ห้องสมุดงานวิจัย สำนักงานคณะกรรมการวิจัยแห่งชาติ
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SUSTAINABILITY ASSESSMENT OF BIOFUELS FOR TRANSPORT IN THAILAND

MR. THAPAT SILAPERTRUKA
ID: 50920113

A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
IN ENVIRONMENTAL TECHNOLOGY

THE JOINT GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT
AT KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI

2ND SEMESTER 2010

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(Assoc. Prof. Dr. Bundit Fungtammasan)	Member
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Abstract

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The dissertation aims to assess the sustainability of biofuels for transport in Thailand by focusing on the four key issues related to their production and use i.e. environmental consequences, full cost performance, long-term security of feedstocks supply and socio-economic impacts. A variety of environmental and economic assessment tools and indicators including net energy balance (NEB), life cycle assessment (LCA), life cycle costing (LCC), externalities assessment based on benefits transfer approach, net feedstock balances, Shannon index, net life cycle greenhouse gas (GHG) emissions and economic input-output (IO) analysis are applied in the study to evaluate the existing biofuels production systems in Thailand i.e. cassava ethanol, sugarcane molasses ethanol and palm biodiesel. The results are discussed as follows:

NEB and LCA show that there are significant differences in energy and environmental performance between the existing production systems even for the same feedstock. The differences are dependent on many factors such as farming practices, feedstock transportation, fuel used in biofuels plants, operation practices and technology of biofuels conversion and waste management practices. In addition, land-use change (LUC) is an important factor in the GHG performance of the first generation biofuels in Thailand as they can possibly increase from 1 to 10 times compared to the cases where LUC is excluded. Therefore, biofuels will contribute to the country's strategic plan on GHG mitigation in the transportation sector only if the production systems are sustainably managed.

LCC and preliminary assessment of externalities of gasohol reveal that in comparison to gasoline at the same performance, the total environmental costs of cassava based ethanol are 6% to 32% lower, depending on the blending level of ethanol into gasoline. However, the environmental benefits of various blends of gasohol, i.e. E10, E20 and E85, cannot compensate for their higher production costs as compared to gasoline. The total environmental costs from palm biodiesel are lower than that of diesel by about 3% for B5 and 76% for B100; the total costs of both B5 and B10 are lower than diesel. However, B100 is still not economically attractive and also faces constraints of feedstock availability.

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Therefore, several measures to improve the environmental performance and enhance the cost-competitiveness of cassava ethanol and palm biodiesel are required.

For the long-term (future) security of feedstock supply, the results show that only high yields improvement can result in a reliable and sufficient supply of feedstocks to satisfy the long-term demands for biofuels and other related industries. Cassava is identified as the critical feedstock for meeting the future ethanol targets and a reduction in cassava export is necessary. Meanwhile, both increase in fresh fruit bunch (FFB) yields and expansion of new oil palm plantation need urgently to be promoted by the government to avoid the shortage of crude palm oil supply.

In terms of socio-economic development, the results obtained from the combination of analytical approach and IO analysis show that producing bio-ethanol and biodiesel requires respectively about 17-20 times and 10 times more workers than gasoline and diesel per unit energy. Direct employment in agriculture contributes to more than 90% of the total employment. Nevertheless, there are significant differences in the characteristics of employment between persons employed in agriculture and biofuel processing sectors in Thailand. The overall impacts of bio-ethanol production in Thailand in the year 2022 are the generation of employment of around 238,700-382,400 persons-year, 55.5 billion THB additional Gross Domestic Product, imported goods worth 58 billion THB but 93 billion THB of reduced petroleum imports.

Finally, the study concludes that Thailand has a large potential to produce and use biofuels for substituting petroleum fuels for domestic consumption and for trade in the global market. Biofuels have the potential to address climate-change mitigation, energy security and socio-economic development especially for the agricultural sector in rural areas. However, these advantages will only be achieved if the appropriate policy measures as suggested in the dissertation are adopted to direct the biofuels production in Thailand towards sustainability.

Keywords:
Sustainability, Biofuels, LCA, Externalities, Socio-economic, Thailand

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NOMENCLATURES

AF	Allocation factor
A.I.	Active Ingredient
AP	Acidification potential
BCRSP	Basel Criteria for Responsible Soy Production
BEFSCI	Bioenergy and Food Security Criteria and Indicators
BioNachV	Biomass Sustainability Order
BOD	Biooxygen demand
BSI	Better Sugarcane Initiative
CDM	Clean Development Mechanism
CE	Cassava ethanol
CFC-11	trichlorofluoromethane
CG	Conventional gasoline
CH_4	methane
CML	CML impact assessment method developed by the Institute of Environmental Sciences of the University of Leiden
CO	carbon monoxide
CO_2	carbon dioxide
COD	Chemical oxygen demand
CPO	Crude palm oil
CSBP	Council on Sustainable Biomass Production
CSTRU	Cassava and Starch Technology Research Unit
CVM	Contingent valuation method
C_2H_4	ethylene
DDG	Dry Distillers Grains
DDGS	Dry Distillers Grains with Solubles
DEDE	Department of Alternative Energy Development and Efficiency
dLUC	direct land-use change
DM	dry matter
EDIP	Environmental Design of Industrial Product
EFB	Empty fruit bunches
EP	Eutrophication Potential

EPA	US Environmental Protection Agency
EPS	Environmental Priority Strategies in product design
eq	equivalent
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FFB	Fresh fruit bunches
g	gram
GAP	Good Agricultural Practices
GBEP	Global Bioenergy Partnership
GDP	Gross domestic product
GHG	Greenhouse Gas
GJ	gigajoule
GSL	Gasoline
GWP	Global warming potential
ha	hectare
HC	hydrocarbon
HPM	Hedonic Pricing Method
HTP	Human toxicity potential
iLUC	indirect land-use change
IMF	International Monetary Fund
IO	Input-Output
ISCC	International Sustainability and Carbon Certification
ISO	International Organization for Standardization
JME	Jatropha Methyl Ester
K	potassium
KAPI	Kasetsart Agricultural and Agro-industrial Product Improvement Institute
kg	kilogram
km	kilometer
kWh	kilowatt hour
L	litre
LCA	Life cycle assessment
LCC	Life Cycle Cost
LCI	Life cycle inventory

LCIA	Life cycle impact assessment
LFS	Labour force survey
LIME	Life-cycle Impact assessment Method based on Endpoint modelling
LUCs	Land-use changes
mg	milligram
MJ	megajoule
ML	million litre
MoE	Molasses ethanol
N	nitrogen
NaOH	sodium hydroxide
NEB	Net Energy Balance
NER	Net Eenrgy Ratio
NESDB	National Economic and Social Development Board
NEV	Net Energy Value
NO_x	nitrogen oxide
NRnEV	Net Renewable Energy Value
NSO	National Statistical Office
OAE	Office of Agricultural Economics
OCSB	Office of the Cane and Sugar Board
OECD	Organization for Economic Co-operation and Development
OH&S	Occupational Health and Safety
P	phosphorus
PKE	Palm kernel extract
PKO	Palm kernel oil
POCP	Photochemical oxidation potential
POME	Palm oil mill effluent
PO_4^{3-}	phosphate
PM	particulate matter
PM_{10}	particulate matter 10 micron
PME	Palm Methyl Ester
PPP	Purchasing power parity
RED	EU Renewable Energy Directive
RP	Revealed Preference

RSB	Roundtable on Sustainable Biofuels
RSPO	Roundtable on Sustainable Palm oil
RTFO	Renewable Transport Fuel Obligation
RTG	Royal Thai Government
RTRS	Roundtable on Responsible Soy
Sb	Antinomy
SCE	Sugarcane ethanol
SETAC	The Society of Environmental Toxicology and Chemistry
SFS	Social Fuel Seal
SOC	soil organic carbon
SO_2	sulfur dioxide
SP	Stated Preference
SSF	Simultaneous Saccharification and Fermentation
TBL	triple bottom lines
TC	ton cane
TFC	Total food consumed
THB	Thai Baht (currency unit)
TJ	terajoule
Total N	Total nitrogen
Total P	Total phosphorus
TTSA	Thai Tapioca Starch Association
UASB	Up-flow Anaerobic Sludge Blanket system
UASFF	Up-flow Anaerobic Sludge Fixed-Film
UN	United Nations
US	United States
USD	US dollar (currency unit)
VOCs	volatile organic compounds
WF	weighting factor
WTA	Willingness to accept
WTP	Willingness to Pay
WWF	World Wide Fund for Nature
1,4-DB	1,4-dichlorobenzene