

**LIFE CYCLE ENERGY AND ENVIRONMENTAL ANALYSIS OF
A MODEL BIOREFINERY IN THAILAND**

Rachasak Chinnawornrungsee

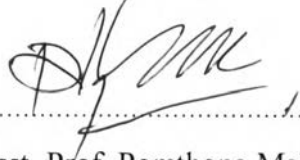
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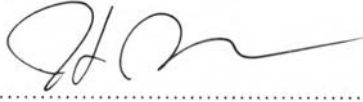
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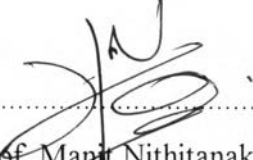
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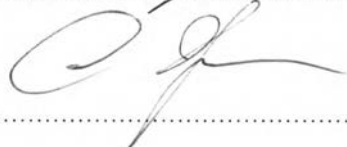

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ABSTRACT

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This study aims to evaluate life cycle energy and environmental impacts associated with the production of biofuel (bioethanol) and biopolymer (polylactic acid, PLA) by using sugarcane and cassava as feedstocks for a possible model biorefinery in Thailand. Since there is currently no biorefinery in the country, secondary data sources from existing bioethanol and PLA plants were used for life cycle analysis (LCA). The system boundary was defined as cradle-to-gate and LCA methodology based on ISO 14040 series was used. Data were analyzed by using commercial LCA software, SimaPro 7.1, with Eco-Indicator 95 and CML 2 baseline 2000. The biorefinery processes was modeled and its performance was evaluated in several aspects such as fuel and biopolymer production, raw materials used, and total revenue generated for various scenarios. The results indicated that the biorefinery showed better performance in both global warming potential (GWP) and energy resources with increasing sugarcane usage. This was due to the use of bagasse and biogas as sources of fuel to generate electricity and steam by using cogeneration system in the biorefinery. In contrast, increasing PLA production led to higher GWP and energy resources impacts because of high electricity and steam usage in the bioplastic production process. Moreover, acidification potential (AP) and eutrophication potential (EP) impacts were also added in the results. Finally, eco-efficiency parameter was developed in order to combine both environmental (GWP, AP, EP, and energy resources) and economic (revenue) aspects by using average revenue gained and average impact associated. Among 5 scenarios studied, the results showed that S4 was the best scenario as it has higher eco-efficiency in several aspects.

บทคัดย่อ

ราชศักดิ์ ชินวรรังสี : การศึกษาการประเมินผลกระทบด้านพลังงานและสิ่งแวดล้อมของแบบจำลองของระบบโรงกลั่นชีวภาพในประเทศไทยตลอดวัฏจักรชีวิต (Life Cycle Energy and Environmental Analysis of a Model Biorefinery in Thailand) อ. ที่ปรึกษา: ผศ. ดร. ปมทอง มาลาคุณ ณ อุทยาน และ รศ. ดร. ชำรงรัตน์ มุ่งเจริญ, 125 หน้า

งานวิจัยนี้ทำการประเมินผลกระทบด้านพลังงานและสิ่งแวดล้อมตลอดวัฏจักรชีวิตของการผลิตเชื้อเพลิงชีวภาพ (ไบโอเอทานอล) และพลาสติกชีวภาพ (พอลิแลคติกเอซิด) โดยใช้ฮ้อยและมันสำปะหลังเป็นวัตถุดิบสำหรับแบบจำลองที่เป็นไปได้ของระบบโรงกลั่นชีวภาพในประเทศไทย เนื่องจากในขณะนี้ยังไม่มีระบบโรงกลั่นชีวภาพในประเทศ ดังนั้นข้อมูลหัตถ์จากโรงงานผลิตไบโอเอทานอล และโรงงานผลิตพอลิแลคติกเอซิด จึงถูกนำมาใช้ในการประเมินผลกระทบตลอดวัฏจักรชีวิต ขอบเขตของการศึกษานี้ครอบคลุมตลอดวัฏจักรของการผลิตผลิตภัณฑ์ ตั้งแต่การเพาะปลูกและการเก็บเกี่ยววัตถุดิบ การขนส่งวัตถุดิบ การแปรรูปวัตถุดิบ ตลอดจนการผลิตไบโอเอทานอลและการผลิตพอลิแลคติกเอซิด โดยใช้วิธีการประเมินตามมาตรฐานสากล ISO 14040 ข้อมูลต่างๆ ที่เก็บรวบรวมถูกนำมาวิเคราะห์โดยใช้โปรแกรม SimaPro 7.1 ด้วยวิธี Eco-Indicator 95 และ CML baseline 2000 เพื่อประเมินภาระสิ่งแวดล้อมด้านต่างๆ โดยเน้นที่ผลกระทบด้านภาวะโลกร้อนและการใช้พลังงาน จากผลการศึกษาพบว่า ระบบโรงกลั่นชีวภาพส่งผลกระทบต่อภาวะโลกร้อนและการใช้พลังงานน้อยลง เมื่อเพิ่มปริมาณการใช้ฮ้อยเป็นวัตถุดิบ เนื่องจากการนำกากฮ้อยและก๊าซชีวภาพมาใช้เป็นเชื้อเพลิงในการผลิตไอน้ำและกระแสไฟฟ้าเพื่อใช้ภายในโรงงาน ในทางตรงกันข้าม การเพิ่มปริมาณการผลิตพอลิแลคติกเอซิด ทำให้ผลกระทบทางด้านภาวะโลกร้อนและการใช้พลังงานสูงขึ้น เนื่องจากการใช้ไฟฟ้าและไอน้ำจำนวนมากในการผลิตพอลิแลคติกเอซิด นอกจากนี้ ผลการศึกษายังแสดงผลกระทบในด้านภาวะการเกิดฝนกรดและภาวะการเกิดน้ำเน่าเสีย อีกด้วย สุดท้าย ตัวแปรของการประเมินประสิทธิภาพเชิงนิเวศเศรษฐกิจ (Eco-efficiency) ถูกสร้างขึ้นเพื่อรวบรวมผลกระทบในด้านต่างๆ (ภาวะโลกร้อน, การเกิดฝนกรด, การเกิดน้ำเน่าเสีย, และการใช้พลังงาน) เข้ากับด้านเศรษฐกิจ (รายได้) โดยใช้รายได้เฉลี่ย และค่าเฉลี่ยผลกระทบด้านต่างๆ ของสถานการณ์ตัวอย่าง จากการศึกษทั้งหมด 5 สถานการณ์ (S1-S5) พบว่า S4 เป็นสถานการณ์ที่ดีที่สุด เนื่องจากมีค่าการประเมินประสิทธิภาพเชิงนิเวศเศรษฐกิจที่สูงในหลายๆ ด้าน

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