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Techno-Economic Analysis and Feasibility of Industrial-Scale Activated Carbon Production from Agricultural Pea Waste Using Microwave-Assisted Pyrolysis: A Circular Economy Approach

Sharif H. Zein * and Ansu Antony

Department of Chemical Engineering, Faculty of Science and Engineering, University of Hull (UoH), Kingston upon Hull HU6 7RX, UK

* Correspondence: s.h.zein@hull.ac.uk; Tel.: +44-1482-466-753

Abstract: This paper examines a novel approach to activated carbon (AC) production that uses pea waste (PW) and to what extent it is economically competitive with current production methods. Additionally, the outcome is to provide a detailed economic analysis to understand whether this process is viable. The focus of this production route and the economic analysis will be on a United Kingdom (UK) basis. The plant will be located within the north UK to minimise storage and transportation costs. It also has extensive links to other clusters of nearby industries that would produce from this process in air pollution control or wastewater treatments. The overall production process is detailed, and detailed equipment specifications, including the sizing of equipment and utility requirements, were also given. Material balance calculations are carried out to assess the performance and improve process designs. An economic analysis is performed to study the potential of biomass-to-AC conversion costs and commercialisation viability. The project's investment is about £100 million. The cost of the plant can be recovered from year 3 (mid) for the 20-year life of the plant. The Net Present Value (NPV) is based on cumulative cash flow. The NPV is calculated as GBP 4,476,137,297.79 for 2020, and the associated internal rate of return (IRR) and the return on investment (ROI) for the project are 55% and 52%, respectively.

Keywords: activated carbon (AC); pea waste (PW); microwave heating; techno-economic analysis; inside battery limits (ISBL); offsite battery limits (OSBL); operational expenditure (OPEX); capital expenditure (CAPEX); fixed capital investment

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1. Introduction

Converting waste into value-added compounds such as activated carbon (AC) is stemmed from the growing negative environmental impact and increasing limitations of fossil fuel resources. Research in this field has accelerated as energy consumption increases over time [1]. Utilising biomass provides a path to combat or mitigate the increasing worldwide demands for energy [2]. This international effort intends to utilise new and alternative technologies, which would lower the changes associated with environmental pollution and, in turn, global climate change through the development of industrial and agricultural technologies from renewable means such as biomass waste. The transition to cleaner energy or materials from renewable resources can be enhanced, allowing nations to have energy security and achieve sustainable development [3]. The significant challenges include integrating with the petrochemical industry, utilising robust technologies, and providing a surplus amount of biomass feedstock for valorisation. Determining a viable and sustainable process route can help increase stakeholder cooperation across value chains.

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