Barriers and incentives for market diffusion of biorefinery technologies

Short paper

IEA Bioenergy: Task 42 Biorefining in a circular economy

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on behalf of Task 42

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2 Introduction

Biorefinery is communicated as key enabling technology in different policy agendas globally, and specifically under different national bioeconomy strategies. The diversity of biorefinery concepts developed mainly in research projects under highly motivated research teams is overwhelming. However, the market diffusion of biorefinery technologies and its products has not taken up expected pace. Several technological barriers related to feedstock supply, conversion process efficiency and intermediate products and products quality are described (see Global biorefinery status report 2022). Non-technological barriers very much circle around problems overcoming the valley of death during the innovation process especially from pilot to demonstration scale connected to a lack of investments, economic feasibility and concrete policy instruments to incentivize market uptake of biorefinery products. In light of various biorefinery concepts, their target markets and their differing technological maturity, we can assume that barriers to commercialization differ. To develop strategies on how to bridge the so-called valley(s) of death, the gap between lab and market, specific knowledge about market environment is needed. The approach of the study presented here in the following builds on a former study (see Global biorefinery status report 2022) to specify generally discussed barriers to biorefinery deployment at hand of three selected biorefinery concepts from high to low technological maturity: lignocellulosic, green, algal biorefineries.

3 Methods

To reach the goal of specifying barriers and incentives for commercialization of biorefineries a quantitative survey on barriers for commercialization of biorefineries was conducted. To begin with barriers and incentives were identified in literature (see e.g. Brunnhofer et al. 2019) and structured along strength, weakness, opportunities and threats referring to commercialization (Figure 1). Participants of the survey were asked to rate the importance and performance of these SWOT-factors. Researchers and biorefinery plant managers were the specified target group of this survey. The data collection took place March-April 2024. To gain insights on special concerns in broader commercialization, an Importance-Performance Analysis (IPA) was conducted for three biorefinery concepts valorizing lignocellulosic, wet green, and aquatic biomass. The IPA methodology was originally developed in the field of marketing to identify which product attributes customers perceive as important, and how they rate the level of performance. For the conducted study a mismatch of importance and performance ratings signals barriers to commercialization.

The survey participants were asked how important they rate (from 1 very unimportant to 5 very important) the factors for a broad commercialization of the lignocellulosic, wet green and aquatic biomass biorefinery. They were additionally asked to rate the current performance (from 1 very poor to 5 very good) of the given factors.

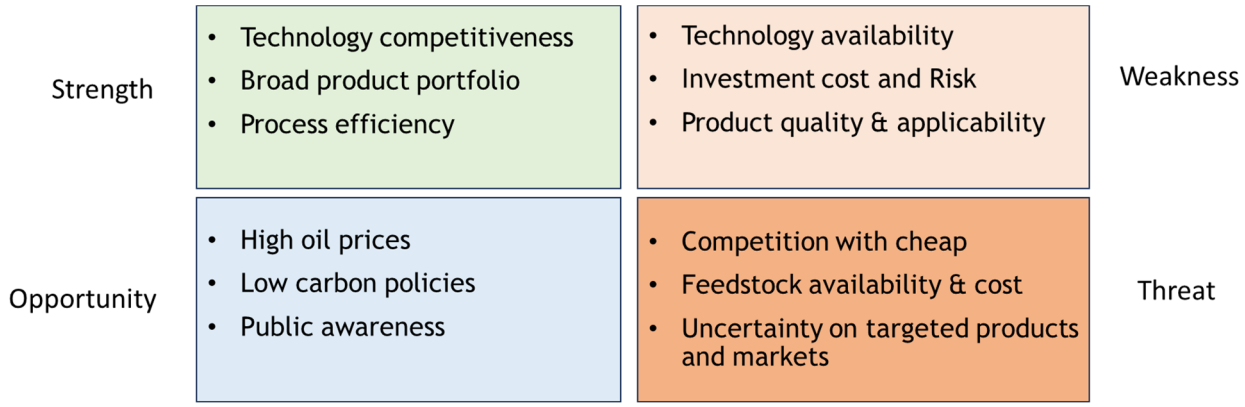

Figure 1: Factors relevant for commercialization were structured along strength, weakness, opportunities and threats.

4 Results

The 51 participants of the survey assigned themselves to university (n=29), non-university research institute (n=10), industry (n=7) and consulting (n=5) with the majority having over 10 years of experience with biorefinery systems and a professional background in engineering (n=23) or chemistry (n=9). The field of expertise was further specified by indicating the main feedstock processed: Lignocellulose (n=23), green wet biomass (n=2), aquatic biomass (n=3) and others (n=15). Most participants were located in Europe (n=23) but also participants from North America (n=8), South America (n=6), Asia (n=4) and Africa (n=2) were reached.

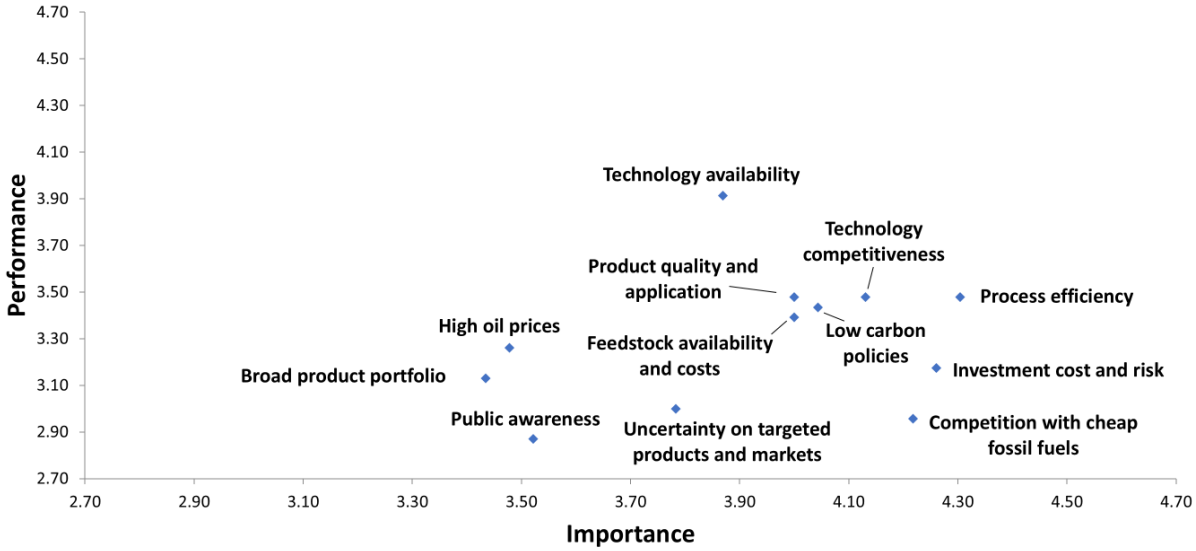

Figure 2: Importance-performance matrix for lignocellulosic biorefinery (n=23).

Figure 2 represents the importance-performance matrix of all SWOT-factors for the lignocellulose biorefinery. It is apparent that no factors were assigned to low importance or low performance, and no major gap results from the rating. The least performance was assigned to the factors public awareness, uncertainty on targeted markets and competition with cheap fossil fuels, which play key issues in market diffusion. These factors spread over a range of importance from rather important to very important. The highest performance considering commercialization was assigned to the availability of the lignocellulosic biorefinery technology.

Figure 3 depicts the results for the green wet biomass biorefinery with the factor of technology availability rated as very important but with comparatively low performance. This indicates that efforts are need to provide the technology to foster commercialization of products. For this biorefinery concept feedstock availability and costs as well as competition with cheap fossil fuels is rated with high performance also, as the feedstock is abundant. Also here, public awareness is rated as being not as important and high performing as other factors regarding commercialization of products.

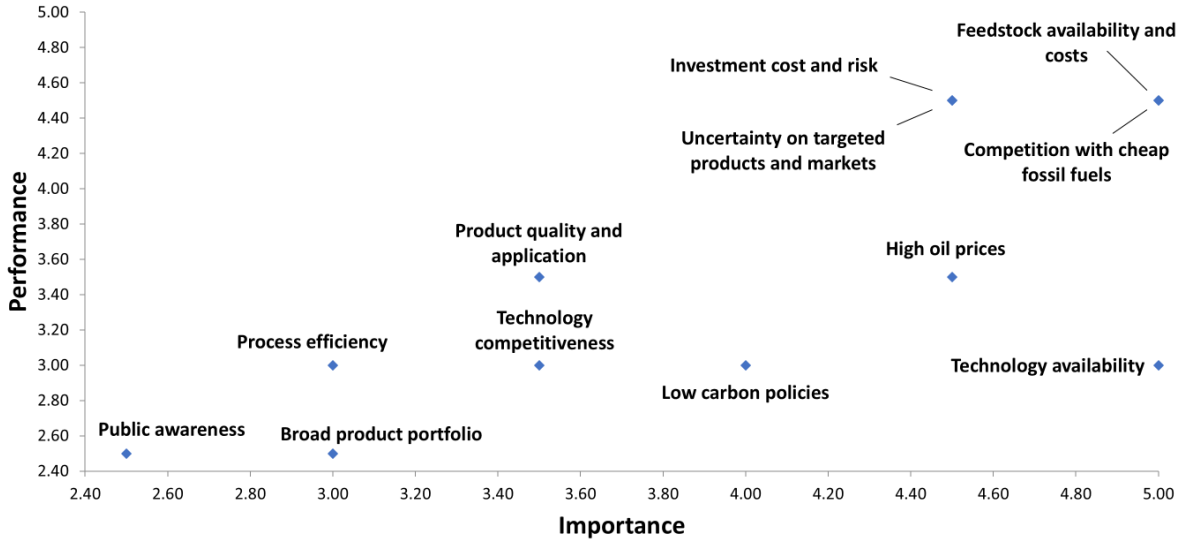

Figure 3: Importance-performance matrix for wet green biomass biorefinery (n=2).

Most commercialization factors for aquatic biomass biorefinery shown in figure 4, are rated rather important and high performing. Feedstock availability and the factor broad product portfolio are rated comparatively lower in importance and performance.

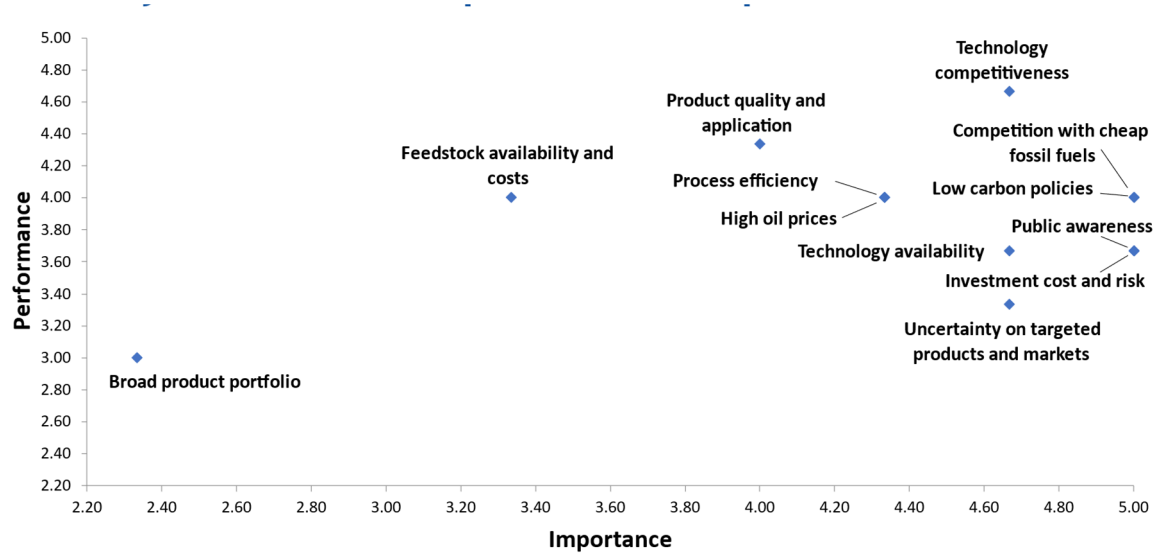

Figure 4: Importance-Performance matrix for aquatic biomass biorefinery (n=3).

5 Discussion

For the conducted study a mismatch of importance and performance ratings signals barriers to commercialization. Perceived gaps indicate that R&D activities prior to market introduction strongly focused on technological development but other interdisciplinary aspects (i.e. market demand, environmental aspects and societal acceptance) that shape innovation diffusion were underrepresented. In this study none of the commercialization factors for the investigated biorefinery concepts were rated as not important nor bad performing. This gives indication, that the market deployment of lignocellulosic, wet green and aquatic biomass biorefineries are perceived to be on the right track. Factors for commercialization discussed in literature were assigned to SWOT. Interestingly public awareness described as opportunity to a broad commercialization was overall rated as relatively unimportant. Note that the importance-performance

ratings represent the perception of the researchers and plant managers who participated in the survey. Contrary to the established lignocellulosic biorefinery, the green wet biomass biorefinery and the aquatic biorefinery do not perceive feedstock availability and costs as barriers to commercialization which is described as a threat in literature.

Especially considering the feedstock expertise, the study is limited by low participation rates for wet green and aquatic biomass biorefinery. Also, the perspectives are very Eurocentric by location of survey participants.

The result presented in this short paper limited to a snapshot of the full study as it is expected to be published scientifically in 2025.

6 Acknowledgements

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7 Literature

Brunnhofer, M., Gabriella, N., Schöggl, J. P., Stern, T., & Posch, A. (2020). The biorefinery transition in the European pulp and paper industry–A three-phase Delphi study including a SWOT-AHP analysis. Forest Policy and Economics, 110, 101882.

Global biorefinery status report 2022 available at https://task42.ieabioenergy.com/publications/global-biorefinery-status-report-2022/