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Solid Biomass
a TechnologyPortrait

Cluster Bioenergie Österreich
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editors:
Cluster Bioenergie Österreich
Postfach 208, A-1013 Wien
Tel. +43/1/470 12 25, Fax. +43/1/470 12 25
E-mail: office@iec.at, Homepage: http://www.bioenergy.at

Stenum GmbH, Forschungsgesellschaft f Stoff- Energie- und Umweltfragen,
Geidorfgürtel 21, A-8010 Graz
Tel. +43/316/367156, Fax. +43/316/367156-13
E-mail: office@stenum.at

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This report can be downloaded at http://energytech.at/biomasse/portrait.html.

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1 THE IMPORTANCE OF BIOMASS AS AN ENERGY SOURCE

The European Union's White Paper defines strategies for the use of renewable sources of energy, and therefore also for biomass. In addition to that, most countries have ratified international agreements such as the reduction targets of Toronto and Kyoto, which resulted in an increased use of biomass at both national and EU level in order to reach these targets. The starting position for the use of biomass in Austria is very good; biomass currently covers 12% of Austria's primary energy supply.

Due to the nature of its landscape Austria has always been a land of forests, which still cover 40% of its area. This is the result of a foresighted policy which introduced legislation ensuring a sustainable use of Austrian forests at the turn of this century. Before that, iron and steel production and the growing population led to an increasingly dramatic exploitation of forests in the 18th and 19th centuries. Erosion, floods and avalanches were the consequences that finally led to strict regulations to prevent deforestation. At the same time the switch to coal as a new energy carrier took place, leading to a steady decline in wood use for energy purposes.

Since the mid 1970s however, a remarkable revival of wood as energy source has taken place. Until 1997 its contribution rose to 11.7% of national primary energy use. Together with the use of hydropower Austria is able to derive a quarter of its energy demand from renewable resources.

Several factors have contributed to this development: higher oil prices, decreasing wood costs due to productivity gains in forestry and increased use of wood wastes for process heat in the wood working industry and in the pulp and paper industry.

In 1995 almost 20% of residences were heated with wood, in addition to those that were supplied with heat from biomass-fuelled district heating plants. The market share of wood is thus considerable, with small scale biomass plants (using pellets, woodchips or logwood) with a capacity of up to 100 kw playing a key part as about 60% of the biomass utilised in Austria is used in this type of installation (Source: EVA).

The revival of biomass use was actively supported by R&D efforts to improve wood combustion technologies. The result of these efforts was a remarkable development which provided the basis for the growth of the market for wood boilers for domestic heating, industrial process heat applications and district heating. Growth has also been stimulated by various other support activities and subsidies. Along with the use of forestry products for bioenergy, agricultural biomass production has also received significant attention. Short rotation forestry has been tested since 1980 and several other crops were investigated.

Due to low prices for fossil energy carriers, fuel wood lost significant market shares to oil and gas in the 90s. In an attempt to counteract this tendency, a new, improved range of services was developed, including new boiler technologies (fully automatic installations), new fuel types (pellets) and new supply strategies (e.g. contracting projects for micro networks and heat supply schemes for individual buildings on the basis of woodchips from forestry).

2 HOW IS BIOMASS CURRENTLY USED?

2.1 Domestic heating

The most significant contribution to renewable energy use in Austria comes from domestic heating with logwood. Since 1990 a marked decline in wood use in domestic heating can be observed, which is due to the replacement of wood stoves and old wood boilers by central heating systems based on natural gas and oil. The reversal of this trend towards increasing use of modern wood boilers is the greatest challenge for Austria's renewable energy policies at present.

This is particularly difficult as the switch to other energy carriers is partly due to the decline of traditional lifestyles that involved producing firewood privately in the forest. Thus the effects of lifestyle changes must be offset by new strategies and services that make heating with wood attractive to young people who give userfriendliness a high priority in the choice of heating systems. Financial incentives have been established in a number of provinces to stimulate the installation of modern wood boilers. Complementary actions will be necessary to enhance fuel supply services, distribution networks and maintenance services. The most convenient option for domestic heating with wood is district heating. More than 400 small scale biomass district heating plants have been established for this purpose within the past 20 years, mostly in rural areas.

In particular, recent developments in the biomass fuel sector (pellets) and in the fields of financing and organisation (contracting, micro networks) offer promising options for the future.

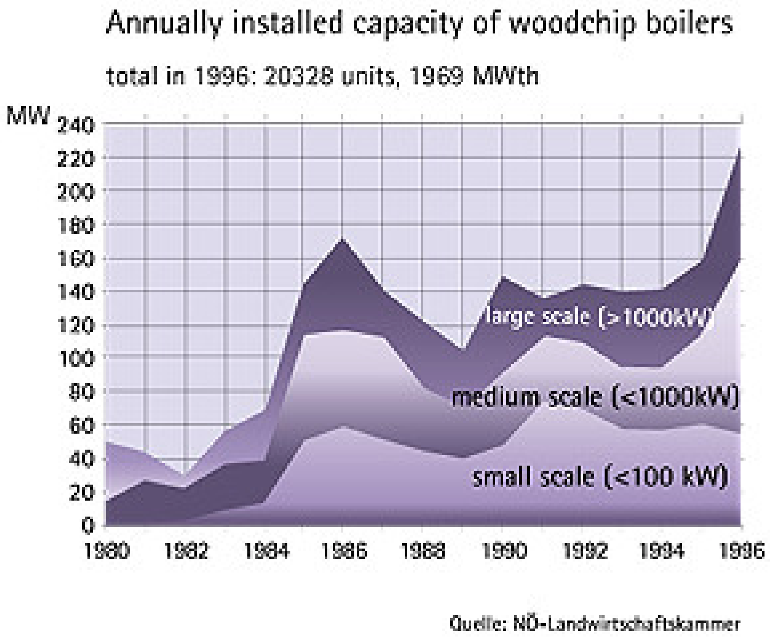
2.2 Industrial biomass use

The second largest contribution to the use of biomass in Austria comes from the pulp and paper industry where bark and black liquor, which contains mainly lignine from wood pulping, are burned in large boilers to provide process heat and electricity.

The third major contribution comes from woodchips, sawmill residues and bark. They are used in the wood industry to produce process heat for drying wood, in biomass district heating plants and in smaller wood chip boilers for domestic heating.

Figure 1 shows the annually installed thermal capacity of woodchip boilers in Austria. These include both district heating (total 483 MW) and industrial boilers (total 1486 MW). All contributions of other renewable energy sources are relatively insignificant. This is also true for straw, which represents a significant potential for bioenergy in Austria that is not used presently, due to the abundance of cheap biomass from forestry.

Fig. 1: Annually installed capacity of woodchip boilers



3 DIFFERENT TYPES OF DOMESTIC HEATING SYSTEMS WITH WOOD

Domestic heating with wood is still by far the largest market for bioenergy both in Austria and in the EU. In no other area of biomass use have equally dramatic improvements of technology been made during the last decade as in domestic heating equipment. Emissions of modern biomass boilers have dropped by two orders of magnitude to values below 100mg CO/m^3 and efficiency has increased from 55% to around 90%.

At present domestic heating with wood is the most efficient and most competitive way of using biomass for energy as the price level of competing fuels for domestic heating is significantly higher than that of fuels for electricity production. Several different technical concepts are available for domestic heating: improved tiled stoves, advanced logwood boilers, woodchip boilers, pellet boilers and pellet stoves.

Improvements in building insulation are leading to significant reductions in fuel demand. This reduces the handling effort and the required storing space for wood fuels – which used to be major disadvantages of heating with wood.

On the technical level, the development from the multi-fuel boiler of the past to today's modern logwood boilers represents a quantum leap in terms of convenience as well as efficiency. Furthermore, thanks to the development of fuels from logwood via woodchips to pellets, a pourable wood-based fuel is now available which can be transported like a liquid, such as oil: wood (in the form of pellets) is supplied by tank lorry and pumped into the pellet tank by means of a fuel hose. Thanks to their automatic ignition systems, these boilers are now fully automatic. Thus they represent a wood-based heating system providing the same level of convenience as fuel oil (except for periodical ash disposal, which can, however, also be taken care of by the chimney sweep).

The following chapters illustrate the technical possibilities available nowadays of using wood as a modern fuel.

3.1 Tiled stoves

Tiled stoves were the most efficient traditional way of burning logwood. Recent developments have led to significant improvements in design, enhancing the efficiency and lowering emissions. Operating comfort could be improved by features such as automatic electric ignition. Tiled stoves are the most popular device for additional heating in Austria and an excellent heating solution for low energy houses. Their price varies strongly according to the fanciness of design. Simple designs can be cheaper than logwood boilers. (Contact: Association of tiled stove producers)

3.2 Pellet boilers and pellet stoves

Wood pellets are a homogeneous fuel with high energy density which allows for simpler and cheaper boilers. Requirements for storage are smaller and heating comfort is equal to oil boilers. This segment is the fastest growing segment of biomass boilers at present. Pellets can be used for stoves, too, which are significantly cheaper than boilers and can provide comfortable and cheap additional heating, e.g. to an existing electric or fossil fuel based heating system.

The price of pellet boilers is about 7500 ECU, the price of pellet stoves is around 2500 ECU. Pellets cost about 30 ECU/MWh in Austria. Recently boilers have been designed that can be fuelled both with pellets and with logwood.

3.3 Logwood boilers

Figure 2 shows the scheme of a new generation logwood boiler. Wood combustion takes place in a two-stage process: gasification in the first stage and high temperature combustion in a specially designed chamber in the second stage.
In order to ensure clean combustion, most producers nowadays use lambda sensors to measure the remaining oxygen in the flue gas so that an optimal quantity of secondary air for the combustion process can be supplied via adjustable valves.

The boiler is generally operated at full power and heats up a hot water storage tank for continuous heat retrieval. The storage tank can serve as a solar boiler in summer if thermal solar collectors are installed. The latest models of logwood boilers do not need a storage tank as they can run at 30% of full power without significantly higher emissions than at full power.

Fig. 2: Scheme of a logwood boiler

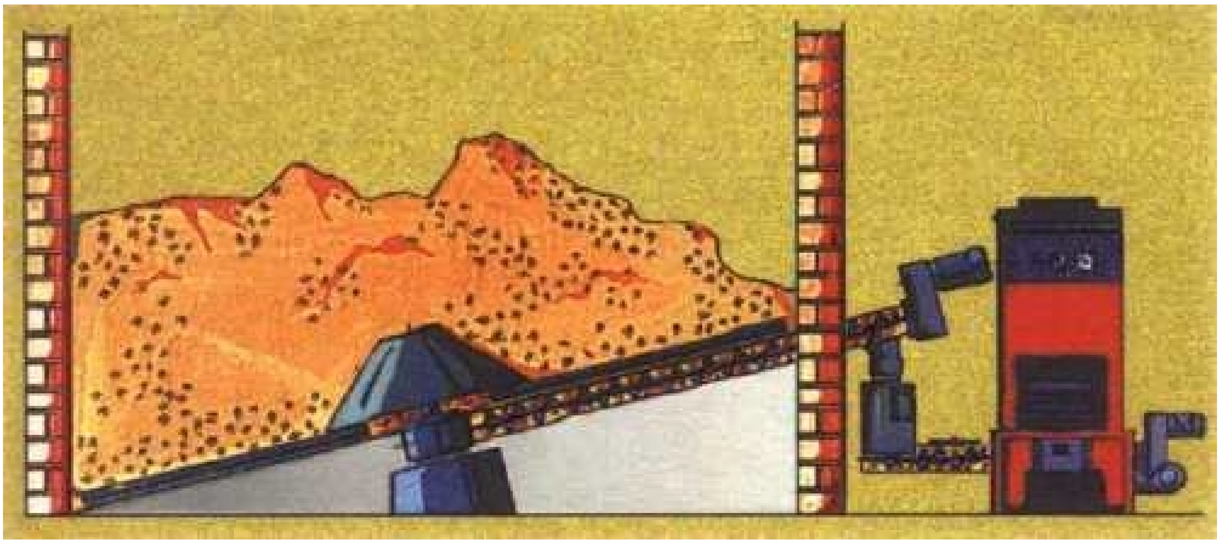
Source: Energy from Biomass – R&D in Austria (Ministry of Science and Transport)

The average price of a unit including storage tank for a single family house is about 6000 ECU. Logwood costs about 25 ECU/MWh. It can be stored outdoors.

3.4 Woodchip boiler

The advantage of woodchip boilers is their automatic feeding system for fuel which allows for full automatic operation and similar user-friendliness as oil or gas fired boilers. State of the art woodchip boilers are equipped with continuous power control and do not need a heat storage tank. A disadvantage of woodchips is their relatively large space requirement for in-door storage. Due to possible variations in fuel humidity, woodchip boilers need advanced electronic control equipment. The possible variation of woodchip size and humidity requires rather robust (and expensive) feeding and control mechanisms. Thus woodchip boilers are significantly more expensive but also more comfortable than logwood boilers. They are a good solution when heat requirements are so high that the effort of logwood handling is un-acceptable. The average price of a unit for a single family house is 11 000 ECU. Woodchips cost 20 - 25 ECU/kWh.

Fig. 3: Scheme of an automatic feeding system of a woodchip boiler



Source: Praktischer Ratgeber Hackgutfeuerungen (RES Regionalenergie Steiermark)

Woodchips are of particular interest if the user has direct access to cheap fuel; this is why they are the fuel of choice for farmers as well as for the timber and woodworking industry.

3.5 Other types of wood boilers

Apart from the above mentioned types there are other centralised heating systems which are especially designed for smaller or low energy houses:

- **tiled stoves** with water pipes;
- **tiled kitchen stoves** (for cooking, as well as space heating [also of adjoining rooms] and water heating);
- **pellet stoves** (pellet-fuelled stove, storage tank for up to 90 hours continuous operation, capacity up to 10 kw);
- **hypocaust heating systems** (heating system distributing heat through flues which can be integrated into the structure of new buildings);
- **hot air heating systems** (heat is released directly into the room through discharge flaps).

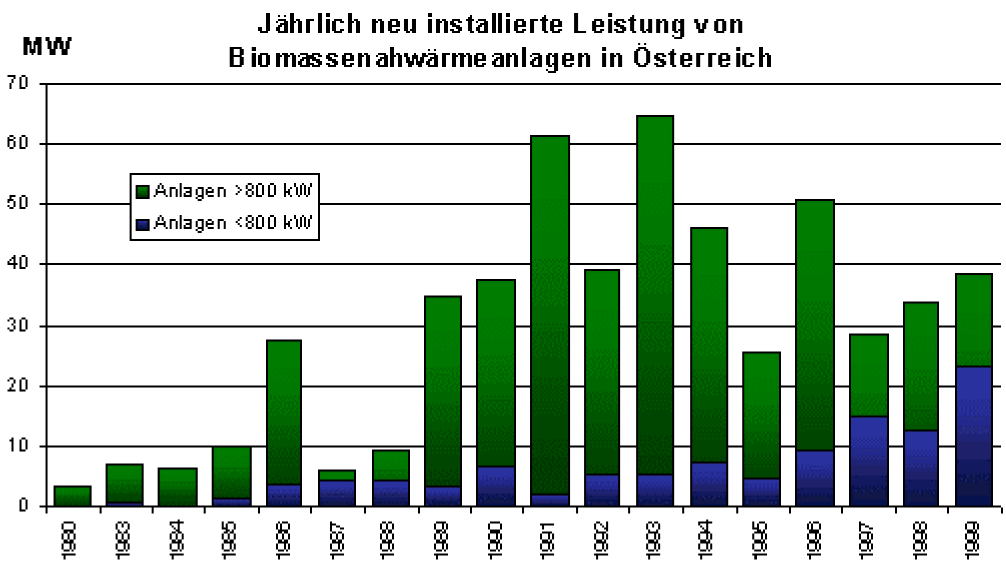
Furthermore, wood-based systems are increasingly being used for additional heating in flats and houses as people appreciate the cosy warmth of wood fires. In the interseasonal period these systems can also be used to heat the entire residence.

- **fireplace heating system** (a closed fireplace from which hot air can be discharged into the room where it is installed or into the rooms above);
- **freestanding stove** (a further development of the classic cast iron stove).

3.6 District heating with biomass – advanced technologies for maximum convenience of use

The introduction of small scale biomass district heating plants is a success story for renewable energy in Austria. Between 1980 and 1998 more than 350 plants were built to provide heating predominantly for rural villages. Recently around 50 new plants have been established yearly. Dedicated political support, the active role of provincial energy agencies and agricultural chambers and substantial subsidies (30-50% of investment costs) have been vital for this success.

Fig. 4: Annually installed capacity of biomass district heating systems in Austria



Biomass district heating plants are fuelled with industrial wood wastes and wood from forestry. Most of the plants are operated by agricultural cooperatives, as many farmers are forest owners seeking to create a market for low-grade wood from thinnings. Dedicated R&D efforts have contributed to the success of biomass district heating by introducing substantial improvements of plant technology.

Recent research has focused on different approaches to minimise the environmental impacts of biomass combustion by minimising NOx emissions and emissions of heavy metals. Cost-effective technologies to minimise fine dust emissions have been developed and new approaches to maximise energy gains from flue gas condensation are under investigation (Contact: BIOS).

In addition to these small-scale district heating networks, however, so-called **micro networks** present a viable option for less densely populated areas where district heating is uneconomical. These networks are frequently operated under contracting schemes or by groups of farmers running heating plants in the low capacity range.

3.7 Wood-based energy contracting: How does it work?

In this type of contracting project, a group of farmers invest in the biomass installation and the required construction work and rent space in the customer's cellar. The operators are responsible for the functioning, maintenance and any repairs of the heating system. As in the case of district heating networks, the customer pays a connection charge and the price for the actual heat intake, which is determined by means of a metre.

The customer is not involved in the organisational side of running the heating system. If the coefficient of performance is favourable, surrounding buildings can also be supplied (directly, or indirectly via heat exchanger). The intention behind **wood-based energy contracting schemes** is to facilitate the use of **biomass heating systems for multi-storey residential buildings, municipal buildings and trade and business establishments** without requiring potential users to bear the investment costs. In effect a kind of micro-district heating plant is set up: customers are supplied with heat without having to deal with the installation, operation or financing of the system.

3.7.1 The success of wood-based energy contracting projects

The dynamic development of this type of contracting project and the great number of projects realised demonstrate the success of this model. The first installation of this kind came on stream in 1995; by early 1998, 34 of them (representing a total capacity of about 3,000 kw) were operating smoothly and successfully. By October of that year, definite plans had been made for 10 more projects with an overall capacity of just over 1,000 kw.

Whereas the customers in such projects have tended to be **public-sector institutions** (town halls, kindergartens, schools) or privately owned houses, there is now a marked trend towards supplying **multi-storey residential buildings**. The initially sceptical housing associations have come to see the advantages, too.

3.7.2 Costs of a wood-based energy contracting project

The current price situation for such schemes is as follows:

The operators (farmers) must come up with approximately 10 to 15% of the capital requirement; the rest can be financed from connection charges and subsidies available under investment promotion schemes (currently about 30 to 50%). The operators can expect to achieve a price of ATS 250 (excluding VAT) per cubic metre (bulk volume) of soft woodchips; maintenance and service work can be charged at the hourly rates set by ÖKL[1] (approximately ATS 100 per hour).

For the customers, this works out to standard biomass district heating rates:

rates for current heat intake: ATS 0.75 to 0.85 (excluding VAT) per kWh

about 10% higher for low energy houses

connection charge (non-recurring): ATS 2,000 to 3,500 per kW in old buildings

ATS 2,500 to 4,000 per kW in new buildings

[1] Österreichisches Kuratorium für Landtechnik und Landentwicklung (Austrian Council for Agricultural Engineering and Rural Development)

4 BIOGENOUS FUELS

4.1 What types of wood-based fuels are there?

Wood is a domestic energy carrier and, as stored solar energy, it is currently the most important renewable energy source besides hydroelectric energy. Basically, **wood-based fuel** is available to the final user in **three different shapes**:

- as **logwood**, the traditional fuel;
- as **woodchips**, and
- in the form of **pellets.**

The terms woodchips and pellets are explained in more detail below.

4.1.1 Woodchips

The term woodchips refers to mechanically processed wood particles, ranging in size from 1 to 100 mm. As far as quality standards are concerned, ÖNORM M7 133 ("Woodchips for energy generation: quality and testing requirements") applies.

The main quality criteria for woodchips are:

- chip size: only the "fine" (smaller than 30 mm) and "medium" grades (below 50 mm) are suitable for small-scale installations;
- water content: this determines the energy content of the fuel on the one hand and its storability on the other;
- bulk density: this indicates the weight per cubic metre (bulk volume) and depends on wood type, particle shape, degree of compaction and water content.

The price of woodchips largely depends on their water content, as a high water content reduces the energy content. Moisture is therefore just as important as chip size in determining the price of woodchips.

In the following table, this is reflected by the percentages in the column headed "relative value". Quality class W35 (limited storability), which designates woodchips that have been stored over one summer, was taken as a basis.

Tab. 1: Different quality classes of woodchips

quality class	water content	relative value
air-dried W20	< 20%	120%
storable W30	> 20; < 30%	110%
storable within limits W35	> 30; < 35%	100%
moist W40	> 35; < 40%	85%
freshly harvested W 50	> 40; < 50%	65%

Source: Stenum GmbH

4.1.2 Pellets

Pellets are wood wastes from the woodworking industry (wood shavings, saw dust, sanding dust) formed into cylindrical shape under high pressure with no bonding agent added. Typically, pellets are 6-8mm in diameter and 5-30 mm long (see figure 6). The maximum water content is 8%. The relevant quality standards are laid down in ÖNORM M 7135.

Pellets are therefore the first **pumpable wood-based fuel**: they can be supplied by tanker, just like heating oil. They are also just as convenient to use, with the added advantage that pellets are a domestically produced, and therefore dependable, energy carrier.

As a result of the pressing process, pellets have a very **high energy content** (4.3 to 5.0 kWh/kg at a density of 1.2 ± 0.1 t/m³). The energy content of pellets is therefore about 3 times that of woodchips, **reducing the required storage space** accordingly. Although the energy content of pellets is about 1/3 that of heating oil, they require practically the same amount of storage room as they do not constitute an environmental hazard and therefore need not be stored in a safe tank. However, it is essential to **keep them dry**. Appropriate storage is only possible if a dry cellar room is available; wooden floor grids may be used to avoid direct exposure to moist cellar floors. Pellets are exclusively produced by the domestic woodworking industry and sold by fuel dealers. This helps to allay many customers' fears regarding security of supply. Furthermore, homogeneous pellet structure can be ensured thanks to industrial production.

Given the precise fuel specifications, boilers can be optimally adjusted, which makes the investment more cost-effective and, most importantly, makes small-scale installations **safer to use**.

Pellets can currently be purchased in bulk (i.e. delivered by tanker) at a price of ATS 2 per kg. In provinces where pellets have been in use for longer periods of time, this price has dropped to as little as ATS 1 per kg.

For more detailed information on pellets, please contact the Austrian Pellets Association (Pelletsverband Austria) (pva@magnet.at, www.pelletsverband.at)

4.1.3 Other biogenous fuels

In addition to **wood-based fuels** (logwood, woodchips and pellets), the following other plant-based energy carriers are subsumed under the umbrella term "biomass":

- straw;
- biogas und sewage gas;
- residues from fruit processing (e.g. stones, husks, …);
- wood wastes from the woodworking industry (saw dust, sanding dust);
- biogenous residues from the woodworking industry (e.g. from the pulp industry);
- biogenous fuels (biodiesel from oil seeds such as rape, methanol from cereals).

These particular energy carriers are currently mainly used industrially.

5 SOLAR ENERGY AND BIOMASS – A GOOD COMBINATION

Much research has been dedicated to the possibilities of storing solar energy in summer to use it for residential heating in winter. In a way, biomass is also a seasonal store of solar energy, however its heat storage density is about 50 times higher than that of a water storage tank. Thus solar energy and biomass is a good combination as it offers the most economic way to realise 100 % renewable energy supply for domestic heating and hot water.

The most economic and effective system to realise a full solar heating system for single family houses is at present the combination of a logwood boiler, a water tank (2-3 m^3) and thermal solar collectors. In summer the solar system provides hot water and stores it in the tank.

In Autumn and spring the solar system can also provide heating (dependent on its size). In winter the biomass boiler uses the heat store, which allows full power operation of the boiler and continuos heat retrieval at any required load.

Biomass district heating systems face a dilemma in summer. On the one hand customers demand district heat supply for hot water preparation, on the other hand heat loads are so low that the biomass boilers cannot be operated properly. Large solar collectors offer a solution to this problem: as heat for bad weather periods is stored in a large water tank they can provide more than 90 % of the energy demand in summer. In winter the storage tank is used for providing peak load heat demand. Consequently smaller biomass boilers can be installed and operated at higher average loads, which reduces costs and improves efficiency. Excess solar energy in summer can be used to dry the woodchips for winter - another way of seasonal energy storage. By 1999 16 biomass district heating systems with solar hot water collectors were in operation in Austria.

Tab. 2: Combined biomass/solar energy district heating systems in Austria (1999)

	start of operations	boiler capacity [kW]	length of district heating network [m]	energy storage capacity [m³]	panel area [m²]
Deutsch Tschantschendorf	1994	600	2.500	34	325
Bildein	1995	1.000	2.960	38	450
Obermarkersdorf	1995	750	3.400	68	567
Unterrabnitz	1995	650	3.800	58	477
Gnas	1996	1.640	2.200	40	441
Urbersdorf	1996	450	1.650	60	350
Bad Mitterndorf	1997	4.000	3.500	140	1.120
Eibiswald	1997	2.000	3.200	105	1.250
Lindgraben	1997	350	1.300	37	350
Poysbrunn	1997	1.000	3.140	85	870
Nikitsch	1997	2.250	6.900	60	780
Kroatisch Minihof	1997	700	3.100	60	740
Soboth	1998	300	-	10	200
Schwanberg	1998	500	-	50	470
Stadl/Mur	1998	-	-	60	490
Judendorf/Strassengel	1999	100	-	-	100
Gleisdorf (Sundays)	1999	40	60	14	230

Source: Energieverwertungsagentur

The most advanced project of low energy full solar housing in Austria is the "Sundays" project in Gleisdorf. It combines a number of innovative achievements at a total construction cost of about 1300 ECU per m^2 of living area. Due to high insulation standards and passive solar energy features, the total energy consumption in one year is 32 kWh/m^2 (a typical value for a new single family house is 100 kWh/m^2). This energy is provided by a combined solar energy and biomass system. The Sundays project is constructed of innovative solid wood panels and even the insulation is made of a new, wood-derived product. Thus the house does not produce any net CO2 for heating and acts as a carbon sink. It will be available on the market as a standard prefabricated house at a competitive price. (Contact: Arge Erneuerbare Energie)

The 1250 m2 solar system of the district heating system of Eibiswald is the largest in Austria. The collectors form the roof of the storage barn for woodchips. A 100 m3 water tank is used for temporary heat storage. The system provides about 500 000 kWh of energy per year. The collector system is made up of 99 large solar modules which were put in place and connected in only 3 days. Total system costs were 220 ECU per m2 of collector surface - the total cost of a typical solar installation for a single family house is 660 ECU/m2 in Austria. (Contact: S.O.L.I.D., Sonnenkraft)

6 BIOMASS R&D IN AUSTRIA – AN OVERVIEW

Given the dominant role of biomass as energy source expenditure for R&D on this topic has exceeded R&D spending on any other source of renewable energy for about two decades. Thus a sound R&D basis has been created at universities and research institutions as well as in industry. Since Austria's accession to the EU participation in EU funded research projects has gained great importance. Austria also actively participates in the International Energy Agency´s Bioenergy Agreement. (Contact: Joanneum Research)

6.1 The complementary role of national and international research

R&D programmes tend to develop a considerable degree of inertia and to become entrenched in certain lines of research. For this reason the division into national programmes and an international agenda is important to sustain different niches for R&D. In the particular case of Austrian national bioenergy R&D programmes this niche is research on options for using biomass as a source of heat by direct combustion. An exemption to this general focus is the successful development of biodiesel and biomass co-combustion and gasification technologies.

The reason for this focus on direct combustion technologies is the general consensus in the Austrian bioenergy community that national R&D should be geared at achieving progress in biomass use in the medium and short term, i.e. acknowledging the present national and international framework conditions. Under these conditions the only feasible markets for biomass use in Austria are domestic heating, process heat and district heating. Market niches exist for combined heat and power production in forest industry, and - in the future - large district heating systems.

Committed policies to enhance bioenergy use have been implemented in several of Austria´s Federal Provinces. They have shown that any attempt to introduce changes in the energy system has to overcome complex nontechnical barriers.
Thus research on non technical barriers and strategies to overcome them has become another focus of Austrian biomass R&D. (Contact: Energieverwertungsagentur).

6.2 Driving forces of national bioenergy R&D

Financial incentives for bioenergy systems were a significant driving force, particularly for industrial bioenergy R&D, as they created a strong market demand for good equipment.

Other important driving forces were the establishment of a national testing site for wood boilers in Wieselburg, a public competition for the best small scale woodchip boiler and the introduction of strict emission standards both for small and large systems. Clearly defined R&D agenda of the Federal Ministry of Research and Transport have contributed to focusing research

6.3 Trends for the future

A new agenda for national bioenergy R&D was published in 1999. It involves a detailed analysis of technical as well as non-technical research tasks which need to be addressed to allow further progress in bioenergy utilisation in Austria. Future research tasks include

- the development of bioenergy systems for the heating requirements of low energy houses,
- the further development of systems which combine biomass and solar energy,
- advanced pellet boilers, and
- non-technical research regarding strategies for increased market penetration of bioenergy.
- Furthermore the problem of enhancing the performance of existing biomass district heating systems will have to be adressed and cost-effective solutions will have to be developed for further emission reduction, and for the efficient central heating of small agglomerations of houses ("micro grids").
- In view of the considerable contribution of methane emissions to the greenhouse effect future research will also place a new focus on enhancing biogas use from anaerobic processes.

7 ADVANCED TECHNOLOGIES FOR BIOMASS BOILERS IN THE MW-RANGE

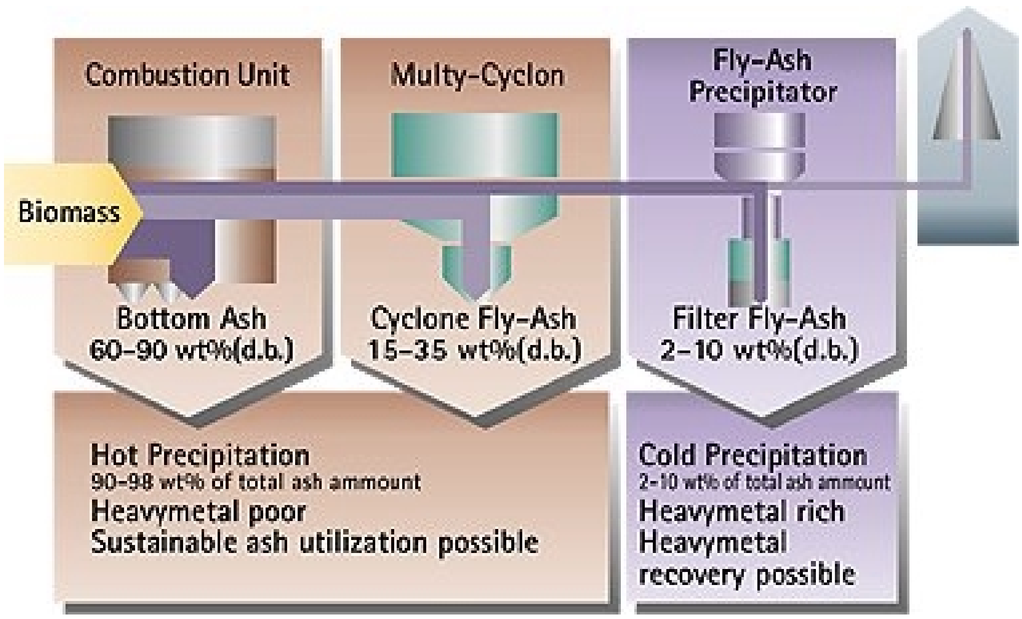
7.1 Solving the problem of heavy metals

Due to environmental pollution heavy metals as Cd and Zn are deposited in trees and can pose an environmental risk when the wood is burned. Dedicated research on the behaviour of heavy metals during wood combustion has led to an understanding of the mechanisms relevant for their deposition in the ashes. Technical measures were developed and realised in a 5 MW district heating plant that lead to a fractionated deposition of heavy metals in the biomass ashes: 80% of Cd are deposited in fine fly ashes that amount to only 5% of the mass of total ashes. Thus the greatest part of ashes can be used for agricultural purposes safely while a small amount must be deposited as toxic waste. Present research is aiming at further increasing the amount of heavy metals in fine fly ashes to 90-95%. As fine fly ashes cannot be removed sufficiently in multicyclone precipitators a second stage of flue gas cleaning by electric precipitators, a flue gas condensation unit or the innovative rotating particle seperator are necessary. (Contact: University of Technology Graz).

7.2 Rotating particle separator: a cost effective technology for the abatement of fine fly ashes

As of January 1998 a new limit value of 50mg/m^3 for dust emissions applies in Austria for biomass combustion units with a nominal boiler capacity of more than 2 MWth. The rotating particle separator (RPS) is a technology newly adapted for the abatement of fine fly ashes from biomass boilers.

Fig. 8: Rotating particle separator: a cost-effective technology for the abatement of fine fly ashes

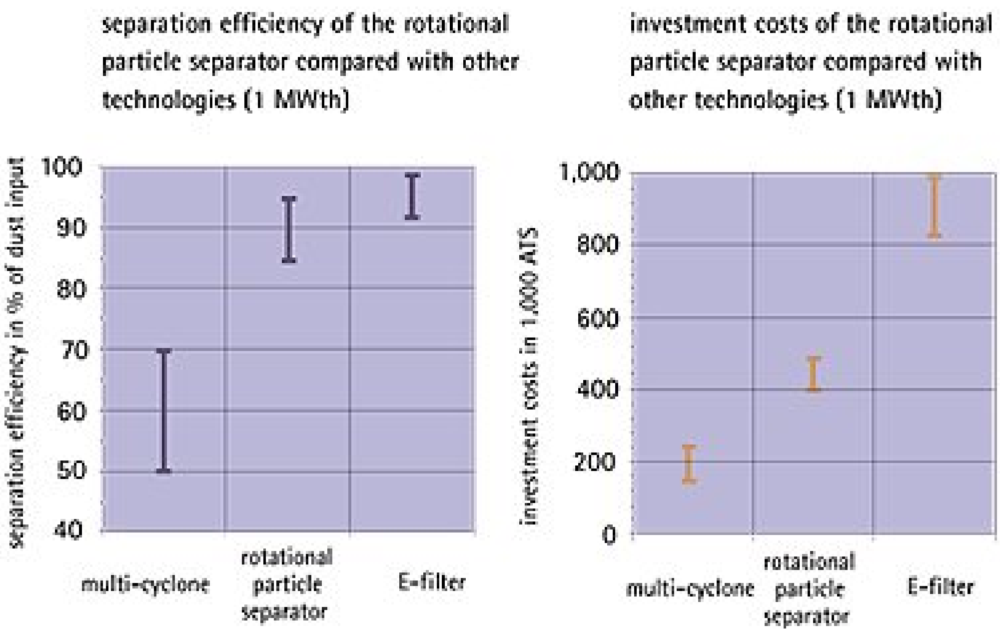


Source: Energy from Biomass – R&D in Austria (Ministry of Science and Transport)

As the diagram shows it is almost as effective as an electric precipitator but significantly cheaper. The RPS consists of three main parts:

- a static body which is designed like a cyclone,
- a filter element rotating around a vertical axis and
- a cleaning system to remove the precipitated particles from the walls of the filter element.

Fig. 9: Separation efficiency and investment costs of different technologies

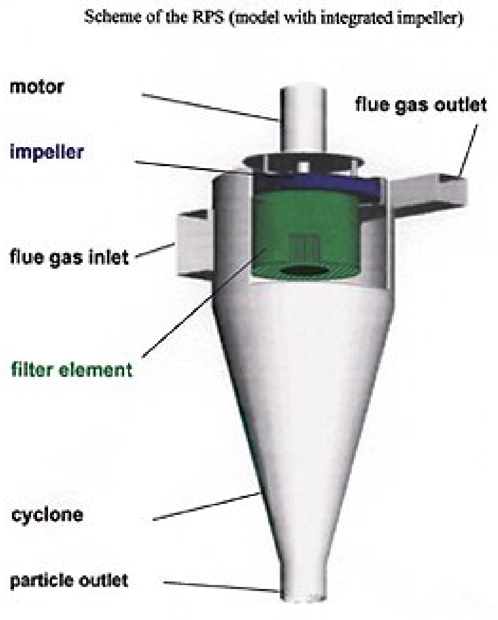


Source: Energy from Biomass – R&D in Austria (Ministry of Science and Transport)

The RPS can be equipped with an impeller fixed at the top of the filter element that covers the pressure drop of the RPS and the boiler so no additional draught fan is necessary. The core of the RPS is the filter element which consists of many small parallel channels with a diameter of about 1.5 mm, rotating as one body around a common axis.

The flue gas is pre-cleaned by the cyclone, enters the filter element from the bottom and flows through the channels in axial direction to the top. As a result of centrifugal forces particles are moved in radial direction towards the walls of the filter channels and are precipitated there. The dust collected and agglomerated on the channel walls is removed periodically by injecting pressurised air at high velocity in reverse flow direction into the channels. This is done by a nozzle moving over the rotating filter element at periodic intervals without disturbing the operation of the RPS. Test runs with a pilot RPS have shown that, due to agglomeration effects of aerosols in the RPS, the precipitation efficiencies reached for particles smaller than 1.0 µm are even better than expected according to calculations. Numerous dust emission measurements were performed during test runs in 1997. The results show that the dust emissions of the plant could be reduced from 120-300mg/m^3 (with multi-cyclone only) to 40-50 mg/m^3 (dry flue gas, 13.0 percent by volume O2).

Fig. 10: Scheme of a rotating particle separator (RPS)



Source: Energy from Biomass – R&D in Austria (Ministry of Science and Transport)

As the pressure drop of a RPS is similar to that of a multi-cyclone the operating costs are comparable and about equal to those of electrostatic filters. A further advantage of the RPS is its low space demand which is equal to a multi-cyclone but significantly lower than the space needed for electrostatic or fibrous filters. Taking these cost factors and the dust precipitation efficiency of the RPS into consideration, the economic as well as ecological advantages of RPS are considerable. (Contact: BIOS)

7.3 Reduction of NO_x-emissions

Due to the nitrogen content of the fuel, biomass boilers have relatively high NO_x emissions, particularly if wastes such as e.g. particle board residues are burned. Austria is involved in international research activities to bring down NO_x emissions, with a focus on primary measures, i.e. by optimising combustion parameters. Especially for fuels with high N content NO_x reductions by primary measures of up to 50% were possible. (Contacts: Joanneum Research; BIOS; Technical University of Vienna)

7.4 Active flue gas condensation with a resorption heat pump

Due to the high water content of bark and woodchips from sawmill industry (typically between 30% and 50%) significant amounts of energy are used for the evaporation of water and lost through the chimney. Flue gas condensation units which are installed in a number of Austrian district heating plants, allow to recover this energy by cooling down flue gases to the point of condensation of the evaporated water. In practice however, the temperature of the water returning from the district heating system is not low enough, to take advantage of this considerable amount of energy.

A new concept for a resorption heat pump with a mechanical compressor has been developed which should allow to recover 6-10 times more energy, than it needs for operation. The power output of such a unit could reach 50-90% of the boiler power, as shown in the graph. This would reduce both fuel costs and boiler costs due to the lower boiler power requirement. The compressor of the heat pump could be powered by a Stirling engine, described in the section on electricity production from biomass. The realisation of a pilot plant is under preparation. (Contact: Joanneum Research).

7.5 State of the art straw combustion

Straw is a large biomass resource which is yet hardly exploited. One of the reasons for the limited use of straw as an energy carrier, are its difficult properties for combustion, particularly the low ash melting temperature. Another problem is straw feeding. The milling of straw for combustion requires a lot of energy and rather robust milling equipment. In Austria a new type of straw boiler for the requirements of small district heating plants was developed.

Advanced control technology and special construction features allow highly reliable straw combustion at extremely low emissions (20mg CO/Nm^3). (Contact: Kohlbach Inc.).

7.6 Technologies for enhanced fuel management and boiler efficiency

A continuous process of technical improvement is accompanying the diffusion of biomass district heating. Among the critical elements of biomass use is the mechanical management of the fuel transport to the boiler. A decade´s experience was necessary to develop fully reliable feeding technology. The most recent innovation serves to remove the need to fill the temporary storage by a tractor or caterpillar. A "Walking Floor" allows to empty the whole contents of the fuel storage barn automatically. (Contact: Mawera).

For the operator of a district heating plant fuel humidity is a critical parameter as it determines the usable energy content of the fuel (unless a flue gas condensation unit is installed). Research has led to a fast, simple, reliable and precise device for fuel humidity. (Contact: Pandis)

8 TECHNOLOGIES FOR ELECTRICITY PRODUCTION WITH BIOMASS

At present electricity production from biomass in Austria is only realised in the pulp and paper industry and in a few large plants of the woodworking industry. Technologies used typically are fluidised bed boilers and conventional steam turbines. In July 1998 a legal requirement was issued, obliging utilities to provide 3% of electricity from renewable resources (not including hydropower or electricity production from black liquor) by 2005. This requirement will increase attention paid to technologies for producing electricity from biomass considerably. The most promising Austrian research projects regarding electricity production deal with co-combustion of biomass in conventional power plants, gasification technologies and Stirling engines. A number of pilot projects are realised or planned.

8.1 Co-combuistion of biomass in conventional power plants

Austrian utilities have realised two projects testing the possibilities of the co-combustion of biomass in pulverised coal power plants. In the plant at St. Andrä a biomass grate was installed at the base of an existing coal boiler, allowing a 10 MWth power contribution from biomass combustion. Due to lack of space, the contribution of biomass cannot be extended however. The project at Zeltweg solves this problem by gasifying the biomass in an external fluidised bed gasifier and feeding the gas directly into the boiler. There are a number of advantages to this strategy: the biomass need not be completely gasified as small char particles in the product gas can also be burned in the coal boiler. Consequently the Circulating Fluidized Bed reactor can be much smaller than for complete gasification which requires longer residence times. There is no need for predrying of biomass or for gas cleaning as the gas is burned under optimal conditions in the coal burner. The product gas can be used as reducing gas in the reburning zone and could reduce or avoid other measures to lower NOx emissions. Finally, gasification allows to simply add a module to existing or newly planned large power plants which is sized according to local biomass availability and allows conversion at the high efficiency and low operation costs of large scale plants. (Contact: Österreichische Draukraftwerke AG)

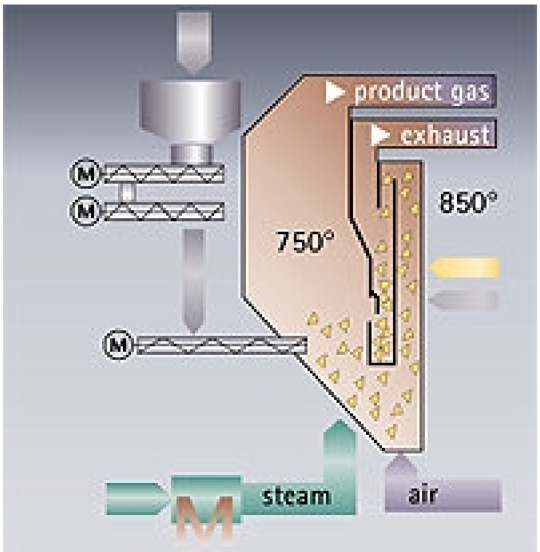
8.2 Gasification in a solid bed reactor and CHP gas motor

Experiments with gasification in a solid bed reactor for heat and power production in a gas motor are conducted at the Technical University of Graz. Gas from a two zone solid bed gasifier (250kWth) is cleaned and cooled in a washer and used in a gas engine. Gasification promises the realisation of cheaper and more effective CHP plants in the low power range typical for many biomass district heating plants. The experiments are designed to clarify the technical feasibility of long term operation of a gas motor with a solid bed gasifier. A pilot project based on a solid bed gasifier with sawdust filters for gas cleaning was set up in 1997 by a farmer in Styria. (Contact: University of Technology Graz, ÖAR)

8.3 Gasification of biomass with steam in a novel fluedised bed system

Usually gasification of biomass is carried out in fixed or fluidized bed reactors with air as gasification agent. In this case the product gas has a low calorific value (around 4-6MJ/m^3) and a high nitrogen content.

Fig. 11: Scheme of a Gasification of biomass with steam in a novel fluedised bed system



Source: Energy from Biomass – R&D in Austria (Ministry of Science and Transport)

A novel fast internally circulating fluidized bed gasifier (FICFB) developed in a cooperation by the Vienna Technical University and Austrian Energy and Environment Inc. yields a high calorific gas with up to 15 MJ/m^3 and very low nitrogen (<3%) and tar content (<0,8g/m^3).

The gasification process is based on an internally circulating fluidised bed system and consists of a gasification zone fluidized with steam and a combustion zone fluidized with air. In the combustion zone char is burned and produces the heat necessary for gasification. The circulating bed material acts as a heat carrier from the combustion to the gasification zone. Gas mixing between these zones is avoided by construction measures so the flue gas from combustion is not mixed with the product gas. The resulting high quality of the product gas can be further enhanced with catalytic bed material. Olivine has proved highly efficient for this purpose.

After two years of successfully operating a 100 kWth laboratory unit a 4 MWth gasifier and a gas engine will be integrated into an existing district heating system and deliver heat and electric power. In an international pilot project catalysts will be used to achieve up to 55% hydrogen content in the product gas which could subsequently be used in a fuel cell for electricity production. (Contact: Technical University of Vienna, AE Energietechnik).

8.4 State of the art gas engines for CHP

Jenbacher Energiesysteme Ltd. has developed gas engines which can utilise an unmatched range of different gases such as biogas, pyrolysis gas and almost any other combustible gas. The heating value of gases that can be turned into electricity at an efficiency of up to 40% lies between 0.5 kWh/m^3 and 34 kWh/m^3. Jenbacher systems apply combustion technologies which have been patented world-wide and achieve guaranteed emission levels below 250 mg/m^3 of NOx and below 300 mg/m^3 of CO when operated with natural gas. The overall energy efficiency of the systems is as high as 88%. (Contact: Jenbacher Energiesysteme)

Fig. 12: Gas engines

Source: Jenbacher Energiesysteme

8.5 Stirling Engine

The Stirling engine is another promising concept for small scale heat and power production. Its advantages are low operation cost, simple design and relatively high efficiency (approx.25%). A 3 kW alpha type Stirling model was constructed and successfully tested. The advantage of this Stirling type is that it can be constructed with standard industrial parts, in this case a Ducati 500cm^3 motor cycle cankcase. The heat exchanger, a bundle of polished metal pipes, is placed into the hot stream of exhaust gas. There is no necessity for hot gas cleaning. Stirling engines in district heating plants could be used primarily for electricity production for plant operation. A Stirling engine could also be used to power the compressor of a flue gas condensation heat pump.

At present Joanneum Research is developing a small Stirling engine CHP production plant with an electric output of 30-100 kW that meets the criteria for series production. (Contact: Joanneum Research)

Fig. 13: Stirling Engine

Sources:

This text is based on the following sources in particular:

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- Moderne Holzheizungen: Neue Technologien – neue Marktchancen!, LEV Landes-energieverein Steiermark (German language)

9 ADDRESSES AND CONTACTS:

Research Institutions:

Bundesanstalt für Landtechnik/ Federal Institute of Agricultural Engineering
DI Manfred Wörgetter
Rottenhauserstr. 1
A-3250 Wieselburg
Tel. +43 7416 52175
Fax +43 7416 52175 45
http://www.blt.bmlf.gv.at
Emission measurement, RME testing and standardisation

Energieverwertungsagentur
Dr.Christian Rakos
Linke Wienzeile 18
A-1060 Wien
Tel. +43 1 586 1524
Fax +43 1 569 488
http://www.eva.wsr.ac.at
biomass R&D policies, research in nontechnical barriers and biomass diffusion strategies

Institut für Grundlagen der und Verfahrenstechnik und Anlagentechnik
University of Technology Graz
Univ.Doz. DI Dr. Ingwald Obernberger
Ao.Univ.Prof. DI Dr. Michael Narodoslawsky
Inffeldgasse 25
A-8010 Graz
Tel. +43 316 873 7464
Fax +43 316 873 7469
http://vt.tu-graz.ac.at/
fractionated heavy metal deposition, NOx reduction, concepts of closed cycle economy

Institut für Land-, Umwelt- und Energietechnik, Universität für Bodenkultur/
Institute of Agricultural, Environmental and Energy Engineering, University of Agriculture
o.Univ.Prof.Dr.phil. Johann Fischer
Nußdorfer Lände 29-31
A-1190 Wien
Tel. +43 1 318 98 77 DW 53
http://www.boku.ac.at/iluet/tt/tt.htm
Technology and emissions of straw and wood combustion

Institut für Verfahrens-, Brennstoff- und Umwelttechnik, Technische Universität Wien/
Institute of Chemical Engineering, Fuel Technology and Environmental Technology
Technical University of Vienna

Getreidemarkt 9/159
A-1060 Wien
Tel. + 43 1 58801 4728
Fax + 43 1 587 63 94
http://edv1.vt.tuwien.ac.at
Univ.Prof. DI Dr. Hermann Hofbauer Tel. DW 15970:
gasification, technology and chemistry of wood combustion, tiled stoves
Dr. Richard Gapes: ABE fermentation, economics of biomass utilisation processes

Institut für Wärmetechnik, Technische Universität Graz/
Institute for Thermal Engineering, University of Technology Graz
o.Univ.Prof. DI Dr. Beate Reetz
Inffeldgasse 25
A-8010 Graz
Tel. +43 316 873 7300
Fax + 43 316 873 7305
http://wt.tu-graz.ac.at/

Joanneum Research, Institut für Energieforschung/
Joanneum Research, Institute of Energy Research
Dr. Josef Spitzer
Elisabethstr. 11
A-8010 Graz
Tel. + 43 316 876 1338
Fax + 43 3168 761 320
http://www.joanneum.ac.at
Biomass combustion, Stirling engine, CO2 modelling of biomass use, NOx emissions

Ökologieinstitut / Austrian Institute for Applied Ecology
Mag. Susanne Geißler
Seidengasse 13
A-1070 Wien
Tel. +43 1 523 61 05
Fax +43 1 523 58 43
http://www.ecology.at
Strategies for sustainable biomass use

Österreichisches Forschungszentrum Seibersdorf, Hauptabteilung Umweltplanung/
Austrian Research Centre Seibersdorf, Environmental Planning
Dr. Markus Knoflacher
A-2444 Seibersdorf
Tel. +43 2254 780 3874
Fax +43 2254 74060
http://www.arcs.ac.at
Energy balances of different biomass utilisation concepts, economic and ecological evaluation of energy systems

Österreichische Vereinigung für Agrarwissenschaftliche Forschung/
Austrian Association for Agricultural Research
Kleine Sperlgasse 1

A-1020 Wien
Tel. +43 1 214 5903 10
Fax +43 1 214 5903 9
http://www.netway.at/oevaf
Biomass policies, concepts for sustainable regional development

Biomass Combustions plants in the MW range:

Babcock Borsig Power - AE Energietechnik
Siemensstr. 89
A-1211 Wien
Tel. +43 1 25045 4259
Fax +43 1 25045 133
http://www.aee.vatech.co.at

Ing. Ernst Kurri
Illnergasse 23-29
A-2700 Wiener Neustadt
Tel. +43 262223865
Fax +43 2622 23865 15

Kohlbach GmbH & Co
Mag. Walter Kohlbach
Grazer Str. 26-28
A-9400 Wolfsberg
Tel. +43 4352 2157-0
Fax +43 4352 2157-11
e-mail: kohlbach.wolfsberg@net4you.co.at

MAWERA Holzfeuerungsanlagen GmbH & CoKG
Alfred Steurer
Neulandstr. 30
A-6971 Hard/Bodensee
Tel. +43 5574 74301
Fax +43 5574 74301-20
mawera.vk@vlbg.at

Österreichische Draukraftwerke AG
DI J. Tauschitz
Kohldorferstr. 98
A-9020 Klagenfurt
Tel. +43 463 202-0
Fax +43 463 25259
tauschitzj@verbund.co.at

Pandis GmbH
Liebenauer Hauptsr. 154
A-8041 Graz
Tel. +43 316 482848
Fax +43 316 482848-14

e-mail : pandis@ping.at

Polytechnik GmbH & CoKG
Luft- und Feuerungstechnik
Thomas Hofmann
Fahrafeld 69
A-2562 Weissenbach
Tel. +43 2672 890-0
Fax +43 2672 890-13
polytechnik@xpoint.at

Sonnenkraft GesmbH
Dr. Herbert Huemer
Im Mühltal
A-4655 Vorchdorf
Tel. +43 7614 6006
Fax +43 7614 6006-17
http://www.sonnenkraft.com

S.o.l.i.d. GesmbH
Dr. Christian Holter
Elisabethstr. 32
A-8010 Graz
Tel. +43 316 386992
Fax +43 316 3845877
e-mail: uno@sbox.tu-graz.ac.at

URBAS Maschinenfabrik GmbH
Mag. Josef Urbas
Th.-Billrothstr. 7
A-9100 Völkermarkt
Tel. +43 4232 2521
Fax +43 4232 2521-55
urbas@happynet.at

Biomass boilers and stoves for domestic heating :

Anton Eder GmbH
Disponent Rudolf Sausguber
Leiten 42
A-5733 Bramberg
Tel. +43 6566 7366
Fax +43 6566 8127
eder.kesselbau@magnet.at

Biogen GesmbH
Ing. Günther List
Plainburgerstr. 503
A-5084 Großgmain

Tel. +43 6247 7121
Fax +43 6247 8795

Compact Heiz- und Energiesysteme
Volkmar Schunn
Energiesysteme GesmbH
Koaserbauerstr. 16
A-4810 Gmunden
Tel. +43 7612 73760 oder 77577-0
Fax +43 7612 73760-17
Email: compact@ooe.net

Fröling Heizkessel- und Behälterbau GmbH
Ing. Gerhard Schöfberger
Industriestr. 12
A-4710 Grieskirchen
Tel. +43 7248 606
Fax +43 7248 62387
http://www.froeling.com

Hager Energietechnik GmbH
Reinhard Hager
Laaer Str. 110
A-2170 Poysdorf
Tel. +43 2552 2110-0
Fax +43 2552 2110-6

Hargassner GmbH
Hr. Hargassner
Gunderding 8
A-4952 Weng
Tel. +43 7723 5274
Fax +43 7723 5274-5

Herz-Feuerungstechnik GmbH
Bruno Ganster
Sebersdorf 138
A-8272 Sebersdorf
Tel. +43 3333 2411
Fax +43 3333 241673
office@herz.feuerung.com

Hoval GmbH
DI Herbert Geyerhofer
Hovalstr. 11
A-4614 Marchtrenk
Tel. +43 7243 550-0
Fax +43 7243 550-15

Köb & Schäfer KG
Herr Böhler
Flotzbachstr. 33
A-6922 Wolfurt
Tel. +43 5574 6770-0
Fax +43 5574 65707
boehler@koeb-schaefer.com

KWB Kraft und Wärme aus Biomasse GmbH
Erwin Stubenschrott
A-8321 St. Margarethen/Raab
Tel. +43 3115 6116-0
Fax +43 3115 6116-4
Email: office@kwb.at
www.kwb.at

Ökofen Forschungs- und Entwicklungs GmbH
Ing. Herbert Ortner
Mühlgasse 9
A-4132 Lembach
Tel. +43 7286 7450
Fax +43 7286 7450-10

Perhofer Bio-Heizungs-GmbH & CoKG
Manfred Salmhofer
Waisenegg 115
A-8190 Birkfeld
Tel. +43 3174 3705
Fax +43 3174 3705-8
biomat-perhofer@hild.at

Rendl Heizkessel & Stahlbau GmbH
Prok. DI H. Hartl
Siezenheimer Str. 31
A-5020 Salzburg
Tel. +43 662 433034-0
Fax +43 662 433034-39

RIKA MetallwarengesmbH & CoKG
Peter Hellinger
Müllerviertel 20
A-4563 Micheldorf
Tel. +43 7582 686
Fax +43 7582 686-43 oder 23
rika.austria@aon.at

Sommerauer & Lindner Heizanlagen
SL-Technik GmbH
Herr Sommerauer
Trimmelkam 113

A-5120 St. Pantaleon
Tel. +43 6277 7804
Fax +43 6277 7818
sl-heizung@eunet.at

Windhager Zentralheizung AG
Ing. Martin Klinger
Anton Windhager Str. 20
A-5021 Seekirchen
Tel. + 43 6212 2341-0
Fax + 43 6212 4228
kli@windhager-ag.at

Thermostrom Energietechnik GmbH
Fr. Dr. Boskovsky
Ennsstr. 91
A-4407 Steyr
Tel. + 43 7252 38271
Fax + 43 7252 38273-25

Kachelofenverband/Association of tiled stove producers
DI Schiffert
Technical development Laboratory
Dassanowskyweg 8
A-1220 Wien
Tel. + 43 1 256 588 50
Fax + 43 1 256 588 520
E-mail: schiffert@server.oekv.co.at

Consultants:

Agrar Plus Projektmanagement für die Landwirtschaft
Julius Raab-Promenade 1
A-3100 St. Pölten
Tel. +43 2742 352 234-0
agrar.plus@aon.at

Arbeitsgemeinschaft ERNEUERBARE ENERGIE
Feldgasse 19
A-8200 Gleisdorf
Tel. +43 3112 5886 0
http://www.datenwerk.at/arge_ee

BIOS
Sandgasse 47
A-8010 Graz
Tel. +43 316 48 13 00
Fax +43 316 48 13 004
e-mail: obernberger@glvt.tu-graz.ac.at
http://www.bios-bioenergy.at

KWI
Schulgasse 4
A-3100 St. Pölten
Tel. +43 2742 3500
Fax +43 2742 35066
Email : kwibox@kwi.at
http://www.kwi.at

iC interdisciplinäre Consulenten
DI Mario Ortner
Kaiserstraße 45
1070 Wien
Tel. 01/521 69-0
Fax. 01/521 69-15
Email: m.ortner@ic-vienna.at
http://www.ic-vienna.at

Bundesländeragenturen :

Energie Tirol
Adamgasse 4
A-6020 Innsbruck
Tel. +43 512 58 99 13
Fax +43 512 58 99 13 30
office@energie-tirol.at
http://www.tirol.com/energie-tirol

Energieinstitut Vorarlberg
Stadtstraße 33/CCD
A-6850 Dornbirn
Tel. +43 5572 31202-0
Fax +43 5572 31202-4
http://www.vol.at/energieinstitut

Landesenergieverein Steiermark
Gerhard Ulz
Burggasse 9/II
A-8010 Graz
Tel. +43 316 877 3389
Fax +43 316 877 3391
e-mail : landesenergieverein@mail.styria.com

Energiebeauftragter des Landes Steiermark
Dipl. Ing. Wolfgang Jilek
Burggasse 9/II
A-8010 Graz
Tel. +43 316 877 4555
Fax +43 316 877 4559
wolfgang.jilek@stmk.gv.at

OÖ Energiesparverband
Dipl.Ing. Dr. Gerhard Dell
(Energietechnologieprogramm Oberöstereich)
Landstraße 45
A-4020 Linz
Tel. +43 732 6584 4380
Fax: +43 732 6584 4383
esv1@esv.or.at
http://www.esv.or.at/esv/

Regionalenergie Steiermark
Ing. Herbert Lammer
Florianigasse 9
A-8160 Weiz
03172/30321,
regionalenergie@styria.com
http://www.regionalenergie.at

Interest organizations:

Bioenergy Austria
Postfach 208
A-1010 Wien
Tel. +43 1 470 12 25
Fax. +43 1 478 17 12
http://www.bioenergy.at

Österreichischer Biomasseverband/
Austrian Biomass Association
Dr. Heinz Kopetz
Franz Josefs Kai 13
A-1010 Wien
Tel. +43 1 533 0797
schmidl@oekosoziales-forum.at

Pelletsverband Austria
Schönbergstr. 21b
A-4616 Weißkirchen
Tel. 07243/60004
e-mail: pva@magnet.at
http://www.pelletsverband.at/

Wirtschaftskammer Österreich/
Federal Chamber of Commerce
Wiedner Hauptatr. 63
A-1045 Wien
Tel. +43 1 501 05 0
Fax +43 1 501 05 260
http://www.wk.or.at/

Funding Institutions:

FFF Forschungsförderungsfonds / Austrian Industrial Research Promotion Fund
DI Doris Pollak
Kärntnerstr. 21-23
A-1010 Wien
Tel. +43 1 512 4584
Fax +43 1 512 4584-41
mailbox@fff.co.at
http://www.fff.co.at

FWF Fonds zur Förderung der wissenschaftlichen ForschungAustrian Science Fund
Dr. Gabriele Fernandes
Weyringerstr. 35
A-1040 Wien
Tel. +43 1 505 67 39
Fax +43 1 505 67 40-86
http://www.fwf.ac.at

Contact for research co-operation:

BIT / Bureau for International Research and Technology Cooperation
Wiedner Hauptstr. 76
A-1045 Wien
Tel. +43 1 581 16 16-0
Fax +43 1 581 16 16-16
http://www.bit.ac.at/bit

Coordination and research policy:

BMVIT - Bundesministerium für Verkehr, Innovation und Technologie
Abteilung für Energie- und Umwelttechnologien
DI Michael Paula
DI Brigitte Weiß
Rosengasse 4
A-1014 Wien
Tel. +43 1 531 20-0
Fax +43 1 531 20-6480
http://www.bmwf.gv.at