

The “Biorefinery Fact Sheet” and its Application to Wood Based Biorefining - Case Studies of IEA Bioenergy Task 42 “Biorefining”

G. Jungmeier¹, R. Van Ree², E. de Jong³, H. Stichnothe⁴, I. de Bari⁵, H. Jørgensen⁶, M. Wellisch⁷, G. Bell⁸, J. Spaeth⁹, K. Torr¹⁰, S. Kimura¹¹

¹Joanneum Research

Elisabethstrasse 18, A-8010 Graz, Austria;

²WUR, Wageningen, The Netherlands

³Avantium Chemicals BV, The Netherlands

⁴VTI, Braunschweig, Germany

⁵ENEA C.R., Italy

⁶University of Copenhagen, Copenhagen, Denmark

⁷Agriculture and Rural Development, Edmonton, Canada

⁸Microbiogen Pty Ltd, Australia

⁹U.S. DOE, USA

¹⁰SCION, New Zealand

¹¹New Energy & Industrial Technology Development Organisation (NEDO), Japan

Abstract

The IEA Bioenergy Task 42 “Biorefining” with its 11 member countries (A, AUS, CA, DK, G, I, IR, J, NL, NZ, USA) has the following definition on biorefining: “Biorefining is the sustainable processing of biomass into a spectrum of bio-based products (food, feed, chemicals, and materials) and bioenergy (biofuels, power and/or heat)”. Wood as a renewable and sustainable resource offers great opportunities for a comprehensive product portfolio to satisfy the different needs in a future BioEconomy. Worldwide many different wood based biorefining concepts are investigated and realised, of which the development status and the perspectives for implementation are quite different. Task 42 developed a “Biorefinery Fact Sheet” for the uniform and compact description of the main characteristics of these biorefineries and their whole value chain. The “Biorefinery Fact Sheets” are initially applied for a first selection of 15 interesting biorefinery systems identified by IEA Bioenergy Task 42, of which 6 are based on wood. Based on these fact sheets an easy and uniform comparison of the different wood based biorefinery concepts is possible. The “Biorefinery Fact Sheet” assists various stakeholders in finding their position on wood based biorefining in a future BioEconomy.

Introduction

The IEA Bioenergy Task 42 “Biorefining” with its 11 member countries (A, AUS, CA, DK, G, I, IR, J, NL, NZ, USA) has the following definition on biorefining: “Biorefining is the sustainable processing of biomass into a spectrum of bio-based products (food, feed, chemicals, and materials) and bioenergy (biofuels, power and/or heat)” [1], [2]. A key driver for the necessary sustainable development is the implementation of the BioEconomy. Wood as a renewable and sustainable resource offers great opportunities for a comprehensive product portfolio to satisfy the different needs in a future BioEconomy. Worldwide many different wood based biorefining concepts are investigated and realised: Currently many wood based biorefineries are commercially operated (e.g. P&P industry), some concepts are realised as pilot and demonstration plants (e.g. gasification of black liquor for synthetic biofuels and chemicals) while others are developed on a conceptual basis (e.g. coproduction of bioethanol and phenol in particle board industry).

Goal and scope

As the development status and the perspectives for implementation and development of these wood based biorefineries are quite different the IEA Task 42 developed a “Biorefinery Fact Sheet” for the uniform and compact description of the main characteristics of these biorefineries: Part A: “Biorefinery plant” with the key characteristics of the biorefinery plant and Part B: “Value chain assessment” with the sustainability assessment based on the whole value chain of the biorefinery. The “Biorefinery Fact Sheets” are initially applied for a first selection of 15 interesting biorefinery systems identified by IEA Bioenergy Task 42 [1], [3], [5], of which the following 6 are based on wood:

- “3-platform (black liquor, pulp, electricity&heat) biorefinery using wood chips for pulp, paper, turpentine, tall oil, bark, electricity and heat”
- “2-platform (syngas, electricity&heat) biorefinery using wood chips for FT-Biofuels, electricity, heat and waxes with steam gasification”
- “3-platform (pulp, syngas, electricity&heat) biorefinery using wood chips for FT-biofuels, electricity, heat and pulp”
- “3-platform (C6 & C5 sugar, lignin, electricity&heat) biorefinery using wood chips for bioethanol, electricity, heat and phenols” (Figure 2)
- “4-platform (hydrogen, biomethane, syngas, electricity & heat) biorefinery using wood chips for biomethane (SNG), hydrogen and carbon dioxide”
- “4-platform (C6 & C5 sugar, lignin & C6 sugar, electricity & heat) biorefinery using saw mill residues, wood chips and sulphite liquor for bioethanol, pulp & paper, electricity and heat”

The naming of the wood based biorefineries follows the classification system developed in Task 42 [2]. The classification of a biorefinery consists of the following four features (Figure 1): platforms, products, feedstocks and processes. With the combination of these four features, different biorefinery configurations can be

described in a consistent manner. In Figure 2 the classification of a “3-platform (C5&C6 sugars, electricity&heat, lignin) biorefinery using wood chips for bioethanol, electricity, heat and phenols” is shown.

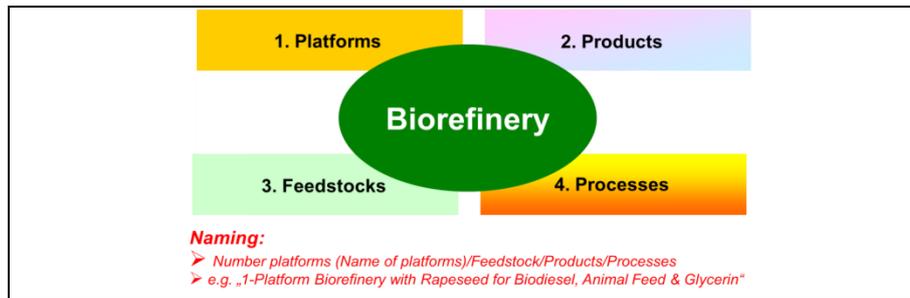


Figure 1: The 4 features to characterize a biorefinery system -and nomenclature of biorefineries in IEA Bioenergy Task 42 [2]

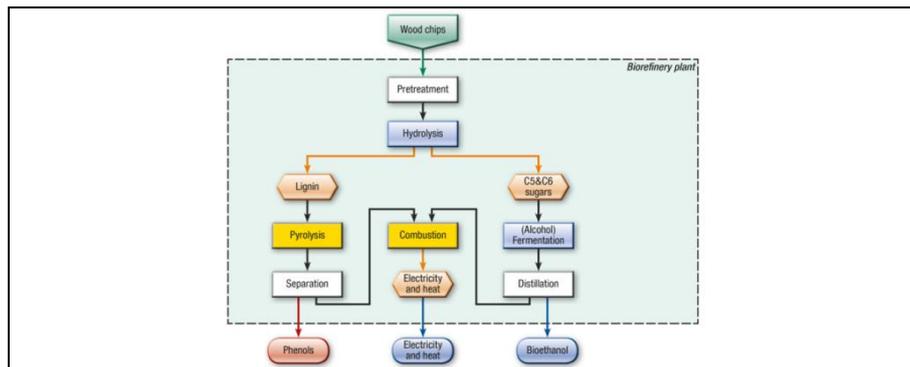


Figure 2: Classification system of a “3-platform (C5&C6 sugars, electricity&heat, lignin) biorefinery using wood chips for bioethanol, electricity, heat & phenols” [2]

The “Biorefinery Fact Sheet”

Due to the development status and the perspectives for implementation and development of biorefineries the IEA task developed a “Biorefinery Fact Sheet” for the uniform description of the key facts of a biorefinery [6]. Based on a technical description and the classification scheme the mass and energy balance is calculated for the most reasonable production capacity for each of the selected biorefineries. Then the three dimensions – economic, environmental and social - of sustainability are assessed for each biorefinery and documented in a compact form in the “Biorefinery Fact Sheet” by using the following methodologies

- Economic assessment with Life Cycle Costing (LCC),
- Environmental assessment with Life Cycle Assessment (LCA),

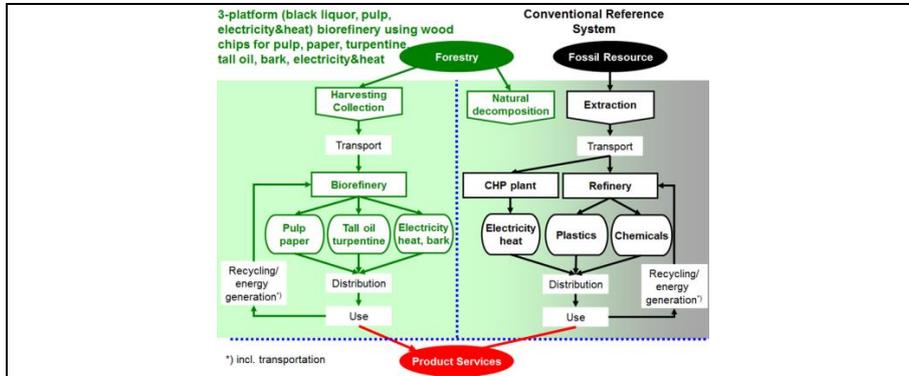


Figure 4: Value chain and reference system of “3-platform (black liquor, pulp, electricity&heat) biorefinery using wood chips for pulp, paper, turpentine, tall oil, bark, electricity and heat” [6]

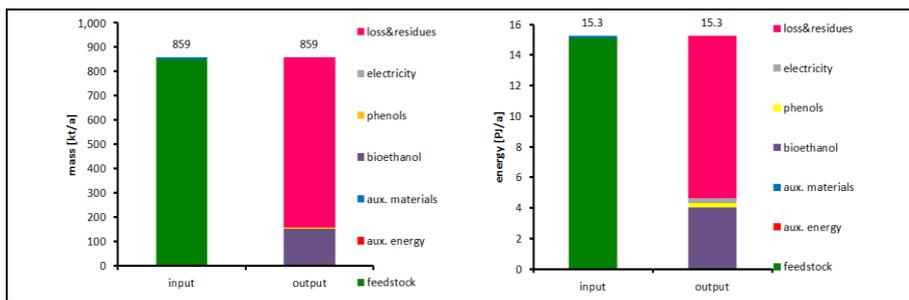


Figure 5: Mass and energy balance of “3-platform (C6 & C5 sugar, lignin, electricity&heat) biorefinery using wood for bioethanol (100 kt/a), electricity, heat & phenols” [16]

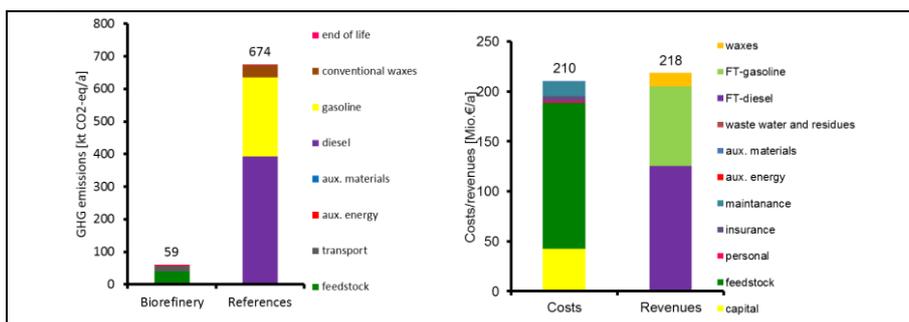


Figure 6: GHG emissions, costs & revenues of “2-platform (syngas, electricity&heat) biorefinery using wood for FT-Biofuels (200 kt/a, electricity, heat & waxes” [6]

Conclusions

Based on these Biorefinery Fact Sheets an easy and uniform comparison of the different wood based biorefinery concepts is possible. The “Biorefinery Fact Sheet” assists various stakeholders in finding their position on wood based biorefining in a future BioEconomy. Further Fact sheets are under preparation and the IEA Task 42 offers the service to make these fact sheets for further biorefineries as part of a continuous process of an international stakeholder involvement.

References

- [1] G. Jungmeier, M. Hingsamer, R. Van Ree, H. Jørgensen, M. Wellisch, H. Stichnote, E. de Jong, I. De Bari, R. Rauch, Energy Driven Biorefineries - A Selection of the Most Promising Biorefinery Concepts to Produce Large Volumes of Road Transportation Biofuels by 2025, Brochure published by IEA Bioenergy Task 42 “Biorefining”, 2013
- [2] F. Cherubini, G. Jungmeier, M. Wellisch, T. Willke, I. Skiadas, R. Van Ree, E. de Jong: Toward a common classification approach for biorefinery systems, Biofpr – Biofuels, Bi-products&Biorefining, 2009
- [3] Jungmeier G., The Possible Role of Wood-Biorefining in a Biobased Industry, International Conference on Processing Technologies for the Forest and Bio-based Products Industries (PTF BPI 2014), Kuchl/Salzburg, Austria, September 24-26, 2014
- [4] G. Jungmeier, H. Stichnothe, I. de Bari, H. Jørgensen, R. Van Ree, E. de Jong, M. Wellisch, P. Walsh, G. Garnier, M. Klembara, A biorefinery fact sheet for the sustainability assessment of energy driven biorefineries – Efforts of IEA Bioenergy Task 42 “Biorefining”, Proceedings of the 21th European Biomass Conference, Copenhagen 2013
- [5] Jungmeier G., Facts&Figures of Biorefineries Integrated in the Pulp&Paper Industry – Case Studies in IEA Bioenergy Task 42 “Biorefining”, Abstract of conference ZUKUNFT.FORUM PAPIER - Die Österreichische Papierfachtagung, June 4 – 5, 2014, Graz, Austria
- [6] Working Document „The Biorefinery Fact Sheet”, Gerfried Jungmeier, Rene van Ree, Henning Jørgensen, Ed de Jong, Heinz Stichnothe, Maria Wellisch, published on Task 42 webpage 19.9. 2014

Acknowledgement: The Austrian participation in Tasks 42 of IEA Bioenergy is financed by the Federal Ministry for Transport, Innovation and Technology / Department for Energy and Environmental Technologies.