A superstructure approach for the application of waste treatment management in biorefineries

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Abstract

This paper outlines a synthesis approach for the integrated management of waste in multi-product biorefineries. Even though targeted at specific components, the treatment of individual biorefinery waste streams can be costly as the by-product volumes are often small in comparison. Moreover, the heavy organic content provides incentives to valorize the biomass content rather than to treat it as waste. An integrated approach can reduce treatment costs and add value to those by-products that are impossible to include in the value chain.

The work introduces a systematic methodology based on synthesis and optimization technologies. A syperstructure approach is set up to screen the waste management technologies and to select treatment policies either as single or hybrid solutions. The systematization is based on a preliminary stream classification [1,2] that is used to allocate by-product streams to potential treatment units. The number, type, capacity and the particular waste treatment technology are addressed as degrees of freedom to optimize. The allocation of streams to technologies and processing units yields a synthesis model that is formulated using cost models for CAPEX and OPEX to trade against benefits produced by the use of waste (cogeneration, biogas production etc).

The synthesis model is optimized using discrete-continuous optimization techniques and can be extended with additional objectives that account LCA metrics. The method has been applied and illustrated in an organosolv biorefinery that produces sugars (C6 and C5) and lignin as intermediates. The biorefinery features fifteen (15) production processes with a possibility to produce a list of twelve (12) products. The analysis considers six (6) different treatment technologies for liquid stream wastes, six (6) for solid stream wastes, seven (7) for gas stream wastes, two (2) for streams that can be re-used and two (2) different approaches for streams containing catalysts that may be regenerated. The application of the method produced a model with 45 binary variables

and 26 continuous variables. The optimization has been applied to assess the benefits in using the integrated approach, sensitivities associated with technology uncertainties and the impact of product portfolios in the analysis.

Keywords: Waste handling, Synthesis, Biorefinery, Lignocellulosic, Mixed Integer.

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