Martina Schaffenberger
Petr Stastny

Overview of biomass technologies and their assessment

Seminar paper

Interdisciplinary Bilateral Winter and Summer School on
Energy Innovations in Austria and the Czech Republic 2008

<u>Research question:</u>

What are the potentials of biomass and the different technologies using biomass in the Czech Republic and Austria? - A comparison of the two countries.

Table of content

Introduction

Every day there are again news on energy corresponding issues on TV or in newspapers, for example the oil-price reaches a new maximum or natural distasters are more common all over the world. So fast action is necessary. Biomass is an oppurtunity for supporting new ways of producing energy especially in Middle Europe. Additionally biomass and producing energy with biomass provides new possibilities for agriculture and forestry. For example fallow land could be reactivated and farmers have new sources of income. Therefore our paper deals with technologies using biomass and provides an short assessment of some of these technologies refering to Czech Republic and Austria. In a further step we are going to compare the potentials of biomass technologies in Austria and Czech Republic.

1. Situation in Austria

1.1 What is biomass?

According to ÖNORM M 7101 biomass in Austria is understand as organic, non-fossil material, which comprises every living and growing substance in nature and their waste materials.[1]

Generally biomass is chemically bonded energy from the sun introduced by photosynthesis. Due to this fact using biomass to supply energy is CO_2-neutral and therefore technologies using biomass are part of regenerative energy sources. They can be used for manufacturing heat, fuels and electricity.[2] The following table (Table 1) provides a short overview on different kinds of biomass and the possibilities of application.

---

[1] www.biomasseverband.at

[2] www.biomasseverband.at

<table>
<tr><th colspan="3">Biomass for
energetic purposes</th><th>Biomass for
non-energetic purposes</th></tr>
<tr><td>s o l i d</td><td>l i q u i d</td><td>g a s e o u s</td><td rowspan="4">• biorefining</td></tr>
<tr><td>• piece of wood
• woodchips
• pellets
• old wood
• straw</td><td>• energy plants
• crops
• sugar cane
• solid biomass</td><td>• pyrolysis
• org. material</td></tr>
<tr><td>o u t p u t s :</td><td>o u t p u t s :</td><td>o u t p u t s :</td></tr>
<tr><td>• heat
• electricity</td><td>• energy for mobility</td><td>• electricity
• heat</td></tr>
</table>

Table 1: Overview on biomass and applications[3]

1.2 How and in which mode can biomass be used?

Wood

The most important and maybe oldest way of using biomass is wood. For more than 400.000 years wood has been taken by humanity to produce heat. Over the years wood has lost its importance due to the fact that oil and natural gas become more and more common. Furthermore people prefered them because of more comfort in heating. But technologies in using wood have been improved nowadays and due to the raising oil price heating with wood has had a great revival.[4]

Heating with wood

Generally the use of biomass for heating purposes needs some special requirements to the material, because the quality of biomass differs. Consequently its physical and chemical properties, which are influencing the combustion process, are different too. For instance it is very important to take untreated raw material to avoid emissions of toxic components. Other basic characters are the partikel size, the shape and the density of the fuels. These are basic parameters for transport, storage and process engeneering. Further fundamentally characteristic figures are calorific values and

---

[3] Haas R., Kranzl L., Bioenergie und Gesamtwirtschaft

[4] Marutzky R., Seeger K., Energie aus Holz und anderer Biomasse

water contents of biomass products, which are shown in Table 1 for some kinds of biomass. These mentioned parameters are influencing the energy density, the process and temperature of combustion. All in all there are many different points which have to be taken in consideration.[5]

Heating material	water content [mass % of raw material]	calorific value [kWh/ kg dry substance]	heating value [kWh/kg raw material]	bulk density [kg raw material/m³]	energy density [kWh/m³]
wood pellets	10,0	5,5	4,6	600	2756
wood chips hardwood dry	30,0	5,5	3,4	320	1094
wood chips hardwood	50,0	5,5	2,2	450	1009
wood chips softwood dry	30,0	5,5	4,4	250	855
wood chips softwood	50,0	5,5	2,2	350	785
hay	18,0	5,1	3,8	200	750
saw mill waste	50,0	5,5	2,2	240	538
straw	15,0	5,2	4,0	120	482
fossil oil	0,0	12,7	11,9	860	10200

Table 2: Energy capicity of heating materials[6] (from Obernberger I., Nutzung fester Biomasse in Verbrennungsanlagen)

There is a great range of variety of wood products used for heating houses and buildings. Firstly there could be differences in the shape of wood, secondly it could differ where the primary product comes from and thirdly there could be disparities in the capacity of the heating plant (f.e. household heating system or community heating plant). In the next paragraph some possibilities of different sorts of wood are going to be discussed, because there are differences in transport, storage and combustion.

Piece of wood[7]

This description compromises piece of wood which are 25 to 50 cm long. Timber out of forests contents 35 (softwood) to 50 (hardwood) per cent water. So it is necessary

[5] Obernberger I., Nutzung fester Biomasse in Verbrennungsanlagen

[6] Obernberger I., Nutzung fester Biomasse in Verbrennungsanlagen

[7] Marutzky R., Seeger K., Energie aus Holz und anderer Biomasse

to dry the whole timber or the piece of wood one to two years to reduce the water content. For the combustion under 20 per cent water content are required. There are also some differences in the combustion of hard and soft wood, because of their unequal chemical composition.

Wood chips[8]

Wood chips are very small pieces of timber with lower quality. Mostly wastes from other work in forests or prepared through special treatment with machines. Wood chips have a higher water content than pieces of wood, but because the bulk density is also higher there are still better results. Furthermore this circumstance leads to better properties in transport and storage. In addition to that the handling of wood chips in combustion systems are much more easier than the handling with piece of wood. In Austria quality of wood chips are defined in a standard (ÖNORM M7133).

Wood pellets[9]

Wood pellets are made from saw mill waste under high pressure. Wood pellets for small combustion plants are without any binder. Due to the low water content, the high energy density and an easy handling combustion system, wood pellets can compensate the disadvantage of higher energy input in production. For this reason they are very popular in households and for some years now the acquisitation of pellets heatings has been growing.

Wastes from saw mill and industry, old wood or used wood[10]

On the one hand industry sectors and companies working with wood like saw mills, carpentries, the furniture industry, the building sector or the paper industry are dealing with problems of littering wood waste. On the other hand old wood from households (furniture, bulky waste) or wood from packacking has to be disposed too.

---

[8] Marutzky R., Seeger K., Energie aus Holz und anderer Biomasse

[9] Marutzky R., Seeger K., Energie aus Holz und anderer Biomasse

[10] Marutzky R., Seeger K., Energie aus Holz und anderer Biomasse

There is the possibility that some of these wastes can be used for producing heat to relieve landfills and to save wood resources. But it is necessary to take wood without any special treatment especially in small combustion systems. Due to the fact that varnishes or binder can cause toxic emission. So this contaminated wood should only be recycled in special plants.

Straw

Straw is a by-product resulting from the growing of commercial crops. According to Global 2000 Austrian farmers produce more than 2 million[11] tons of straw every year. In agriculture straw is mainly used for litter in stables, but especially in farms without animals there is a huge spill-over. Thus energy related purposes could be a way to consume this straw. For instance straw can be applied for insulation purposes in the building area or for producing energy. In particular in Denmark it is very common to take straw for running power plants.[12]

However, there are some problems using straw for heating. Firstly there are troubles with dust, secondly a huge amount of ash is built and thirdly high NO_x and halogen emissions are released, so special boilers are needed. Furthermore only large straw combustion plants are profitable, due to the fact that the input costs for straw combustions systems are higher than for systems using wood. The higher input costs are caused by the need of loading systems for pressed bales of straw, which are much larger than pieces of wood. Regarding CO_2-emissions the combustion of straw is CO_2-neutral, but the calorific value and the bulk density of straw is very low compared to other sorts of biomass as you can see in Table 2. Thus the high CO_2-emissions by the transport of straw should also be considered. An alternative provide straw pellets, which have an calorific value of 5000 kWH per ton.[13]

[11] Baumaterial Stroh, www.global2000.at

[12] Fenger, The use of straw as energy resource

[13] Heizen mit Stroh, www.thema-energie.de

Energy plants

In these paragraph we are discussing all other plants needed for energy production. It is not our target to discuss every single plant, but the proceeds or technologies the plants can be used for.

Biodiesel

Many plants or more in detail the seeds of these plants are taken to produce vegetable oil. In a further step biofuels are made from these oils. In particular the oils are mixed with sodium- or potassium hydroxide to get fett acid methyl or ethyl esters and glycerin. Due to this process the viscosity of the vegetable oils are decreasing and therefore it is possible to use the biodiesel for displacing fossil diesel. Examples for plants which can be used for biodiesel production are canola, palm trees, corn or other used vegetable oil.

Bioethanol[14]

In another process it is possible to manufactur bioethanol from plants like sugar cane and corn. To get bioethanol it is necessary to treat corn and crops within a hammer mill. Afterwards the wheat is put into a tank with mash, cooked and mixed with an enzyme. Additionally sugar sirupe is added continuously. In the fermentation step the enzyme is converting the starch into sugar and then the sugar is converted through yeast into ethanol under releasing CO_2. Furthermore it is necessary to seperate the alcohol from the mash. This seperation is made by destillation and some further cleaning step. Then it is possible to use the arising alcohol as fuel.

Assessment of biofuels (first generation)[15]

In the last few months biodiesel became more and more criticized. Firstly the life cycle analysis and combined CO_2-emission balance is not as good as maybe thought a few years ago. Generally the growing of such energy plants often needs much fertilizers and the harvest output is very small, because only some parts of the plant are used for further proceeds. Although people who claim for biodiesel argue that

[14] Doppler M., Treibstoffe aus Getreide und Zucker

[15] http://de.wikipedia.org

biofuels have a higher niveau of energy, because they provide energy for mobility. Therefore they say it is legitimate to have a higher energy input than output.

Secondly discussions around growing food prices give a bad impression on biofuels. That’s why many people think that areas for growing food are more important than areas for producing fuels, which is certainly a substantial argument. Nevertheless this is a problem of all ernergy related biomass products, which are competing with food production. Although there are many areas today which are fallow land, thus energy plant could be an instrument to reactivate them. Besides one idea of using biofuel was to provide feed for “animals” (tractors) on farms like in earlier times, when farmers have to grow food for their transport-animals like horses. But in our point of view there are too many “transport animals” nowadays. And to import energy plants due to a lack of resources in our countries is the wrong way to gain independence from abroad energy providers.

Additionally the reputation of biofuels has become worse regarding the problems with materials of engines in cars. These problems are caused by the different characteristics of biofuels, in particular biodiesel. For instance biodiesel has a higher water content and a higher steaming point. Due to the higher steaming point more biodiesel is accumulated in motor oil and is leading to pluggings in cylinders. So many people avert biofuels to protect their cars and to avoid expensive services. In our opinion these disadvantages could be solved through new technologies and materials in engines.

On the other hand the combustion of biodiesel releases less emissions, like NO_x or sulphuric components. Furthermore biodiesel is not as dangerous for water than fossil fuel and is bioagredable. Although this last mentioned characteristics also leads to a reduced durability of biofuels.

A further argument against biofuels could be the fact that the growing of biofuels could lead to monocultures and could danger other important parts of world’s nature like rain forests. According to reports on TV such problems already exist in Brazil, where growing sugar cane for bioethanol is very common.

Green Biorefinery[16]

Green Biorefinery represents a “multi-product”-system based on grassland utilization. Grass is the educt for many products, like proteins, lactic acid, fibres and biogas. Gaining this products requires the silage of grass. This means grass is treated by anaerobic fermentation in a silo and fermentation acids are generated. Thus the pH-value is low and the silage remains stable and can be stored. Due to this circumstance it is possible to produce uninterrupted further products. After the silage process the different fractions are seperated and supplied to the next passes and these products can be obtained:

- Lactic acid (from sugars), lactic acid ester and dilactid
- Proteins
- Xanthophylle (part of protein fraction)
- Fibres
- Energy (electricity and heat through biogasproduction)

The whole process is shown in the following diagramm (figure 1):

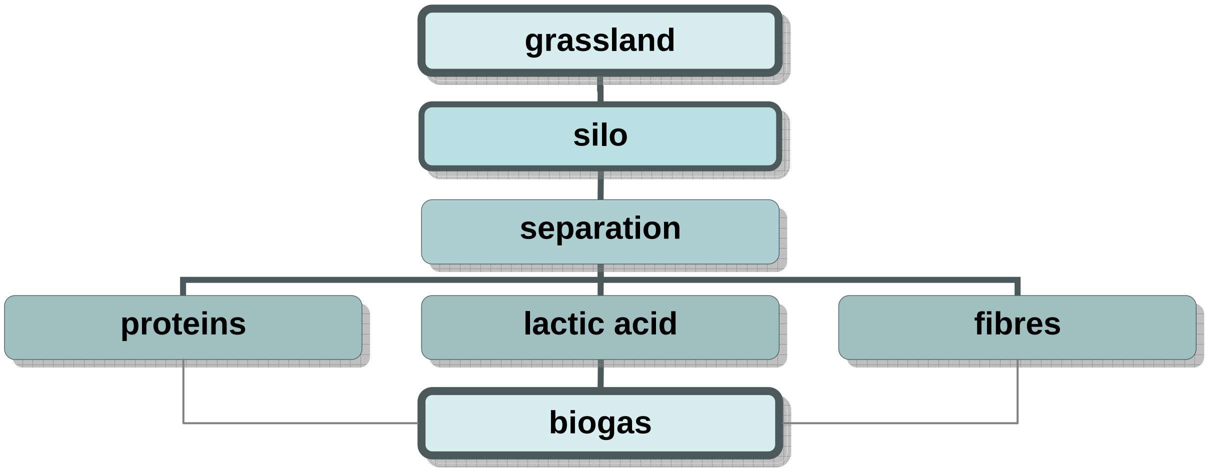


figure 1: biorefinery process[17]

[16] Kromus S., Narodoslawsky M., Krotscheck C., Grüne Bioraffinerie

[17] Kromus S., Narodoslawsky M., Krotscheck C., Grüne Bioraffinerie

The idea behind green biorefinery is to find a new way to gain similar products like in conventional refineries. This means to get educts for the chemical industry and the energy production sector. Biorefinery can achieve both requirements and some more. With the possibility to gain biogas from grass under anaerobic conditions and lactic acid. But all in all lactic acid is the key product for further applications and the most profitable product too, because it is an important educt for chemical, pharmaceutical and cosmetic manufactures. Therefore it is very important to receive a high yield in lactic acid. Nevertheless there are applications for the other fractions too. For instance the gained proteins can be used as fermentation promoter, feeding stuff, varnish or in the food industry. The fibres are applied for feeding stuff or insulation.

Comparing the process of green biorefinery with the assembly of biodiesel or bioethanol there are many advantages concerning green biorefinery. First of all biorefinery has the great property using whole plants and not only fruits or seeds, which are very small parts of a plant. Due to this fact the cost-benefit-equetation for biorefenery is better than for biodiesel or bioethanol in particular considering the various products made by biorefinery. Secondly facing the growing prices for food and therewith combined discussions on biofuels, biorefinery is a process which doesn’t work with food. Therefore it hardly can be criticized like biofuels. On the contrary in our point of view biorefinery forces the reactivation of fallow land, which isn’t used at the moment and supports the maintenance of cultural landscape.

Biogas

Biogas production is an fermentation of organic material or organic waste under anaerobic conditions. The main product is Methan, which is manufactured by bacteria. The arisen Methan can be used for combustion in a combined heat and power unit. Therefore it is possible to gain electricity and heat. Such kind of process is often used and it is called combined heat and power.

***Biomass gasification*[18]**

Another way to produce biogas is biomass gasification. Although this techonologie offers many further applications. For example the arising gas can be used for the synthesis of biofuels or chemical products, as reduction gas in steel industry or even the building of hydrogen could also be reached.

Very important for gasification of biomass is the choosen reaction gas. Generally there are two different ways. Firstly the use of air as gasification agent leads to an autothermal gasification. This means that the necessary energy amount for the reaction is provided by a partly combustion of the biomass itself. On the contrary the second process is an allothermal process, where the needed heat for gasification is offered indirectly. However, the choosen reaction conditions are responsable for the products. For instance an autothermal gasification with a mixture of O_2 and steam leads to less nitrogen and a high yield of hydrogen.

The biomass gasification can be combined with many further processes like Fischer-Tropsch-synthesis or the production of synthetic natural gas. The following diagramm (figure 2) shows some of the possible links.

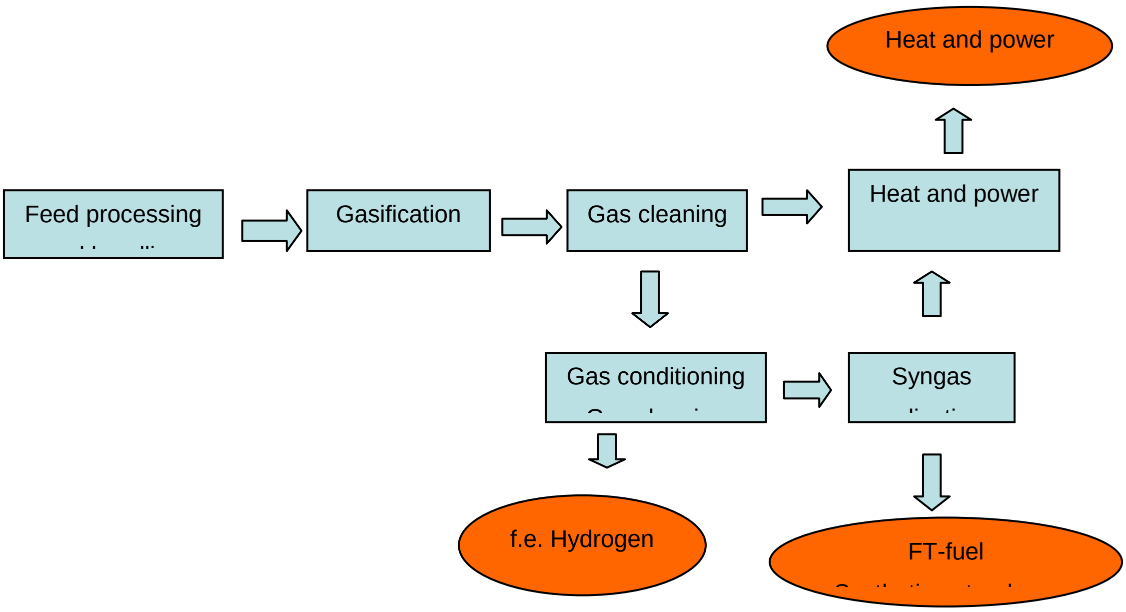


figure 2: gasification process combined with FT and SNG[19]

---

[18] Hofbauer H., Fischer Tropsch fuels and SNG

[19] Hofbauer H., Fischer Tropsch fuels and SNG

Fischer-Tropsch-Synthesis[20]

This application has been known since more than 80 years and for instance it was used in world war second to produce fuels from coal, thus fossil oil was rare. Nowadays the technology is also applied for manufacturing fuels from biomass raw material like timber or straw. Through this application product gas (CO/H_2) is changed into liquid alkans, alkenes or alcohols (equation x) supported by a catalyst based on iron or cobalt. The arisen carbohydrogens can substitute commercial fuels in cars or can be applied in further synthesis.

$$n\,CO + (2n+1)H_2 \Longrightarrow C_nH_{2n+2} + H_2O \text{ (Alkane)}$$
$$n\,CO + (2n)\,H_2 \Longrightarrow C_nH_{2n} + n\,H_2O \text{ (Alkene)}$$
$$n\,CO + (2n)\,H_2 \Longrightarrow C_nH_{2n+1}OH + (n-1)\,H_2O \text{ (Alkohole)}$$

Synthetic natural gas[21]

A further product of the gasification process could be synthetic natural gas, which includes the following steps:

$$CO\,(g) + 3\,H_2\,(g) \Longrightarrow CH_4\,(g) + H_2O\,(g)$$
$$CO + H_2O \Longrightarrow CO_2 + H_2$$
$$2\,CO \Longrightarrow CO_2 + H_2$$

The reaction is supported by a catalyst based on nickel. The arising product is mainly made of two components: Methan (47%) and CO_2 (40%). After a cleaning step the Methan can be used as fuel for cars or in combined heat and power units.

Regarding to the above mentioned technologies (biogas, gasification...) it generally has to be considered, that larger reactors always lead to higher efficiencies. Furthermore poly-generation of f. e. Fischer-Tropsch fuels and Synthetic natural gas

[20] Hofbauer H., Fischer Tropsch fuels and SNG
[21] Hofbauer H., Fischer Tropsch fuels and SNG

also increases the general efficiencies of the plant. Although yields of each product are decreasing in average due to general reaction parameters.

In our point of view the production of biogas is value contribute to energy independence and biogas production with organic waste or grass does hardly compete with food production. On the contrary organic waste can be used in a positiv way and afterwards it can be taken as fertilizers for agricultural purposes.
Gasification and resulting technologies like Fischer-Tropsch-Synthesis are still in development. But our researches show that reaction conditions nowadays provide higher efficiencies. Furthermore the fast increase of the oil price lead to a better ability of bio-technologies to compete with fossil fuels. A significant advantage of biomass to liquid fuels (BtL) is the possibility to influence the composition of the fuel. Additionally the emissions of BtL are free of aromates and sulphur and the NO_x- and partikel emissions are reduced in compensation to fossil fuels. Besides further abilities of BtL are also satisfying, because 1 L of BtL-fuel subsitutes 0,97 L of commercial diesel.[22]

1.3 Potentials and development in Austria

Wood

47 per cent of Austria’s area are forests. This means 3,3 Mio hectars in Austria are used for forestry. 72 per cent of the forests are owned by private persons, 16 per cent belong to the “Bundesforste” and 9 per cent are public area. The woods content 24 per cent hard wood and 67 per cent soft wood. Furthermore woods and forests have important functions in Austria. On the one hand they provide space for relaxing, nature and protection and on the other hand they have an important role in economy. In 2006 19 Mio solid cubic meters of wood were cut down, but nevertheless the whole amount of wood in Austria is growing by 31 Mio solid cubic meters every year. So forests provide the greatest source of energy for Austria. Therefore there was a trend back to wood combustion in Austria in the last years. For instance in 2006 15.200 automatic wood combustion plants were built. Between 1980 to 2006 98.109

[22] Steckbrief BtL, www.btl-platform.de

of these facilities from large scale plants to small scale plants were installed in Austria with an overall performance of nearly 7 Mio kW. Most of the small scale plants are pellests combustion systems, where it was seen the greatest increase.[23]

Straw

As we mentioned above straw is a by-product resulting from the growing of grops. In particular in the eastern federal states of Austria (Upper Austria, Lower Austria and Burgenland) we find a large amount of straw, which isn't further used in stables for animals. Thus this straw is a spill-over product and therefore using this straw in energy production would make sense. However, from another point of view too much other costs and problems, like investment costs for combustion units, would arise if straw is combusted at the moment.

Energy plants for fuels

As mentioned in the general assessment above the use of energy plants like canola is not the most efficient way to use biomass. This is also suitable regarding the situation in Austria. There is not enough area to grow enough plants to satisfy the need of energy for mobility in Austria and imports of energy plants from other countries would lead to a new dependence of our country. So biofuels, like biodiesel or bioethanol could contribute positively in some way, but they aren't the non-plus-ultra solution.

Raw material for Biorefining

According to estimates of the Bundesanstalt für Alpenländische Landwirtschaft (BAL)-Gumpenstein there is a huge potential of grass in Austria. The amount of grass are between 500.000 to 100.000 t dry mass per year. So grass could take the second place behind wood, which is the most important kind of biomass in Austria.[24]

---

[23] Forst, www.lebensministerium.at

[24] Kromus S., Narodoslawsky M., Krotscheck C., Grüne Bioraffinerie

Furthermore due to the great variety of products and ways of using grass will be an essential fragment in a renewable energy mix for Austria. However, biorefining could also make its contribute to our cultural landscape. Due to the fact that more and more farms are closed many grazing lands are unused. Therefore the use of grass for biorefining could reactivate fallow land and grazing land will be cut again. Additionally it could also provide new chances for farmers.

Raw material for biogas

In my point of view biogas production has wide potentials in Austria, because for biogas production many different types of raw material can be used. Besides the raw material can often be used in two steps. For instance firstly silage is used for gaining lactic acid and afterwards it can be involved in biogas production. Also waste from farms or organic waste from households can be used, which generates also a great potential of likely raw material. However, discussing all possible raw materials and their potentials would go beyond the scope of this paper. So summarizing we think biogas is a very important part of energy generation by biomass in Austria and its importance will increase in the next decades.

Raw material for gasification, Fischer-Tropsch-synthesis and SNG

Due to the fact that these technologies are using the same raw materials like wood heatings and biorefining, the potentials are quite the same. More precisely there occures a competition between these technologies in raw material.

1.4 Literature

- Marutzky R., Seeger K.; Energie aus Holz und anderer Biomasse, 1999, DWR-Verlag
- Obernberger I., Nutzung fester Biomasse in Verbrennungsanlagen, Schriftenreihe Themische Biomassenutzung, Band I, 4. Auflage, 2005
- Kromus S., Narodoslawsky M., Krotscheck C., Grüne Bioraffinerie, Schriftenreihe Nachhaltig Wirtschaften, 2002

Downloads:

- Was ist Biomasse? (www.biomasseverband.at, download am 05.05.2008)
- Haas R., Kranzl L., Bioenergie und Gesamtwirtschaft (www.nachhaltigwirtschaften.at, download am 16.05.2008)
- Baumaterial Stroh (www.global2000.at, download am 16.05.2008)
- Fenger, The use of straw as energy resource, Beitrag Mitteleuropäische Biomassekonferenz 2008 (www.biomasseverband.at, download am 07.04.2008)
- Heizen mit Stroh (www.thema-energie.de, download am 17.5.2008)
- Doppler M., Treibstoffe aus Getreide und Zucker, Beitrag Mitteleuropäische Biomassekonferenz 2008 (www.biomasseverband.at, download am 07.04.2008)
- Biotreibstoffe (http://de.wikipedia.org, download am 17.05.2008)
- Hofbauer H., Fischer Tropsch fuels and SNG, Beitrag Mitteleuropäische Biomassekonferenz 2008 (www.biomasseverband.at, download am 07.04.2008)
- Steckbrief BtL (www.btl-platform.de, download am 18.05.2008)

Forst (www.lebensministerium.at, download am 17.05.2008)

2. Situation in the Czech Republic

2.1 Biomass

Biomass is renewable organic materials, such as wood, agricultural crops or wastes, and municipal wastes. In contrary to fossil fuels, its usage has a minimal impact on the environment. Biomass sources are mainly wastes of agricultural and industrial activities, municipal wastes, or it is a result of production activities in agriculture and forestall activities.

Classification of types of biomass

Waste biomass

- **Vegetal wastes from agricultural production and country side maintenance**: corn straw and rape straw, cereal straw, hay, shrubbery wastes, wine fields, plantations, green fields and grass fields maintenance wastes
- **Wood wastes**: wood maintenance wastes, hardwood and softwood chips, roots, tree stumps,…
- **Industrial production organic wastes**: combustible wastes from wood industry (pellets, chips, bark), wastes from vegetal production facilities (i.e. sugar production), diary production wastes, slaughterhouse wastes, distillery wastes and so on
- **Animal production wastes**: yard dung, sewage, feed waste, etc.
- **Municipal organic wastes**: bilge water, solid municipal organic wastes

Biomass intentionally produced for energy production purposes:

- **Energy plants:** cereals, rape-colza, sunflower, flax, pumpkin, potatoes, corn, sugar cane
- **Fast growing tree species:** willow tree, poplar tree, alder tree, locust

Due to the big extension of field, which is used for agriculture and forest (87% from the whole area), the Czech Republic has very good conditions for the growth of energy plants. However, there is a lack of specialized machines needed for the cultivation of fast growing tree species. The purchase of the required technology would cause the price increase of the produced energy. Therefore, the focus in production of biomass plants in the Czech Republic is rather on so called energy plants. Growing of energy plants only requires common techniques, which are used during the classic plants cultivation, they have short vegetative period, they are easier to plant, and it is possible to process them for non-energetic purposes as well.

Amount of usable biomass in the Czech Republic

Biomass fuel type	**mil.tun**
Wood wastes	1.7
Rape straw, cereal straw	2.5
Fast growing tree species and energy plants	1
Municipal waste	1.5
Combustible waste from industrial production	1
Total	7.7

Area of agriculture fields in the Czech Republic

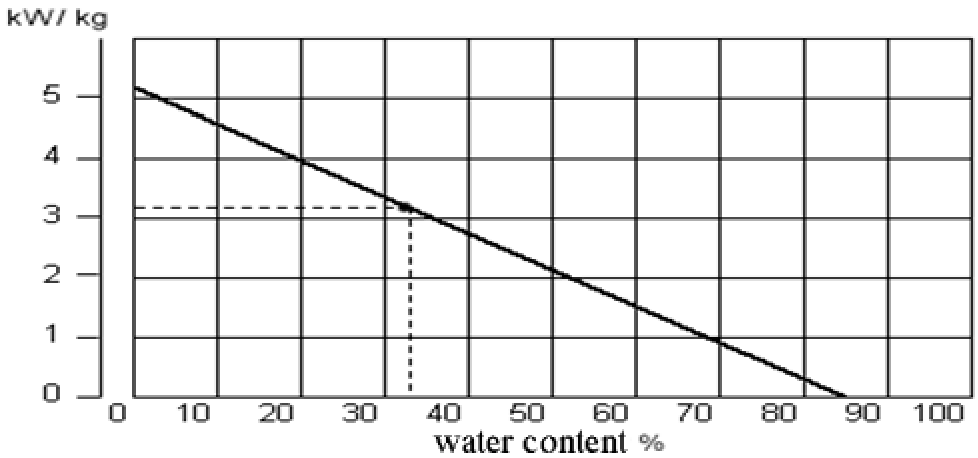
Area required for production of food plants	**Thousands of ha**
Arable land	2626
Grass field, pasture land	422
Culture in the agriculture field	75
Total	***3123***
Free fields for other purpose	
Arable land	465
Grass field, pasture land	523

2.2 Properties of the Biomass

Biomass as a fuel

The most important property of the biomass is its heating value. In other words it is the heat released by combustion of a unity amount of biomass fuel (assuming that the water produced during the combustion remains in gaseous state). Biomass fuel efficiency is influenced by the amount of combustible parts (organic part without water and ash matter, the mix of combustible hydrocarbons - cellulose, hemi-cellulose and lignin). This means then, that the heat value depends basically on the amount of water. Heating power of the dried biomass is between 15-19 MJ/kg. With increasing amount of resins or oils in biomass fuel, heat efficiency increases and inversely greatly falls with increasing contents of water.

Calorific value depends on percentage water content:



Type of combustible	Water amount (%)	Heat value (MJ/kg)	Density [kg/m3]
Wood chunk	10	16.41	375
Wood chunk	20	14.28	400
Wood chunk	30	12.18	425
Wood waste	10	16.4	170
Wood waste	20	14.28	190
Wood chips	30	12.18	210
Wood chips	40	10.10	225
Cereal straw	10	15.50	120
Corn straw	10	14.40	100
Flax straw	10	16.9	140
Rape straw	10	16.0	100

Heat value of the individual energy plants with variable contents of water

Type of the combustible	Water Contents[%}	Heat value [MJ/kg]	[kg/m3]= [kg/plm]	[kg/prm]	[kg/prms]
Broadleaf wood	15	14.605	678	475	278
Evergreens	15	15.584	486	340	199
Pine tree	20	18.4	517	362	212
Willow tree	20	16.9			
Alder tree	20	16.7			
Hornbeam	20	16.7			
Locus	20	16.3			
Oak tree	20	15.9	685	480	281
Fir tree	20	15.9			
Ash	20	15.7			
Beech	20	15.5	670	469	275
Spruce	20	15.3	455	319	187
Birch tree	20	15			
Larch	20	15			
Aspen	20	12.9			
Wood chips	30	12.18			210
Cereal strew	10	15.49		120	
Corn strew	10	14.40		100	
Flax strew	10	16.9		140	
Rape strew	10	16.00		100	

Units used in the table: **1 plm** = 1 m^3 wood without spaces
1 prm = 1 m^3 space metr wood chunk ~ 0,6 to 0,7 plm
1 prms = 1 m^3 wood sawdust particles ~ 0,4 plm

Type of the fuel	Heat value [MJ/kg]	MG/dm3	Density [kg/dm3]
Oil	43.97	32.53	0.74
Diesel fuel	42.5	36.97	0.87
Light furnace oil	42.5	36.97	0.87
Heavy furnace oil	41.45	39.36	0.95
Black coal	24	-	-
Brown coal	14.6	-	-
Firewood (20% H2O)	14.23	5.5	0.4
Cereal strew (10% H2O)	15.49	1.86	0.12

Another significant factor is the amount of ash matter, resp. its melting temperature. If the melting temperature is lower than the fire temperature during the combustion (i.e. strew or alfalfa combustion, ash melting temperature between 800-900C) the furnace grate is usually being sealed up. This can be prevented by adding the fuel with higher ash matter melting temperature.

Chemical elements in biomass

Biomass contains 40-50% of carbon, 4-6 % of hydrogen, up to 1% nitrogen and 3-40% of oxygen. The focus elements are, however, sulphur and chlorine. While the amount of sulphur in biomass is lower than in the case of other fuel, the amount of chlorine is slightly higher. This increased value means no danger for the environment. It is not necessary to fear the toxic hydrogen chloride produced during the combustion because it is released only in case of conversion of organically fixed chlorine.

The content of metals in biomass depends on the location of produced biomass. The amount of iron and light metals (calcium, magnesium, sodium, zinc) is considered significant factor.

Solid fuels with less than 15% of water content

Type of fuel	Amount of dry mass turning into gas	C[%]	O[%]	H[%]	N[%]	S[%]	Cl[%]
Strew	75-80	44	35	5	0.5	0.1	0.2
Wood	70-75	43	37	5	0.1	0	0
Wood coal	23-25	71	11	3	0.1	0	0
Brown coal	47-57	58	18	5	1.4	2	0
Black coal	24-28	73	5	4	1.4	1	0

2.3 How is the biomass processed and for which purposes it is used?

The form of the processing is deduced from biomass properties (water contents and dry mass). There exist 2 main principles for the obtaining the energy from biomass. These are thermo-chemical and biochemical transformation. Thermo-chemical transformation is based on combustion or gasifying and a biochemical transformation is then fermentation and anaerobic rot out. A special form of processing is the mechanic-chemical transformation.

Biomass processing posibilities

Thermo-chemical transformation	Pyrolysis (Gas, oil production)
	Gasifying (Gas production)
Bio-chemical transformation	Fermentation (ethanol production)
	Anaerobic rot out (production of biogas)
Mechanic-chemical transformation	Oil pressing (Oil, liquid fuel production)
	Raw bio-oil processing (biodiesel, oil products)
	Milling, crushing, pressing (solid fuels production)

Thermo-chemical transformation

During the combustion flammable gaseous components are being released, these components are in general called wood gas. The combustion with access of oxygen is called a simple combustion, in the opposite case the process is called gasifying. Released gas is transmitted to the other part of the combustion space and there the gas is combusted similarly like others gases. During this process small amount of CO2 is being released without any significant impact of the environment. This CO2 amount corresponds to the amount, which the original vegetal plant consumed during the growing period. Modern furnaces for biomass combustion work with great efficiency (80-90%), the combustion of biomass is therefore comparable to the combustion of natural gas.

Biomass in the form of wood chunks, wood fuel cakes, pellet, wood chips and strew is used as a fuel. Pellet is granule of 5 x 20 mm, made from pressed wood waste. Its advantage is possibility of usage in the supply bin for automatic fuel refilling. Variously shaped wood fuel cakes made also from pressed wood waste can be bought in bigger supermarkets.

Wood briquets and pellets:

Examples of instrumentality for producing heat:

automatical kettle working with split fuelwood

wood gasification kettle

fireside

pellets fireside

Biomass is used also in the production of vapor and then also electricity. Direct combustion can be used in the production of vapor – the power for steam turbine similar to those we can see in coal power plants. Even though this technology is very sophisticated and various input materials can be combusted, its disadvantage is that it requires large investment per unit of power, furthermore its efficiency is low and there is no further place for radical technological improvement.

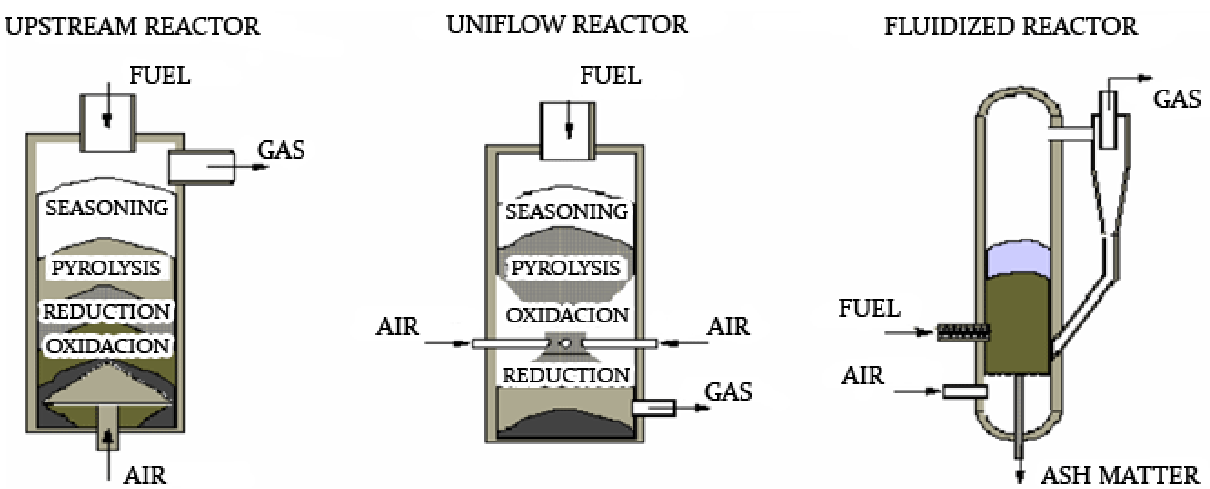
More efficient technology is gasifying. Using this method, some 65-70% of energy is converted into gas that is further combusted in the gas turbine similar to electric energy being produced in gas power plants. Cost of gas turbines are relatively low, moreover there is high potential in improving the gasifying technology itself.

Power plant with biomass gasifying technology consists of following sections:

- Preparation and transport of the fuel
- Reactor for gasifying
- Gas cleaner and mix system
- Turbine, resp. combustion motor

This technology is nevertheless very sensitive to the used type of biomass. Combustion in gas turbines or motors requires use of a very clean gas and because different types of biomass perform differently, it is necessary to carefully control of the input materials. The best biomass fuel is usually wood coal but with reduced amount of water and other substances.

Types of reactors:



It is common to combust biomass together with coal. The proportion of biomass is then about 5-20%.

In the Czech Republic, the production of electricity from biomass increases every year. In the 2007, the CEZ group produced 249 GWh of electricity from biomass in domestic power plants (other 102 GWh was produced by the polish Skawina). For comparison, in 2006 CEZ in the Czech Republic produced only 163 GWh (in 2005 then 115 GWh) energy from biomass.

The most significant facility, in the sense of the amount of production, is the power plant Hodonin belonging to CEZ with production over 116 GWh (year to year increase 85%) and taking over the leading position form polish Skawina (102GWh).

Significant increase of production from biomass was achieved also in Porici (increase of 38% to 79 GWh) and Tisova (increase of 32% to 41 GWh.) power plants. Percentual increase was the biggest in heating plant Teplarna Dvur Kralove, which in the total production supported only 12 GWh.

The total amount of combusted biomass in the Czech Republic reached last year 241 000 tons (everything combusted mixed with black coal), another 136 000 tons of biomass was combusted the same way in Skawina. In the renewable resources frame of CEZ group biomass is the second most significant resource after the water power plants.

Biomass production in the CEZ group

	2007 (MWh)	**2006 (MWh)**	**Year to year increase**
Tisova	41297	31346	32%
Porici	79247	57427	38%
Teplarna Dvur Kralove	12732	2104	505%
Hodonin	115966	62708	85%
Other CEZ power plants in the CR	0	9851	-
Total in the Czech Republic	249239	163436	52%
Skawina	101680	-	-

Biochemical transformation

Ethanol is product of sugar fermentation requiring moisture environment. Theoretically from 1 kg can be derived about 0.65 l of clean ethanol. In reality it is usually 90-95%. The produced alcohol is separated by distillation and it is a valuable liquid fuel for the combustion motors. Suitable biomass materials for bio-ethanol production are especially sugar cane, cereals, corn or potatoes.

Since January 2008 in the Czech Republic is compulsory to mix 2% of bio-ethanol into the gasoline for cars. The ratio is going to increase in 2009 it is going to be 3.5%. This way we should be able to reach lower level of dependency on imported fossil fuels.

Thanks to the complex biochemical reactions in solid municipal waste dump, the so called dump gasses are produced. The composition of these gases changes over years. The average amount of solid municipal waste per person per year is 310 kg. Approximately 35% is then made of combustible organic waste, from this production of 0.3 m3/kg of gas can be achieved.

Another product of the biochemical transformation is biogas. It is a product of decomposition of organic materials (dung, plants, bilge water,…) in closed tanks without the access of air. Organic material decompose into inorganic substances and gas. It is caused by anaerobic bacteria. The residues after this process become adequate fertilizers.

Biogas contains 50-77% methane and its heat value varies from 19.6 to 25.1 MH/dm3. For biogas production in agriculture frequently sewage is used, which are liquid and hard excrements of animals with water, less often strew dung, grass waste, corn or potatoes are used.

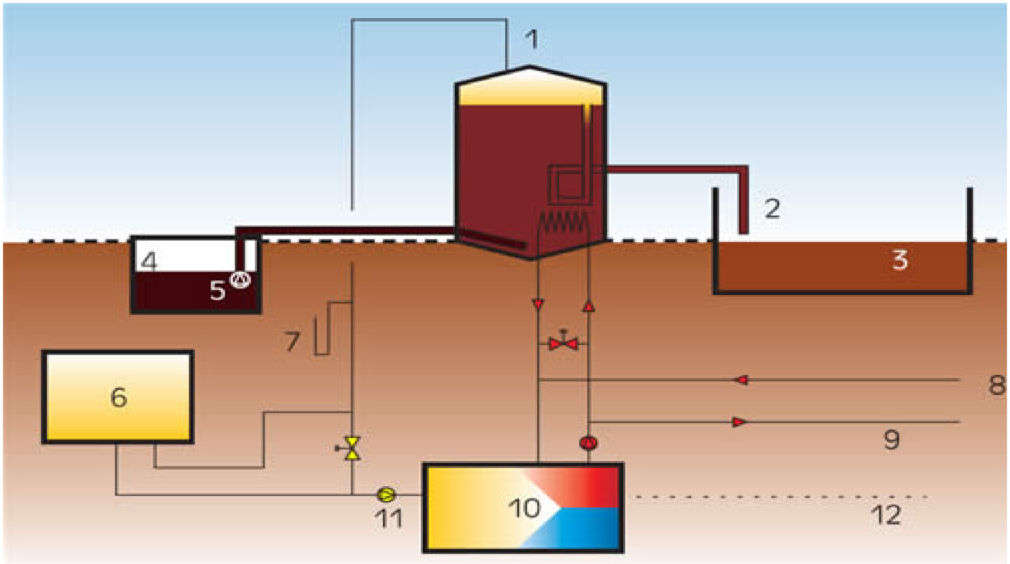
In the air-proof reactor the biomass is warmed up and remains at this temperature for set period of time. Depending on the present bacteria kind, the temperature where the biomass is warmed up is decided.

Optimal temperature range for the anaerobic bacteria:

Bacteria	Temperature of the fermented material [C]
Psychrophil	15-20
Mezophil	37-43
Thermophil	55

Sewage processing system

Biogas section diagram



Legend: 1 – biogas exhaust, 2 – mud overhang, 3 – degasificated sewage buffer, 4 – buffer storage reservoir, 5 – mud pump, 6 – gas container, 7 – water seal, 8 – distrikt heating connection, 9 – heat from combined heat and power unit, 10 - combined heat and power unit, 11 – air blower, 12 – lectricity from combined unit.

Mechanical-chemical transformation

Under the high temperature and catalyses treatment the pressed rape oil changes into metylester. This product is called the biodiesel of the first generation, and because its production is more expensive than common diesel fuel, it is mixed with some oil derivates or with linear alfa ethylenic hydrocarbon. This product is then called biodiesel of the second generation and has a competitive price comparing with diesel fuel. The condition remains that it must contain at least 30% of the rape oil metylester.

Since September 2007 in the Czech Republic, it is compulsory to mix 2% of metylester into the diesel fuel. Again these regulation is going to be more strict in future reaching 4.5% in 2009. In 2010 due to EU regulation, the bio component should reach 5.75% of overall volume of gasoline and diesel consumption in EU.

2.4 Legislative and biomass support in the Czech Republic

Conditions of production of electricity from renewable resources of energy, and therefore for biomass are closely described in the law 180-2005Sb. The purpose of this law is to protect the climate and the environment, to support the usage of renewable energy sources (therefore also biomass), to ensure long period increase of renewable sources on the utilization of primary energetic resources and to contribute to the use of natural resources and to the sustainable development of our society. Also the purpose of this law is to create conditions for the fulfillment of the desired goal: to reach in 2010 the 8% from the energy consumption in the Czech Republic will be energy produced from renewable resources, and to further contribute and increase this ratio after 2010. This law deals primarily with guaranteed government support for electricity generation based on renewable sources.

Guaranteed price for energy from biomass:

Form of electric energy production	CZK/kWh
Biogas produced in biogas stations	2.98
Biogas produced in water cleaning stations	2.23
Biomass combustion category I (biomass growth on purpose)	2.93
Biomass combustion category II (forest biomass and residual biomass from agriculture)	2.6
Biomass combustion category III (industrial waste biomass)	2.29

Ministry of environment law # 5/2007 Sb. deals with biomass variety definition, form of application and parameters of the biomass for the support of electricity production. It is concerned about the types and forms of biomass which are from the environment protection point of view supported by the government.

From the European agriculture fond for the country development (EAFRD) 2007-2013 the application and use of biomass will be supported. The support will be objected to the modernization of the farming involved in the cultivation, processing and usage of biomass, that is obtained particularly from own agriculture activities.The support can be used for the technological innovation investment and other investment necessary for the processing and usage of the on-purpose-growth biomass as well as waste-biomass for energetic and material purposes. This support can also be aiming into the research and development of new agricultural products and processing technique in animal or agro cultivation.

One of the specific objectives of this normative is the preventing of negative effects of the agriculture production on the environment. The support is aimed to agriculture entrepreneurs and it will be supported up to 50% expenses, while the maximum support per candidate is 90mil.CZK for program period. This fond is regulated by the Ministry of Agriculture of the Czech Republic. From this fond special education will be supported. The support will be objected for educational projects which should increase the knowledge for the engagement of new products, production methods, technologies and knowledge connected with new activities in the frame of diversification of industrial and non-industrial activities coming from the need of development of the farms, and improvement knowledge with the purpose of long-term development in every other aspect. The support is designed to agricultures and other people who take part in agriculture activities, water and forest activities and their diversification. The grant is given up to 75% input expenses, maximally 15000 CZK for one course. Moreover, further education and information activities will be supported, in the frame of the distribution of the information: information about the laws dealing with natural resources management, implementation of new productions, methods and technologies corresponding with sustainable development. This fond will also support the use of professional consulting, which purpose will be to improve the individual managerial capabilities. This way more rapid development in the field of agriculture, environmental protection, sustainable development and such will be promoted.

2.5 Biomass usage in the Czech Republic

Solid biomass makes up to 90% of all renewable energy resources used for thermal energy production. The biggest amount of biomass is used to heating the households, usually the biomass is combusted mixed with coal. The biggest number of furnaces for biomass combustion can be found in the South Bohemia countryside. Companies producing the thermal energy from biomass usually consume the whole volume of produced energy by themselves. The production in the local bio thermal power plants is still in the beginning, with only about 40 such facilities. Very unsatisfactory is then the situation in the production and consumption of fuel cakes and pellets made from biomass.

On the so called green energy production, biomass has a 21% share. In the Czech Republic there is currently 37 production facilities for producing electricity form biomass. More than one third produced electricity is further transmitted to the energetic network. It is usually produced by the largest power plants. Since 2004 the consumption of vegetal mass is increasing and also the usage of wood pellets and vegetal waste pellets is being tested. Biogas makes 5% share on green energy production. The biggest share in biogas production has capital city Prague.

Bio fuels in the Czech Republic are currently produced almost only from rape oil. Rape is being growth in the area of 265 000 ha. The bio fuel share in the overall fuel market was in 2004 2.46%, which is unfortunately significant decrease from 1999 (5.15%). In the Czech Republic, there is 16 methylester of rape oil production facilities.

2.6 Information sources

[1] www.alternativni-zdroje.cz/vyroba-energie-biomasa.htm

[2] www.biom.cz

[3] www.biomasa-info.cz/cs/projekt.htm

[4] www.eia.doe.gov/kids/energyfacts/sources/renewable/biomass.html

[5] www.ekobydleni.eu

[6] en.wikipedia.org/wiki/Biomass

[7] www.i-ekis.cz/?page=biomasa

[8] www.tzb-info.cz/t.py?i=4&t=15

[9] www.zelenykruh.cz/dokumenty/infolist-biomasa.pdf