Consequential Life Cycle Assessment of a Novel Resource Recovery Solution for Food Waste Management

Haodong Lin[1], Aiduan Borrion[1]

[1] *Department of Civil, Environmental and Geomatic Engineering, UCL, London WC1E 6DE, UK*

E-mail contact address: haodong.lin@ucl.ac.uk

1. Introduction

Annual GHG emissions from food waste (FW) in the UK was estimated as 27 Mt CO_2eq, accounting for 5.9% of national GHG emissions (Jeswani et al. 2021). Anaerobic digestion (AD) can not only produce biogas for renewable energy but also nutrients from digestate, which can mitigate GHG emissions (Chozhavendhan et al. 2023). Perspective assessments of strategies can support decision making for policies and investments (Adrianto et al. 2021), while consequential life cycle assessment (cLCA) method has been suggested as one of the methods (Weidema et al. 2018). However, studies of cLCA application on FW management with resources recovery in the UK's AD industry is not well established to inform decision-making.

2. Methods

This study follows ILCD guidance (European Commission 2010), defining the goal as to assess impacts of climate change, freshwater eutrophication, terrestrial acidification, and water consumption of the proposed resource recovery (RR) solution, supporting decision making for UK's FW management with the AD. The scope of this study covers AD activities and RR processes, as shown in Figure 1 (system boundary). The AD activities include FW collection and pretreatment, biogas production and use, and water use for equipment management. The RR unit designed by the project NOMAD (https://www.projectnomad.eu/), consists of solid-liquid separation, antibiotic removal, and nutrient recovery processes, to generate organic fertiliser and water. Two scenarios were established, a Business-As-Usual (BAU) scenario and a RR scenario. BAU scenario includes the AD activities, and the pasteurised liquid digestate was delivered for storage and land application. RR scenario also covers the AD activities, but the digestate is treated in the RR unit. Generated water was used onsite while recovered nutrients (organic fertiliser) were applied to lands. The RR unit was powered by electricity produced by biogas. The surplus water and power were exported to the market. The functional unit (FU) is processing one tonne FW. The environmental impacts were assessed, following the ReCiPe 2016 method (Huijbregts et al. 2017). The average data for foreground of the system boundary was collected from the AD plant, project NOMAD, and literature, while marginal data from Ecoinvent database (Wernet et al. 2016) was used for the background.

3. Results and discussion

The overall results show that, with the proposed RR solution, FW management with the AD in the UK has more environmental advantages than the BAU scenario in all studied impact categories (see Figure 2). Introducing the RR unit brings negligible impacts for FW management with the AD. Turning digestate into organic fertiliser, the RR scenario saves impacts caused by digestate storge, reducing impacts of 4.5 kg CO_2eq/FU and 1.8 kg SO_2eq/FU. Credits claimed for avoidance of mineral fertiliser in the RR scenario are more than that in BAU scenario for all impact categories, due to high-quality organic fertiliser produced. Exported water can further offset impacts for water consumption impact categories (-0.3 m^3/FU).

4. Conclusions

This study assessed the environmental impacts of a novel solution for FW management with the AD, and better environmental impacts were observed. Recovering nutrients and water from digestate can reduce impacts by avoiding digestate storage and offset impacts by credits claimed for exporting high-quality organic fertiliser and water. However, further studies are recommended to provide insights economically and socially.

5. Acknowledgements

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6. References

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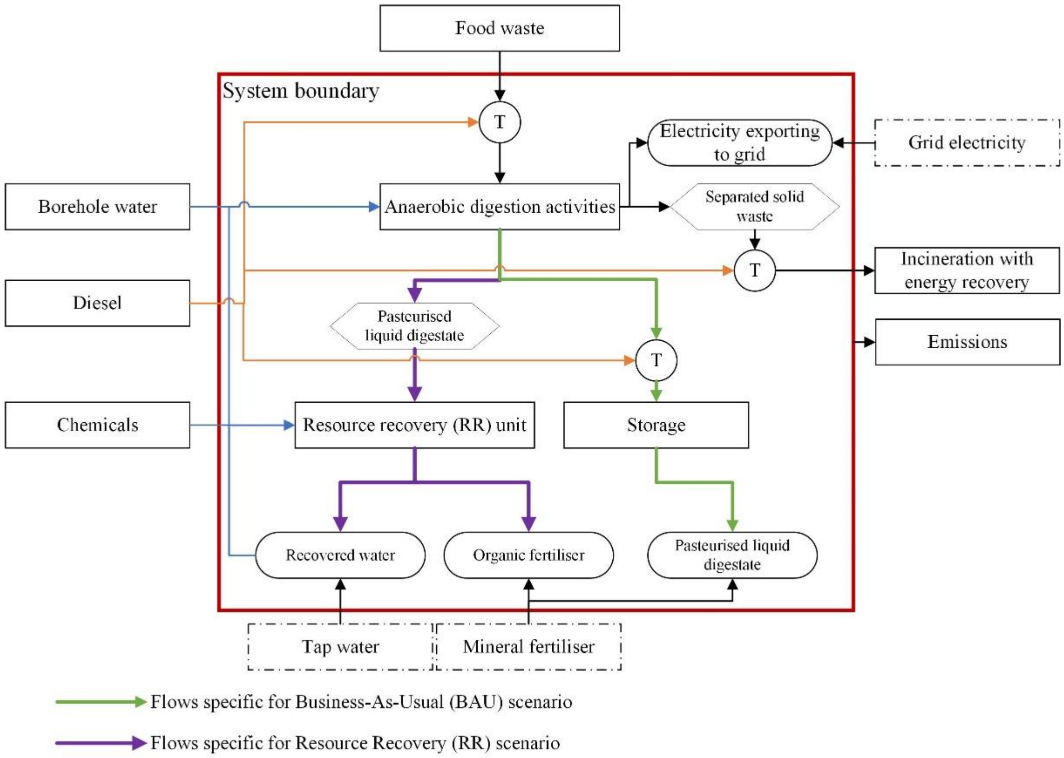

Figure 1. System boundary in this study.

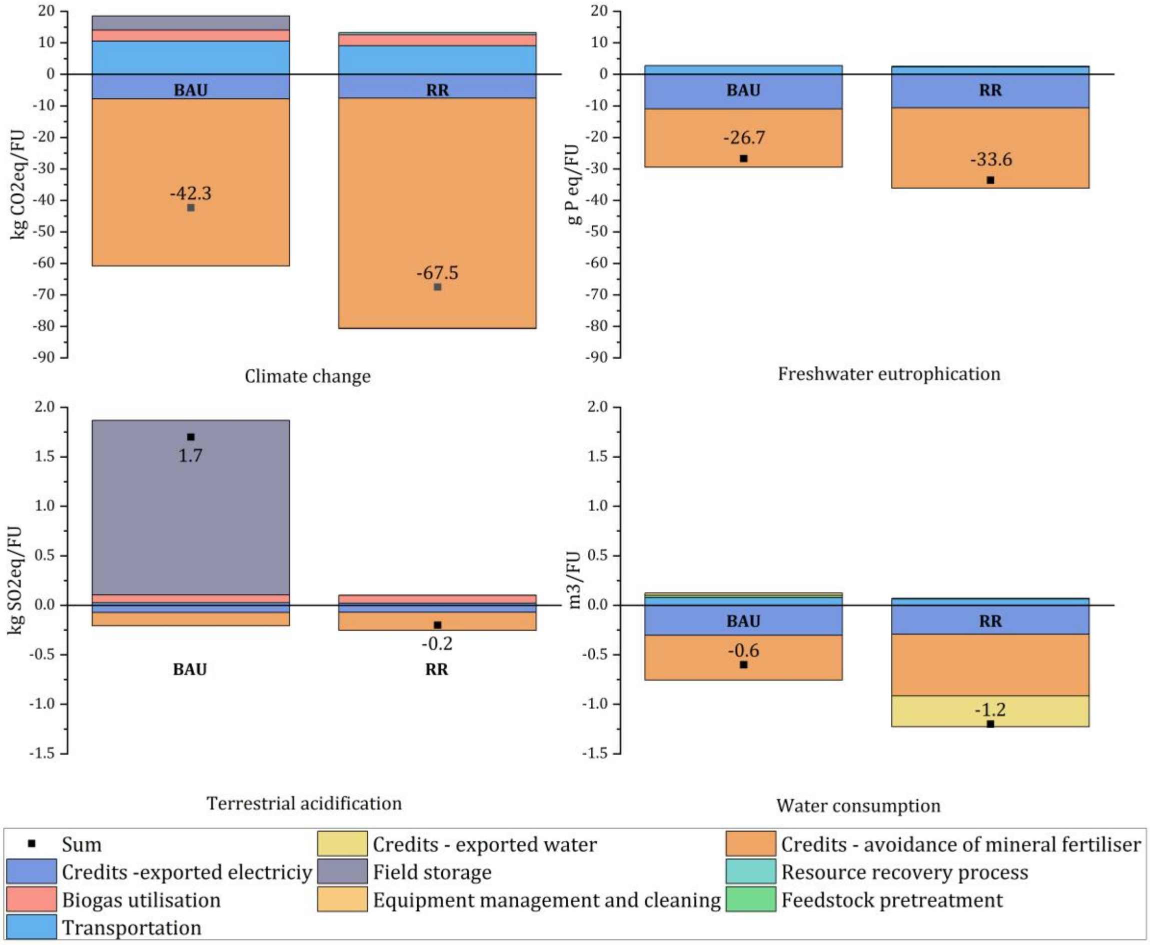

Figure 2. Breakdown results of the impact categories studied.