The potential of pyrolysis technology in climate change mitigation – influence of process design and –parameters, simulated in SuperPro Designer Software

This report investigates whether or not it would be possible to produce carbon-negative energy from pyrolysis of wheat straw in a series of Danish agricultural scenarios. A combination of process simulation in SuperPro Designer software, correlations derived from literature studies and experimental work, and overall balance calculations has been applied in the process. The study deviates from other studies of pyrolysis and biochar production by the inclusion of substitution energy impact on the overall carbon-balance. Substitution energy is integrated to account for the gap between the energy production from the pyrolysis and the full energy potential of the biomass, quantified by complete conversion in either combustion or gasification systems. It was concluded that it is feasible to produce carbon-negative energy under a variation of different settings, but also that the negative carbon-balance is only robust for the slow pyrolysis scenario. The CO2 benefit of the most carbon-negative slow pyrolysis process is estimated to be around 10 % of the atmospheric carbon stored in the original biomass when natural gas is applied for energy substitution. This process avoids the emission of around 150-200 kg CO2/ton wheat straw with substitution energy with a Denmark 2007 average carbon-intensity. This result is weighted against the net emissions of the carbon-“neutral” process of conventional combustion. This emission is in this report estimated to be around 50 – 150 kg CO2/ton straw depending on scenario settings. The final results of the study have been compared to another study with convincing results. Results concluded that the primary force of the pyrolysis technology is the recalcitrant char product and not the pyrolysis oil. Based on this, the study suggests that despite the trend in commercial pyrolysis technology that focuses on fast pyrolysis processes with maximized bio-oil production, the twin challenge of climate mitigation and sustainable energy production is most efficiently addressed with a combination of slow pyrolysis and complete biomass conversion through combustion or gasification instead.

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