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LIFE CYCLE ASSESSMENT MODELLING CONSIDERING UNCERTAINTY – THE MORE ROBUST RECOMMENDATION

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Life cycle assessment (LCA) modelling is commonly used for assessing new waste management technologies as well as waste management systems to be implemented. Even though waste is a very heterogeneous material, most LCA studies only consider the uncertainty to a limited degree focusing on sensitivity of process choices or not even assessing the uncertainty of the system at all (Laurent et al., 2014a and 2014b).

This study therefore sets out to see what new knowledge would be gained if the modelling considered the uncertainty of all parameters used in the modelling of the technologies assessed, and how this could support the decision support. To carry out the modelling we used the LCA model EASETECH (Clavreul et al., 2014) developed at the Technical University of Denmark. EASETECH allows both single values, as well as distributions of values. This allows us to consider the aleatoric variability and epistemic uncertainty of data.

We used case study for the handling of shredder residue (SR) in Denmark as a modelling case. SR is the "residual fraction from mechanical shredding of metal containing scrap originating from different sources and processed at recycling stations or metal recovery businesses" (Hyks et al., 2014). Danish SR is typically a mixture of 20% automotive shredder residues (ASR) and 80% of other residues originating from different sources (e.g. white goods, dismantled boats, industrial bulky waste, metal scrap). SR is currently disposed of in hazardous waste landfills in Denmark; however, legislative and economic issues mandate exploring alternative solutions for its management. SR was considered as a proper case study because the environmental effects of its handling in conventional waste treatment technologies are uncertain, due to the very heterogenic nature of the SR, both with regards to variation over time and elemental composition.

The assessment compared the potential environmental impacts and depletion of abiotic resources in relation to four alternative scenarios, all including the sorting of recyclables and disposal of residues <4 mm to controlled landfills after biological stabilization. The scenarios were: S1) landfilling of all residues not recyclable; S2) co-combustion at a waste incineration plant of >4 mm residue; S3) pyrolysis of >4 mm residue; S4) co-combustion at a cement kiln of >4 mm residue. For each of the main technologies (Sorting, Incineration, Pyrolysis, Cement Kiln, Landfill) distributions (normal, lognormal and triangular) were assigned to process parameters and emissions. Besides the distributions mean values were also assigned so conventional average life cycle impact assessment (LCIA) values could be calculated for comparison.

Normalized environmental impact potentials for non-toxic categories are presented in Figure 1. Mean (triangle), maximum (square) and minimum (rhombus) values are presented for each category for the 4 scenarios. With regards to climate change, most of the scenarios do not vary considerably, the only exception being S3 (based on pyrolysis). Similar conclusions were drawn for most of the impact categories analyzed. The reason for these results is that this treatment technology (i.e. pyrolysis) is still under development, whereas most of the other technologies are more mature, and good inventory data could be employed in the study. Including the uncertainty in the LCA modelling allowed us recognizing that a lot more data about pyrolysis of SR is needed before a robust decision can be made whether or not to use pyrolysis as a viable treatment technology. This stresses the fact that, when modelling up and coming technologies, it is important to consider the full uncertainty for the technology when compared to more mature technologies which are associated with a smaller degree of uncertainty.

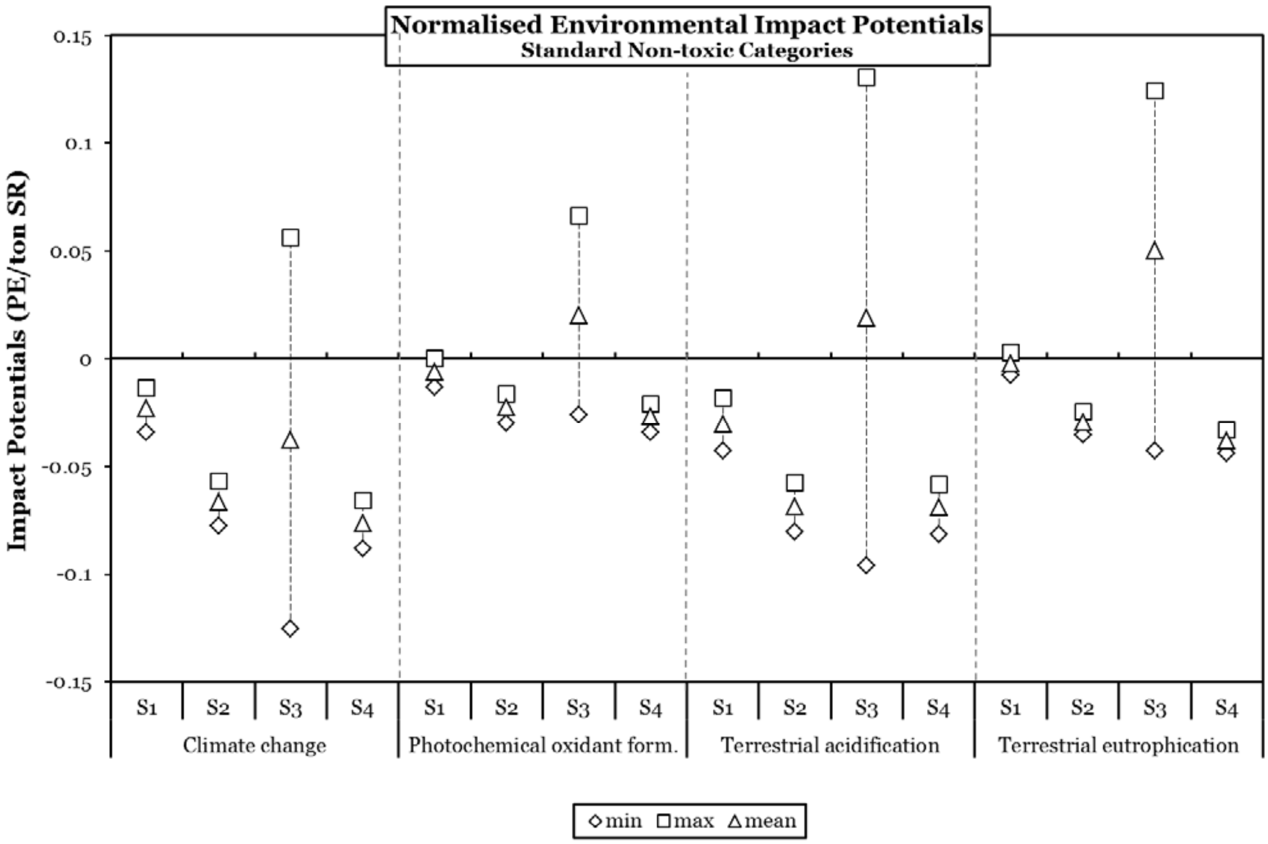

Figure 1 - Normalised potential non-toxic impacts from treatment of 1 ton SR in the four assessed scenarios (PE = person equivalent), including min-max ranges from the Monte Carlo runs.

References:

Clavreul, J., Baumeister, H., Christensen, T.H., Damgaard, A. 2014. An environmental assessment system for environmental technologies. Environmental Modelling & Software 60: 18–30

Hyks, J., Oberender, A., Hjelmar, O., Cimpan, C., Wenzel, H., Hu, G., & Cramer, J. (2014). Shredder residues: Problematic sub-stances in relation to resource recovery. Miljøprojekt Nr. 1568, Miljøstyrelsen, Copenhagen, Denmark.

Laurent, A., Bakas, I., Clavreul, J., Bernstad, A., Niero, M., Gentil, E., Hauschild, M.Z., Christensen, T.H., 2014a. Review of LCA studies of solid waste management systems--part I: lessons learned and perspectives. Waste Management 34, 573–88.

Laurent, A., Clavreul, J., Bernstad, A., Bakas, I., Niero, M., Gentil, E., Christensen, T.H., Hauschild, M.Z., 2014b. Review of LCA studies of solid waste management systems--part II: methodological guidance for a better practice. Waste Management 34, 589–606.