# Greenhouse impact of the use of peatland for energy – scenarios considering peatland utilisation and after-treatment

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## Summary

The greenhouse impact of the use of peatland for energy has been assessed using life cycle assessment. The utilisation of peatland has been taking into account comprehensively: first the area is used for fuel peat production and then for biomass production (afforestation or cultivation of reed canary grass). Utilisation of forestry-drained peatland in Finland for energy production causes a somewhat lower climate impact than using coal even within a 100 year time horizon, if the utilisation of renewable biomass produced in the after-treatment of the peatland is taken into account. If cultivated peatland is used for energy production, the greenhouse impact is lower than the use of forestry-drained peatland or coal for energy.

**Key index words**: Greenhouse impact, peatlands, fuel peat production, forestry-drained peatlands, cropland

## Introduction

Peatlands are sources and sinks of greenhouse gases (GHGs). When peatland is utilised for energy production it affects climate in many ways, e.g. changing the GHG fluxes of peatland, producing emissions from the production and combustion of peat and after-treatment. The objective of this study is to study the greenhouse impact of the utilisation of peatland for energy production. First the peatland is used for fuel peat production. After that the area is after-treated either by afforestation or cultivation of reed canary grass. The biomass produced from the after-treatment period is assumed to be used further for energy production. The greenhouse impact of coal has also been assessed in order to provide a comparison with peat. All carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$) emission and sink fluxes during the life cycle of assessed energy production chains are taken into account, but other environmental impacts have not been considered.

The greenhouse impact of the use of peat energy was studied earlier in Finland in the research programme *Greenhouse Impact of the use of Peat and Peatlands in Finland*. In this programme the greenhouse impact of peat energy was studied using life cycle analysis (Kirkinen *et al.* 2007b). However, the life cycle was only limited to the peat energy produced from the peatland. In this study the system boundaries include also the utilisation of the peatland after fuel peat production for production of renewable energy. The whole exploitation of the peatland has been taken into account for 100 and 300 year time horizons.

Those peatlands studied were forestry-drained peatland and cropland (cultivated peatland), which are sources of GHG emissions. There are two different peat production methods considered: typical milled and newly-developed (biomass dryer) method. After-treatment choices are assumed to be either afforestation or cultivation of reed canary grass in the residual peat production area. In both after-treatment cases, the biomass produced is further utilised for energy production. The reference situation is taken as the normal development of the studied peatland over the assessed time horizons. The comparative energy chain, where coal is utilised for energy production, includes the production of coal in Russia, from where coal is transported to Finland and combusted by using pulverized fuel firing.

## Methods

In this study a life-cycle analysis (LCA) is applied to the measurement of the greenhouse impact from all activities necessary for producing energy from peatland. Radiative forcing (RF) is used for measuring the greenhouse impact. It can be used to describe the perturbation of the radiation energy balance of the Earth due to emission and sinks of GHGs. RF is useful in greenhouse impact assessment of the use of peat, since it can take into account the GHG fluxes as a function of time.

In this study Relative Radiative Forcing Commitment (RRFC) is used in order to assess the greenhouse impact and interpret the results (Kirkinen *et al.* accepted). RRFC describes how much energy is absorbed *($E_{abs}(t)$)* in the Earth system within a given time horizon *t* due to the changes in the GHG concentrations caused by the production and combustion of the fuel compared to the energy released in the combustion of the fuel *($E_{fu}$)*. RRFC *(= $E_{abs}/E_{fu}$)* can also be expressed as a function of time in order to give a dynamic cumulative picture on the caused effect. It enables to study different time horizons separately depending on the different climate policies and goals.

In the calculation of greenhouse impact all GHG emissions and possible sequestrations have been taken into account. Greenhouse impact can be assessed with the following equation 1:

$$I = I_P - I_R \tag{1}$$

where $I_P$ describes the greenhouse impact of the production of energy from the peatland (emissions from the fuel peat production, transportation of peat and biomass from after-treatment phase, use of working machines, storage, fertilizers, combustion etc.). $I_R$ stands for the greenhouse impact from the reference situation i.e. unrealized impact of the GHG emissions and sinks from peatland when area is not taken into peat production but continues its development over the studied time horizon. Greenhouse impact *I* is calculated by entering the information of the $CO_2$, $CH_4$ and $N_2O$ emissions and sinks as a function of time to the REFUGE calculation model (Monni *et al.* 2003). More information on the background assumptions made in the use of this model in the calculation is provided by Kirkinen *et al.* (2007a).

## Greenhouse gas emission data of studied energy production chains

Information about the GHG fluxes in different phases of the life cycle of studied chains is presented in the following table (Table 1). Emissions (positive values) and sinks (negative values) of $CO_2$, $CH_4$ and $N_2O$ of different phases are listed. More detailed data is available in Kirkinen *et al.* (2007a). The following assumptions are made in order to enable calculations: 1 PJ of energy was produced in each chain. The energy content of peatland is ca. 9 400 MWh ha$^{-1}$. Peat layer is assumed be 2 m thick. Peat will be produced during first 5 to 20 years depending on whether or not peat is produced by milled peat production method or developed method respectively. The annual productivity of afforestation is 51 200 MJ ha$^{-1}$, whereas the productivity of the cultivation of reed canary grass is 100 800 MJ ha$^{-1}$ (Kirkinen *et al.* 2007a).

## Results

When coal is used for energy production, it causes during a 100-year time horizon a warming impact of nearly 180 times the fuel energy produced. The warming impact is the energy absorbed in the earth system (atmosphere, surface, oceans) during 100 years due to the changes in the GHG concentrations caused by the production and combustion of the fuel (Figure 1, upper bars). In a 300 year time horizon almost 350 times the energy produced is absorbed into earth's system, when using coal for energy production (lower bars). The corresponding values for the chains where peatland is used for energy production can also be seen from Figure 1.

**Table 1.** Greenhouse gas emissions of the different stages of life cycle of the studied fuel chains (Kirkinen *et al.* 2007a). Positive values describe emissions, negative values sinks.

| **Utilisation of peatland** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
|---|---|---|---|
| Forestry-drained peatland (g m$^{-2}$ a$^{-1}$) | 224 | 0 | 0 |
| Cropland (g m$^{-2}$ a$^{-1}$) | 1760 | -0.147 | 1.297 |
| Peat production, milled peat production (incl. working machines, storage, peat production area) (g MJ$^{-1}$) | 9.32 | 0.0046 | 0.000025 |
| Peat production, developed peat production (incl. working machines, biomass dryer, storage) (g MJ$^{-1}$) | 2.46 | 0.0008 | 0.0003 |
| Combustion of peat (g MJ$^{-1}$) | 105.9 | 0.0030 | 0.005 |
| *After-treatment:* | | | |
| Reed canary grass | | | |
| Cultivation (incl. production of fertilizers), production and combustion (g MJ$^{-1}$) | 7.81 | 0.0037 | 0.035 |
| Afforestation | | | |
| Sequestration of carbon into growing forest, above and below ground litter (g m$^{-2}$ a$^{-1}$) | -610 | - | - |
| Utilisation of wood biomass (production and combustion) (g MJ$^{-1}$) | 2.10 | 0.00212 | 0.00383 |
| **Utilisation of coal** | | | |
| Production (in Russia), transportation (g MJ$^{-1}$) | 3.61 | 0.59 | 0 |
| Combustion (g MJ$^{-1}$) | 94.6 | 0.0007 | 0.0005 |

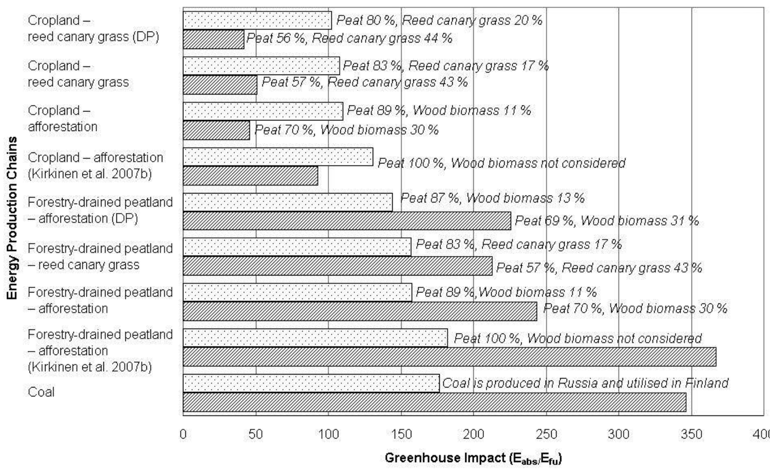


**Figure 1.** The greenhouse impact of studied energy production chains for 100 year and for 300 year time horizons, upper and lower bars, resp. The text for each chain tells the shares of peat and renewable energy within the time horizons. Also the greenhouse impact of an earlier study (Kirkinen *et al.* 2007b) has been included in order to compare the impact, when only the utilisation of peat from peatland has been taken into account in energy production.

When cultivated peatlands are used for energy production the greenhouse impact is lower compared to the utilisation of coal and forestry-drained peatland. Developed peat production method (DP) reduces the impact slightly. If forestry-drained peatlands are used for peat and biomass production the impact is somewhat lower than the use of coal for energy. If only peat energy is taken into account as in previous study (Kirkinen *et al.* 2007b), the impact is higher than coal in 100 year time horizon, but lower in 300 year, if utilised peatland is cropland. The utilisation of the residual peat production area for biomass energy production clearly lowers the greenhouse impact of the utilisation of peatland.

## Discussion

This study assesses the greenhouse impact of different energy production chains for 100 and 300 year time horizons as has been studied in earlier studies (e.g. Kirkinen *et al.* 2007b). However, if the increase of the average surface temperature of earth needs to be limited to 2–3 degrees, then the increase of GHG concentrations in the atmosphere needs to peak and start to decline during the next two to three decades (IPCC 2007). In this case the 100 year time horizon may be seen as more relevant since the emissions need to be cut already during this period in order to achieve the stabilization of GHG concentration levels in the atmosphere.

## Conclusion

The greenhouse impact of the utilisation of peatland in energy production has been studied. In this study the after-treatment phase of the life cycle has been fully taken into account, which means utilising the biomass produced in the residual peat production area in the after-treatment phase for energy production as well. This point of view gives a more comprehensive picture from the greenhouse impact of utilising peatland for energy production.

When peatland is used for energy production comprehensively (utilising the residual production area for biomass production after peat production), the greenhouse impact is somewhat lower than the use of coal for energy already in 100 year time horizon in the considered cases in Finnish conditions. If the studied case is limited to fuel peat only, thus not accounting the renewable bioenergy produced in the after-treatment phase, the greenhouse impact would be slightly greater than that of coal. This is seen more especially if croplands, which are strong sources of GHG emissions, are taken into energy production, the impact is clearly lower than using coal for energy production from the life cycle point of view. New technological ways to improve peat production also have an affect. The newly developed peat production method is moderately more climate friendly than the typical milled peat production method. Cultivation of reed canary grass and afforestation are approximately similar after-treatment choices from a climate point of view.

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