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Global warming and energy yield evaluation of Spanish wheat straw electricity generation - A LCA that takes into account parameter uncertainty and variability

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Abstract— This paper aims to provide more accurate results in the life cycle assessment (LCA) of electricity generation from wheat straw grown in Spain through the inclusion of parameter uncertainty and variability in the inventories. We fitted statistical distributions for the all the parameter that were relevant for the assessment to take into account their inherent uncertainty and variability. When we found enough data, goodness of fit tests were performed to choose the best distribution for each parameter and, when this was not possible, we adjusted triangular or uniform distributions according to data available and expert judge. To obtain a more complete and realistic LCA, we considered the consequences of straw exportation for the agricultural system, specially the loss of soil organic carbon and the decrease of future fertility. We also took into account all the inputs, transformations and transports needed to generate electricity in a 25 MWe power plant by straw burning. The inventory data for the agricultural, the transport and the transformation phases were collected considering their most common values and ranges of variability for the Spanish case. We used Monte Carlo simulation and sensitivity analysis to obtain global warming potential (GWP) and fossil energy (FOSE) consumption of the system. These results were compared with those of the electricity generated from natural gas in Spanish power plants, as fossil reference energy system. Our results showed that for the majority of the simulations electricity from wheat straw biomass combustion produced less greenhouse gases (GHG) emissions and consumed less fossil energy than electricity from natural gas. However, only 58% of the simulations achieved the sustainability threshold of 60% GHG savings proposed by the European Union (EU). Our analysis showed that agricultural field works and the loss of soil organic carbon due to straw exportation were the most important phases for FOSE consumption and GWP respectively. According to parameters sensitivity analysis, the loss of soil organic carbon was completely dependent on the isohumic coefficient and the soil carbon content factor values. Due to this fact, local and specific estimates of these parameters are relevant tasks to be performed in order to reduce uncertainties and provide a definitive answer to the compliance of the EU sustainability criteria.

Index Terms— Bioenergy; Crop residues; Life cycle assessment (LCA); Global warming potential; Uncertainty; Sustainability criteria

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