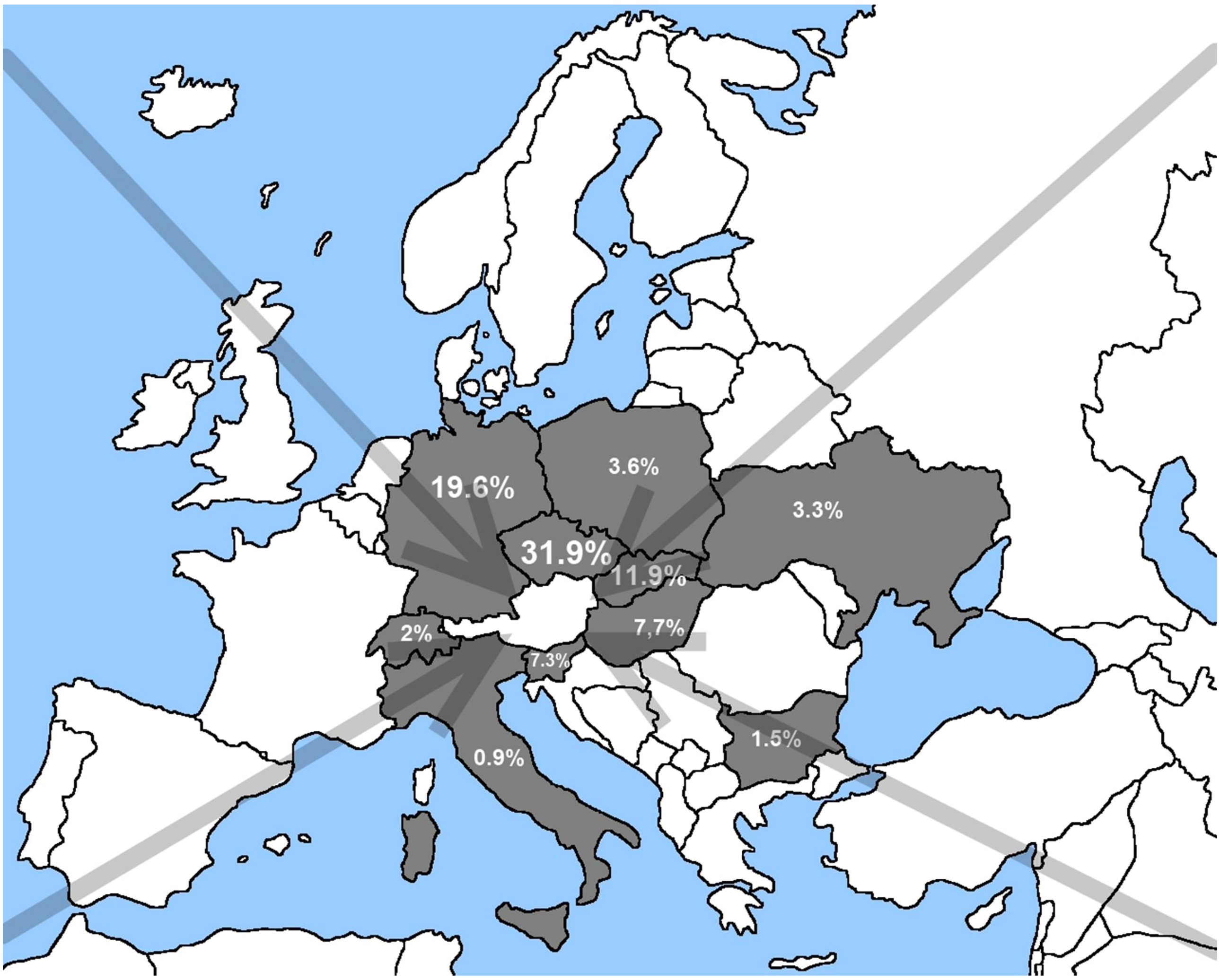
The inverse relation between domestic roundwood extractions and their imports shows that lower timber harvests are compensated by higher import rates in the Austrian economy and thus proving the before stated hypothesis wrong. High domestic extraction rates do therefore not affect the Austrian economy as a supply shock which enlarges the overall wood supply substantially for longer periods due to the application of wood fibres' cascade use potential. The maxima are rather induced by natural causes (e.g. wind damages) and consequently followed by low domestic extraction rates (due to afforestation). The enlarged domestically harvested volumes are consumed in the respective year and thus help to reduce the required import quantities of timber. Nevertheless the import volumes will need to increase subsequently – as illustrated in figure 34 – due to the consequential drop of domestic roundwood cuttings after reaching its peak, so that the domestic timber input remains at least constant. Throughout the analysed time interval mainly coniferous wood species got imported to Austria as illustrated in figure 34.

Import trade flows – 2010

The FAOSTAT provides within its forestry trade flow database information on the origins of industrial roundwood imports. Unfortunately no such data is available for wood fuel neither for overall wood imports (which would obviously allow re-tracing the origins of imported wood fuels) which is why only trade flows of industrial roundwood are discussed and analysed in this paper. Tracking the various roundwood imports is, however, a laborious task including many conceptual difficulties (e.g. due to different customs classifications) wherefore not all import flows could be re-traced by the FAO – as can be seen by the immoderate adjustment value presented inter alia in table 14. Even though the breakup of trade flows still needs further improvement their analysis is informative and roughly shows Austria's main import partners for industrial roundwood.

Table 14 presents the industrial roundwood import partners for Austria in 2010. The below listed countries are sorted in a descending order due to their reported timber flows to Austria. As can be seen in table 14, the top ten international roundwood provider for Austria were all European countries consisting of all countries sharing a border with Austria (besides Lichtenstein) and only three non-neighbouring countries – figure 35 illustrates the relations. The Czech Republic represented the most important timber provider for Austria in 2010 delivering almost a third of Austria's overall roundwood imports (31.9% of 8.04 million cubic meters). Another big fraction was provided by Germany, namely 19.6%, followed by Slovakia (11.9%) – figure 35 presents the values. This means that these three countries provided more than half (63.4%) of the roundwood fibres purchased by Austria from other economies (in 2010) wherefore the Czech Republic, Germany and Slovakia can be interpreted as the main import partners of Austria in 2010. As can be seen in figure 35, the fractions provided by Hungary and Slovenia are also of a considerable magnitude before the individual country shares drop significantly.

Figure 35: Top ten industrial roundwood import partners and import shares for Austria in 2010



Source: by author based on FAOSTAT

As already stated above, re-tracing the origin of the imported roundwood quantities is connected with several conceptual difficulties wherefore the trade flow data estimated by the FAOSTAT needed to be adjusted so that overall imports are again matching. The fraction required for adjustment is, however, not inconsiderable as it represents almost 9% of the overall timber imports to Austria in 2010 which is even more than the quantities purchased from Hungary add up for. The adjustment value represents timber flows to Austria for which the origin could not be identified which means that the origin of one out of ten roundwood imports was unknown in 2010. It is very likely that these flows are composed by purchases from several countries thus augmenting the so far estimated country shares or even bringing new countries into account. Adding the unknown import flows to their corresponding country can, however, distort the here presented picture considerably, as the adjustment value is rather high, wherefore the here presented data should only be interpreted as a rough indicator.

Table 14: Industrial roundwood import trade flows to Austria by country of origin in 2010, in 1000 m³

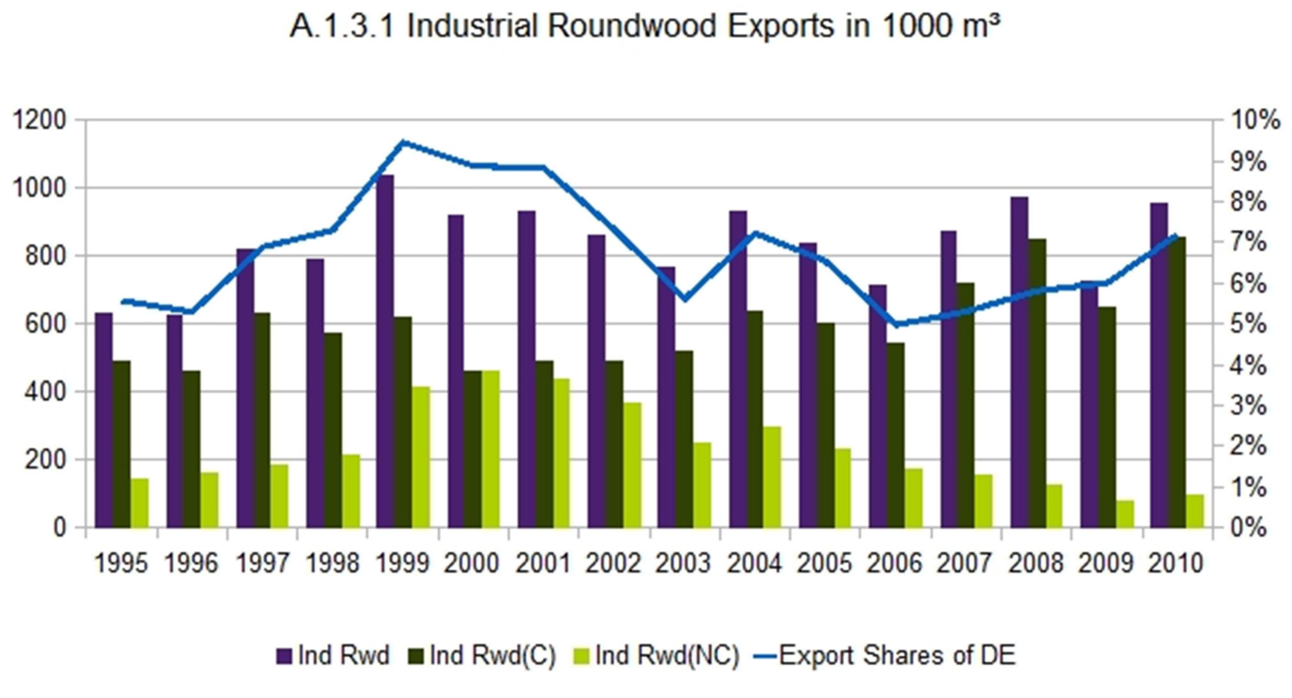
	Industrial Roundwood(C)	Industrial Roundwood(NC)	Industrial Roundwood
		in 1000 m³	
Czech Republic	2409.0	158.2	**2567.2**
Germany	1384.0	189.0	**1573.0**
Slovakia	794.0	163.0	**957.0**
Hungary	312.9	280.0	**592.9**
Slovenia	540.3	43.4	**583.6**
Poland	288.0	3.5	**291.5**
Ukraine	175.0	88.0	**263.0**
Switzerland	124.4	32.7	**157.1**
Romania	101.2	16.1	**117.3**
Italy	69.7	1.1	**70.8**
Bosnia and Herzegovina	42.3	16.5	**58.7**
Croatia	4.3	27.0	**31.3**
France	26.0	2.4	**28.4**
Estonia	11.8	0.0	**11.8**
Bulgaria	8.1	0.0	**8.1**
Denmark	6.9	0.0	**6.9**
Russian Federation	5.0	0.7	**5.7**
Finland	5.0	0.1	**5.1**
Norway	5.0	0.0	**5.0**
Belarus	4.7	0.0	**4.7**
Sweden	3.0	0.5	**3.5**
United States of America	1.0	1.0	**2.0**
Luxembourg	1.4	0.0	**1.4**
Netherlands	1.4	0.1	**1.4**
Latvia	1.0	0.3	**1.3**
Costa Rica	0.9	0.0	**0.9**
Lithuania	0.5	0.2	**0.7**
Belgium	0.1	0.1	**0.2**
Portugal	0.1	0.0	**0.1**
Spain	0.1	0.0	**0.1**
Canada	0.0	0.0	**0.0**
Unspecified	0.0	0.0	**0.0**
South Africa	0.0	0.0	**0.0**
Brazil	0.0	0.0	**0.0**
Israel	0.0	0.0	**0.0**
Others (adjustment)	372.6	317.5	**690.1**
Total	**6699.5**	**1341.2**	**8040.7**

Source: by author based on FAOSTAT

Exports

As the Austrian economy was an industrial roundwood net-importer for the here considered time span, timber exports were always of a smaller magnitude than their imports – figure 36 shows inter alia this change of magnitude. Whilst roundwood imports were ranging between 4.5 and 9.1 million cubic meters, exported volumes were only exceeding the million cubic meter mark once (in 1999). The timber fraction serving foreign trade was therefore never more than 10% of the domestically harvested volume – as illustrated by the light blue line in figure 36 representing the exported shares of the Austrian roundwood fellings (DE). On average only a fraction of 6.8% (of the domestically extracted roundwood volume) was annually destined for foreign trade in the Austrian economy. The global export quantity peak of the here considered time interval was, as already mentioned, in 1999 (1.05 million cubic meters) and the global minimum was reached with an exported volume of 625 000 cubic meters in 1996. The highest export share also took place in 1999 whereas in 2006 the domestic extraction fraction serving foreign trade reached its minimum (5%) even though the exported volume exceeded the in 1996 to other countries sold timber quantities by almost a hundred thousand cubic meters (93 000 m³). This relation can, however, be explained due to the annual changes in domestic extractions which were lower in 1996, thus yielding lower export quantities despite a higher timber export share than in 2006.

Figure 36: Exports of industrial roundwood in 1000 m³ and exported timber shares of domestic extractions for Austria from 1995 to 2010



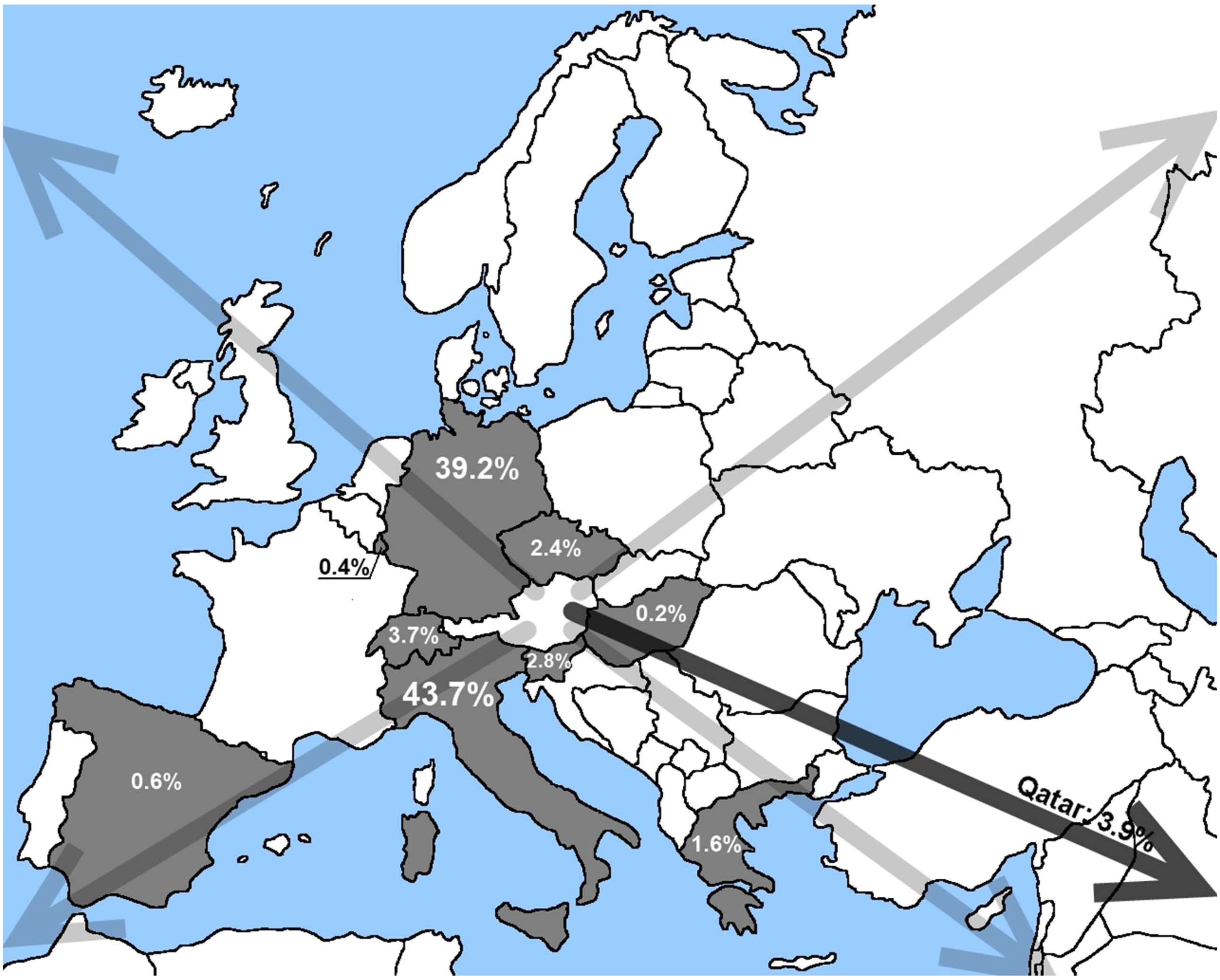
Source: by author based on FAOSTAT

Export Trade Flows – 2010

Information on the destination of industrial roundwood leaving Austria was, as for import trade flows, gathered from the FAOSTAT forestry trade flows database. As for imports, the destination of the various export flows are only presented for industrial roundwood by the FAO and connected with similar conceptual difficulties which are reflected in the immoderate volume of the adjustment value – presented in table 15. Nevertheless Austria's main timber recipients for the year 2010 are discussed in the following even though the presented results should only be interpreted as rough indicators (due to the conceptual difficulties and the consequently high adjustment value).

Table 15 presents Austria's timber recipients in a descending order for the year 2010. It can be easily seen that Italy and Germany purchased amongst all the other countries the biggest fractions of Austrian timber. Their purchased volumes added up exceeded, however, the total exported timber quantities of Austria in 2010 significantly thus indicating double counting of traded timber flows. The double counting can be induced by re-exported industrial roundwood flows not identifiable by the FAO and hence counter balanced by a considerably high adjustment value of 0.89 million cubic meters which is almost the same volume that the Austrian timber exports exhibited in 2010 (0.96 million cubic meters). Reducing the trade flows to each country by its accurate adjustment value can hence distort the results considerably wherefore the in the following presented should be interpreted with caution.

Figure 37: Top ten industrial roundwood recipients and export shares in 2010



Source: by author based on FAOSTAT

Amongst the top ten recipients for Austrian timber only one country, Qatar, is not located in Europe – figure 37 illustrates the relation. With a purchased volume of 71 350 cubic meters (in 2010) Qatar represents the third biggest purchaser of Austrian roundwood exports. Nevertheless acquisitions of Austrian timber from Germany and Italy are significantly higher and form with shares of 43.7% (Italy) and 39.2% (Germany) – not taking the adjustment value into account – the distinct top of the recipient ranking. Figure 37 presents the top ten trading partners of Austria for roundwood exports in 2010 as well as their purchased shares (not taking the adjustment value into account). It can be easily seen in figure 37 that Austria delivers almost all its neighbouring countries (except Slovakia and Lichtenstein) even though the Austrian economy also purchases timber from these countries.

Table 15: Industrial roundwood export trade flows from Austria by country of destination in 2010, in 1000 m³

	Industrial Roundwood(C)	Industrial Roundwood(NC)	Industrial Roundwood
	in 1000 m³		
Italy	733.1	73.8	**806.9**
Germany	708.3	15.6	**723.9**
Qatar	68.9	2.5	**71.4**
Switzerland	66.7	1.2	**67.8**
Slovenia	51.0	0.7	**51.8**
Czech Republic	43.1	0.7	**43.8**
Greece	29.8	0.0	**29.8**
Spain	10.0	0.1	**10.1**
Luxembourg	6.7	0.0	**6.7**
Hungary	1.8	2.3	**4.1**
Tunisia	4.0	0.0	**4.0**
Belgium	3.5	0.1	**3.6**
Saudi Arabia	3.1	0.2	**3.3**
Croatia	3.2	0.0	**3.2**
France	2.5	0.4	**2.8**
Romania	0.5	2.2	**2.7**
Japan	2.5	0.0	**2.5**
Poland	1.6	0.0	**1.7**
China	1.6	0.0	**1.6**
Sweden	1.2	0.1	**1.4**
Bosnia and Herzegovina	0.7	0.0	**0.7**
Ireland	0.6	0.0	**0.6**
Malta	0.5	0.0	**0.5**
Netherlands	0.5	0.0	**0.5**
Denmark	0.3	0.1	**0.4**
Portugal	0.4	0.0	**0.4**
United States of America	0.2	0.0	**0.2**
Slovakia	0.2	0.0	**0.2**
Belize	0.1	0.0	**0.1**
Turkey	0.1	0.0	**0.1**
Azerbaijan	0.1	0.0	**0.1**
Singapore	0.0	0.0	**0.0**
Bulgaria	0.0	0.0	**0.0**
Estonia	0.0	0.0	**0.0**
Norway	0.0	0.0	**0.0**
India	0.0	0.0	**0.0**
Lithuania	0.0	0.0	**0.0**
United Kingdom	0.0	0.0	**0.0**
Albania	0.0	0.0	**0.0**
Israel	0.0	0.0	**0.0**
Others (adjustment)	-890.7	-1.4	**-892.1**
Total	**856.1**	**98.7**	**954.9**

Source: by author based on FAOSTAT

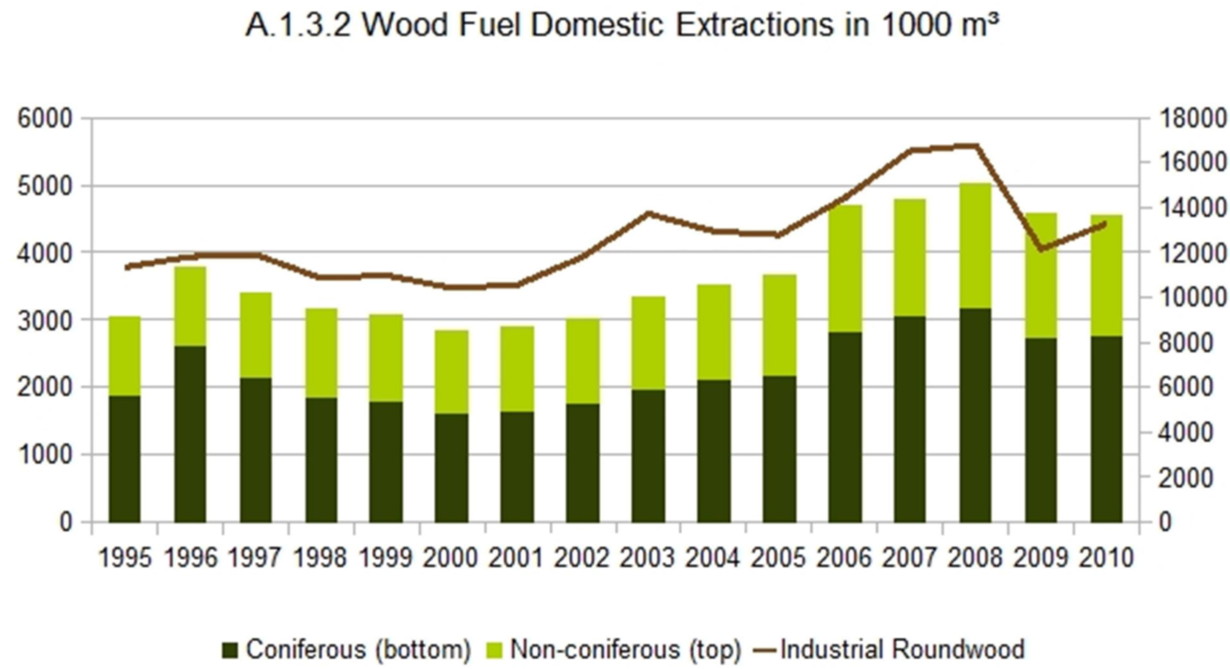
3.3.4. A.1.3.2 Wood fuel – Domestic extraction

Wood fuels comprise, within the framework of an EW-MFA, all kinds of wood fibres extracted or imported for the purpose of energy generation, hence crossing the system border entering the analysed economy (Eurostat, 2012; FAOSTAT Joint Forest Questionnaire, 2013). The common usage of industrial wood residues for the production of wood fuel is therefore not accounted for within an EW-MFA, as these wood fibre sources have already been part of the economy when being applied (Eurostat, 2012).

Nevertheless fuel wood from fresh cut fibres can and does also consist of wood residues, namely harvesting residues such as branches, rejects or trimmings (Eurostat, 2012; FAOSTAT Joint Forest Questionnaire, 2013). Hence the extraction volumes for wood fuels show a certain correlation to the extraction quantities of industrial roundwood – as illustrated in figure 38.

The brown line crossing figure 38 indicates total domestic industrial roundwood extractions (coniferous and non-coniferous) in Austria for the here considered time interval. The timber removal line is geared to the secondary ordinate, thus domestic roundwood extraction quantities can be found on the right hand side of the diagram presented in figure 38, due to the significantly higher extraction volumes of timber. The annual domestic extractions of wood fuel are illustrated by the several bars (referring each to one year) which are already split up into their coniferous (bottom) and non-coniferous (top) fractions. The magnitude of removals for wood fuel is indicated on the primary y-axis. Comparing both ordinates to each other rapidly reveals the significant change in scale between industrial roundwood removals and wood fuel extractions. Nevertheless the quantitative volumes of non-coniferous wood fibre extractions exceeded the non-coniferous removal quantities for industrial roundwood by about half a million cubic meters (on average per annum) from 1995 to 2010.

Figure 38: Domestic extractions of wood fuels in relation to industrial roundwood cuttings for Austria, in 1000 m³



Source: by author based on FAOSTAT

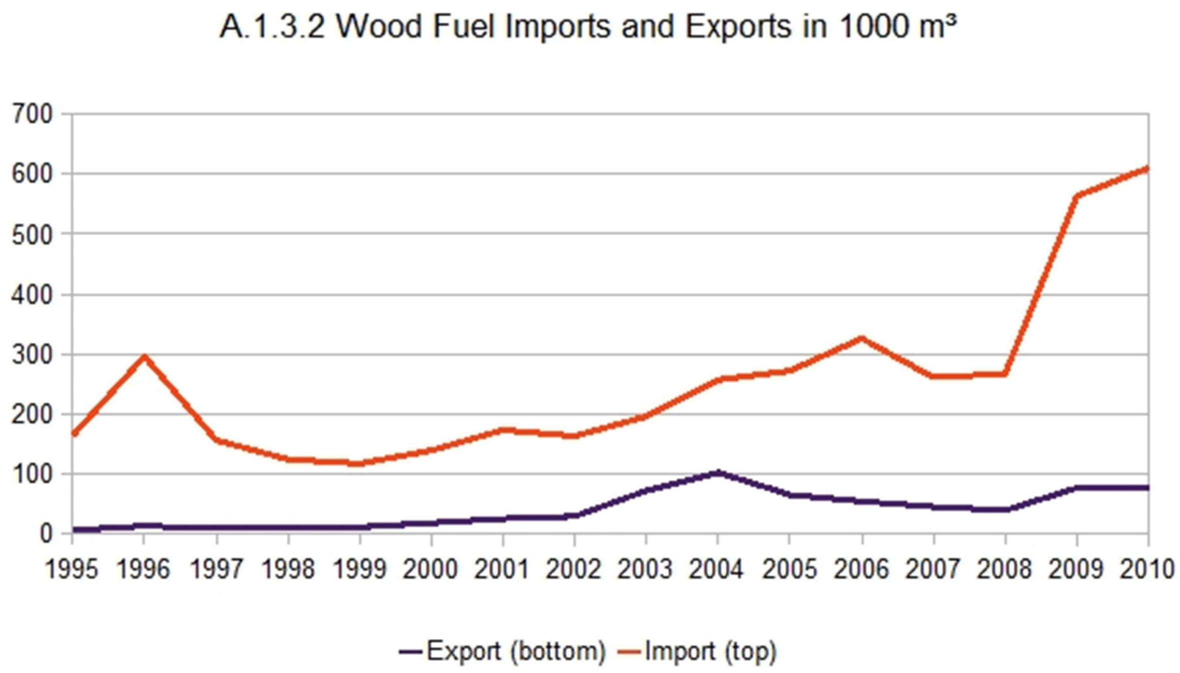
The above described correlation of wood fuel extractions to roundwood fellings can be easily observed in figure 38. The decrease of roundwood extractions until the year 2000 clearly affected the production quantities of wood fuel negatively, so that extractions for wood fuels also reached their overall minimum for the here considered time span in the year 2000 (2.86 million cubic meters). As roundwood fellings augmented in the subsequent years, cuttings for wood fuels developed likewise until the year 2008 which represented an overall maximum for both industrial roundwood and wood fuel fellings (5 million cubic meters).

Wood fuels such as pellets and briquettes are commodities suitable for long distance transport and hence international trade (Steirer F., 2009). Furthermore high market prices on fossil fuels as well as key decisions on energy and climate policies augmented the importance of renewable energy sources, wherefore commodities with formally little economic value such as wood harvesting residues witnessed an increasing demand in the recent years which is expected to continue in the near future (Steirer F., 2009). In the following it is discussed how Austria is adapting to these changes and which role the Austrian economy plays in international wood fuel trade.

3.3.5. A.1.3.2 Wood fuel – Foreign trade

Evaluating the traded wood volumes serving the wood fuel production, from and to Austria, indicates rather obviously that the Austrian economy is a net-importer of wood fuels. As for industrial roundwood, Austria was importing significantly higher volumes of wood fuel for each year within the analysed time span – figure 39 shows the relations. The exported wood fuel volumes (represented by the lower line in figure 39) were therefore below wood fuel imports (upper line in figure 39) for each year between 1995 and 2010. This indicates that the Austrian economy has so far not adjusted to the changes in the energy market, hence remaining a responder to adjustments in economy and climate policies which is to a certain degree reflected by the harsh augmentation of imported wood fuels in the year 2008. Nevertheless wood fuels can as well be produced from industrial residues or saw mill by-products, thus expanding the production quantities through the advisable application of recycled wood fibres which is not monitored by EW-MFA. A terminate description of the Austrian wood fuel market can therefore only be undertaken if recycled wood fibres are respected as well.

Figure 39: Wood fuel imports and exports for Austria from 1995 to 2010, in 1000 m³



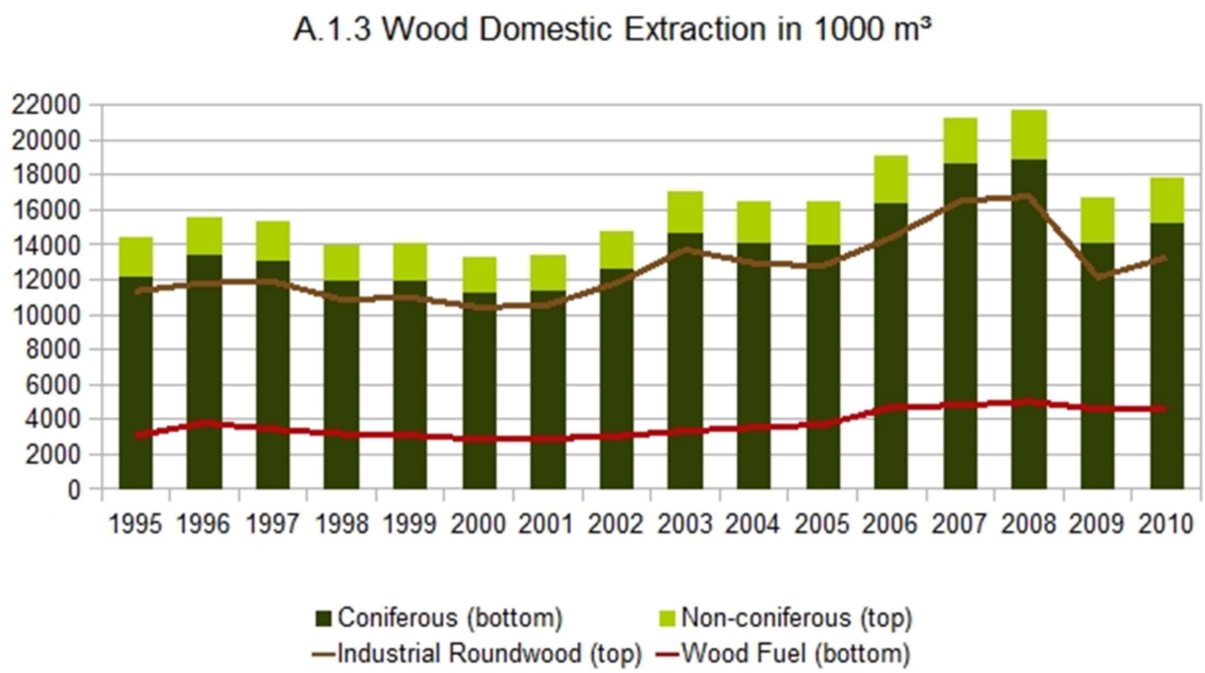
Source: by author based on FAOSTAT

Data on traded wood fuels was gathered from the FAOSTAT forestry database which does not, unlike for industrial roundwood, differentiate between wood fuels originating from coniferous and non-coniferous wood. The lack of information on the respective tree species leads to conceptual difficulties for the conversion of traded wood fuel volumes into weight due to the specific gravity of different tree species which requires the application of the respective cubic meters to metric tonnes conversion factors. The conversion of wood extractions and trade into their weight is necessary for establishing an EW-MFA of biomass for Austria, as the calculation unit for EW-MFA is metric tonnes. For composing an EW-MFA of biomass for Austria assumptions on the coniferous and non-coniferous shares of traded wood fuels need to be applied so that the respective conversion factors can be used.

Unfortunately the FAOSTAT trade statistics on wood fuel do not provide any information on import and export trade flows, as it was the case for industrial roundwood. Moreover no data on overall wood trade flows is available, which would allow re-calculating the flows corresponding to wood fuels. It is, however, known that countries such as Denmark, the Netherlands or Italy depend considerably on wood fuel imports, thus representing net-importers of wood fuels (Steirer F., 2009). On the other hand countries such as the Baltic states belong to the circle of wood fuel net-exporters (almost exporting their entire wood fuel production) wherefore it is likely that wood fuel trade streams from this region will also flow to Austria (Steirer F., 2009).

3.3.6. A.1.3 Wood – Domestic extraction

Figure 40: Domestic extractions of wood in Austria between 1995 and 2010, in 1000 m³



Source: by author based on FAOSTAT

Domestic extraction volumes of the category A.1.3 Wood consist of tree removals for industrial roundwood and wood fuel. As the fellings for these two causes developed similarly, the overall extraction rates of wood will vary likewise between 1995 and 2010. Figure 40 shows the development path of wood extractions in Austria and verifies its expected similarities, meaning that as for industrial roundwood and wood fuel also for the aggregate wood the lowest domestic extraction quantities were reached in 2000 (1.33 million cubic meters) and the maximum for the here considered time interval was reached as for the two sub-groups in 2008 (21.80 million cubic meters). The extraction volumes illustrated in figure 40 are separated between coniferous (bottom) and non-coniferous (top) wood sources. Removals of coniferous tree species represent the clear majority of felled trees in Austria for each year and consist mainly of coniferous cuttings for industrial roundwood. Domestic industrial roundwood extractions are presented in the brown line (top) in figure 40 and indicate their annual shares of the overall wood fellings in Austria. Domestic extractions for wood fuel are illustrated by the red line (bottom) in figure 40 and are clearly of a smaller magnitude than harvested timber. Nevertheless the considerable shares of non-coniferous wood extractions for wood fuel (which also exceed non-coniferous wood removals for timber quantitatively) significantly expanded the non-coniferous shares in A.1.3 Wood.

On average about 16.37 million cubic meters of wood were removed in Austria and entered the Austrian economy annually between 1995 and 2010. Overall a volume of 261.86 million cubic meters of wood was extracted in Austria throughout the analysed time span, of which 85.5% were coniferous wood species. Material flows within the framework of an EW-MFA are, however, recorded in metric tonnes wherefore the domestic wood extraction volumes need to be converted into their respective weights by applying conversion factors respecting the specific gravity of different tree species as well as the standard moisture content of 15%. The conversion factors used for the here executed survey are provided by the Eurostat EW-MFA Compilation Guide (2012) – 0.52 t/m³ for coniferous wood and 0.64 t/m³ for non-coniferous wood (Eurostat, 2012). Applying these factors yields an overall domestic wood extraction weight of 140.73 million tonnes and average annual removals of 8.80 million tonnes (which equals an amount of 168 Titanics). Due to the difference in the specific gravity of non-coniferous and coniferous wood, the shares measured from the overall extracted weights differ slightly, augmenting the shares of non-coniferous wood extractions by about 3%. Table 16 illustrates the converted extraction weights in thousands of tonnes for the years 1995 and 2010.

Table 16: Converted domestic extraction weights of wood for Austria 1995 and 2010, in 1000 tonnes

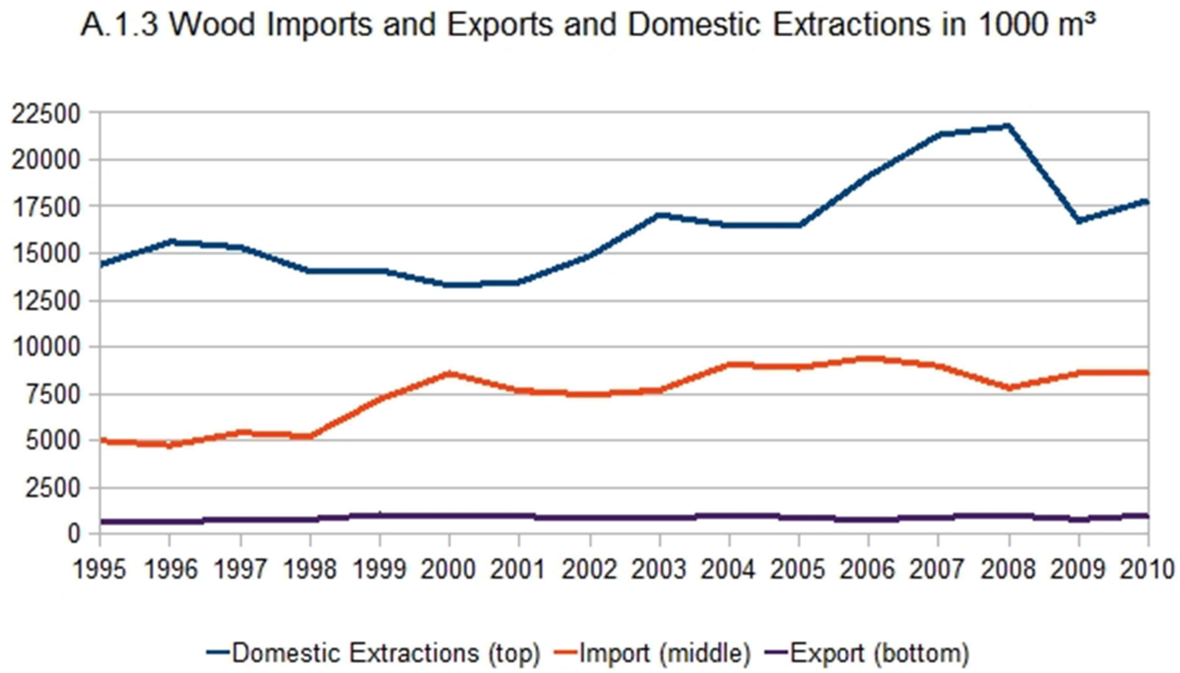
	1995	2010
	in 1000 t	
Industrial Roundwood (C)	5369.5	6522.0
Wood Fuel (C)	972.4	1432.3
Wood (C)	**6341.9**	**7954.3**
Industrial Roundwood (NC)	652.8	473.1
Wood Fuel (NC)	761.0	1148.9
Wood (NC)	**1413.8**	**1622.0**
Industrial Roundwood (C+NC)	6022.3	6995.1
Wood Fuel (C+NC)	1733.4	2581.2
Wood (C+NC)	**7755.7**	**9576.2**

Source: by author based on FAOSTAT; Eurostat, 2012

3.3.7. A.1.3 Wood – Foreign trade

Foreign trade quantities of wood are, similar to domestic wood extractions, composed by the added up import and export volumes of industrial roundwood and wood fuel. Austria was between 1995 and 2010 a clear net-importer of timber, meaning that the Austrian industrial roundwood import volumes exceeded the respective exports in each year. Furthermore timber imports developed inversely to the domestic extraction rates of Austria. Likewise for industrial roundwood, the Austrian economy represents also a net-importer of wood fuels – even though the traded volumes are at significantly lower levels than the traded volumes of timber. As Austria is importing higher fractions of wood fibres in both sectors, the overall wood fibre imports will consequently exceed the exported volumes as well for each year – as can be seen in figure 41.

Figure 41: Imports and exports of wood in relation to domestic wood extractions for Austria, in 1000 m³



Source: by author based on FAOSTAT

Due to the magnitude of timber trade flows (especially imports), industrial roundwood represents the main driving force of the Austrian wood trade, so that the development of wood imports and exports is significantly influenced by timber. It is therefore obvious that the Austrian overall wood trade behaves, likewise timber imports, inversely to the domestic extraction of wood, meaning that in years of low domestic extraction rates wood imports augment whereas for instance in 2008 wood imports decreased (as 2008 represents the maximum of domestic wood extractions for the here considered time interval). This relation can also be easily observed in figure 41 which sets the import (middle orange line) and export (bottom purple line) volumes of wood in relation to the respective domestic extraction (top blue line) quantities.

In order to integrate traded wood flows from and to Austria in an EW-MFA the respective volumes need to be converted into their weight (at the standard moisture content) respecting the specific gravity of different tree types. The conversion factors applied for adjusting the international wood flows from and to Austria are provided by the Eurostat EW-MFA Compilation Guide (2012) and the same as for converting the domestically extracted wood volumes into its weights (0.52 t/m³ coniferous and 0.64 t/m³ non-coniferous) (Eurostat, 2012). Apart from applying different conversion factors for coniferous and non-coniferous wood (so that tree type differences are at least to some degree respected) the respective coniferous and non-coniferous traded wood shares need to be known. A requirement that is easily met for industrial roundwood, as the FAO differentiates between coniferous and non-coniferous traded timber within its trade database. For wood fuel, however, such a separation is not available wherefore certain assumptions need to be established in order to convert traded wood fuel volumes into their weights.

Estimating the coniferous and non-coniferous shares of wood fuel exports is, however, a rather simple task as the respective exports got extracted in Austria and as the shares of domestically extracted coniferous and non-coniferous wood fuels are provided by the FAOSTAT. It is therefore assumed that wood fuel exports from Austria exhibit the same coniferous and non-coniferous shares as domestic extractions in the respective year. The same idea is also used for estimating the wood species shares for wood fuel imports to Austria. As the imported wood fuels needed to be extracted as well, the domestic coniferous and non-coniferous extraction shares of the respective wood fuel deliverer will define (or at least significantly influence) the tree species shares of the traded wood fuels. Unfortunately there is no trade flow data on wood fuel available wherefore the respective information on industrial roundwood is used to identify the main import trade partners of Austria. As already presented in figure 35 “Top ten industrial roundwood import partners and import shares for Austria in 2010“ wood is mainly purchased from European countries by Austria wherefore average shares of coniferous and non-coniferous wood fuels for Europe (excluding Austria) are calculated for each year and subsequently applied to the Austrian wood fuel imports. After identifying the species shares of the imported wood fuel volume and applying the respective conversion factors the traded wood fuel weights can be estimated.

As these estimations are based on assumptions they are per definition connected with inaccuracies which do not respect any kind of deviation. It is for instance possible that some countries export a higher share of coniferous wood fuels and vice versa and hence are not representing their domestic extraction shares. The same can be the case for Austria. Even though the domestic extraction shares of coniferous and non-coniferous wood fuels are rather balanced, the Austrian economy can still sell bigger fractions of coniferous wood fuels (or non-coniferous wood fuel) internationally which would in turn affect the traded wood fuel weights. In order to define a boundary for the here undertaken estimation the two extremes – all traded wood fuel is coniferous and all traded wood fuel is non-coniferous – are therefore calculated so that the estimations based on the before discussed assumptions can be set in relation.

Table 17 and table 18 present the calculated wood fibre imports and exports from and to Austria in thousands of tonnes for the years 1995 and 2010. The imported weights exceed the magnitude of exported wood fibres significantly by almost 2.4 million tonnes in 1995 and approximately 4.2 tonnes in 2010. As stated further above, overall wood trade from and to Austria is defined by the sum of wood fuel and industrial roundwood imports and exports. For the calculation of traded wood weights as presented in table 17 and table 18 the estimations on wood fuel weights based on the above stated assumptions (wood species shares of wood fuel trade represents domestic extraction shares of coniferous and non-coniferous wood) is applied. As already discussed, the difference in coniferous and non-coniferous wood shares affects the calculated weights due to their specific gravity. In order to illustrate the respective boundaries, traded wood fuel weights assuming each traded fuel got extracted from a coniferous respectively non-coniferous tree are also presented in table 17 and table 18. In 1995 wood fuel imports to Austria could vary by 19 700 tonnes according to the wood species shares and in 2010 the possible deviation was about 73 200 tonnes. Export rates from Austria were in relation to the respective imports rather low throughout the considered time span, hence the variation in traded wood fuel weights due to different wood species shares are also of a smaller scale. In 1995 wood fuel exports could vary by 800 tonnes and in 2010 by 9

100 tonnes according to their coniferous and non-coniferous shares.

Wood fibre imports augmented by about 73% from 1995 to 2010. Import quantities of industrial roundwood developed similar by approximately 66% over the considered time span. Wood fuel imports, however, grew by 368% in the same time interval. This considerable expansion indicates inter alia the raising significance and importance of renewable energy sources such as wood fuels due to constantly increasing prices for fossil fuels and political decisions towards renewable energy supply (2020 targets) (Steirer F., 2009). Furthermore this growth in wood fuel imports shows as well which position the Austrian economy is taking in this situation of change. The harsh augmentation of wood fuel imports is, however, counterbalanced by a steep increase in wood fuel exports of about 1 265%. Nevertheless wood fuel exports from Austria are of a significantly lower magnitude than their imports to Austria, as for instance the exported wood fuel weights of 2010 were less than half of the imported weights of 1995 – a year which represents times when wood fuels were still a commodity of small economic value and renewable energy of little political interest (Steirer F., 2009).

Table 17: Wood fuel imports to Austria for 1995 and 2010, in 1000 tonnes

Imports	**1995**	**2010**
	in 1000 t	
Industrial Roundwood (C)	2054.0	3483.4
Industrial Roundwood (NC)	565.8	858.4
Wood fuel (C)	25.8	114.1
Wood fuel (NC)	73.2	250.6
Wood fuel – all coniferous	*85.3*	*317.8*
Wood fuel – all non-coniferous	*105.0*	*391.0*
Wood (C)	2079.8	3597,5
Wood (NC)	639.0	1109.0
Wood (C+NC)	**2718.8**	**4706,5**

Source: by author based on FAOSTAT; Eurostat, 2012

Table 18: Wood fuel exports from Austria for 1995 and 2010, in 1000 tonnes

Exports	1995	2010
	in 1000 t	
Industrial Roundwood (C)	254.8	445.2
Industrial Roundwood (NC)	91.0	63.2
Wood fuel (C)	1.9	23.9
Wood fuel (NC)	1.5	19.1
Wood fuel – all coniferous	*3.1*	*39.4*
Wood fuel – all non-coniferous	*3.9*	*48.5*
Wood (C)	256.7	469.1
Wood (NC)	92.5	82.3
Wood (C+NC)	**349.2**	**551.4**

Source: by author based on FAOSTAT; Eurostat, 2012

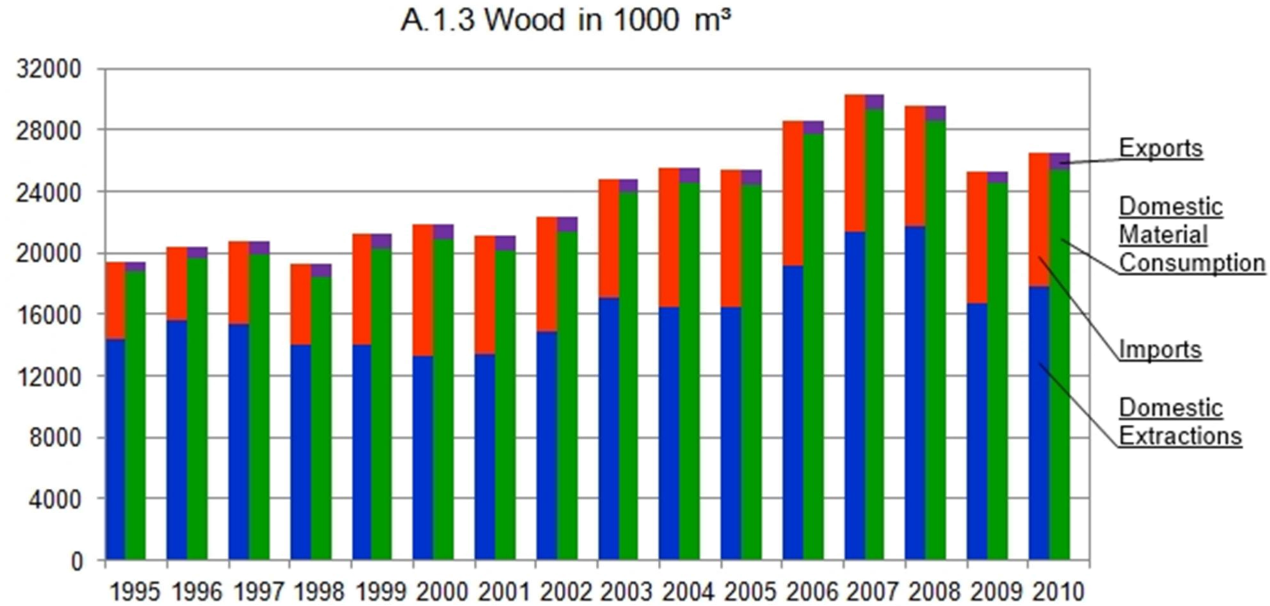
3.3.8. A.1.3 Wood – Direct Material Input and Domestic Material Consumption

Converting wood volumes into their respective weights is connected with several inaccuracies, as differences in tree types and vegetation circumstances can only be respected to a certain degree. Furthermore the estimation of traded wood fuel weights depends on assumptions concerning their coniferous and non-coniferous wood shares, which leads to further inaccuracies. For these reasons it seems advisable to first discuss the derivable EW-MFA indicators in cubic meters, before presenting the converted data (weights) for Direct Material Input (DMI) and Domestic Material Consumption (DMC) of wood for Austria from 1995 to 2010.

Figure 42 illustrates the DMI and DMC of wood for Austria in thousands of cubic meters from 1995 to 2010. The Austrian DMI of wood is represented by the stacked bars on the left hand side of each year in figure 42 and composed by domestic wood removals and imports. The DMI slightly exceeds the Austrian wood consumption which is presented by the lower part of the stacked bars on the right hand side of each year in figure 42. This small difference illustrates the rather small wood export shares of the Austrian economy, illustrated by the top part of the stacked bars on the right hand side of each year in figure 42. Focusing on domestic extractions and imports of wood indicates a certain inverse relation between the two rates while increasing totally throughout the here considered time span, meaning that a low domestic wood harvest is usually absorbed by augmented wood imports and vice versa. This relationship helps establishing a rather constant growth of overall available wood fibres. Taking a look at the DMI as presented in figure 42 indicates that before 2006 the wood input into the Austrian economy was growing rather constantly with some minor drops in 1998, 2001 and 2005. In 2006, however, domestic wood removals were increasing significantly, without a respective decrease in imports and thus augmenting the overall wood input into the Austrian economy for the subsequent years until the year 2009.

As domestic fellings are balanced by wood imports, the DMI does not exhibit the same global minimum and maximum as domestic extraction volumes for the here considered time interval. The smoothing of domestic wood harvest fluctuations by the respective imports moved the DMI

Figure 42: Direct Material Input and Domestic Material Consumption (and composing factors) of wood for Austria from 1995 to 2010, in 1000 m³

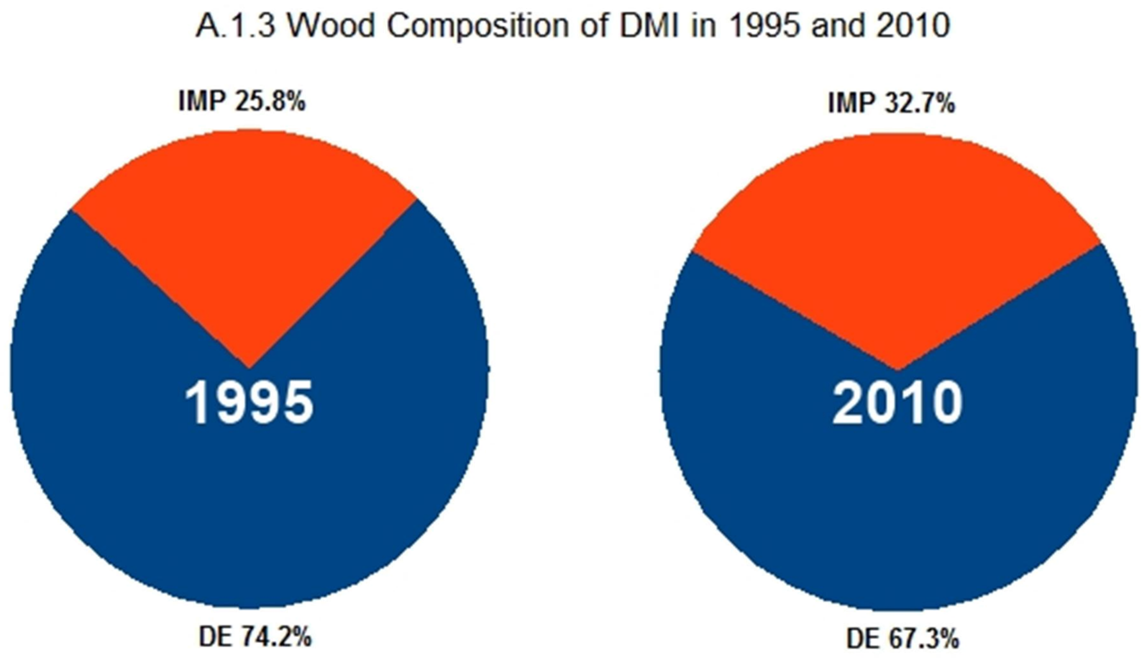


Source: by author based on FAOSTAT

minimum to the year 1998 (19.3 million cubic meters) and the maximum to 2007 (30.3 million cubic meters). From 1996 on domestic wood extractions were decreasing, experiencing, however, a rather harsh drop in 1998 which was not sufficiently counterbalanced by the imported wood volumes. From 2005 on domestic wood extractions were increasing steeper as they have ever done before (throughout the here considered time span) while import volumes remained more or less constant and hence augmenting the DMI of wood for Austria significantly. This growth reached its peak in 2007 as domestic wood cuttings developed with a lower growth rate than the previous years exhibited and import volumes were reduced in the subsequent years, thus leading to a drop of available wood fibres within the Austrian economy.

From 1995 to 2010 the direct wood input into the Austrian economy augmented from 19.4 million cubic meters in 1995 to 26.5 million cubic meters in 2010 with a variance between 19.3 million cubic meters (1998) and 30.3 million cubic meters (2003). As the DMI is composed by the added up domestic extraction and import quantities, both factors could have induced this growth. Figure 43 presents, however, the respective domestic extraction and import shares of wood for the Austrian economy and thus illustrates the driving force of the Austrian DMI for wood.

Figure 43: A.1.3 Wood, composition of DMI in 1995 and 2010 for Austria



Source: by author based on FAOSTAT

It can be seen in figure 43 that the significance of domestic wood extractions expressed by their DMI shares decreased throughout the here analysed time interval. Even though the domestic wood harvest volume augmented from 1995 to 2010 by 23.8%, imported wood volumes increased more rapidly and expanded by 73.1% from 1995 to 2010. Therefore imported wood fibres captured a bigger share in 2010, compared to the 1995 values, of the expanding direct wood input of the Austrian economy. Nevertheless domestic wood extractions still accounted for more than half (67.3%) of the DMI in 2010, hence still representing the main driving force of wood fibre input for production, export and consumption in Austria. Nevertheless the rapid increase of wood imports significantly influenced the further expansions of the Austrian DMI of wood throughout the here considered time interval.

Subtracting wood exports from the direct wood input yields the total wood supply available and applied within the Austrian economy – the Domestic Material Consumption (DMC) of wood. As Austrian wood exports were playing an insignificant role, remaining constantly at a rather low level, throughout the here analysed time interval, domestic wood consumption does not differ too much from direct wood inputs into the Austrian economy. In 1998 domestic consumption of wood also reached with an overall volume of 18.5 million cubic meters its minimum and peaked with a quantity of 29.4 million cubic meters simultaneously to the direct wood input in 2007. Domestic wood consumption was on average by 880 000 cubic meters lower than DMI of wood between 1995 and 2010, or in other words – export quantities exhibited an annual average volume of 880 000 cubic meters.

The harsh augmentation in domestic wood cuttings (especially in the last third of the here considered time span) was, however, not sufficient to cover the wood demand within the Austrian economy, wherefore wood fibres also needed to be imported. The gap between domestic extractions and domestic consumption, as presented in figure 42, shows the required import quantities in order to obtain the respective wood consumption levels. It can be easily seen that the domestic cuttings and consumption are drifting more and more apart, while the absolute domestic wood consumption and extraction volumes are growing. A relation that raises several concerns regarding sustainability and hence the future of the Austrian economy.

Infinite growth is not in the nature of a finite system. Every economy or industry is, however, embedded in the finite ecosystem of our planet and will, as long as infinite growth is the aim, sooner or later exceed the natural capacities of our ecosystem and hence participate in destroying our planet. It is therefore advisable to establish a sustainable and more or less constant level of domestic wood consumption, thus following a logistic growth path as exhibited by any natural system on our planet, while successively reducing domestic extractions, which represent with an annual average volume of 16.4 million cubic meters (two million cubic meters per capita) already a considerable magnitude. A reduction in domestic wood removals (without adversely affecting domestic wood consumptions) can, however, only be achieved by using wood fibres accordingly to their potential, hence improving cascade use and the recycling stream of wood. Wood is a highly versatile resource exhibiting a high cascade use potential, which makes the direct extraction of wood for wood fuels more than inadvisable (Mantau U., 2010).

Apart from the ecological perspective and strategies – that influence the lives of future generations on this planet – the economic aspect of the Austrian wood industry's development also raises concerns. The era of cheap fossil fuels is ending, leading to severe problems in covering the energy demand (especially of industrialised economies). The steadily growing prices for fossil fuels increase, however, the significance of backstop technologies, which are getting more and more affordable due to raising costs in the application of fossil fuels. As humanity is to a certain extend aware of the effects from today's decisions for future generations, new means of satisfying the energy demand will have to be renewable and embedded in our ecosystem (so that mistakes undertaken by previous generations will not be made again). Due to the characteristics of the Austrian landscape – Austria is neither significantly exposed to the sun nor exhibits big open or coastal areas for centrally organized large scale wind energy generation (covering considerable shares of today's excessive energy use in Austria) – biomass (next to hydro-energy) forms the central energy carrier serving a sustainable energy generating system in Austria. 30.8% of the Austrian energy supply was generated from renewables of which 39.4% were generated from biomass (and 39.5% from hydro-energy) in 2010 (Biermayr P., 2011).

The raising dependence on wood imports in Austria is therefore concerning. Wood fuels such as pellets and briquettes will experience rising global importance on international markets in the near future as they represent commodities that can be conveniently transported over long distances (as well as due to high prices for fossil fuels) (Steirer F., 2009). Apart from the energetic use, wood fibres are on the verge of entering the textile and chemical market, hence (further) increasing the pressure on woody biomass (Steirer F., Mantau U., 2009; Persas T., Mensink M., 2011). Binding oneself to wood imports will therefore affect one's future position in these emerging industries drastically. Taking a look at the Austrian physical trade balance of wood, which can be extracted from the difference between export and import quantities illustrated in figure 42, indicates that the Austrian government in cooperation with the wood harvesting and processing sector needs to divert its course by 180° in order to benefit from future changes in the wood market and to achieve the European Union's 2020 renewable energy targets not only in the short-run.

Means to decrease the dependence on wood imports without negatively affecting the domestic wood consumption and to achieve the 2020 targets with a long-term perspective – hence establishing a more sustainable wood supply – are to improve the recycled wood streams as well as using wood fibres according to their potential (cascade use). Implementing these two strategies helps extending the domestic wood supply, thus reduces the required import quantities and therefore decreases Austria's dependence on wood imports. Furthermore these simple and obvious strategies contribute in establishing a sustainable economy which does not trim or adversely affect the possibilities of future generations, as an improved reuse of wood fibres contributes in slowly reducing domestic wood extractions (without lowering the DMC thereby). Trying to achieve one's 2020 obligations – Austria needs to expand the renewable energy shares to 34% in 2020 (30.8% in 2010) – by expanding domestic extractions and imports of wood obviously countervails the within the EU's 2020 targets intended sustainability improvement of the EU member states' economies.

Expanding domestic extraction quantities by the respective import amounts yields the magnitude of the Direct Material Input of an economy. Subtracting the exports from the DMI yields the Domestic Material Consumption of an economy. As wood flows are measured in volumes, the respective flows needed to be converted into their weights so that wood flows can be included in the here executed EW-MFA for Austria. Tables 17 and 18 presented already the respective wood weights. Setting these quantities in relation yields the DMI and DMC of wood for Austria expressed in tonnes – as can be seen in table 19.

Table 19: Domestic Extractions (DE), Imports (IMP), Exports (EXP), Direct Material Input (DMI = DE + IMP) and Domestic Material Consumption (DMC = DMI - EXP) of wood for Austria for 1995 and 2010, in 1000 t

	1995	2010
	in 1000 t	
DE Industrial Roundwood	6022.3	6995.1
DE Wood Fuel	1733.4	2581.2
DE Wood	**7755.7**	**9576.3**
IMP Industrial Roundwood	2619.8	4342.1
IMP Wood Fuel	99.0	364.7
IMP Wood	**2718.8**	**4706.8**
EXP Industrial Roundwood	345.7	508.4
EXP Wood Fuel	3.4	43.0
EXP Wood	**349.1**	**551.4**
DMI Industrial Roundwood	8642.1	11337.2
DMI Wood Fuel	1832.4	2945.9
DMI Wood	**10474.5**	**14283.1**
DMC Industrial Roundwood	8296.4	10828.8
DMC Wood Fuel	1829.0	2902.9
DMC Wood	**10125.4**	**13731.7**

Source: own calculations based on FAOSTAT; Eurostat, 2012

3.4. A.1 Biomass

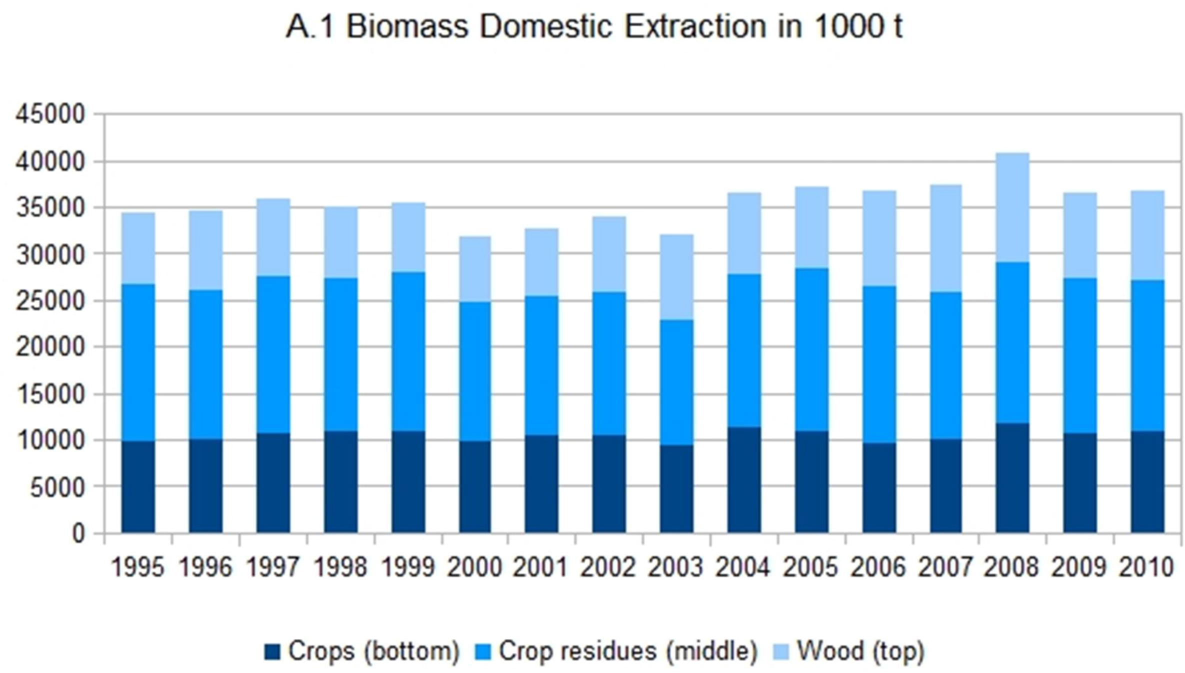
Category A.1 Biomass represents within this survey all crop, crop residues, fodder crops, grazed biomass and wood flows to and from Austria – domestic extractions, imports and exports. As already mentioned in chapter 2. Method – Economy-wide Material Flow Accounts the two digit sub-group A.1.4 Wild Fish Catch, Aquatic Plants/Animals, Hunting and Gathering was, due to its insignificance for the here executed survey, not accounted for and thus is not included in category A.1 Biomass here.

In the following the domestic extraction, import and export quantities of the by sub-group A.1.4 reduced category A.1 Biomass are presented. The respective material flows are presented in metric tonnes and thus connected to certain inaccuracies due to the conversion of wood flows. After presenting domestic extraction, import and export weights, the DMI and DMC of biomass are presented and discussed.

3.4.1. A.1 Biomass – Domestic Extraction

Domestic extractions of the EW-MFA category A.1 Biomass are composed by domestic crop harvests, the applied fraction of the thereby accruing crop residues, fodder crop harvests, grazed biomass uptake by the livestock and wood removals from the forest entering the analysed economy. Hence annual domestic biomass extraction quantities equal the added up annual extraction weights of the EW-MFA categories – A.1.1 Crops, A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass and A.1.3 Wood – presented above. As already mentioned in chapter , domestic extraction quantities of crop residues, fodder crops and grazed biomass exhibited amongst the three analysed categories (A.1.1, A.1.2 and A.1.3), with annual average harvests of 16.2 million tonnes, the highest extraction values for Austria from 1995 to 2010. Thus category A.1.2 significantly influenced the level of biomass extractions in Austria and accounted on average for 45.6% of the annual domestic biomass extractions. Nevertheless crop and wood harvests exhibited with annual average extraction weights of 10.6 million tonnes of crops and 8.80 million tonnes (16.37 million cubic meters) of wood considerable magnitudes. Domestic crop extractions accounted therefore, on average for about 29.7% of overall biomass harvests per year and wood extractions formed almost a fourth (24.7%) of the annual biomass extractions in Austria. Figure 44 presents the annual biomass extraction levels for Austria from 1995 to 2010 and illustrates their respective crops, crop residues (used), fodder crops and grazed biomass, as well as wood shares.

Figure 44: Domestic biomass extractions for Austria from 1995 to 2010, in 1000 t



Source: by author based on FAOSTAT; Eurostat EW-MFA database; Eurostat, 2012

In 2008 biomass extractions in Austria were peaking with an overall weight of about 40.8 million tonnes – as presented in figure 44. In the same year domestic crop and wood harvests were also exhibiting their highest extraction quantities between 1995 and 2010. Hence the simultaneous maximum of domestic crop and wood harvests augmented total biomass extractions significantly, as domestic crop and wood production account together for almost 55% of annual biomass extractions in Austria. Between 1995 and 2010 domestic biomass extractions reached their lowest level with an overall weight of approximately 32 million tonnes in 2000. Three years later the Austrian biomass harvest was again close to its minimum with an overall weight of about 32.1 million tonnes. From 1996 to 2000 domestic wood removals were dropping, reaching their lowest level (for the here considered time span) in 2000. From 1999 to 2000 domestic crop extractions were also decreasing considerably, only slightly exceeding their minimum value of 2003. The same accounts for crop residues (used), fodder crops and grazed biomass which experienced a harsh drop in 2000, but were experiencing yet another significant decrease in 2003. Hence the minimum in domestic wood removals as well as the rather low extraction values of crops and applied crop residues, fodder crops and grazed biomass induced the minimum of domestic biomass extractions in 2000. The minimum in crop as well as crop residues, fodder crops and grazed biomass extractions let domestic biomass harvests decrease once again in 2003 and would have let them drop below their minimum level of 2000 if wood removals were not augmenting significantly in 2003.

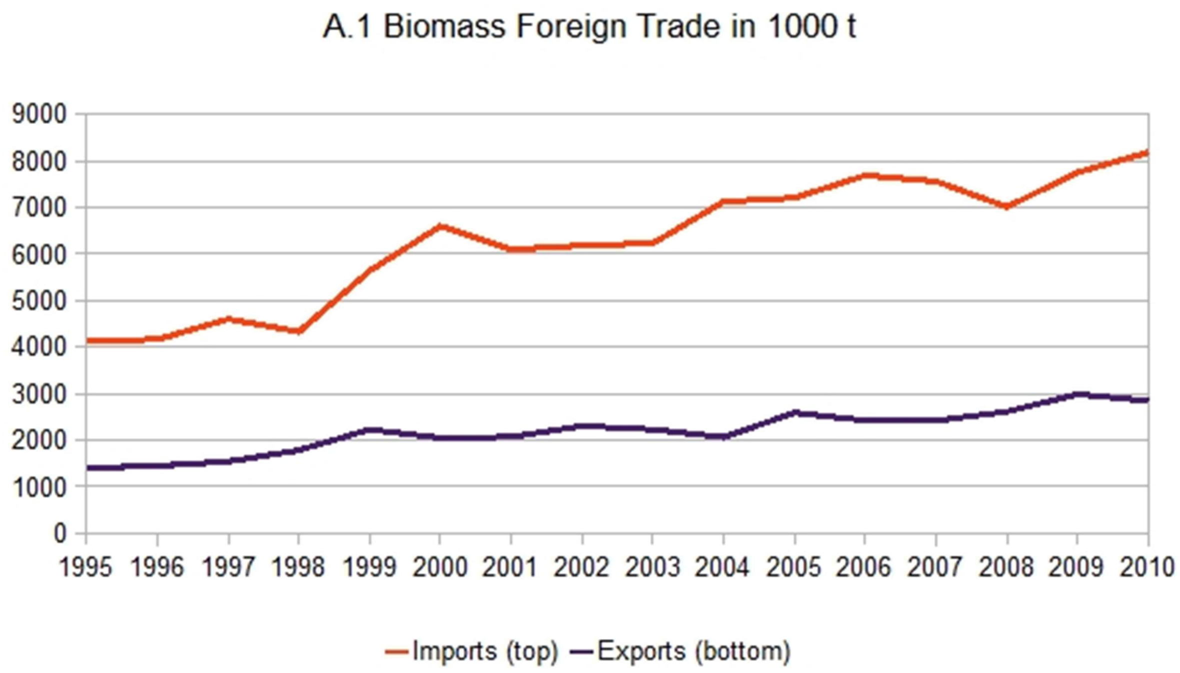
On average about 35.6 million tonnes of biomass got annually extracted in Austria, with an annual average growth rate of 0.4%, between 1995 and 2010. The main driver of biomass extractions in Austria represents the category A.1.2 as crop residues (used), fodder crops and grazed biomass exhibited the highest extraction shares (on average 45.6% p.a.) throughout the here considered time span. Nevertheless applied crop residues, fodder crops and grazed biomass weights developed rather constantly (even decreased slightly) between 1995 and 2010. Hence category A.1.2 is responsible for a considerable fraction of domestic biomass extractions but did not induce any further growth or acceleration of domestic biomass harvests. The expansion of biomass extractions in Austria was therefore triggered off by the (between 1995 and 2010) growing crop and wood extractions. Domestic crop extractions exhibited annual average growth rates of about 0.7% and wood even of 1.4% for the here considered time span, which makes wood the main accelerator of biomass extractions in Austria.

3.4.2. A.1 Biomass – Foreign trade

Similar to domestic biomass extractions, foreign trade of biomass is composed by the import and export flows of crops, applied crop residues, fodder crops and wood. Amongst those three two digit sub-groups (A.1.1, A.1.2, A.1.3) wood exhibited the largest foreign trade volumes from and to Austria between 1995 and 2010. The magnitude of wood trade was varying between 0.35 million tonnes and 5.08 million tonnes. Besides wood, trade quantities of crops formed also a considerable fraction of total biomass trade, but were with a foreign trade interval from 0.88 million tonnes to 3.21 million tonnes clearly of a lower scale than wood flows from and to Austria. Unlike for domestic biomass extraction, crop residues (used) and fodder crops were only making up small shares of biomass trade flows, varying only between 0.12 million tonnes and 0.31 million tonnes. Hence wood, and to a notable extend also crops, can be identified as the main driving forces of absolute biomass foreign trade.

Besides crop residues (used) and fodder crops, imports to the Austrian economy (of wood and crops) were exceeding the respective export quantities in each year throughout the here considered time span. Hence the Austrian economy was a net-importer of biomass from 1995 to 2010 – as can be seen in figure 45. On average about 4.08 million tonnes of foreign wood was entering the Austrian economy annually, whereas on average only 0.49 million tonnes of wood got exported per year from 1995 to 2010 – yielding an average annual physical trade imbalance of 3.59 million tonnes. A similar relation can also be observed for crop trade, even though the physical trade imbalance is of a significantly smaller magnitude. About 1.99 million tonnes of crops were on average annually imported to Austria from 1995 to 2010. Annual average exports accounted, however, for about 1.48 million tonnes – hence exhibiting annual average trade imbalances of about 0.51 million tonnes. Applied crop residues and fodder crop exports were, on the other hand, exceeding the respective import amounts on average by about 6 000 tonnes (average annual imports 0.21 million tonnes and exports 0.22 million tonnes) per year, but of a too small scale to impact total biomass trade considerably. Hence biomass imports exceeded biomass exports in each year throughout the here considered time interval.

Figure 45: Imports and exports of biomass to and from Austria between 1995 and 2010, in 1000 t



Source: by author based on FAOSTAT; Eurostat EW-MFA database; Eurostat, 2012

On average about 6.29 million tonnes of foreign biomass was entering the Austrian economy per annum, developing from their lowest level of 4.15 million tonnes in 1995 to their highest value of 8.19 million tonnes in 2010 and thus exhibiting a constant augmentation throughout the here considered time interval. On the other hand biomass exports accounted on average for about 2.19 million tonnes per annum varying between 1.41 million tonnes (1995) and 2.99 million tonnes (2010). Biomass imports were therefore exceeding biomass exports by on average about 4.1 million tonnes in each year. In 2010 the physical trade imbalance of biomass was peaking with imports exceeding exports by about 5.35 million tonnes, In 1996 import and export rates were (for the here considered time interval) closest to each other yielding a physical trade imbalance of 2.72 million tonnes.

As can be seen in figure 45, foreign trade of biomass was experiencing a significant growth from 1995 to 2010. On average biomass imports were augmenting by about 4.6% per annum and exports by even 4.8% p.a.. Comparing these values to annual domestic biomass extraction growth rates, which were about 0.4%, indicates a significantly steeper augmentation of foreign trade than domestic harvests of biomass and thus a considerably quicker expansion of import shares in the direct biomass input of the Austrian economy – which is analysed and discussed in detail in the following section.

Amongst the three categories composing biomass trade, crops exhibited the steepest foreign trade growth. Crop imports were on average increasing by about 6.2% per annum and the respective exports by about 5.7%. Hence foreign trade of crops represented the main accelerator of additional biomass trade flows from and to Austria. Crop residues (used) and fodder crop imports were also rising considerably by on average 5.6% per annum, whereas the respective exports augmented rather slowly with an average growth rate of 2.9%. Wood trade, which exhibited the biggest shares in absolute biomass trade, was growing rather slow with annual average import and export growth rates of about 3.7% and 3.1%. Bearing, however, the magnitude of traded wood in mind, shows that wood trade has still a considerable impact on the expansion of biomass trade, even though exhibiting the lowest growth rates.

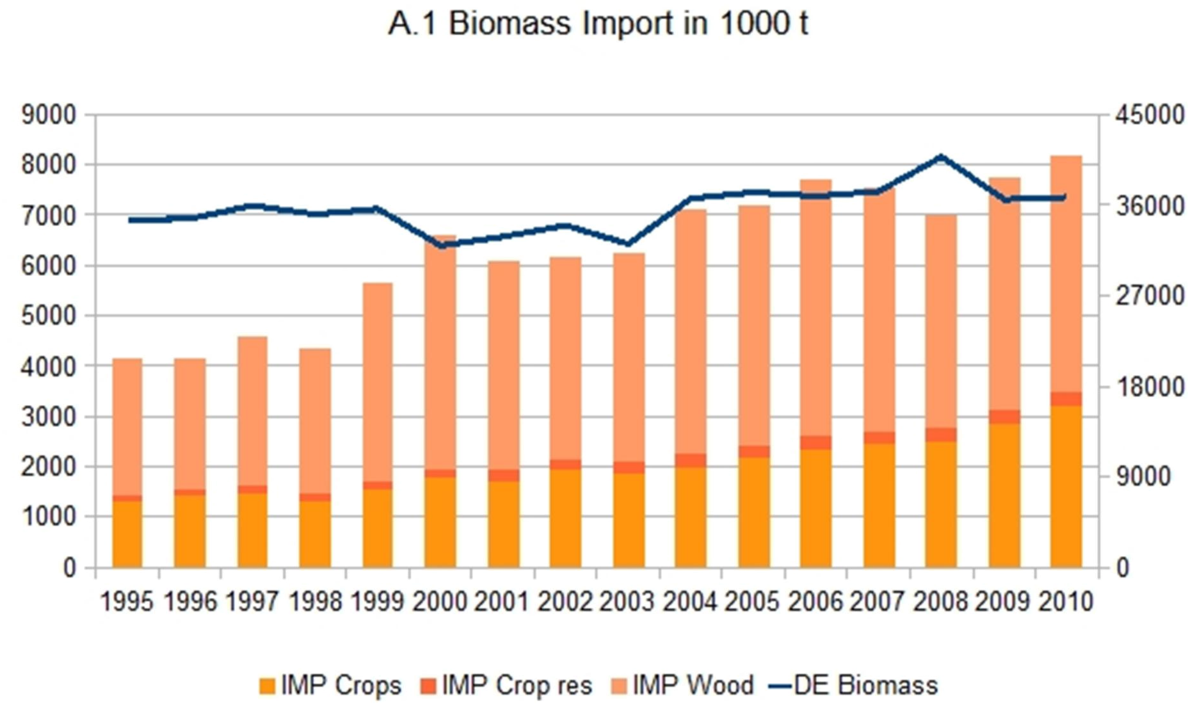
High foreign trade growth rates are in general not concerning, especially if they develop likewise. Austria exhibited, however, a rather big physical trade imbalance of biomass between 1995 and 2010 – as can be seen in figure 45. Under these circumstances similar import and export growth rates are to a certain extend concerning, as they are not contributing in reducing the physical trade gap of the Austrian economy. Hence Austria will remain to a certain and constantly expanding extend dependent on the foreign trade of biomass. Due to the European Union's 2020 targets on renewable energy, as well as the constantly increasing prices on fossil fuels, biomass will play a central role in the near future especially in industrialised economies (Steirer F., 2009). Thus not tackling the trade imbalance of biomass but rather letting the gap between biomass imports and exports increase – as presented in figure 45 – will adversely affect the economic and political position of Austria in the near future. The harsh augmentation of the observable biomass trade imbalance can be set in relation to the European Union's 2020 targets. As biomass is due to the characteristics of the Austrian landscape the most promising and therefore central renewable energy resource for Austria to achieve augmenting the renewable energy share by 3.2% until 2020 – from 30.8% (in 2010) to 34% (2020) (Mantau U., Steirer F., 2007; Biermayr P., 2011). Intending, however, to achieve this goal by increasing biomass imports and domestic extraction quantities, countervails clearly the hidden agenda of improving sustainability of the European Union member state's economies in the course of the EU's 2020 targets.

Imports

Between 1995 and 2010 about 6.29 million tonnes of biomass were on average imported to the Austrian economy in each year, reaching the maximum with an overall import quantity of 8.19 million tonnes in 2010 and "starting" at their respective minimum of 4.15 million tonnes in 1995. Hence biomass imports exhibited a rather constant growth throughout the here considered time interval with some minor drops in 1999, 2001, 2007 and 2008. On average imports were augmenting by about 4.6% per annum between 1995 and 2010.

Figure 46 presents the annual biomass import quantities to Austria for the here considered time interval. Biomass import is composed by imported crops, straw, fodder crops and wood. The bars in figure 46 representing annual biomass import are therefore divided into the respective shares of crops, straw and fodder crops, and wood imports. Biomass import quantities are geared to the primary (left) ordinate in figure 46, hence import quantities are presented on the left y-axis in figure 46. Besides biomass import domestic biomass extractions are also illustrated in figure 46. Due to the significant difference in the magnitudes of biomass imports and the respective domestic extractions, domestic biomass harvests are geared to the secondary (right) ordinate, hence harvest quantities can be extracted from the right-hand y-axis in figure 46.

Figure 46: Import of biomass separated into the composing factors and domestic biomass extractions for Austria from 1995 to 2010, in 1000 t



Source: by author based on FAOSTAT; Eurostat EW-MFA database; Eurostat, 2012

Analysing the development of biomass imports with regard to their annual domestic extraction quantities shows a rather inverse relation. From 1995 to 1999 domestic biomass extractions remained on a rather steady level with some minor peaks or drops which were countervailed by biomass imports in the respective subsequent year, indicating a lagged inverse relation of biomass imports and their domestic extractions for the first third of the here considered time span. In 2000 biomass harvests in Austria were decreasing significantly by about 3.7 million tonnes. Biomass imports were simultaneously augmenting by about a million tonne and thus partly absorbing the harsh drop in domestic biomass extractions. In 2001 domestic biomass harvests were augmenting by about 0.9 million tonnes. Due to the growth in domestic harvests, biomass imports were reduced by about half a million tonne in 2001. Two years later biomass extractions were significantly dropping again. Import adjustments came, however, delayed, namely in the subsequent year of 2004, into effect, indicating a rather unexpected drop in domestic biomass harvests. In 2008 domestic biomass extractions were peaking and simultaneously biomass imports dropped significantly. In the subsequent years biomass extractions remained on a rather constant level whereas biomass imports continued growing.

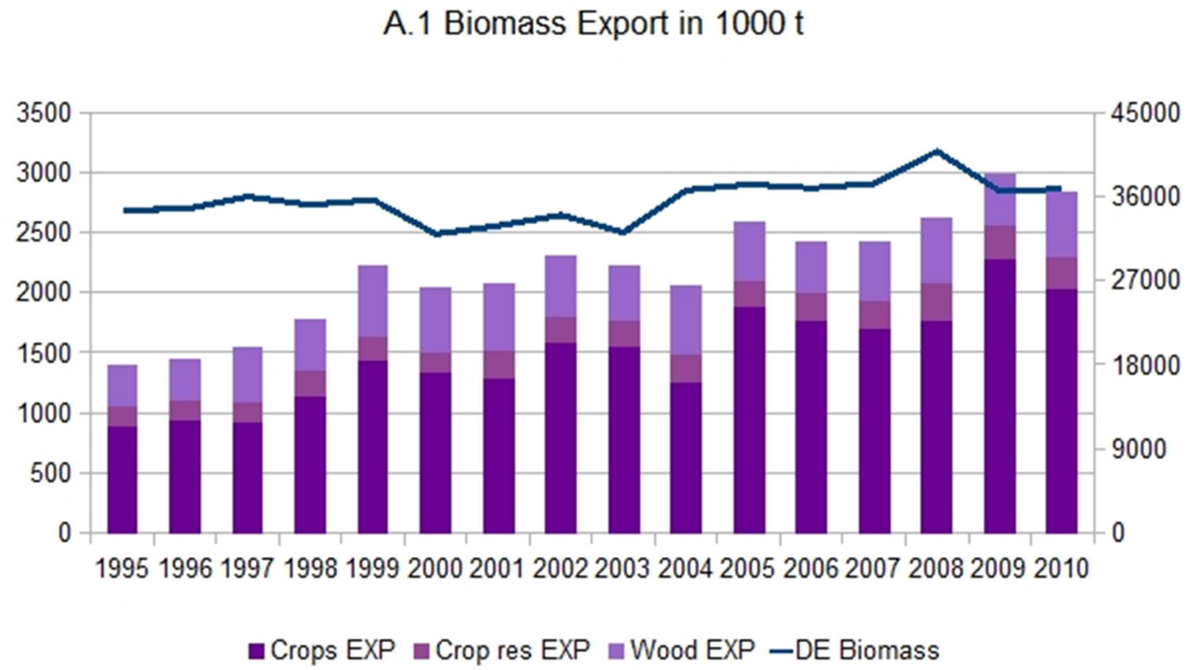
On average about 65.1% of the overall biomass import was composed by imported wood fibres, making wood imports the main driving force of biomass imports. Figure 46 illustrates the relation. The upper section of the annual biomass import bars in figure 46 represents wood imports to the Austrian economy. It can be easily observed that wood imports exceeded crop and straw and fodder crop imports in each year, even though crop imports exhibited a steep growth throughout the here considered time interval – as can be seen in the lower section of the annual biomass import bars in figure 46. The harsh growth of crop imports led to a significant augmentation of crop import shares in the annual biomass import quantities, so that in 2010 almost 40% of the overall biomass import was composed by crop imports. On average crop imports accounted for about 31.5% of the annual biomass import volume. Straw and fodder crop imports on the other hand exhibited rather low quantities from 1995 to 2010. Nevertheless they experienced a steep increase in relative terms, expanding straw and fodder crop imports significantly – but still on a rather low level, as presented by the middle section of the annual biomass import bars in figure 46.

Exports

On average about 2.19 million tonnes of biomass got annually exported from Austria between 1995 and 2010, which is only about a third of the annual average biomass import volume to Austria – indicating once more the considerable physical trade imbalance of the Austrian economy. In 2009 biomass exports from Austria peaked with an overall weight of 2.99 million tonnes and exhibited their respective minimum with 1.41 million tonnes at the beginning of the here considered time interval in 1995. In comparison to biomass imports, exports did not increase as constantly. Nevertheless developing with an average annual growth rate of 4.8%.

Figure 47 presents the development of biomass exports from Austria between 1995 and 2010. As for biomass imports, biomass exports are composed by the annual exported crop, straw and fodder crop, as well as wood quantities. The bars in figure 47 illustrate annual biomass exports which are separated into their composing categories. The magnitude of annual biomass exports can be extracted from the primary ordinate in figure 47. Besides biomass exports, domestic biomass extractions are also presented in figure 47. Domestic biomass extractions are represented by the blue line in figure 47, which is geared to the secondary ordinate due to significant different magnitudes of biomass exports and harvests. Biomass exports from Austria were developing between 1.41 million tonnes and 2.99 million tonnes whereas domestic biomass harvests were varying between 31.97 million tonnes and 40.8 million tonnes.

Figure 47: Export of biomass separated into the composing factors and domestic biomass extractions for Austria from 1995 to 2010, in 1000 t



Source: by author based on FAOSTAT; Eurostat EW-MFA database; Eurostat, 2012

Between 1995 and 2010 biomass exports developed in general likewise to domestic biomass extractions, even if delayed in some years. From 1995 to 1999 biomass exports were, however, significantly increasing at rather constant domestic harvests. A development which was possible due to the rather insignificant biomass export levels accounting for only 4% of overall domestic harvests until 1999. From 1999 to 2000 domestic biomass extractions were decreasing by about 3.7 million tonnes. In order to absorb the domestic harvest losses biomass imports were considerably augmented by about a million tonne. Additionally biomass export quantities were reduced by about 0.2 million tonnes to contribute in absorbing the drop in domestic biomass extractions. In 2002 biomass harvests were almost reaching their 1999 levels again, thus biomass exports from Austria were increasing as well. In 2003, however, harvests were dropping again wherefore biomass exports were adjusted accordingly in the same and the subsequent year. After the drop in 2003, domestic biomass extractions increased rapidly again, exceeding average biomass harvests by about 1.1 million tonnes in 2004. Biomass exports developed likewise, but delayed by a year hence augmenting significantly in 2005. In 2008 biomass extractions were peaking (for the here considered time span) triggering again augmented biomass exports in the subsequent year off, wherefore biomass exports reached their maximum with 2.99 million tonnes in 2009.

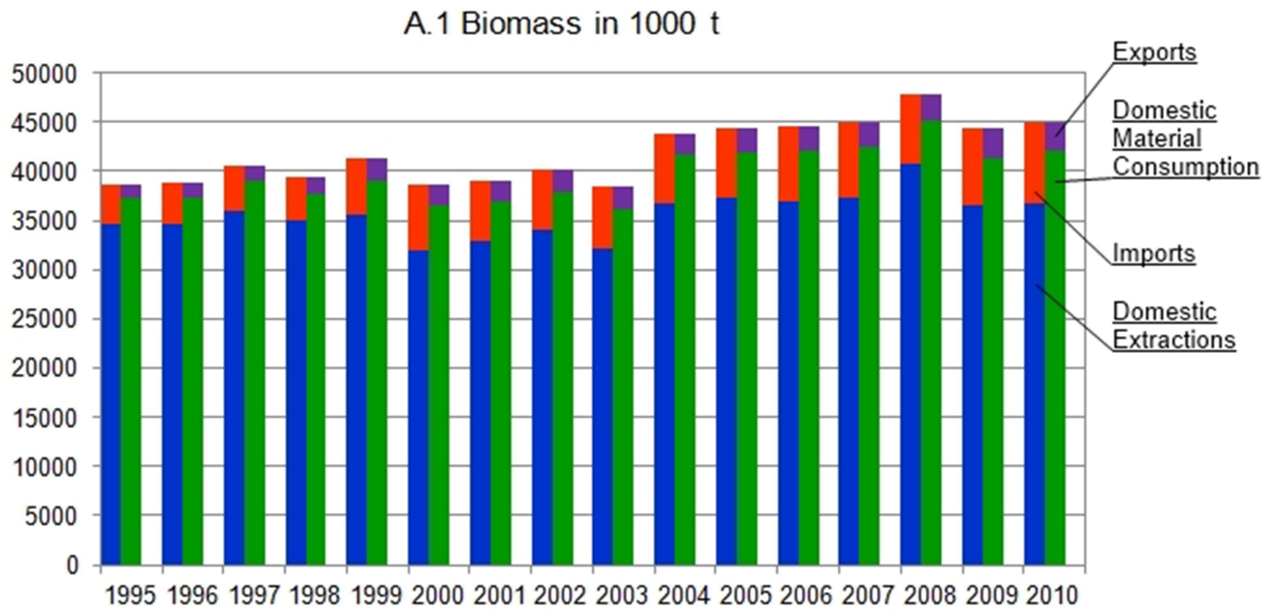
As can be seen in figure 47 crop exports – represented by the lower section of the annual biomass export bars – formed the clear majority of biomass exports in each year between 1995 and 2010. On average about 66.8% of the annual biomass exports were composed by crops. Crop exports even expanded their respective shares throughout the here considered time span. In 1995 about

62.9% of overall biomass exports were crops, whereas in 2010 crop exports accounted for 71.2%. In 2009, when biomass exports were peaking, crop exports composed 76.2% of the overall exported weight. Bearing in mind that biomass exports were doubling from 1995 to 2010, shows that crop exports expanded significantly and thus represent the main driving force of biomass exports for the here considered time interval. The remaining (average) third of biomass exports was consequently composed by wood and straw and fodder crop exports, of which on average 22.9% were annual wood exports and 10.3% straw and fodder crop exports. As can be seen in figure 47, wood and straw and fodder crop exports expanded their export volumes in absolute terms as well. Wood exports were developing with an annual average growth rate of 3.1% and straw and fodder crop exports increased by 2.9% on average. Crop exports, on the other hand, exhibited a significantly higher growth rate of on average 5.7% per annum. Crop exports developed therefore more rapidly than biomass exports did on average (4.8% per annum), making crop exports also the main accelerator of biomass export growth.

3.4.3. A.1 Biomass – Direct Material Input and Domestic Material Consumption

Setting domestic biomass extractions and their respective foreign trade flows in relation, as presented in chapter 2.3. Derivable indicators, yields the EW-MFA indicators Direct Material Input (DMI) and Domestic Material Consumption (DMC). Figure 48 presents the annual magnitudes of direct biomass input and domestic biomass consumption of Austria from 1995 to 2010. Furthermore the EW-MFA indicators composing factors – domestic extractions, imports and exports of biomass – are also presented in figure 48. The stacked bars on the left hand side of each time interval in figure 48 represent the Austrian Direct Material Input of biomass and thus consist of domestic biomass extractions and imports – as indicated in figure 48. The right bars of each time interval in the figure below are composed by domestic biomass consumption and exports (as illustrated in figure 48) and thus equal direct biomass input in each year, as DMC equals DMI minus exports. From 1995 to 2010 the Austrian biomass consumption exceeded domestic biomass harvests by on average 4.1 million tonnes in each year. Furthermore the magnitude of biomass consumption in Austria augmented more rapidly than biomass extractions throughout the here considered time interval, hence inducing a growth in biomass imports, as can be seen by the composition of the Austrian direct biomass input represented by the left hand side stacked bars in figure 48. As biomass exports from Austria did not expand significantly from 1995 to 2010, the growth in biomass imports additionally widened the physical biomass trade imbalance of the Austrian economy – as presented by the difference between export and import shares illustrated in figure 48. In the following the Austrian direct biomass input, domestic biomass consumption as well as the physical trade of biomass are discussed in detail.

Figure 48: Direct Material Input and Domestic Material Consumption (and composing factors) of biomass for Austria from 1995 to 2010, in 1000 t



Source: by author based on FAOSTAT; Eurostat EW-MFA database; Eurostat, 2012

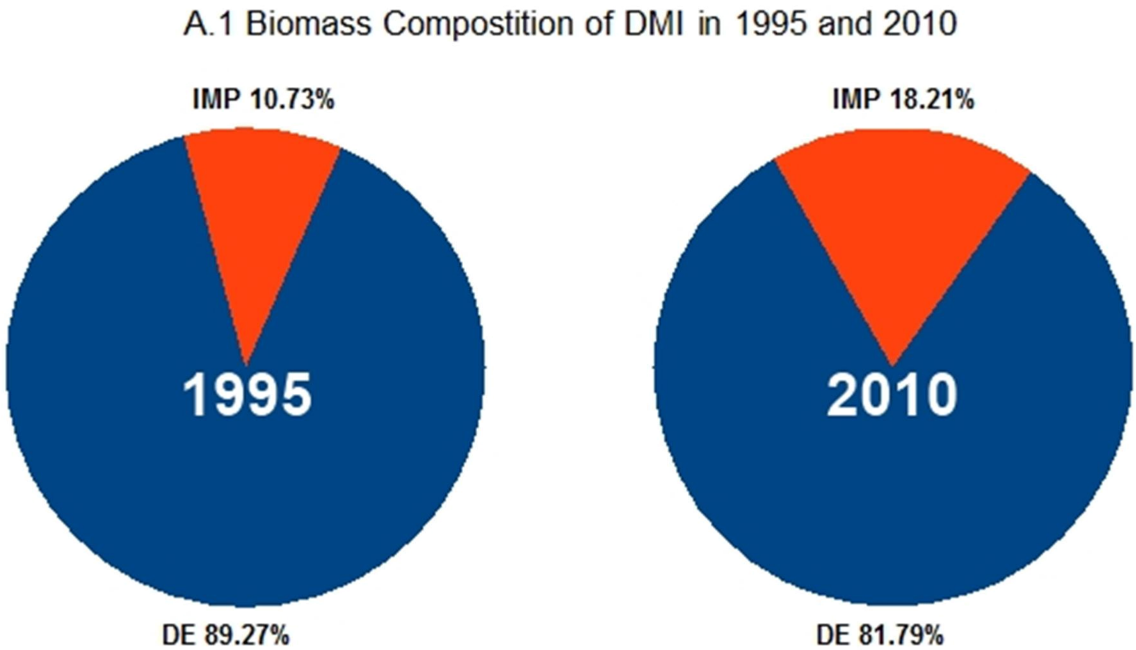
Direct biomass input was of a slightly higher magnitude than domestic harvests from 1995 to 2002. On average DMI of biomass exceeded domestic biomass extractions by about 5.22 million tonnes per annum, indicating rather low import fractions of the Austrian direct biomass input from 1995 to 2002. From 2003 on biomass imports experienced a significant growth due to a considerable increase in wood and crop imports. Hence domestic biomass inputs were exceeding domestic harvests considerably by on average 7.35 million tonnes per annum from 2003 on. From 1995 to 2010 domestic biomass extractions were by about 6.29 million tonnes (annually on average) lower than the respective DMI.

Annual direct biomass inputs accounted on average for about 41.85 million tonnes between 1995 and 2010. Similar to domestic biomass extractions the Austrian DMI of biomass exhibited its lowest values in 2000 and 2003, but unlike domestic harvests the overall DMI minimum (for the here considered time span) was reached with a weight of 38.37 million tonnes in 2003. In 2000 domestic biomass inputs were, however, exceeding the 2003 value by only 0.2 million tonnes (38.57 million tonnes in 2000). As discussed in the previous chapters 3.4.1. A.1 Biomass – Domestic Extraction and 3.4.2. A.1 Biomass – Foreign trade, domestic harvests were dropping significantly in 2000. Nevertheless the losses in domestic biomass production were partly absorbed by augmented import volumes and a reduction in exports in the same year. In 2003 domestic crop and applied crop residues, fodder crop and grazed biomass extractions were decreasing significantly, but the respective foreign trade quantities were not adjusted in the same year but rather in the subsequent year of 2004 – as can be seen in figure 48. Hence the domestic extraction drop of 2003 was not absorbed by properly adjusted foreign trade volumes in the same year and thus lead to the lowest DMI value from 1995 to 2010.

In 2008 direct biomass inputs were peaking with an overall weight of 47.81 million tonnes due to the peak in domestic biomass extractions. From 1995 to 2010 the DMI of Austria augmented from 38.69 million tonnes to 44.98 million tonnes varying, however, between the lowest value of 2003 (38.37 million tonnes) and the respective maximum of 2008 (47.81 million tonnes). On average direct biomass inputs were growing by about 1% per annum, exhibiting a steeper growth than domestic biomass harvests (0.4%). DMI growth was therefore significantly influenced and accelerated by the rather fast augmenting import rates of biomass to Austria which exhibited an annual average growth rate of about 4.6%. Making biomass imports the main driving force in the further expansion of DMI flows between 1995 and 2010.

Nevertheless domestic biomass harvest quantities clearly exceed biomass imports to Austria in each year and thus representing significantly bigger shares in the composition of annual direct biomass inputs. Hence domestic biomass harvests were the main driving force for DMI flows from 1995 to 2010. Figure 49 illustrates the discussed relation for the time interval boundaries 1995 and 2010. In 1995 domestic harvests accounted for 89.3% of direct biomass inputs whereas biomass imports formed only a significantly smaller fraction (the remaining 10.7%). Due to the steep growth of biomass imports, their respective DMI shares were expanding throughout the here considered time interval and leading to a considerable DMI share of almost a fifth in 2010. Bearing in mind that direct biomass inputs augmented by about 6.29 million tonnes from 1995 to 2010, indicates that biomass imports expanded significantly within the here analysed time interval. Nevertheless domestic biomass extractions were still forming, with a share of 81.8% in 2010, a considerable fraction of the Austrian DMI and thus still representing the clear driving force of DMI flows. Even though the respective domestic harvest shares were decreasing throughout the here considered time span and thus indicating an under average growth compared to the average annual DMI increase of 1%.

Figure 49: Composition of direct biomass input of Austria in 1995 and 2010



Source: by author based on FAOSTAT; Eurostat EW-MFA database; Eurostat, 2012

Subtracting biomass exports from the respective DMI yields domestic biomass consumption (DMC) of Austria. As export quantities of biomass from Austria were rather low between 1995 and 2010, the DMC does not differ much from the DMI for the here considered time interval. On average direct biomass inputs exceeded domestic biomass consumption by about 2.19 million tonnes per annum from 1995 to 2010 – representing the annual average export quantity of biomass leaving the Austrian economy. As biomass exports remained rather constantly on a low level throughout the here considered time span, domestic biomass consumption developed similar to DMI of biomass and thus exhibiting the respective minimum and maximum in the same years. Domestic biomass consumption was therefore peaking with an overall weight of 45.19 million tonnes in 2008 and dropped to its lowest value of 36.13 million tonnes in 2003. From 1995 to 2010 the DMC of biomass in Austria augmented by 4.85 million tonnes from 37.28 million tonnes to 42.13 million tonnes and exhibited an average annual growth rate of 0.8%.

Domestic biomass consumption of Austria exceeded the domestic biomass harvests in each year between 1995 and 2010 – as illustrated in figure 48. Biomass consumption was annually on average by about 4.1 million tonnes above domestic biomass extractions in Austria throughout the here considered time span. Furthermore DMC of biomass exhibited a faster growth (0.8% p.a.) than domestic harvests (0.4% p.a.) did, letting domestic biomass consumption and domestic biomass extractions drift further apart – as can be seen in figure 48. In 1995 the difference between DMC and domestic harvests accounted for 2.74 million tonnes whereas 5.35 million tonnes were separating biomass consumption and extractions in Austria in 2010. The arising and steadily growing gap between the Austrian biomass consumption and harvests needed to be filled by steadily augmenting imports. Biomass imports were with an annual average growth rate of 4.6%

significantly growing throughout the here considered time span. As the difference between DMC and domestic biomass extractions was annually widening from 1995 to 2010 – indicating a certain trend for the near future – biomass imports will consequently need to further increase in the near future and thus augmenting the dependence of the net-importer Austria on biomass imports.

Connecting the net-importer role of Austria to the European Union's 2020 targets on renewable energy, as well as to constantly increasing costs of fossil fuels and emerging technologies especially in the application of wood fibres, raises several concerns. The Austrian government agreed to expand the Austrian renewable energy share to 34% in 2020 (Mantau U., Steirer F., 2007). In 2010 30.8% of the Austrian energy supply was generated from renewable sources, of which hydro-power plants accounted for 39.5% and biomass for 39.4% (Biermayr P., 2011). Due to the characteristics of the Austrian landscape (neither significantly exposed to the sun nor exhibiting big open or coastal areas for wind energy) and the unbalanced cost-benefit relation of newly erected hydro-power plants, biomass forms the most promising renewable energy source for achieving the aspired renewable energy share expansion of almost 4%. The importance of energy crops as well as of wood fuel for the Austrian economy could already be observed by the harsh domestic extraction and/ or import growth of maize, wheat, sugar crops, rapeseed, soybeans or palm oil which clearly represented the main driving forces and accelerators of domestic crop extractions and imports of and to Austria from 1995 to 2010. Apart from these crops, of which all can be applied for the production of certain biofuels, cuttings of wood serving energy purposes as well as their respective imports were augmenting considerably throughout the here considered time span – what leads to the conclusion that Austria is trying to achieve its 2020 targets by burning fresh cut crops and wood fibres and thus indicating a rather short-term strategy. Expanding domestic or international biomass extractions (through augmented import levels) clearly countervails improving the sustainability of industrialised economies, interlinked and intended by the European Union's 2020 targets. Austria is rather trying to find an alternative to satisfy their domestic energy demand at moderate costs, due to the constantly increasing prices on fossil fuels, disregarding the global impact of this short-term strategy and perspective, than undertaking efforts in creating a more sustainable economy.

Apart from countervailing the improvement of a sustainable economy and adversely affecting our ecosystem by the application of fresh cut crops and wood fibres in the generation of energy and heat, Austria is also negatively affecting its own position in international competition by steadily increasing the net-imports of biomass. Pressure on biogenic materials is expected to further grow in the near future, due to increasing fossil fuel prices, renewable energy targets of the European Union and the improvement in the application of biomass and especially wood fibres (Steirer F., 2009). Wood fibres are for instance on the verge of entering the textile and chemical market, which increases specially the demand of high quality, hence fresh cut, wood fibres (Steirer F., Mantau U., 2009; Persas T., Mensink M., 2011). Relying on steadily augmenting biomass imports can therefore confront the Austrian economy with high costs for their energy supply in the near future, as fresh harvested or cut fibres will experience an increase in their demand due to new technologies for the application of biogenic materials. Taking a look at the Austrian physical trade imbalances of biomass from 1995 to 2010 – which can be extracted from the difference between export and import quantities illustrated in figure 48 – raises several concerns and drastically modifies the observed Austrian strategy of achieving the 2020 targets, indicating the short-term perspective of obtaining the Austria's 2020 obligations. On average the physical trade imbalance of biomass was growing by about 4.6% per annum, augmenting from imports exceeding exports by 2.74 million tonnes in 1995 to a difference of 5.35 million tonnes in 2010. Bearing in mind that the 2020 targets are not reached yet, a further increase in the Austrian physical trade imbalance is to be expected.

As already pointed out several times throughout this thesis, biogenic materials possess a certain cascade use potential, which if employed expands the available biomass supply significantly. Biofuels, biogas and processed wood fuels such as pellets and briquettes can also be gained from plant and wood residues, liquid manure and/or organic waste (Lichtblau G., Pölz W., Stix S., Winter R., 2012; Umweltbundesamt Austria, 2013b). The employment of this cascade use potential requires an improvement of recycling streams, so that still applicable biomass can enter the supply-side once again. Improving recycling streams obviously increases the sustainability of an economy, as less material needs to be extracted (domestically or globally) to satisfy the DMC. This represents, however, a strategy with a rather long-term perspective and obviously higher investment costs today but also higher benefits for the future. Discounting these benefits, however, lets short-term strategies as the one Austria is following, unfortunately, appear more appealing today than avoiding high costs for energy supply of future generations and help reducing the depletion of our ecosystem. An annual average per capita biomass consumption of about 4.88 tonnes from 1995 to 2010 or a per capita consumption of 5.03 tonnes in 2010 should, however, be alarming enough.

Economy-wide Material Flow Accounts revisited

Economy-wide Material Flow Accounts are, like Air Emission Accounts, Energy Accounts or Water Accounts, part of Environmental Accounts, which are inter alia undertaken by the Eurostat and the European Union member states. Environmental Accounts help monitoring the links between the environment and economy, e.g. the use of raw materials, resource efficiency, impacts of economic activities or our lifestyle on the environment, etc. (Eurostat, 2012, Eurostat, 2013). The Beyond GDP initiative, attempting to generate appealing indicators such as the GDP but also including environmental and social-aspects of human well-being, boosted the attention assigned to Environmental Accounts (Eurostat, 2010). EW-MFA and the thereof derivable Domestic Material Consumption and Direct Material Input indicators represent promising alternatives for generating appealing social-wealth indicators, which lead to further developments of the method and its application within the European Union. EW-MFA measures, roughly describing, the material flows crossing the system boundaries into and from the analysed economy. As the aim of this thesis is to measure the emergence as well as the Direct Material Input and Domestic Material Consumption of biomass in Austria between 1995 and 2010, the EW-MFA framework (especially the input flows side) appeared to be rather suitable for achieving the stated target.

The aim of undertaking an EW-MFA is to derive appealing indicators, such as the DMC and DMI. Material flows into an economy, even if the analysis is reduced to biomass flows only, comprise several different materials which all need to be reduced to a common denominator, in order to sum all flows up and calculate the desired appealing indicators. Hence all material flows must be converted into the same accounting unit before entering the EW-MFA framework which monitors material flows in their weights. Materials which are not recorded in their respective weights need therefore to be converted, as it is the case for wood. Wood is an essential input, as presented in this thesis, representing on average about a third (31.1%) of the annual domestic biomass consumption in Austria. Converting wood extractions, imports and exports, however, from the recorded volumes into their respective weights induces inaccuracies distorting the EW-MFA results and indicators. The volume to weight relation of a tree differs significantly due to the tree species, as well as due to the region the tree was growing. Hence a complete and detailed set of wood volume to weight conversion factors is required to minimize inaccuracies, but yet not available. The thereof accruing impreciseness is therefore accepted in order to derive appealing social-wealth indicators. Nevertheless the Eurostat provides in their 2012 EW-MFA Compilation Guide wood volume to weight conversion factors differing at least between coniferous and non-coniferous tree species and already raised their concerns towards the lack of a complete conversion factor set in their 2001 EW-MFA Methodological Guide (Eurostat, 2012; Eurostat, 2001). Before being able to convert wood volumes into weight, however, the tree species and origin of each wood fibre crossing the system boundary needs to be known, which is unfortunately not the case for traded wood fuel, as presented in this thesis. Assumptions needed therefore to be applied in order to convert the respective flows and thus further expanding the inaccuracies and distortions of the appealing DMC and DMI indicators.

For analysing the biomass flows into the Austrian economy and calculating the DMI and DMC of biomass, only the input-side of the EW-MFA method (besides exports in order to measure the DMC) needed to be employed – thus monitoring only the biomass flows crossing the system boundary into the economy (besides exports). Biomass possesses, however – as pointed out several times throughout this thesis – a certain cascade use potential and thus can be applied more than once. Employing the cascade use potential of biomass contributes therefore in expanding the DMC without additional domestic extractions, imports or reduced export quantities. Thus monitoring the cascade use of biomass – following the material flows after crossing the system boundary into the economy – is significantly insightful. It helps in analysing if the cascade use potential of the applied biomass is properly employed or if for instance fresh cut or harvested biomass serves directly for the generation of energy or heat, which does not allow any further application of the used material. An EW-MFA provides therefore information on the material flows entering and leaving an economy, but does not help answering if our level of material consumption is sustainable. Nevertheless, constantly growing extractions and import quantities, as observed for biomass flows in Austria from 1995 to 2010, do not suggest a sustainable development.

During the research on wood flow data, the by the EUwood team developed method of a Wood Resource Balance (WRB) was found. A WRB is an attempt to confront wood fibre inputs into an economy to their respective applications within the analysed economy. It therefore continues tracking wood flows after crossing the system boundary defined by the EW-MFA framework. WRB help in analysing the cascade use factor of wood within an economy and thus present information on recycled wood quantities as well as the application of industrial wood residues (saw mill by-products, from pulping, etc.). The accounting unit is in cubic meters of solid wood equivalents, measuring the wood volumes flowing from one sector to another. WRB have been established by the EUwood team for the EU-27 for the years 2005 and 2007. As this thesis is serving a survey regarding biomass extraction and application in Austria (within the FLIPPR Project), an attempt is undertaken in the following survey to generate a WRB for Austria between 2005 and 2010 (based on the results presented here and by the EUwood team for the years 2005 and 2007). In a further attempt the development of at least the framework for a similar resource balance monitoring crops and crop residues from 2005 and 2010, is also undertaken in the subsequent survey.

4. Conclusion

An Austrian citizen consumed on average about 4.88 tonnes of fresh cut biomass per annum, which resembles a daily average consumption of 13.4 kilograms from 1995 to 2010. On a daily basis an Austrian citizen required about 4 kilograms of fresh harvested crops, 5.3 kilograms of crop residues, fodder crops and grazed biomass and 4.5 kilograms of fresh cut wood in 2010. This equals an average biomass consumption of an Austrian citizen of 13.8 kilograms per day (in 2010) which exceeded the EU 27 average by about 4.8 kilograms in 2010. An average EU 27 citizen was therefore consuming about 9 kilograms of biomass per day in the same year, of which 3.5 kilograms were composed by fresh harvested crops, 3.9 kilograms by crop residues, fodder crops and grazed biomass and only 1.6 kilograms by wood. The per capita crop and crop residues consumption in Austria was only slightly exceeding the per capita EU 27 consumption. Fresh cut wood, on the other hand, got at considerably higher levels – 2.9 kilograms per capita per day – domestically consumed in Austria than on average in the EU 27 in 2010.

The amongst industrialised economies excessive Domestic Material Consumption – as illustrated above – of biomass in Austria paired with significant and expanding physical trade imbalances of crops and wood, which are however required to stimulate the Austrian biomass consumption, are alarming. Industrialised economies should exhibit decreasing or at least constant levels of material extraction, as these economies have already undergone the exponential growth and the thereby interlinked exponential increase of material extraction and consumption. The next logical step in the development of an economy is therefore the transition from an industrialised economy to a sustainable one, as an exponential growth is only feasible as long as natural capacities and the boundaries of our ecosystem tolerate and permit such a development path. Consequentially the exponential growth and material extractions of industrialised economies need to be throttled so that our economic system does not exceed the capacities of our ecosystem. The today observable exponential material consumption of industrialised economies needs therefore to be diverted into a logistic growth path which goes along and resembles the development of natural and hence sustainable systems within our ecosystem.

Throughout the here undertaken EW-MFA biomass survey of the Austrian economy the opposite was, however, observable from 1995 to 2010. Biomass extractions in Austria were increasing throughout the here considered time interval. In some years the domestic extraction quantities of crops or wood or crop residues dropped, wherefore the reduced biomass flows got to a certain extend absorbed by foreign trade and thus foreign extractions induced by Austria. A development from an industrialised economy with high and constantly increasing material extractions towards a sustainable economy could, at least for biomass, not be identified for the Austrian economy from 1995 to 2010.

Sustainability and especially covering the, due to employing fossil fuels, considerably high energy demand of industrialised economies via renewable energy sources experienced a boost in the political agenda of the affected countries, such as the EU 27 member states, in the recent years. If the increased attention assigned to renewable energy sources are a consequence of the steadily decreasing global fossil fuel supply and thus the increasing fossil fuel prices or an intention of improving sustainability amongst industrialised economies, is a matter of perspective. Fact is, however, that the European Union decided to augment their renewable energy share to 20% in 2020. Austria contributes in achieving this ambitious target by expanding the national renewable energy share to 34% in 2020. In 2010 about 30.8% of the Austrian energy supply was composed by renewables, of which the biggest shares were generated by hydro-power plants (39.5%) and biomass (39.4%) (Biermayr P., 2011). Wind or solar power were with 2.1% (wind) and 2% (solar) of lesser importance for the 2010 renewable energy fraction in Austria (Biermayr P., 2011). Due to the characteristics of the Austrian landscape wind or solar power exhibit only a small potential for the future energy supply of Austria. The benefits of erecting additional hydro-power plants is in no relation towards their respective social-costs, wherefore biomass represents the most promising renewable energy source for Austria. The renewable energy share expansion of 3.2% from 2010 to 2020 will therefore be mainly accomplished by the application of biomass. Throughout this paper significantly increasing extraction and import quantities of these biogenic energy carriers such as maize, palm oil, soybeans, rapeseed or wood fuel of and to Austria were observed, indicating a rather short-term strategy for achieving the 2020 renewable energy target. Augmenting the renewable energy share implicates improving sustainability which is, however, countervailed if extraction quantities (domestic or abroad) are further expanding therefore. Thus it can be presumed that Austria only tries to find an affordable alternative to fossil fuels without paying attention to the global and long-term effects of its actions.

A first step in improving sustainability and in achieving the respective 2020 target is to rethink today's energy use of industrialised economies. Furthermore the obsolete material stock within an economy represents as well a pool of economically valuable and applicable resources. A better employment of these resources contributes therefore in reducing material extractions and thus relieves our ecosystem to a certain extend. Especially within the controversial agenda of biofuels the employment of recycled biogenic materials plays a central role, as burning fresh cut or harvested biomass in order to generate energy and thus serve the excessive energy consumption of industrialised economies is devastating. Apart from letting post-consumer biogenic materials re-enter the supply stream of an economy, the application of biomass, and especially wood, is interlinked with the production of several residues accruing during processing which of course can be reused for different causes. If fresh cut wood enters the saw mill industry a certain fraction, depending on the applied technology, will become a residue accruing while processing. These by-products' fibres still possess the quality of fresh cut wood and thus can be re-applied in various ways – for instance in the production of panel boards or of pulp. Pulping yields another interesting by-product, namely black liquor, which can be applied for energy or heat generation. Panel boards will, after they have been used, re-enter the supply stream as recycled post-consumer wood and can for instance serve the pellet production for the generation of energy or heat. Hence an extracted biogenic material does not only augment the material supply of an economy by its respective weight or volume. It rather expands the material supply of an economy by a multiple of its respective weight or volume, due to the degree of cascade use.

Data on post-consumer wood for the EU 27 are presented in “Management of Recovered Wood” (COST E31, 2007) and “Wood Processing Strategy” (COST E44, 2008) and provided by the European Co-operation in the Field of Scientific and Technical Research (COST), the Joint Wood

Energy Enquiry (JWEE, 2007) and the Eurostat database for waste wood. These data got cross-checked by the EUwood task force with studies (BioXchange, 2005) on post-consumer wood per capita in Germany and the Netherlands (Leek N., 2010). Within these surveys post-consumer wood quantities of the EU member states were estimated for the year 2007. Overall about 1.12 million cubic meters of post-consumer wood were available within the Austrian economy in 2007 (Leek N., 2010; COST E31, 2007; COST E44, 2008). Of these 1.12 million cubic meters about 45% (0.5 million cubic meters) were recovered for material use, 42% (0.47 million cubic meters) served the generation of energy and 13% (0.15 million cubic meters) remained unused (Leek N., 2010; COST E31, 2007; COST E44, 2008). Compared to the overall EU 27 values of re-applying post-consumer wood, Austria exhibits an improved recycling system even though 13% remained unused in 2007. For the EU 27 the unused fraction accounted, however, for about 36.8% (20.42 million cubic meters) in 2007 (Leek N., 2010; COST E31, 2007; COST E44, 2008). All in all 55.42 million cubic meters of post-consumer wood were available within the EU 27 in 2007, of which 32.7% (18.12 million cubic meters) re-entered the material stream and 30.6% (16.94 million cubic meters) were recovered for the generation of energy or heat (Leek N., 2010; COST E31, 2007; COST E44, 2008).

Within the framework of a Wood Resource Balance (WRB) established by the EUwood team, wood supply (of fresh cut fibres, residues and post-consumer wood) are contrasted to their applications which allows calculating for the cascade use factor of the analysed economy. The cascade use factor is formed by putting the overall wood use of an economy in relation to its supply of fresh cut wood fibres (domestic extractions plus imports minus exports) (Mantau U., 2010). If the cascade use factor is for instance one, it means that the overall wood use is covered only by the fresh cut wood fibres entering the economy. If the cascade use factor is therefore above one, cascade use of wood fibres is taking place. Unfortunately WRB data for the EU 27 have so far only be published for the years 2005 (Steirer F., 2009) and 2007 (Steirer F., Mantau U., 2009). According to these data the cascade use factor of the EU 27 was 1.53 (overall wood use of 778.99 million cubic meters / fresh cut wood supply of 509.57 million cubic meters) in 2005 and 1.53 (overall wood use of 800.73 million cubic meters / fresh cut wood supply of 523.51 million cubic meters) in 2007 (Steirer F., 2009; Steirer F., Mantau U., 2009). Austria exhibited, however, lower cascade use factors for both years, namely 1.41 (overall wood use of 49.1 million cubic meters / fresh cut wood supply of 34.73 million cubic meters) in 2005 and 1.46 (overall wood use of 52.19 million cubic meters / fresh cut wood supply of 35.7 million cubic meters) in 2007 – but at least exhibiting an improvement in their cascade use of wood from 2005 to 2007 (Steirer F., 2009; Steirer F., Mantau U., 2009). Unfortunately no further WRB data is available as well as no such data for crops, wherefore a subsequent survey based on the here distilled results is undertaken in order to establish a WRB for Austria from 2005 to 2010 and to generate a similar framework for crops.

5. Literature and Data

Biermayr P. (2011), *Erneuerbare Energie in Zahlen, Die Entwicklung erneuerbarer Energie in Österreich im Jahr 2010*, Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), Abteilung Umweltökonomie und Energie, Vienna

BioXchange (2005), *The trading floor for Biomass in Europe, Final Report, Annex 5.1 Origin and Commercialisation Structure of Post-Consumer Wood in Germany and The Netherlands,* by order of the European Commission, DG Environment, Contract No. 4.1030/CO2-031/2002

Bringezu S., Kleijn R. (1997), *Regional and National Material Flow Accounting: From Practice to Paradigm for Sustainability*, Wuppertal Institute for Climate, Environment and Energy, Wuppertal

Bringezu S., Schütz H. (2001), *Material use indicators in the European Union, 1980-1997*, Eurostat Working Paper 2/2001/B/2, Luxembourg

COST E31, European Co-operation in the Field of Scientific and Technical Research (2007), *Management of Recovered Wood, 3rd European COST E31 Conference*, Klagenfurt

COST E44, European Co-operation in the Field of Scientific and Technical Research (2008), *A European Wood Processing Strategy: Country Reports*, University of Ghent

European Union Regulation (EC) 1169/2011 (2011), *Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004 Text with EEA relevance*, Official Journal L 304, 22/11/2011 p. 0018 – 0063, downloaded 10.2013 from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:304:0018:01:EN:HTML

European Union Regulation (EC) No. 1760/2000 (2000), *Regulation (EC) No 1760/2000 of the European Parliament and of the Council of 17 July 2000 establishing a system for the identification and registration of bovine animals and regarding the labelling of beef and beef products and repealing Council Regulation (EC) No 820/97*, Official Journal L 204, 11/08/2000 p. 0001 – 0010, downloaded 10.2013 from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000R1760:EN:HTML

EUROSTAT (2001), *Economy-wide material flow accounts and derived indicators, A methodological guide*, European Comission, Luxembourg

EUROSTAT (2002), *Material use in the European Union 1980-2000: Indicators and analysis*, European Comission, Luxembourg

EUROSTAT (2012), *Economy-wide Material Flow Accounts (EW-MFA), Compilation Guide 2012*, European Comission, Luxembourg

Eurostat EW-MFA Questionnaire (2012), *Economy-wide material flow accounts*

Questionnaire, Version 31 July 2012, downloaded 04.2013 from http://epp.eurostat.ec.europa.eu/portal/page/portal/environmental_accounts/methodology/data_collections

Eurostat (2013), *What do environmental accounts measure?,* downloaded 10.2013 from http://epp.eurostat.ec.europa.eu/portal/page/portal/environmental_accounts/introduction

Eurostat (2010), *Environmental Accounts, Historical Background,* downloaded 10.2013 from http://epp.eurostat.ec.europa.eu/portal/page/portal/environmental_accounts/introduction/historical

FAOSTAT (2013), *Metadata, Classifications – Production; Metadata Concepts and Definitions – Glossary,* downloaded 04.2013 from http://faostat.fao.org/site/384/default.aspx and http://faostat.fao.org/site/375/default.aspx

FAOSTAT Joint Forest Questionnaire (2013), *Joint Forest Sector Questionnaire, Forest Products Definitions, FAOSTAT,* downloaded 04.2013 from http://faostat.fao.org/Portals/_Faostat/documents/pdf/FAOSTAT-Forestry-def-e.pdf

Fischer-Kowalski M. and Haberl H. (2007), *Socioecological Transitions and Global Chang, Trajectories of Social Metabolism and Land Use,* Edward Elgar, Cheltenham, Northampton

Fischer-Kowalski M. and Haberl H. (1997), *Stoffwechsel und Kolonisierung: Konzepte zur Beschreibug des Verhältnisses von Gesellschaft und Natur,* in: Gesellschaftlicher Stoffwechsel und Kolonisierung von Natur, p 3-12, Gordon&Breach, Amsterdam

Fonseca, M.A. (2009), *Forest Product Conversion Factors for the UNECE region,* Geneva Timber and Forest Discussion Paper 49

Giljum S., Behrens A., Jölli D., Vogt K., Kovanda J., Niza S., Stodulski W. (2005), *Material input data for the GINFORS model, Technical Report,* Work Package 3.1., Sustainable Europe Research Institute (SERI), Vienna

Giljum S., Hinterberger F., Bruckner M., Burger E., Frühmann J., Lutter S., Prgmaier E., Polzin C., Waxwender H., Kernegger L., Warhurst M. (2009), *Overconsumption, Our Use of the World's Natural Resources,* Sustainable Europe Research Institute (SERI) and Global 2000 (Friends of the Earth Austria), Vienna

Hinterberger F., Giljum S., Hammer M. (2003), *Material Flow Accounting and Analysis (MFA), A Valuable Tool for Analyses of Society-Nature Interrelationships*, Sustainable Europe Research Institute (SERI), Vienna

Huehn M. (1993), *Harvest index versus grain/straw-ratio. Theoretical comments and experimental results on the comparison of variation*, University Kiel

Kemanin A., Stöckle C., Huggins D., Viega L. (2007), *A simple method to estimate harvest index in grain crops*, Field Crops Research 103 (2007) p. 208 – 216

Köppl A., Reinsberger K., Schleicher S., Bittermann W. (2012), *Nationaler Aktionsplan für erneuerbare Energie, Österreichischer Fortschrittsbericht 2011 im Rahmen der RL2009/28/EG*, Österreichisches Institut für Wirtschaftsforschung, Vienna

Lebensministerium Austria (2011), *Zuckerrübe in Österreich*, downloaded 09.2013 from http://www.lebensministerium.at/land/produktion-maerkte/pflanzliche-produktion/zucker-staerke/Zuckerruebe.html

Leek N. (2010), *Post-consumer wood, pp 119-123, in EUwood - Methodology Report*, Hamburg

Lichtblau G., Pölz W., Stix S., Winter R. (2012), *Ökobilanz ausgewählter Biotreibstoffe, Erstellt im Rahmen des Projekts proVision: „Biokraftstoffe – Potentiale, Risiken und Zukunftsszenarien",* Umweltbundesamt Austria, Vienna

Liebhard P. (1997), *Influence of primary tillage on yield, yield characteristics and selected quality criteria of sugar beet(Beta vulgaris L. ssp. vulgaris var. altissima Doell) in the center of Upper Austria (part 8)*, Universität für Bodenkultur, Vienna

Mantau U. (2010), *Method of the Wood Resource Balance, pp 14-29, in EUwood – Methodology Report*, Hamburg

Mantau U. (2005), *Development of methods to generate market information and linkages between biomass supply and demand, INFRO -Information Systems for Resources,* Hamburg

Mantau U. et al. (2010), *EUwood - Real potential for changes in growth and use of EU forests, Methodology Report*, Hamburg

Mantau, U. & Bilitewski, B. (2010), *Stoffstrom-Modell- Holz 2007, Rohstoffströme und CO2-Speicherung in der Holzverwendung*, *Forschungsbericht für das Kuratorium für Forschung und Technik des Verbandes der Deutschen Papierfabriken e.V. (VDP)*, Celle, Germany

Mantau U., Steirer F. (2007), *Wood resources aivailability and demands – implications of renewable energy policies, A first glance at 2005, 2010 and 2020 in European countries*, Hamburg

MCPFE, UNECE and FAO (2007), *State of Europe's forests 2007, The MCPFE report on sustainable forest management in Europe*, MCPFE Liaison Unit Warsaw, UNECE and FAO, Warsaw

Milota E., Petrovic B. (2012), *Standard-Dokumentation Metainformationen (Definitionen, Erläuterungen, Methoden, Qualität) zu Materialflussrechnungen*, Statistik Austria, Vienna

Moll S., Bringezu S., Schütz H. (2005), *Resource Use in European Countries, An estimate of material and waste streams in the Community, including imports and exports using the instrument of material flow analysis*, Wuppertal Institute for Climate, Environment and Energy, Wuppertal

Oldenburger J. (2010), *Landscape care wood, pp 98-111, in: EUwood - Methodology Report*, Hamburg

Pearce D. (2001), *Measuring resource productivity: background paper by David Pearce, London*

Prem J., Beer R. (2012), *Nachhaltige Wirtschaft in Österreich, Österreichischer Waldbericht – Datensammlung 2012,* Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW), Vienna, downloaded 04.2013 from http://www.lebensministerium.at/publikationen/forst/waldbericht/datensammlung_2012.html

Presas T., Mensink M. (2011), *The Forest Fibre Industry*, *2050 Roadmap to a low- carbon bio*-economy, Confederation of European Paper Industries (CEPI), Brussels

Saal U. (2010), *Industrial wood residues, pp 124-145, in: EUwood - Methodology Report*, Hamburg

Schuchert W. (2011), *Triticale*, Max-Planck Institute for Plant Breeding Research, Cologne, downloaded 09.2013 from http://www2.mpipz.mpg.de/pr/garten/schau/Triticale/Triticale%28d%29.html and http://onion81.mpiz-koeln.mpg.de/oeffentlichkeitsarbeit/kulturpflanzen/Nutzpflanzen/Triticale/index.html

Schütz, H., Bringezu S. (1999), *Use and Relevance of Statistics in an International Material Flow Study*, Summary report to Planistat

Steirer F. (2009), *Geneva Forest Study Paper 51, Current Wood Resources Availability and Demands, National and Regional Wood Resource Balances EU/EFTA Countries*, UNECE/FAO Timber Section, Geneva

Steirer F., Mantau U. (2009), *Wood Resource Balance 2007, Methodology, first results and data for review and comments; Integration with EFSOS II wood energy scnario*, UNECE, University of Hamburg

Strasser M., Baud S. (2012), *Umweltgesamtrechnungen, Modul Integriete NAMEA,* Projektbericht, Statistik Austria, Vienna

Umweltbundesamt Austria (2013a), *Ethanol im Tank*, downloaded 09.2013 from http://www.umweltbundesamt.at/umweltsituation/verkehr/kraftstoffe/biokraftstoff1/bioethanol/

Umweltbundesamt Austria (2013b), *Biokraftstoffe als Alternative,* downloaded 10.2013 from http://www.umweltbundesamt.at/umweltsituation/verkehr/kraftstoffe/biokraftstoff1/

UNECE, FAO Forestry and Timber Section (2009), *Joint Wood Energy Enquiry 2007 Background Data Analysis*, Geneva

Working Group on Environmental Information and Outlooks (OECD, 2007), *Measuring Material Flows and Resource Productivity, The OECD Guide*, Organisation for Economic Co-Operation and Development (OECD)

Data

- Eurostat EW-MFA database, http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Eurostat Population database, http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Food an Agriculture Organization of the United Nations (FAO) Statistics FAOSTAT, Material Extraction, Trade, Detailed Trade Matrix, Forestry Trade Flows, http://faostat3.fao.org/faostat-gateway/go/to/home/E

- Statistik Austria EW-MFA database,
  http://statcube.at/superwebguest/login.do?guest=guest&db=deumwmfa
- Statistik Austria National Accounting Matrix including Environmental Accounts (NAMEA),
  http://statcube.at/superwebguest/login.do?guest=guest&db=deumwnam1
- Statistik Austria Gesamtenergiebilanz,
  http://statcube.at/superwebguest/login.do?guest=guest&db=deumwnam1
- Statistik Österreich Außenhandelsstatistik,
  http://statcube.at/superwebguest/login.do?guest=guest&db=deahlgrhs
- UNcomtrade,
  http://comtrade.un.org/db/
- UNdata, United Nations Statistics Devision (UNSD), Commodity Trade Statistics Database,
  http://data.un.org/Explorer.aspx
- Temperate and Boreal Forest Resource Assessment 2000 (TBFRA 2000),
  http://www.unece.org/forests/fra/welcome.html

Annex I: A.1 Biomass – Domestic Extraction, Foreign Trade, Direct Material Input, Domestic Material Consumption

in 1000 t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
A.1.1 Crops, DE	9 875	10 197	10 790	10 928	11 038	9 931	10 531	10 469	9 544	11 345	10 984	9 696	10 183	11 777	10 811	10 888
A.1.1 Crops, IMP	1 310	1 445	1 465	1 315	1 545	1 768	1 716	1 928	1 846	1 994	2 178	2 355	2 437	2 510	2 834	3 209
A.1.1 Crops, EXP	884	936	914	1 142	1 433	1 328	1 290	1 580	1 547	1 244	1 871	1 767	1 693	1 769	2 279	2 024
A.1.1 Crops DMI	11 185	11 642	12 255	12 242	12 584	11 699	12 247	12 397	11 390	13 339	13 163	12 051	12 620	14 288	13 645	14 096
A.1.1 Crops DMC	**10 300**	**10 706**	**11 341**	**11 100**	**11 150**	**10 372**	**10 957**	**10 816**	**9 843**	**12 095**	**11 292**	**10 284**	**10 928**	**12 519**	**11 366**	**12 072**
A.1.2 Crop Residues (used),..., DE	16 910	16 056	16 920	16 603	17 006	14 888	15 070	15 526	13 440	16 454	17 417	16 897	15 773	17 336	16 726	16 323
A.1.2 Crop Residues (used),..., IMP	121	120	164	147	179	184	219	220	236	261	246	253	264	281	273	275
A.1.2 Crop Residues (used),..., EXP	173	163	177	200	203	177	232	217	215	242	223	235	230	305	280	267
A.1.2 Crop Residues (used),..., DMI	17 031	16 176	17 084	16 750	17 185	15 072	15 289	15 746	13 676	16 715	17 663	17 150	16 037	17 617	16 999	16 598
A.1.2 Crop Residues (used),..., DMC	**16 858**	**16 013**	**16 907**	**16 550**	**16 982**	**14 895**	**15 057**	**15 529**	**13 461**	**16 473**	**17 440**	**16 915**	**15 807**	**17 312**	**16 719**	**16 331**
A.1.3 Wood, DE	7 756	8 379	8 242	7 547	7 577	7 149	7 259	7 981	9 147	8 861	8 860	10 286	11 408	11 683	9 016	9 576
A.1.3 Wood, IMP	2 719	2 601	2 975	2 872	3 919	4 650	4 164	4 039	4 151	4 876	4 784	5 085	4 860	4 223	4 651	4 707
A.1.3 Wood, EXP	349	352	453	444	597	546	552	510	471	580	500	425	500	543	432	551
A.1.3 Wood, DMI	10 474	10 979	11 218	10 419	11 496	11 799	11 423	12 020	13 298	13 737	13 644	15 371	16 268	15 906	13 667	14 283
A.1.3 Wood, DMC	**10 125**	**10 627**	**10 765**	**9 975**	**10 899**	**11 253**	**10 871**	**11 510**	**12 827**	**13 157**	**13 145**	**14 946**	**15 768**	**15 362**	**13 235**	**13 732**
A.1 Biomass, DE	**34 540**	**34 631**	**35 952**	**35 078**	**35 621**	**31 968**	**32 859**	**33 976**	**32 131**	**36 660**	**37 262**	**36 879**	**37 364**	**40 796**	**36 553**	**36 787**
A.1 Biomass, IMP	**4 150**	**4 166**	**4 605**	**4 333**	**5 643**	**6 602**	**6 100**	**6 186**	**6 233**	**7 131**	**7 208**	**7 692**	**7 561**	**7 014**	**7 758**	**8 190**
A.1 Biomass, EXP	**1 407**	**1 450**	**1 544**	**1 786**	**2 233**	**2 051**	**2 074**	**2 308**	**2 233**	**2 066**	**2 594**	**2 426**	**2 422**	**2 617**	**2 991**	**2 843**
A.1 Biomass, DMI	**38 690**	**38 797**	**40 557**	**39 411**	**41 264**	**38 571**	**38 959**	**40 162**	**38 365**	**43 791**	**44 470**	**44 571**	**44 926**	**47 810**	**44 311**	**44 977**
A.1 Biomass, DMC	**37 284**	**37 347**	**39 013**	**37 625**	**39 031**	**36 520**	**36 885**	**37 855**	**36 132**	**41 725**	**41 876**	**42 145**	**42 503**	**45 193**	**41 320**	**42 135**

A.1.2 Crop residues (used), …, = A.1.2 Crop Residues (used), Fodder Crops and Grazed Biomass

DE = Domestic Extraction; IMP = Import; EXP = Export; DMI = Direct Material Input; DMC = Domestic Material Consumption

Annex II: A.1.1 Crops – Domestic Extraction, Foreign Trade, Direct Material Input, Domestic Material Consumption

In 1000 t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Cereals, DE	4 455	4 706	5 272	5 033	5 038	4 722	5 108	4 755	4 519	5 606	5 195	4 460	4 758	5 748	4 862	5 036
Cereals, IMP	228	285	264	358	346	373	395	690	503	557	658	761	792	732	1 163	1 419
Cereals, EXP	606	682	643	874	1 108	944	870	1 129	1 004	759	1 264	1 124	1 058	1 102	1 101	1 166
Cereals, DMI	4 682	4 991	5 536	5 390	5 384	5 096	5 503	5 445	5 022	6 163	5 853	5 221	5 550	6 480	6 026	6 455
Cereals, DMC	**4 076**	**4 309**	**4 892**	**4 516**	**4 276**	**4 152**	**4 632**	**4 316**	**4 019**	**5 405**	**4 589**	**4 097**	**4 492**	**5 378**	**4 925**	**5 289**
Fibrecrops, DE	2	4	7	6	5	4	3	1	3	3	2	4	3	2	3	3
Fibrecrops, IMP	27	30	39	32	34	40	37	39	25	30	28	18	12	12	7	7
Fibrecrops, EXP	1	1	1	0	1	1	1	2	2	2	2	1	1	0	1	1
Fibrecrops, DMI	29	34	46	38	39	44	40	41	28	33	30	22	15	13	10	10
Fibrecrops, DMC	**29**	**33**	**45**	**38**	**38**	**43**	**39**	**39**	**26**	**31**	**28**	**21**	**14**	**13**	**9**	**9**
Fruits, DE	938	857	947	1 042	1 040	1 092	1 027	1 062	1 111	1 150	1 032	1 117	1 178	1 200	1 150	1 037
Fruits, IMP	564	589	632	392	598	706	598	502	570	610	634	653	615	667	618	654
Fruits, EXP	83	110	108	79	108	132	153	141	186	169	215	231	214	232	236	265
Fruits, DMI	1 502	1 447	1 580	1 434	1 638	1 798	1 625	1 564	1 681	1 760	1 665	1 769	1 792	1 867	1 768	1 692
Fruits, DMC	**1 419**	**1 337**	**1 471**	**1 354**	**1 529**	**1 666**	**1 472**	**1 423**	**1 495**	**1 592**	**1 451**	**1 538**	**1 578**	**1 635**	**1 532**	**1 426**
Nuts, DE	13	13	10	14	15	17	16	14	20	18	17	18	19	19	19	6
Nuts, IMP	5	7	8	6	5	4	4	6	5	5	6	5	5	4	4	4
Nuts, EXP	0	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1
Nuts, DMI	19	19	18	20	20	21	20	19	25	23	23	23	24	24	23	10
Nuts, DMC	**19**	**19**	**17**	**19**	**19**	**20**	**18**	**17**	**23**	**21**	**22**	**22**	**23**	**23**	**22**	**9**
Oilcrops, DE	366	204	219	265	324	229	246	238	211	258	265	309	272	320	327	352
Oilcrops, IMP	73	104	104	171	132	239	202	233	236	281	364	394	485	559	535	598
Oilcrops, EXP	123	73	44	73	67	79	71	117	142	125	161	167	198	211	191	185
Oilcrops, DMI	440	308	324	436	455	468	447	471	447	538	629	703	758	879	861	950
Oilcrops, DMC	**317**	**235**	**280**	**363**	**389**	**389**	**376**	**354**	**305**	**413**	**468**	**536**	**560**	**668**	**670**	**765**

In 1000 t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Other crops, DE	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0
Other crops, IMP	98	97	108	111	117	102	123	127	133	126	104	114	121	111	76	66
Other crops, EXP	8	5	8	7	7	7	8	10	12	13	10	15	11	11	10	10
Other crops, DMI	98	98	108	111	117	102	124	128	134	127	105	114	122	112	76	66
Other crops, DMC	**90**	**93**	**100**	**104**	**111**	**95**	**115**	**118**	**121**	**114**	**95**	**100**	**111**	**101**	**66**	**56**
Pulses, DE	77	102	169	184	146	104	120	105	106	135	107	110	74	59	49	59
Pulses, IMP	14	17	15	11	9	9	11	7	9	8	7	4	5	7	7	8
Pulses, EXP	1	2	10	10	11	7	8	5	6	7	13	12	6	4	3	4
Pulses, DMI	92	119	184	195	154	113	131	112	115	143	114	114	79	66	56	67
Pulses, DMC	**91**	**117**	**174**	**184**	**143**	**106**	**123**	**107**	**108**	**136**	**101**	**102**	**73**	**62**	**53**	**63**
Roots&Tubers, DE	724	769	677	647	712	695	695	684	560	693	763	655	669	757	722	672
Roots&Tubers, IMP	102	85	68	55	69	60	61	72	86	80	69	97	103	100	106	105
Roots&Tubers, EXP	16	10	17	17	24	34	61	34	36	27	47	70	56	60	82	84
Roots&Tubers, DMI	826	854	745	702	781	755	755	756	647	773	832	751	772	857	829	777
Roots&Tubers, DMC	**810**	**844**	**728**	**684**	**757**	**721**	**695**	**722**	**610**	**746**	**785**	**681**	**716**	**797**	**747**	**693**
Sugarcrops, DE	2 886	3 131	3 012	3 314	3 217	2 560	2 773	3 043	2 485	2 902	3 084	2 493	2 656	3 091	3 083	3 132
Sugarcrops, IMP	0	0	0	0	1	0	1	0	1	0	1	0	0	1	1	0
Sugarcrops, EXP	0	0	0	0	1	0	0	0	0	1	5	3	0	0	488	153
Sugarcrops, DMI	2 886	3 131	3 012	3 314	3 217	2 560	2 774	3 044	2 486	2 902	3 085	2 493	2 657	3 093	3 084	3 132
Sugarcrops, DMC	**2 886**	**3 131**	**3 012**	**3 314**	**3 217**	**2 559**	**2 774**	**3 044**	**2 486**	**2 901**	**3 080**	**2 491**	**2 656**	**3 093**	**2 596**	**2 979**
Vegetables, DE	412	410	476	423	542	508	544	565	527	580	520	530	554	580	595	590
Vegetables, IMP	199	231	227	179	235	234	285	252	279	296	306	309	298	317	318	346
Vegetables, EXP	46	52	82	79	105	121	117	140	156	141	153	143	148	147	167	155
Vegetables, DMI	611	641	704	602	777	742	829	816	806	876	826	839	852	897	913	937
Vegetables, DMC	**565**	**589**	**622**	**523**	**672**	**621**	**712**	**676**	**650**	**736**	**673**	**696**	**705**	**750**	**746**	**782**
A.1.1 Crops, DE	**9 875**	**10 197**	**10 790**	**10 928**	**11 038**	**9 931**	**10 531**	**10 469**	**9 544**	**11 345**	**10 984**	**9 696**	**10 183**	**11 777**	**10 811**	**10 888**
A.1.1 Crops, IMP	**1 310**	**1 445**	**1 465**	**1 315**	**1 545**	**1 768**	**1 716**	**1 928**	**1 846**	**1 994**	**2 178**	**2 355**	**2 437**	**2 510**	**2 834**	**3 209**
A.1.1 Crops, EXP	**884**	**936**	**914**	**1 142**	**1 433**	**1 328**	**1 290**	**1 580**	**1 547**	**1 244**	**1 871**	**1 767**	**1 693**	**1 769**	**2 279**	**2 024**
A.1.1 Crops, DMI	**11 185**	**11 642**	**12 255**	**12 242**	**12 584**	**11 699**	**12 247**	**12 397**	**11 390**	**13 339**	**13 163**	**12 051**	**12 620**	**14 288**	**13 645**	**14 096**
A.1.1 Crops, DMC	**10 300**	**10 706**	**11 341**	**11 100**	**11 150**	**10 372**	**10 957**	**10 816**	**9 843**	**12 095**	**11 292**	**10 284**	**10 928**	**12 519**	**11 366**	**12 072**

Annex II: A.1.1.1 Cereals – Domestic Extraction, Foreign Trade

Domestic Extractions in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Barley	1 065	1 083	1 258	1 212	1 153	855	1 012	861	882	1 007	880	914	811	968	835	778
Buckwheat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Canary seed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cereals, nes	0	210	260	254	230	228	278	294	268	303	306	288	316	327	39	42
Fonio	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maize	1 474	1 736	1 842	1 646	1 700	1 852	1 771	1 667	1 708	1 945	2 021	1 472	1 696	2 147	1 891	2 169
Millet	0	2	3	3	3	4	3	5	6	8	9	7	8	9	8	7
Mixed grain	49	50	47	48	47	36	37	33	34	37	36	48	30	31	19	22
Oats	162	153	197	164	152	118	128	117	129	139	128	131	99	108	109	98
Popcorn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quinoa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rice, paddy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rye	314	156	207	236	218	183	214	171	133	213	164	94	189	219	184	164
Sorghum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Triticale	87	76	106	128	120	135	157	172	169	236	198	110	209	251	254	231
Wheat	1 304	1 240	1 352	1 342	1 416	1 313	1 508	1 434	1 191	1 719	1 453	1 396	1 399	1 690	1 523	1 518
Cereals, DE	**4 455**	**4 706**	**5 272**	**5 033**	**5 038**	**4 722**	**5 108**	**4 755**	**4 519**	**5 606**	**5 195**	**4 460**	**4 758**	**5 748**	**4 862**	**5 036**

Import in 1000 t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Barley	41	96	63	65	53	144	82	100	94	111	134	157	143	152	174	134
Buckwheat	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1
Canary seed	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0
Cereals, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Maize	64	55	38	55	65	93	92	265	199	246	196	221	303	214	401	617
Millet	2	2	1	1	2	1	3	1	1	1	1	1	3	1	1	2
Mixed grain	0	0	0	0	0	2	1	1	2	2	2	1	2	2	4	9
Oats	5	19	18	18	12	12	14	13	12	15	12	13	12	12	14	11
Rice, paddy	0	0	0	0	1	2	2	2	2	2	3	2	1	2	2	2
Rye	2	33	35	30	37	26	38	19	38	41	38	65	48	43	59	56
Sorghum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Triticale	0	0	1	0	0	7	3	4	3	5	7	11	7	4	7	8
Wheat	111	78	106	186	175	85	158	283	152	134	266	289	272	300	498	569
Cereals, IMP	**228**	**285**	**264**	**358**	**346**	**373**	**395**	**690**	**503**	**557**	**658**	**761**	**792**	**732**	**1 163**	**1 419**
Export in 1000 t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Barley	223	135	96	102	448	261	102	75	63	64	87	158	77	51	67	83
Buckwheat	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Canary seed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cereals, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Maize	89	115	77	266	126	153	208	268	324	254	343	366	367	447	455	320
Millet	1	1	1	1	4	5	4	6	7	9	7	6	6	4	9	12
Mixed grain	0	0	0	0	1	0	1	0	1	2	1	1	1	2	1	2
Oats	2	2	3	7	21	1	3	8	9	5	13	9	7	5	7	14
Rice, paddy	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rye	8	82	4	4	80	13	11	7	5	6	10	8	7	11	11	9
Sorghum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4
Triticale	1	1	0	0	0	0	0	1	2	1	3	2	2	2	4	3
Wheat	283	344	463	494	429	510	539	763	592	417	800	574	590	579	544	710
Cereals, EXP	**606**	**682**	**643**	**874**	**1 108**	**944**	**870**	**1 129**	**1 004**	**759**	**1 264**	**1 124**	**1 058**	**1 102**	**1 101**	**1 166**

Annex II: A.1.1.2 Roots & Tubers – Domestic Extraction, Foreign Trade

Domestic Extraction in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Cassava	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potatoes	724	769	677	647	712	695	695	684	560	693	763	655	669	757	722	672
Roots and Tubers, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweet potatoes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taro (cocoyam)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yautia (cocoyam)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roots & Tubers, DE	**724**	**769**	**677**	**647**	**712**	**695**	**695**	**684**	**560**	**693**	**763**	**655**	**669**	**757**	**722**	**672**

Import in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Potatoes	102	85	68	55	69	60	60	71	86	80	69	97	103	100	106	105
Roots and Tubers, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweet potatoes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roots & Tubers, IMP	**102**	**85**	**68**	**55**	**69**	**60**	**61**	**72**	**86**	**80**	**69**	**97**	**103**	**100**	**106**	**105**

Export in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Potatoes	16	10	17	17	24	34	61	34	36	27	47	70	56	60	82	84
Roots and Tubers, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweet potatoes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roots & Tubers, EXP	**16**	**10**	**17**	**17**	**24**	**34**	**61**	**34**	**36**	**27**	**47**	**70**	**56**	**60**	**82**	**84**

Annex II: A.1.1.3 Sugar Crops – Domestic Extraction, Foreign Trade

Domestic Extraction in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Sugar beet	2 886	3 131	3 012	3 314	3 217	2 560	2 773	3 043	2 485	2 902	3 084	2 493	2 656	3 091	3 083	3 132
Sugar cane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sugar crops, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sugar Crops, DE	**2 886**	**3 131**	**3 012**	**3 314**	**3 217**	**2 560**	**2 773**	**3 043**	**2 485**	**2 902**	**3 084**	**2 493**	**2 656**	**3 091**	**3 083**	**3 132**
Import in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Sugar beet	0	0	0	0	1	0	1	0	1	0	1	0	0	1	1	0
Sugar cane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sugar Crops, IMP	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**0**	**1**	**1**	**0**
Export in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Sugar beet	0	0	0	0	1	0	0	0	0	1	5	3	0	0	488	153
Sugar cane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sugar Crops, EXP	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**5**	**3**	**0**	**0**	**488**	**153**

Annex II: A.1.1.4 Pulses – Domestic Extraction, Foreign Trade

Domestic Extraction in 1000t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Bambara beans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beans, dry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broad beans, horse beans, dry	17	10	6	5	6	7	7	9	9	8	10	12	11	8	7	11
Chick peas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cow peas, dry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lentils	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lupins	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0
Peas, dry	60	93	162	178	140	97	112	96	93	122	90	90	57	45	35	33
Pigeon peas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulses, nes	0	0	0	0	0	0	0	0	2	3	4	5	4	3	4	11
Vetches	0	0	0	0	0	0	0	0	1	2	2	2	2	2	3	4
Pulses, DE	**77**	**102**	**169**	**184**	**146**	**104**	**120**	**105**	**106**	**135**	**107**	**110**	**74**	**59**	**49**	**59**

Import in 1000t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Beans, dry	4	5	3	2	3	4	3	3	3	3	2	2	2	2	2	2
Broad beans, horse beans, dry	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1
Chick peas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lentils	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1
Lupins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peas, dry	10	10	10	7	4	3	5	3	4	4	3	1	2	2	3	4
Pulses, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vetches	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulses, IMP	**14**	**17**	**15**	**11**	**9**	**9**	**11**	**7**	**9**	**8**	**7**	**4**	**5**	**7**	**7**	**8**

Export in 1000t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Beans, dry	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0
Broad beans, horse beans, dry	0	1	0	0	0	0	0	0	0	0	3	3	1	0	0	0
Chick peas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lentils	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lupins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peas, dry	1	1	8	9	10	7	7	5	6	6	10	8	5	3	2	4
Pulses, nes	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Vetches	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulses, EXP	**1**	**2**	**10**	**10**	**11**	**7**	**8**	**5**	**6**	**7**	**13**	**12**	**6**	**4**	**3**	**4**

Annex II: A.1.1.5 Nuts – Domestic Extraction, Foreign Trade

Domestic Extraction in 1000t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Almonds, with shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arecanuts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brazil nuts, with shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cashew nuts, with shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chestnuts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hazelnuts, with shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kolanuts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuts, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pistachios	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Walnuts, with shell	13	13	10	14	15	17	16	14	20	18	17	18	19	19	19	6
Nuts, DE	**13**	**13**	**10**	**14**	**15**	**17**	**16**	**14**	**20**	**18**	**17**	**18**	**19**	**19**	**19**	**6**

Import *in 1000t*	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Almonds, with shell	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0
Arecanuts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brazil nuts, with shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cashew nuts, with shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chestnuts	3	2	4	3	3	2	2	4	3	3	3	3	3	2	3	3
Hazelnuts, with shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuts, nes	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Pistachios	1	3	3	2	1	1	0	0	0	0	0	1	1	1	0	0
Walnuts, with shell	1	0	1	0	1	0	1	1	1	0	0	0	0	0	0	0
Nuts, IMP	**5**	**7**	**8**	**6**	**5**	**4**	**4**	**6**	**5**	**5**	**6**	**5**	**5**	**4**	**4**	**4**

Export *in 1000t*	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Almonds, with shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arecanuts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brazil nuts, with shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cashew nuts, with shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chestnuts	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0
Hazelnuts, with shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuts, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pistachios	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
Walnuts, with shell	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Nuts, EXP	**0**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Annex II: A.1.1.6 Oil Crops – Domestic Extraction, Foreign Trade

Domestic Extraction in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Anise, badian, fennel, corian.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carobs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicory roots	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chillies and peppers, dry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cinnamon (canella)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cloves	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cocoa beans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coffee, green	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ginger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maté	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural rubber	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nutmeg, mace and cardamoms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pepper (Piper spp.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peppermint	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrethrum,Dried	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spices, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tobacco, unmanufactured	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vanilla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil Crops, DE	**1**	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**

Import* *in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Castor oil seed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coconuts	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundnuts, with shell	1	2	1	2	2	2	1	1	1	1	1	1	1	1	1	1
Hempseed	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linseed	2	3	2	1	2	2	2	2	4	3	3	5	3	4	8	8
Mustard seed	4	5	5	6	6	5	4	5	5	4	4	3	4	4	4	4
Oilseeds, Nes	4	5	6	4	6	6	6	9	10	7	8	10	14	9	12	11
Olives	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0
Palm kernels	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Palm oil	13	16	16	19	17	14	14	15	15	23	37	40	48	60	51	54
Poppy seed	2	1	1	3	3	2	3	3	4	4	4	4	5	5	8	8
Rapeseed	2	8	15	43	29	108	60	72	64	104	177	207	240	272	247	303
Safflower seed	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Soybeans	20	13	22	19	14	13	30	22	18	22	32	43	97	108	100	112
Sunflower seed	23	50	36	73	53	86	79	100	115	113	97	81	71	95	102	97
Oil Crops, IMP	**73**	**104**	**104**	**171**	**132**	**239**	**202**	**233**	**236**	**281**	**364**	**394**	**485**	**559**	**535**	**598**

Export* *in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Castor oil seed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coconuts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundnuts, with shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hempseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linseed	0	0	0	0	1	1	1	5	3	2	4	3	5	3	2	3
Mustard seed	0	0	1	1	1	1	1	2	1	2	1	1	2	2	1	1
Oilseeds, Nes	1	2	2	2	2	3	3	3	3	3	4	4	5	4	8	10
Olives	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Palm kernels	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Palm oil	1	1	1	1	1	2	2	2	3	4	4	4	1	8	5	0
Poppy seed	0	0	0	1	0	0	1	1	1	1	3	2	2	3	4	5
Rapeseed	43	60	7	6	23	23	28	40	60	14	29	15	72	95	59	75
Safflower seed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybeans	41	6	11	10	27	32	15	12	16	20	20	31	42	32	45	40
Sunflower seed	36	4	22	53	11	17	21	53	56	80	96	107	70	63	65	50
Oil Crops, EXP	**123**	**73**	**44**	**73**	**67**	**79**	**71**	**117**	**142**	**125**	**161**	**167**	**198**	**211**	**191**	**185**

Annex II: A.1.1.7 Vegetables – Domestic Extraction, Foreign Trade

Domestic Extraction in 1000t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Artichokes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asparagus	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
Beans, green	11	7	7	8	7	6	5	6	5	6	6	6	6	6	7	6
Cabbages and other brassicas	54	53	63	87	78	71	108	118	84	100	89	96	99	92	94	92
Carrots and turnips	31	34	47	36	76	60	65	71	73	81	79	77	74	81	84	86
Cassava leaves	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cauliflowers and broccoli	9	8	11	7	9	9	10	10	8	10	8	8	8	7	7	7
Chillies and peppers, green	7	6	6	5	5	8	8	8	9	10	9	10	15	18	18	15
Cucumbers and gherkins	25	26	40	39	45	43	44	43	43	42	38	36	39	37	42	41
Eggplants (aubergines)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Garlic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leeks, other alliaceous veg	0	0	0	0	0	0	0	0	6	7	6	6	5	5	6	6
Leguminous vegetables, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Lettuce and chicory	41	49	52	50	54	61	60	61	51	54	57	59	62	57	55	48
Maize, green	0	0	0	0	0	0	0	0	4	4	5	8	11	15	14	10
Mushrooms and truffles	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1
Okra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onions (inc. shallots), green	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onions, dry	60	70	92	102	135	96	117	111	103	118	103	100	98	123	139	154
Peas, green	12	12	10	10	8	6	5	4	4	4	5	8	9	11	12	9
Pumpkins, squash and gourds	0	0	0	0	0	0	0	0	14	15	11	10	16	15	16	15
Spinach	6	7	11	4	7	7	8	10	9	9	10	11	12	13	10	9
String beans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tomatoes	25	19	18	19	20	24	27	30	35	36	35	39	45	42	42	44
Vegetables fresh nes	129	118	117	55	98	115	84	88	75	82	55	53	52	54	46	44
Vegetables , DE	**412**	**410**	**476**	**423**	**542**	**508**	**544**	**565**	**527**	**580**	**520**	**530**	**554**	**580**	**595**	**590**

Imports in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Artichokes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asparagus	1	1	2	2	2	2	2	2	2	2	3	3	3	2	3	3
Beans, green	1	1	1	2	2	2	2	2	2	3	3	3	2	2	2	2
Cabbages and other brassicas	17	17	13	12	17	14	17	17	18	20	16	17	15	17	19	19
Carrots and turnips	8	7	10	10	8	8	9	8	10	10	12	14	16	24	17	23
Cauliflowers and broccoli	8	8	8	8	8	6	7	5	5	6	7	7	6	6	6	7
Chillies and peppers, green	20	23	25	32	39	41	49	49	58	53	54	55	48	52	54	54
Cucumbers and gherkins	24	27	30	12	23	20	29	26	26	34	30	33	26	27	28	27
Eggplants (aubergines)	2	2	2	2	3	3	5	5	4	4	5	4	4	5	5	6
Garlic	6	5	5	5	5	4	5	4	4	5	4	4	4	5	4	4
Leeks, other alliaceous veg	4	12	3	3	4	3	5	4	6	5	7	6	5	5	6	5
Leguminous vegetables, nes	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Lettuce and chicory	28	40	35	32	35	37	45	39	35	46	46	47	41	41	44	44
Maize, green	0	0	0	0	0	0	0	0	0	0	2	1	1	2	1	1
Mushrooms and truffles	7	7	9	13	13	14	17	14	13	14	14	12	11	11	12	13
Onions (inc. shallots), green	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1
Onions, dry	12	15	17	21	10	13	16	13	15	17	12	15	29	27	24	26
Peas, green	0	0	0	0	0	1	0	1	1	0	0	1	1	2	2	2
Pumpkins, squash and gourds	3	3	4	1	5	6	8	7	10	10	10	11	9	10	12	15
Spinach	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Tomatoes	43	50	50	11	47	46	51	40	49	48	59	55	52	49	48	62
Vegetables fresh nes	16	11	11	11	12	12	15	14	18	18	19	19	22	27	28	32
Vegeables, IMP	**199**	**231**	**227**	**179**	**235**	**234**	**285**	**252**	**279**	**296**	**306**	**309**	**298**	**317**	**318**	**346**

Export ***in 1000t***	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Artichokes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asparagus	0	0	0	0	0	0	1	1	1	1	0	0	0	1	1	1
Beans, green	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0
Cabbages and other brassicas	6	5	9	7	7	8	10	8	11	9	10	7	9	9	8	6
Carrots and turnips	2	3	7	7	11	12	12	15	16	14	17	19	21	17	18	13
Cauliflowers and broccoli	1	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1
Chillies and peppers, green	0	1	3	10	16	19	22	24	28	24	25	23	22	26	28	25
Cucumbers and gherkins	8	10	8	6	14	11	11	13	14	14	13	13	10	13	12	12
Eggplants (aubergines)	0	0	0	0	1	1	2	3	2	2	3	2	2	3	3	3
Garlic	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0
Leeks, other alliaceous veg	0	2	1	1	1	1	3	3	5	3	3	3	1	2	3	3
Leguminous vegetables, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lettuce and chicory	1	1	1	1	1	1	1	2	2	3	3	3	4	5	7	7
Maize, green	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Mushrooms and truffles	1	2	2	4	6	6	7	6	5	4	5	4	2	1	2	2
Onions (inc. shallots), green	0	0	0	0	0	0	0	1	1	2	2	4	2	4	5	5
Onions, dry	19	20	40	31	37	49	33	47	47	41	44	39	48	37	48	40
Peas, green	0	0	4	5	1	1	2	3	5	3	3	4	3	1	1	0
Pumpkins, squash and gourds	0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	3
Spinach	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Tomatoes	4	4	4	2	3	5	4	6	11	10	13	9	12	13	14	22
Vegetables fresh nes	2	2	3	3	5	4	5	6	6	6	7	7	7	9	10	8
Vegetables, EXP	**46**	**52**	**82**	**79**	**105**	**121**	**117**	**140**	**156**	**141**	**153**	**143**	**148**	**147**	**167**	**155**

Annex II: A.1.1.8 Fruits – Domestic Extraction, Foreign Trade

Domestic Extraction in 1000t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Apples	384	368	477	416	410	490	410	479	423	484	453	509	478	551	486	489
Apricots	17	13	12	9	23	14	11	6	17	16	13	25	15	15	24	13
Avocados	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bananas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Berries Nes	5	5	5	5	5	7	8	8	9	10	6	5	5	3	2	1
Blueberries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carobs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cashewapple	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cherries	29	22	21	31	25	30	32	22	29	27	26	27	34	27	30	52
Citrus fruit, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cranberries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Currants	18	16	20	19	20	23	19	20	18	20	19	19	20	20	19	19
Dates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Figs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fruit Fresh Nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fruit, tropical fresh nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gooseberries	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Grapefruit (inc. pomelos)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grapes	290	274	234	351	364	304	329	351	337	365	302	301	350	399	314	232
Kiwi fruit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lemons and limes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mangoes, mangosteens, guavas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oranges	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other melons (inc.cantaloupes)	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0	0
Papayas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Domestic Extraction in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Peaches and nectarines	11	11	10	8	10	10	8	7	7	9	8	9	8	8	9	8
Pears	124	78	70	132	114	130	109	104	175	124	118	117	176	85	169	121
Persimmons	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pineapples	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantains	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plums and sloes	41	54	77	49	45	57	75	43	69	70	62	80	68	63	72	78
Pome fruit, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quinces	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Raspberries	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Sour cherries	5	4	4	5	5	5	6	4	5	5	4	5	6	5	5	4
Stone fruit, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strawberries	14	11	16	13	18	20	18	17	16	18	16	14	15	19	17	16
Tangerines, mandarins, clem.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Watermelons	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Fruits, DE	**938**	**857**	**947**	**1 042**	**1 040**	**1 092**	**1 027**	**1 062**	**1 111**	**1 150**	**1 032**	**1 117**	**1 178**	**1 200**	**1 150**	**1 037**

Import in 1000t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Apples	137	179	200	62	117	224	102	62	80	81	102	87	116	116	60	73
Apricots	8	13	9	4	11	11	11	10	13	12	15	12	8	13	14	14
Avocados	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3
Bananas	111	96	94	88	102	93	85	78	80	90	102	130	102	120	116	126
Berries Nes	1	1	0	1	1	2	2	3	3	2	2	2	2	1	1	1
Blueberries	0	1	0	0	0	0	1	1	1	2	2	2	1	2	3	2
Carobs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cherries	1	2	3	3	9	7	12	11	17	24	22	25	20	12	21	21
Citrus fruit, nes	0	0	0	0	0	0	0	0	1	2	0	0	0	1	0	0
Cranberries	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Currants	8	2	8	10	10	10	6	6	7	12	2	1	1	2	1	2
Dates	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2
Figs	1	0	1	1	1	2	2	4	4	5	6	5	4	5	6	6
Fruit Fresh Nes	3	3	7	9	11	13	15	14	21	19	10	11	12	16	15	17
Fruit, tropical fresh nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gooseberries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grapefruit (inc. pomelos)	8	6	7	8	9	10	10	12	13	17	17	27	18	22	18	19
Grapes	39	36	41	21	47	54	56	47	47	60	63	56	49	52	51	49
Kiwi fruit	15	10	11	12	10	10	10	7	7	9	10	12	11	11	12	12
Lemons and limes	32	25	21	19	27	24	24	23	27	23	34	34	36	37	44	44
Mangoes, mangosteens, guavas	1	1	1	2	2	3	2	3	4	4	4	3	3	4	4	5
Oranges	63	68	63	31	62	70	74	54	53	62	52	56	53	50	52	59
Other melons (inc.cantaloupes)	9	7	8	10	9	9	11	11	11	14	13	12	12	13	14	19
Papayas	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Peaches and nectarines	25	30	26	3	31	33	32	25	32	27	35	29	25	25	32	30
Pears	18	21	20	5	19	16	18	20	27	17	21	19	16	16	20	19
Persimmons	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pineapples	5	5	5	4	5	6	6	6	7	9	11	14	15	16	15	16
Plantains	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plums and sloes	3	5	6	7	6	6	11	6	8	4	7	6	5	8	7	9
Quinces	0	0	1	1	2	1	2	2	2	2	2	2	2	2	3	2
Raspberries	3	2	9	8	8	6	6	13	10	14	11	6	12	15	9	7
Sour cherries	3	2	3	3	7	5	6	2	7	5	2	2	5	2	2	1
Stone fruit, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strawberries	11	11	20	27	23	19	22	18	22	24	22	20	17	17	20	17
Tangerines, mandarins, clem.	39	42	41	22	39	40	42	37	25	44	38	45	40	44	44	49
Watermelons	17	19	25	29	29	30	28	23	37	23	27	28	24	38	28	27
Fruits, IMP	**564**	**589**	**632**	**392**	**598**	**706**	**598**	**502**	**570**	**610**	**634**	**653**	**615**	**667**	**618**	**654**

Export in 1000t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Apples	34	39	58	34	40	43	44	44	71	50	71	88	86	78	86	105
Apricots	0	0	0	1	1	2	3	2	4	4	4	3	3	7	4	4
Avocados	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bananas	23	27	9	8	8	14	8	1	2	7	17	16	15	20	15	17
Berries Nes	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
Blueberries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carobs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cherries	0	1	1	1	6	5	10	10	15	23	19	22	19	11	19	21
Citrus fruit, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cranberries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Currants	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Dates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Figs	0	0	0	0	1	2	2	3	4	6	5	4	3	5	6	6
Fruit Fresh Nes	1	1	1	2	3	2	2	4	5	3	3	3	4	6	7	8
Fruit, tropical fresh nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gooseberries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grapefruit (inc. pomelos)	0	1	1	2	4	5	5	9	9	13	13	24	15	18	15	15
Grapes	3	5	7	8	14	22	23	21	20	30	29	22	19	21	16	20
Kiwi fruit	3	2	2	2	2	1	1	0	0	0	1	1	1	1	1	1
Lemons and limes	2	7	2	1	4	2	3	2	3	4	10	9	10	12	17	18
Mangoes, mangosteens, guavas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Oranges	3	5	5	1	1	3	8	6	5	4	8	5	5	6	9	8
Other melons (inc.cantaloupes)	0	1	0	1	2	2	2	3	3	2	3	3	2	3	4	3
Papayas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peaches and nectarines	3	3	1	1	2	2	2	3	3	1	3	3	3	4	4	3
Pears	1	3	1	0	1	1	2	3	3	2	2	1	2	1	2	2
Persimmons	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pineapples	0	0	0	0	0	1	0	0	1	1	1	1	1	2	2	3
Plantains	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plums and sloes	1	3	5	3	2	4	9	3	6	2	4	2	2	4	2	3
Quinces	0	0	0	0	1	1	2	2	2	2	2	2	2	2	2	2
Raspberries	0	0	0	1	1	0	0	1	1	1	1	2	4	4	2	1
Sour cherries	0	0	1	1	2	2	4	1	2	0	0	0	2	0	1	0
Stone fruit, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strawberries	1	1	1	1	1	1	1	1	1	2	2	2	1	2	2	2
Tangerines, mandarins, clem.	5	8	5	4	5	7	11	10	7	7	9	10	8	11	14	15
Watermelons	1	1	5	6	7	7	9	9	19	4	6	6	8	12	4	8
Fruits, EXP	**83**	**110**	**108**	**79**	**108**	**132**	**153**	**141**	**186**	**169**	**215**	**231**	**214**	**232**	**236**	**265**

Annex II: A.1.1.9 Fibre Crops – Domestic Extraction, Foreign Trade

Domestic Extraction in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Agave Fibres Nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton lint	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fibre Crops Nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flax fibre and tow	1	4	7	6	5	4	3	1	0	0	0	0	0	0	0	0
Hemp Tow Waste	1	0	0	0	0	0	0	0	3	3	2	4	3	2	3	3
Jute	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kapok Fruit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manila Fibre (Abaca)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Bastfibres	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ramie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Seed cotton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sisal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fibre Crops, DE	**2**	**4**	**7**	**6**	**5**	**4**	**3**	**1**	**3**	**3**	**2**	**4**	**3**	**2**	**3**	**3**

Import ***in 1000t***	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Agave and Sisal, raw	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Binder or baler twine of sisal or agave	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton lint	24	28	36	30	32	36	34	36	21	26	26	18	11	11	6	6
Cottonseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fibre Crops Nes	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Flax fibre and tow	1	1	2	2	2	3	2	2	3	3	1	0	0	0	0	0
Hemp Tow Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jute	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
Manila Fibre (Abaca)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ramie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fibre Crops, IMP	**27**	**30**	**39**	**32**	**34**	**40**	**37**	**39**	**25**	**30**	**28**	**18**	**12**	**12**	**7**	**7**
Export ***in 1000t***	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Agave and Sisal, raw	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Binder or baler twine of sisal or agave	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton lint	0	1	0	0	0	0	0	1	1	1	1	1	1	0	1	1
Cottonseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fibre Crops Nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flax fibre and tow	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Hemp Tow Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jute	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manila Fibre (Abaca)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ramie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fibre Crops, EXP	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**1**	**1**	**0**	**1**	**1**

Annex II: A.1.1.10 Other Crops – Domestic Extraction, Foreign Trade

Domestic Extraction in 1000t	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Anise, badian, fennel, corian.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carobs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicory roots	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chillies and peppers, dry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cinnamon (canella)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cloves	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cocoa beans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coffee, green	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ginger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maté	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural rubber	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nutmeg, mace and cardamoms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pepper (Piper spp.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peppermint	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrethrum,Dried	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spices, nes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tobacco, unmanufactured	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Crops, DE	**1**	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**

Import in 1000t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Anise, badian, fennel, corian.	2	2	3	3	2	2	3	2	2	2	2	2	2	2	2	2
Carobs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicory roots	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chillies and peppers, dry	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Cinnamon (canella)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cloves	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cocoa beans	15	15	17	18	20	19	23	22	25	23	10	9	11	11	18	12
Coffee, green	62	63	67	66	70	50	65	64	65	62	52	66	69	65	27	32
Ginger	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Hops	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Maté	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural rubber	2	2	4	4	4	4	5	5	5	4	5	4	3	4	3	0
Nutmeg, mace and cardamoms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pepper (Piper spp.)	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	2
Pyrethrum,Dried	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spices, nes	1	1	1	1	1	1	1	1	2	2	3	3	3	3	3	3
Tea	2	2	2	2	3	2	2	2	2	2	3	2	3	3	3	3
Tobacco, unmanufactured	8	7	8	10	10	14	19	25	26	23	23	20	23	15	10	5
Vanilla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Crops, IMP	**98**	**97**	**108**	**111**	**117**	**102**	**123**	**127**	**133**	**126**	**104**	**114**	**121**	**111**	**76**	**66**

Export in 1000t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Anise, badian, fennel, corian.	0	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Carobs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicory roots	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chillies and peppers, dry	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1
Cinnamon (canella)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cloves	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cocoa beans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coffee, green	4	2	1	1	1	0	2	0	1	2	1	5	1	2	1	1
Ginger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maté	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural rubber	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nutmeg, mace and cardamoms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pepper (Piper spp.)	0	0	1	0	0	0	0	1	1	1	1	1	1	1	1	2
Pyrethrum,Dried	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spices, nes	1	1	2	2	2	3	3	5	6	7	4	4	4	2	2	2
Tea	1	1	1	1	1	0	1	0	1	1	1	2	2	2	2	2
Tobacco, unmanufactured	2	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Vanilla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Crops, EXP	**8**	**5**	**8**	**7**	**7**	**7**	**8**	**10**	**12**	**13**	**10**	**15**	**11**	**11**	**10**	**10**

Annex III: A.1.2 Crop Residues (used), Fodder Crops and Grayed Biomass – Domestic Extraction, Foreign Trade, Direct Material Input, Domestic Material Consumption

in 1000t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
A.1.2.2.1 Fodder crops, DE	12 091	11 518	12 278	11 903	12 185	10 414	10 205	10 883	9 392	11 609	12 827	11 988	11 298	12 395	12 131	11 597
A.1.2.2.1 Fodder crops, IMP	112	104	133	123	147	154	180	181	191	212	206	208	222	241	224	222
A.1.2.2.1 Fodder crops, EXP	171	160	173	196	197	167	221	208	204	228	211	222	217	287	263	249
A.1.2.2.1 Fodder crops, DMI	12 203	11 622	12 411	12 026	12 332	10 568	10 385	11 064	9 583	11 821	13 033	12 196	11 520	12 636	12 355	11 819
A.1.2.2.1 Fodder crops, DMC	12 032	11 462	12 238	11 830	12 135	10 401	10 164	10 856	9 379	11 593	12 822	11 974	11 303	12 349	12 092	11 570
A.1.2.2.2 Grazed biomass, DE	2 412	2 420	2 414	2 414	2 526	2 627	2 627	2 627	2 378	2 582	2 582	2 699	2 180	2 180	2 180	2 180
A.1.2.2.2 Grazed biomass, IMP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A.1.2.2.2 Grazed biomass, EXP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A.1.2.2.2 Grazed biomass, DMI	2 412	2 420	2 414	2 414	2 526	2 627	2 627	2 627	2 378	2 582	2 582	2 699	2 180	2 180	2 180	2 180
A.1.2.2.2 Grazed biomass, DMC	2 412	2 420	2 414	2 414	2 526	2 627	2 627	2 627	2 378	2 582	2 582	2 699	2 180	2 180	2 180	2 180
A.1.2.1 Crop residues (used), DE	2 408	2 118	2 227	2 286	2 296	1 846	2 238	2 016	1 671	2 264	2 008	2 209	2 295	2 761	2 416	2 546
A.1.2.1 Crop residues (used), IMP	10	15	31	24	32	30	38	39	45	49	40	45	42	40	49	53
A.1.2.1 Crop residues (used), EXP	2	3	4	4	6	9	11	10	11	14	11	13	13	18	16	18
A.1.2.1 Crop residues (used), DMI	2 418	2 133	2 258	2 310	2 328	1 876	2 276	2 055	1 716	2 313	2 048	2 254	2 337	2 801	2 465	2 599
A.1.2.1 Crop residues (used), DMC	**2 416**	**2 130**	**2 254**	**2 306**	**2 322**	**1 867**	**2 265**	**2 045**	**1 705**	**2 299**	**2 037**	**2 241**	**2 324**	**2 783**	**2 449**	**2 581**
A.1.2 Crop Residues (used),..., DE	**16 910**	**16 056**	**16 920**	**16 603**	**17 006**	**14 888**	**15 070**	**15 526**	**13 440**	**16 454**	**17 417**	**16 897**	**15 773**	**17 336**	**16 726**	**16 323**
A.1.2 Crop Residues (used),..., IMP	**121**	**120**	**164**	**147**	**179**	**184**	**219**	**220**	**236**	**261**	**246**	**253**	**264**	**281**	**273**	**275**
A.1.2 Crop Residues (used),..., EXP	**173**	**163**	**177**	**200**	**203**	**177**	**232**	**217**	**215**	**242**	**223**	**235**	**230**	**305**	**280**	**267**
A.1.2 Crop Residues (used),..., DMI	**17 031**	**16 176**	**17 084**	**16 750**	**17 185**	**15 072**	**15 289**	**15 746**	**13 676**	**16 715**	**17 663**	**17 150**	**16 037**	**17 617**	**16 999**	**16 598**
A.1.2 Crop Residues (used),..., DMC	**16 858**	**16 013**	**16 907**	**16 550**	**16 982**	**14 895**	**15 057**	**15 529**	**13 461**	**16 473**	**17 440**	**16 915**	**15 807**	**17 312**	**16 719**	**16 331**

Annex IV: A.1.3 Wood in cubic meters – Domestic Extraction, Foreign Trade, Direct Material Input, Domestic Material Consumption

In 1000 m³	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	*2010*
A.1.3.2 C Industrial Roundwood(C), DE	10 326	10 825	10 917	10 098	10 186	9 607	9 695	10 900	12 774	11 973	11 846	13 514	15 570	15 722	11 344	12542,287
A.1.3.2 C Industrial Roundwood(C), IMP	3 950	3 552	4 125	3 959	5 765	7 020	6 130	6 035	6 379	7 650	7 517	7 808	7 325	6 418	6 924	6699,511
A.1.3.2 C Industrial Roundwood(C), EXP	490	462	634	575	622	463	492	494	519	638	601	544	719	849	648	856,149
A.1.3.2 C Industrial Roundwood(C), DMI	14 276	14 377	15 042	14 057	15 951	16 627	15 825	16 935	19 153	19 623	19 363	21 322	22 895	22 140	18 268	19241,798
A.1.3.2 C Industrial Roundwood(C), DMC	13 786	13 915	14 408	13 482	15 329	16 164	15 333	16 441	18 634	18 985	18 762	20 778	22 176	21 291	17 620	18385,649
A.1.3.2 NC Industrial Roundwood(NC), DE	1 020	987	985	760	802	809	867	910	945	970	940	916	951	1 049	800	739,157
A.1.3.2 NC Industrial Roundwood(NC), IMP	884	899	1 152	1 154	1 328	1 431	1 363	1 254	1 119	1 162	1 112	1 294	1 397	1 132	1 112	1341,225
A.1.3.2 NC Industrial Roundwood(NC), EXP	142	163	185	217	417	461	440	370	250	297	235	174	157	125	80	98,718
A.1.3.2 NC Industrial Roundwood(NC), DMI	1 904	1 886	2 137	1 914	2 130	2 240	2 230	2 164	2 064	2 132	2 052	2 210	2 348	2 181	1 912	2080,382
A.1.3.2 NC Industrial Roundwood(NC), DMC	1 762	1 723	1 952	1 697	1 713	1 779	1 790	1 794	1 814	1 835	1 817	2 036	2 191	2 056	1 831	1981,664
A.1.3.2 Industrial Roundwood, DE	11 346	11 812	11 902	10 858	10 988	10 416	10 562	11 810	13 719	12 943	12 786	14 430	16 521	16 772	12 144	13281,444
A.1.3.2 Industrial Roundwood, IMP	4 834	4 451	5 277	5 113	7 093	8 451	7 493	7 289	7 498	8 812	8 629	9 102	8 722	7 550	8 036	8040,736
A.1.3.2 Industrial Roundwood, EXP	632	625	819	792	1 039	924	932	864	769	935	836	718	876	974	729	954,867
A.1.3.2 Industrial Roundwood, DMI	16 180	16 263	17 179	15 971	18 081	18 867	18 055	19 099	21 217	21 755	21 415	23 532	25 243	24 322	20 180	21322,18
A.1.3.2 Industrial Roundwood, DMC	15 548	15 638	16 360	15 179	17 042	17 943	17 123	18 235	20 448	20 820	20 579	22 814	24 367	23 348	19 451	20367,313
A.1.3.1 Wood Fuel, DE	3 059	3 797	3 423	3 175	3 095	2 860	2 905	3 036	3 336	3 540	3 685	4 705	4 796	5 024	4 584	4549,512
A.1.3.1 Wood Fuel, IMP	164	296	156	124	117	139	173	163	196	257	272	326	261	267	564	611,015
A.1.3.1 Wood Fuel, EXP	6	13	9	11	11	18	25	29	72	102	65	54	45	39	77	75,758
A.1.3.1 Wood Fuel, DMI	3 223	4 093	3 579	3 299	3 212	2 999	3 078	3 199	3 532	3 797	3 957	5 031	5 057	5 291	5 147	5160,527
A.1.3.1 Wood Fuel, DMC	3 217	4 080	3 570	3 288	3 201	2 981	3 053	3 170	3 460	3 695	3 892	4 977	5 012	5 252	5 071	5084,769
A.1.3 Wood, DE	14 405	15 609	15 325	14 033	14 083	13 276	13 467	14 846	17 055	16 483	16 471	19 135	21 317	21 795	16 727	17830,956
A.1.3 Wood, IMP	4 998	4 747	5 433	5 237	7 210	8 590	7 666	7 452	7 694	9 069	8 901	9 428	8 983	7 817	8 600	8651,751
A.1.3 Wood, EXP	638	638	828	803	1 050	942	957	893	841	1 037	901	772	921	1 013	805	1030,625
A.1.3 Wood, DMI	19 403	20 356	20 758	19 270	21 293	21 866	21 133	22 298	24 749	25 552	25 372	28 563	30 300	29 612	25 327	26482,707
A.1.3 Wood, DMC	**18 765**	**19 718**	**19 930**	**18 467**	**20 243**	**20 924**	**20 176**	**21 405**	**23 908**	**24 515**	**24 471**	**27 791**	**29 379**	**28 599**	**24 522**	**25452,082**

Annex V: A.1.3 Wood in metric tonnes – Domestic Extraction, Foreign Trade, Direct Material Input, Domestic Material Consumption

In 1000t	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
A.1.3.2 C Industrial Roundwood(C), DE	5 370	5 629	5 677	5 251	5 297	4 996	5 041	5 668	6 642	6 226	6 160	7 027	8 096	8 176	5 899	6 522
A.1.3.2 C Industrial Roundwood(C), IMP	2 054	1 847	2 145	2 059	2 998	3 650	3 188	3 138	3 317	3 978	3 909	4 060	3 809	3 337	3 601	3 484
A.1.3.2 C Industrial Roundwood(C), EXP	255	240	330	299	323	241	256	257	270	332	313	283	374	441	337	445
A.1.3.2 C Industrial Roundwood(C), DMI	7 424	7 476	7 822	7 310	8 295	8 646	8 229	8 806	9 960	10 204	10 069	11 087	11 905	11 513	9 499	10 006
A.1.3.2 C Industrial Roundwood(C), DMC	7 169	7 236	7 492	7 011	7 971	8 405	7 973	8 549	9 690	9 872	9 756	10 805	11 531	11 072	9 162	9 561
A.1.3.2 NC Industrial Roundwood(NC), DE	653	632	630	486	513	518	555	582	605	621	602	586	609	672	512	473
A.1.3.2 NC Industrial Roundwood(NC), IMP	566	575	737	739	850	916	872	803	716	744	712	828	894	724	712	858
A.1.3.2 NC Industrial Roundwood(NC), EXP	91	104	118	139	267	295	282	237	160	190	150	111	100	80	51	63
A.1.3.2 NC Industrial Roundwood(NC), DMI	1 219	1 207	1 368	1 225	1 363	1 434	1 427	1 385	1 321	1 364	1 313	1 414	1 503	1 396	1 224	1 331
A.1.3.2 NC Industrial Roundwood(NC), DMC	1 128	1 103	1 249	1 086	1 096	1 139	1 146	1 148	1 161	1 174	1 163	1 303	1 402	1 316	1 172	1 268
A.1.3.2 Industrial Roundwood, DE	6 022	6 261	6 307	5 737	5 810	5 513	5 596	6 250	7 247	6 847	6 762	7 614	8 705	8 847	6 411	6 995
A.1.3.2 Industrial Roundwood, IMP	2 620	2 422	2 882	2 797	3 848	4 566	4 060	3 941	4 033	4 722	4 621	4 888	4 703	4 062	4 312	4 342
A.1.3.2 Industrial Roundwood, EXP	346	345	448	438	590	536	537	494	430	522	463	394	474	521	389	508
A.1.3.2 Industrial Roundwood, DMI	8 642	8 683	9 190	8 535	9 658	10 080	9 656	10 191	11 281	11 568	11 382	12 502	13 408	12 909	10 723	11 337
A.1.3.2 Industrial Roundwood, DMC	8 296	8 339	8 741	8 097	9 067	9 544	9 119	9 697	10 851	11 047	10 919	12 108	12 934	12 388	10 334	10 829
A.1.3.1 Wood Fuel, DE	1 733	2 118	1 935	1 810	1 767	1 636	1 662	1 731	1 900	2 014	2 099	2 673	2 703	2 836	2 605	2 581
A.1.3.1 Wood Fuel, IMP	99	178	93	75	71	84	104	98	118	155	163	196	157	161	339	365
A.1.3.1 Wood Fuel, EXP	3	7	5	6	6	10	14	17	41	58	37	31	25	22	44	43
A.1.3.1 Wood Fuel, DMI	1 832	2 296	2 028	1 884	1 838	1 720	1 767	1 829	2 018	2 169	2 262	2 869	2 860	2 997	2 944	2 946
A.1.3.1 Wood Fuel, DMC	1 829	2 289	2 023	1 878	1 832	1 709	1 752	1 812	1 977	2 111	2 225	2 838	2 835	2 975	2 901	2 903
A.1.3 Wood, DE	7 756	8 379	8 242	7 547	7 577	7 149	7 259	7 981	9 147	8 861	8 860	10 286	11 408	11 683	9 016	9 576
A.1.3 Wood, IMP	2 719	2 601	2 975	2 872	3 919	4 650	4 164	4 039	4 151	4 876	4 784	5 085	4 860	4 223	4 651	4 707
A.1.3 Wood, EXP	349	352	453	444	597	546	552	510	471	580	500	425	500	543	432	551
A.1.3 Wood, DMI	10 474	10 979	11 218	10 419	11 496	11 799	11 423	12 020	13 298	13 737	13 644	15 371	16 268	15 906	13 667	14 283
A.1.3 Wood, DMC	**10 125**	**10 627**	**10 765**	**9 975**	**10 899**	**11 253**	**10 871**	**11 510**	**12 827**	**13 157**	**13 145**	**14 946**	**15 768**	**15 362**	**13 235**	**13 732**