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LIFE CYCLE ASSESSMENT OF ENERGY BIOMASS FROM REWETTED PEATLANDS

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SUMMARY

Using a life cycle assessment approach, the energy demand and greenhouse gas emissions of energy crop production on rewetted peatlands were estimated. The results show that the primary energy consumed during the analysed life cycles is small compared to the energy content of the biomass. If hard coal is substituted by biomass from rewetted peatlands, between 82 % and 92 % of the greenhouse gas emissions and between 70 % and 83 % primary energy depletion can be avoided.

The substitution of hard coal by biomass from rewetted peatlands as fuel in power plants offers a promising potential to reduce primary energy depletion and greenhouse gas emissions.

KEY WORDS: Paludiculture, life cycle assessment, energy biomass, land use, rewetted peatlands

INTRODUCTION

Agriculture and forestry on drained peatlands are connected to numerous negative impacts on the environment. These include greenhouse gas emissions, nutrient leaching and the loss of biodiversity. Restoration of drained peatlands can reduce these impacts (Succow and Joosten, 2001; Parish et al., 2008).

Rewetting of drained peatlands does not exclude continued land-use. Vegetation established after rewetting can be managed with adapted techniques. The cultivation of biomass on wet and rewetted peatlands, so-called paludiculture (latin 'palus' = swamp), is a sustainable alternative to drainage based peatland agri- and silviculture. Biomass from paludiculture (paludi-biomass) is, depending on the type of crop cultivated, suitable for energetic and material utilisation or can be used as food and fodder (Wichtmann and Joosten, 2007).

The need of specialized machines and techniques to realise harvesting under wet conditions and low energy density of gramineous biomass, suggests increased energy consumption during harvest, transport and utilisation of paludi-biomass compared to fossil fuels and other biomass. This leads to the question of whether the energetic use of paludi-biomass is a reasonable alternative to fossil fuels.

Present studies concerning this subject are based on rough estimations (Hunston Engineering Ltd., 2006; Wichmann and Wichtmann, 2009; ELP and Ash, 2010). This paper presents the results of a screening life cycle assessment for energy biomass from rewetted peatlands. The focus is on energy and greenhouse gas balances for Reed Canary Grass (*Phalaris arundicea*) and Common Reed (*Phragmites australis*) from harvest to combustion.

MATERIALS AND METHODS

Using a life cycle assessment (LCA) approach, largely following the guidelines of the ISO standards 14040 and 14044 (ISO, 2006a; ISO, 2006b), energy demand and greenhouse gas emissions of energy crop production on rewetted peatlands were evaluated. The study considers Reed Canary Grass (RCG) and Common Reed (CR) which are common plants growing on wet and rewetted peatlands (Wichmann and Wichtmann, 2009).

The following assumptions are made: RCG and CR round bales are harvested by using adapted grassland machinery (scenarios RCG 1, RCG 2, CR 1). In scenario CR 2 chopped Common Reed is harvested by a tracked vehicle. The yield is 5 t dm $(ha\ a)^{-1}$ (RCG) respectively 10 t dm $(ha\ a)^{-1}$ for CR. The heating value (H_u) is 16,5 for RCG biomass and 17,5 GJ $(t\ dm)^{-1}$ for CR (see Schröder et al., 2012). The round bales are dried with heated air in a bale drying machine whereas the chopped biomass is dried by ventilation only. In addition scenario RCG 2 and CR 2 include local pelletizing of the biomass. The processed biomass is transported over 125 km (RCG) respectively 75 km (CR) which is the assumed patch of the 600 MW hard-coal-fired power plant where 10 % of the biomass is co-fired. Before combustion, further energy is needed to mill the biomass.

The life cycle being described in the previous paragraph will be compared to conventional hard coal combustion. Fig.1 depicts the life cycle steps and the basic life cycle comparison presented in this paper exemplary.

The life cycle comparison considers photosynthesis, harvest, drying, processing, transport and fuel processing at the power plant as well as combustion and ash disposal.

The greenhouse gas and energy balances contain credits for the photosynthesis in which CO_2 is withdrawn from the atmosphere and solar energy is converted to chemically bound energy during the growth of the biomass. The substitution of hard coal by paludi-biomass avoids greenhouse gas emissions and depletion of energy carriers caused by the firing of hard coal and its upstream chains. These savings are also credited within the life cycle comparison.

The study uses data from the database GEMIS (2010). It includes emissions and energy consumption of products and processes and their upstream chains. Data for Germany in the year 2010 is used. Modelling of machines and processes are realised as proposed in Borken et al. (1999). Yields and biomass properties as well as aspects of the product system are taken from Wichmann and Wichtmann (2009). The study refers to the amount of fuel providing 1 GJ energy. The impact categories assessed are primary energy of energy carriers used as fuel (GEMIS, 2010) and global warming potential with a time horizon of 100 years (Forster et al., 2007).

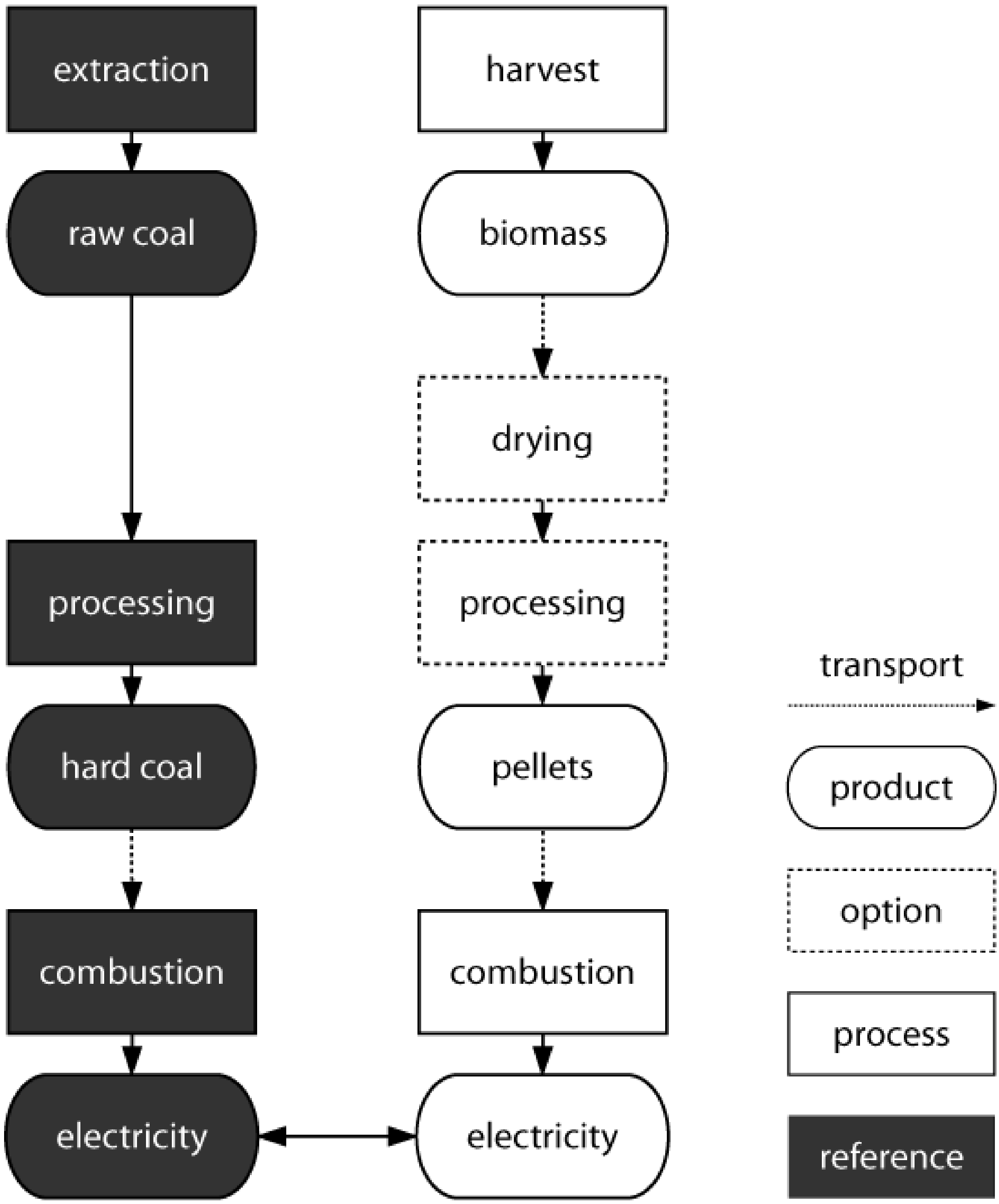

Fig. 1. Basic steps and principles of the life cycle comparison. The considered life cycle steps of hard coal (left) and biomass from paludiculture (right) are illustrated.

RESULTS

The results show that the primary energy consumed during the analysed life cycles is only a minor part of the energy chemically bound in the biomass. Energy consumption and greenhouse gas emissions follow similar patterns.

Heated air drying causes the highest expenses during the life cycle path. 15 % of the energy content of the biomass is needed for warm air drying. Pelletizing consumes energy which equals about 10 % of the biomass energy. Expenses for harvest and transport of the biomass are relatively small. If drying is not considered, baling the biomass is superior to pelletizing. The reduced primary energy demand and greenhouse gas emissions during transport of pelletized biomass cannot compensate for the efforts of pellet production. However, drying is the crucial factor determining the life-cycle comparison. The significantly lower demands of cold air drying in scenario SR 2 leads to the highest savings of all scenarios despite pellet production. Fig. 2 shows the primary energy consumption and greenhouse gas emissions connected to single life cycle steps.

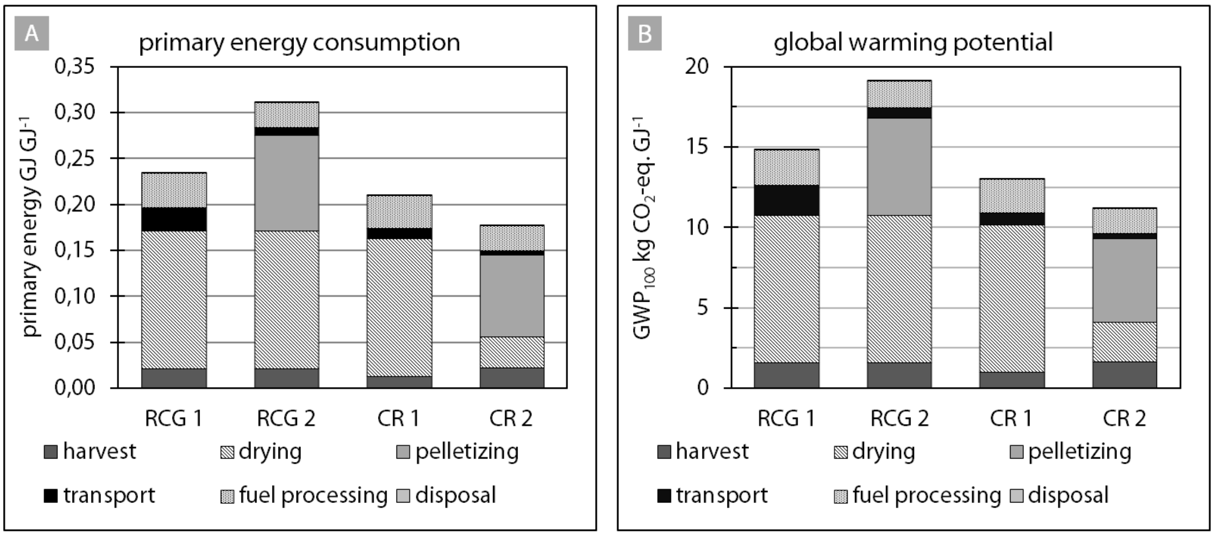

Fig. 2. Primary energy consumption (A) and global warming potential (B) differentiated by scenario and life cycle stages. For clearness combustion is not depicted (see Fig. 3).

The utilisation of paludi-biomass leads to considerable less greenhouse gas emissions and fossil fuel depletion than the use of hard coal. If hard coal is substituted by biomass from rewetted peatlands, between 82 % and 92 % of the greenhouse gas emissions and between 70 % and 83 % primary energy depletion can be avoided. The results of the life cycle comparison between paludi-biomass and hard coal are shown in Fig. 3.

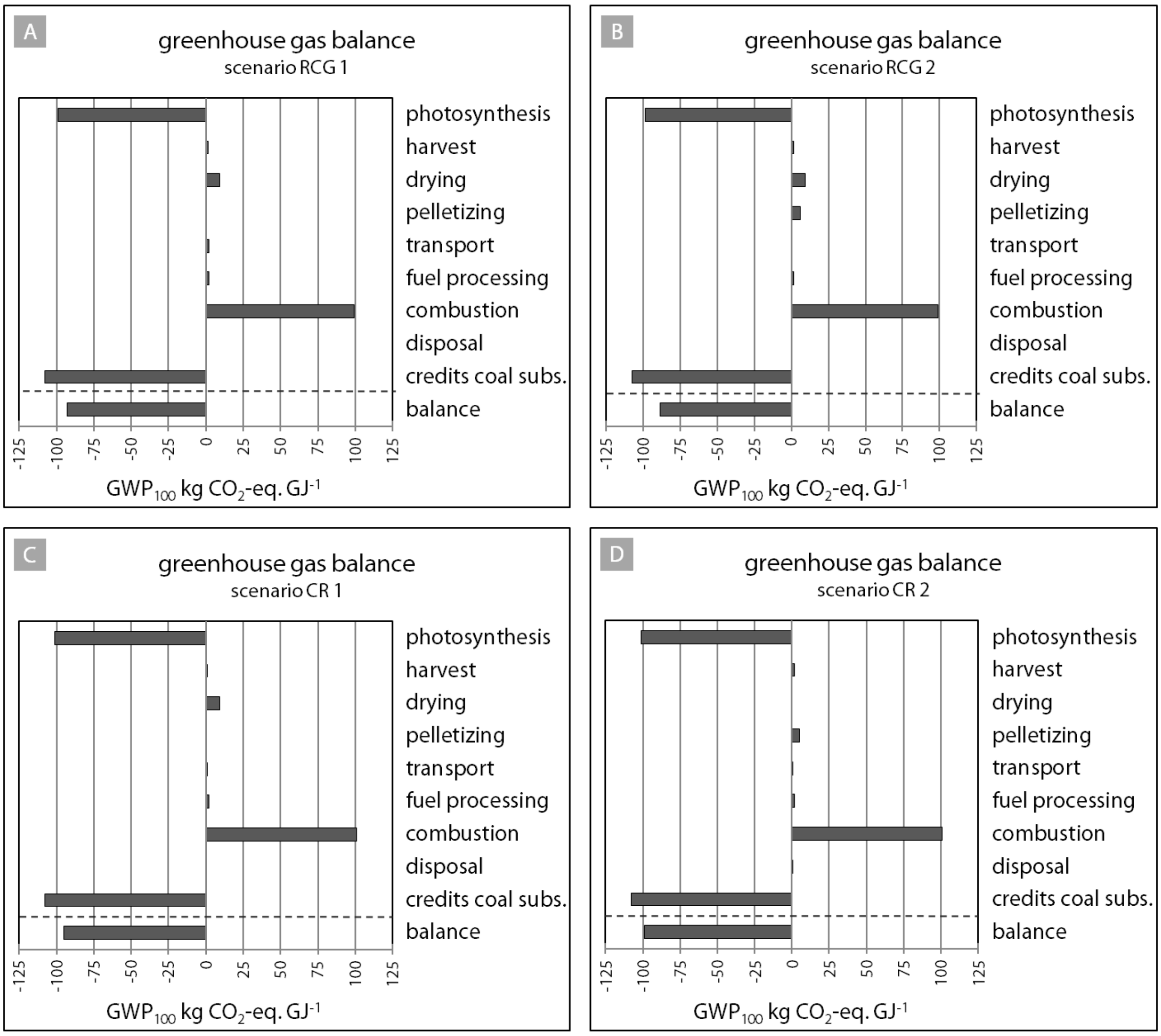

Fig. 3 Greenhouse gas balance for the different scenarios (A, B, C, D). The primary energy balances show similar patterns. The figures are differentiated by life cycle stage and expenses (right part) and credits (left part) which mean environmental burden or relief. The lowest bar of the particular diagram indicates the result of the balance, in these cases greenhouse gas emission savings compared to hard coal firing.

CONCLUSIONS

The substitution of hard coal by biomass from rewetted peatlands as fuel in power plants leads to significant reduction of primary energy depletion and greenhouse gas emissions. These savings are additional to and in the same order of magnitude as possible emission reductions from rewetting drained peatlands (Tanneberger and Wichtmann, 2011).

It is likely, that this biomass can be used as co-fuel in peat fired power plants as well. This would lead to even higher reductions of greenhouse gas emissions, since peat-firing results in higher greenhouse gas emissions per GJ than hard-coal-firing.

Best results can be achieved if energy intensive heated air drying is avoided and the biomass is harvested and transported as bales. Pelletizing is connected to high energy consumption and is unreasonable if only the LCA perspective is considered.

In order to improve the accuracy of the assessment, further data has to be collected. Results depend on the specific scenarios and conditions and the calculations must be adapted for each particular case.

REFERENCES

Borken, J., Patyk, A., and Reinhardt, G.A. (1999). Basisdaten für ökologische Bilanzierungen: Einsatz von Nutzfahrzeugen in Transport, Landwirtschaft und Bergbau (Basic data for environmental analysis: use of commercial vehicles in transport, agriculture and mining). 223 pp. Vieweg Verlag, Wiesbaden.

ELP and Ash, N. (2010). New opportunities for the sustainable management of fens : Reed pelleting, composting and the productive use of fen harvests : Final report. 65 pp. Broads Authority, Norwich.

GEMIS (2010). Globales Emissions-Modell Integrierter Systeme (GEMIS) 4.6 (Global Emission Model for Integrated Systems). Institut für angewandte Ökologie e.V., Freiburg.

Hunston Engineering Ltd. (2006). The effectivness of reed as a convenience fuel : A project of pelletise reeds. Hunston Engineering Limited & The Royal Society for the Protection of Birds, Hunston & Sandy.

ISO (2006a). Environmental management - Life cycle assessment - Principles and framework (ISO 14040:2006). 20 pp. International Organization for Standardization, Genf.

ISO (2006b). Environmental management - Life cycle assessment - Requirements and guidelines (ISO 14044:2006). 46 pp. International Organization for Standardization, Genf.

Parish, F., Sirin, A., Charman, D., Joosten, H., Minayeva, T., Silvius, M., and Stringer, L. (2008). Assessment on peatlands, biodiversity and climate change : main report. 179 pp. Global Environment Centre & Wetlands International, Kuala Lumpur & Wageningen.

Schröder, C., Wichtmann, W., Wichmann, S., and Joosten, H. (2012). Agricultural use of rewetted fen peatlands in North East Germany. This volume.

Succow, M. and Joosten, H. (2001). Landschaftsökologische Moorkunde (landscape ecological peatland studies). 622 pp. Schweizerbart, Stuttgart.

Tanneberger, F. and Wichtmann, W. (2011). Carbon Credits from peatland rewetting : Climate - biodiversity - land use. 223 pp. Schweizerbart, Stuttgart.

Wichmann, S. and Wichtmann, W. (2009). Bericht zum Forschungs- und Entwicklungsprojekt Energiebiomasse aus Niedermooren (ENIM) (Report on the research and development project energy biomass fens). 190 pp. Institut für Dauerhaft Umweltgerechte Entwicklung der Naturräume der Erde (DUENE), Greifswald.

Wichtmann, W. and Joosten, H. (2007). Paludiculture : peat formation and renewable resources from rewetted peatlands. *IMCG Newsletter* 24-28.