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Production of biomass in wet peatlands (paludiculture).

The EU-AID project ‚Wetland energy' in Belarus – solutions for the substitution of fossil fuels (peat briquettes) by biomass from wet peatlands

Abstract: *In Belarus, a pilot project demonstrating site adapted management of wet peatlands for biomass production have started recently. In cooperation with local stakeholders, the currently environmentally unfriendly peat extraction for energy will be converted into a sustainable land use system. By replacing the peat briquettes with locally produced briquettes using biomass from rewetted peatlands the income situation of remote and rural areas will be improved. In various combustion trials of peatland biomass in Germany and Belarus the suitability of the material for energy production has been demonstrated. The EU-Aid funded project in Belarus is realized by the Michael Succow Foundation in cooperation with the International Sacharov Environmental University (ISEU) and the Institute for Nature Management of the National Academy of Sciences (IfNM).*

Applied, site-specific management concepts, employing site adapted machinery for reed and sedge vegetation on wet peatlands will not only result in avoidance of environmentally harmful peat extraction, but also in benefits for distinctive biodiversity. This site adapted peatland management (paludiculture) comprises the reduction of greenhousegas (GHG) emissions by rewetting of drained peatlands and by the replacement of fossil fuels by biomass from these sites. Under favourable conditions additionally CO_2 sequestration by new peat formation reestablishes. The biomass will be harvested with site adapted machinery and processed to fuel briquettes.

Zusammenfassung: *In Weißrussland werden zwei Pilotstandorte für die Bewirtschaftung nasser Moore (Paludikultur) aufgebaut. In Kooperation mit lokalen Akteuren soll die derzeitig nicht umweltgerechte Nutzung von Mooren in ein nachhaltiges Landnutzungssystem überführt werden. Fossile Energieträger (Torfbriketts) werden durch Paludibiomasse ersetzt und neue Erwerbsmöglichkeiten im ländlichen Raum werden erschlossen. Die Michael Succow Stiftung arbeitet mit der „International Sacharov Environmental University" (ISEU) und dem „Institute for Nature Management" der Akademie der Wissenschaften, Weißrussland (IfNM), zusammen, gefördert durch EU-Aid.*

An praktischen Beispielen werden Perspektiven für die Bewirtschaftung nasser Moore, die früher sporadisch zur Streu- und Heuwerbung genutzt oder zur Energietorfgewinnung abgetorft wurden, entwickelt. Diese Flächen würden anderenfalls verbuschen und damit als Brutbiotop für z.B. Seggenrohrsänger oder als Jagdrevier für den Schelladler verlorengehen. Der Aufbau und die Optimierung einer Ernte- und

Verarbeitungskette für Biomasse aus nassen Mooren ist vorgesehen. Die Biomasse wird mit angepasster Spezialtechnik geerntet und zu Energie-Briketts verarbeitet. Voruntersuchungen haben gezeigt, dass die Biomasse für eine thermische Verwertung gut geeignet ist.

1 Introduction

Based on earlier successfully implemented peatland rewetting projects in Belarus (Tanneberger & Wichtmann 2011) and biomass-related expertise of Michael Succow Foundation and Greifswald University, this project deals with the sustainable utilisation of wet or rewetted peatlands (paludiculture).

1.1 Land use on peatlands

In Central Europe organic soils are at present usually managed as pastures and meadows under intensively drained conditions. The harvested biomass is used for hay or silage, either as fodder for dairy cows or for supplying biogas plants. Drainage based agricultural peatland utilisation is connected with several negative aspects: Peat oxidation, shrinkage and subsidence of the soil lead to nutrient losses to ground and surface waters and to GHG emissions to the atmosphere (Wichtmann & Wichmann 2011) as well as environmental impacts by smoke and GHG emissions from peatland fires (Parish et al. 2008).

Vast areas of cultivated and extracted peatland have been abandoned due to economic non-viability of traditional management concepts under present production and market prices, but are still drained and cause signifikant emissions of GHGs. Several scientific publications show that rewetting drained peatlands will substantially reduce the GHG emission (especially CO_2 and N_2O, e.g. Couwenberg et al. 2011). Röder and Osterburg (2011) propose to abandon peatland areas which are in agricultural use after rewetting for a cost-effective reduction of GHG emissions. But rewetting does not necessarily imply that the area is left to natural development and lost for any future agricultural use. The challenge is to combine both – the reduction of emissions and the continuation of agricultural use, ultimately resulting in income generation for the rural population.

1.2 Paludiculture

Paludicultures (from Latin ‘palus’ = swamp) use biomass from wet and rewetted peatlands under conditions which maintain the peat body, facilitate peat accumulation and provide the ecosystem services associated to natural peatlands. Paludicultures use only the share of net primary production that is dispensable for peat formation. In zones of the world where plant productivity is high enough, peat is generally formed by roots and rhizomes and peatlands by nature hold vegetation of which aboveground parts can be harvested without substantially harming peat formation (Wichtmann & Joosten 2007). Paludicultures comprise any biomass use from wet and rewetted peatlands, from harvesting spontane-

ous vegetation on natural sites to artificially established crops on rewetted sites (Joosten et al. in prep.).

By combining peatland rewetting with biomass production (paludiculture), the area is not abandoned after rewetting and diversifies the local income situation in often marginal regions. Agricultural or silvicultural use can continue under sustainable, site adapted wet conditions. Additionally, paludicultures can contribute to avoid GHG emissions if rewetted peatlands are used for the production of biomass to replace fossil raw materials and fossil fuels (Wichtmann & Joosten 2007).

1.3 Paludiculture land use options

Options for paludiculture on rewetted peatlands with commercial potential have a wide range from traditional agricultural uses, fodder and fertilizer, to production of industrial raw materials, and fuel production (Wichtmann & Tanneberger 2009). Besides traditional yields of food, feed, fibre, and direct combustion, the biomass can be used as a raw material for industrial biochemistry, for producing high quality liquid or gaseous biofuels and for further purposes like extracting and synthesising pharmaceuticals and cosmetics (Joosten et al. in prep.).

In recent years various options for site adapted land use on wet and rewetted peatlands have been developed and tested. Some of them revitalize traditional forms of land use through new utilization schemes, e.g. reed cutting instead for the production of roofing material for new developed construction materials like insulation panels. Other traditional low intensity or soft uses include hunting and fishing (Wichtmann & Tanneberger 2011). Furthermore biofuels provide innovative products for growing demands on the market. In all these concepts a mean water level constantly close to the soil surface must be realised.

2 Framework of the project

The project is implemented in close cooperation with the International Sacharov Environmental University (ISEU) and the Institute for Nature Management (IfNM) of the National Academy of Sciences, Belarus. Other departments of the National Academy of Sciences, Belarus, the University of Greifswald and the Centre for Agricultural Landscape Research (ZALF) in Müncheberg are involved in the project. Practical activities are combined with scientific assessments of ecological site characteristics, biomass properties, and economic viability. The project is funded by the EU-Commission in the frame of the EU-Aid programme ‚Environmental protection and sustainable utilisation of natural resources including energy''.

2.1 Goals and tasks of the project

Two pilot sites for paludiculture in Belarus will be established in the project frame. In cooperation with local stakeholders (zakaznik, peat factory kolkhozes, local

energy supplier) the present unsustainable peatland utilisation, in social, economical, and ecological respect shall be developed towards a sustainable land management. The major aim is the production of biomass briquettes in paludiculture for the substitution of fossil fuels and generation of rural income perspectives.

Applied, site-specific management concepts for reed and sedge vegetation on wet peatlands will not only result in avoidance of environmentally harmful peat extraction, but also in benefits for characteristic biodiversity. Without management the envisaged sites would successively encroach with shrubs and therefore be lost as breeding habitats (e.g for the aquatic warbler) or hunting habitats (e.g. for the greater spotted eagle). The biomass will be harvested with site adapted machinery and processed to fuel briquettes.

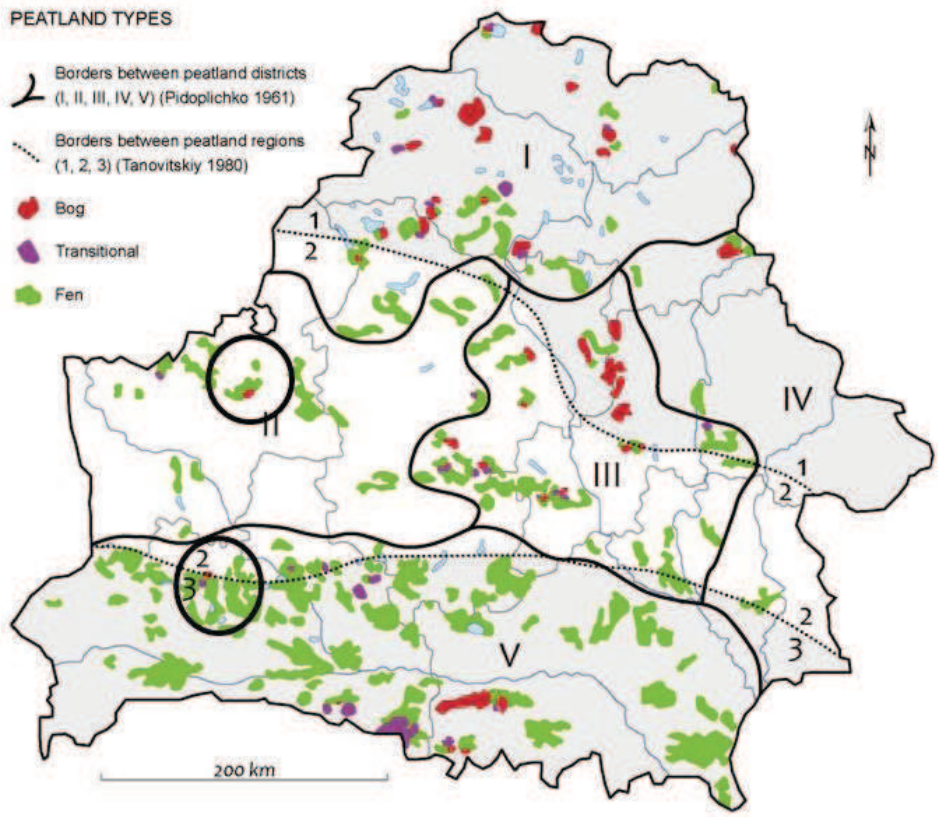

Fig. 1: Distribution of peatland types in Belarus (from Tanneberger & Wichtmann, 2011) and location of sampling sites (circles) Dokudovskoe (north) and Sporava (south).

Such site adapted machinery will be used at Sporava peatland in Southern Belarus starting in 2012 on approximately 500 ha annually. Here, mowing machinery, drying and milling facilities as well as briquetting equipment has been installed by an earlier project (Tanneberger & Wichtmann 2011). Within the EU Aid project, experience in paludiculture will be enlarged from near-natural, wet fens (Sporava) to rewetted, excavated sites. Harvesting machinery will be improved and another harvesting machine will be newly developed, based on the Belarus experience and Belarusian technology.

In Belarus, more than half (1 505 000 ha) of the total of 2 939 000 ha of peatland (= 15 % of the total land area) has been drained (Tanovitskaya & Bambalov, 2009) (see Fig. 1 for distribution of peatlands). More than 70 % (1 085 200 ha) are currently used for agriculture. Large areas of strongly and slightly drained peatland have been abandoned within the last twenty years. A recent assessment (Tanovitskaya 2011) indicates that in total 530,120 ha of drained Belarusian peatlands have a potential for rewetting, including 255,600 ha of peatlands after peat extraction, 24,000 ha of degraded peatlands ineffectively used for forestry, and 250,520 ha of degraded peatlands ineffectively used for agriculture. A large share of this area should be suitable also for paludiculture.

2.2 Characteristics of investigation sites

Potential yields and biomass characteristics at one abandoned wet fen site (Sporava) and one rewetted, former peat extraction site (Dokudovskoe) have been studied by an earlier project (Wichtmann & Tanneberger 2009).

2.2.1 Sporava

The Sporava peatland is located in the Brest region, Beriosa district. It is situated in the floodplain of the Yaselda river, constituting one of the largest, least modified floodplain mires in Belarus and Europe (~20.000 ha). The vegetation is dominated by sedge communities and wet meadows, with associated reedbeds, willow thickets and agricultural grasslands. The area is partly used for haymaking and cattle grazing. Large parts of the peatland have been abandoned through the last 20 years. The current water management seems to be beneficial for the site (Wichtmann & Tanneberger 2009).

The site comprises an extensive area of suitable breeding habitat for the globally threatened Aquatic Warbler (Acrocephalus paludicola) and an internationally significant proportion of the Caricetum elatae vegetation community (Wichtmann et al. in prep.). Today, the site is in dire need of vegetation management. Overgrowing with bushes is enormous and fast with an estimated annual rate of 5% loss of open mire habitat, presumably rather accelerating (Wichtmann & Tanneberger 2009).

2.2.2 Site characteristics Dokudovskoe

Dokudovskoe peatland is located in Grodno region, Lida district. It is partly extracted. The overall peatland area is 7,811 ha, the area of the depleted site area 3,583 ha. It is planned to rewet the extracted parts of the peatland by the peat factory successively. The current water level in the degraded peatland is 1.2-1.5 m below soil surface. Peat fires occur frequently. The sampling took place in an excavated area (about 100 ha), rewetted about 15 years ago. On this site large reedbeds develoed after rewetting.

The site complies with the situation how other excavated areas will look like 5 to 15 years after rewetting. The overall goal at this site is to show whether a change from peat as a raw material to biomass from rewetted peatlands would be feasible. This could be a signal for all other 33 peat factories in Belarus and could, on the long run, show the way out of the utilization of peat as a fuel (Wichtmann & Tanneberger 2009).

3 First results from preliminary investigations

Both sampling sites are representative for a large part of the Belarusian peatlands. Representative sampling has been made to obtain first ideas on potential biomass yields and biomass qualities for these sites (eight subsites of 0.25 m^2 per sample). At Dokudovskoe only Common Reed (*Phragmites australis*) dominated stands have been sampled. At Sporova additionally Reed Canary grass (*Phalaris arundinacea*) and Sedge (*Carex spec.*) dominated sites have been investigated. In 2009 sampling took place mid of March under spring like conditions, in 2010 the sites have been sampled end of March/beginning of April under frost conditions and snowfall (Wichtmann et al. in prep.).

3.1.1 Results for biomass yields

The yields of biomass from the investigated sites differ by species dominating the vegetation (Reed, Reed Canary Grass or Sedges) and by year of sampling. The lowest mean values have been obtained for Sedges in Sporova 2009 (7 t DM/ha). The highest yields in Table 1 are also for Sedges at the same sampling site, but in 2010. In this case the sampling conditions must be considered (ice covering the area, snow falling during sampling) so that only some portions of the biomass could be sampled at only two subplots.

Table 1: Biomass yields on sampling site from Reed in Dokudovskoe (D) near Lida and from Reed Canary Grass (RCG) Sedges and Reed from Sporova (S). Mean yield (t DM/ha) and standard deviation (SD) are given. Sampling in 2009 and 2010 (Wichtmann et al. in prep.)

Site/year	2009		2010	
	Mean	SD	mean	SD
Reed (D)	11.7	5.9	7.3	4.8
RCG (S)	9.6	1.9	3.8	4.0
Sedge (S)	7.0	1.9	31.1	7.7
Reed (D)	9.8	3.9	5.9	7.5

Average yields of about 12.5 t of dry Reed biomass per hectare and year were found for sites surveyed in eastern Germany (Wichmann & Wichtmann 2009). Much lower yields were obtained during studies of Kask et al. (2007) in Estonia. Different site conditions (medium water tables, nutrient conditions, ecologi-

cal type of Reed) may be responsible for the differences. This will be further studied within the project.

3.1.2 Results from laboratory analyses

Samples have been analysed for parameters relevant for the thermal utilisation of the biomass like Nitrogen, Carbon, Phosphorus, Sulphur, Chlorine and ash content (see Table 2).

Table 2: Results of analysis of main relevant components of biomass from both pilot sites: from Reed in Dukodovskoe (D) near Lida and from Reed Canary Grass (RCG), Sedges and Reed from Sporova (S), (Wichtmann et al. in prep.) in % DM

	N		C		P		S		Cl		Ash	
Site/year	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Reed (D)	0.43	0.65	46.94	46	0.03	0.04	0.09	0.1	0.014	0.034	4.1	4.4
RCG (S)	0.61	0.95	46.7	46.74	0.06	0.073	0.13	0.12	0.012	0.014	4.3	3.0
Sedge (S)	0.72	0.99	47.07	46.02	0.06	0.075	0.1	0.13	0.013	0.026	5.3	5.6
Reed (S)	0.49	0.7	46.62	45.52	0.04	0.035	0.09	0.11	0.046	0.05	4.6	5.7

Results of the ultimate analysis (average values) of biomass from the study sites in Belarus are shown in Table 2. The nitrogen content is very low so that no problems for combustion of these biomasses concerning nitrogen oxide emissions are expected. Compared to pine wood the higher contents of Chlorine, Sulphur and ash might cause problems regarding emissions and process management if the reed is used in conventional combustion technologies (Barz et al. 2012). Sulphur and Chlorine are air-polluting elements. During combustion these elements mainly convert to SO_x and HCl and may be responsible for corrosion of smoke conducting tubes. Their concentration in the biomass is rather low. The values for ash content of the different biomass samples vary in range between 3-5.7 % which is in the same range as the values for straw or miscanthus but not as low as values obtained for wood (Barz et al. 2012). Ongoing project investigations will further elucidate these issues.

3 Conclusions

The biomass from wet and rewetted peatlands is a promising option, beyond the scope as alternative energy resource in Belarus, that needs further investigation. With the EU-Aid-project sustainable peatland utilisation concepts will be tested and improved as alternatives for the present ecologically and environmentally questionable management. Fossil energy (peat briquettes) will be substituted by bio-fuels. New options for income generation in rural areas will be opend up. Adapted land use on abandoned wet meadows for bio fuel production will be reinstalled to prepare them as habitats for bird species like Aquatic Warblers and hunting grounds for Greater Spotted Eagles.

Paludiculture fosters income generation from primary production where previously a often subsidy oriented, non-sustainable land use of drained peatland took place. Income e.g. from selling fuel briquettes may cover costs for production, relating to harvesting and processing of the biomass. Most paludiculture activities fall into autumn or winter, traditionally low workload bearing seasons for agricultural entrepreneurs. In such a situation, employees may be kept in work and additional jobs could be generated, dependent on the level of biomass processing and value creation.

The obtained figures for yields of biomass and biomass quality make optimistic and show that the biomass is suitable for production of energy fuels. The EU-AID project will give more data and broaden the basis for further realistic assumptions on sustainable biomass use from wet and rewetted peatlands in Belarus.

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