How much biochar does gasification energy need to be carbon neutral?

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Indirect land use changes (iLUC) from bioenergy emerge whenever an energy crop is planted in arable land. Due to their overarching magnitude from a life-cycle perspective, they have been repeatedly recommended to be included in bioenergy's greenhouse gas (GHG) accountings, despite their challenging quantification and inherent uncertainties. Marginal or abandoned lands have been often quoted as the solution to avoid these undesired effects from bioenergy. However, land abandonment and marginalization is to a large extent a socio-economic process, and thus heavily depends on specific, constantly changing socio-political context and economic circumstances in place. We suggest a carbon negative bioenergy system that compensates for potential iLUC emissions and losses in soil organic carbon (SOC). A consequential life cycle assessment on willow bioenergy has been performed, distinguishing marginal and arable land scenarios. Specific soil types and their estimated SOC changes have been considered [9], as well as iLUC emissions for the arable case. Taking the study case of a willow plantation combined with a medium-scale gasification plant in Denmark, we illustrate the biochar needed from the process in order to remain carbon neutral. The time scopes assessed are 20 and 100 years and it is assumed a fossil fuel (FF) free Denmark beyond 2050 as targeted by government (no FF displacement occurs after 2050). Results show that willow on marginal land remains carbon negative (4% biochar fraction) for the short term, while as much as 31,8% of biochar (or 0,95 Mg C ha-1 yr-1) would be necessary in 100 years to be carbon neutral (taking natural vegetation as reference baseline). As for arable land willow, a biochar fraction of 34,1% (or 2,32 Mg C ha-1 yr-1) would be necessary in the short term to compensate for iLUC emissions, while a 4% would suffice to make it carbon negative in the long term, as iLUC "dilutes" over 100 years. To achieve such high biochar fractions (>10%), lower process temperatures are needed, which affect negatively the long-term stability of biochar. This can put at risk the claimed GWP reduction benefits. This study did not consider impacts on other environmental aspects as ecosystem services and biodiversity, which are deemed to be rather important and significant for iLUC