Integrated 1st and 2nd generation sugarcane bio-refinery for jet fuel production in Brazil: Techno-economic and greenhouse gas emissions assessment

This study presents a techno-economic analysis and an environmental assessment, of the whole production chain (biomass production, sugar extraction, biomass pretreatment, sugars fermentation, and products recovery and purification), of a fully autarkic sugarcane-based biorefinery for biojet fuel production. All scenarios considered correspond to 1st/2nd generation integrated biorefineries (i.e. simultaneous use of sugarcane juice stream and lignocellulosic fractions) with a production scale of 208 kton (biojet fuel) yr−1. In this paper, we compared multiple options for the most relevant processing steps of the biorefinery: eight biomass pretreatment technologies (i.e. dilute acid, dilute acid + alkaline treatment, steam explosion, steam explosion + alkaline treatment, organosolv, alkaline wet oxidation, liquid hot water and liquid hot water + alkaline treatment); two biojet fuel production routes from sugars (i.e. ethanol to jet and direct fermentation); one biojet fuel production route from biomass (i.e. fast pyrolysis); two biojet fuel production routes from lignin obtained after biomass pretreatment (i.e. fast pyrolysis and gasification Fischer- Tropsch); and one alternative use for lignin (i.e. co-generation). From the combination of these key features, 81 scenarios are selected and compared. Furthermore, three potential technological improvements were analysed for selected scenarios: i) recovery of acetic acid and furfural (for cases with bagasse pretreatment); ii) production of succinic acid from a fraction of concentrated juice; iii) increase of operation time (from 200 to 320 days yr−1) by using sweet sorghum as cumulative feedstock. The different scenarios are compared first based on the minimum jet fuel selling price (MJSP) and then based on their environmental performance (i.e. greenhouse gas (GHG) emissions and non-renewable energy use (NREU)). Among the scenarios considering biomass pretreatment, the lower MJSP are obtained when 1G/2G sugars are upgraded via ethanol fermentation (ETJ) (i.e. SO2 steam explosion: 3409 US $ton−1, and wet oxidation: 3230 US $ton−1). Additional technological improvements may help to further reduce the MJSP either marginally (2%, by using 1G sugars for succinic acid production) or significantly (30%, by increasing the operation time). Thus, the lowest MJSP here calculated is 1725 US $ton−1 (with 1G sugars to biojet fuel via ethanol, and bagasse to biojet fuel via fast pyrolysis). Finally, for all scenarios considered, the GHG emissions and NREU were found to be lower than 42.5 kg CO2eq.GJ−1 and 700 MJ GJ −1 respectively (except for scenarios with fast pyrolysis of bagasse where those figures were further reduced by 50% and 80% respectively). Although, the MJSP calculated for all scenarios are higher than those of the fossil jet fuel reference, the significant potential for environmental impacts reduction (in terms of GHG emissions and primary energy use) are encouraging for further research in costs reduction and technology development.

General information
State: Published
Organisations: Novo Nordisk Foundation Center for Biosustainability, Research Groups, Biomass Conversion and Bioprocess Technology, Delft University of Technology
Pages: 733-747
Publication date: 2018
Peer-reviewed: Yes

Publication information
Journal: Renewable Energy
Volume: 129
ISSN (Print): 0960-1481
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 5.38 SJR 1.847 SNIP 2.008
Web of Science (2017): Impact factor 4.9
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.83 SJR 1.661 SNIP 2.05
Web of Science (2016): Impact factor 4.357
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.51 SJR 1.767 SNIP 2.085
Web of Science (2015): Impact factor 3.404
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 4.51 SJR 1.925 SNIP 2.621