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PRODUCTION AND ENERGETIC UTILIZATION OF BIOMASS FROM REWETTED PEATLANDS

ENERĢĒTISKĀS BIOMASAS RAŽOŠANA REKULTIVĒJAMĀS KŪDRAS ATRADNĒS UN TĀS IZMANTOŠANA

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Introduction

The strong increase of the worldwide energy demand, the predominant use of fossil sources and the known related consequences for the environment (e.g., acid rain, GHG emissions and global warming) and for national economies (e.g., dependency from energy source imports, increasing prices, competition between national economies to get the energy resources etc.) requires a structural change of the fossil source based energy economies towards to a sustainable energy economy. Increasing the share of renewable energy in the energy balance enhances sustainability and biomass is one of the most important renewable energy sources in

Europe. In Germany for example the biomass demand for energetic utilization (supported by governmental regulations like the German "Act on Granting Priority to Renewable Energy Sources" is increasing enormously. We recognize a raise of the prices and particulate regional shortages of biomass supply for Biomass CHP plants. On the other hand the renewable energy act created conditions for a lucrative use of biomass in co-generation power plants, so the biomass demand will continuously increase in the near future. Besides the classical biomass fuels, for example, such as wood, a new biomass sources must be made available to avoid bottle necks in the future.

Common reed (*Phragmites australis*) is such a promising biomass source. Common reed is a perennial and fast growing plant. The data to the biomass yield varies strongly in dependence of the cultivation location (3.6 – 43 t/ha). In the North-Germany lowlands, where nearly 20 percents of the agricultural areas are more or less degraded fens, often more than 15 *t /ha* dry matter of reed biomass can be produced. The use of such areas (used in the past predominant as grasslands for cattle breeding) is not in competition to the food or feed production, because in Germany cattle breeding decreased dramatically within the last decade. By that the federal state of Mecklenburg-Vorpommern has a surplus of about 800 thousand hectares of set aside grasslands [1].

Besides the necessary water regulation measures for conventional agricultural use are very cost intensive which cannot be covered by meat or milk production. To avoid damage and exhaustion of soil resources also the production of reed as energy source must proceed under attention of environmental and as well economic aspects. Furthermore, concerning an environment friendly utilization of reed as energy source a considerable demand for research and development exist. The R&D demand is caused by the difference in chemical composition, physical properties and partially due to the critical reaction behavior of reed as a solid fuel in relation to the classical solid biomass feedstock wood.

1. Reed Production on Rewetted Peatlands

Until now, most of the peatlands in Northern Germany are still managed as grasslands with low intensity to assert EC-money under minimal efforts. To meet EC-Cross Compliance (CC) conditions, it is necessary to mulch the grassland at least every second year. Due to the decrease in land-use pressure and the problems of conventional fen utilization, new concepts for environmentally compatible land use of former grasslands have received a growing attention. The rewetting of former peatlands and the transformation in a site for the production of biomass as energy source is such a new land use concept.

Northern Germany is covert with about 830 Thousand hectares of peat lands [1]. It is assumed that about ¼ of these areas could be rewetted without restrictions concerning shortages in water availability. These areas should be rewetted and used for the production of biomass as source for energy [6]. The rest should be continuously managed as grasslands for agricultural needs. On the rewetted areas a considerable dynamic of vegetation development will happen. The plant biomass, which growths after rewetting, is of different species and qualities. Depending on water regime, trophy level, seed potential and other factors, the development of the vegetation first leads to reed beds of Reed Canary Grass (*Phalaris arundinacea*), Sweet Reedgrass (*Glyceria maxima*), Common Reed, or Cattail (*Thypha spec*.), more

rarely to sedge (*Carex spec*.) reed-beds, but also to Grey Willow (*Salix cinerea*) shrubbery.

After rewetting the plant communities develops spontaneously, and the biomass can be harvested according to the intended use. Because of the productivity of such a site and the possible yield of biomass (see Table 1), the site adapted and sustainable use of rewetted peat lands for the production of biomass is an innovative and cost effective chance for agriculture. It's assumed that high productivity yields of about 10 - 15 tons dry biomass per hectare and year are possible and 2 Million tons dry biomass for the Energy production could be harvested from this peatlands in Northern Germany.

Table 1. Productivity of reeds and wetlands [7]

Species	Productivity
	t /ha per year
Common Reed (*Phragmites australis*)	3.6 .. 43.5
Cattail (*Typha latifolia*)	4.8 .. 22.1
Reed Canary Grass (*Phalaris arun*dinacea)	3.5 .. 22.5
Sweet Reedgrass (*Glyceria maxima*)	4.0 .. 14.9
Great Pond-sedge (*Carex riparia*)	3.3 .. 12.0
for comparison: Fallow wet grassland	6.4 .. 7.4
High-intensity grassland	8.8 .. 10.4

Another reason for the actual restoration measures of the governments of some federal states are environmental aspects and nature conservation plays an important role within the restoration programs of the federal states. The continuation of actual grassland use, connected with the drainage of the peat lands, brings huge amounts of CO^2 into the atmosphere. Rewetting aims to stop the process of peat decomposition, caused by the drainage activities. Future land use concepts on fen peat lands must meet the goals of international conventions (e.g. biodiversity convention or climate convention) and must orientate at the reduction of GHG emissions. These goals are achievable by rewetting of the peat soils with water levels at soil surface over the whole year. New peat forming conditions (natural carbon sinks) can be achieved by this. After rewetting of the former heavily drained eutrophic – polytrophic peat lands these areas have the potential to accommodate high productive Common Reed (*Phragmites australis*) and Reed Canary Grass (*Phalaris arundinacea*) stands [2]. These species can growth under very wet and ponded conditions naturally, but to accelerate the natural cover process it is also possible to cultivate Common Reed. As an alternative option also the cultivation and harvest of cattail (*Typha latifolia*) [3] and the afforestation of fens with black alder (*Alnus glutinosa*) [4] could be of interest.

Normally, the restored peatlands are not farmed and their further development occurs uncontrolled. The monitoring of the restoration process can avoid uncontrolled and unwanted effects of the nature conservation measures. Several sustainable land-use alternatives were tested during research projects within the last years. The restoration measures were aimed to avoid or minimize the negative environmental impacts of degraded fen peatlands.

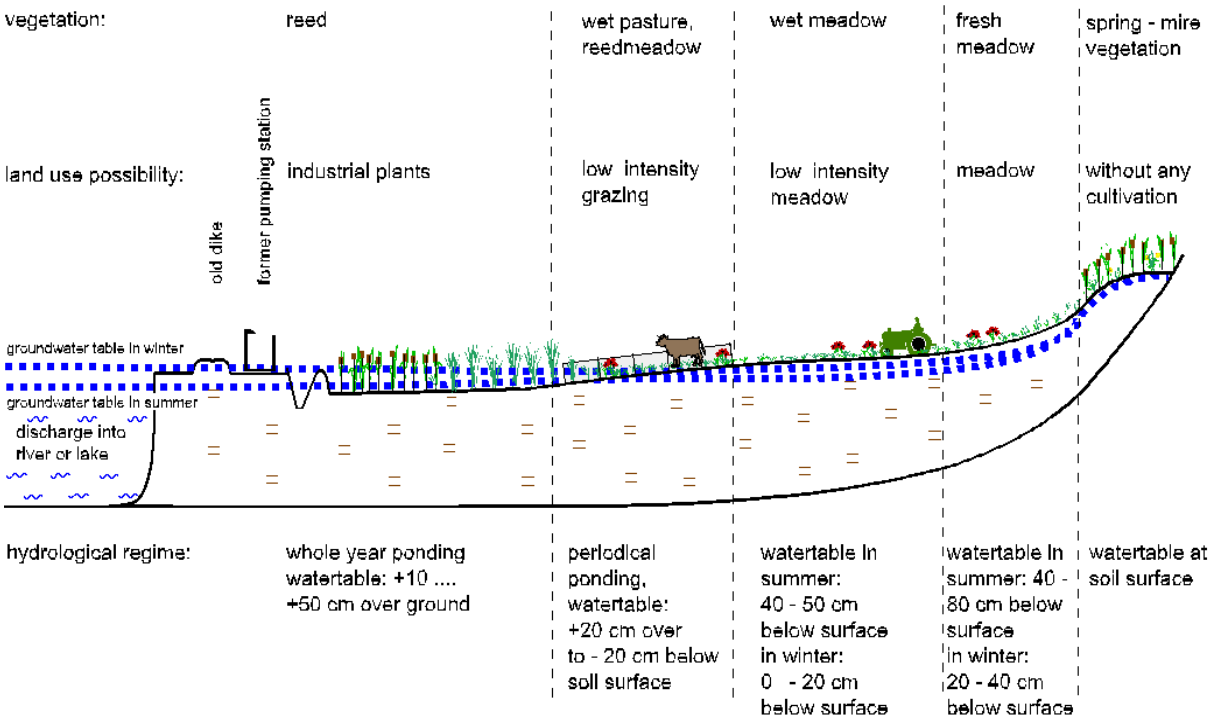

Figure 1. Suggestion for a sustainable land use of fens. Profile cross-section of a fen after restoration [5]

Farmers do not want to give up land use and accordingly do not feel up to allocate peat lands for restoration measures only since the implementation of acreage independent payments by the EC in 2005 which made subsidies independent on production. But beside EU payments the production of biomass can provide the farmers with an additional profit.

Harvesting the biomass from rewetted sites allows for sustaining their typical functions and has the following advantages:

Assessment of alternatives for site-adapted land use, adoption of new land-use concepts with minimal damage to the environment:

- Mitigation of CO_2-gas emissions;
- Fostering of peat-forming plant species, restoration of the sink function, e.g. for carbon and nitrate;
- Restoration of habitats for mire key-species, improvement of the habitat function;
- Production of raw materials for energetic and industrial uses;
- Nutrient removal from ground- and surface waters;
- Revitalization of traditional land uses combined with new ways of processing.

2. Characterization of common reed as fuel

Biomass feedstock's distinguish between each other in a wide range and also exhibit a great difference towards solid fossil fuel. The essential difference is expressed by the heating value (LHV) and the elementary composition of the feedstock. The results of the proximate- and ultimate-analysis of common reed are shown in Table 2, were for comparison also values for other potential biomass fuels and fossil fuels are illustrated.

Table 2. Comparison of fuel analysis for biomass samples and fossil fuels [9]

Feedstock	LHV [*MJ/kg*]	Volatile [%]	Ash [%]	Ultimate analysis (*mf)* in %					
				C	*H*	*N*	*O*	*S*	*Cl*
Fossil fuels:									
hard coal	31,8	38,8	6,3	79,4	5,1	1,5	6,6	1,0	<0,2
brown coal	27,0	55,0	7,6	68,4	5,5	1,8	15,4	1,3	-
Biomass fuels:									
common reed	17,7	66,8	8,8	46,5	5,9	0,3	42,5	0,14	0,16
miscanthus	17,8	81,0	2,7	47,2	6,5	0,7	41,7	0,13	0,23
pine wood	18,7	84,0	0,3	50,9	6,6	0,2	42,0	0,02	0,01
wheat straw	17,1	79,6	5,3	46,7	6,3	0,4	41,2	0,1	0,4
grain straw	17,5	80,1	4,6	47,0	6,2	0,4	41,7	0,1	0,34
maize straw	16,8	-	5,3	45,6	6,4	0,3	43,3	0,04	0,16
rape straw	17,0	78,7	6,5	48,3	6,3	0,7	38,0	0,2	-

The LHV of common reed is significant lower than the heating value for fossil fuels and requires higher fuel inputs for the same energetic output (which is generally valid for all solid biomass fuels). However, compared to other biomass fuels the relative high value of LHV = 17,7 *MJ/kg* indicates that reed is an promising energy source.

The nitrogen content is very low so that no problems concerning nitrogen oxide emissions were expected (for biomass combustion processes only the formation of *NOx* from fuel nitrogen is important, the formation of thermal *NO* occurs only at high temperatures to a great extent and plays during biomass combustion a minor role).

Compared to pine wood the higher contents of chloride, sulfur and ash might cause problems regarding emissions and process management if the reed is used in conventional combustion technologies. Sulfur and chlorine are air-polluting relevant elements. During combustion these elements mainly convert to *SOx* and *HCl*. Especially the chloride content could increase the risk of Cl-corrosion.

3. Orientating small scale combustion examinations in a 50 kW boiler

The aim of the small scale combustion examination was to convert the chemical energy of the reed (indicated by the LHV) into thermal energy of the flue gas as complete as possible to minimize any losses. Furthermore the ecological operation of the combustion technology is the most important criteria for the evaluation in order to keep within the emission limits. A Biomass Boiler, Typ "SOLARFOCUS therminator" with a capacity of 50 *kW* was used for the combustion experiments (see Fig.2). This boiler is part of the biomass combustion test facilities at the Laboratory for Integrated Energy Systems and after modifications applicable for different biomass fuels like firewood, briquettes, pellets and wood chips.

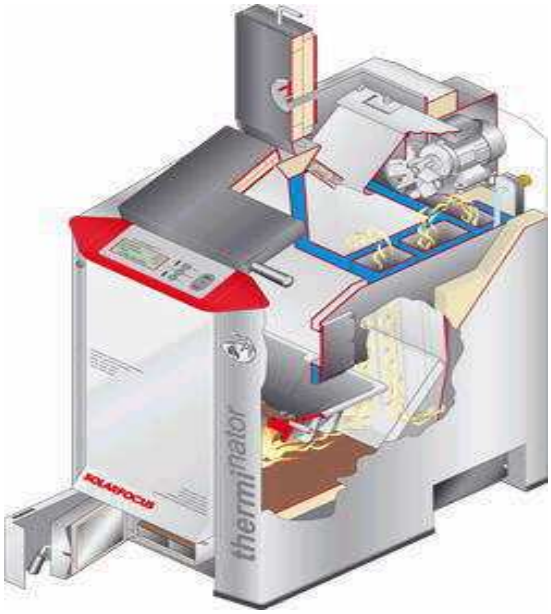

Figure 2: Biomass Boiler, Typ "SOLARFOCUS therminator"

The reed was used in form of small bales (see Fig. 3) and reed chaff (see Fig. 4).

Figure 3. Small reed bales

Figure 4. Reed chaff

The results of the first orientating examinations in the small scale application indicated that common reed can be used as biogenious fuel. Tab.3 shows the results of the exhaust gas analysis.

Table 3. Results of the exhaust gas analysis – common reed combustion, [8]

Flue gas component	Average value	Maximum value
CO	220 *ppm*	321 *ppm*
NO	200 *ppm*	263 *ppm*
O^2	9 *Vol%*	7 *Vol%*
CO^2	11,5 *Vol%*	13,4 *Vol%*

The used reed was harvested in March 2005 (in Hungary) so that the potassium content of the fuel is already low. Examinations of the ash melting

behavior showed that the ash melting point (which is directly related to the potassium content in the biomass fuel) is above 1420 °C. No ash slagging was recognized in the combustion chamber.

Because of the rigid structure of the blades of reed and the high ash content of nearly 9 % the ash can block the fixed grate of the furnace and thus interfere the air supply and the exchange of the reaction products. It was necessary to riddle the fire bed each 15 minutes to ensure a continuous operation the test facility.

Figure 5: Fire bed during reed chaff combustion

Figure 6: fine and coarse ash fraction

An unwanted effect of riddling the fire bed is that considerable amounts of unburned reed have been moved to the ash chamber. Figure 6 illustrate the different ash fractions found in the ash chamber. Especially the coarse ash fraction contains a considerable amount of unburned carbon (see Table 4.).

Table 4. Carbon content in the ash fractions [9]

	Fine ash fraction	Coarse ash fraction
Share of the fraction in %	89,1	10,9
Carbon content in %	1,0	53,11

The resulting low total fuel utilization of only 93,3 % doesn't satisfy the requirements of an environment friendly combustion (convert the chemical energy as complete as possible into thermal energy) and optimization measures are required.

4. Conception for commercial reed utilization

To be able to estimate the possibility of a commercial use of reed as energy source small scale examinations are insufficient. Furthermore, the combined generation of heat and power is of particular interest, caused by economic conditions defined in the German Renewable Energy law (fixed price electricity purchase for electricity generated from renewable sources). Operators of Biomass CHP plants evince a great interest to make new biomass sources available. Within the framework of the cooperation project "ENIM", the industrial partner (GMK - Gesellschaft für

Motoren und Kraftanlagen mbH) will provide a power plant for large scale combustion examinations.

Development, planning, construction and operation of power plants are the main business fields of GMK and they have set up more than 20 biomass CHP plants, among these the first biomass power station with ORC-cycle technology in Mecklenburg Vorpommern which one will be used for the commercial tests runs. Since 2001 this power plant (see Fig. 7) is in operation and wood chips are used as fuel for the combined heat and power generation.

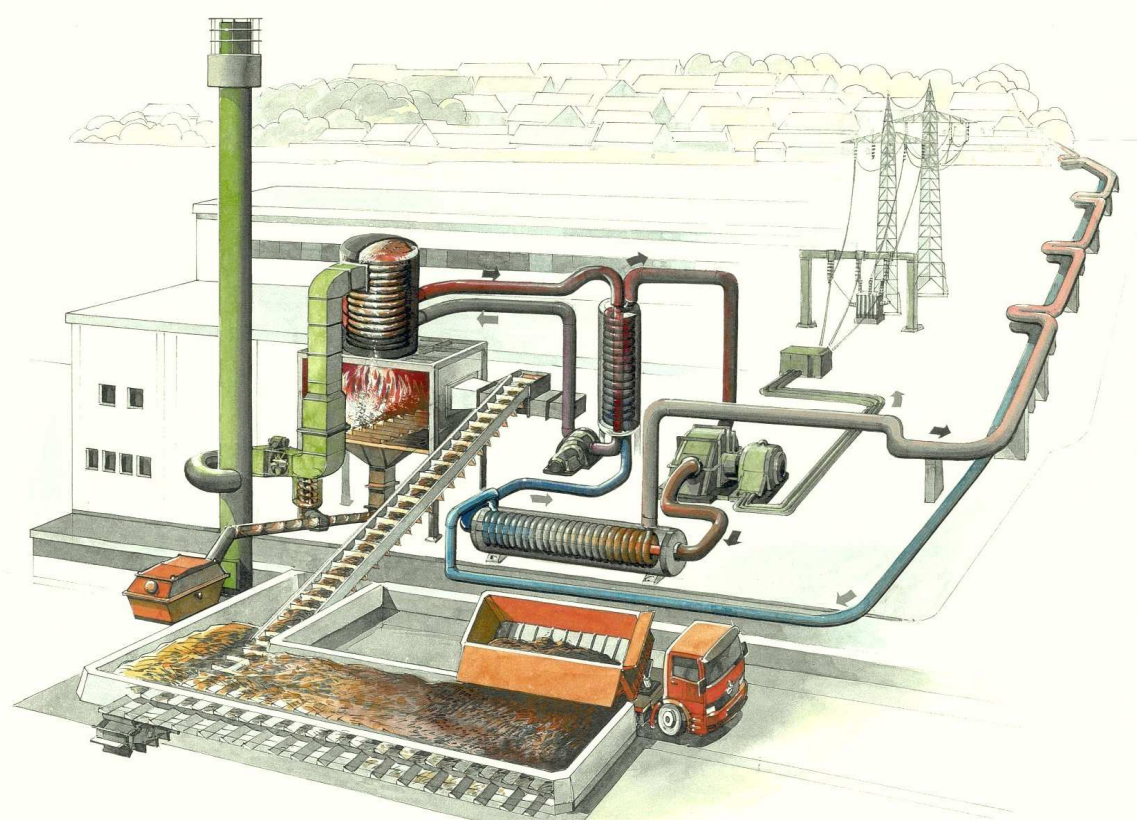

Figure 7. ORC-cycle biomass power plant in Friedland, planned, constructed and operated by GMK

Examinations for the commercial utilization of common reed will proceed under commercial conditions. For this purpose the reed will be used at first in various mixtures with wood chips. If procurable the share of reed will be raised in relation to wood chips to the point off 100 % reed utilization. The agricultural partners of the ENIM project will ensure the fuel supply with common reed during the test runs and for further operation of the power plant.

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Barz M., Ahlhaus M., Vendelin W., Timmermann T., Enerģētiskās biomasas ražošana rekultivējamās kūdras atradnēs un tās izmantošana

Tāpat kā daudzi citi biomasas kurināmā veidi, parastā niedre (Phragmites australis) tiek uzskatīta par perspektīvu bioenerģijas veidu. Projekta ``ENIM`` ietvaros sadarbības partneri no zinātniskajām iestādēm, rūpnieciskajiem un lauksaimniecības uzņēmumiem attīsta integrētu procesu rekultivētās kūdras atradnēs iegūstamo parasto niedru izmantošanai kombinētai siltuma un elektroenerģijas ražošanai ar biomasu darbināmās koģenerācijas (CHP) stacijās. Tiek pētīti ekoloģiski saderīgi niedru ražošanas, novākšanas un nepieciešamās loģistikas risinājumi ar gala mērķi pielāgot koģenerācijas stacijas komerciālai niedru izmantošanai enerģētikā. Projektu atbalsta Vācijas Federālais Vides Fonds (DBU), un tā realizācija dos lielu ieguldījumu ilgtspējīgā, ekoloģiski tīrā zemes izmantošanā un videi draudzīgā energoekonomijā.

Barz M., Ahlhaus M., Wichtmann W., Timmermann T. Production and Energetic Utilization of Biomass from Rewetted Peatlands

Among other biomass fuels, common reed (Phragmites australis) is considered as a promising source for Bioenergy. Within the project "ENIM" partners from science, industry and agriculture develops an integrated process to use common reed from rewetted peatlands for the combined heat and power generation in a biomass CHP plant. Ecologically compatible solutions of the reed production and harvesting will be investigated, the necessary logistic will be developed and finally the process of the power plant will be adapted for the commercial utilization of reed as fuel. The project is supported by the German Federal Environmental Foundation (DBU) and will contribute to a sustainable and ecological land use and an environment friendly energy economy.

Barz M., Ahlhaus M., Wichtmann W., Timmermann T. Производство и энергетическая утилизация биомассы из рекультивируемых торфяников

Среди других видов биотоплива, тростник (Phragmites australis) рассматривается как многообещающий источник биоэнергии. В проэкте "ENIM" участвуют люди из разных сфер деятельности - науки, промышленности и сельского хозяйства, стремящиеся развивать комплексный процесс использования тростника из отработанных торфяников, для одновременного производства тепла и электричества в когенерационной электростанции, использующей биомассу. Экологически совместимые решения тростникового производства и сбора урожая будут исследованы, развита необходимая логистика иб наконец, тенологический процесс электростанции будет приспособлен для коммерческой утилизации тростника в качестве топлива. Проект поддерживается Немецким Федеральным Экологическим Фондом (DBU), и будет способствовать стабильному, экологическому использованию земельных участков и дружественной по отношению к окружающей среде экономии энергии.