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ASSESSMENT OF CLIMATE IMPACT OF ENERGY PEAT UTILISATION SCENARIOS FROM A LIFE CYCLE PERSPECTIVE – IMPORTANCE OF PEATLAND TYPE, PRODUCTION METHOD AND AFTERTREATMENT

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SUMMARY

This study presents updated calculations of the climate impact of energy peat utilisation scenarios for average Swedish conditions. It concludes that it is possible to achieve peat utilisation chains where the climate impact, considered over a 100 year period, is lower than the climate impact of the peat combustion stage only. The initial conditions at the peatland used for peat cutting, the peat production method and the chosen aftertreatment of the cutaway are important factors for the overall climate impact.
The study contains a discussion on the use of radiative forcing and GWP summarised emissions as measures of climate impact.

KEYWORDS: Energy peat, climate impact, life cycle assessment, radiative forcing, drained peatland

INTRODUCTION

The policy signals on energy peat utilisation in Sweden are ambiguous. Whereas peat utilisation in power production is promoted by qualifying for green electricity certificates, the power producers must, according to the EU ETS (EU Emissions Trading Scheme), present emission allowances for the CO_2 emissions associated with the combustion of the peat.

Previous studies of the life cycle of energy peat utilisation (Savolainen et al. 1994, Zetterberg et al. 2004, Nilsson and Nilsson 2004, Holmgren et al. 2006, Holmgren 2006, Kirkinen et al. 2007, Hagberg and Holmgren 2008) have shown that the climate impact is more complex than just considering the emissions at the combustion stage, as is the case in the EU ETS.

This study presents estimates of total emissions and climate impact for different peat. utilisation scenarios valid for Swedish conditions. The calculations are based on a compilation of the latest data of greenhouse gas (GHG) fluxes from the different stages of the energy peat life cycle (Hagberg and Holmgren 2008). The aim is to show how, and to what extent, the climate impact of energy peat utilisation can be reduced by the choice of peatland, peat production method and aftertreatment.

MATERIAL AND METHODS

The model

In this study the climate impact of energy peat utilisation chains from a life cycle perspective, including emissions of CO_2, N_2O and CH_4 is considered. The climate impact is described by radiative forcing, and the same methodology as used by several previous studies (Savolainen et al. 1994, Nilsson and Nilsson 2004, Holmgren et al. 2006, Holmgren 2006, Kirkinen et al. 2007 and Zetterberg et al. 2004) was applied. A detailed description of the radiative forcing model used in this study is given in Holmgren et al. 2006. The model has been updated by the latest information on carbon cycling given in IPCC, 2007. The emission scenarios of the peat production and utilisation in this study include emissions from peat harvesting, transportation, storage and combustion as well as emissions from the aftertreated cutaway and compares them to the reference situation (i.e. emission levels at preharvesting conditions)
The study also presents total GWP summarised emissions for the peat utilisation scenarios. The GWP factors used in this study are the ones valid for a 100-year time frame and given in IPCC, 2007, i.e. 25 for CH_4 and 298 for N_2O.

Scenario description and emission estimates

The studied peat utilisation scenarios are summarised in Table 1. Average emission estimates for the different peatland types found in the literature are used in the calculations, except for the two best case scenarios where the higher range in the reported emission estimates has been used. The peat utilisation scenarios are compared to two scenarios where the same amount (in MJ) of coal and forest residues is combusted, respectively. A summary of the data used for the different scenarios is given in appendix and a thorough description of the emission inventory is given in Hagberg and Holmgren 2008. Two peat harvesting technologies are considered: conventional harvesting (milling method) and the new excavation-dryer method (EDM) which is being developed (Silvan et al. 2010).

Table 1 Investigated energy peat utilisation scenarios

Input data for coal and forest residue scenarios.

Fuel scenario	**CO_2 [g MJ^{-1}]**	**N_2O [mg MJ^{-1}]**	**CH_4 [g MJ^{-1}]**	**Reference**
Coal	98.69	0.52	0.2107	Sokka et al. 2005; Kirkinen et al. 2008
Forest residues	3.45	0.225	$1.15 *10^{-3}$	CONCAWE 2006; Uppenberg et al. 2001

RESULTS

Climate impact of peat utilisation scenarios

The calculated climate impact in terms of accumulated radiative forcing of the different fuel chains is shown in Fig. 1. The results show that the climate impact of energy peat utilisation in heat and power plants can be either higher or lower than coal utilisation and the level indicated by the EU ETS emission factor for peat combustion. The specific conditions at the peatland used for peat harvesting clearly influences the climate impact. Using peatlands with high initial emissions will result in a lower climate impact than for low emission sites. The scenarios with the highest climate impact are pristine mires harvested with the conventional production method. All peat utilisation scenarios in Fig. 1 are comparable with coal and the “combustion only” scenario during the first 30-40 years. After 100 years the climate impact of the cultivated peatland scenarios is ~30-50 % lower than the coal scenario, whereas the climate impact of the forestry drained peatland scenarios is still of comparable magnitude to the coal scenario. Compared to the EU ETS combustion emission factor for peat, the climate impact of these scenarios after 100 years is ~40-50% lower and 12-20 % lower, respectively. Fig. 2 shows that the resulting accumulated radiative forcing and the GWP summarised emissions for the scenarios differ. For instance, the GWP summarised emissions for the cultivated peatland scenario (No. 7) is negative after 300 years, whereas the corresponding value for radiative forcing is close to zero but positive. An important difference is that radiative forcing takes the timing and dynamics of the GHG emissions into consideration, which GWP does not. Hence, radiative forcing is a more accurate measure of the climate impact.

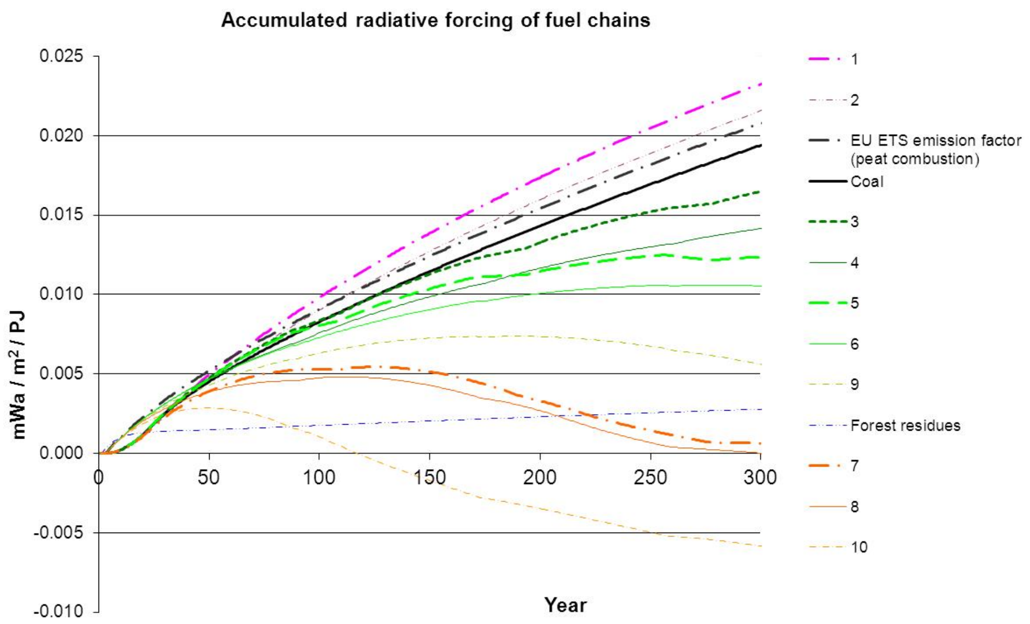

Fig. 1. Accumulated radiative forcing of fuel chains. Scenario numbers refer to Table 1.

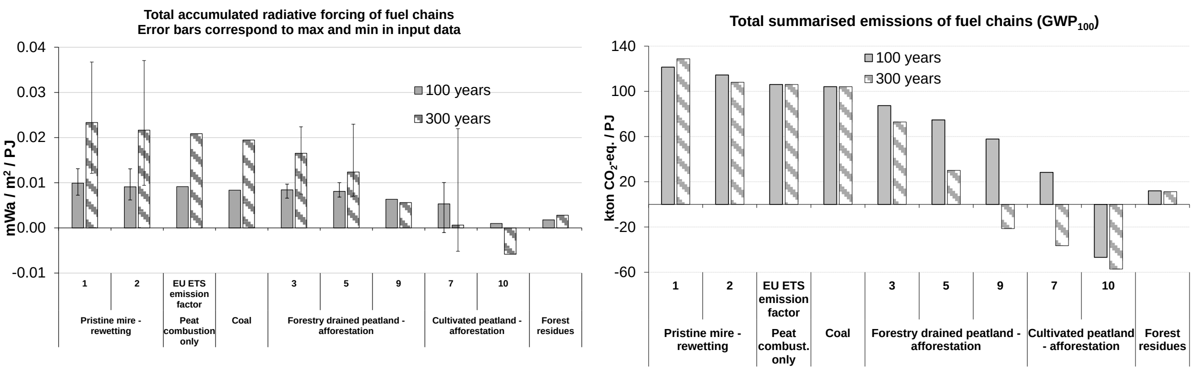

Fig. 2 Accumulated radiative forcing (left) and GWP summarised emissions (right) due to energy peat utilisation from the scenarios after 100 and 300 years respectively. The error bars indicate results due to the max and min input data given in Appendix.

DISCUSSION

This study shows that by harvesting GHG leaking peatlands large emissions will occur in the short term, but with proper aftertreatment long term emissions that would otherwise occur could be avoided. In order to decide which management option for drained peatlands is the best from a climate impact point of view, a larger scope is needed than was used in this study. The study demonstrates that the climate impact of peat utilisation is high in the short term but could be significantly lower in a longer time perspective. For a discussion on the relevance of different time perspectives please consult Zetterberg and Chen (manuscript).

The emission estimates set for the reference case have the greatest impact on the long term results. The uncertainty increases with the length of the chosen time perspective; for more information on uncertainties and sensitivity analysis we recommend earlier work (Nilsson and Nilsson, Holmgren et al. 2006, Kirkinen et al. 2007).

CONCLUSIONS

The climate impact from energy peat utilisation can be significantly different if viewed from a life cycle perspective rather than only considering the emissions at the combustion stage. There are important sources and sinks of GHGs at peatlands before harvesting, during harvesting and after harvesting that should be taken into account to provide a more complete assessment of the total climate impact of peat utilisation.

Like previous studies, this study shows that peat utilisation from drained peatlands has a lower climate impact than peat utilisation from pristine mires. In a time perspective of 100 years the climate impact of peat utilisation from drained peatlands can be lower than from coal utilisation. Despite large uncertainties in the emission estimates the study clearly shows that the climate impact of peat utilisation can be substantially reduced if peat production is focused on drained peatlands used for forestry or cultivation, and if the cutaways are afforested. It also requires a time perspective of approximately 100 years.

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APPENDIX

Input data for the peat scenarios. Positive values indicate emission to the atmosphere, negative values indicate uptake from the atmosphere.

Stage in utilisation chain	**CO_2 emissions [g m^{-2} yr^{-1}]**			**N_2O emissions [g m^{-2} yr^{-1}]**			**CH_4 emissions [g m^{-2} yr^{-1}]**		
	In this study	Min	Max	In this study	Min	Max	In this study	Min	Max
Before harvesting									
Pristine mire -ombrotrophic (bog)	55	-175	285	0	-	-	7	2	12
Pristine mire -minerotrophic (fen)	-55	-245	135	0	0	0.03	17	4	30
Cultivated peatland	1780	270	7000	1.5	-0.1	4.8	0	-0.22	0.3
Drained forested peatland (high fertility) - soil emissions	818	257	1111	0.5	0.3	0.81	0	-0.4	0.0
Drained forested peatland (low fertility) - soil emissions	458	257	1111	0.01	0	0.018	2	-0.1	3.7
Drained forested peatland (high fertility) - carbon uptake in forest	-820	-290	-1310						
Drained forested peatland (low fertility) – carbon uptake in forest	-416	-120	-770						
During harvesting (conventional harvesting method, 20 years plus 2 years pre-drainage)									
Production area	980	504	1490	0.3	0.1	0.55	3.7	1.6	5.7
Stockpiles	250	125	375	0			0		
Harvesting equipment and transports	1 g CO_2 MJ^{-1}			0.025 mg N_2O MJ^{-1}			0.7 mg CH_4 MJ^{-1}		
Surrounding area (considered for pristine mires only)	980	504	1490	0.3 first 5 years 0.08 thereafter			3.7	1.6	5.7
During harvesting (new harvesting method, 1 year)									
Production area	770			0.1			0		
Stockpiles	400			0			0		
Harvesting equipment and transports	0.5 g MJ^{-1}			0.012 mg MJ^{-1}			0.35 mg MJ^{-1}		
Peat combustion									
conventional production method, 45% moisture content	105.2 g MJ^{-1}	-	107.3 g MJ^{-1}	6 mg MJ^{-1}			5 mg MJ^{-1}		
new production method, 30% moisture content	100 g MJ^{-1}			6 mg MJ^{-1}			5 mg MJ^{-1}		
Combustion emissions according to default factor in EU ETS	106 g MJ^{-1}			0 mg MJ^{-1}, so far N_2O emissions are not included in the EU ETS			0 mg MJ^{-1}, so far CH_4 emissions are not included in the EU ETS		
Aftertreatment - wetland restoration	-120	-271	28	0	0	0.03	17	4	30
Aftertreatment – afforestation									
Soil emissions after conventional production method	1100 exp. decrease during 85 years when 50% of the residual peat has been decomposed. Thereafter slow release.			Linear decrease from 0.15 to 0.06 g after 45 years.			0		
Soil emissions after new production method	550 exp. decrease during 45 years when 50% of residual peat has been decomposed. Thereafter slow release.			Linear decrease from 0.15 to 0.06 g after 15 years.			0		
Carbon uptake in growing forest	-820	-290	-1310						
Carbon accumulation in soil	-150 during one rotation, then 0								
Best case scenarios									
Cultivated peatlands – soil emissions before harvesting	3550			4.8			0.3		
Drained forested peatland – soil emissions before harvesting	1111			0.81			3.7		
Carbon uptake in growing forest before harvesting	-618								
Carbon uptake in growing forest - afforestation	-820								
All other emissions	Same as scenarios with new harvesting method								