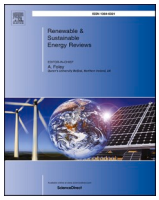
Renewable and Sustainable Energy Reviews 154 (2022) 111817

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser



Biorefining of oil palm empty fruit bunches for bioethanol and xylitol production in Indonesia: A review

Sri Suhartini [a,b,*], Novita Ainur Rohma [a], Efri Mardawati [c], Kasbawati [d], Nur Hidayat [a,b], Lynsey Melville [e]

[a] Department of Agro-industrial Technology, Faculty of Agricultural Technology, Universitas Brawijaya, Malang, East Java, Indonesia
[b] Sustainable Bioresources, Waste Technology and Bioeconomy (SBistec) Research Group, Universitas Brawijaya, Malang, East Java, Indonesia
[c] Department of Agro-industrial Technology, Faculty of Agro-industrial Technology, Universitas Padjadjaran, Sumedang, West Java, Indonesia
[d] Applied Mathematics Laboratory, Department of Mathematics, Hasanuddin University, Makassar, Sulawesi, Indonesia
[e] Bioresource and Bioeconomy Research Group, Faculty of Computing, Engineering and Built Environment, Birmingham City University, Birmingham, West Midlands, United Kingdom

ARTICLE INFO

Keywords:
Bio-based products
Bioenergy
Biomass valorization
Biorefinery
Circular economy

ABSTRACT

Indonesia has an intensive agro-industrial sector which evolves large volumes of residues each year. Currently, these residues are under-utilized and have a deleterious impact on the environment, Oil Palm Empty Fruit Bunches (OPEFBs) in particular are highly abundant and offer good potential for conversion to bioenergy and bio-based products, in particular bioethanol and xylitol (widely used as an artificial sweetener and can substitute sugar in food and pharmaceutical industries). This paper provides a comprehensive review of the techno-economic opportunities and challenges for the wider utilization of OPEFBs for the generation of bioethanol and xylitol in Indonesia. This review highlights the significant potential for the valorization of OPEFB based on resource availability in the country (828 MWe/year or 45.86 Mt/year) and growing demand for both bioethanol (from 0.22 billion L in 2019 to 10.38 billion L in 2025) and xylitol (up to 2.20 kt in 2020). Various process configurations were explored to assess the potential for simultaneous co-production of bioethanol and xylitol. A mass balance and techno-economic assessment showed that the preferred scenario was Scenario 3 (co-production of bioethanol with xylitol and lignin) and that this has the potential to generate 46,145 kL bioethanol, 7.716 kt xylitol, and 25.704 kt lignin per year. This is significant given the limited production for both bioethanol and xylitol in the country currently. Further work is required to address challenges around technical, policy and supply chains. This work provides an original and novel strategy to support the wider adoption of commercially viable bioethanol production in Indonesia.

1. Introduction

Indonesia, like many developing nations, faces the challenge of providing access to clean, safe, and affordable energy. Rapid population growth and expansion of industry have led to an increase in energy demand. However, inadequate infrastructure, centralized energy production and a lack of financial and policy instruments to support investment in technologies mean that the country is not currently meeting its targets to increase the share of renewable energy up to 23% by 2025 and up to 31% by 2030 [1]. It has been estimated that, in 2019, fossil fuels (i.e. gasoline, coal and natural gas) accounted for 90.82% of all energy, while renewable energy (i.e. solar, hydropower, wind energy, and biomass) accounted for less than 10% [1,2]. In Indonesia, fossil fuels have significant environmental impacts (i.e. air pollution, greenhouse gas/GHG emissions) [3,4]; as well as negative impacts on human health [5,6]. Currently, renewable energy has good potential to address the challenges of energy supply and demands [7]; as well as fossil fuels depletion [8]. The ambition to shift to renewable energy has been translated into policy at a national level via the Indonesian Ministry of Energy and Mineral Resources (MEMR) Regulation No. 20 Year 2014. This policy promotes the utilization of biomass for bioenergy and focuses on the creation of a national biofuel market. More recently, the MEMR Regulation No. 12 Year 2015 imposes the mandatory use of

* Corresponding author. Department of Agro-industrial Technology, Faculty of Agricultural Technology, Universitas Brawijaya, Jl. Veteran Malang, 65145, Indonesia.
E-mail addresses: ssuhartini@ub.ac.id (S. Suhartini), novitarohma@student.ub.ac.id (N.A. Rohma), efri.mardawati@unpad.ac.id (E. Mardawati), kasbawati@unhas.ac.id (Kasbawati), nhidayat@ub.ac.id (N. Hidayat), Lynsey.Melville@bcu.ac.uk (L. Melville).

https://doi.org/10.1016/j.rser.2021.111817
Received 12 December 2020; Received in revised form 12 September 2021; Accepted 22 October 2021
Available online 30 October 2021