DeMoBio - Decentralized Modular Biorefinery-container

Decentralized Pretreatment of Lignocellulosic Residues: Process Concepts and Techno-Economic Assessment

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The transformation towards sustainable carbon sources requires the development of process chains that are both feedstock-flexible and economically viable. While large-scale biorefineries benefit from economies of scale, they face challenges with renewables such as seasonal variability, logistical constraints, and the heterogeneity of solid lignocellulosic residues, i.e. small lots of the same quality. Previous studies have shown that variations in feedstock composition lead to significant fluctuations in product yield, thereby affecting the economic performance of central large-scale facilities (cf. [1], [2], [3], [4]). A decentralized, modular preprocessing approach adapted to the specific raw material can address these limitations.

This contribution presents a potential process design for the decentralized conversion of lignocellulosic residues to soluble chemicals. As first process step, extrusion can homogenize and pretreat the biomass directly into a crude ready for transportation. The pretreatment is carried out in a twin-screw extruder which operation was validated at a technology provider. However, the demonstration of a chemical unit operation in a modular container poses challenges of space, mechanics and regulation, of which final design (see Figure 1 and Figure 2) and as-built layout are presented.

Additionally, a central downstream processing hub for the conversion of crude into levulinic acid including separation was designed and evaluated based on an existing process concept [5]. On this basis, a techno-economic comparison between central and decentralized processing will be discussed. The results show inherent correlation between feedstock cost, investment and capacity. Together, these findings illustrate advantages and disadvantages of decentralized processing in container-based unit operations for robust, flexible, and economically competitive value chains for bio-based platform chemicals.

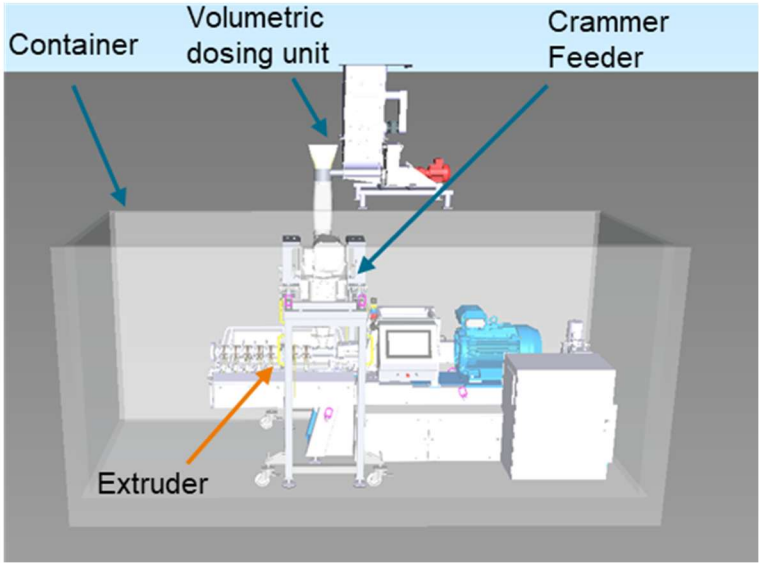

Figure 1: 3D-Model of DeMoBio-extruder in 20'' container (first illustration).

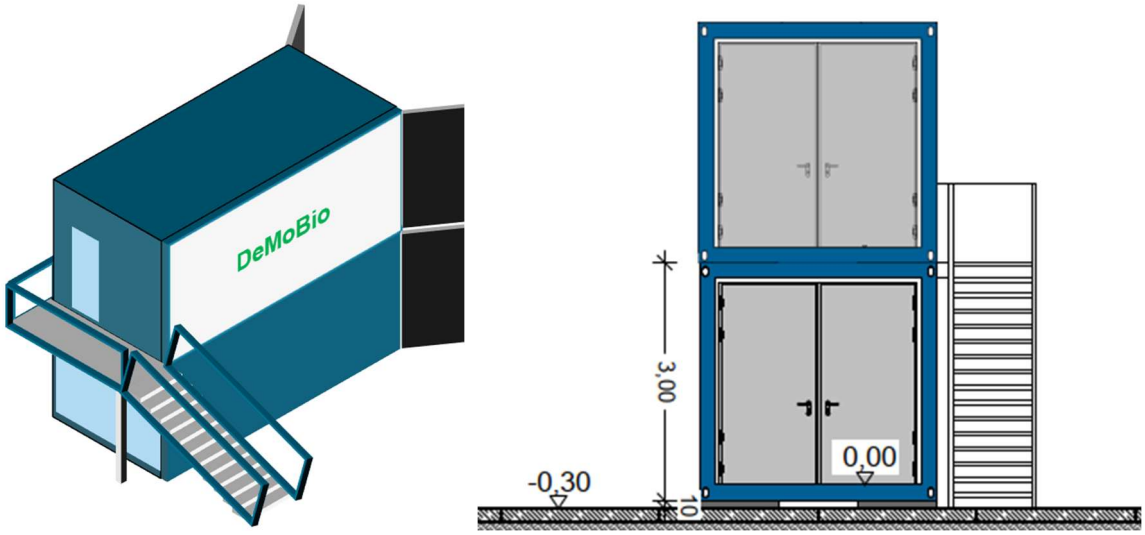

Figure 2: Layout of demonstration plant, 2x 20'' container.

[1] Lindmeyer, M., Viell J., et al., Achema (2021) LINK.
[2] Lindmeyer, M., Viell J., et al., Achema (2022) LINK.
[3] Lindmeyer, M., Viell J., et al., Dechema Forum (2024).
[4] J. Viell, S. Theis, R. Götz, A. Weber-Bernard, A. W. W. Echtermeyer und M. Lindmeyer, „Benefits and Challenges for Decentralized Use of Biomass as Feedstock for Chemicals“ Chemie Ingenieur Technik, Bd. 97, Nr. 6, pp. 642-651, 2025. (https://doi.org/10.1002/cite.202500043).
[5] Rehwasser et al., “Techno-Economic Modeling and Optimization of a Lignocellulosic Biorefinery for Gamma-Valerolactone and 1,4-Pentanediol Production”, submitted.