ECO-EFFICIENCY EVALUATION OF A BIOREFINERY MODEL FOR BIOFUEL AND BIOCHEMICALS PRODUCTION IN THAILAND BASED ON LIFE CYCLE ASSESSMENT APPROACH

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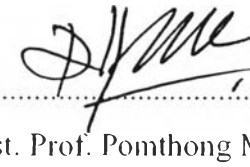

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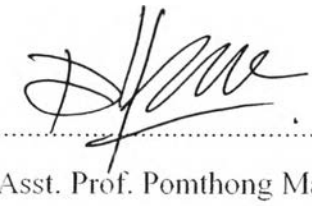

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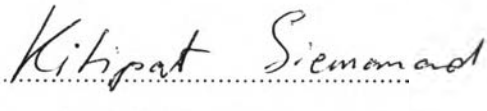

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ABSTRACT

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This study focuses on creating a biorefinery model for the production of bio-ethanol, lactic acid (LA) and biosuccinic acid (BSA) from sugarcane and cassava by evaluating the performance of the biorefinery in both environmental and economic aspects based on the life cycle assessment (LCA) approach. Global warming potential (GWP), energy resources, and profit were used as key performance indicators of the biorefinery within the cradle-to-gate system boundary. Based mostly on secondary data sources, the inventory data were extracted for the unit processes within the biorefinery boundary and used for LCA analysis by using commercial software, SimaPro 7.1, with Eco-Indicator 95 and CML 2 baseline 2000 methods. In addition, five scenarios were created by varying ratios of feedstocks and products. The results indicated that increasing sugarcane consumption led to better performance in GWP, AP, EP, and energy resources. This was due to the high amount of avoided steam and electricity generated from bagasse although cassava residues (pulp and rhizome) had been fully utilized. Increasing BSA ratio led to better AP and EP but worse performance in GWP and energy resources since LA process consumed high steam, sulfuric acid, and CSL. In the other hand, much higher electricity consumption in BSA process could cause worse GWP and energy resources. Finally, eco-efficiency indicators were developed as a single index for evaluating both environmental and economic aspects. Scenario 5, with highest sugarcane usage and BSA production, was shown to be the most suitable scenario, which had the highest eco-efficiency in all aspects.

บทคัดย่อ

วศิน คุณาเขมากร : การประเมินประสิทธิภาพเชิงนิเวศเศรษฐกิจของแบบจำลองโรงกลั่นชีวภาพเพื่อการผลิตเชื้อเพลิงและสารเคมีชีวภาพในประเทศไทยโดยวิธีการประเมินวัฏจักรชีวิต (Eco-efficiency Evaluation of a Biorefinery Model for Biofuel and Biochemicals Production in Thailand Based on Life Cycle Assessment Approach)
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งานวิจัยนี้มุ่งเน้นไปที่การสร้างแบบจำลองโรงกลั่นชีวภาพสำหรับการผลิตเอทานอล กรดแลคติกและกรดซัคซินิคชีวภาพจากอ้อยและมันสำปะหลังโดยการประเมินประสิทธิภาพการทำงานของโรงกลั่นชีวภาพในด้านสิ่งแวดล้อมและเศรษฐกิจบนพื้นฐานของวิธีการประเมินวัฏจักรชีวิต (LCA) ภาวะโลกร้อน การใช้พลังงานและผลกำไรถูกนำมาใช้เป็นตัวชี้วัดประสิทธิภาพที่สำคัญของโรงกลั่นชีวภาพตั้งแต่การเพาะปลูกจนกระทั่งได้เป็นผลิตภัณฑ์ ข้อมูลส่วนใหญ่มาจากแหล่งข้อมูลทุติยภูมิซึ่งนำมาใช้สำหรับการวิเคราะห์ตลอดวัฏจักรชีวิตโดยใช้โปรแกรม SimaPro 7.1 ด้วยวิธี Eco-Indicator 95 และ CML 2 baseline 2000 นอกจากนี้สถานการณ์ทั้งห้ายังถูกสร้างขึ้นโดยปรับเปลี่ยนอัตราส่วนทั้งในวัตถุดิบและผลิตภัณฑ์ ผลการวิจัยพบว่าการเพิ่มสัดส่วนการใช้อ้อยนำไปสู่ประสิทธิภาพที่ดีขึ้นในด้านภาวะโลกร้อน การเกิดฝนกรด การเกิดน้ำเน่าเสียและการใช้พลังงานเนื่องจากไอน้ำและไฟฟ้าปริมาณมากที่ผลิตได้จากชานอ้อยแม้ว่าของเหลือจากมันสำปะหลัง (กากและเหง้า) จะได้รับการใช้ประโยชน์ทุกด้านแล้ว การเพิ่มสัดส่วนการผลิตกรดซัคซินิคชีวภาพนำไปสู่ประสิทธิภาพที่ดีขึ้นในด้านการเกิดฝนกรดและการเกิดน้ำเน่าเสีย แต่ในด้านภาวะโลกร้อนและการใช้พลังงานกลับแย่ลง เนื่องจากในด้านกระบวนการผลิตกรดแลคติกใช้ปริมาณไอน้ำ กรดกำมะถันและน้ำหมักข้าวโพดสูง ทั้งนี้ปริมาณการใช้ไฟฟ้าในการผลิตกรดซัคซินิคชีวภาพที่สูงมากก่อให้เกิดภาวะโลกร้อนและการใช้พลังงานที่เพิ่มขึ้นเช่นกัน ตัวชี้วัดประสิทธิภาพเชิงนิเวศเศรษฐกิจถูกสร้างขึ้นเป็นดัชนีสำหรับการประเมินทั้งด้านสิ่งแวดล้อมและเศรษฐกิจในเวลาเดียวกัน สถานการณ์ห้า (S5) ซึ่งมีการใช้อ้อยและการผลิตกรดซัคซินิคชีวภาพมากที่สุดเป็นสถานการณ์ที่เหมาะสมที่สุด เพราะมีประสิทธิภาพเชิงนิเวศเศรษฐกิจที่สูงที่สุดในทุกด้าน

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