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Sustainability assessment of the management of second generation biomass

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ABSTRACT: The Bioeconomy Strategy was launched by the European Union (EU) in 2012 to promote the transition from a fossil- to a bio-based economy. To meet ambitious energy and climate mitigation targets, extensive use of first generation biomass has occurred in the last years incurring environmental, economic, and social concerns in relation to the actual sustainability of the supply and transformation processes. To circumvent these issues, second generation biomass has been often proposed as an alternative and, among the others, biowaste (e.g. from household or industry). According to the biomass pyramid, biomass should first be used to produce high-value products (e.g. pharmaceuticals), and only when the biomass is no longer suitable for the mentioned applications it should be used for fuel and energy purposes. Following policy reccomendations, life cycle thinking should be applied to document the sustainability of bioeconomy pathways. In this study, we focus on biowaste and evaluate sustainability of a variety of utilisation pathways by applying life cycle assessment and life cycle costing. Scenarios are assessed investigating both high- (e.g. animal feed production) and low-value products (e.g. energy recovery from incineration). The results obtained are expected to fill the research gap with respect to economic and social assessment of second generation biomass usage, and to assist decision makers in deciding the best application of the mentioned biomass.

Keywords: residual biomass, biowaste, LCA, LCC, circular economy, bioeconomy, life cycle thinking

1. INTRODUCTION

The European Union (EU) launched in 2012 the Bioeconomy Strategy to move from a fossil- to a bio-based economy (European Commission, 2012). The cornerstone of the bioeconomy is cascading, which implies that first all valuable componenets of biomass should be extracted to produce pharmaceuticals, fine chemicals, etc., and to produce energy and fuels only when the biomass is no longer suitable for the manufacture of high-value products (Official Journal of the European Union, 2013) (Figure 1).

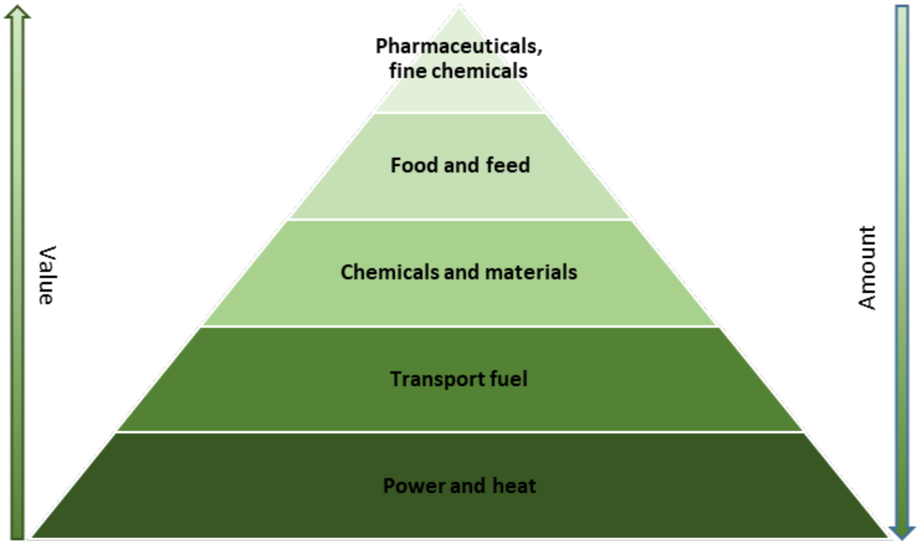

Figure 1. The biomass pyramid, based on Official Journal of the European Union (2013).

Due to the policies implemented at EU level, the production of first generation biomass to meet the demand of bio-based fuels has been extensive (McCormick and Kautto, 2013). Further, the increased production of first generation biomass for energy purposes not only contributes to the "fuel vs food" debate, but also highly affects land use changes, having both direct (e.g.removal of forests) and indirect effects (United Nations, 2016). Therefore, more interest has risen towards the use of second generation biomass (United Nations, 2016). In particular, in this study, biowaste (from, for example, household or industry) is investigated as second generation biomass.

To identify the best application of biowaste, life cycle thinking (LCT) should be applied (European Commission, 2012). LCT holds a holistic perspective over a product/service life cycle, as it includes both the environmental, economic, and social sphere (Life cycle initiative, 2019). Indeed, it is important to couple environmental aspects with economic priorities as modern society is driven by monetary constraints (Martinez-Sanchez et al., 2015). However, most of the available literature has focused only on the environmental assessment investigating the lower levels of the biomass pyramid (i.e. fuel and energy production) for second generation biomasses (see, among the others, Amtozar-Ladislao & Turrion-Gomez, 2008; Guerrero & Muñoz, 2018; Wiloso et al., 2012). Therefore, to fill the research gap, this study aims at applying LCT for assessing the sustainability of the use of biowaste focusing on the higher stages of the biomass pyramid.

2. METHODOLOGY

The sustainability of different applications of biowaste is assessed by means of two different tools: Life Cycle Assessment (LCA), assessing the environmental sphere, and Lify Cycle Costing (LCC), assessing the economic and social ones.

A cradle-to-grave LCA is performed for several scenarios investigating the best use of biowaste when comparing its applications from low-value to high-value products (Figure 1). The LCA is performed in accordance with the ISO standards for LCA (ISO, 2006 a,b), and applying a consequential approach (Weidema, 2003; Weidema et al., 2009). Following the consequential approach, the multi-functionalities of the systems are handled through system expansion identifying marginal products/services (Weidema, 2003; Weidema et al., 2009).The geographic scope of the study is Denmark and the temporal scope is 2019.

Departing from the methodology proposed in Martinez-Sanchez et al. (2015), the economic and social benefits/impacts are assessed for the scenarios investigated in the LCA. A conventional, environmental, and societal LCC are performed and the results are expected to complement the environmental assessment.For more details on the LCC methodology, please refer to the original publication (Martinez-

Sanchez et al., 2015).

3. RESULTS AND DISCUSSION

Preliminary results, both for the LCA and LCC, will be presented and discussed. However, departing from the findings of Albizzati et al. (2019) and Tonini et al. (2018), it is expected that, from an environmental point of view, the benefits from high-value applications of biowaste, will outweigh the energy and fuel purposes. The economic assessment will allow complementing the environmental assessment helping decision makers to balance the results obtained with the two tools. Finally, the societal LCC results will give a holistic perspective as environmental and economic results are expressed with one indicator.

4. CONCLUSIONS

The Bioeconomy Strategy proposed by the EU promotes a bio-based economy in favour of a fossil-based one. In order to achieve the EU goals, extensive use of first generation biomass has occurred in the last years. Due to environmental, economic, and social concerns related to the use of first generation biomass, more interest has grown towards second generation biomass. In this study, as second generation biomass, biowaste generated at household or industry level, is investigated.

The best use of biowaste should be identified by means of the biomass pyramid and applying life cycle thinking. Several scenarios addressing both high- and low-value products are assessed by means of Life Cycle Assessment and Lyfe Cycle Costing. The results obtained will fill the research gap in the topic and help decision makers identifying the best application of biowaste.

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