Federal Ministry
Transport, Innovation
and Technology

NACHHALTIGwirtschaften

Bioenergy in Austria

Technological expertise for biomass-based heat, power and transport fuels

D. Bacovsky, D. Matschegg

Reports of Energy and Environmental Research

52/2019

More reports and Downloads: http://www.nachhaltigwirtschaften.at

Imprint

Owner and Publisher:
Federal Ministry for Transport, Innovation and Technology
Radetzkystr. 2, 1030 Wien

Responsibility and Coordination:
Department for Energy and Environmental Technology
Head: DI Michael Paula

Bioenergy in Austria

Technological expertise for biomass-based heat, power and transport fuels

Dina Bacovsky, Doris Matschegg

BEST - Bioenergy and Sustainable Technologies GmbH

(formerly known as BIOENERGY 2020+ GmbH)

Graz, November 2019

Bioenergy and
Sustainable Technologies

A Survey on behalf of the Federal Ministry for Transport, Innovation and Technology

Preliminary note

Bioenergy represents an important pillar of domestic energy supply. Through many years of research and development efforts, Austria has been able to present itself as an innovation leader and is one of the world leaders in the use of bioenergy. Due to its advantages - storage capacity and use of sustainable and regional resources - the share of bioenergy in the domestic energy market has almost doubled compared to 1990.

In addition to national RTI initiatives, the Austrian Ministry of Transport, Innovation and Technology (BMVIT) also focuses on participation in transnational activities, such as the Bioenergy Technology Collaboration Program of the International Energy Agency (IEA), in which Austria has been involved for over 40 years in promoting innovation and take advantage of synergies.

The present survey helps to bring Austria's strengths into international networks and supports all future efforts and measures regarding bioenergy as an important component of a comprehensive bioeconomy.

Michael PAULA
Head of Department Energy and Environmental Technologies
Austrian Ministry for Transport, Innovation and Technology

Table of Content

Executive Summary

Bioenergy in Austria is a success story, both in terms of technological development as well as of market implementation. A strong biomass resource base along with policy measures providing national demand for bioenergy have provided the environment needed for companies and research institutes to engage in joint research projects, develop bioenergy technologies and become widely renown for related expertise. Today, some 100 companies provide bioenergy technologies, backed up by some 20 research institutes and 40 universities and technical colleges active in the field of bioenergy.

The share of bioenergy in total energy consumption increased from 9 % to 17 % between 1990 and 2017. In 2016, biomass provided 35 % of heat demand, 6.4 % of electricity demand, and 6.7 % of transport fuel demand in Austria. Of the total final energy consumption of 1,121 PJ in 2016, 35 % were based on renewable energy resources, of which bioenergy with a share of 55 % constituted the major part. Bioenergy in the form of heat, electricity and transport biofuels is produced in 2,377 biomass heating plants, 128 biomass CHPs, 292 biogas facilities, 9 biodiesel facilities and one ethanol production facility. The bioenergy sector provides around 20,000 green jobs and creates an annual turnover of some 3 billion €.

Yet the sector still has to grow. Austria has defined goals for reducing GHG emissions and transitioning to a low-carbon energy system. The Austrian Climate and Energy Strategy published in 2018 (#mission 2030) states that “Austria intends to reduce its greenhouse gas emissions by 2030 by 36 % compared to 2005”. Bioenergy research, development and deployment play a key role in this transition.

Biomass potential

In Austria, the production of bioenergy is primarily based on forest residues. The forest area in Austria currently amounts to roughly 4 million hectares (ha) of forest, which corresponds to 47.9 % of the total state surface. In 2016, 10,550,100 t-atro woody biomass and residues from the wood industry have been used for energy production in Austria, supplying about 199 PJ. Wood chips and other forest residues are mainly used in (regional) heating plants.

Agricultural land represented 16 % (1.35 million ha) of the total state surface in 2015. The biggest share, with 47.2 %, is used for feed production to feed animals for human consumption. Less than one third (31.4 %) is used for food production and just a small fraction (7.5 %) of agricultural biomass is used for the production of bioenergy. Agricultural biomass and residues are primarily used for the production of transport biofuels. Conventional transport biofuel production is based on oil crops, sugar crops and starch crops. Current production of these crops sums up to more than 8 million t of biomass, but most of this goes into food and feed production. Advanced biofuel production aims to utilize dedicated bioenergy crops (such as short rotation forestry and miscanthus) or agricultural residues. While current production of dedicated bioenergy crops and agricultural residues sums up to 29.3 million t (including 25 million t of manure), annual additional potential is estimated to sum up to 1.2 - 3 million t, providing 22.7 - 54.6 PJ of bioenergy.

Various waste streams, such as municipal solid waste, biogenic waste, biogenic urban waste and municipal sewage sludge, currently sum up to 3.2 million t, with a potential to provide 17 – 20.6 PJ of bioenergy by 2030.

The total annual additional biomass potential for bioenergy production can be estimated at 54.9 to 102.5 PJ. However, the maximum potential can only be realized with appropriate accompanying measures such as value chain optimization, biomass ash recirculation, renaturation etc..

Technological expertise

Biomass combustion for the production of heat is a well-established technology in Austria. Appliances range from household boilers and stoves fired by log wood, wood chips, or pellets to biomass heating plants that provide district heat to households and industry. 2,377 biomass heating plants are operational, and around half of the Austrian households use some kind of biomass-based heating system. More than 50 companies offer such biomass boilers, stoves and heating plants, related wood processing equipment, heating plant components, measurement equipment and related engineering services.

Electricity production from biomass always includes heat production and thus takes place in CHPs. Technologies used are biomass combustion, biomass gasification and anaerobic digestion, each followed by electricity generation and transfer of heat to the heating system. While biomass combustion and anaerobic digestion are well-established with 128 and 292 facilities respectively, the use of gasification technology is rare with only 22 installed facilities. Continued research is required to fully bring this technology into the market. Around ten companies and research institutes are involved in gasification-related R&D.

The production of so-called conventional transport biofuels (from food and feed crops) is well-established in Austria. Currently, nine biodiesel facilities and one ethanol facility produce biofuels. There are two internationally renowned technology providers, one for biodiesel and one for ethanol technology. Currently there is no commercial production of advanced biofuels, but one company is planning to produce ethanol from the fermentation of brown liquor in a pulp refinery. Demonstration facilities for the production of biomethane via gasification, FT-liquids from syngas, and the integration of biomass into a fossil oil refinery exist. Austrian companies are involved in a number of advanced biofuels demonstration projects around the globe, and are backed up by world-class research at Austrian research institutes.

Advanced biofuel pathways pursued by Austrian companies and research institutes include cellulosic ethanol, methanation of syngas, synfuels such as FT-liquids and mixed alcohols, co-processing in oil refineries, algae based pathways and electrofuels. Sixteen EU-funded research projects are currently being executed in this field with Austrian participation.

Austria is also engaging in international cooperation through its participation in the IEA Bioenergy Technology Collaboration Programme. In this programme, national experts from research, politics and industry work closely together with experts from other countries. This cooperation enables a worldwide transfer of information and the coordination of national programs and research in the field of bioenergy use.

Political framework

The most important EU regulation driving bioenergy deployment is the Renewable Energy Directive, published in 2009, and its successor RED-II, published in 2018. The Renewable Energy Directive has been transposed into national law through a number of legislative pieces. The envisaged path towards reaching the targets for 2020 is laid down in the National Renewable Energy Action Plan, which was submitted to the European Commission in 2009.

Measures for the heating and cooling sector include the Environmental Measures Support Act, which is a support for environmental protection in general, and the guidelines for domestic environmental support, which specifically promote renewable energies. The Green Electricity Act, updated in 2012, is the support policy for energy from renewable sources in the electricity sector. It sets targets of new installations until 2020. A feed-in-tariff scheme supports the pay-off of the investments. For the transport sector the most important piece of legislation is the Fuel Ordinance Amendment. It establishes a quota for biofuels: by 2020, 8.45 % (with regard to energy content) of diesel and petrol have to be substituted by energy from renewable resources.

Further legislation, transposing the new RED-II into national law, has yet to be created and will constitute the framework for targets beyond 2020. RED-II is especially important for creating market demand for advanced biofuels, setting targets of 0.2 % advanced biofuels by 2022, 1 % by 2025, and 3.5 % by 2030.

Outlook

Bioenergy in Austria can significantly contribute to addressing the climate crisis, a complex phenomenon which can only be tackled with a holistic and integrated approach. Related R&D should span all aspects of the necessary transition of the energy system, including

- Societal aspects such as sustainability, public acceptance, and affordability,
- Environmental aspects such as GHG emissions and local emissions, and impacts on soil, water, and biodiversity,
- Increased supply of biomass in a sustainable manner, and
- Development and deployment of efficient and economic technologies for the production and use of bioenergy.

In the light of the recent steep increase in public awareness that bold action to fight the climate crisis is required now, there will be further demand for bioenergy technologies worldwide, offering market opportunities for Austrian companies and allowing Austria to play a leading role in energy innovation.

1 Introduction

Austria has ambitious goals for reducing GHG emissions and transitioning to a low-carbon energy system. The Austrian Climate and Energy Strategy published in 2018 (#mission 2030) states that "Austria intends to reduce its greenhouse gas emissions by 2030 by 36 % compared to 2005. That means that a coordinated climate and energy policy is needed that strikes a balance between ecological sustainability, competitiveness/affordability and security of supply both now and in the future".

The strategy lists eight horizontal tasks which describe the key areas for action under climate and energy policy and twelve flagship projects which constitute the first key steps. Bioenergy research, development and deployment play a key role in many of these.

The Austrian Ministry of Transport, Innovation and Technology has commissioned this report "Bioenergy in Austria" as to provide the basis for establishing action plans as required for the energy and bioeconomy sectors. The report focuses on the description of the Austrian technological expertise; the availability of feedstock and the political framework are just covered briefly. A more detailed assessment of the potential availability of in particular agricultural biomass will also be needed for the mentioned action plans, but are outside of the scope of this report.

The report starts with a description of the current share and future role of bioenergy in Austria. Then the biomass potentials are classified and determined. The focus lies on biomass residues from forest and agriculture and wastes, which can be used energetically. For each residue, the current production, consumption and potential are stated. The outcome is summarised in a table presenting the additional annual biomass potential until 2030.

The focus of the report is on the description of the technological expertise in Austria. This part includes flagship projects from the sectors heating and cooling, electricity and transport, which open the market for industrial scale bioenergy. Special attention is given to R&D activities, demonstration plants, involved companies and research institutions for the transport sector. This chapter displays various commercial and future technologies and the current know-how of Austrian companies and research institutions.

Finally, the political framework, promoting the use of bioenergy, is briefly described. This includes EU and Austrian legislation, with relevant directives, like Green Electricity Act and Fuel Ordinance, tax abatements and the integrated climate- and energy strategy, which are set to reach the 20-20-20 targets by using, among others, bioenergy.

2 The success of bioenergy in Austria

Bioenergy in Austria is a success story, both in terms of technological development as well as of market implementation. A strong biomass resource base along with policy measures providing national demand for bioenergy have provided the environment needed for companies and research institutes to engage in joint research projects, develop bioenergy technologies and become widely renown for related expertise. Today, some 100 companies provide bioenergy technologies, backed up by some 20 research institutes and 40 universities and technical colleges active in the field of bioenergy.

In 2016, biomass provided 35 % of heat demand, 6.4 % of electricity demand, and 6.7 % of transport fuel demand in Austria. 35 % of the total final energy consumption (1,121 PJ in 2016) were based on renewable energy resources, of which bioenergy with a share of 55 % constituted the major part (Plank & Pfemeter, Basisdaten 2017 Bioenergie, 2017). The share of bioenergy in total energy consumption increased from 9 % to 17 % between 1990 and 2017 (bmnt, bmbwf, bmvit, 2019).

Due to the renewable expansion law, a further increase of the bioenergy share is expected. Among the benefits of bioenergy are the increase in national self-sufficiency, the reduction of greenhouse gas emissions and the creation of regional added value. Continuous technical development of all forms of biomass (solid, liquid, gaseous) is needed to expand the market leadership and research capabilities of Austrian companies and therefore increase chances on export markets and create domestic added value. (bmnt, bmbwf, bmvit, 2019)

Bioenergy in form of heat, electricity and transport biofuels is produced in around 2,377 biomass heating plants, 128 biomass CHPs, 292 biogas facilities, 9 biodiesel facilities and one ethanol production facility (Pfemeter, Bioenergie Atlas Österreich, 2019). The bioenergy sector provides around 20,000 green jobs and creates an annual turnover of some 3 billion €. (Pfemeter, Plank, & Liptay, Bioenergie 2030, 2015)

The main potential of biomass is in the decentralised heating sector in form of high-efficient CHPs. There is a great deal of untapped potential on the heat market, as there is a high dependency on fossil fuels in this sector. A National Heat Strategy will be defined to set out the details. Heat and electricity from biomass do not depend on weather conditions and can therefore help to stabilize the energy supply. Supply and demand can be balanced and production of heat, cooling energy, electricity and biofuels can be demand-driven. Biomass, in form of agricultural and forestry products and residues, is an important source for domestic energy supply. The key to integrated urban development is to use heat and cooling energy, supplied centrally in urban areas from waste heat from high-efficiency CHPs, refuse incineration, industry and biomass plants (bmnt, bmvit, 2018).

The major part (80 %) of bioenergy consumed in Austria is composed of solid biofuels (IEA Bioenergy, 2018). This includes log wood, pellets and briquettes, biogenic waste (from households), waste wood, wood char and other solid biogenic. Solid bioenergy is mainly consumed by wood and wood processing industries, followed by non-ferrous metals, paper, pulp & print and chemicals & petrochemicals production. Other consumers are conversion processes (Schipfer & Kranzl, 2015). The most important kind of solid biomass is wood, and it is mainly used for district and process heat. Besides that, wood also makes an important contribution to the production of green electricity. Compliance with air emission standards requires special attention (bmnt, bmbwf, bmvit, 2019).

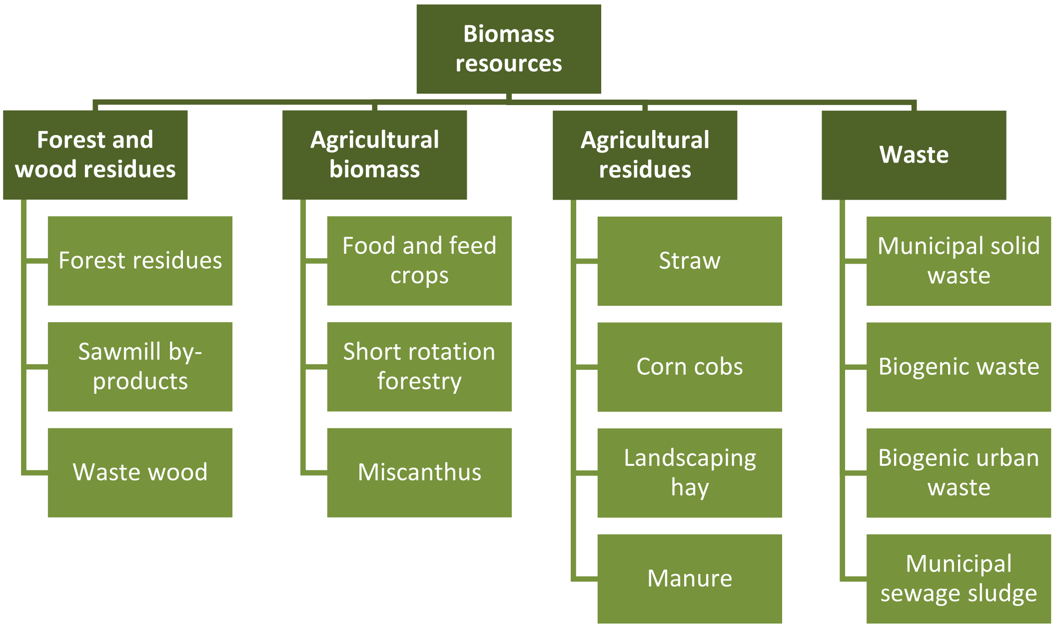
Liquid bioenergy carriers, including black liquor and other liquid biogenics, are mainly used for the production of biofuels (biodiesel – FAME, bioethanol) or consumed by heat and power (CHP) or pure power production (Schipfer & Kranzl, 2015). Biofuels are the single most effective measure towards reducing greenhouse gas emissions from the transport sector. Austria has several pilot and demo plants to research about thermo-chemical processes, direct liquefaction of solid biomass and the cultivation and utilization of aquatic biomass. The national target for the transport sector to replace 5.75 % of fossil fuels with biofuels has been exceeded and the share of biofuels is currently at 6.7 %. Increasing research activities in the field of advanced bioenergy is planned (bmnt, bmbwf, bmvit, 2019).

Gaseous bioenergy carriers, including biogas, landfill gas and sewage gas are mainly transformed into power and partly into heat. A small amount is used in the pulp, paper and print industry, followed by food and chemical industries (Schipfer & Kranzl, 2015). The so called “greening the gas” should be a key issue of energy politics. A main share of natural gas should be replaced by biomethane, produced from biogenic residues (bmnt, bmbwf, bmvit, 2019).

3 Biomass potential as base for a technology roll-out

Biomass resources for energetic use can be distinguished by the source of biomass into forest and wood residues, agricultural biomass, agricultural residues and waste, see Figure 1 below.

Figure 1: Biomass resources for energetic use



3.1 Forest and wood residues

The Austrian Forest Inventory (ÖWI-Österreichische Waldinventur) has been carried out since the 1960s. According to the ÖWI 2007/09, the forest area in Austria amounts to 3.99 million hectares (ha) of forest, which corresponds to 47.6 % of the total state surface. The latest figures from the Forest Inventory 2018 show that the share of forest area increased to 47.9 % in 2018.

Wood flows in Austria consist of the following process steps:

- Cultivation (in mostly privately owned forests with less than 200 ha)
- Logging/harvesting (production of log wood, forest wood chips, etc.; residues)
- Logistics and transport
- Sawmill industry (production of sawn wood; residues: sawmill by-products)

Figure 2 on the next page shows the wood flow in Austria in more detail. Smaller branches are chopped to produce wood chips, bigger ones are cut in order to obtain log wood, and the upper part of the trunk is used as industrial roundwood. The main part of the trunk, together with imported sawlogs pass through the sawmill industry. Sawmill by-products are products arising during sawmill processes, such as sawdust, sawshavings and bark.

The central player in the Austrian wood market is the sawmill industry. The Austrian sawmill industry is a large and highly successful industrial sector with more than 1,000 active companies employing nearly 10,000 workers. The Austrian sawmill industry is almost exclusively small and medium-sized throughout Austria and a very important factor for Austria's foreign trade balance. The availability of forest and wood residues for energetic use largely depends on the functioning of the sawmill industry; without the utilization of wood for sawlogs there would be no residues to use for bioenergy purposes.

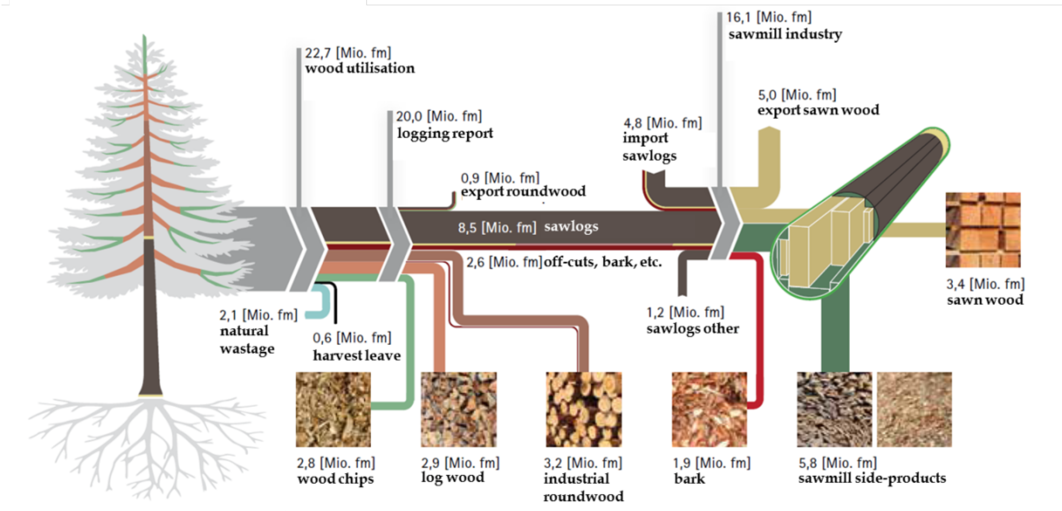


Figure 2: Wood flows in Austria 2016 (Pfemeter, Bioenergie Atlas Österreich, 2019)

3.2 Agricultural biomass and residues

In 2016, the cultivated farmland in Austria amounted to 2.67 million ha (= 32 % of the total state area). Around half of this area is arable land (1.34 million ha), the other half is permanent pasture (1.26 million ha) (BMNT, 2018b). In 2015, 47.2 % of this agricultural land was used for feed production to feed animals for human consumption. Less than one third (31.4 %) was used for food production and just a small fraction (7.5 %) of agricultural biomass was used for the production of bioenergy. This includes the production of transport biofuels, electricity from biogas and dedicated bioenergy crops. Taking into account the substitution effects of protein feed, only 1% of arable land was used for the production of transport biofuels. (Plank & Pfemeter, Basisdaten 2017 Bioenergie, 2017).

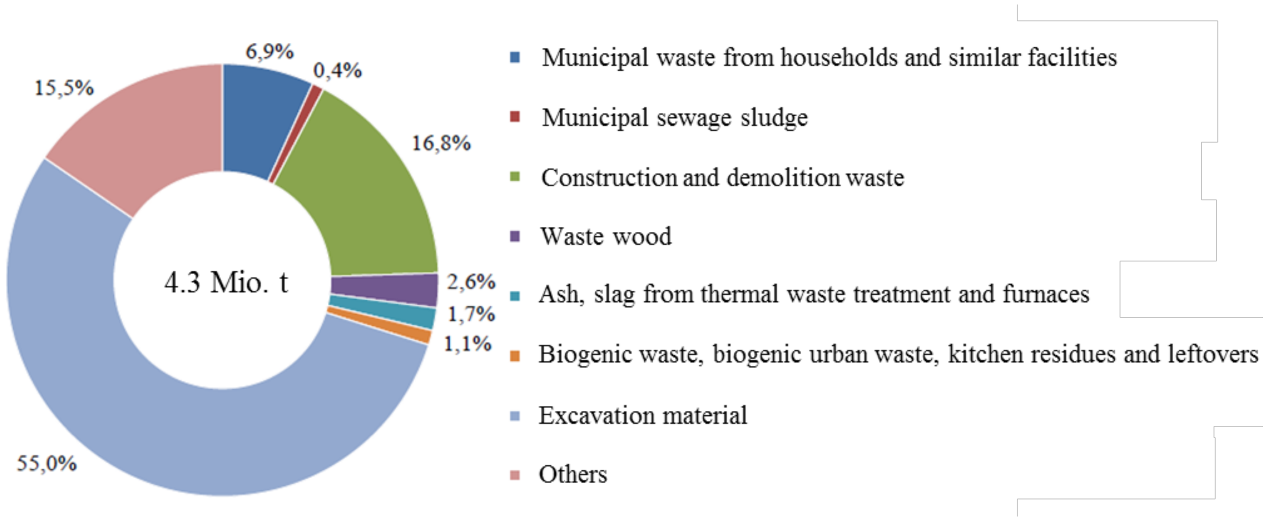
Agricultural biomass and residues are primarily used for the production of liquid bioenergy (transport biofuels). Conventional transport biofuel production is based on oil crops, sugar crops, starch crops, used cooking oil and animal fats. Current production of food and feed crops sums up to more than 8 million t of biomass, but most of this goes into food and feed production. New technologies for the production of advanced biofuels aim at utilizing dedicated bioenergy crops (such as short rotation forestry and miscanthus) or agricultural residues.

Advanced biofuels could be produced from energy crops, agricultural residues, and industrial side-streams. Current activities in the area of energy crops on agricultural land currently focus on the cultivation of miscanthus and short rotation forestry (SRF). In addition to energy crops, by-products and residues of agricultural origin such as straw, corncobs, landscape hay or manure can be used as raw materials for advanced biofuels production.

3.3 Waste

In 2016, 4.3 million t of waste were generated in Austria. Figure 3 shows the composition of total waste by source (Bundesministerium für Nachhaltigkeit und Tourismus, 2018). More than half of the waste generated is excavation material, followed by construction and demolition waste. The fractions that are interesting for bioenergy production include municipal (solid) waste from households and similar facilities (6.9 %), municipal sewage sludge (0.4 %), and biogenic waste and biogenic urban waste (1.1 %).

Figure 3: Composition of total waste in 2016, (Bundesministerium für Nachhaltigkeit und Tourismus, 2018)



Waste can contribute to increase the biomass potential in Austria, for example by using it in biogas or combustion plants. In this report, the potentials of municipal solid waste, municipal sewage sludge, biogenic waste, and biogenic urban waste are considered.

3.4 Biomass availability

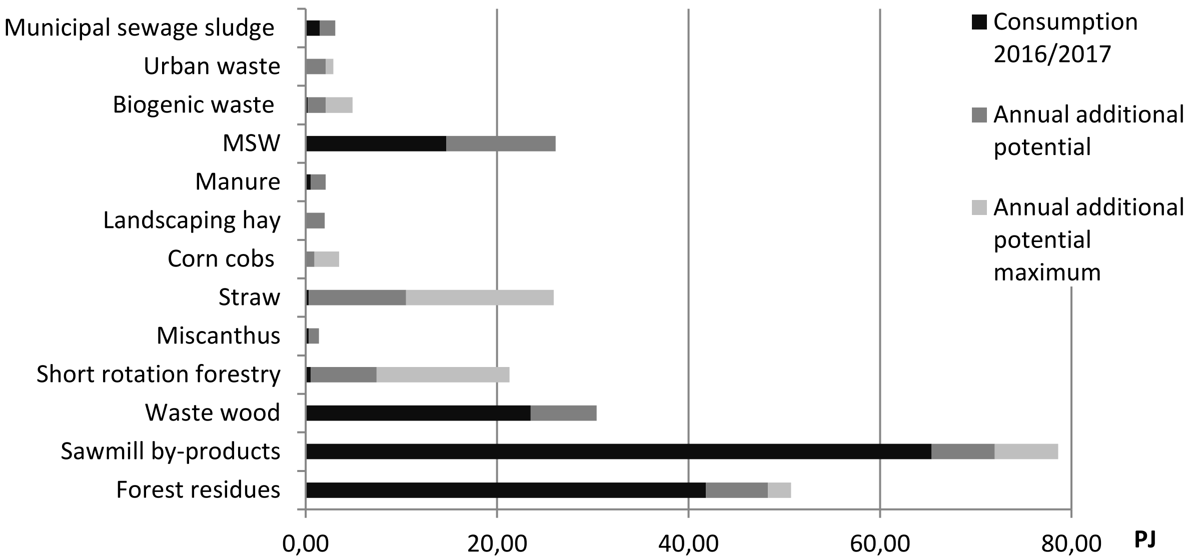
Biomass availability for all sectors is described in detail in Annex 1: Biomass potential. To summarize information from Annex 1, current annual biomass availability for energetic use in Austria is around 148.7 PJ. The additional annual biomass potential for energy production until 2030 is estimated to be between **54.9 and 102.5 PJ.**

Figure 4 below summarizes the current consumption of biomass for energy production and the annual additional biomass potential until 2030. Current consumption is indicated by black bars, the lower boundary of additional biomass potential by dark grey bars, and the upper boundary by light grey bars.

Most of the current consumption of biomass for energy production comes from forest and wood residues. Additional biomass potential to a large extent comes from the agricultural sector, more specifically from the use of straw and corn cobs and from short rotation forestry. It should be noted that the maximum additional biomass potential can only be realized if appropriate accompanying measures such as value chain optimization, biomass ash recirculation, renaturation etc. (see chapter 8.1.3 Agricultural residues for details) are taken.

Not depicted in Figure 4 are food and feed crops, which constitute the main feedstock base for the production of conventional transport biofuels. Only a small percentage of these is used to produce biofuels, and the exact percentage is not available. However, due to the ongoing debate on food vs. fuel and the cap on biofuels produced from food and feed crops as imposed by RED-II, there is no additional potential for this type of biomass.

Figure 4: Current consumption of biomass for energy production and annual additional potential until 2030 in PJ



4 Technological expertise

Austrian companies have highly acknowledged expertise in most commercial biomass conversion technologies and related manufacturing. Austrian researchers also work at the forefront of technology development of future technologies. Table 1 summarises commercial and future technologies.

Table 1: Overview of technologies

Sector	Commercial technologies	Future technologies
Heating and cooling	Small-scale combustion Large-scale combustion Biomass co-firing	Power and heat via gasification
Electricity	Large-scale combustion Biomass co-firing Anaerobic digestion + electricity production	Power and heat via gasification
Transport fuels	Transesterification to biodiesel Hydrotreatment to HVO Ethanol fermentation Anaerobic digestion + upgrading to biomethane	Cellulosic ethanol Biomass gasification Methanation of syngas Synfuels Co-processing in refineries Algae fuels Electrofuels

4.1 Heating and cooling

Currently, 2,377 biomass heating plants and 128 biomass CHPs are operational in Austria, providing 9.6 TWh_{th} per year (Pfemeter, Bioenergie Atlas Österreich, 2019). In addition, thousands of households are using small-scale biomass boilers or stoves for heat provision. In 2017 alone, more than 11,000 biomass boilers were sold on the Austrian market (Biermayr, et al., 2018). The technology of biomass combustion is well established and there are more than 50 companies (Pfemeter, Bioenergie Atlas Österreich, 2019) offering biomass boilers and stoves from small-scale (4 kW_{th}) to large scale (up to 60 MW_{th}). A list of all boiler and stove producers in Austria is provided in Annex 2. Appliances used include log wood boilers, wood chip boilers, pellet boilers, space heaters and CHPs. Biomass-based heat provides 35 % of heat consumption in Austria (Plank & Pfemeter, Basisdaten 2017 Bioenergie, 2017).

Cooling with biomass is not yet big in Austria, but some decentralized cooling with adsorption cooling systems operated on biomass exist. However, currently no market figures are available and no companies with a focus on it are known. Cooling networks are not yet available in Austria, but it is possible to use district heating networks for cooling purposes in summer. Currently, Austria is most likely to be cooled with split units, i.e. reversed heat pumps. This method is currently preferable from an economic point of view.

As to highlight the technological expertise of Austrian companies and the implementation in the Austrian market, some examples for biomass heating or cooling in Austria are cited in the tables below.

Table 2: Flagship project 1 - heating and cooling

Name/Location	**Biomass heating plant in Kaindorf an der Sulm**
Description	The biomass heating plant "Kaindorf an der Sulm" went into operation in December 2015 and is part of the district heating Leibnitz, which also includes a micro grid. The operators voluntarily decided to comply with an emission value <10 mg/Nm³, by condensation of exhaust gas and using a downstream wet electrostatic precipitators.
Performance	6 MWth (3.2 MW boiler plus 1.6 MW boiler plus 1.2 MW high-efficiency boiler trough condensation of exhaust gas)
Input	25.000 srm/a wood chips
Further Information	https://www.haselbacher.at/nahwaerme

Table 3: Flagship project 2 - heating and cooling

Name/Location	**BioWärme Attnang-Puchheim GmbH**
Description	Since 2008, the company S.Spitz GmbH is producing process steam for its operations itself. Spitz is the first European food producer to realize such a system. In addition to steam for its own use, the biomass heat and power plant also supplies the Attnang-Puchheim region with local heat from renewable resources. It comprises an electrostatic filter for dedusting the biomass steam boiler system and an ORC module.
Output	54,000 MWh_{th} and 4,500 MWh_{el}
Input	wood chips
Further Information	https://www.spitz.at/de/unternehmen/ueber-uns/nachhaltigkeit/biowaerme.html

Table 4: Flagship project 3 - heating and cooling

Name/Location	**Lehner Wolle GmbH in Waizenkirchen**
Description	The company Lehner Wolle GmbH generates heat and cooling from biomass for an optimal room and production climate. Heat is generated by a pellet boiler and cooling by an absorption cooling system. In addition, there is rainwater evaporative cooling and heat recovery with a waste water heat exchanger.
Performance	100 kW_{th} 210 kW cooling
Input	pellets
Further Information	https://www.landwirt.com/Lehner-Wolle-kuehlt-und-heizt-mit-Biomasse,,8721,,Bericht.html

4.2 Electricity / CHPs

Currently 292 biogas facilities and 128 biomass CHPs are operational in Austria, providing 3.0 TWh_{el} per year. In 2016, biomass contributed 6.4 % to the total Austrian power supply of 261 PJ, including wood-based biomass, liquor, biogas, waste and other solid biogenics. (Pfemeter, Bioenergie Atlas Österreich, 2019)

Technologies used are biomass combustion, biomass gasification and anaerobic digestion. Electricity is produced via a steam or gas turbine. Heat exchangers allow the provision of heat for regional use; in industrial installations often steam is produced for own use. Technology providers of CHPs and biogas plants are listed in Annex 2.

The tables below show some examples for biomass utilization in the electricity sector, hereby highlighting different technologies.

Table 5: Flagship project 4 - electricity

Name/Location	**BHKW-1-Beteiligungs-GmbH in Heiligenkreuz**
Description	This biomass CHP, operating since 2006, uses a stationary fluidized-bed technology with an extraction condensing turbine. In future, power and heat will be used to supply a planned high-tech facility for the production of pharmaceutical herbs.
Performance	43 MW_{th}, 10 MW_{el}, 6 MW_{th} for district heating
Input	biomass
Further Information	http://www.repotec.at/index.php/biomassekraftwerk-heiligenkreuz.html

Table 6: Flagship project 5 - electricity

Name/Location	**Wood gas CHP plant in Dornbirn-Hatlerdorf**
Description	The CHP plant in Dornbirn is operating since 2014. Wood is charred in a pyrolysis unit and then converted into combustible gas in the gasification unit. This gas drives a motor, which generates electricity via a generator. The special feature of this system is the floating-fixed-bed gasifier, which enables high purity without tars, high efficiency and a high raw material flexibility. What remains is condensed water from the fuel and biochar.
Performance	180 kW electricity, 350 kW heat
Input	6,000 m^3/a wood chips
Output (goal)	1.25 GWh_{el}, 2.45 GWh_{th}
Further Information	https://www.energieautonomie-vorarlberg.at/de/holzvergaser

Table 7: Flagship project 6 - electricity

Name/Location	Biogas Bruck an der Leitha GmbH & Co KG
Description	The biogas plant in Bruck an der Leitha was founded in 2000, combined with a CHP plant. Power and heat are fed into the public power grid and the local heating grid. Since 2014 biogas is upgraded to biomethane and fed into the gas grid.
Input	34,000 t/a organic residues from food and feed industry, kitchen and canteen waste, agricultural residues
Output	5,200,000 m³/a biogas 3,300,000 m³/a biomethane, power and heat, 34,000 m³/a fertilizer
Further Information	http://www.energiepark.at/biogas/anlagenbeschreibung/

4.3 Transport fuels

In 2016, a total of about 330 PJ of transport fuels was consumed in Austria, 6.7 % of which were biofuels. More than half of it was biodiesel, followed by other liquid biogenic fuels, such as HVO and bioethanol. About 6 % (77,000 ha) of Austrian arable land was utilized for transport biofuels production in 2015, but taking into account the substitution effects of protein feed, only 1 % of arable land was used. (Plank & Pfemeter, Basisdaten 2017 Bioenergie, 2017). In Austria one large bioethanol production facility and nine smaller FAME (biodiesel) production facilities were operating in 2016 (Bacovsky, Update on Implementation Agendas 2018, 2018). The entire demand for bioethanol can be covered by one production facility. Table 8 shows the production of biofuels in Austria in 2016.

Table 8: Production facilities of biofuels in Austria 2016 (Bacovsky, Update on Implementation Agendas 2018, 2018)

Company	City	Kind of fuel	Capacity [ML/a]
AGRANA Bioethanol GmbH	Pischelsdorf	Bioethanol	246
Total bioethanol production			**246**
Biodiesel Süd GmbH	Bleiburg	FAME	22
Münzer Bioindustrie GmbH	Wien	FAME	157
Eco Fuels Danube GmbH	Krems	FAME	56
HPF Biokraft Hirtl GmbH	Fehring	FAME	5
Abid Biotreibstoffe GmbH	Hohenau	FAME	56
Novaol Austria GmbH	Bruck an der Leitha	FAME	107
Biodiesel Kärnten GmbH	Arnolstein	FAME	56
Münzer Paltental	Gaishorn am See	FAME	67
Brantner Energy GmbH	Krems	FAME	17
Total FAME production			**543**

The production facility for bioethanol and two FAME production facilities are described further in the following tables.

Table 9: Flagship project 7 - transport

Name/Location	**AGRANA Biorefinery in Pischelsdorf**
Description	The bioethanol plant of AGRANA is part of an extensive biorefinery, which produces not only bioethanol, but also starch, protein feed and high-purity carbon dioxide.
Input	600.000 t/a wheat and corn
Output	250,000 m³/a bio-ethanol 107,000 t/a starch, 23,000 t/a wheat protein, 55,000 t/a bran, 180,000 t/a protein feed
Further information	https://www.agrana.com/produkte/bioethanol/

Table 10: Flagship project 8 - transport

Name/Location	**Münzer Bioindustrie in Vienna and Gaishorn am See**
Description	Münzer Bioindustrie is the largest Austrian biodiesel producer, with a production facility in Vienna and one in Styria. 206,000 tons of high-quality FAME (fatty acid methyl ester) are produced each year.
Input	Used cooking oils and greases
Output	200,000 t/a (140,000 t/a in Vienna and 60,000 t/a in Gaishorn am See)
Further information	https://www.muenzer.at/de/home.html

Table 11: Flagship project 9 - transport

Name/Location	**Novaol in Bruck an der Leitha**
Description	In 2013 the biodiesel plant Novaol was taken over by the by Bunge Austria GmbH. At the Bruck an der Leitha site, biodiesel (FAME) is produced from vegetable oils.
Input	95,000 t/a vegetable oil
Output	107,000 m³/a
Further information	https://www.novaol.it/bungeKCNvl/Home.action;jsessionid=9961A79B270F9F9E364DB6CD8BC98BEE

Technology providers for commercial technologies include BDI for biodiesel and Vogelbusch for ethanol, both of which are internationally renowned.

4.4 Advanced biofuels R&D in the transport sector

4.4.1 Overview

Advanced biofuels have a number of advantages: They expand the raw material base for the production of biofuels to include residues from forestry and agriculture, resulting in greater raw material potential and thus greater biofuel potential. They also have higher greenhouse gas emission reduction potential. Some technologies can even use CO_2 and store electricity from renewable sources in fuels.

Although global production capacities for advanced biofuels have increased rapidly in recent years, they are still tiny in comparison with the quantities required. Conventional and advanced biofuels together currently account for about 3 % of transport fuel consumption worldwide (about 74 million tons out of 2,627 million tons consumed in 2014); yet the combined advanced biofuels production capacity has reached only about 1 % of the current conventional biofuel production.

The reason is that advanced biofuels production technologies are technically not yet fully developed and still have to be tested in pilot and demonstration plants or first industrial plants to be brought to market maturity. In recent years, an increasing number of production plants have been put into operation on a demonstration or industrial scale. (Bacovsky, 2nd Generation Biofuels - Auf dem Weg zum Durchbruch?, 2016)

Austrian companies such as BDI, Aichernig Engineering (former Repotec), Andritz and Vogelbusch deliver know-how and components for advanced biofuel production facilities to all over the world. Within Austria currently no commercial production of advanced biofuels exists, but Austro-Cel Hallein is planning to produce ethanol from the fermentation of brown liquor in its pulp refinery. There are several demonstration scale facilities in Austria, including facilities for the production of biomethane via gasification, FT-liquids from syngas, and the integration of biomass into a fossil oil refinery, see Table 12 for details. (Bacovsky, 2nd Generation Biofuels - Auf dem Weg zum Durchbruch?, 2016).

Table 12: Production facilities of advanced biofuels in Austria 2016 (Bacovsky, Update on Implementation Agendas 2018, 2018)

Company/project	Technology	Capacity	Status
BDI/bioCRACK	This **pilot plant** was installed at the refinery in Schwechat in the course of an R&D project and was producing biogas, pyrolysis oil, raw fuel (diesel) and biochar through a liquid phase pyrolysis of pre-treated biomass and conditioned carrier oil.		dismantled in 2015; continuing project: bioBOOST
Bio SNG Güssing	The Bio SNG Güssing facility was a **demoplant**, which was operating for several years within an R&D project. It produced biomethane through gasification of wood chips and subsequent methanation. This technology was later integrated in the commercial scale demonstration facility GoBiGas in Sweden.	100 m³/a (1 MW)	closed 2016
BIOENERGY 2020+/1-barrel-per-day	This **demoplant** produces FT-liquids through gasification of wood chips and synthesis of the intermediate syngas.	50 m³/a	Operational, for R&D projects
AustroCel Hallein	A **commercial production** of bioethanol through fermentation of brown liquor at the pulp mill is planned. This technology is already demonstrated since decades in Borregaard in Norway.	30,000 m³/a	planned

4.4.2 Advanced biofuel production technologies

Advanced biofuel pathways pursued through Austrian companies and research institutes include cellulosic ethanol, biomethane via gasification, FT-liquids and mixed alcohols from syngas, co-processing in oil refineries, hydrothermal liquefaction and electrofuels. Sixteen EU-funded research projects are currently being executed in this field with Austrian participation.

4.4.2.1 Cellulosic ethanol

The furthest developed advanced biofuel technology is the production of bioethanol from lignocellulosic agricultural residues, such as straw and corn cobs. Three industrial-scale plants were built in the USA (by Abengoa, POET-DSM and Du Pont) and other demonstration plants were built in Italy (Beta Renewables), Brazil (Raizen Energia) and Denmark (Inbicon). Austrian companies supply valuable know-how and plant components: Andritz has supplied pre-treatment plants for POET-DSM and Beta Renewables, Vogelbusch has supplied the distillation and rectification for the plant of Inbicon.

4.4.2.2 Gasification

A whole range of technologies is based on gasification of biomass to a high-energy synthesis gas. The synthesis gas can be converted to various fuels, such as Fischer-Tropsch diesel, ethanol, methanol, DME (di-methyl ether), mixed alcohols or methane. For the first step, the gasification of biomass, there are different process variants, but the most developed one is an Austrian technology: the gasification in a dual internally circulating fluidized-bed. This technology was developed at the University of Technology in Vienna and is now being commercialized by the companies Aichernig Engineering and Güssing Renewable Energies.

4.4.2.3 Methanation of syngas

At the Bio SNG Güssing this technology was demonstrated until 2016. The largest biomethane production plant from biomass gasification and subsequent methanation is a commercial-scale demonstration plant commissioned in 2014 in Gothenburg, Sweden (GoBiGas), which is currently not operating. The Austrian company Aichernig Engineering (former Repotec) has designed a carburetor for this purpose. The further expansion of the plant on an industrial scale was planned, but was not carried out despite the commitment of funding from the NER 300 program. In the current configuration and with current natural gas prices in Sweden, the facility cannot be operated economically and thus was closed.

4.4.2.4 Synfuels

There is worldwide research on the production of so-called synfuels from biomass-based synthesis gas. There are many different approaches, from chemical catalysis to hydrocarbons to biochemical utilization by microorganisms. Particularly promising is the Fischer-Tropsch process developed in 1925 for the catalytic conversion of synthesis gas into gaseous and liquid hydrocarbons. Originally developed for the large-scale processing of coal, the plant components must be reduced by orders of magnitude to meet the logistics of biomass processing plants, updated to modern standards and foremost adopted to renewable feed materials. In Austria, BIOENERGY 2020+ operated a 1 barrel / day plant for the production of Fischer-Tropsch fuels. During production, a mixture of hydrocarbon chains of different lengths is produced, so that not only very clean burning diesel, but also kerosene for aviation can be produced. Despite ample interest, reaching as far as China, and UAE, development is currently stalled due to insufficient funding for the necessary gasification infrastructure and research.

4.4.2.5 Co-processing in refineries

Research is ongoing on how to process biomass directly at the refinery. The Austrian company BDI, which builds plants worldwide for the production of conventional biodiesel, has operated a pilot plant in the Schwechat refinery in cooperation with OMV. In the bioCRACK process, biomass is added to the vacuum gas oil in the refinery and processed through liquid-phase pyrolysis. All resulting fractions are processed into products within the refinery. Both, the pyrolysis oil and the crude diesel produced in the bioCRACK process, are partly biogenic and cause lower greenhouse gas emissions than pure fossil fuels. So far, however, no partner for a large-scale demonstration could be found.

4.4.2.6 Algae based pathways

Another way of avoiding competition with land for the production of food and feed is the production of microalgae in aquatic systems. Microalgae can absorb CO_2 and use it for their growth. Major challenges include the cultivation of the microalgae and the separation of the algae biomass from the nutrient medium (in which only about 2 to10 grams per liter are included). For further processing, the algae biomass must be concentrated, hereby consuming large amounts of energy. At present, a production of biofuels from algae is not economic, which is why current efforts are aimed at the production of higher value products. BDI operates a demonstration plant for algae cultivation and has recently inaugurated an industrial facility for the production of astaxanthin for use in the cosmetics industry in the Ökopark Hartberg. The company Ecoduna has built and already operated for one year a demonstration plant with 1 ha of algae cultivation in Bruck an der Leitha, which will supply about 100 tons of algae biomass per year.

4.4.2.7 Electrofuels

Not yet that much demonstrated is the production of so-called electrofuels (or e-fuels, power-to-gas, or power-to-liquid). The idea behind these technologies is to use cheap surplus electricity to split water by electrolysis and thereby generate hydrogen. This hydrogen can be combined with carbon dioxide to form fuels, which are then called electrofuels. Well suited for combination with hydrogen is the synthesis gas from the gasification of biomass. In this case, the carbon content of the biomass entering the product can be increased further as compared to conventional gasification and synthesis. In addition, the use of surplus electricity can contribute to the stabilization of electricity grids. The basic production paths are known, but not yet economically feasible. A pilot project is currently underway in a consortium of OMV, EVN, Fronius, HyCentA and Energieinstitut Linz. BIOENERGY 2020+ is carrying out research on enhancing the recovery of FT-products from biomass syngas by adding hydrogen, hereby producing electrofuels.

4.4.3 R&D institutes

A wide range of research activities on biofuels is taking place in numerous R&D institutes, as listed below.

- ACIB - Austrian Centre of Industrial Biotechnology
- AEE Intec – Arbeitsgemeindschaft Erneuerbare Energie
- Agricultural Technical School Tulln
- AIT – Austrian Institute of Technology
- BIOENERGY 2020+
- Energy park Bruck/Leitha
- Francisco Josephinum - BLT

- Güssing Energy Technologies
- HEI - Hornbachner Energy Innovation
- HyCentA - Hydrogen Center Austria
- Joanneum Research
- Karl Franzens University Graz
- Lignosol Technology
- University of Applied Sciences Upper Austria (Wels)
- University of Innsbruck
- University of Johannes Kepler
- University of Leoben
- University of Natural Resources and Life Sciences (BOKU)
- University of Technology Graz
- University of Technology Vienna

4.4.4 R&D projects

Austrian companies and research institutes are engaged in numerous R&D projects, part of which are either nationally or internationally funded. A recent search in the database of the national Austrian funding agency (FFG) revealed three currently ongoing projects on biofuels (IEA Bioenergy Task 39: Market implementation of biofuels, IEA Bioenergy Task 44: Flexible Bioenergy and System Integration, and ReGas 4 Industry). Searching the CORDIS database for EU-funded projects on biofuel projects funded through the Horizon 2020 programme and filtered by Austrian participation provided 80 results, of which 22 are considered to deal with transport biofuels. Sixteen of these EU-funded projects are currently ongoing.

The following examples serve to highlight Austrian R&D work.

BECOOL

The main objective of the BECOOL (EU-funded) and BioVALUE (Brazil) projects is to strengthen EU-Brazil cooperation on advanced lignocellulosic biofuels. Information alignment, knowledge synchronization, and synergistic activities on lignocellulosic biomass production logistics and conversion technologies are key targets of both projects and will bring mutual benefits.

Participants: IIASA - International Institute for Applied Systems Analysis + 13 from other European countries
TRL: not available
Further information: https://www.becoolproject.eu/
Status: ongoing (May 2021)

bioCRACK/bioBOOST

The bioCRACK technology enables increased diesel production from vaccum gas oil. This technology is suitable for crude oil refineries to generate second generation biofuels. The follow-up EU-funded project bioBOOST concentrates on dry and wet residual biomass and wastes as feedstock for de-central conversion by fast pyrolysis, catalytic pyrolysis and hydrothermal carbonisation to the intermediate energy carriers oil, coal or slurry.

Participants: BDI – Bioenergy International AG (bioCRACK), University of Applied Sciences Upper Austria +12 from other European countries (bioBOOST)
TRL: 6
Further Information: https:/www.bdi-bioenergy.com/de
Status: closed

BioDie2020

BioDie2020 is an EU-funded project and will recover unconventional, degraded waste oils & fats, notably from water company infrastructures, and demonstrate the conversion of these wastes as a sustainable feedstock for biodiesel production.

Participants: BDI – Bioenergy International AG +4 from other European countries
TRL: not available
Further information: https://biodie2020.eu/
Status: closed

CO2-free logistics

The production of hydrogen through a high pressure PEM electrolyzer and the utilization of this hydrogen in fuel cell-powered fork lift trucks will be demonstrated.

Participants: DB/Schenker, Fronius, HyCentA, and University of Johannes Kepler
TRL: 8
Further information: not available
Status: unknown

COLHD

In this EU-funded project, a consortium of industrial and academic leading players, covering the entire value chain of road transport, has joined forces to commonly address the need to prove feasible and environmental-friendly cases of alternative fuels to fossil diesel for road transport, acknowledging the importance of reducing GHG emissions (beyond EURO 6) with affordable developments.

Participants: SAG Motion GmbH +15 from other European countries
TRL: not available
Further information: http://colhdproject.eu
Status: ongoing (October 2020)

ETIP Bioenergy SABS 2

ETIP-B-SABS 2 is an EU-funded follow-up project and will support and empower renewable fuel and bioenergy stakeholders' contributions to the Energy Union and, more specifically, the Strategic Energy Technology (SET)-Plan. The European Technology and Innovation Platform Bioenergy aims to actively engage with these stakeholders and link their needs to policy making of the European Commission, and the project´s objective is to support ETIP-Bioenergy in this task.

Participants: BIOENERGY 2020+ GmbH + 4 from other European countries
TRL: not applicable
Further information: http://www.etipbioenergy.eu
Status: ongoing (August 2021)

Heat-to-Fuel

Heat-to-Fuel is a Horizon 2020 EU-funded project carried out by 14 partners from across Europe (three from Austria) that aims to upgrade alternative, residual biomass feedstocks and convert excess heat to liquid 2nd generation biofuels in a combined gasification, Fischer-Tropsch and aqueous phase reforming plant.

Participants: Güssing Energy Technologies, BIOENERGY 2020+, University of Technology Vienna + 11 from 6 other European countries
TRL: 3-6
Further information: http://www.heattofuel.eu
Status: ongoing (September 2021)

OPTISOCHEM

OPTISOCHEM is an EU-funded project and aims to demonstrate the performances, reliability as well as environmental and socio-economic sustainability of the entire value chains, for the transformation of excess wheat straw into bio-Isobutene (bio-IBN) derivatives.

Participants: University of Johannes Kepler +5 from other European countries
TRL: not available
Further information: http://www.optisochem.eu
Status: ongoing (May 2021)

OSCYME

The project OSCYME develop a continuous enzymatic hydrolysis process, using a plug-flow reactor with substantial effects on conversion rates. The objective is to reduce energy costs as well as the amount of enzymes needed in order to reuse waste products as resources for bioethanol or chemical production in an economic way.

Participants: AEE Intec, ACIB, Möstl Anlagenbau GmbH +1 from other European country
TRL: not available

Further information: Homepage AEE Intec
Status: ongoing

Reformer Steam Iron Cycle (RESC)

The Reformer Steam Iron Cycle (RESC) is suitable to attain high-purity pressurized hydrogen from a broad range of renewables and residues in decentralized on-site applications. A 10kWth lab prototype system for high purity hydrogen production exceeding 99.999% has been developed. The significantly enlarged reactor system comprises of a combined steam reformer and fixed bed chemical looping system within a single unit.

Participants: OMV, AVL, University of Technology Graz
TRL: 3
Further information: Elsevier
Status: unknown

STEELANOL

The EU-funded STEELANOL project is based on producing bioethanol via an innovative gas fermentation process, using exhaust gases emitted by the steel industry. The technology will allow the capture and reuse of a portion of carbon emitted by the steel industry without need to rebuild the BAT (Best Available Technologies) steel plant while supplying the transport sector with high grade biofuel, that does not compete in any way with food crops or land for food crops.

Participants: Primetals Technologies Austria GmbH + 4 from other European countries
TRL: not available
Further information: http://www.steelanol.eu/en
Status: closed

TORERO

The EU-funded project TORERO will demonstrate a technology concept for producing bioethanol from a wood waste feedstock, fully integrated in a large-scale, industrially functional steel mill. The wood waste is converted to biocoal by torrefaction and replaces fossil powdered coal in a steel mill blast furnace. The carbon monoxide in blast furnace exhaust fumes is microbially fermented to bioethanol.

Participants: Joanneum Research + 4 from other European countries
TRL: not available
Further information: http://www.torero.eu
Status: ongoing (April 2020)

VALUEMAG

VALUEMAG is an EU-funded project, which aims to provide solutions for microalgae production and harvesting as well as scaling up biomass transformation systems in order to provide new technologies for aquatic/marine biomass integrated bio-refineries.

Participants: Ecoduna AG, Ecoduna Production GmbH, Eparella GmbH +10 from other European countries
TRL: not available
Further information: https://www.valuemag.eu/
Status: ongoing (March 2020)

Vienna gasifier

A gasifier, applying high-temperature gasification in a dual-fluidised bed reactor for the production of synthesis gas (CO, H2), followed by downstream processing to gases, liquids and chemicals (e.g. green gas, green hydrogen, green diesel) from sewage sludge and other residues, that are currently burned, will be installed.

Participants: BIOENERGY 2020+
TRL: 4-7
Further information: Bioenergy 2020+ GmbH
Status: planned

WASTE2FUELS

WASTE2FUELS is an EU-funded project, which aims to develop next generation biofuel technologies, capable of converting agrofood waste (AFW) streams into high quality biobutanol. By valorising 50% of the unavoidable and undervalorised AFW as feedstock for biobutanol production, WASTE2FUELS could divert up to 45 million tonnes of food waste from EU landfills, preventing 18 million tonnes of GHG emissions and saving almost 0.5 billion litres of fossil fuels.

Participants: University of Technology Vienna + 20 from other European countries
TRL: not available
Further information: http://www.waste2fuels.eu/
Status: closed

Winddiesel

The “Winddiesel” process combines two existing technologies. A biomass-to-liquid (BtL) plant, consisting of a dual fluidized bed (DFB) gasification plant and a Fischer-Tropsch (FT) plant, will be expanded to include CO2-separation and electrolysis. This enables production of diesel with surplus electricity, in the sense of a power-to-liquid (PtL) process.

Participants: Güssing Energy Technologies, University of Technology Vienna, Aichernig Engineering, EC Engineering, Bilfinger Bohr- und Rohrtechnik, Energie Burgenland
TRL: 6-7
Further information: www.winddiesel.at
Status: closed

4.5 International cooperation in bioenergy R&D

Austria is an active participant in the IEA Bioenergy Technology Collaboration Programme[1] (IEA Bioenergy TCP). The goal of IEA Bioenergy is to promote the use of environmentally sustainable and competitive bioenergy based on the sustainable use of biomass to provide a substantial contribution to a sustainable energy supply. This is done by initiating, coordinating and promoting research, development and demonstration projects through international cooperation and the targeted exchange of information between experts from research, industry and politics in the participating countries.

The cooperation takes the form of thematic networks ("Tasks") and is led by an Executive Committee to which the participating countries send representatives. Austria is currently participating in the following Tasks:

- Task 32: Biomass Combusting and Co-firing
- Task 33: Gasification of Biomass and Waste
- Task 37: Energy from Biogas
- Task 39: Commercialising Conventional and Advanced Liquid Biofuels from Biomass
- Task 42: Biorefining in a future BioEconomy
- Task 44: Flexible Bioenergy and System Integration

Work in the individual Tasks of IEA Bioenergy is complemented by work of the Executive Committee, which steers and coordinates the Tasks, inter-task projects, special projects and strategic projects, and actively communicates results of IEA Bioenergy work to scientists and industrial and political decision makers alike.

Austria has been a member of IEA Bioenergy since 1978. Participation is funded by the Federal Ministry of Transport, Innovation and Technology (BMVIT). At present, 22 countries from Europe and overseas and the European Commission are participating in IEA Bioenergy. The cooperation

[1] IEA Technology Collaboration Programmes are international networks of independent experts that enable governments and industries from around the world to lead programmes and projects on a wide range of energy technologies and related issues. The experts in these collaborations work to advance the research, development and commercialisation of energy technologies.

thus enables a worldwide transfer of information and the coordination of national programs and research in the field of bioenergy use.

In IEA Bioenergy, national experts from research, politics and industry work closely together with experts from other countries. Austria's cooperation with IEA Bioenergy supports and promotes:

- Austrian R&D work through the international exchange of knowledge
- International dissemination of results of the Austrian R&D
- Networking between relevant stakeholders within Austria
- The initiation of international R&D projects and scientific exchange programs and
- The establishment of contacts between Austrian companies and international companies with the aim of cooperation

5 Political framework

As part of the European Union, Austria is compelled to make its contribution to reach the 20-20-20 targets from the **Climate & Energy Package**. These include 20 % reduction in EU GHG emissions, compared to 1990, raising the share of renewable energies of EU energy consumption to 20 % and improving the energy efficiency by 20 %. Austria has committed itself to these targets. According to the **Renewable Energy Directive** an increase of the share of renewable energies in total gross final energy consumption to 34 % until 2020 is targeted (Schipfer & Kranzl, 2015), with a split in sectors as displayed below:

- Overall target: 34.2 %
- Heating and cooling: 32.6 %
- Electricity: 70.6 %
- Transport: 11.4 %

51 % of the increased renewable share is expected to be bioenergy, the rest hydropower, wind and photovoltaics (IEA Bioenergy, 2018). According to the **Effort Sharing Decision**, a reduction of GHG emissions has to account for 16 %, compared to 2005. Additionally, the **Energy Strategy Austria** discussed aiming to stabilize Austria´s final energy consumption at 1,100 PJ by 2020 (Schipfer & Kranzl, 2015).

For achieving these targets, a political framework has been established, which is briefly described below.

European Union

To reach the 20-20-20 targets, following measures are put in place by the European Union. The **EU Emission Trading Directive** was published as base for the **EU Emission Trading Scheme** (ETS). The **Effort Sharing Decision** was defined to set targets individually according to the member states relative wealth and availability of renewable energy sources. The **Renewable Energy Directive** (RED) was published to raise the share of renewable energy; it was updated by the **RED-II** in 2018. The EU target for renewable energy sources consumption has been raised to 32% by 2030 and a minimum of 14% renewable energy of the total energy consumed in road and rail transport by 2030, was set. It also introduces new sustainability criteria for forestry feedstocks. Biofuels and bioenergy from forest materials must comply with requirements of the EU Land Use, Land Use Change and Forestry (**LULUCF**) Regulation. The proposal of the RED-II was part of the **Clean Energy for all Europeans** initiative, published by the Commission in 2016. Additionally, all EU member states have submitted **National Renewable Energy Action Plans** (NREAPs) to the Commission in 2009. To use energy more efficient at all stages of the energy chain, the **Energy Efficiency Directive** has been defined and national energy targets have been submitted in the form of **National Energy Efficiency Action Plans** (NEEAPs) to the Commission in 2014. Also, a legal framework for environmentally safe use of carbon capture and storage technologies has been created (Schipfer & Kranzl, 2015).

Austria

One of the main drivers for bioenergy production in Austria is EU legislation. The EU has established a legal framework including the **Renewable Energy Directive** (RED), which is binding for all member states and has to be implemented into the respective national laws.

In 2016, four Federal Ministries published the policy support document "Green book for an integrated energy and climate strategy. This document provided the base for the climate and energy strategy. "The **Austrian Climate and Energy Strategy (#mission 2030)**, approved by the Federal Government in 2018, aims to reduce GHG emissions by 36 % by 2030 and to decarbonize energy provision by 2050. The share of renewables shall be increased from 33.5 % to 45-50 % by 2030, with a sub target of fully renewable electricity production by 2030. Additionally, the energy efficiency shall be increased by 39 % by 2030 as compared to 2015, with a 1,200 PJ limit of total primary energy demand in 2030 (bmnt, bmvit, 2018).

One of the flagship projects of the Austrian Climate and Energy Strategy is focusing on the bioeconomy. Based on that, the **National Bioeconomy Strategy** was formed in 2018. The main topics of this strategy are: circular economy, innovation, efficiency measures, regional development and high-quality jobs (bmnt, bmvit, 2018).

National funding of research is provided through the Austrian Research Promotion Agency (FFG). Owners and providers of funds for the research programs are the Austrian Ministry for Transport, Innovation and Technology (bmvit) and the Federal Ministry of Science, Research and Economy (bmwfw). Besides instruments that are open to all fields of research there are thematic calls, such as the IEA Research Cooperation and the New Energies 2020 program. The **New Energies 2020 R&D program** offers 16 million € for R&D activities regarding efficient energy use, renewable energies and intelligent energy systems. (Bacovsky, Update on Implementation Agendas 2018, 2018).

Heating and cooling

Measures for the heating and cooling sector include the **Environmental Measures Support Act**, which is a support for environmental protection in general, and the **guidelines for domestic environmental support**, which promotes renewable energies specifically. (Schipfer & Kranzl, 2015). Renewable energy subsidies in industry and commercial buildings are mainly federally funded, whereas renewable energy subsidies in residential buildings are mostly funded by the federal states. Therefore, the main supporters for heating and cooling projects in Austria are the federal states. Furthermore there is a subsidy scheme for wood heating from the **Climate & Energy Fund** for replacing fossil fuels based heating systems with pellet and wood chip central heating systems and pellet stoves (Schipfer & Kranzl, 2015). Building Regulations ban fossil-fueled heating systems in new buildings.

Electricity

The **Green Electricity Act,** updated in 2012, sets targets of new installations until 2020. A feed-in-tariff scheme supports the pay-off of the investments. For biomass and biogas, new installations of 200 MW have been designated (IEA Bioenergy, 2018). It also includes investment grants for plants based on waste liquor of the pulp and paper industry as well as small and medium hydro power plants (Schipfer & Kranzl, 2015). The feed-in-tariff scheme has proven to be very successful, yet when the premium feed-in-tariff for an installation expires after 13 or 15 years this often puts the installation out of business as continuing the production is not economic any more.

In the course of the Austrian Climate and Energy Strategy, the **Renewable Expansion Law** will be issued in 2020. Details and the transition to this law are still being discussed. In any case, this should be an integrated law, including, among others, the Green Electricity Act, the **Electricity Management and Organization Act** and the Gas Economy Act (Bundesministerium Nachhaltigkeit und Tourismus, 2018).

Transport

The **Renewable Energy Directive** (RED) and the **Fuel Quality Directive** (FQD) are binding for all member states and need to be implemented into the respective national laws. The **Fuel Ordinance Amendment** lays down the **Biofuels Directive**, the Renewable Energy Directive and the Fuel Quality Directive in Austrian law (Schipfer & Kranzl, 2015). A quota for biofuels has been set: by 2020, 8.45 % (with regard to energy content) of diesel and petrol have to be substituted by energy from renewable resources (IEA Bioenergy, 2018).

In Austria, the RED and FQD sustainability criteria have been implemented by two separated ordinances, the **Ordinance on Agricultural Feedstocks for Biofuels and Bioliquids** and the **certification of commercialized biofuels** (Bacovsky, Update on Implementation Agendas 2018, 2018).

The **Austrian Decree on Transportation Fuels** lead to an amendment of the Austrian tax law, stipulating that there would be no tax on biodiesel and ethanol to a certain limit. It allows blending of up to 7 % of biodiesel with fossil diesel. Together with the amendment to the Fuels Ordinance in 2004, the **Mineral Oil Act** has been revised. Accordingly, tax concessions are granted for sulphur-free fuels with a biofuel share of at least 4.4 %. Pure biofuels have been exempted from mineral oil tax since 2000. The **Bioethanol Blending Order** that entered into force on 1st October 2007 allows refunding of the mineral oil duty for E75 blends (Bacovsky, Update on Implementation Agendas 2018, 2018).

Further legislation, transposing the new RED-II into national law, has yet to be created and will constitute the framework for targets beyond 2020. RED-II is especially important for creating market demand for advanced biofuels, setting targets of 0.2 % advanced biofuels by 2022, 1 % by 2025, and 3.5 % by 2030.

6 Summary and outlook

Austria has sufficient biomass available to utilize it for the production of heat, electricity and transport fuels, and there is additional biomass potential that can be realized by 2030. There is technological expertise in place for most bioenergy technologies, and Austrian companies already have an excellent track record of providing technologies and equipment around the world. The Austrian home market for bioenergy technologies is facilitated by a supportive political framework; yet the framework has some shortcomings and should be adjusted to further support existing bioenergy installations.

Political targets for fighting the climate crisis through the use of bioenergy in all sectors exist, but could be more ambitious and – even more important – still have to be backed up by concrete action plans in order to implement existing technological solutions and further develop new technologies.

The climate crisis is a complex phenomenon which can only be tackled with a holistic and integrated approach. Related R&D should span all aspects of the necessary transition of the energy system, including

- Societal aspects such as sustainability, public acceptance, and affordability,
- Environmental aspects such as GHG emissions and local emissions, and impacts on soil, water, and biodiversity,
- Increased supply of biomass in a sustainable manner, and
- Development and deployment of efficient and economic technologies for the production and use of bioenergy.

In the light of the recent steep increase in public awareness that bold action to fight the climate crisis is required now, there will be further demand for bioenergy technologies worldwide, offering market opportunities for Austrian companies and allowing Austria to play a leading role in energy innovation.

7 References

Bacovsky, D. (2016). *2nd Generation Biofuels - Auf dem Weg zum Durchbruch?* Österreichischer Biomasseverband.

Bacovsky, D. (2018). *Update on Implementation Agendas 2018.* IEA Bioenergy Task 39.

Biermayr, P., Dißauer, C., Eberl , M., Enigl, M., Fechner, H., Fischer, L., . . . Wopienka, E. (2018). *Innovative Energietechnologien in Österreich Marktentwicklung 2017.* Österreich: bmvit.

bmnt, bmbwf, bmvit. (2019). *Bioökonomie - Eine Strategie für Österreich.* Wien: bmnt, bmbwf, bmvit.

bmnt, bmvit. (2018). *#mission 2030 - Austrian Climate and Energy Strategy.* Vienna: bmnt, bmvit.

Bundesministerium für Nachhaltigkeit und Tourismus. (2018). *Die Bestandsaufnahme der Abfallwirtschaft in Österreich Statusbericht 2018.* Österreich: Bundesministerium für Nachhaltigkeit und Tourismus.

Bundesministerium für Nachhaltigkeit und Tourismus. (2018). *Grüner Bericht 2018 - Bericht über die Situation der österreichischen Land- und Forstwirtschaft.* Wien: Bundesministerium für Nachhaltigkeit und Tourismus.

Bundesministerium Nachhaltigkeit und Tourismus. (2018). *Energie in Österreich 2018 - Zahlen, Daten, Fakten.* Wien: Bundesministerium Nachhaltigkeit und Tourismus.

Bundesministerium Nachhaltigkeit und Tourismus. (2018). *Erneuerbaren Ausbau Gesetz 2020 - EAG 2020.* Wien: Bundesministerium Nachhaltigkeit und Tourismus.

Dißauer, C. (November 2018). Biomassepotentiale im Kontext von Bioökonomie und Energiewende. Kufstein, Tirol, Österreich : Bioenergy2020+.

Holzer, L., Dißauer, C., Meierhofer, M., Pointner, C., & Strasser, C. (2017). *Marktakteure und Mengenverfügbarkeit ausgewählter biogener Roh- und Reststoffe sowie Anreize und Hindernisse zu deren Verwertung.* Wieselburg: Bioenergy2020+.

IEA Bioenergy. (2018). *Country report Austria - 2018 update - Bioenergy policies and status of implementation.* IEA Bioenergy.

Krutzler, T., Wiesenberger, H., Heller, C., Gössl, M., Stranner, G., Storch, A., . . . Schindler, I. (2016). *Szenario erneuerbare Energie 2030 und 2050.* Wien: Umweltbundesamt.

Lampert, C. (2014). *Stand der temporären Abdeckung von Deponien und Deponiegaserfassung.* Wien: Umweltbundesamt.

Lampert, C., Reisinger, H., & Zethner, G. (2014). *Bioabfallstrategie.* Wien: Umweltbundesamt.

Pfemeter, C. (2019). *Bioenergie Atlas Österreich.* Wien: Österreichischer Biomasse-Verband.

Pfemeter, C., Liptay, P., & Kahr, S. (2019). *Bioenergie Atlas Österreich.* Wien: Österreichischer Biomasse-Verband.

Pfemeter, C., Plank, J., & Liptay, P. (2015). *Bioenergie 2030.* Österreich: Österreichischer Biomasseverband.

Plank, J., & Pfemeter, C. (2017). *Basisdaten 2017 Bioenergie.* Österreich: Österreichischer Biomasseverband.

Plank, J., & Pfemeter, C. (2017). *Bioenergie Atlas Österreich.* Österreich: Österreichischer Biomasseverband.

Schipfer, F., & Kranzl, L. (2015). *Sustainable International Bioenergy Trade: Securing supply and demand - Country report Austria 2014.* Wien: TU Wien.

Streicher, W., Schnitzer, H., Tatzber, F., Heimrath, R., Wetz, I., Hausberger, S., . . . Oblasser, S. (2010). *Energieautarki für Österreich 2050 Feasibility Study Endbericht.* Österreich: Klima- und Energiefond.

Wörgetter, M., Haslinger, W., & Kranzl, L. (2012). *FTI Roadmap BioHeating and Cooling.* Wien: bmvit.

8 Annexes

8.1 Annex 1: Biomass potential

The potentials indicated are always annual additional and until 2030.

8.1.1 Forest and wood residues

Forest residues

Forest residues include aboveground tree sections (mainly residues from harvest operations = logging residues), such as branches, needles, treetop pieces, trunk sections etc., which are not suitable for material use and are therefore chipped and used energetically. Due to changed harvesting methods (whole tree harvesting), logging residues are becoming more important. However, not all forest residues can be removed from the forest, because of economic and ecological reasons since these residues provide habitat, improve soils and provide nutrients etc. (Holzer, Dißauer, Meierhofer, Pointner, & Strasser, 2017). Figure 5 shows the detailed wood flows in Austria.

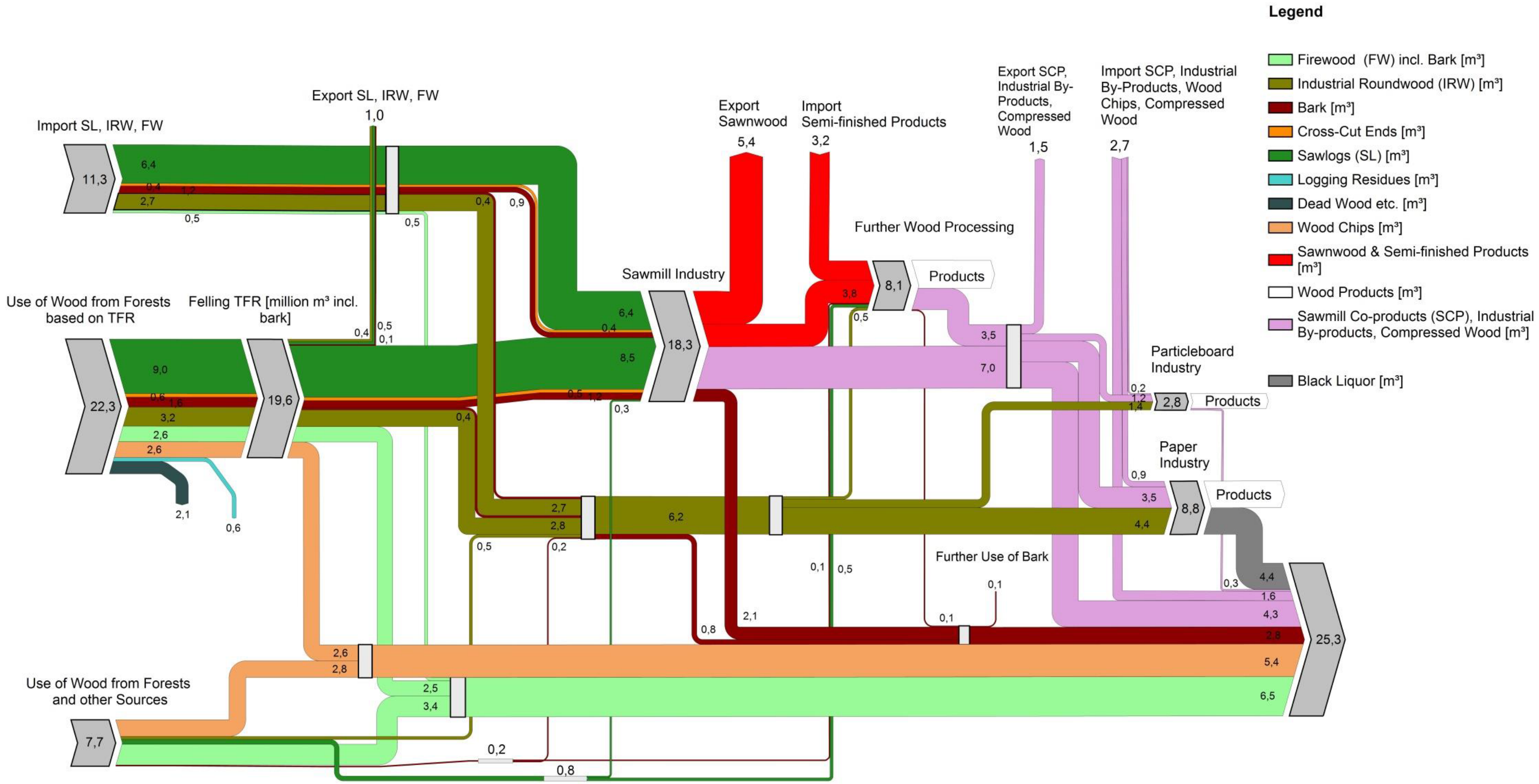


Figure 5: Wood flows in Austria, All values given in million m³; values <0.1 million m³ are not shown; numerical values partially rounded, Issue: June 2018 / Reference year: 2016 *Source: klimaaktiv, Austrian Energy Agency, FHP, Federal Ministry Republic of Austria- Sustainability and Tourism, https://www.klimaaktiv.at/erneuerbare/energieholz/holzstr_oesterr.html*

Production and Consumption:

In 2016, about 2,251,800 t-atro[2] wood chips have directly been used for energy production (see Figure 5). In total 10,550,100 t-atro woody biomass from the forest and residues from the wood industry have been used for energy production in Austria. Wood chips and other forest residues are mainly used in (regional) heating plants (see Figure 6).

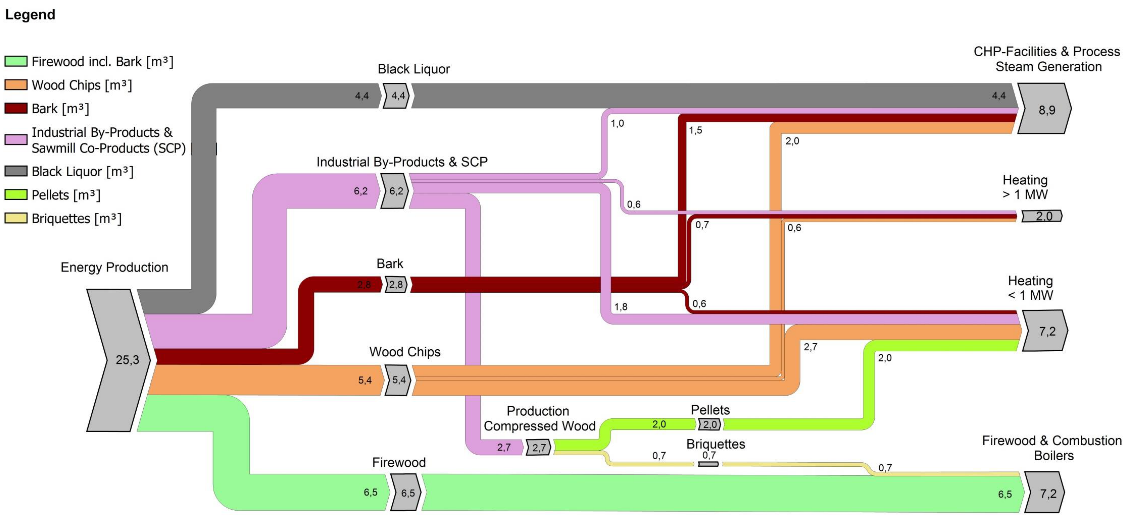


Figure 6: Wood flows in Austria-Energy production, All values given in million m³; values <0.1 million m³ are not shown; numerical values partially rounded, Issue: June 2018 / Reference year: 2016 Source: klimaaktiv, Austrian Energy Agency, FHP, Federal Ministry Republic of Austria- Sustainability and Tourism, https://www.klimaaktiv.at/erneuerbare/energieholz/holzstr_oesterr.html

At industrial scale, wood chips and forest residues can also be converted to advanced biofuels or intermediates, such as BioSNG, BtL, Biocrude, Methanol or BioDME, through various thermo-chemical pathways.

Potential:

The additional annual available forest biomass is estimated to be between 1.7 and 3.5 million t-atro (Dißauer, 2018). However, this potential also includes forest biomass for material and cascading use. By increasing the material use of biomass also a higher proportion of bioenergy is enabled. According to HOBI (Holz- und Biomasseaufkommensstudie), an annual increase of the wood inventory of 4 million fm is realistic (Plank & Pfemeter, 2017b). If 20.7 % is directly used for energy production, there would be an annual forest residues potential of about 828,000 fm (= 345,772 t-atro). The project Up2ndUse (Holzer et al. 2017) also refers to the HOBI scenario and assumes an additional annual potential between 843,000 and 1.13 million fm (= 352,037 - 471,888 t-atro) of forest residues. However, the future development of damaged wood and tree species composition are unknown, therefore the potential is hard to estimate.

[2] t-atro=0 % water content; 1m³=0,417 t-atro

Additional potential of forest residues

	Value	Year	Source
Current consumption-woody biomass for energy production	10,550,100 t-atro	2016	Wood flows in Austria 2016-klimaaktiv
…thereof wood chips and forest residues	2,251,800 t-atro	2016	Wood flows in Austria 2016-klimaaktiv
Additional potential	345,772 - 471,888 t-atro	Annual	Plank & Pfemeter 2017b, Holzer et al. 2017

Sawmill by-products

The central player in the Austrian wood market is the sawmill industry. The Austrian sawmill industry is a large and highly successful industrial sector with more than 1,000 active companies employing nearly 10,000 workers. The Austrian sawmill industry is almost exclusively small and medium-sized throughout Austria and a very important factor for Austria's foreign trade balance. Around 80 % of the solid wood biomass manipulated in Austria passes through the sawmill industry. Sawmill by-products are products arising during sawmill processes, such as sawdust, sawshavings and bark.

Production and Consumption:

The “Federal Waste Management Plan” records 3,659,628 t (=2,378,758 t-atro) sawmill by-products in 2016. Sawmill by-products (bark, splinters, sawdust and shavings) are already used materially and energetically. For instance, sawmill by-products are used in the paper and panel industry as raw material and to produce pellets and briquettes. In 2016, 3.47 million t-atro sawmill by-products (including imports, pellets and briquettes) and wood industry by-products (see Figure 6) are used for energy production. Bark is mostly used as fuel in CHPs and large-scale heating plants (Plank & Pfemeter, 2017a).

Potential:

The production of sawmill by-products depends on the development of the sawmill and wood industry. If an annual economic growth of 1.8 %[3] is assumed and the competing uses are considered, the additional annual sawmill by-product potential will be between 348,423 and 698,847 t-atro until 2030.

[3] Source: Finanzministerium, Langfristige Budgetprognose Bericht gem. § 15 (2) BHG 2013

Additional potential of sawmill by-products

	Value	Year	Source
Current production-sawmill by-products	2,378,758 t-atro	2016	BMNT, 2018
Current consumption-energetic use of sawmill by-products **and** wood industry by-products	3,470,000 t-atro	2016	Wood flows in Austria-klimaaktiv, 2018
Additional potential	348,423-698,847 t-atro	2030	Own calculation- Increasing sawmill and wood industry assumed

<u>Waste wood (post-consumer and demolition wood)</u>

The “Abfallwirtschaftsgesetz” (AWG 2002) defines waste wood as followed: wood or wood products whose owner wants to get rid of, or has already disposed of, or wood that must be collected, stored, promoted and treated in the public interest. Sawmill by-products are seen as side-stream residues and therefore are not waste, if they are not declared as waste (Holzer et al. 2017). Waste wood includes demolition wood, construction wood and post-consumer wood such as wooden packaging and wooden waste. The “Recyclingholzverordnung Novelle 2018” improves the separation of the waste wood and requires a wood waste recycling, therefore material use is to prefer (Dißauer, 2018).

<u>Production and Consumption:</u>

Waste wood represents a very heterogeneous waste stream. Due to the diverse use of wood, it accumulates in almost every sector of industry and households. The “Federal Waste Management Plan” registered 5,181,596 t (=4,663,436 t-atro) of wood wastes in 2017, including sawmill by-products (=3,942,596 t; 2,562,687 t-atro). The wood waste fractions SN 17201 and 17202, which can be regarded as the classic waste wood for recycling purposes (=construction and demolition wood, post-consumer wood including packaging), amounted to 700,000 t (=630,000 t-atro) in 2017. As stated before, sawmill by-products (excl. bark) and post-consumer as well as demolition wood are recycled in the paper and panel industry. Uncontaminated post-consumer and demolition is also used for gardening and landscaping purposes. Contaminated wood wastes are burned using the energy content.

<u>Potential:</u>

Depending on the economic development, the increase of the annual additional potential of uncontaminated demolition and construction wood as well as postconsumer wood including packaging (SN 17201 and 17202) until 2030 is between 22,000 and 65,000 t (=19,800 – 58,500 t-atro) (Dißauer, 2018). Hence, an additional potential of about 430,560 t-atro in 2030 (and 1,291,950 t-atro in 2050) can be assumed. However, since other industries (particularly the panel industry) will also profit from the economic growth and will compete for the additional amounts, the free potential will be significantly lower.

Additional potential of waste wood

	Value	Year	Source
Production of waste wood excluding sawmill by-products …thereof uncontaminated demolition and construction wood as well as postconsumer wood including packaging (SN 17201 and 17202)	2,100,749 t-atro 630,000 t-atro	2017	BMNT, 2018
Additional potential	430,560 t-atro	Annual	Own calculation

8.1.2 Agricultural biomass

Food and feed crops

The term food and feed crops combines starch, sugar and oil crops.

Production and Consumption:

In 2017, 4,8 million t of starch crops, 2,9 million t of sugar crops and 378,608 t of oil crops was harvested in Austria, but most of this goes into food and feed production. (Bundesministerium für Nachhaltigkeit und Tourismus, 2018)

Potential:

Conventional biofuel production is based on food and feed crops, but due to the concurrence to food and feed production, the potential will stagnate.

Additional potential of food and feed crops

	Value	Year	Source
Production & Consumption	8,078,608 t	2017	BMNT, 2018 (Grüner Bericht)
Additional potential	-		

Short rotation forestry (SRF)

The management of short rotation forestry on arable land is an extensive form of land use due to the low demand of fertilizers and pesticides compared to other crops. Fast growing tree species (willows, poplar, etc.), can be used as energy crop in multi-annual harvest cycles. The rotation time (period of the harvesting cycles) depends on the planting group, the intensity of use, the intended use of the raw material and the given site conditions. When the trees are ready for harvesting (after 2 to 8 years), they will be cut, chipped and transported.

Production and Consumption:

The cultivated area of SRF in Austria in 2005 was about 280 ha. In 2016, the SRF area amounted to 2,336 ha. As average annual yield 11 t-atro/ha can be assumed. Hence, the SRF harvest equaled to 25,696 t-atro in 2016. In 2017, 2,421ha (= 26,631 t-atro) of SRF were cultivated (Dißauer, 2018). The harvested quantities are mainly used in heating plants. In addition, SRF timber could be processed, for instance, in the panel industry first (cascading use).

Potential:

The SRF cultivation area could be increased by using grassland fallow land (119,133 ha) or by the renaturation of fallow commercial and industrial areas (in Austria, according to the Federal Environment Agency, there are 13,000 hectares of industrial wasteland). Furthermore, surface sealing should be reduced. If these measures are implemented, the potential of SRF lies between 390,000 – 1,180,000 t-atro per year (Dißauer, 2018).

Additional potential of SRF

	Value	**Year**	**Source**
Production & Consumption	26,631 t-atro	2017	Statistics Austria, 2018
Additional potential	390,000 – 1,180,000 t-atro	Annual	Dißauer, 2018

Miscanthus

Over the past years the cultivation of the energy crop "Miscanthus Sinensis Giganteus" for energetic use increased. Miscanthus is a persistent crop with a low fertilizer demand. The planting of Miscanthus is carried out via the placing of rhizomes with a density of 10,000 units / ha. In the first two years of cultivation a weed control is necessary. Miscanthus has similar needs as corn, so it needs good agricultural soils with a sufficient water supply. Miscanthus can be harvested as whole plant or chaffed. In particular to the purpose of pelletizing or briquetting usually a corn chopper is used for the harvest. Because of the low water content Miscanthus is suitable for storage. The delivery is done with a specially designed conveyor belt wagon, so that the charging can be done without a fan or without major construction efforts. On well water-bearing soil layers a harvest of 20 t dry matter / ha is possible, on average the harvest amounts 14 t dry matter / ha and year.

Production and Consumption:

In 2016 Miscanthus was cultivated on 1,128 ha land. Hence, about 15,792 t-atro Miscanthus were harvested (Holzer et al., 2017). Miscanthus is mainly used in heating plants but is also processed for material utilisation (e.g. fibre production, building material, litter).

Potential:

According to the Austrian Biomass Association, the cultivation area of Miscanthus could be increased to 5,000 ha until 2030 and therefore the potential amounts to 70,000 t-atro per year (Pfemeter et al., 2015).

Additional potential of miscanthus

	Value	Year	Source
Production & Consumption	15,792 t-atro	2016	Statistics Austria, 2018
Additional potential	70,000 t-atro	Annual	Pfemeter et al., 2015

8.1.3 Agricultural residues

Straw

Straw - as a by-product of grain production - is a potential raw material for energy production. Straw is usually left on the field as fertilizer or used as litter and then as fertilizer in terms of a circular economy yet. To leave the straw at the field offers, in addition to the nutrient supply and humus formation, the following benefits:

- Protection of the soil from water and wind erosion
- Increasing the air-carrying pore volume and crumb stability
- Increasing the water storage capacity and the "rain digestibility" (infiltration rate)
- Improvement of nitrogen balance

However, when wheat is followed by rape, the straw harvest could be beneficial since less plant material is left on the field to rot. Thus it must be decided for each individual case, whether the use of straw makes sense. Furthermore, then nutrient balance could be improved by straw-ash recirculation or fertilization with wood ash, if this is legally permissible in the future.

Production and Consumption:

In 2017, Statistics Austria recorded 1,482,727 t_{dm}[4] of grain straw, 2,293,961 t_{dm} maize straw and 168,827 t_{dm} rape straw[5]. As mentioned before, straw is mainly used as fertilizer and as litter. In Austria, straw is only used for energy purposes in small quantities yet. In 2016, 20.000 t of straw were energetically used in eight district heating plants in Lower Austria (Dißauer, 2018).

Potential:

In total, the straw potential would amount to 3,945,515 t_{dm} based on the data of 2017. However, due to the use as fertilizer and as litter, the available potential is limited. Hence, the annual potential of straw for energy production purposes is between 592,625 t_{dm} and 1,481,562 t_{dm}, depending on the possibility of ash recirculation. Furthermore, the actual available annual amount of straw depends on weather and climatic developments.

In order to mobilize straw potentials, the following measures should be taken:

- Support of Austrian agriculture
- Facilitate yield increase in agriculture (integrated systems, special crop rotations)
- Building up regional supply chains
- Nutrient recycling (ash recirculation)

Additional potential of straw

	Value	**Year**	**Source**
Production	3,945,515 t_{dm}	2017	Statistics Austria, 2018
Consumption-energetic use	~20.000t	2016	Dißauer, 2018
Additional potential	592,625 t_{dm} and 1,481,562 t_{dm}	Annual	Dißauer,2018

Corn cobs

Corn cobs are residues of grain production. Before 1960 the corn was harvested by hand and corn cobs were often used as fuel. Since automatical harvesters have been used. the corn cobs are usually left on the field. An exception is the harvest of corn for seeding purpose at which the whole corn cob is reaped. However, corn cobs can be harvested with relatively little effort with an adapted harvester.

[4] dm=dry mass

[5] Statistics Austria „Statistik der Landwirtschaft 2017“, 2018; corn:straw relationship=1,1; water content=15 %

Production and Consumption:

In 2017, 209,476 ha of corn were cultivated (Statistics Austria, 2018). If a potential yield of 1,5 t_{dm} corn cobs per ha are assumed, about 314,214 t_{dm} of corn cobs were produced (Dißauer, 2018). Corn cobs are usually left on the field or used as feed. In Styria small amounts are used for energy production.

Potential:

Currently, a potential of 50.000 t_{dm} per year seems realistic (Biermayr et al., 2018). However, if optimized harvesting procedures and supply chains would be established, the annual potential of corn cobs could be increased to 85.000 – 200.000 t_{dm} per year (Dißauer, 2018).

Additional potential of corncobs

	Value	Year	Source
Production	314,214 t_{dm}	2017	Dißauer, 2018
Additional potential	85,000 – 200,000 t_{dm}	Annual	Dißauer, 2018
	50.000 t_{dm}	Annual	Biermayr et al., 2018

Landscaping hay

Production and Consumption:

The main goal of nature protection areas such as Natura 2000 areas or biosphere reserves is to maintain and preserve the ecological situation by an extensive, environmental friendly and adapted cultivation of the agriculture. One obstacle in the fulfillment of the conservation requirements is the usability of the harvested goods in today's intensive agriculture. Due to the late mowing time in the year the hay of abandoned/protected meadows has a reduced feed quality and therefore isn't suitable for animal feeding. Other possibilities for the energetic utilisation of that hay in biogas or combustion plants should be investigated. The harvest of hay from extensive cultivated meadows amounts to 3 – 4 tons hay /ha / a. The water content is around 15 % at harvesting point.

Potential:

The Austrian Biomass Association assumes that the landscaping hay of 5 % of extensive grassland (37,000 ha) could be used for energy production until 2030 (Pfemeter et al., 2015). This would correspond to 110,075 t_{dm} per year.

Additional potential of landscaping hay

	Value	Year	Source
Additional potential	110,075 t_{dm}	Annual	Pfemeter et al., 2015

Manure

Production and Consumption:

According to the Federal Waste Management Plan the total amount of manure in Austria was about 25 million t in 2016. Manure is used as fertilizer on agricultural land or energetically in biogas plants. About 50,900 t of manure were used in biogas or composting plants in 2016.

Potential:

If the use of manure is increasing, the Austrian Biomass Association predicts a potential of 6.1 PJ through biogas until 2030 (Pfemeter et al., 2015).

Additional potential of manure

	Value	Year	Source
Production	25,000,000 t	2016	BMNT, 2018
Energetic consumption	50,900 t	2016	BMNT, 2018
Additional potential	6.1 PJ	2030	Pfemeter et al., 2015

8.1.4 Waste

Municipal solid waste (MSW)

The main fractions of municipal solid waste from households (MSW) are: biogenic waste, hygiene articles, plastics, paper, cardboard and paper. MSW is usually thermally treated in special waste disposal facilities. In addition, there are several mechanical-biological waste treatment facilities. Mechanical-biological waste treatment is a combined process of mechanical and biological processes for the treatment of mixed municipal waste, similar industrial waste and sewage sludge and other waste suitable for treatment: After a first segregation of large packaging materials, the MSW will be shredded and sieved. The resulting fine fraction mainly consists of biogenic components and is further treated biotechnologically. The coarse fraction represents a high-calorific fraction, which is pressed or pelletized and afterwards used energetically. The middle fraction is mostly, after an aerobic treatment, shredded and sieved for a second time. The then resulting coarse fraction is used energetically and the rest is being deposited (Holzer et al., 2017).

Production and Consumption:

In 2015, 1,431,600 t of MSW were produced (Holzer et al., 2017) and in 2016 1,437,000 t (BMNT, 2018). In 2015, 1,162,100 t of MSW were thermally treated and in 2016 1,173,000t (BMNT, 2018).

Potential:

According to the Federal Waste Management Plan (BMNT, 2018) the amount of MSW will remain at a comparable level in the next years. The water content of MSW is about 23 %. Therefore, the potential is about 908,700 t_{dm}.

Additional potential of MSW

	Value	Year	Source
Production	1,431,600 t	2015	BMNT, 2018
	1,437,000 t	2016	BMNT, 2018
Consumption-thermal treatment	1,162,100 t	2015	Holzer et al., 2017
	1,173,000 t	2016	BMNT, 2018
Additional potential	908,700 t_{dm}	Annual	BMNT, 2018

Biogenic waste

Biogenic waste includes tree cuttings, green waste and leftovers (biogenic waste bin) from **households**. The composition of the biogenic waste depends on the season, annual rainfall, settlement structure etc. (BMNT, 2018). About 14.5 % of the biogenic waste in Austria are avoidable food waste (= approx. 157,000 t per year). By reducing food waste along the entire chain from agriculture to the end consumer, the potential of biogenic waste will decrease, but arable land can be potentially used otherwise. According to a WHO study, the avoidable food waste equals 1.4 billion ha of land worldwide (Dißauer, 2018).

Production and Consumption:

In 2016, 1,013,500 t (= 116 kg per person) biogenic waste from households were collected (BMNT, 2018). This biogenic waste can be separated into two categories:

- Biogenic waste bin: 530,700 t
- Green waste from households: 482,800 t

Biogenic waste is usually composted or used as raw material in biogas plants. In 2016, 15,922 t of biogenic waste were thermally treated. (Bundesministerium für Nachhaltigkeit und Tourismus, 2018)

Potential:

According to Statistics Austria, a population growth of about 5 % can be expected until 2030. It can be assumed, that the biogenic waste will increase to the same extent. Therefore, the potential of biogenic waste will amount to 1,064,175 t in 2030. Since a large part of biogenic waste is composted, the potential for energy production is limited to 212,835 to 532,088 t. The water content of the biogenic waste fluctuates widely. Due to longer interim storage periods, an around 30 % can be assumed for the potential calculation in t_{dm}.

Additional potential of biogenic waste

	Value	Year	Source
Production	1,013,500 t	2016	BMNT, 2018
Consumption – thermal treatment	15,922 t	2016	BMNT, 2018
Additional potential	148,985 t_{dm}-372,462 t_{dm}	Annual	Own calculation

Biogenic urban waste

Biogenic urban waste means those biogenic wastes that occur on **public and semi-public land** and are assigned to the following types of waste:

- Municipal garden and park waste (clippings, leaves as well as tree and shrub cut)
- Cemetery waste (flowers, wreaths, soil, but also candle remnants etc.)
- Roadside green (grass, tree and shrub cut, may be contaminated with heavy metals)

Municipal garden and park waste is mostly collected by the communities, partially chopped and transported to green waste composting plants or exploited together with biogenic waste. Depending on the degree of soiling and the collection fraction, cemetery waste is composted or subjected to treatment in mechanical-biological or thermal plants. Roadside green is collected by the responsible road authorities and then used biologically or thermally (BMNT, 2018).

Production and Consumption:

The "Federal Waste Management Plan" publishes a production of urban waste of 472,300 t in 2015 and 472,400 t. in 2016.

The production of 2016 in more detail:

- Municipal garden and park waste: 188,800 t
- Cemetery waste: 62,800 t
- Roadside green: 220,800 t

A part of the municipal garden and park waste as well as the roadside green remains at the site and rots without treatment. This share is not included in the production amount. Small amounts are thermally treated, but the exact number is unknown.

Potential:

The potential of biogenic urban waste will not change over the next years (Holzer et al., 2017). If the share of biogenic urban waste, which is so far rotting without treatment, is used, there will be an increase of potential, but probably not in an economical way. Hence, based on an average water content of 30 % and considering the share for compost production, the energetic potential for biogenic urban waste will be between 165,340 t_{dm} and 231,476 t_{dm}.

Additional potential of biogenic urban waste

	Value	Year	Source
Production	472,400 t	2016	BMNT, 2018
Additional potential	165,340 t_{dm} - 231,476 t_{dm}.	Annual	Holzer et al., 2017 and own calculation

Municipal sewage sludge

Sewage sludge consists primarily of solid and liquid substances, mainly of anthropogenic origin, produced during the treatment of sewage. Sewage sludge includes raw sludge, which is the starting substrate of the sewage treatment plant, and excess sludge, which results from the biodegradation processes of bacteria and protists. By sedimentation, biological processes, technical drying and other methods, the sewage sludge is stabilized, dewatered and thus prepared for recycling or disposal. Purposes of the treatment are: transportability, hygienisation by killing pathogens and destroying pollutants, and keeping the odor load as low as possible.

Sewage sludge contains a variety of nutrients, such as nitrogen, phosphorus and calcium in relatively large quantities. For this reason sewage sludge was and is used as a fertilizer substrate in agriculture. However, as it also contains a large number of pollutants, hence the use as fertilizer is controversial in Austria and generally forbidden on organically farmed areas (Lampert et al., 2014).

Production and Consumption:

Nearly 95 % of the Austrian population is connected to the public canal network. In 2016, the amount of produced sewage sludge was 238,000t_{dm}. About 53 % of the sewage sludge (126,670 t_{dm}) were thermally treated. The rest was used in agriculture, composting plants, etc.(BMNT, 2018).

Potential:

According to Statistics Austria, a population growth of about 5 % can be expected until 2030. It can be assumed, that sewage sludge will increase to the same extent. Therefore, the potential of sewage sludge for energy production will be about 133,000 t_{dm} in 2030.

Additional potential of municipal sewage sludge

	Value	Year	Source
Production	238,000 t_{dm}	2016	BMNT, 2018
Consumption- Thermal treatment	126,670 t_{dm}	2016	BMNT, 2018
Additional potential	133,000 t_{dm}	Annual	Own calculation

8.1.5 Summary

Table 13 shows the current consumption of biomass for energetic use. Biomass availability for energetic use is around 148.7 PJ.

Table 13: Annual additional domestic biomass consumption for energetic use

Category		Consumption in t-atro or t_{dm}	Consumption in PJ
Forest and wood residues	Forest residues (incl. wood chips)	2,251,800*	41.8
	Sawmill by-products (incl. wood industry by-products)	3,470,000*	65.4
	Waste wood (post-consumer and demolition wood)	1,470,749**	23.5
Agricultural biomass	Food and feed crops[1]	Not available	Not available
	Short rotation forestry	26,631**	0.5
	Miscanthus	15,792*	0.3
Agricultural residues	Straw	~20,000*	0.3
	Corn cobs	-	-
	Landscaping hay	-	-
	Manure	50,900*	0.5
Waste	MSW	1,173,000*	14.7
	Biogenic waste	15,922*	0.2
	Urban waste	-	-
	Municipal sewage sludge	126,670*	1.5
Total			**148,7**

* 2016, ** 2017

[1] The exact number of food and feed crops used to produce bioenergy in Austria is unknown. One of the reasons is that Austria relies on imports of raw materials and biofuels.

Table 14 shows the annual additional biomass potential for energy production in 2030. The biomass potential for energy production can be estimated between **54.9 and 102.5 PJ** (see chapter 8.1.6 in Annex 1 for the assumed heating values). However, the maximum potential can only be realized with appropriate accompanying measures (value chain optimization, biomass ash recirculation, renaturation etc.).

Table 14: Annual additional domestic biomass potential for energy production in 2030

Category		**Potential in t-atro or t_{dm}**	**Additional potential in PJ**
Forest and wood residues	Forest residues	345,772 - 471,88	6.5 – 8.9
	Sawmill by-products	348,423 – 698,847	6.6 – 13.2
	Waste wood (post-consumer and demolition wood)	430,560	6.9
Agricultural biomass	Food and feed crops	-	-
	Short rotation forestry	390,000 - 1,180,000	6.9 – 20.8
	Miscanthus	70,000	1.1
Agricultural residues	Straw	592,625-1,481,562	10.2 – 25,6
	Corn cobs	50,000 – 200,000	0.9 – 3.5
	Landscaping hay	110,075	2.0
	Manure	-	1.6
Waste	MSW	908,700	11.4
	Biogenic waste	148,985 – 372,462	1.9 – 4.7
	Urban waste	165,340 – 231,476	2.1 – 2.9
	Municipal sewage sludge	133,000	1.6
Total			**54.9 - 102.5**

8.1.6 Heating values

Lower heating values

Biomass	**Heating Value in MJ/kg$_{dm}$**
Forest residues	18.85
Sawmill by-products	18.85
Waste wood (post-consumer and demolition wood)	16.00
Food and feed crops	17.90
Short rotation forestry	17.64
Miscanthus	15.84
Straw	17.28
Corn cobs	17.28
Landscaping hay	18.30
Manure	10.00
MSW	12.50
Biogenic waste	12.50
Urban waste	12.50
Municipal sewage sludge	12.00

8.2 Annex 2 – Technology providers

Boilers, stoves and CHP producers

		log wood boilers	wood chip boilers	pellet boilers	space heaters	> 500kW	Wood gas CHP
Agro Forst & Energietechnik GmbH	9470 St. Pail i. L.					•	
Andritz Energy & Environment GmbH (AE&E)	8074 Raaba					•	
Austroflamm GmbH	4631 Krenglbach				•		
BERTSCHenergy Josef Bertsch GmbH & Co. KG	6700 Bludenz					•	
Billensteiner GmbH	3150 Wilhelmsburg				•		
Binder Energietechnik GmbH	8572 Bärnbach		•	•		•	
Biokompakt Heiztechnik GmbH	4391 Waldhausen	•	•	•			
Biotech Energietechnik GmbH	5300 Hallwang			•			
Bösch KG	6890 Lustenau	•		•			
Buderus Austria Heiztechnik-GesmbH	4600 Wels				•		
calimax Entwickl. u. Vertr. GmbH	6830 Rankweil				•		
Christof Holding AG	8051 Graz						•
Dumag Brennertechnologie GmbH	1037 Wien					•	
Anton Eder GmbH	5733 Bramberg	•		•	•		
Enickl Friedrich, Ing., „Tropenglut"	4407 Dietach		•			•	
En-Tech Energietechnikproduktion GmbH	9300 St. Veit/Glan			•	•		
ETA Heiztechnik GmbH	4716 Hofkirchen/Trattnach	•	•	•			
Evotherm Heiztechnik Vertriebs GmbH	5121 Tarsdorf		•	•			
Fröling Heizkessel-u. Behälterbau GesmbH	4710 Grieskirchen	•	•	•		•	•
Gast Herd- und Metallwarenfabrik	4407 Steyr	•			•		
Gebe GmbH	1140 Wien	•	•	•		•	
Gilles Heiz-und Energiesysteme GmbH	4810 Gmunden		•	•		•	
Guntamatic Heiztechnik GmbH	4722 Peuerbach	•	•	•		•	
Haas+Sohn Ofentechnik GmbH	5412 Puch			•	•		
Hallach GmbH	3040 Neulengbach				•		
Hargassner GmbH	4952 Weng	•	•	•			•
Herz Energietechnik GmbH	7423 Pinkafeld	•	•	•		•	
Hoval Gesellschaft m.b.H.	4614 Marchtrenk	•		•			
Integral Engineering und Umwelttechnik GmbH	2544 Achau					•	
Kesselbau Sutterlüty GmbH	6971 Hard a. Bodensee					•	
KÖB Holzfeuerungen GmbH	6922 Wolfurt	•	•			•	
Kohlbach Energieanlagen GmbH	9400 Wolfsberg					•	
Kurri Ges.m.b.H.	2700 Wiener Neustadt		•	•			
KWB – Kraft und Wärme aus Biomasse GmbH	8321 St. Margarethen/Raab	•	•	•			
Lignotherm Heizsysteme GmbH	9852 Trebesing	•	•	•			
Lohberger Heiz&Kochgeräte Technologie GmbH	5231 Schalchen	•			•		
Lohberger Heiztechnik GmbH	5231 Schalchen	•		•	•		
Mawera Holzfeuerungsanlagen GesmbH	6971 Hard a. Bodensee		•			•	
NTH-Heiztechnik GMBH	3385 Prinzersdorf	•		•	•		
ÖkoFEN Forschungs- u. Entwicklungs GesmbH	4133 Niederkappel			•			
Olymp OEM Werke GmbH	6430 Ötztal-Bahnhof	•		•	•		
Perhofer GmbH	8190 Birkfeld	•	•	•	•	•	
Pöllinger Heizungstechnik GmbH	3385 Gerersdorf		•	•			
Polytechnik Luft- u. Feuerungstechnik GmbH	2564 Weissenbach		•	•		•	
RIKA Innovative Ofentechnik GmbH	4563 Micheldorf				•		
Schmid energy solutions GmbH	8501 Lieboch	•	•	•		•	•
Solarfocus GmbH	4451 St. Ulrich/Steyr	•	•	•			
Sommerauer & Lindner - Technik-GmbH	5120 St. Pantaleon		•	•			
Strebelwerk GmbH	2700 Wiener Neustadt	•	•	•		•	
SynCraft Engineering GmbH	6130 Schwaz						•
Thermostrom Energietechnik GesmbH	4407 Steyr-Dietachdorf	•	•	•		•	
Thöni Industriebetriebe GmbH	6410 Telfs					•	•
TM Feuerungstechnik GmbH	8271 Bad Waltersdorf		•			•	
Urbas Maschinenfabrik GesmbH	9100 Völkermarkt					•	•
VAS Energy Systems GmbH	5071 Wals-Siezenheim					•	
Windhager Zentralheizung GmbH	5201 Seekirchen/Wallersee	•		•			
Wolf Klimatechnik Vertriebs GmbH	4034 Linz	•		•			
WTI Wärmetechnische Industrieanlagen GmbH	3380 Pöchlarn					•	

(Pfemeter, Bioenergie Atlas Österreich, 2019)

Planning and engineering companies (biogas, biofuels)

Ing. Aigner Wasser – Wärme – Umwelt GmbH, 4501 Neuhofen
Agrar Plus GmbH, 3100 St. Pölten
BDI – BioEnergy International AG, 8074 Grambach/Graz
Bioenergie Niederösterreich reg. Gen.mbH, 3643 Maria Laach
Biomasseverband Oberösterreich, 4021 Linz
BIOS Bioenergiesysteme GmbH, 8020 Graz
Energie AG Oberösterreich Tech Services GmbH, 4020 Linz
EVN AG, 2344 Maria Enzersdorf
KELAG Wärme GmbH, 9506 Villach
nahwaerme.at Energiecontracting GmbH, 8020 Graz
Purnes GmbH, 3643 Maria Laach
Repotec, 7540 Güssing
Ing. Leo Riebenbauer GmbH, 8243 Pinggau
SEEGEN Salzburger Erneuerbare Energie Gen.m.b.H., 5082 Grödig
SWET GmbH, 9220 Velden am Wörthersee
WRS Energie- u. Baumanagement GmbH, 4040 Linz

(Pfemeter, Bioenergie Atlas Österreich, 2019)

Federal Ministry for Transport, Innovation and Technology
Radetzkystr. 2, 1030 Vienna
bmvit.gv.at