

**SUSTAINABLE PROCESS DESIGN STUDY OF CELLULOSIC-BASED  
BIOFUEL: BIOETHANOL PRODUCTION FROM RICE STRAW**

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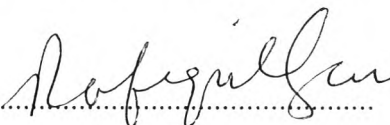
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## ABSTRACT

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This study focused on the sustainable process design of bioethanol production from rice straw using various tools including: process simulation, sustainability analysis, economic evaluation and life cycle assessment (LCA). The process simulator program, PRO/II 9.1, was used to generate a base case design of the bioethanol conversion process using rice straw as a feedstock. The sustainability analysis software, SustainPro, was then used to analyze relevant indicators in sustainability metrics, which were further employed to provide directions for improvements. To evaluate profitability of the process, ECON software was used as a tool. Lastly, evaluation of the life cycle environmental burdens associated with bioethanol production was performed by using LCA software, SimaPro 7.1. Based on SustainPro results, five ideas of new design alternatives were generated for possible improvement. The ideas were heat integration to reduce energy; wastewater exchange heat as utility; wastewater recovery by evaporation; wastewater recovery using membranes; and the combustion of lignin as fuel. Based on these ideas, fifteen alternative designs were generated from different combinations of these ideas. Finally, all alternatives were compared with the base case design to show the improvements of these designs for more sustainable.

## บทคัดย่อ

ภัทรุตม์ นิธินันท์ : การศึกษาการออกแบบกระบวนการผลิตเชื้อเพลิงชีวภาพจากวัสดุประเภทเซลลูโลสที่ยั่งยืน: การผลิตไบโอเอทานอลจากฟางข้าว (Sustainable Process Design Study of Cellulosic-based Biofuel: Bioethanol Production from Rice Straw) อ. ที่ปรึกษา : ผศ. ดร. ปมทอง มาลากุล ณ อยุธยา และ ศ. ดร. ราฟีก กานี่ 216 หน้า

งานวิจัยนี้มุ่งเน้นศึกษาการออกแบบกระบวนการผลิตไบโอเอทานอลจากฟางข้าวอย่างยั่งยืนโดยใช้เครื่องมือหลายประเภท ได้แก่ การจำลองกระบวนการผลิต การวิเคราะห์ความยั่งยืน การวิเคราะห์เชิงเศรษฐศาสตร์ และการประเมินวัฏจักรชีวิต (LCA) โปรแกรม PRO/II 9.1 ได้ถูกนำมาใช้ในการสร้างแบบจำลองพื้นฐานสำหรับกระบวนการผลิตไบโอเอทานอลโดยใช้ฟางข้าวเป็นวัตถุดิบ จากนั้นโปรแกรมวิเคราะห์ความยั่งยืน SustainPro จึงถูกนำมาใช้ในการวิเคราะห์ตัวชี้วัดด้านความยั่งยืนเพื่อนำมาหาแนวทางปรับปรุงแบบจำลองกระบวนการ สำหรับการวิเคราะห์ผลกำไรของกระบวนการนั้นใช้โปรแกรม ECON และท้ายสุด ทำการประเมินผลกระทบต่อสิ่งแวดล้อมด้วยโปรแกรมประเมินวัฏจักรชีวิต SimaPro 7.1 จากผลการวิเคราะห์ของโปรแกรม SustainPro แบบจำลองทางเลือกใหม่ได้ถูกสร้างขึ้นโดยอาศัยแนวความคิดหลักห้าแบบเพื่อการปรับปรุง คือ การบูรณาการทางความร้อนเพื่อลดการใช้พลังงาน การนำน้ำทิ้งมาใช้ในการแลกเปลี่ยนความร้อน การนำน้ำทิ้งกลับมาใช้ใหม่โดยใช้เครื่องระเหย การนำน้ำทิ้งกลับมาใช้ใหม่โดยใช้เมมเบรน และการนำลิกนินมาเผาไหม้เป็นเชื้อเพลิง จากแนวความคิดทั้งห้า สามารถนำมาผสมผสานกันได้แบบจำลองทางเลือกทั้งหมดสิบห้าทางเลือก จากนั้นจึงทำการเปรียบเทียบระหว่างแบบจำลองพื้นฐานกับแบบจำลองทางเลือกต่างๆ เพื่อแสดงให้เห็นถึงการปรับปรุงกระบวนการเพื่อให้เกิดความยั่งยืนขึ้น

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