Economical Aspects of Biomass Usage in Czech Republic and Austria

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28th June 2006

Abstract:
The paper try to reveal the economical background of the usage of biomass for electricity or heat production under conditions of Czech republic and Austria. Since the technical potential of biomass in both countries is to be known as very high, we will try to find out, how big potential does the biomass could give from the economical point of view. We will emphasize on two specific fields of the usage of biomass. These are using biomass in domestic boilers and using biomass for the electricity production in big industrial appliances. In order to combine the praxis with the theory we will do two case studies, from which one will be dealing with the industrial power plant and the second one with the domestic boiler, both using biomass as source of energy.

The main research question is how economical is it to use the biomass for the electricity or heat production under conditions of Czech republic and Austria. We will try to reveal the economical trends in the biomass sources of energy and also the economical development of the technologies, which are produced in order to create energy out of biomass either in the form of electricity or in the form of heat.
Comparison of gas fuelled and biomass fuelled combined heat and power plant in the urban area in view of investment and emission handling

1. Market Potential for Biomass Usage in Domestic Boilers up to 50 kW Nominal Output in Czech Republic

1.1. Number of flats

Biomass boilers are mostly suitable in the rural areas. There are some major reasons for it, especially the following ones.

- In many rural areas there is no natural gas infrastructure built.
- Biomass is easily accessible through the farm industry connected to the rural areas.
- Also houses could be spread around the area in a way that the building of infrastructure for the central heating would be inefficient.

The czech statistical office has made in last 15 years two major surveys regarding the energy consumption in flats and houses. According to the statistic survey Energo 2004[1] there were in year 2001 in total 1.623.893 flats in villages up to 5000 inhabitants, which is almost 40 % of all flats in the country.

Average heated area in flats in rural regions is 88,3 m2.

Average costs for energy per flat in rural areas is 940,-- Euro per year.

1.2. Energy Demand in Family Houses and Flats

			Fuel consumption			
Type of the house	nominal output of installed boiler	energy demand per year in kWh	wooden pellets t/year	standard grain t/year	heating oil kg/year	natural gas m^3/year
old flat – poor insulation	35	60000	12	14	5800	6700
middle old flat - standard quality	20	35000	7	8	3400	3900
new modern flat – standard quality	10	20000	4	5	1750	2200

Table 1: Energy Demand of Standard Flats[2]

Note 1: all family houses are 700 m3

Note 2: standard grain = wheat, oat, barley

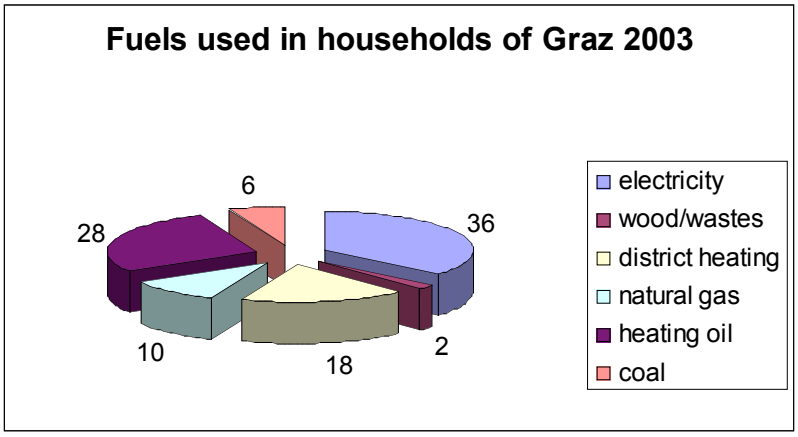
Acording to the data from Energo 2004 survey the average energy demand per flat in rural areas of Czech republic is 110 GJ and from that 91 GJ goes for heating of these flats. It means that the average energy demand per flat is 25000 kWh per year. This data contains both family houses and flats in blocks of flats.

[1] www.czso.cz

[2] Source: own measurements

Case study: Energy consumption in households of Graz, Austria

In 2003[3] the houses in Graz were heated up in the following structure of fuels:



The total demand for energy in Graz in 2003 was ca 7300 TJ, which is about 400.000 t of Biomass per year, from this about 300.000 tons need to be used for heating, which is about 1,5 billion kWh.

The average house in Graz has four floors with 150 m^2 each and the average heated area is 1600 m^3. Such house could be heated up with 50 kW pellet boiler with the yearly consumption of 20 tons of wooden pellets.

[3] RAGGAM August: Klimawandel, Biomasse als Chance gegen Klimakollaps und globale Erwärmung, Ökosoziales Forum Österreich, Styrian 2004, page 93

1.3. Fuel Prices in Czech Republic – June 2006

Fuel	Type of boiler	Efficiency of boiler	Operational costs (Euro per year)
Wooden logs	Standard boiler	75 %	250
Pellets from grain	Automatic boiler	85 %	320
Brown coal	Automatic boiler	82 %	390
Standard grain	Automatic boiler	85 %	420
Brown coal	Classic boiler	55 %	530
Wooden pellets	Automatic boiler	90 %	530
Natural gas	Standard boiler	89 %	1.050
Electricity	Standard boiler	90 %	1.400

Table 2: Comparison of Running Costs in Domestic Boilers[4]

Note 1: consumption is counted for the yearly energy demand for 80 GJ, which is 22,2 MWh.

Note 2: standard grain = grain from wheat, oat or barley

1.4. Market potential regarding current prices

The energy market is highly competitive and standard rules of substitution of goods is working here well. The demand for different technologies depends significantly on the price of fuel needed for the boiler. In the last two years the prices of natural gas and heating oil raised up significantly, which brought lot of attention to the boilers for solid fuels. The boom on the market for such boilers is tremendous, it is not unusual that companies producing boilers for solid fuels (which is in Czech republic especially coal or wooden logs) raised up the production by more than 50 % in one year[5]!

Since the prices of grain stay low also in a long term, the demand for grain burning is rising as well. In moment when the heating with grain becomes as expensive as heating with brown coal, the demand for grain burning boilers is raising up significantly.

Heating with wooden logs has a long tradition, but the trends in the market lead to the comfortable use of the technologie and this could not be performed by manually operated boilers for wooden pieces.

[4] Source: www.tzb-info.cz

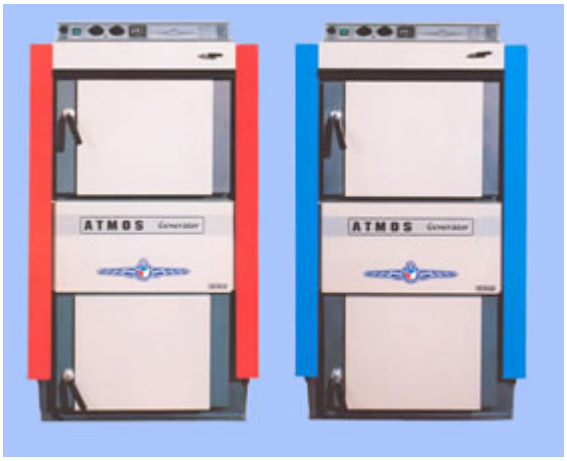
[5] These informations are gained through personal talks with sales managers of the market leaders of solid fuel boiler producers on the Czech market, such as ATMOS, BENEKOV, DAKON, OPOP, VIADRUS

2. Domestic boilers up to 50 kW for biomass burning – current technologies

There are two major types of technologies used nowadays for biomass burning in Czech Republic

2.1. Gasifying Boilers for Wooden Logs Burning

An example is boiler from ATMOS[6]. Such boilers are commonly used in households. Price of such boiler with nominal output 25 kW is about 1.300,-- Euro. The efficiency could be between 75 to 85 %. The biggest advantage of the boiler is relatively low price and very low running costs. The disadvantage is the low comfort caused by fact that boiler must be loaded more times per day and also risk that the wet fuel would cause the corrosion of the body of the boiler and thus the lifetime of the product would be strongly damaged.



Picture 1: Wooden Log Boiler

2.2. Automatic Boilers for Wooden Pellets or Grain Burning

An example of universal boiler for wooden pellets as well as for grain burning is from company BENEKOV[7]. Such boiler with the nominal output 25 kW costs about 2.800,-- Euro. The efficiency reaches up to 90 %. The biggest advantage is high level of comfort provided by the automatic loading system. Such boiler requires attention only once in 5 to 10 days. The disadvatage is higher investment cost in comparison with gasifying boiler for wooden logs.

[6] www.atmos.cz
[7] www.benekov.com

Picture 2: Automatic Boiler for Pellets or Grain

2.3. Investment costs of domestic boilers

Type of boiler	Price for unit 25 kW nominal output (in Euro)	Price per kW installed (in Euro)
Electric boiler	650,--	26,--
Classic boiler for coal	700,--	28,--
Standard boiler for natural gas	800,--	32,--
Classic boiler for wooden logs	1.300,--	52,--
Automatic boiler for coal	2.400,--	96,--
Automatic boiler for pellets or grain	2.800,--	112,--

Table 3: Comparison of Prices of Different Domestic Boilers[8]

The high price of automatic boilers for wooden pellets prevent this technology from being spread up as much as the classic boilers for coal. The high efficient automatic boilers for pellets or grain burning cover not more than 1 % of the total market with solid fuel burning boilers. Between 10 to 20 % of the market is covered by gasyfing boilers for wooden pieces burning. The rest of the market of technologies for solid fuels is taken by classic boilers for coal.

[8] Source: informations from price lists of market leaders of the given technology on the czech market

3. Grain Burning in Czech Republic

3.1. Technical Potential

There are about 4,3 milions hektar of agricultural land in Czech republic[9]. It is expected, that about 30 % of this land in the future could be used for energetic purposes. There were different analysis of the potential of biomass in Czech republic made and according to them the total agricultural area unsuitable for food purposes is about 1,3 mil hektars.[10]

There are different ways how the land could be used for energetic purposes. In principle the energy potential gained from each hektar could be the same no matter which kind of crop is used. The energy potential of biomas per hectar differs from the type of the land and it is expected, that it could be between 8 and 17 tons of dry biomass per hectar per year[11].

Choosing the appropriate energy crop depends very much on the requirements for the further investments on utilization of this crop. From this point of view, the standard grain has a significant advantage. Wheat, oat, barley or maze are being cultivated and grown for centuries. Farmers have equipment to grow them and they do not have to invest further money into the utilization of the grain. Moreover the common agricultural politics is causing permanent overproduction of grain, for example in year 2004 the overproduction of grain in Czech republic was about 2 mil. tons[12]. One ton of grain could give about 4000 kWh. The average flat in rural areas needs about 25.000 kWh per year, which is about 6,25 tons of grain. 2 mil tons of grain could bring heat for 320.000 flats in rural areas, which is energy needed for heating up of 18 % of the flats in villages up to 5.000 inhabitans, in which about 7 % of all czech citizens would live.

In case that 1,3 mil hectares of land in Czech republic were used for growing even standard grain, then there could be significantly more biomass gained. The average yield from one hectar of different crops in our country is following:

Type of cereal	Grain/ha (in tons)	Straw/ha (in tons)
Wheat winter crop	4,5	8,1
Barley winter crop	4	3,2
Oat	3	4,2

Table 4: Average Yield from Different Kinds of Cereals[13]

If 1,3 millions hectare of land were used for wheat growing, then about 5,85 mil tons of grain could be gained. This grain could be used for heating up of 936.000 flats, which is almost 60 % of all flats in towns up to 5000 inhabitans and in which almost 20 % of czech citizens

[9] www.czso.cz
[10] Janouch František and Schleicher Stefan: Energy for sustainable development, Charles University, Prague, 2005, page 202
[11] Janouch František and Schleicher Stefan: Energy for sustainable development, Charles University, Prague, 2005, page 200
[12] http://www.agroweb.cz/projekt/clanek.asp?pid=2&cid=18774
[13] Source: Pastorek Zdeněk[13]

would live. Moreover, there would be about 10 mil tons of straw left which could be used for co-firing or district heating.

3.2. Bureaucratic Barriers

The biggest barrier for grain burning in Czech republic as well as for Austria is the fact, that officially grain burning is not allowed and also not forbidden. In June 2006 it is still not possible to certify a boiler for grain burning.

The quick raising of prices of heating oil and natural gas though moved the EU authorities to start thinking seriously about new alternative fuels, such as grain or cereals residues. Lots of promising statements were issued in the Action plan for biomass[14] issued by the EU commission, where the clear statements are written about the necessity of the support of biomass use in the EU in general and also in specific fields, such as energy crops etc.

The biggest support to grain burning could be gained not through subsidies, but through declaration of grain as recognized fuel. Such thing would allow boiler producers certify officially boilers for this fuel and this way the technologies could spread out significantly faster than it is now.

3.3. Trends on the Market

Grain burning started in Denmark about twenty years ago. On this market there are dozens of producers of domestic as well as industrial boilers that could use different types of grain as a fuel. The Danish experience started to be noticed in other countries only in recent years and using grain as a fuel in boilers becomes common nowadays in most countries of the Europe. Though the experience of customers, producers as well as legislation in most countries is usually still low and thus this does not spread really quick yet.

The driving forces for grain burning is the quick raising up of natural gas and heating oil prices. As soon as it became very efficient for farmers to burn grain they started to search for producers of such technologies and producers try to modify the older versions of their products from pellets, wooden chips or coal burning into grain burning. Exactly the same trend is happening on the Czech market as well. In June 2006 the price of brown coal is about the same level as the official price of grain. That is the moment when it becomes interesting for farmers to start searching for new technologies, which could burn their own products.

Production of wooden pellets is strongly limited by the resources for their production. Thus the trends on market are mixing different leftovers from the cereals into the form of pellets. Due to this fact there are dozens of different pellets produced in each European country.

[14] Announcement of EU commision: Action plan for biomass, SEK 2005, 1573, 7.12.2005

4. Price for Biomass Heat in Austria

4.1. Pellets

The price of the heat from pellets depends on the price of the pellets. For the coming season a price for pellets from 219 up to 226 € per ton will be expected.[15] The following price for the heat equals 5,5 €ct./kWh (assumption: heating value equals 4 kWh/kg). It is still nearly 25 % under the price for heating oil (0,706 €ct./l[16] it is equivalent to 7,06 €ct./kWh).

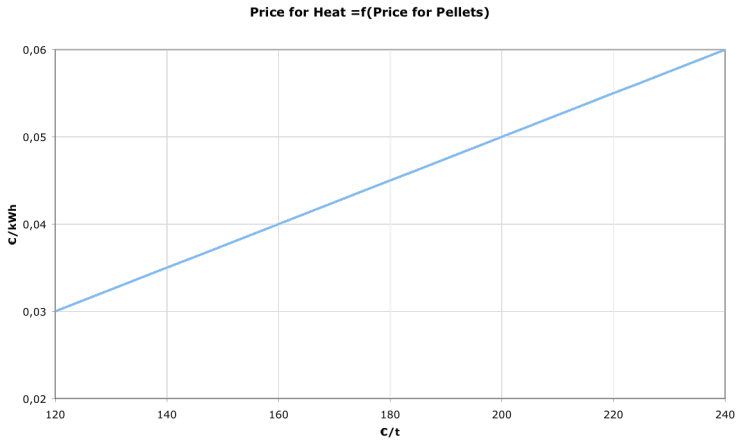


Figure 1: Price for Heat from Pellets[17]

The price for pellets increased 2005 in case of a higher demand than expected, because of the unexpected the growth in the number of pellets boiler. Austrian quotas of pellets were sold in advance for 2005, so we had to import pellets from Sweden and other countries.[18]
In 2006 the expected pellets price will be higher than 2005. First in 2007 the production capacity of pellets will be increased and the price will decrease.[19] As you can see in Figure 2: Prices for Pellets and Oil, the price for the heat from pellets is much lower than the price for heat from heating oil.
The quality for pellets if standardized and so the heating value is every time the same.

[15] Source: o.V., http://www.lagerhaus.at/netautor/napro4/appl/na_professional/parse.php?mlay_id=30000&xmlval_ID_KEY%5B0%5D=4306, 25-06-06
[16] Source: o.V., http://www.iwo-austria.at/60.0.html, 25-06-06
[17] Source: own construction
[18] Source: personal dialogue with Josef Bärenthaler from Energieagentur Judenburg, Knittelfeld, Murau, 10-03-06
[19] Source: personal dialogue with Friedrich Lettner from the Technical University of Graz, 14-06-06

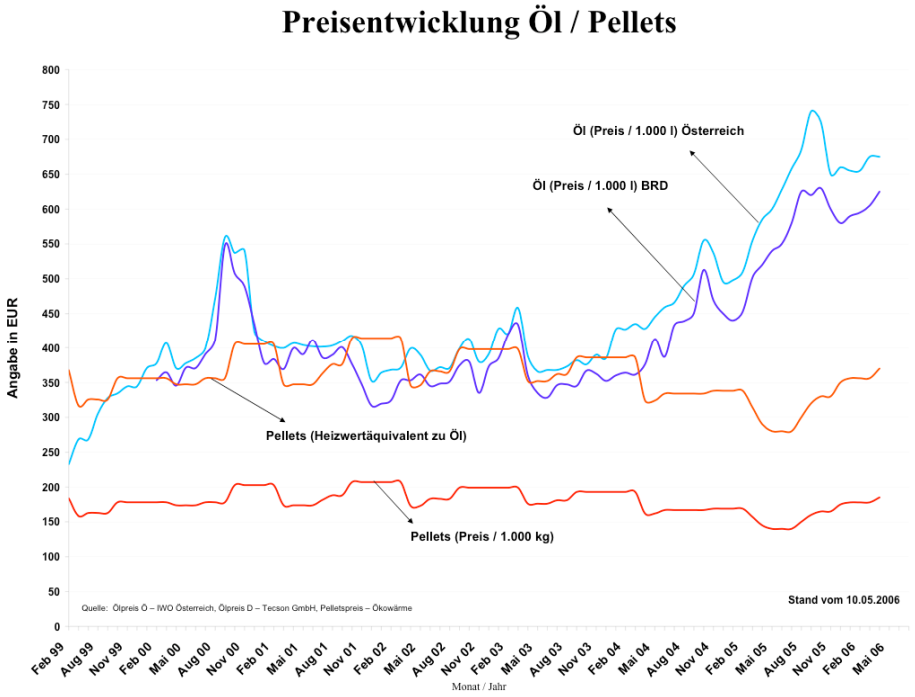


Figure 2: Prices for Pellets and Oil[20]

4.2. Wood Chips

The price for wood chips depends very strongly from the quality of them. An average price from 14 € per pouring space meter (srm) will be assumed (see Figure 4: Price for Wood Chips). At a price of 14 €/srm the price for the heat from the wood chips depends on the heating value and the water content of them.

The wood chips are not standardized like the pellets. So the burning process is much more difficult to handle. For this reason, wood chips boiler are much bigger and more expensive than pellets boiler with the same heating output.

In Figure 3: Price for Heat from Wood Chips, you can see the price for the heat from wood chips. With the assumed price of 14 €/srm the price for heat is about 1,4 €ct./kWh with a heating value of 1000 kWh/srm (very positive heating value with very low water content). At a heating value of 500 kWh/srm, the price for the heat doubles. i. e. 2,8 €ct./kWh. A realistic value is near 730 kWh/srm. It means a price for heat of 2 €ct./kWh and thus nearly one third of the 2006 expected price for heat from pellets.

It is not considered, that the price for wood chips burner and the storage for wood chips is much higher than it would be for pellets. It is only the price for the fuel.

[20] Source: o.V., http://www.uwe-energie.de/Preisentwicklung-Oel_Pellets.pdf, 25-06-06

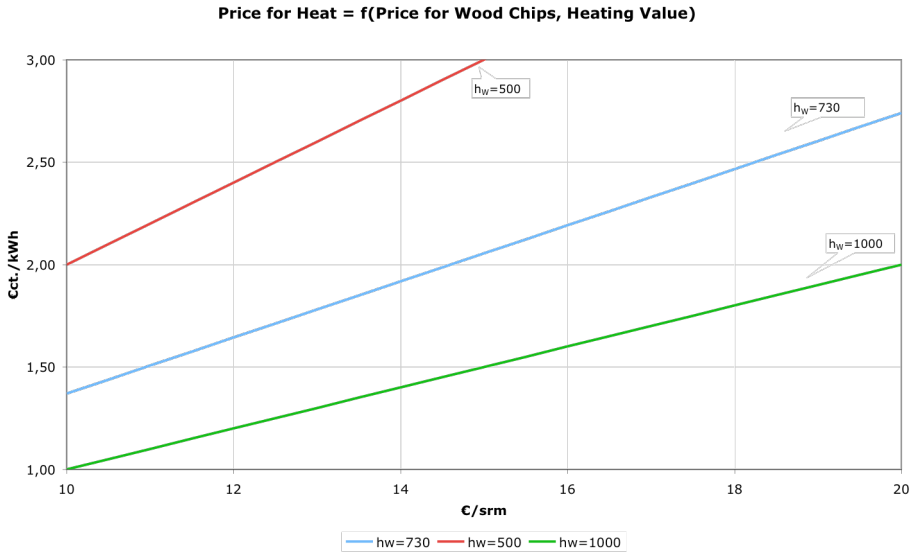


Figure 3: Price for Heat from Wood Chips[21]

Figure 4: Price for Wood Chips[22]

4.3. Grain Burning in Austria

The price for high quality wheat is much lower than the price for pellets. The price in 2006 equals 126,5 €/t[23]. Low quality wheat and barley will be available under 100 €/t.[24] The price for heat from grain thus is 2,1 €ct./kWh (assumed heating value = 4,7 kWh/kg or 17 MJ/kg[25]). The price thus is in the area of wood chips. But the transport, storage and pumping of grain is similar to the technology of pellets and much easier than for wood chips.
But there are several problems in burning grain:

[21] Source: own construction
[22] Source: o.V., http://www.carmen-ev.de/dt/energie/bezugsquellen/hackschnipreise.html, 25-06-06
[23] Source: o.V., Lebensministerium http://infonet.lebensministerium.at/article/articleview/48498/1/5146, 26-06-06
[24] Source: o.V., Österreichisch Bauernzeitung, http://www.bauernzeitung.at/OEBZ-Inhalt/Archiv/oebz12_06.pdf, p 4, 16-06-06
[25] Lettner, Script from lection: Biomassetechnologien für eine nachhaltige Energieversorgung, SS06, p 60.

- Low melting point of the ash (736°C, cp. wood: 1389°C) [26]
- Higher ash content
- More clinker and corrosion of the boiler
- Higher emissions
- No licensed boiler in Austria[27]

At the moment “Energy grain” is not standardized and there are no emission limits are defined. So some who heat with grain, they are in a grey zone. Individual permission for commercial use is possible.[28]

5. Power Production from Biomass

5.1. Introduction

There are basically three different methods to produce power from the solid biomass. First is to burn the biomass and use the heat to produce steam and use the steam in a Clausius-Rankine-Cycle and Organic-Rankine-Cycle (steam turbine). Second method is the pyrolysis of the biomass. Biomass will be heated up to a few hundred degrees under low oxygen atmosphere. The gas, which will exhaust, can be used, after cleaning, in a combustion engine or in a gas turbine. Third method is the production of biogas via bacteria under anaerobic conditions. Biogas can be used in a combustion engine. Biogas is not considered in this work.

5.2. Steam Turbine Process

The steam turbine process is well advanced. But there are some big problems with biomass compared with coal-fired processes. In biomass is up to 1 % chlorine, especially in the bark and stem goods (e.g. wheat straw includes 0,4 % chlorine[29]). Chlorine hydrates to hydrochloric acid and causes high temperature corrosion, thus a main steam temperature from 420-450 °C should not be transgressed. The electric efficiency depends mainly on the steam conditions. A back-pressure turbine can reach an efficiency from 10-20 % in installations up to a few MW.[30]
In Güssing is one steam turbine installed with an extraction-condensing turbine with 2 MW electric output. The efficiency of this steam process is 20 %. The advantage of the extraction-condensing turbine is, that high temperature heat (steam) can be extracted.
The specific investment costs an average out at 1500 €/kWh.

[26] ebd. p. 29
[27] Jauschnegg in: „Der fortschrittliche Landwirt“, Heft 11/2006, p. 52f
[28] ebd.
[29] Lettner, Script from lection: Biomassetechnologien für eine nachhaltige Energieversorgung, SS06, p 74.
[30] o.V., Innovative Verfahren zur Wärme- und Stromerzeugung aus Biomasse, Landwirtschaftsverlag, Münster 2001, p 112.

5.3. Organic-Rankine-Cycle (ORC)

The ORC process is similar to a conventional steam process. But instead of water an organic fluid is used as process fluid. The organic fluid evaporates at a lower temperature and lower pressure than water. A big advantage thus is, that no steam boiler guardsman is affordable. Also an advantage is the lower temperature in the biomass boiler, thus there is no problem with high temperature corrosion.
The investment costs are higher than compared with a conventional steam process and the electric efficiency is about 11-13 % in the whole system and 15-17 % from the supplied heat. The spread in these two efficiencies is caused by the thermo-oil-cycle, which is needed to protect the organic fluid against disintegration.
ORC cycles are used in small-scaled power plants up to 500 kW.[31]

5.4. Pyrolysis of Biomass

Pyrolysis is a process where biomass will be heated up under a low oxygen atmosphere. The process can be autothermic. Part of the fuel will be oxidized fully to produce the heat for the process. Second possibility is an allothermic process, where heat must be supplied from another source. The gas, which will be produced, is high loaded with condensable freight (tar) depending on the time for heating up the biomass.[32]

Hydrogen	7-25 %
Carbonmonoxide	15-25 %
Methane	0-4 %
Nitrogen	40-55 %
Carbondioxide	8-15 %

Table 5: Contents of an Average Product Gas[33]

The average heating value equals 4,5-6 MJ/kg (1,25-1,7 kWh/kg).
It is very difficult to handle this gas, when tar is inside. The tar load must be extracted, but the gas has a very high temperature. To use the heat from the gas it is possible to send it through a heat exchanger but then the tar condenses in the heat exchanger and destroys the heat exchanger. Another possibility is to quench the hot gas but then the high temperature heat is away. But the gas must be cooled down and the tar must be extracted to use the gas in a combustion engine or in a gas turbine. If the gas will be burned in a gas boiler the extraction is not necessary. But then the high exergetic value of the gas will not be used.[34]

The advance of the electric efficiency can be seen in Figure 5: Electric Efficiency. “Exergetischer Wirkungsgrad der ersten Umwandlungsstufe” (x-axis), means the first conversion, e. g. the conversion from the solid fuel to gas in case of the pyrolysis. The

[31] ebd. p. 120.
[32] Notes from lection: „Biomassetechnologien für eine nachhaltige Energieversorgung“ Technical University of Graz, SS06.
[33] o.V., Innovative Verfahren zur Wärme- und Stromerzeugung aus Biomasse, Landwirtschaftsverlag, Münster 2001, p 34.
[34] Notes from lection: „Biomassetechnologien für eine nachhaltige Energieversorgung“ Technical University of Graz, SS06.

"Exergetischer Wirkungsgrad der zweiten Umwandlungsstufe" (y-axis, right) means the second conversion, e. g. from the gas to mechanic energy via combustion engine or a gas turbine. On the left y-axis, "Elektrischer Wirkungsgrad", is the scale for the over all electric efficiency.

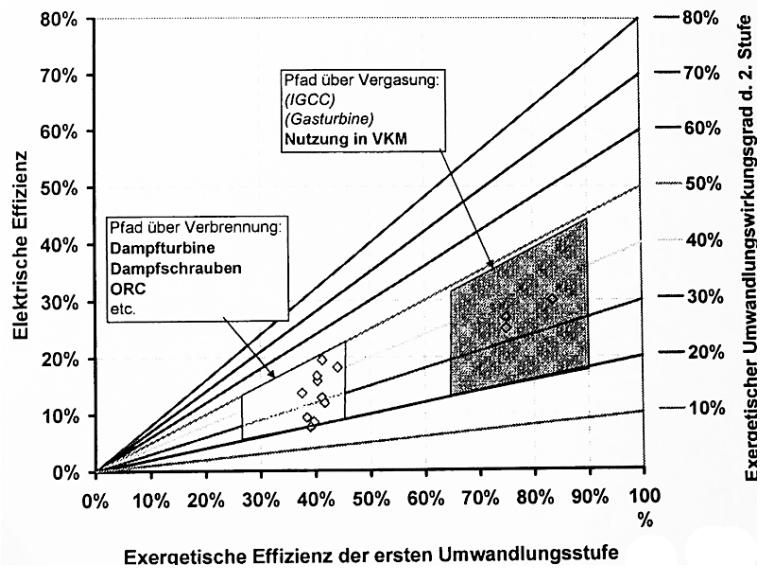


Figure 5: Electric Efficiency[35]

5.5. Comparison of Gas- and Steam Turbine

A modern, conventional gas- and steam turbine reaches an electric efficiency up to 55 % and a overall efficiency of 90 %. The specific investment costs are 800 €/kWh. That's half of the costs for a conventional rankine process.[36]

This low investment costs are caused, among other things, by the low costs for the emission handling. Natural gas insists mainly methane. Methane oxidizes only to carbon dioxide and steam. Caused by the high burning temperatures there is also nitrogen oxide inside, but nitrogen oxide is very easy to handle in a catalyst.

There is no sulphur or any aerosol in the exhaust gas, which could make troubles in the boiler or in the exhaust gas manipulation.

That's the reason, why now in Austria many gas- and steam turbines would be built – with sizes above 100 MW. The district heating supplier for Graz, the power plant in Mellach expands its capacity with a gas- and steam turbine with a power of 800 MW.[37]

[35] Lettner, Script from lection: Biomassetechnologien für eine nachhaltige Energieversorgung, SS06, p 139.
[36] o.V., TechnologiePortrait Kraft-Wärme-Kopplung, energytech.at, 2002, p. 32
[37] o.V., kontakt – Die Mitarbeiterzeitung des Verbund, http://www.verbund.at/at/medien/magazin/2005_01_kontakt.pdf, 26-06-06

6. Country Profile Czech Republic

The Czech Republic is a landlocked country between two mountain systems, where most rivers joining the North, the Baltic or the Black sea have their spring.[38] Even though the population density is above European average, most of the settlements have less than 1000 inhabitants.[39] The main energy sources are coal and natural gas, which is an improvement compared to the prolonged utilization of low-quality coal, that is to blame for the high levels of pollution especially sulphur in the past. [40]Renewable energy currently has only a share of 2,6 % of PES, a percentage that could be more than ten times higher by an efficient exploitation of the potential of biomass alone. The Czech Energy Works (CEZ) that holds the monopoly in energy production in the country owns 65% of all the installations. Wind power and biomass are expected to see most of the development of RES.[41] The reason for this doesn't only in the high share of unused potential of this sorts of RES but also in the new promotion scheme of renewables Act 180/2005, that substantially supports electricity generation of RES only.[42]

Area	78.866 sq km
Arable Land	38,82%
Forest Area	2.648 mill. hectares (2005)
Forest Land	34,27% (2005)
Population	10,235.455
GDP per capita	$18.100 (2005 est.)
GDP Composition per sector	(2004 est.)
-agriculture	3,4%
-industrie	39,3%
-services	57,3%
DCPES	1.840 PJ (2003)

Table 6: Czech Republic Country Statistic 2006[43]

[38] See: European Renewable Energy Council, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF , 2004

39 See: Ministry of the Environment of the Czech Republic and Czech Hydrometeorological Institute,

http://unfccc.int/resource/docs/natc/czenc4.pdf#page=85

, 2004

40 Compare: Black & Veatch, http://ebrdrenewables.com/sites/renew/countries/Czech%20Republic/profile.aspx , 2005

41 See: Remrova, M., Mitteleuropäische%20Biomassekonferenz%202005/Vorträge/Remrova_long.pdf, 2005

42 See: Knàpek, J., Interdisciplinary Winterschool Graz [System Aspects of RES], 2006

[43] The CIA World Fact Book, quoted by: Austrian Energy Agency, [Energy Profile Czech Republic], http://www.eva.ac.at/enercee/cz/index.htm, 2004,

Of all the possibilities the Czech Republic has for the generation of energy with RES wind power and biomass are the most promising.44 Especially energy crops and agricultural waste offer a vast potential, that is yet untapped.45
But the implementation of biomass boilers for replacing fossil fuels does get only little support by the government since the new promotional scheme for renewables (Act 180/2005) offers subsidies for green electricity exclusively.46

6.1. Biomass in Czech Republic

The Czech Republic is blessed with a large variaty of possibilities for the utilization of RES and biomass is on top of it. Fuelwood dominates the list with biogas from agricultural products and waste treatment in second. [47] 70% of the country's RES derive from biomass for heating. Yet this is only about one-tenth of the potential of biomass.[48] Not only that the utilization of biomass for energy generation lies significantly behind capacity, agriculturel land unsuitable for the production of food goods could be of use for the plantation of energy crops in large scale.[49]

Biofuel	Available potential TJ/y^{-1}	Present utilization TJ/y^{-1}	%
Fuelwood and woodwaste	32 800	16 200	49,4
Cereal straw	6 050	39	0,6
Straw from oil plants	9 800	170	1,7
Energy plants (from marginal lands)	12 000	0	0
Biodiesel	9 200	2 300	25
Biogas	7 000	1 000	14,2
Total	76 850	19 709	25,6

Table 7: Available potential and present utilization of biomass in Czech Republic, 2000[50]

[44] See: Remrova, M., Mitteleuropäische%20Biomassekonferenz%202005/Vorträge/Remrova_long.pdf , 2005
[45] See: Habart, J., http://www.biom.cz/index.shtml?x=823784 [Biomass Utilization in ČR], 2005
[46] See: Knàpek, J., Interdisciplinary Winterschool Graz [System Aspects of RES], 2006
[47] Compare: Renewable Energy Journal N°. 14, http://ec.europa.eu/energy/res/publications/doc1/rej_14.pdf [Renewables New],
[48] See: Black & Veatch, http://ebrdrenewables.com/sites/renew/countries/Czech%20Republic/profile.aspx [EBRD Energy Country Profile, ČR], 2005
[49] See:Habart, J., http://www.biom.cz/index.shtml?x=823784 [Biomass Utilization in ČR], 2005
[50] Source: Black & Veatch, [EBRD Energy Country Profile, C.R.], http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF, p. 8, 2003

Potential for Development

Of potentially 6 million tons biomass only 1,6 mil. tons dry mass have been used as RES in 1999 in Czech Republic. [51]With the additional area of the 0,5 mil.ha fallow lands mentioned above for cultivation the amount of biomass dry mass would be more than twice as much. Yet these resources remain mostly untouched because of the heat produced by coal.

Source of biomass	Technical potential PJ	Accessible potential PJ
Forest biomass	77,6	44,8
Biomass from agriculture	275	136
Biogas	33	16

Table 8: Energy potential from different sources in ČR[52]

6.2. RES in Czech Republic

Czech Republic has a fair amount of possibilities for the utilization of RES. Biomass, wind, small hydropower, waste and geothermal heat are available and in form of various installations as RES represented.[53] The least of the RES by matters of energy production capacity are photovoltaic systems that lack appropriate technology and sufficient sun hours per year for efficient application on large scale. [54]This does not include thermal energy though, which is likely to be found as a heating support system in the residential sector.

RES	Produced energy GJ	Share on PES %	Share on RES energy production %
Biomass	30.968.389	1,7462	73,97
Biodegradable part of the waste	2.082.003	0,1174	4,97
Biogas	1.168.921	0,0659	2,79
Hydropower	4.980.481	0,2808	11.89
Wind power	14.040	0,0008	0,03
Liquid fuels for driving mechanisms	2.660.000	0,15	6,35
Total	6.760.023	2,3611	100,00

Table 9: Share of Biomass on Total RES Utilization in ČR, 2003[55]

[51]Compare: Black & Veatch, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF [EBRD Energy Country Profile, C.R.], 2003

[52] Source: Habart, J., http://www.biom.cz/index.shtml?x=823784 [Biomass Utilization in ČR], , 2005, o. S.

[53] See: Lukesova, V., http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr115019e.html [Renewable energy in ČR], 2003

[54] Compare: Black & Veatch, http://ebrdrenewables.com/sites/renew/countries/Czech%20Republic/profile.aspx [EBRD Energy Country Profile, ČR], 2005

[55] MPO statistics, quoted by: Knàpek, J., Interdisciplinary Winterschool Graz [System Aspects of RES], 2006, o.S.

6.3. Wind energy

The utilization of wind energy has tradition in Czech Republic since the 13th century. [56]There are several areas with the appropriate wind speed and people are experienced in the technology of making use of it. 17 of 23 wind turbines that have been installed in the early 90's are still functioning with a total capacity 6.825 MW.[57] In 2003 two wind power stations with total capacity of 1200 kW were set up in the village of Jindrichovice pod Smrkem[58]. Since then the main barrier for further installations had been the low feed-in tariffs before the new promotion scheme for renewables was introduced.[59]

Table 6:

Wind speed (m/s)	Installed capacity (MW)	Expected generation (GWh/y)
4,1- 5,0	2.571	2.236
4,6- 5,0	2.368	2.053
5,1- 6,0	8.208	12.312
> 6,0	888	1.776

Table 10: Electricity Production from Wind Energy in ČR, 2003[60]

The installation of 2 of the 17 wind power stations, the Mravenečnik windmill farm generating 478 MWh 2004 and the Novy Hradek wind power plant generating 58 Mwh 2004 has been implemented by the ČEZ power group, a major player in energy production in Central Europe.[61] This company has announced that wind energy will be the main emphasis of its investments in the development of RES in the next 15 years.[62] The usable potential for wind energy is estimated to be 3.710 TJ on the basis of 30 TJ generated in this way in 2003.[63] The technically available potential is reported to be 4000 TJ/y while the economically available potential would only be 100 TJ.[64]

[56] Compare: Black & Veatch, http://ebrdrenewables.com/sites/renew/countries/Czech%20Republic/profile.aspx [EBRD Energy Country Profile, ČR], 2005
[57] See: EBRD, Renewable Energy Resource Assesment, quoted by: Austrian Energy Agency, http://www.eva.ac.at/enercee/cz/energysupply.htm
[Energy Profile Czech Republic], 2004,
[58] See: European Renewable Energy Council, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF
[Renewable Energy Czech Republic], 2004
[59] See: Black & Veatch, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF [EBRD Energy Country Profile, ČR], 2003
[60] OZE, http://www.env.cz/AIS/web-pub.nsf/8c74f8eb26f7d18bc1256d9d00498f4b/8b871b10fddf1a49c1256e7700365ab2/$FILE/OZE-english.pdf, [Potential for RES in ČR], 2003, o.S.
[61] See: ČEZ, a.s., http://www.cez.cz/presentation/eng/instance_view.jsp?instance_id=90523&folder_id=7974 [Presentation, Press release], 2006
62 See: EZ, a.s, http://www.cez.cz/presentation/eng/instance_view.jsp?instance_id=78822&folder_id=7630# [Presentation, ČEZ Group introduction], 2006
63 See: Lukesova, V., http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr115019e.html
[Renewable energy in ČR], 2003
64 See: National Programme of Effective Energy Use and RES Utilisation, quoted by: Regional Environmental Center, http://www.kyomecha.org/pdf/REC_report_part2(DH+biomass).pdf [DH and biomass], 2005

6.4. Biomass as RES

Fuel wood and wood waste dominate the renewable energy sector of RES in Czech Republic, because of their widespread use in the low-temperature market (See: Table 5 and 7). Several hundred boilers are operating in industry and municipalities with a capacity between 200 kW and 10 MW where as more than 35.000 gasifing wood boilers between 20 kW and 50 kW are installed in the domestic sector for individual use next to an increasing number of tile stoves and the remaining out-of-date heaters.[65] Even though fossil fuels like coal are entitled to make most of the heat, two-thirds of biomass is already invested in the low temperature market.[66]

Bio fuel	Gross production TJ	Share on heat from RES %
Biomass industrial	16.980	42,30%
Biomass households	19.500	48,58%
Solid biomass total	36.480	90,89%
Biogas	968	2,41%
Solid municipal wastes	2052	5,11%
Heat pumps	580	1,45%
Solar thermal collectors	57	0,14%
Total	40.138	100%

Table 11: Structure of Heat Generation from RES in ČR, 2004[67]

6.5. Best practice of RES

There are two projects that can be seen as the ones that paved the way for the utilization of biomass as RES in Czech Republic. Both, the installation in the town of Hartmanice and the installation in Dešná, are substitutions for coal boilers that had to be replaced because of pollution. In Hartmanice the local remote heating operating since 1995/96 is powered by wood waste provided by local sawmills.[68] Two boilers each with a capacity of 1750 kW and a smaller boiler of 880 kW supply the town with heat and warm water.[69] In the village of Dešná

65 See: European Renewable Energy Council, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF [Renewable Energy Czech Republic], 2004

66 See: Black & Veatch, http://ebrdrenewables.com/sites/renew/countries/Czech%20Republic/profile.aspx [EBRD Energy Country Profile, ČR], 2005

67 MPO 2004, quoted by: Knàpek, J., Interdisciplinary Winterschool Graz[System Aspects of RES], 2006, o.S.

68 See: Nenicka, T., http://archive.greenpeace.org/nuclear/renewable/powerforchange.html#4.3.1 [Greenpeace, Power for Change], 1996

69 See: Jevič,P. et.al., http://www.vuzt.cz/konferen/k13.pdf

sufficient heating not only for the municipality itself but also for the neighbour villages is provided by the surrounding fields mostly.[70] The installed heat output of 2700 kW total derives from the combustion of straw blocks with the option of burning wood chips additionally.[71] The benefits for named villages are not constricted to improved air quality and the comfort of district heat supply but also the following:

- The municipally can make their own price for the heat provided.
- [72]New opportunities for rural labor forces were created.
- The local business gets supported by the fuel purchase of the municipality.

6.6. Bioenergetic facilities

There are 148 installations reported by the NGO CALLA utilizing biomass as heating source in Czech Republic. [73] The number breaks down into 94 boilers operating in companies of timber related business, 27 in agricultural sites and 27 in district heating plants. Additionally 31 installations use biogas for heat generations. These figures leave out the individual use of biomass, which increases the number significantly. The following table, even though far from being current, forms a picture of the dimension and the proportions of the utilization of biomass by a broader definition.

Type of facilities	Number of facilities
Small individual boilers with capacity > 50 kW	40.000
Medium boilers with capacity 50-200 kW	430
Municipal boilers with capacity 200-500 kW	60
Municipal boilers with capacity < 500 kW	17
Biogas plants	10

Table 12: Number of Bioenergetic Facilities in the Czech Republic[74]

[Local heat supply with biofuels], 2000

[70] See: European Renewable Energy Council, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF, 2004 [Renewable Energy Czech Republic], 2004

[71] See: Jevič,P. et.al., http://www.vuzt.cz/konferen/k13.pdf [Local heat supply with biofuels], 2000

[72] Compare: European Renewable Energy Council, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF [Renewable Energy Czech Republic], 2004

73 Compare: http://calla.ecn.cz/atlas/list.php?type=2; quoted by: Regional Environmental Center, http://www.kyomecha.org/pdf/REC_report_part2(DH+biomass).pdf [DH and biomass], 2005

[74] Source: Jaroslav Váòa: Nové cíle v energetickém využití biomasy a pøíprava high-technologiík jejich zabezpeèování. Biom.cz, 2001, http://biom.cz/index.shtml, quoted by: Regional Environmental Centre, http://www.kyomecha.org/pdf/REC_report_part2(DH+biomass).pdf [DH and biomass], 2005, p.67

There are 4 power plants with co-combustion of biomass next to coal or lignite implemented by the CEZ power group, Tisova, Pořiči, Ledvice and Hodonin. [75]Even though Hodonin utilizes the greatest amount of biomass with 30.000 tons compared to 1 mil. Tons of lignite, 25 % of the fossil fuel could be substituted with biomass. Additionally a heat and power plant powered by sorrel, straw and hay with the capacity of 10 MW is planned in Hradec Kralove. [76]The project is expected to operate within the second half of 2005. The EGST Company is already in contact with local farmers for fuel supply.

6.7. The legal situation for RES in Czech Republic

The major intentions of the government are documented in the State Energy Policy as to integrate the energy industry with economic, social and environmental needs. [77] Even though the latest version of this open paper has been approved 2001 for the duration of at least 15 years, the State Energy Concept created within its framework from 2004 sets out the following targets for the utilisation of RES:

- Optimal utilisation of RES for the strengthening of national independence on external sources
- Increase of energy system reliability
- Reduction of the negative influence of the energy production for the environment
- Contribute to the solution of landscape protection problems
- Provide a solution of social and unemployment problems

The State Energy Concept has to consider the production of biomass of all kinds whether solid, gas or liquid in every sector possible be there forestry, agriculture or petrochemical industry in accordance with the EU energy policy.

6.7.1. Law

There are two basic laws outlining the legal framework of the energy sector in Czech Republic. The first is created to develop an energy market according to the standards of the EU, the second one to improve the efficiency of energy generation of all kinds on a national level.

- The law n. 458/2000 Coll. “for business conditions and State governmental execution in energy areas and for the change of certain laws” better known as “energy law” states the following points.[78]
  - “Status, rights and responsibilities of independent regulatory authority for energy sector

[75] Compare: Habart, J., http://www.biom.cz/index.shtml?x=823784 [Biomass Utilization in ČR], 2005
[76] Compare: European Renewable Energy Council, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF [Renewable Energy Czech Republic], 2004
[77] Compare: European Renewable Energy Council, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF [Renewable Energy Czech Republic], 2004
[78] See: European Renewable Energy Council, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF [Renewable Energy Czech Republic], 2004

- Creation of clear and non-discriminating economic conditions…
- Scope, method and order of energy sector state regulation, …
- Support for the creation of other legislative, economic and technical conditions needed in order to involve the Czech energy sector into the integrated inner EU market…
- …the assessment of regulation method on regional level and respective price policy – support of centralized heat supply, mainly from CHP production"[79]

❖ The law n. 406/2000 Coll. "for energy efficiency" is responsible for the organization of the process towards energy efficiency, utilization of RES and CHP production on a higher level. [80]The optimal exploitation of regional energy sources is as well part of it as a new definition of the National program of energy efficiency and renewable and secondary energy sources use. The late agenda sets out the goals for energy consumption reduction, the utilization of RES and the exploitation of secondary energy sources for the time between 2002 and 2005.

❖ A support for environmental friendly projects such as the utilization of RES for energy generation is provided by the State Environmental Fund. [81] 2003 the Ministry of Environment spent an amount of about 9,9 million € for 74 projects related to renewable energy in this way.

6.8. Promotion scheme for Renewables

In accordance with the EU the Czech Republic agreed to increase the share of RES up to 5-6 % of TPES and renewable electricity to 8% of the electricity output by 2010.[82] To reach especially the second set out target the government approved the Renewable Act n. 180/2005.[83] Producers of green electricity may chose between fixed feed-in-tariffs for the utilization of RES only in power generation and green bonuses, which can be also applied to biomass co-firing plants.[84] The amount of the subsidy depends on the quality of the RES used for the process, but the tariff should be sufficiently high to guaranty a payback of the investments for the installation until the payments come to an end, that is within 15 years. The promotion scheme is expected to create 4000 new jobs in biomass production and approximately 23.000 more in related businesses.[85] On the other side the heat production with RES remains untouched by the new law, thus there is no incentive for making further use of the processing heat, like f.e. CHP. [86] Also the act does neither prevent the problem of

[79] European Renewable Energy Council, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF [Renewable Energy Czech Republic], 2004, p.12
[80] Compare: European Renewable Energy Council, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF [Renewable Energy Czech Republic], 2004
[81] Compare: Austrian Energy Agency, http://www.eva.ac.at/enercee/cz/index.htm [Energy Profile Czech Republic], 2004
[82] See: IEA, [Renewable policies and meassures, ČR], 2006
[83] See: Habart , J. and Šafařik, M., http://biom.cz/index.shtml?x=231689, [Provision for RES in ČR], 2005
[84] Compare: Knàpek, J., Interdisciplinary Winterschool Graz, [System Aspects of RES], 2006
[85] See: Habart , J. and Šafařik, M., http://biom.cz/index.shtml?x=231689, [Provision for RES in ČR], 2005
[86] Compare: Knàpek, J., Interdisciplinary Winterschool Graz, [System Aspects of RES], 2006

multiple subsidies for one project nor does it recognize difficulties that may arise at the end of the support payments for the green power plants in 15 years.

6.9. Czech Republic developments in RES

Various regions within the Czech Republic have developed differently in the utilization of RES. According to natural conditions wind energy can be utilized only at the borders close to the mountains.[87] The utilisation of biomass however cannot be located that easily. Středočesky is the region with the largest agricultural area. [88]Together with the region of Jihočesky, where the most perenial grass grows, the highest harvest of straw can be brought in. But not for this reason the regions with the greatest potential for the utilization of biomass are Vysocina, Kralovehradecky and Jihocesky in that order.

- Vysonica is experienced in the utilization of biogas from livestock and of wood residues. The region is reported to be very supportive in promoting energy generation with biomass and has several solid biomass plants as well as biogas plants operating.
- A huge boiler generating 67 TJ with biomass is in operation in Kraloveradecky. Additionally there have been feasibility studies for further installations with positive results in several municipalities but none of the proposed DH plants have been implemented yet.
- The people in Jihočesky may have the most experience in implementing and utilizing installations powered by biomass. Dešná and Hartmanice are situated here, the heating stations of them are known as the pilot schemes for renewable energy in Cech Republic.

6.10. Time to grow

The future of biomass in Czech Republic lies not so much in fuel wood but in energy crops. Agriculture has large areas of cultivated land to its disposal, is able to meet domestic demand of basic agricultural goods and has the capacity left for the production of biomass as RES.[89] With the proviso of sustainable development and crop rotation 1,5 mil. hectares of agricultural land for the growth of energy crops would be sufficient to reach the renewable target for 2010 and hold the level indefinitely.[90] The development of RES from the fields would strengthen the independence of the regions as the municipalities as well, support the agricultural sector in times of change and make efficient use of waste products.[91]

[87] See: Black & Veatch, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/Policy%20Review%20Czech%20Rep_engl.PDF, [EBRD Energy Country Profile, ČR], 2003
[88] Compare: Regional Environmental Center, http://www.kyomecha.org/pdf/REC_report_part2(DH+biomass).pdf, [DH and biomass], 2005
[89] See: Regional Environmental Center, http://www.kyomecha.org/pdf/REC_report_part2(DH+biomass).pdf, [DH and biomass], 2005
[90] See: Habart, J., http://www.biom.cz/index.shtml?x=823784, [Biomass Utilization in ČR], 2005
[91] See: OZE, http://www.env.cz/AIS/web-pub.nsf/8c74f8eb26f7d18bc1256d9d00498f4b/8b871b10fddf1a49c1256e7700365ab2/$FILE/OZE-english.pdf, [Potential for RES in ČR], 2003

6.11. Forecast

Even though the potential of biomass can be better used for heat generation than for electricity production, the second branch will experience more increase in utilization in Czech Republic than the first for the next 15 years. The reason for this lies in the crucial factor of financial support for the installation. The promotion scheme for RES utilization (Act n. 180/2005) offers subsidies for electricity production but not for heat generation with biomass.[92] This fits in nicely with the announced plans of the ČEZ power group to invest heavily in wind power generation and may attract others to go into green electricity. Whereas municipalities with regional untapped wealth's of biomass resources lack the amount of money even with the financial aid from the government (SEF) to replace their coal driven heating system with an efficient yet too expensive biomass boiler.[93]

Electricity from RES	2004 (GWh)	2010 (GWh) (roughly estimated)
Electricity from biomass total	560	2.200
_Co- combustion	_305	_600
_From pulp and paper industry	_200	_220
_Clear biomass combustion	_28	_1.180
_Biogas plant	_27	_200
Wind energy	20	930
Hydro power	1.986	2.320
Geothermal	0	15
Photovoltaic	0	15
Total RES	2.536 (4,2%*)	5.480 (8 %*)

Table 13: Production of Renewable electricity with Proposed Development to 2010[94]

*: share of renewable electricity to total electricity output in ČR

[92] See: Knàpek, J., Interdisciplinary Winterschool Graz, [System Aspects of RES], 2006
[93] See: Remrova, M., Mitteleuropäische%20Biomassekonferenz%202005/Vorträge/Remrova_long.pdf, [Small Scale Biomass Energy], 2005
[94] Source: Habart, J., http://www.biom.cz/index.shtml?x=823784, [Biomass Utilization in ČR], 2005, o.S.

7. Indices