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Bioenergía y biorrefinerías para caña de azúcar y palma de aceite

Bioenergy and Biorefineries for Sugar Cane and Oil Palm

Brasil / Brazil

XVIII Conferencia Internacional sobre PALMA DE ACEITE

18th International Oil Palm Conference 22 al 25 de septiembre de 2015

Bioenergia y biorefinerias para caña de azucar y palma de aceite

Electo Eduardo Silva Lora   Jose Carlos Escobar Palacio

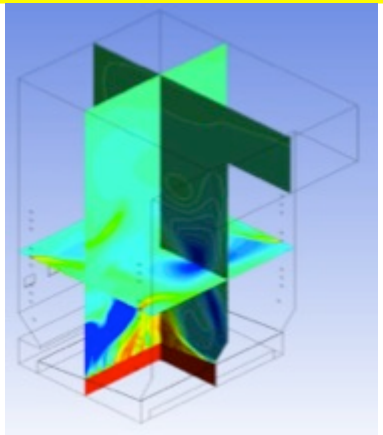
Universidad Federal de Itajubá, BRASIL

TÓPICOS

1. Introduccion: UNIFEI. NEST. Bioenergia y sustentabilidad
2. Concepto de biorefinerias. Clasificacion y estado del arte.
3. Aplicacion del ACV en biorefinerias. Indicadores energéticos y ambientales.
4. Algunas consideraciones sobre la evaluación econômica y de sustentabilidad.
5. Productividad energética de la caña de azucar y la palma de aceite.
6. Posibles procesos y productos a incluir en esquemas actuales de biorefinerias en el sector palmero y azucarero topologias.
7. Historial de la relacion NEST/PALMA DE ACEITE
8. Posibilidades de interacción y complementacion entre la industria de azucar y alcohol y el sector de la palma de aceite.

I - Introduccion: UNIFEI. NEST. Bioenergia y sostenibilidad

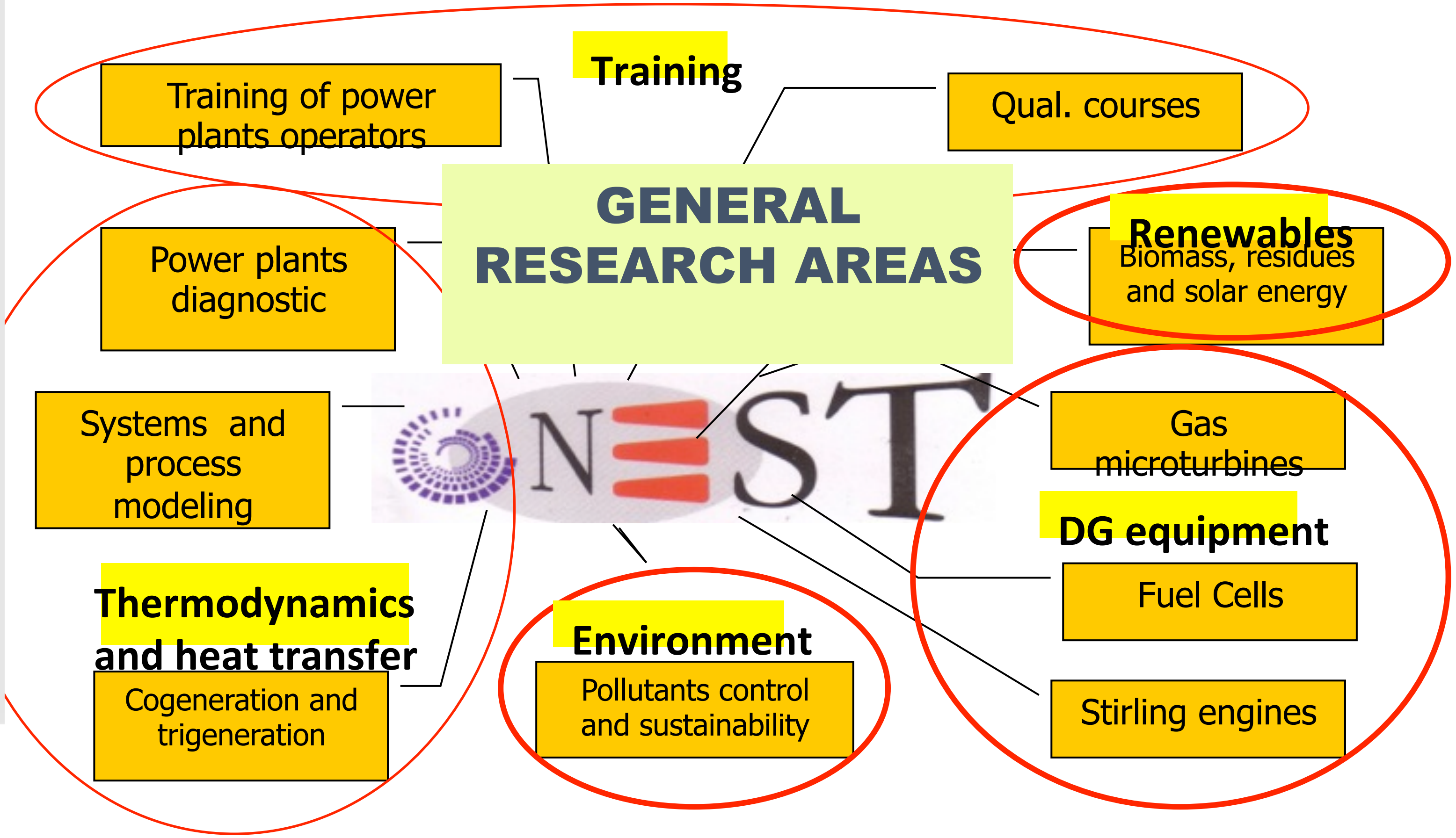
ITAJUBÁ – University city in the South of Minas Gerais State
BRASIL
90000 inhabitants



UNIVERSIDAD FEDERAL de ITAJUBÁ

UNIFEI
A technological university

1913



- 30 investigadores
- 6 profesores
- 40 MSc y 12 Ph.D defendidos (Varios de ellos colombianos

BIOFUELS

36 authors from 7 countries

1100 pages

Chapter 1- Biofuels: fundamentals

Chapter 2 Biomass combustion.

Chapter 3- Biodiesel.

Chapter 4 – Biogas.

Chapter 5 – Conventional Bioethanol.

Chapter 6 – Syngas.

Chapter 7 – BTL (biomass-to-liquid).

Capítulo 8 – Lignocellulosic ethanol.

Chapter 9 – BioH2 and bioFC.

Chapter 10 - Biofuels in IC Engines.

Chapter 11 Biofuels in gas microturbines (MTG)

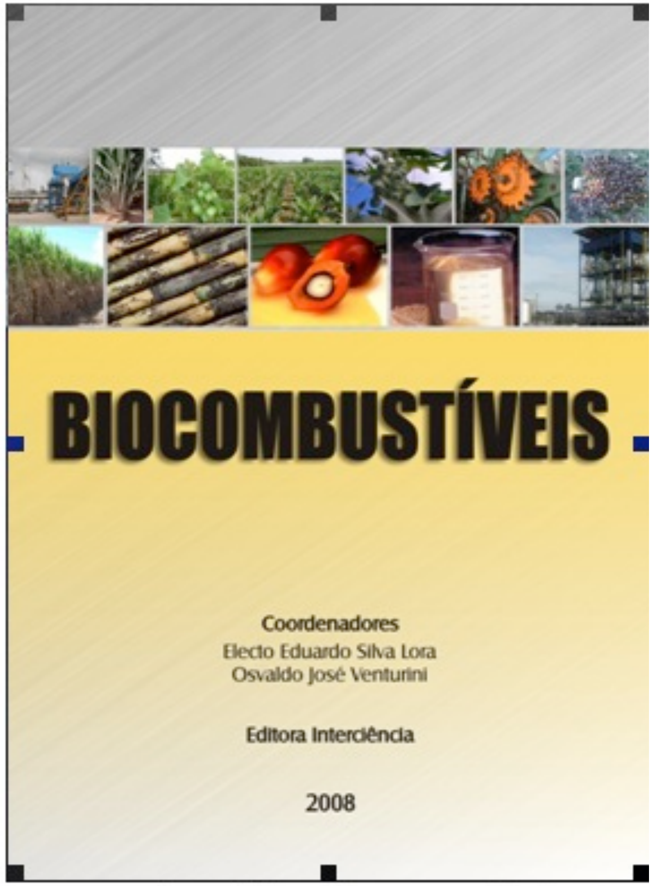
Chapter 12 – Residues– stillage and glicerine.

Chapter 13 – Cogeneration.

Chapter 14 – Planning and projects management in biofuels.

Chapter 15 – Environmental Integrated Evaluation

Chapter 16 – The future of biofuels: Biorefineries, algae and bioeletricity



La biomasa generada como residuo durante la producción de alimentos en la industria agrícola es una fuente de energía renovable (bioenergía). La sinergia entre la producción de alimentos y de bioenergía conlleva a una disminución de los precios de los alimentos, un crecimiento de la oferta de fuentes de energía, un efecto regulador en los precios de los combustibles fósiles, y evita la generación excesiva de gases de efecto invernadero y otras sustancias contaminantes.

En este libro, editado por la Red de Aprovechamiento de Residuos Orgánicos en la Generación de Energía (Bioenergía), se sustenta esta hipótesis mediante la descripción y ejemplos de acopio, pre tratamiento y transformación de la biomasa en bioenergía. Adicionalmente, y dado que el uso de la biomasa compite fuertemente con el uso de los combustibles fósiles, en sus últimos capítulos aborda el tema de la evaluación técnico-económica y gestión de proyectos energéticos así como de evaluación de la sustentabilidad.

La obra es producto del esfuerzo de diferentes académicos, industriales y organizaciones quienes a lo largo de los últimos 10 años han promovido y desarrollado diversos proyectos, con el fin de mejorar el abastecimiento de energía, de manera sostenible y contribuir a la amortiguación del Calentamiento Global mediante el uso de la bioenergía.

José María Rincón Martínez
Coordinador de la Red.

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CYTED

José María Rincón Martínez
Eduardo Electo Silva Lora
Editores

Bioenergía: Fuentes, conversión y sustentabilidad

Red Iberoamericana de Aprovechamiento de Residuos Orgánicos en Producción de Energía

Bioenergía:
Fuentes, conversión y sustentabilidad

José María Rincón Martínez
Eduardo Electo Silva Lora

Editores

CYTED

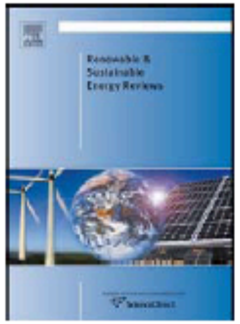
346 citations in other papers

Renewable and Sustainable Energy Reviews 13 (2009) 1275–1287

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

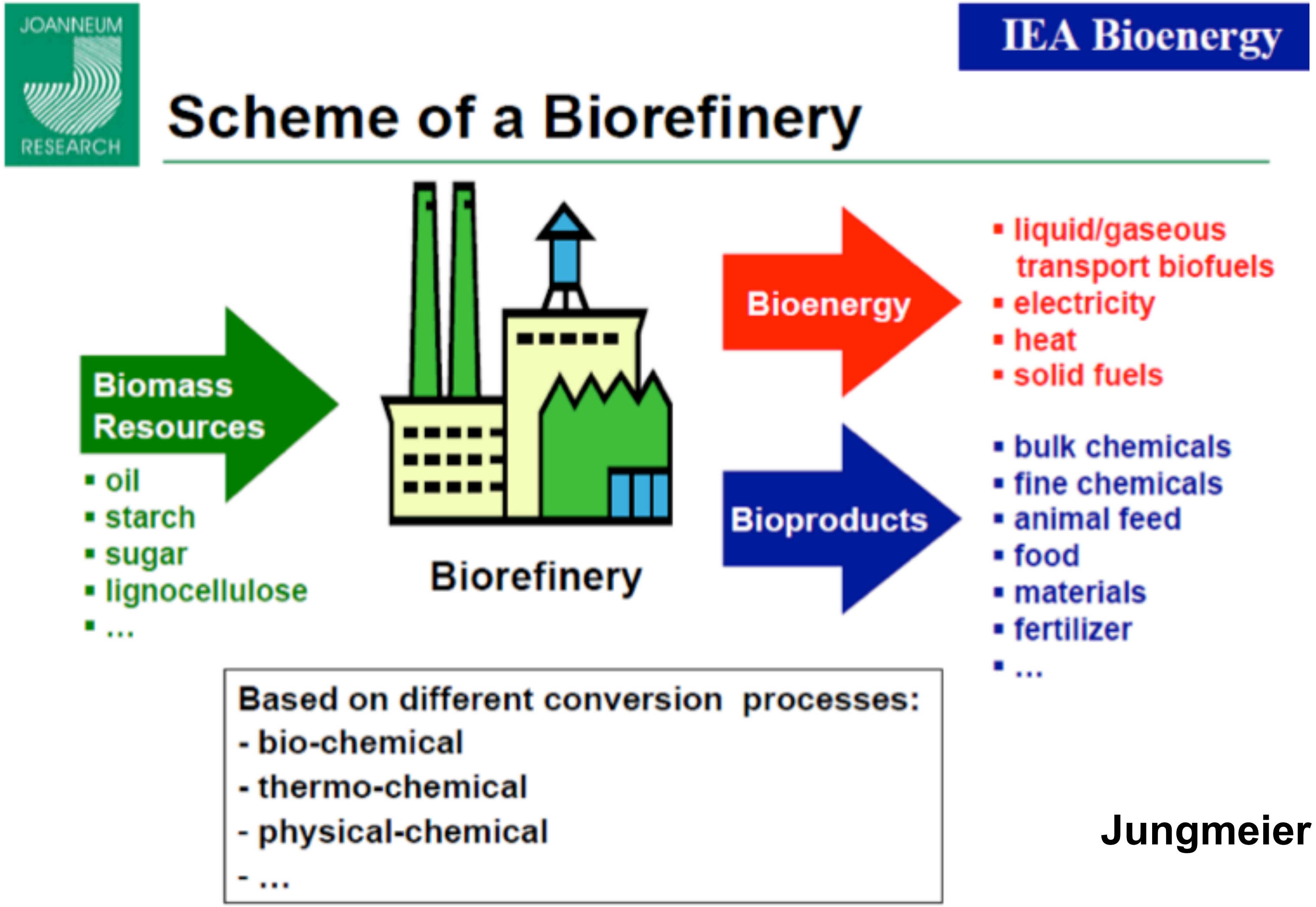


Biofuels: Environment, technology and food security

José C. Escobar [a], Electo S. Lora [a,*], Osvaldo J. Venturini [a], Edgar E. Yáñez [b], Edgar F. Castillo [c], Oscar Almazan [d]

[a] *NEST - Excellence Group in Thermal Power and Distributed Generation, Mechanical Engineering Institute, Universidade Federal de Itajubá, Brazil*
[b] *CENIPALMA, Oil Palm Research Center - Cenipalma, Calle 21 # 42-C-47, Bogotá, Colombia*
[c] *CENICAÑA - Sugarcane Research Center of Colombia, Calle 58 N, # 3BN-110, A.A., 9138 – Cali, Colombia*
[d] *ICIDCA - Instituto Cubano de Investigaciones de los Derivados de la Caña de Azúcar, Via Blanca y Carretera Central 804, San Miguel del Padrón, A.P. 4036, La Habana, Cuba*

II- Concepto de biorefinerias. Clasificacion y estado del arte.

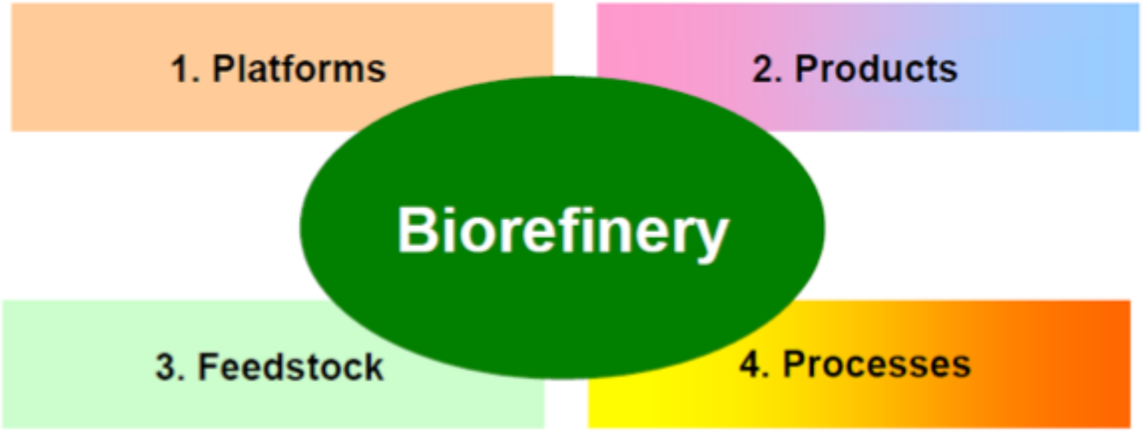


Jungmeier y Pucker, 2010

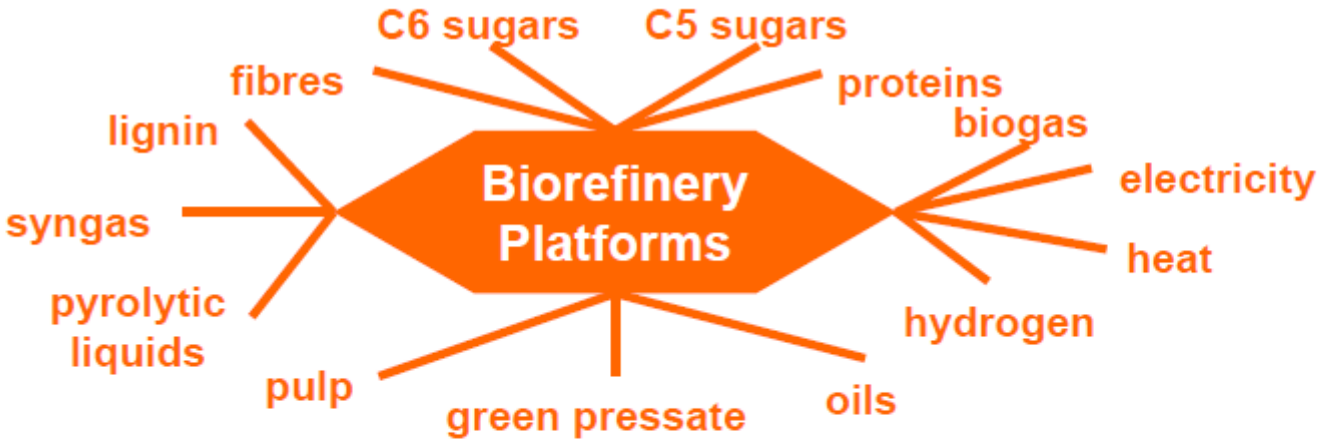
El concepto de biorefinerias por la IEA

IEA Bioenergy Task 42 Biorefinery Definition

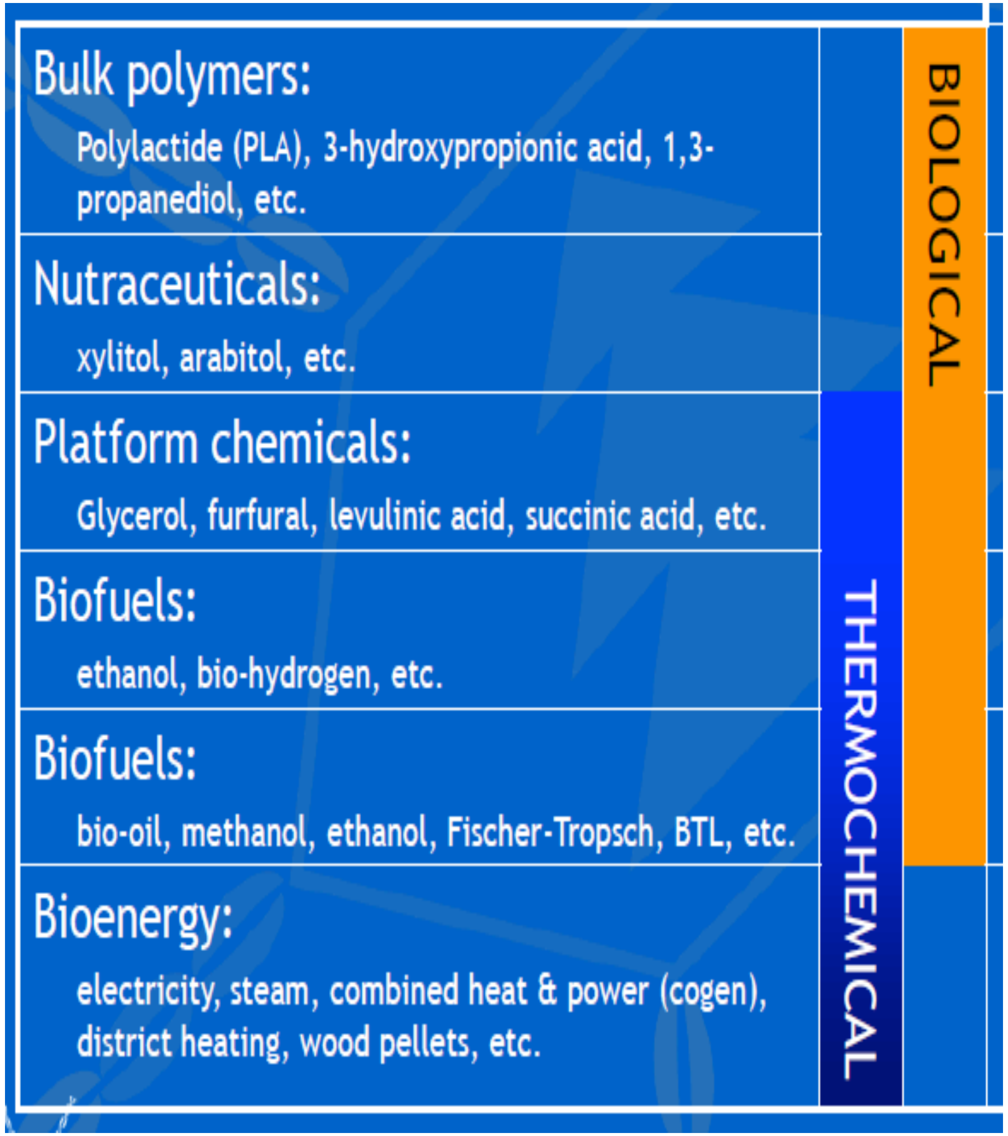
"Biorefinery is the sustainable processing of biomass into a spectrum of marketable products (food, feed, materials, chemicals) and energy (fuels, power, heat)"



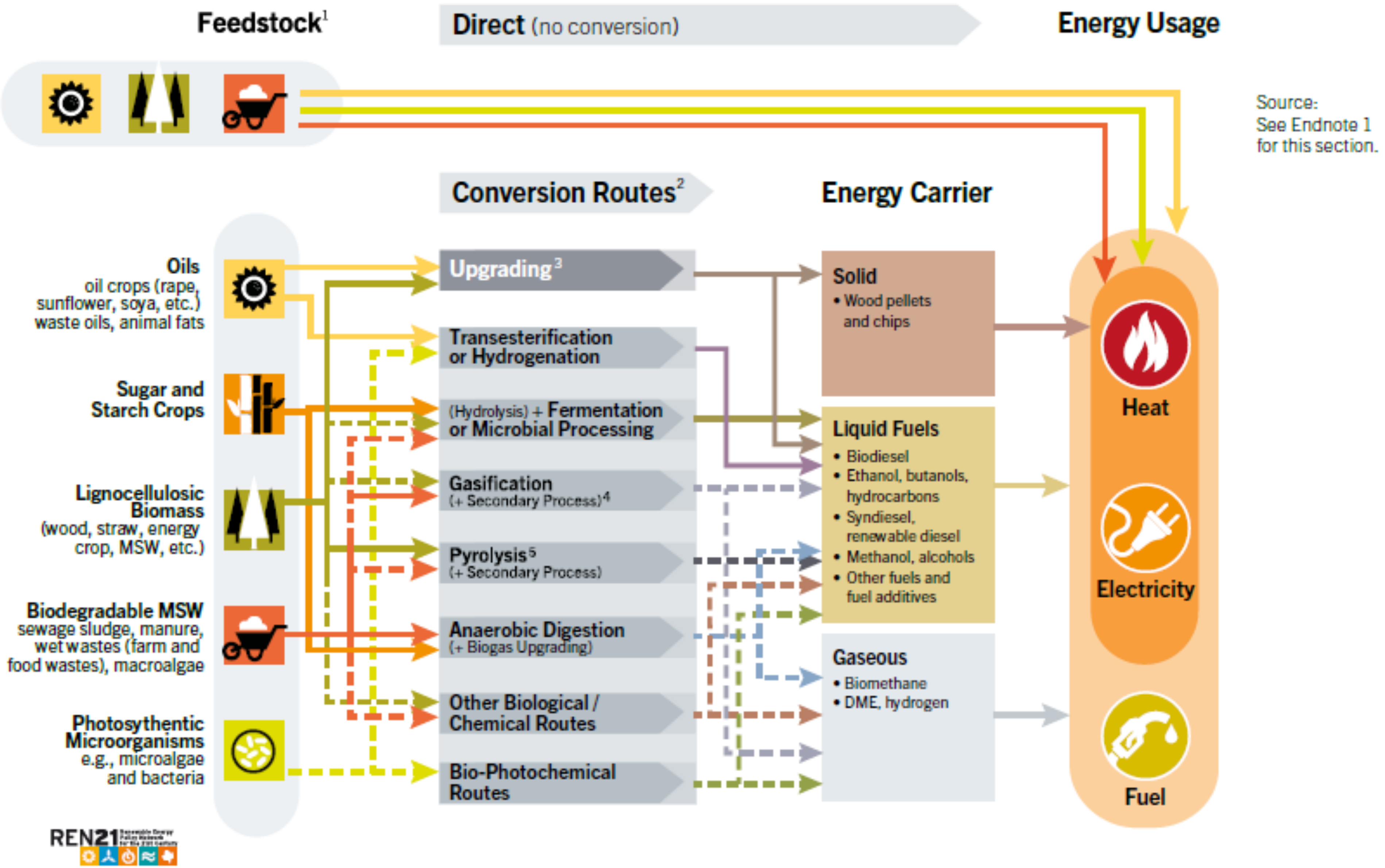
Clasificacion de las biorefinerias



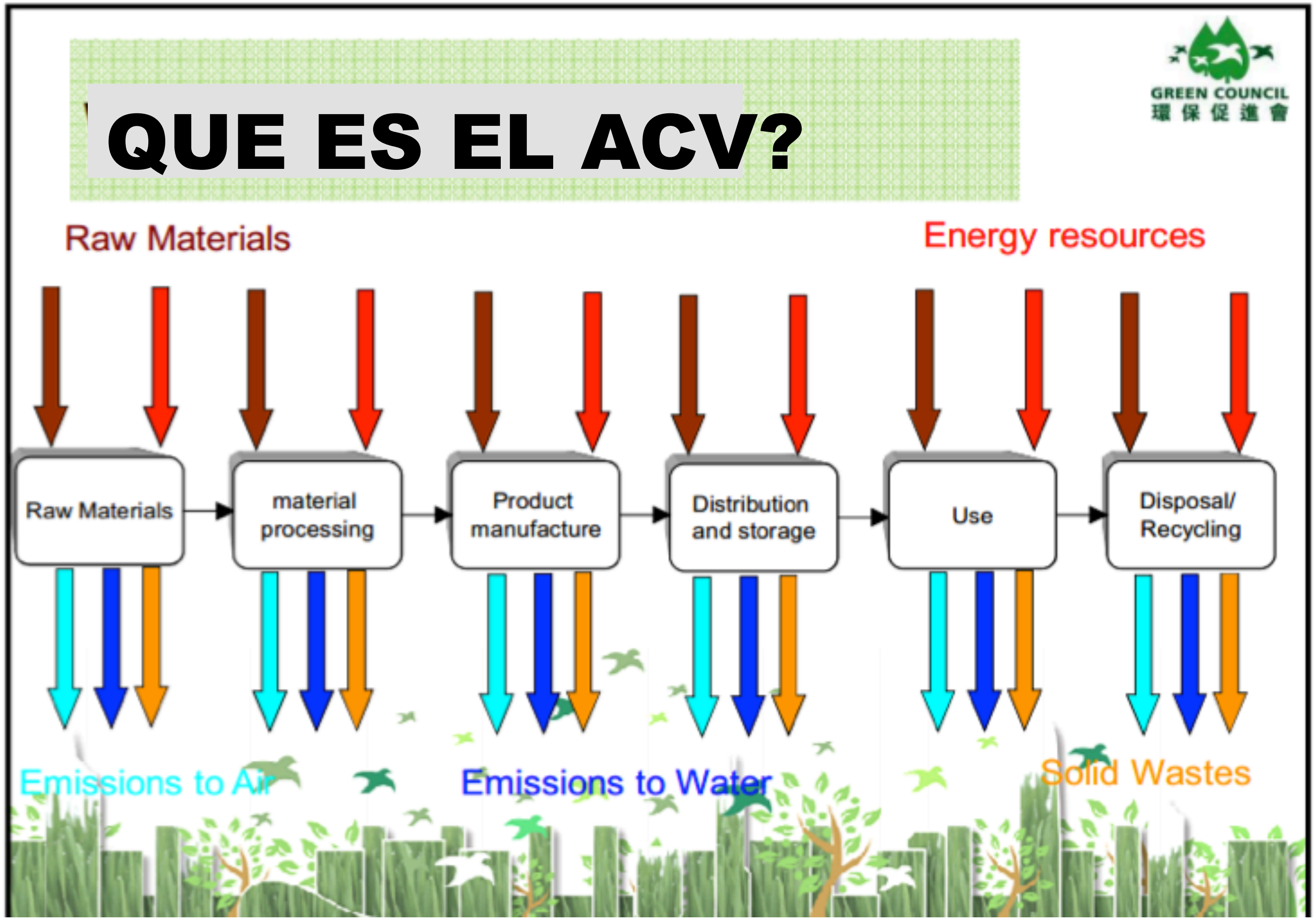
Jungmeier y Pucker, 2010



Bioenergy Conversion Pathways



III- Aplicacion del ACV en biorefinerias. Indicadores energéticos y ambientales.

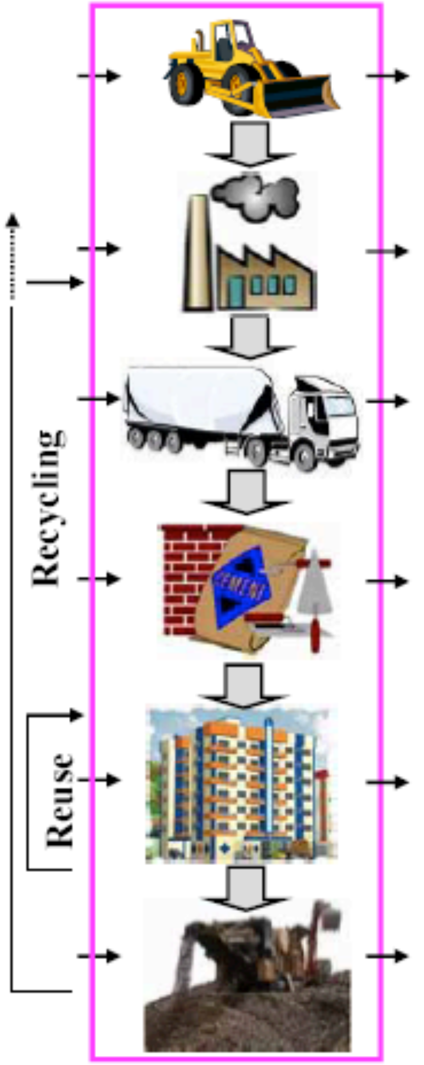


What is LCA?

LCA **is an** ***objective tool*** **for** ***analyzing*** **and** ***quantifying*** **the** ***environmental consequences*** **of** ***products*** **(services) during all their** ***life-cycle*****, from the extraction of raw materials, through industrial production, including the use phase and the end-of-life disposal**

"from-cradle-to-grave"

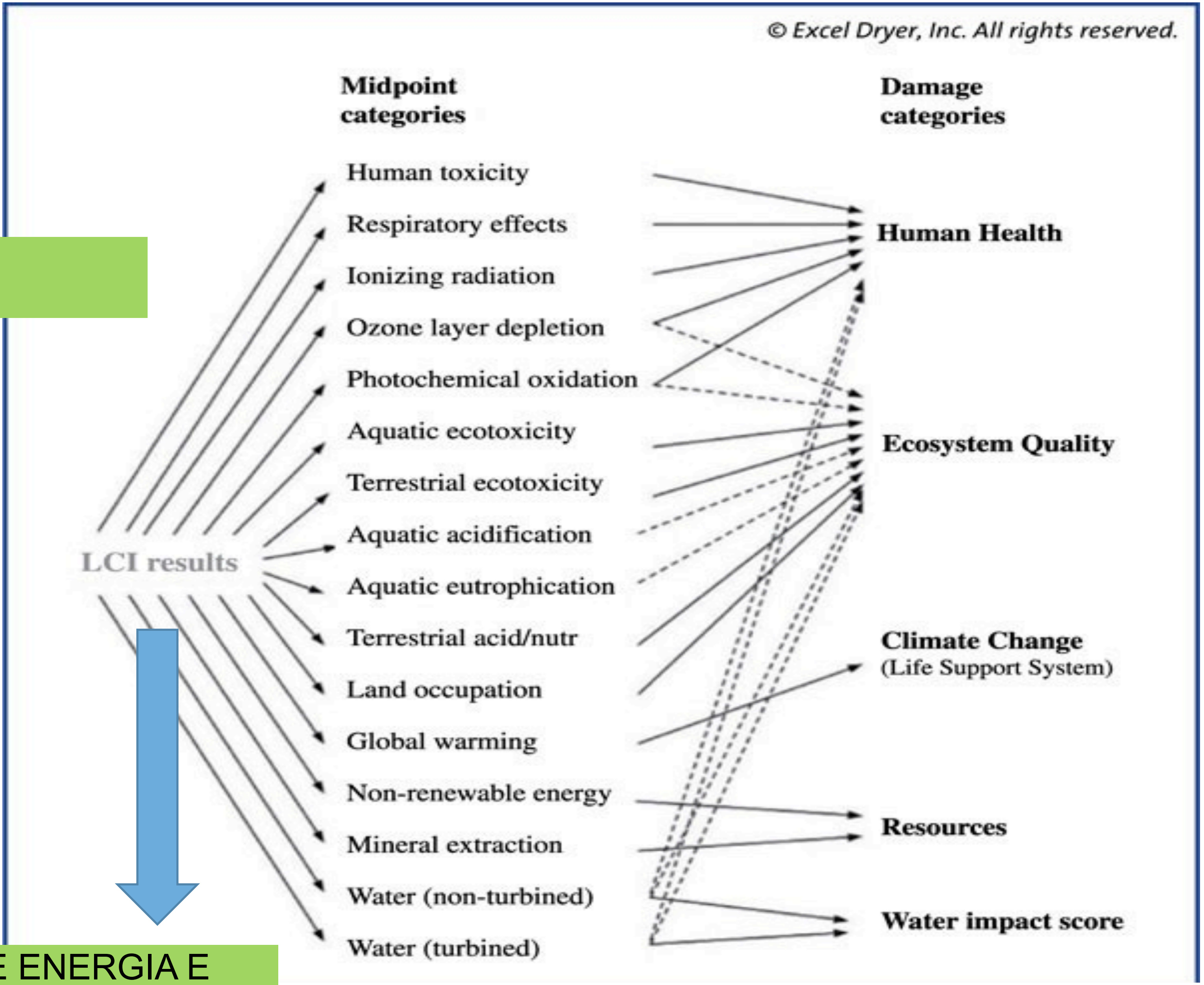
Environmental consequences of production/use systems encompass resource conservation issues as well as all kind of emissions harmful to human health and ecosystem quality



LCA identifies and quantifies **energy** and **materials** used, as well as **releases** to the environment and their **potential impacts** throughout the whole life cycle

Study boundary

IMPACT 2002



BALANCE DE ENERGIA E DE GEI

SUSTAINABILITY INDICATORS

- Economic indicators (production costs).
- Output/Input (NER - net energy ratio).
- Substituted fossil fuel per hectare.
- Avoided greenhouse gases emissions (CO_2 savings).
- Environmental Impacts (Impact categories indicators).
- Carbon emissions due to land use changes.
- Renewability Indicator (exergy or emergy accounting)…….
- Social indicators

Table 5: Energy ratio and GHG emissions of ethanol production

Reference	GHG emissions in kg CO_2/kg ethanol	GHG reduction in %	Energy ratio
		Brazilian studies	
Cavalett et al. (2013)	0.672	–76.0	–
Seabra et al. (2011)	0.597	–78.7	9.0
Walter et al. (2011)	1.035	–63.1	–
Luo et al. (2009)	0.378	–86.5	–
Macedo et al. (2008)	0.553* 0.438**	–80.3 –84.4	9.3* 11.6**
		Other countries	
Argentina (*Acreche* and *Valeiro*, 2013)	1.420	–49.3	3.4
Mexico (*García* et al., 2011)	2.582	–7.8	2.1
Thailand (*Silalertruksa* and *Gheewala*, 2009)	0.869	–68.9	3.0
Petroleum gasoline (*Wang* et al., 2011)***	2.80	–	–

* 2005 scenario. ** 2020 scenario. *** The European value of petroleum gasoline life cycle GHG emissions is 83.8 kg CO_2-eq/GJ and the USA value ranges between 90 and 110 kg CO_2-eq/GJ (*Wang* et al., 2011).

Rocha et al., 2014

IV- Algunas consideraciones sobre la evaluación económica y de sustentabilidad.

Part A: Biorefinery Plant Mass and Energy Balance

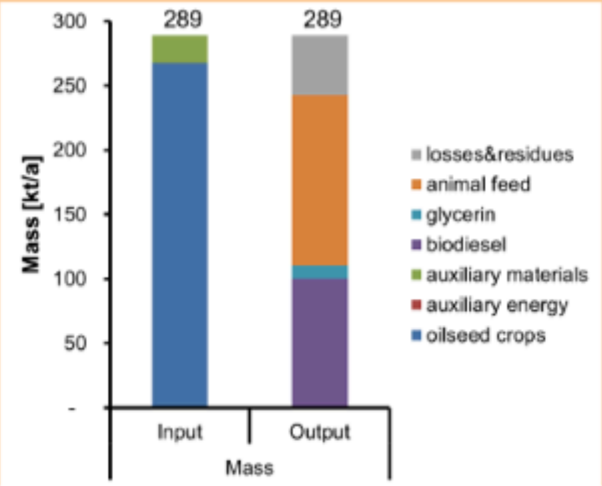
JOANNEUM RESEARCH RESOURCES

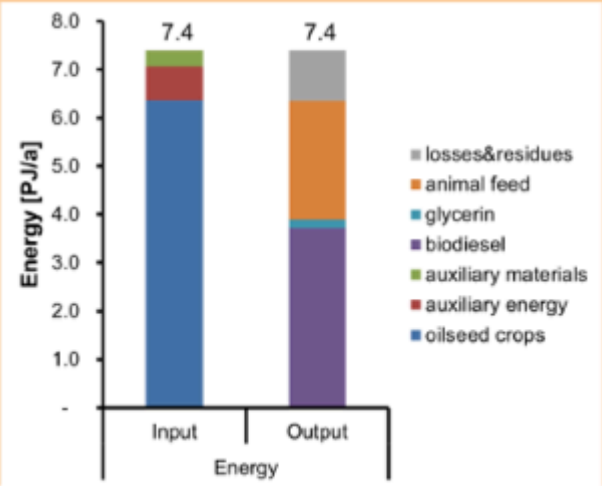
IEA Bioenergy
Task 42 Biorefining

Biorefinery plant					
Biorefinery Complexity Index (Products/Platform/Feedstock/Processes)				8 (3/1/1/3)	
State of technology:	commercial				
Products			Auxiliaries (external)		
biodiesel	100	[kt/a]	electricity	0.06	[PJ/a]
glycerin	11	[kt/a]	heat	0.64	[PJ/a]
animal feed	132	[kt/a]	materials	21	[kt/a]
Feedstock			Costs		
oilseed crops	268	[kt/a]	investment	50	[Mio €]
water content	10%	[%]	feedstock	414	[€/t]
Efficiencies			mass	energy	
input to products			84%	86%	
input to transportation biofuel			35%	53%	

***1-platform** (oil) biorefinery using **oilseed crops** for **biodiesel**, glycerin and feed*

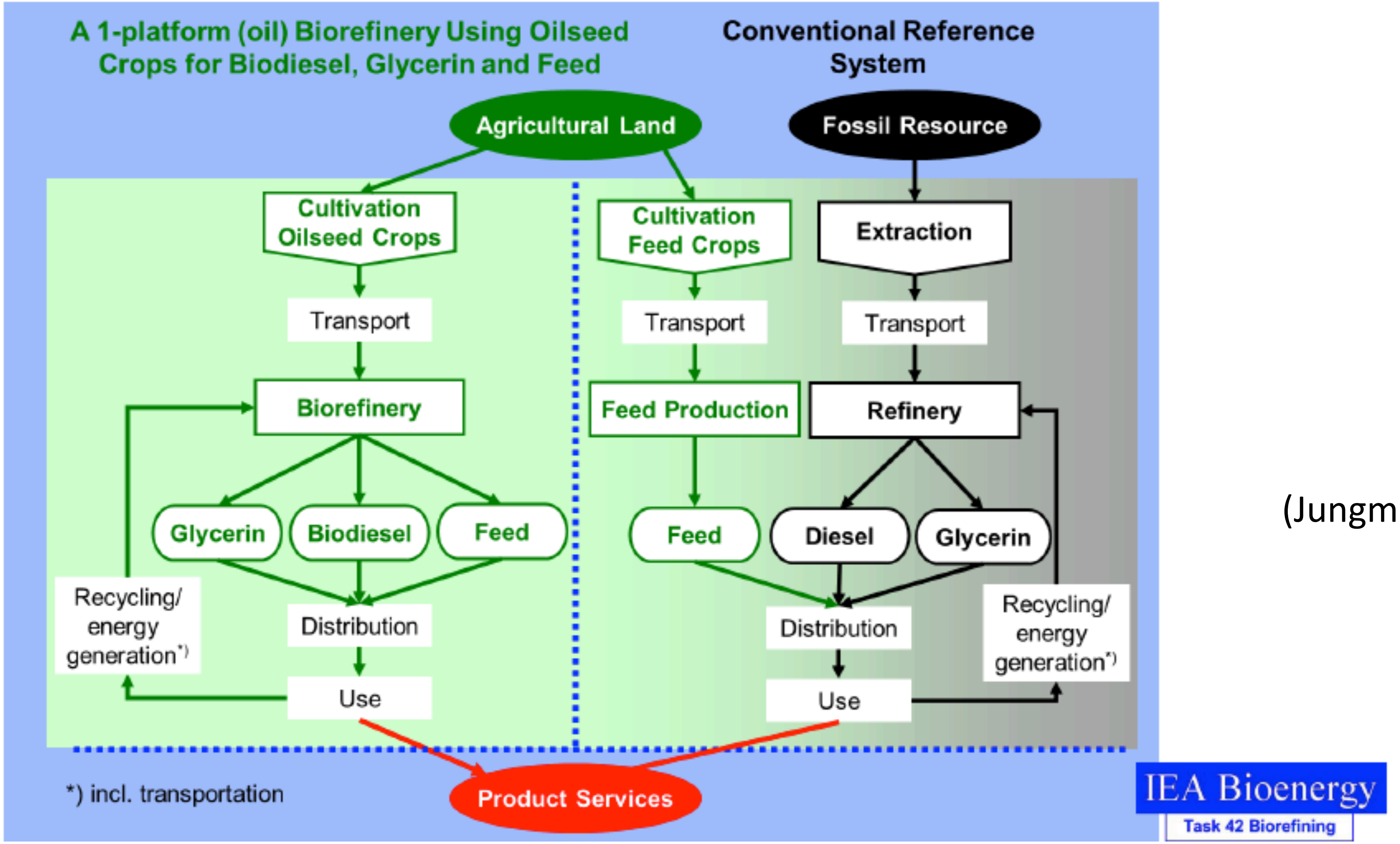
Own calculations using energy balance from BioGrace





(Jungmeier, 2012)

Part B: Value Chain Assessment System Boundaries&Reference System



(Jungmeier, 2012)

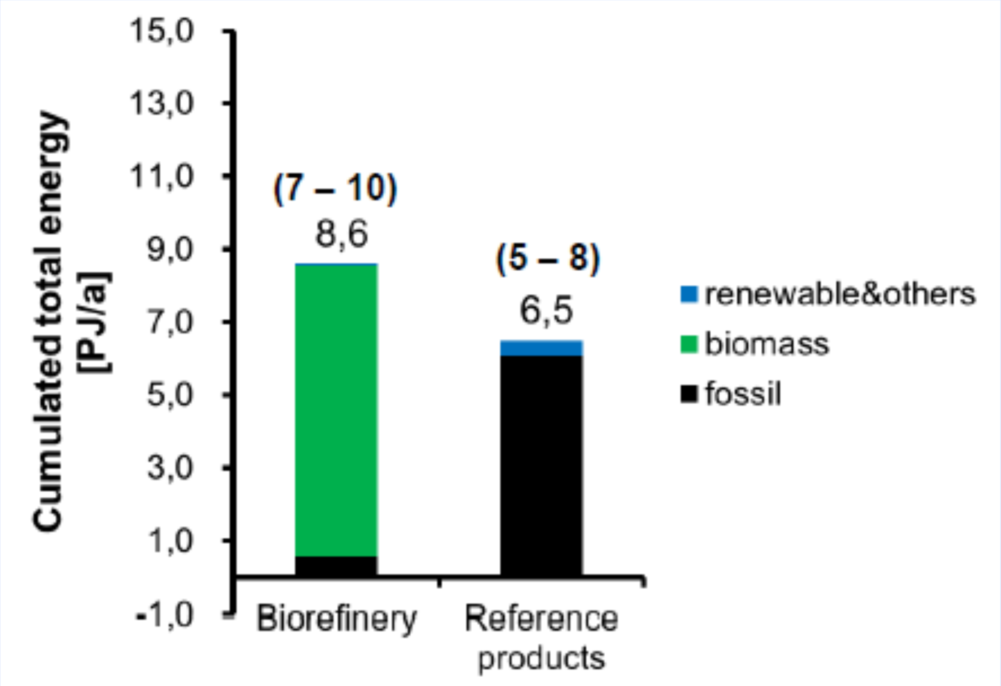
Part B: Value Chain Assessment Primary Energy&GHG Emissions

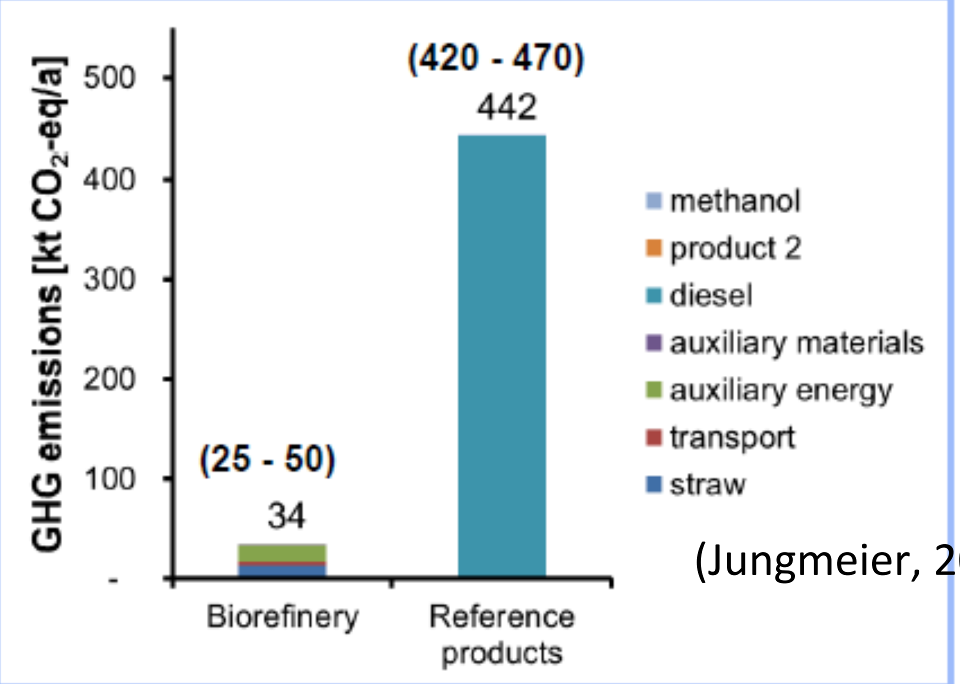
JOANNEUM RESEARCH RESOURCES

IEA Bioenergy

Task 42 Biorefining

***3-platform** (pyrolysis oil, syngas, electricity&heat) biorefinery using **straw** for **FT-biofuels** and methanol with oxygen gasification*





(Jungmeier, 2012)

LCA GHG emissions – Ethanol production in 1G and 2G biorefineries

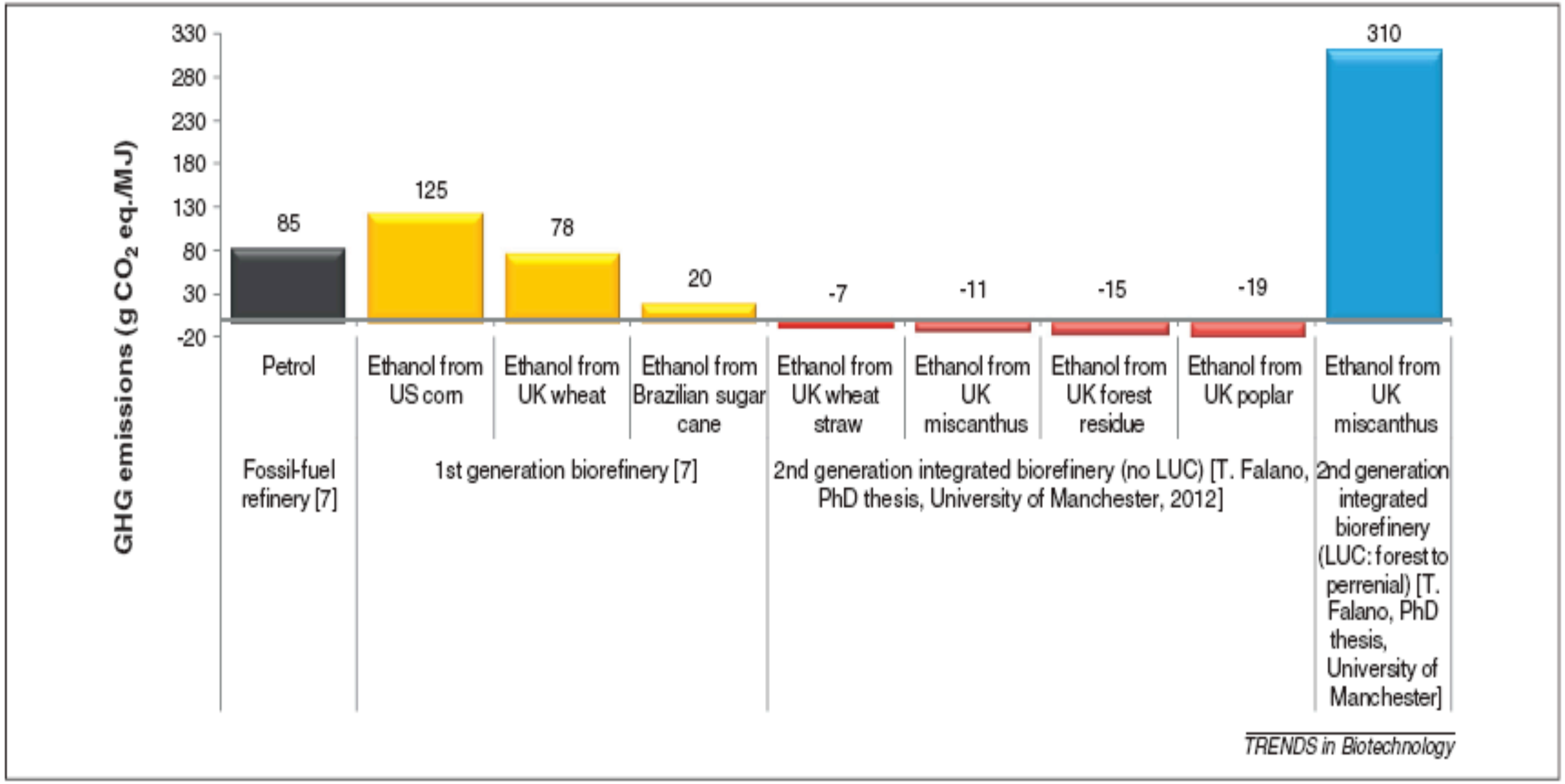
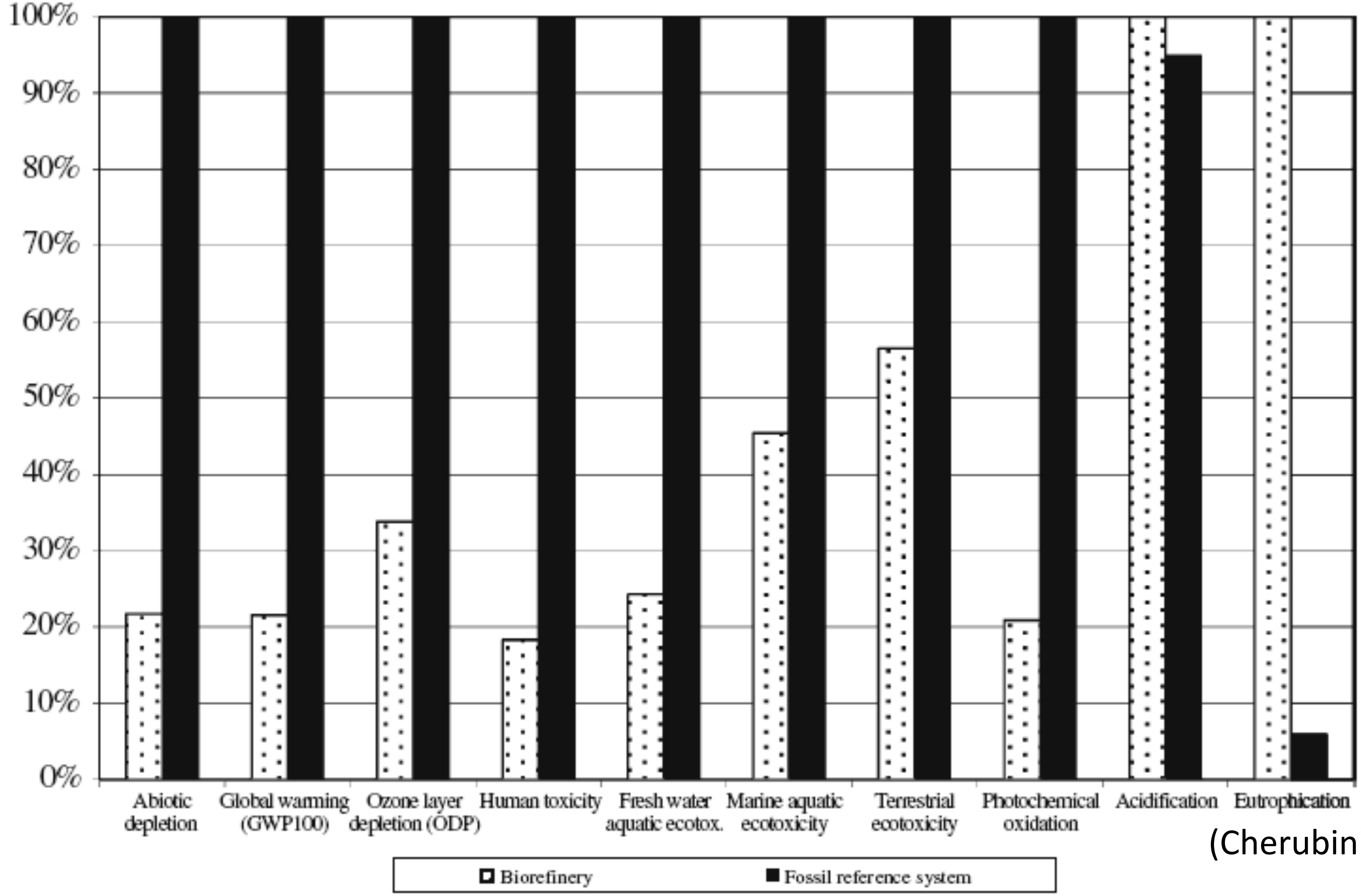


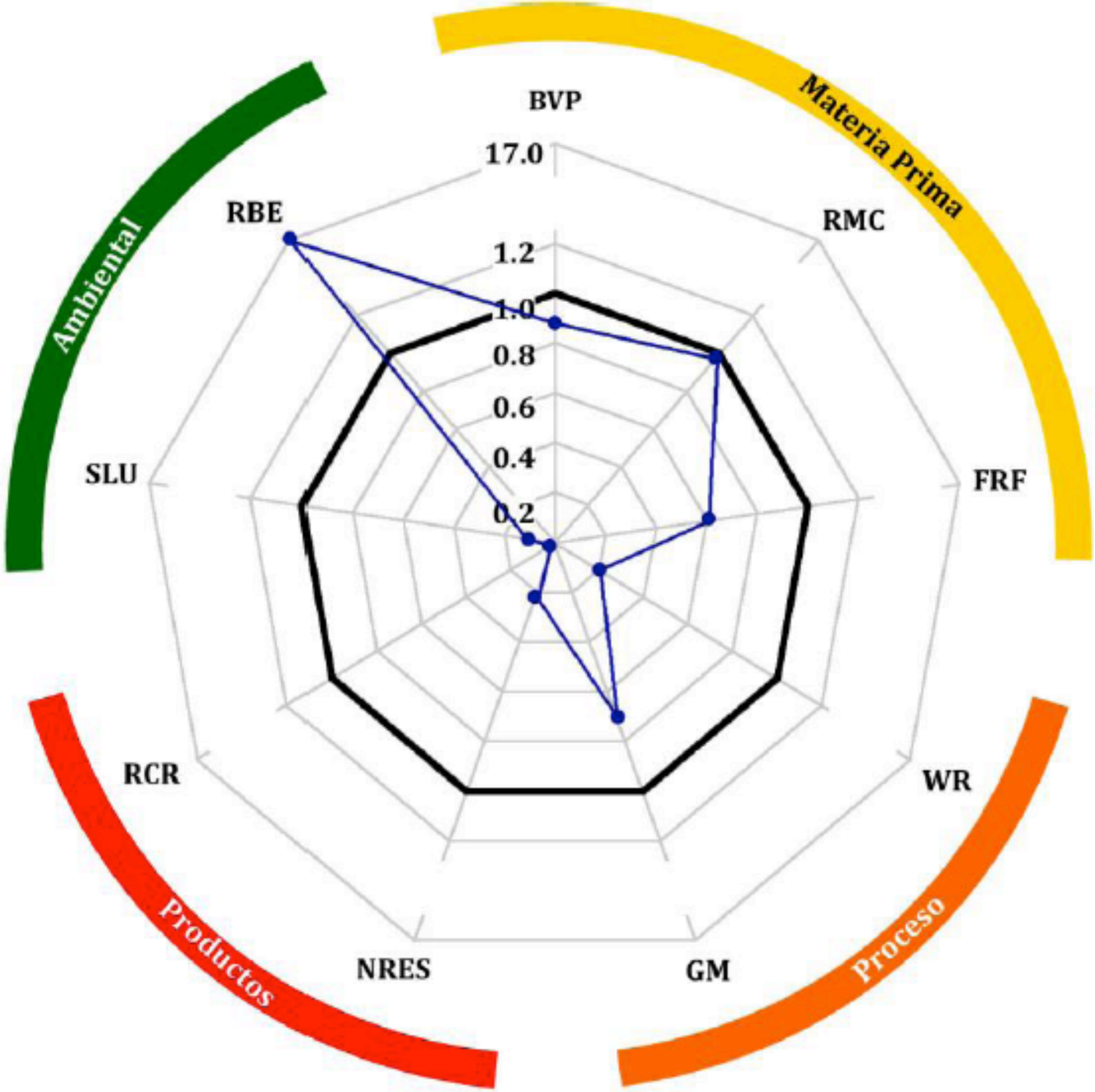
Figure 2. On a life-cycle basis, ethanol produced in an integrated biochemical refinery saves up to 104 g CO_2 eq./MJ compared to petrol (85 g CO_2 eq./MJ for petrol compared to −19 g CO_2 eq./MJ for ethanol from UK poplar) owing to the credits for the co-products, in this case electricity, lactic acid, and acetic acid. Ethanol from sugar cane in Brazil saves 65 g CO_2 eq./MJ, whereas ethanol from corn has much higher greenhouse gas (GHG) emissions than petrol. Land-use change (LUC) can increase GHG emissions significantly – in the case of biofuel from miscanthus to 310 g CO_2 eq./MJ or 3.6 times higher than petrol. GHG emissions for all fuel options are from 'cradle to grave', encompassing production of the feedstocks and fuels as well as fuel combustion during use of vehicles.

(Azapagic, 2014)

Comparacion entre los impactos ambientales de la biorefineria y del sistema de referencia fósil (CML impact assessment method)



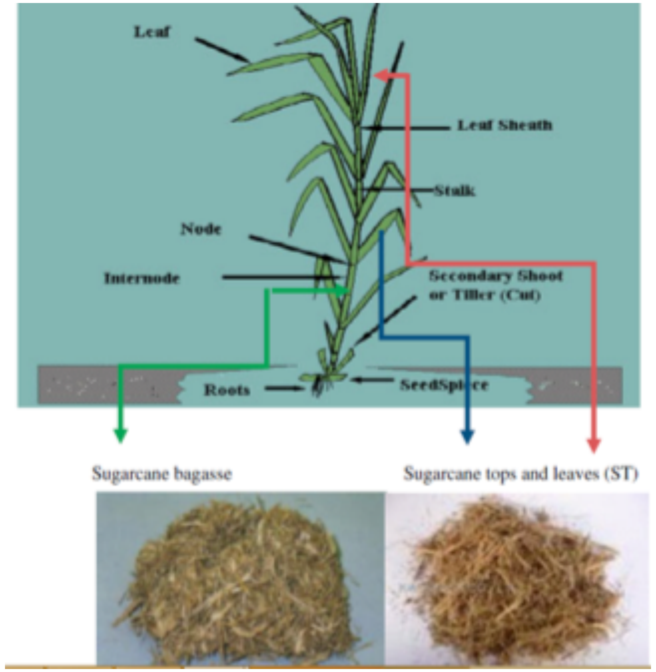
(Cherubini y Jungmeier, 2010)

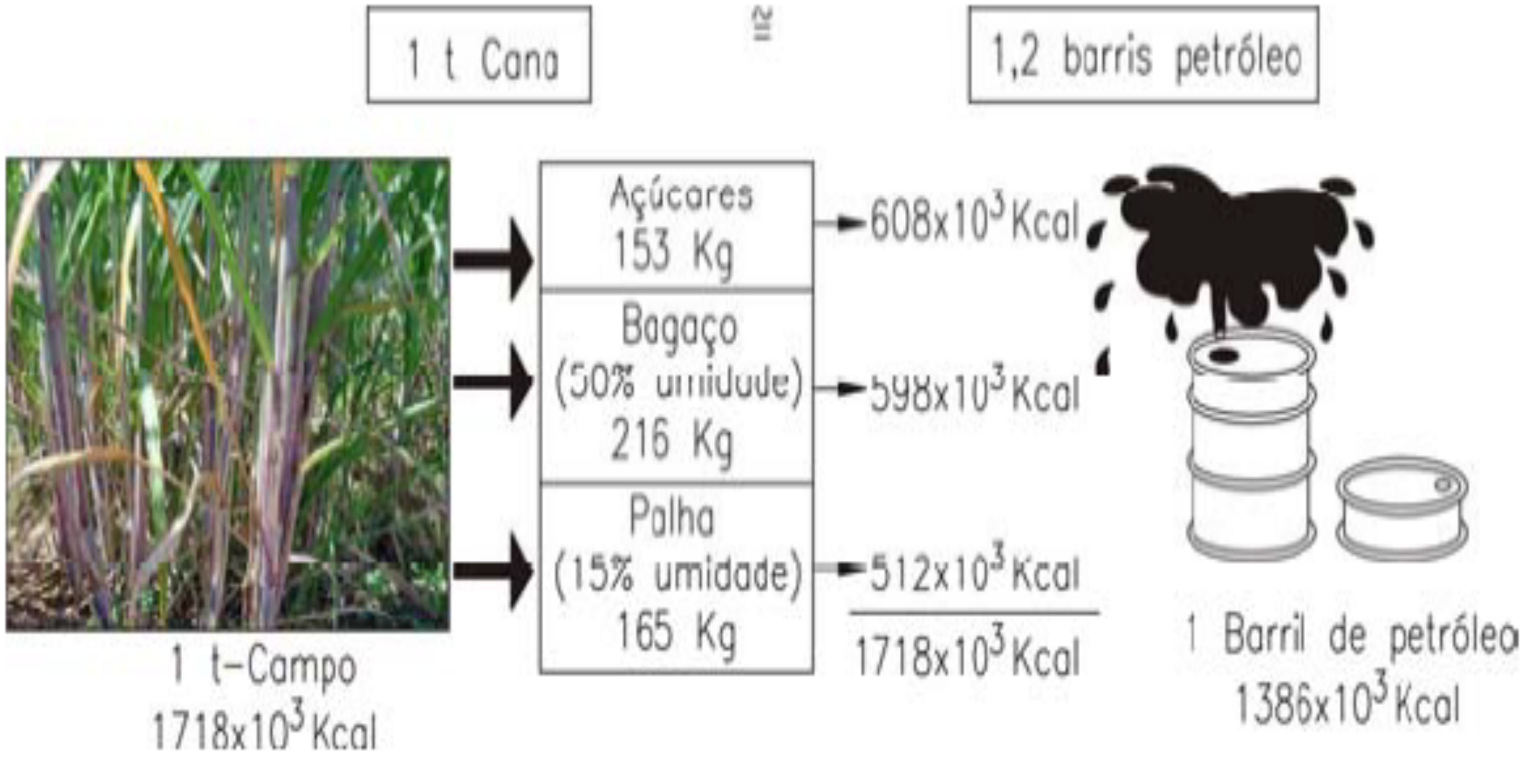


(Sacramento, 2012)

Figura 3.- Diagrama de radar con la huella de sostenibilidad del caso de estudio

V- Productividad energética de la caña de azucar y la palma de aceite.





(Olivério, 2003)

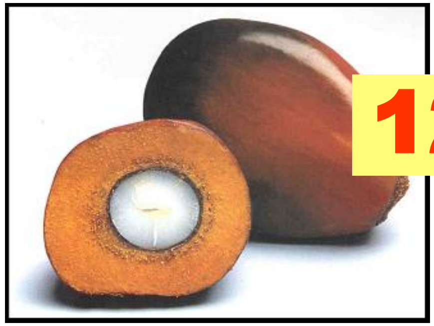
CACHOS VACIOS FRESCOS -FFB

RESIDUOS DE BIOMASA

EFB (20-23%)

Fibras (11-14%)

124.8 GJ/ ha.year



Fruto de la palma

Cáscaras (5-7%)

Sustainable production of african palm oil in Brazil

According to the National Institute for Space Research (INPE), Brazil's Amazon region lost 111,087 sq km of forest cover between 2004 and 2012, including

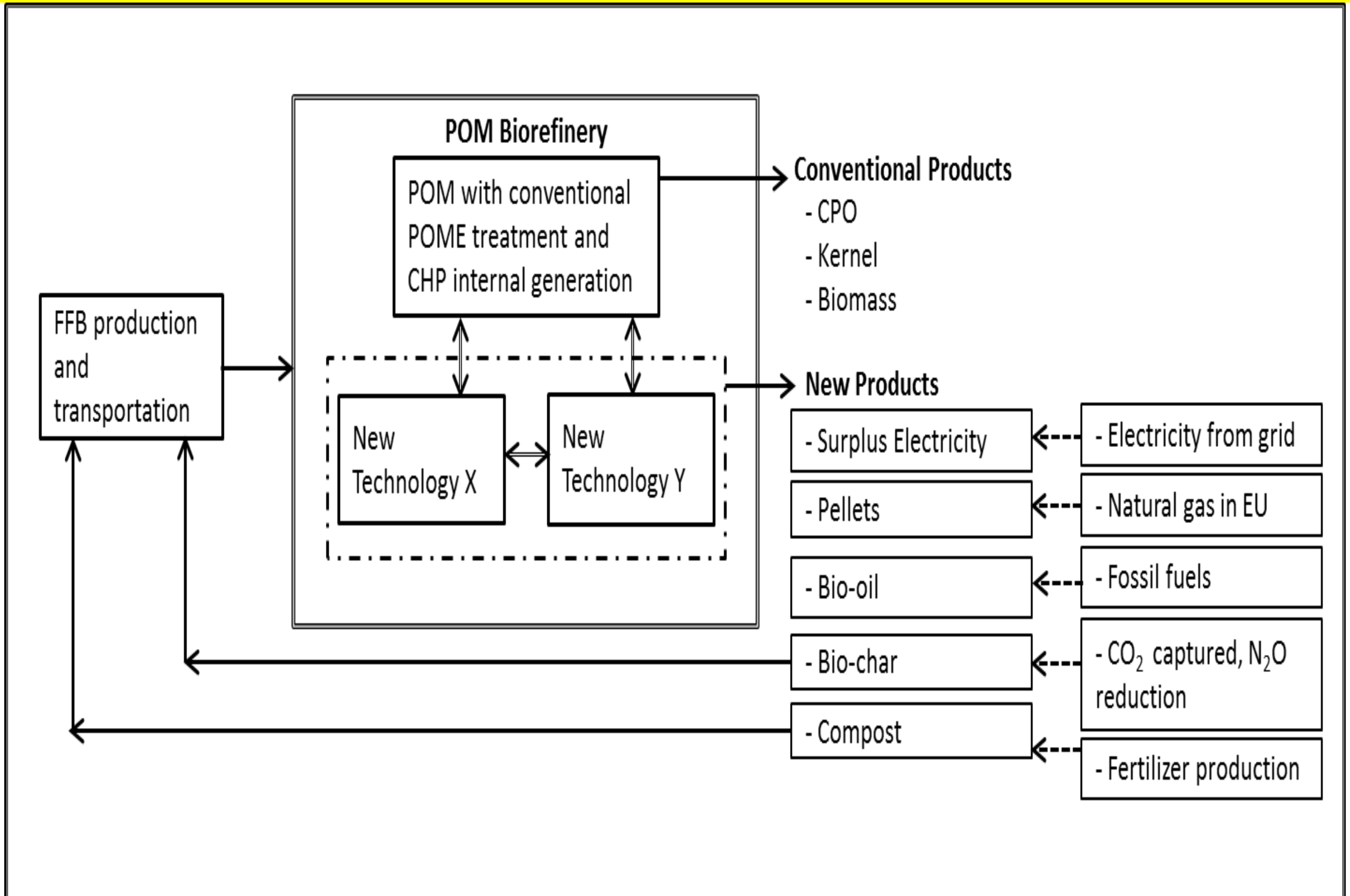
31,8 milhões de hectares.

a) Amazônian degraded lands

b) Reconversion of sugar cane areas.

VI- **Posibles procesos y productos a incluir en esquemas de biorefinerias en el sector palmero y azucarero.**

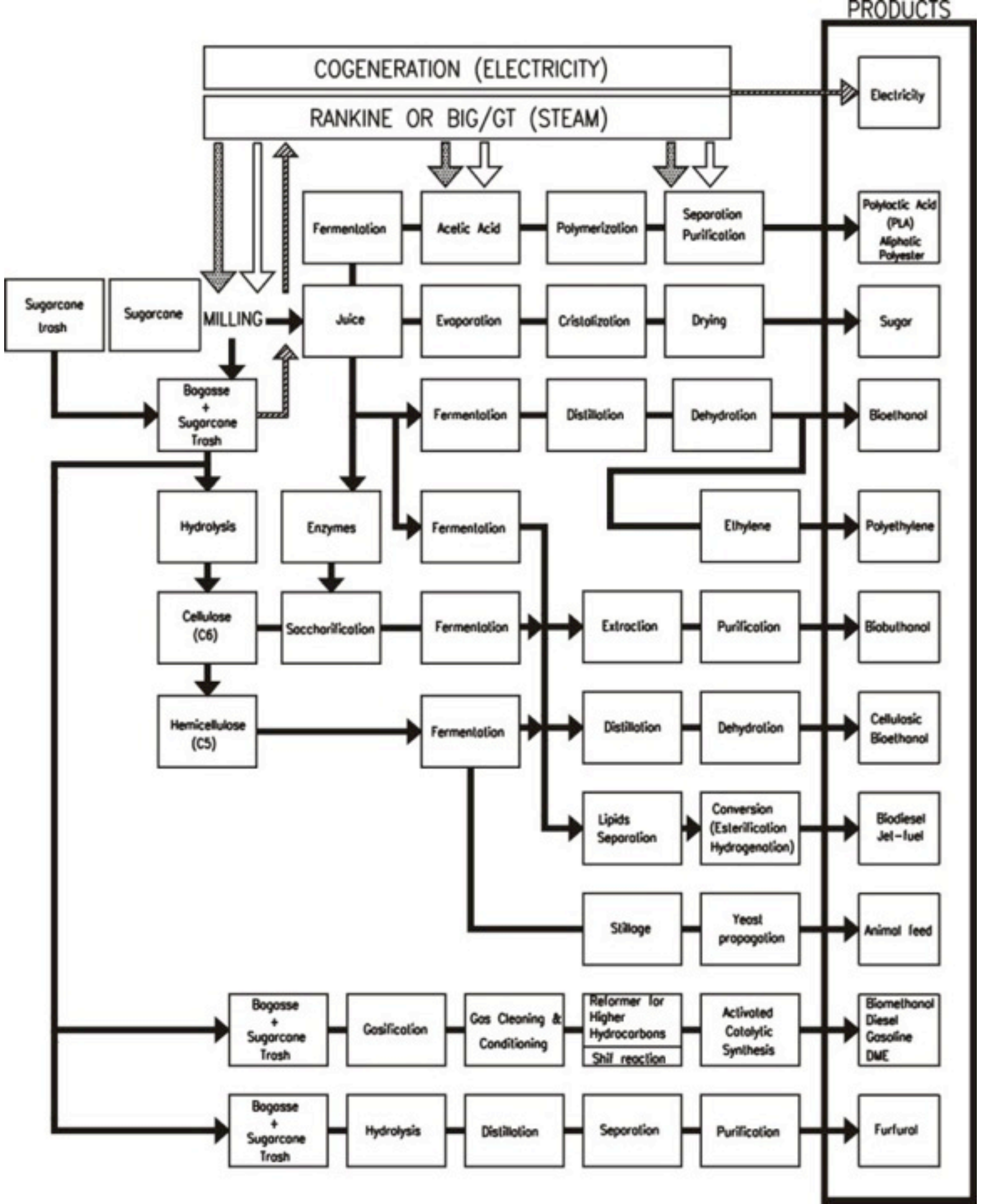
Boundary conditions for LCA of POM biorefinery concepts



Electo Eduardo Silva Lora, Mateus Henrique Rocha, José Carlos Escobar Palacio, Osvaldo José Venturini, Maria Luiza Grillo Renó and Oscar Almazán del Olmo

The sugar and alcohol industry in the biofuels and cogeneration era: a paradigm change (part II)*

Paper presented at the XXVIII Congress of the International Society of Sugar Cane Technologists, Sao Paulo, Brazil, 24–27 June 2013 and published here with the agreement of the Society.


PRODUCTS
COGENERATION (ELECTRICITY)
RANKINE OR BIG/GT (STEAM)
Electricity
Fermentation
Acetic Acid
Polymerization
Separation Purification
Polylactic Acid (PLA) Aliphatic Polyester
Sugarcane trash
Sugarcane
MILLING
Juice
Evaporation
Cristalization
Drying
Sugar
Bagasse + Sugarcane Trash
Fermentation
Distillation
Dehydration
Bioethanol
Hydrolysis
Enzymes
Fermentation
Ethylene
Polyethylene
Cellulose (C6)
Saccharification
Fermentation
Extraction
Purification
Biobuthanol
Hemicellulose (C5)
Fermentation
Distillation
Dehydration
Cellulosic Bioethanol
Lipids Separation
Conversion (Esterification Hydrogenation)
Biodiesel Jet-fuel
Stillage
Yeast propagation
Animal feed
Bagasse + Sugarcane Trash
Gasification
Gas Cleaning & Conditioning
Reformer for Higher Hydrocarbons
Shif reaction
Activated Catalytic Synthesis
Biomethanol Diesel Gasoline DME
Bagasse + Sugarcane Trash
Hydrolysis
Distillation
Separation
Purification
Furfural

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Energy Conversion and Management

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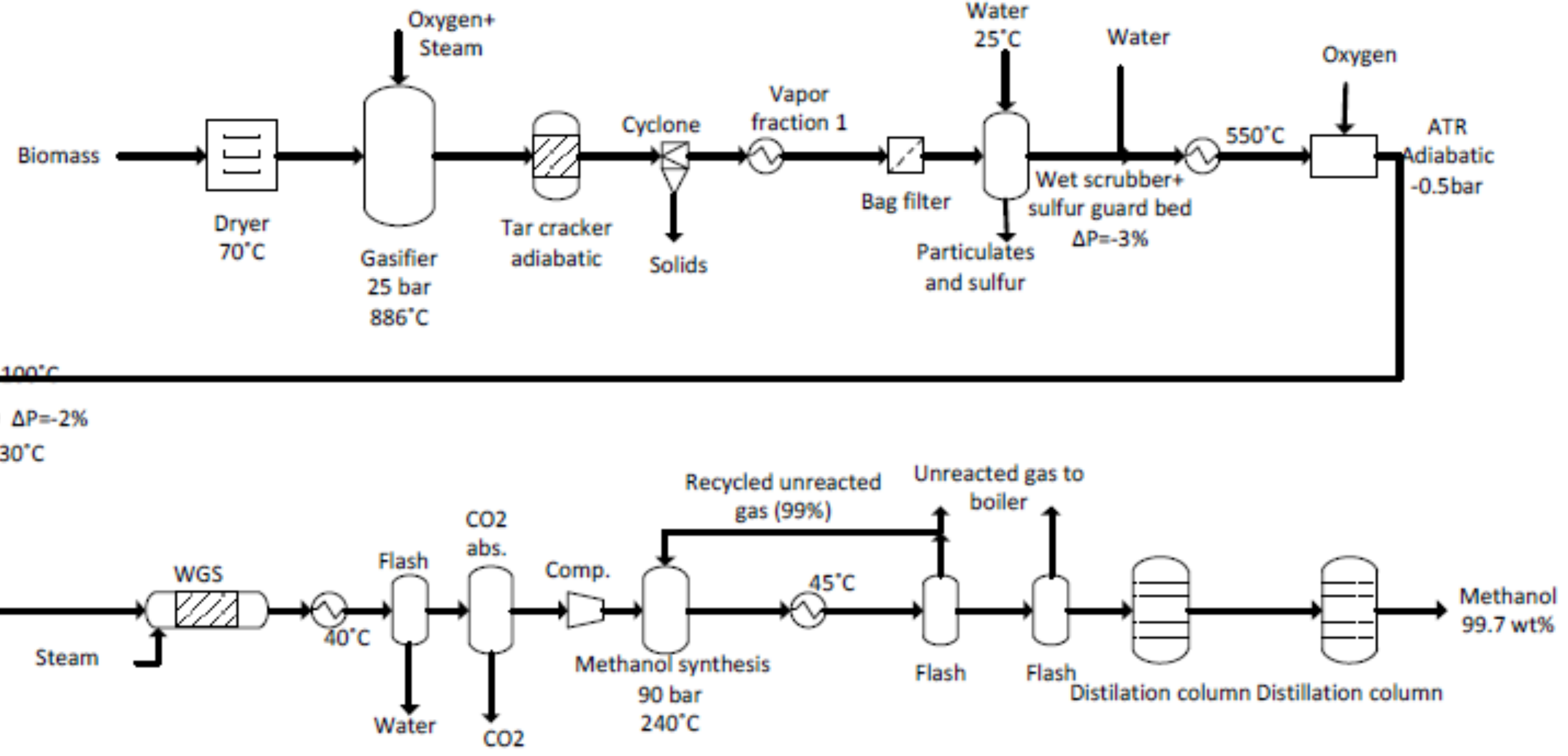
Sugarcane biorefineries: Case studies applied to the Brazilian sugar–alcohol industry

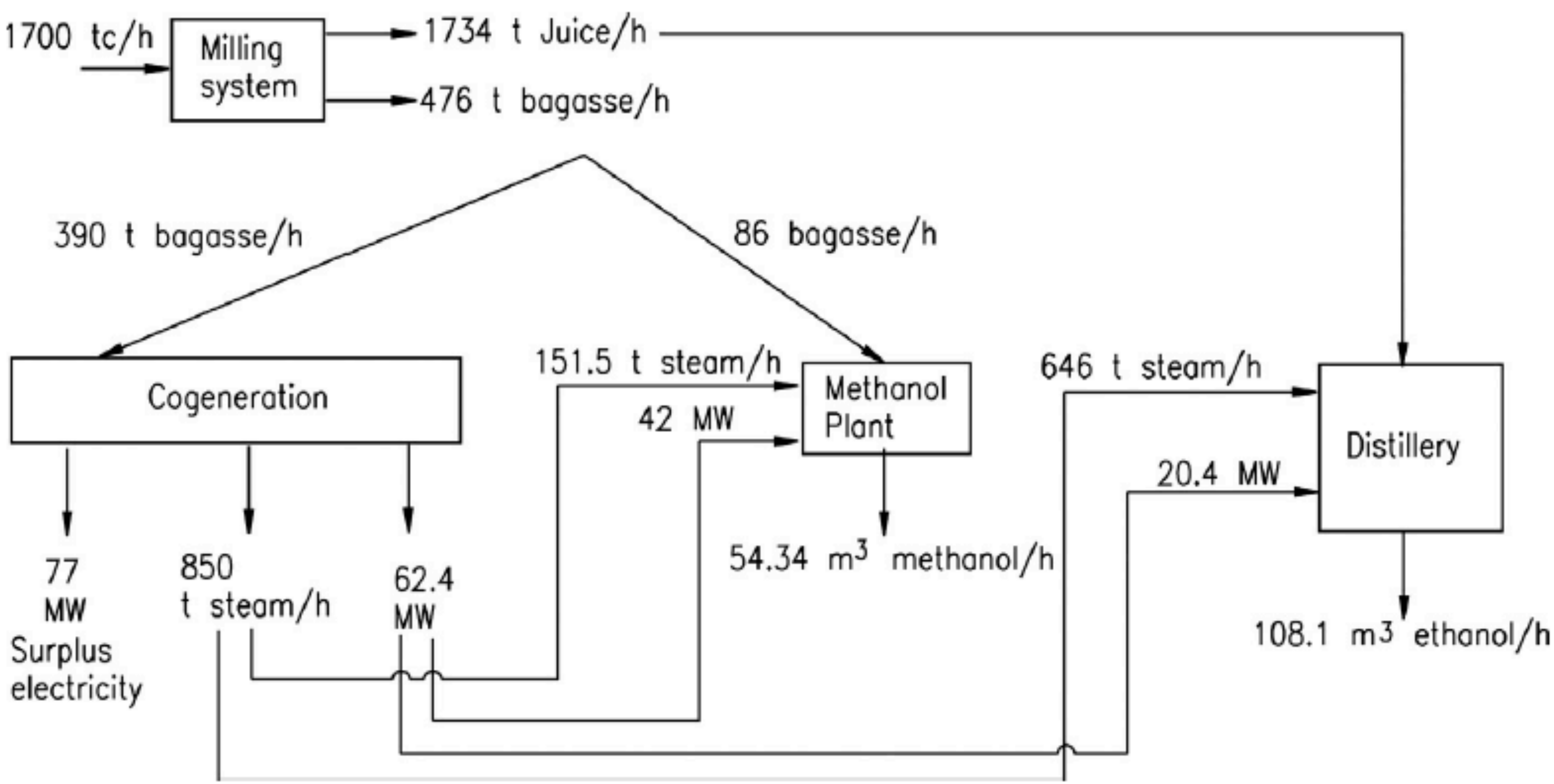
Maria Luiza Grillo Renó [a,*], Oscar Almazán del Olmo [b], José Carlos Escobar Palacio [a], Electo Eduardo Silva Lora [a], Osvaldo José Venturini [a]

[a] Federal University of Itajubá, Av. BPS 1303, CP 50 Itajubá, MG, Brazil

[b] ICIDCA – Instituto Cubano de Investigaciones de los Derivados de la Caña de Azúcar, Via Blanca y Carretera Central 804, San Miguel del Padrón, C.P. 4036 La Habana, Cuba

Produccion de metanol a partir de la biomasa – ruta termoquimica




1700 tc/h
Milling system
1734 t Juice/h
476 t bagasse/h
390 t bagasse/h
86 bagasse/h
Cogeneration
151.5 t steam/h
42 MW
Methanol Plant
646 t steam/h
Distillery
20.4 MW
54.34 m3 methanol/h
77 MW Surplus electricity
850 t steam/h
62.4 MW
108.1 m3 ethanol/h

VII- Historial de la relación NEST/PALMA DE ACEITE

NEST
Núcleo de Excelência em Geração Termelétrica e Distribuída

ACV, COGENERACION, SUSTENTABILIDAD

COGENERACIÓN ENERGÉTICA EN EL SECTOR AGROPECUARIO CONCRETAMENTE EL SUBSECTOR DE LA PALMA DE ACEITE

CONTRATO DE ASISTENCIA TÉCNICA

NIT 800.145.882-4

SUBSCRITO ENTRE CENIPALMA Y FUPAI

Informe Final

FUPAI

JULIO – 2005

NIFEI
Universidade Federal de Itajubá

Avaliação do impacto energético e ambiental da cogeração no balanço energético e no ciclo de vida do biodiesel de óleo de palma africana.

TRABALHO DE DISSERTAÇÃO DE MESTRADO

Programa: ENGENHARIA MECÂNICA
Área de concentração: CONVERSÃO DE ENERGIA

Mestrando: Edgar Eduardo Yáñez Angarita

Orientador Prof. Dr. Electo Eduardo Silva Lora.
Co-Orientador Prof Dr. Osvaldo Jose Venturini.

Renewable Energy 34 (2009) 2905–2913

Contents lists available at ScienceDirect

Renewable Energy

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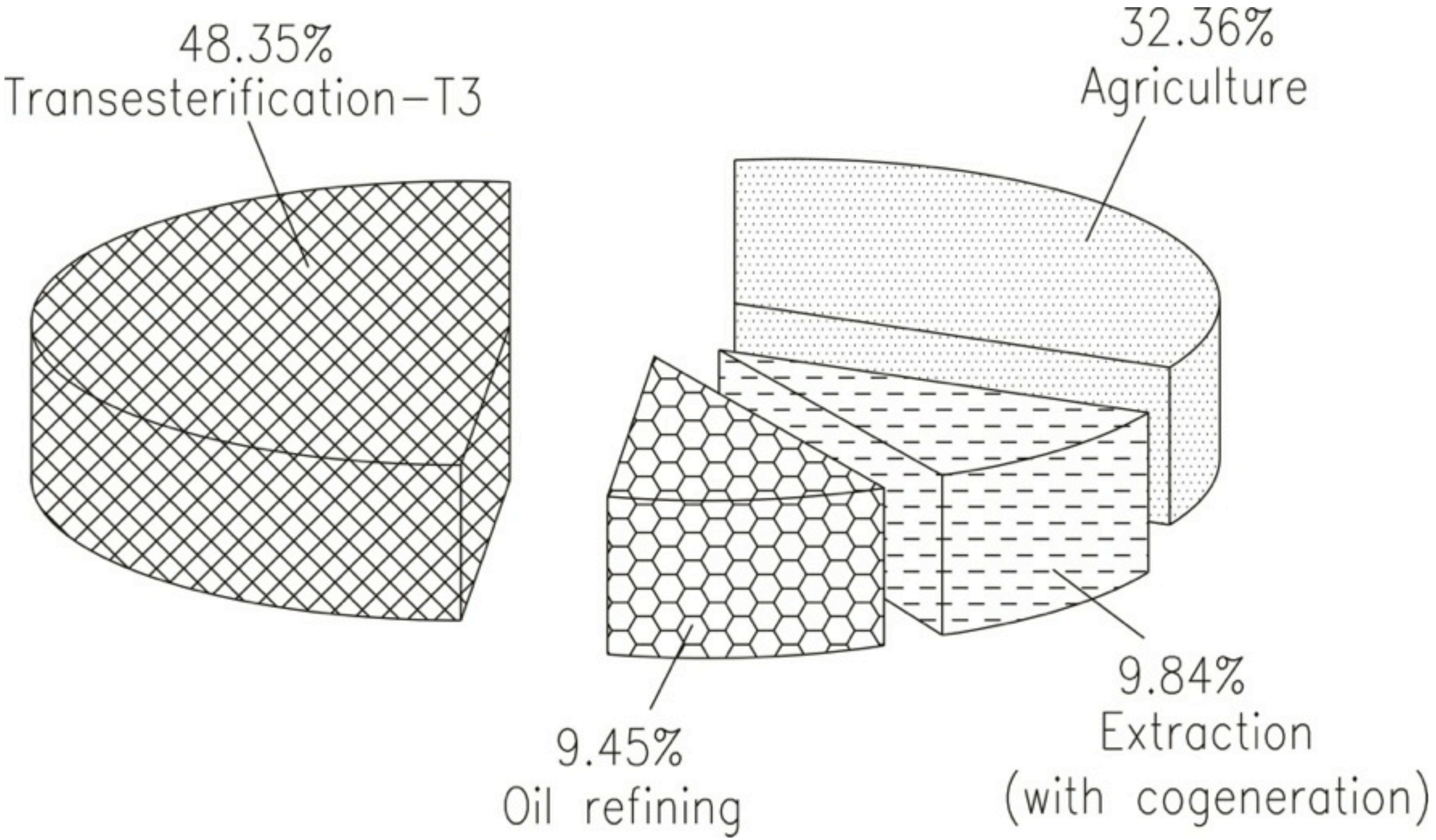
Technical note

The energy balance in the Palm Oil-Derived Methyl Ester (PME) life cycle for the cases in Brazil and Colombia

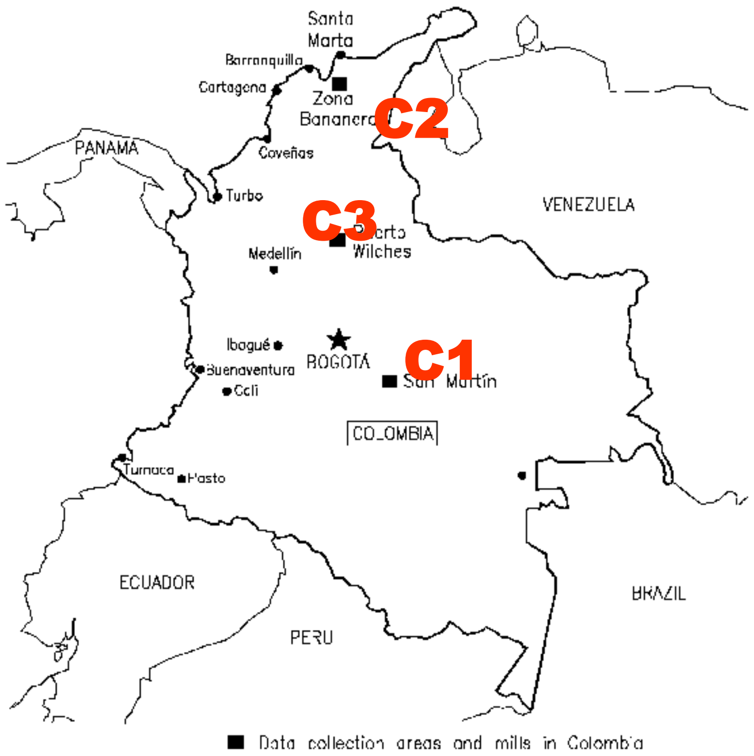
Edgar Eduardo Yáñez Angarita[a,*], Electo Eduardo Silva Lora[b], Rosélis Ester da Costa[b], Ednildo Andrade Torres[c]

[a] Oil Palm Research Center – CENIPALMA Cll 20A # 43 A 50, Piso 4. Bogotá D.C., Colombia
[b] Federal University of Itajubá/Excellence Group in Thermal and Distributed Generation NEST (IEM/UNIFEI), Brazil
[c] Bahia Federal University – UFBA, Brazil

PARTICIPATION OF LC STAGES IN TOTAL ENERGY CONSUMPTION



RELACIÓN OUTPUT/INPUT (NER – NET ENERGY RATIO)



The output/input average value when fossil methanol is replaced by biomethanol should be in the range 8–9, as methanol is responsible for about 43 percent of the fossil energy consumed during the PME life cycle.

INPUT, [MJ / kg Biodiesel]	C1	C2	C3
Agrícola	3,2069	4,2376	2,6326
Extração – incluindo cogeração (biomassa)	1,0629	1,2721	0,7279
Refinação do óleo	0,9804	0,9804	0,9804
Transesterificação –T1, *Borken et. al. (2006)*	5,7608	5,7608	5,7608
Transesterificação – T2, Ácidos graxos.	20,5472	20,5472	20,5472
Transesterificação – T3, *Lurgi (2007)*	5,0194	5,0194	5,0194
Total Input, usando T1	11,0110	12,2509	10,1017
Total Input, usando T2	25,7974	27,0373	24,8881
Total Input, usando T3	10,2696	11,5095	9,3603
Total Input, com aporte de Cachos vazios e usando T3	9,9621	11,2020	9,0528
OUTPUT, [MJ / kg Biodiesel]	**C1**	**C2**	**C3**
Fibra, (10% excedente)	0,8572	0,7246	0,6656
Cascas, (29% excedente)	2,7913	2,6483	1,8517
Biogás	0,0552	0,0552	0,0552
Torta Palmiste	2,5406	2,3863	2,4658
Óleo de palmiste	6,0063	5,6416	5,8296
Glicerina	2,0938	2,0938	2,0938
Ácidos graxos	1,2766	1,2766	1,2766
Biodiesel	39,60	39,60	39,60
Total Output	**55,2210**	**54,4264**	**53,8383**
O / I (Sem aporte dos Cachos vazios), usando T3	**5,3771**	**4,7288**	**5,7518**
O / I (Com aporte dos Cachos vazios), usando T3	**5,5431**	**4,8586**	**5,9471**

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Cogeneration potential in the Columbian palm oil industry: Three case studies

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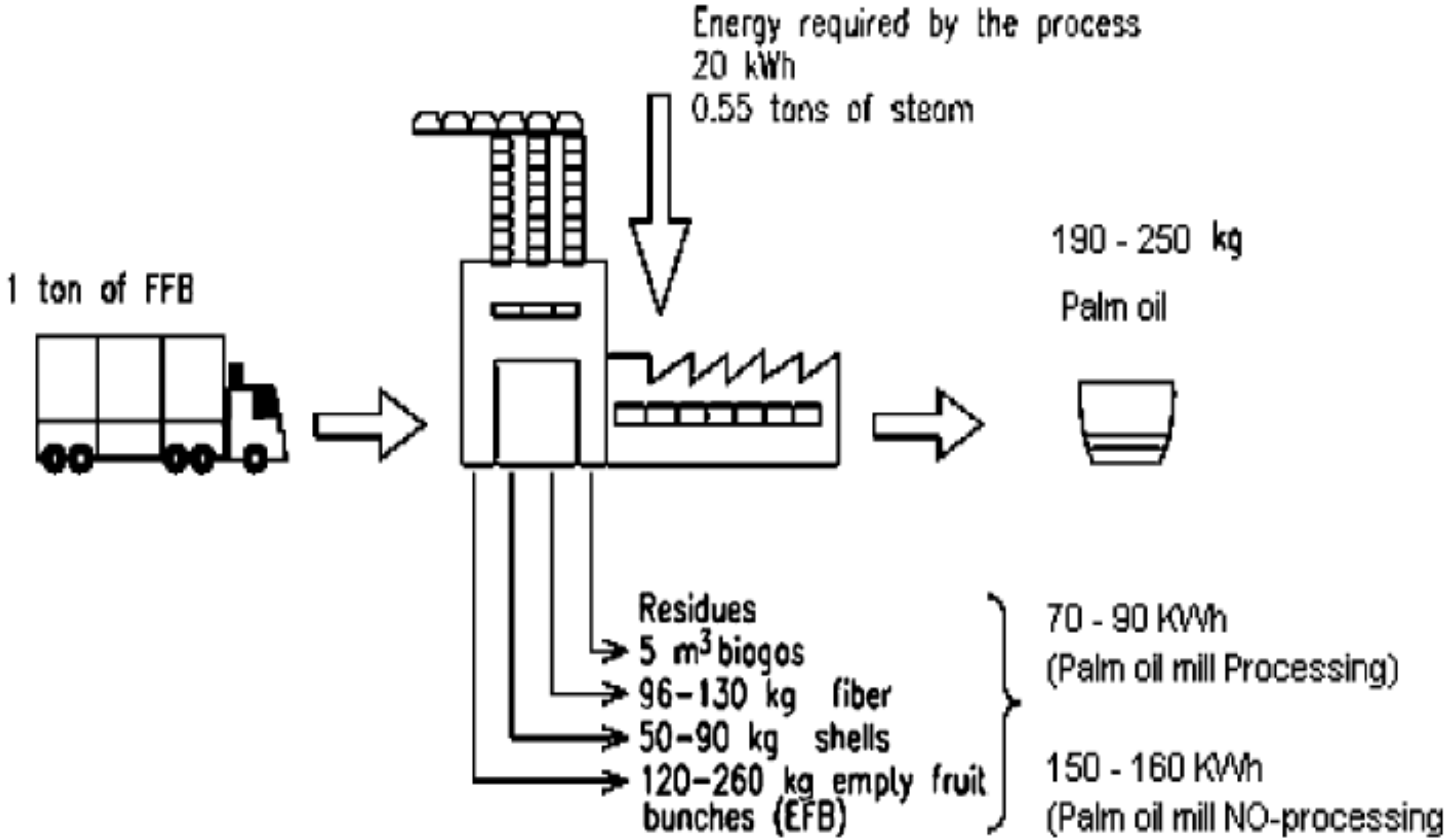
Energy required by the process
20 kWh
0.55 tons of steam
190 - 250 kg
Palm oil
1 ton of FFB
Residues
5 m3 biogas
96–130 kg fiber
50–90 kg shells
120–260 kg empty fruit bunches (EFB)
70 - 90 KWh
(Palm oil mill Processing)
150 - 160 KWh
(Palm oil mill NO-processing

LCA of Palm oil biorefinery concepts

WSU, PNNL, Cenipalma, UNIFEI

Evolution of Palm Oil Mills into Bio-refineries: Part 2: Technical and Environmental Assessment of Six Bio-refinery Options

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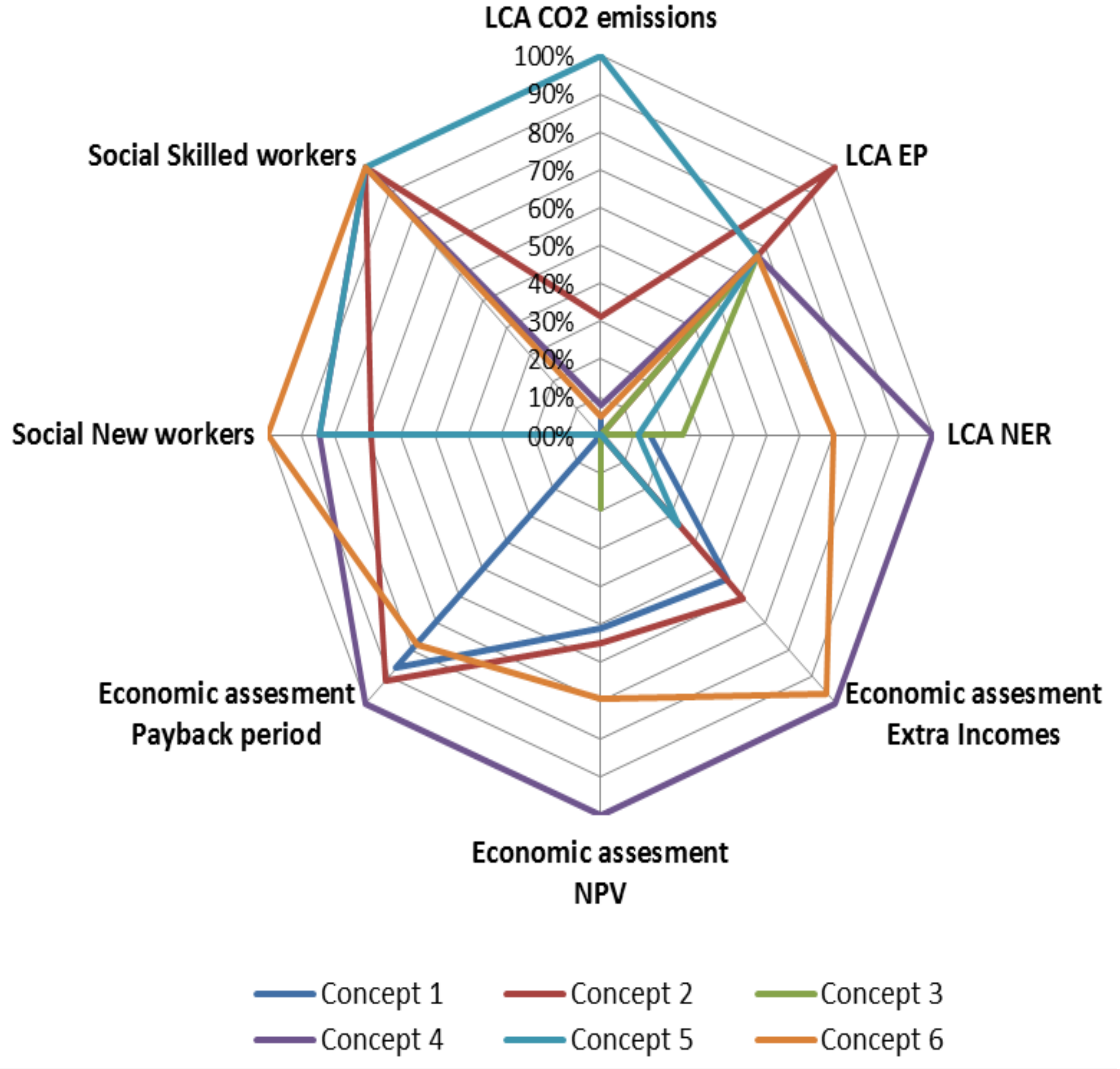
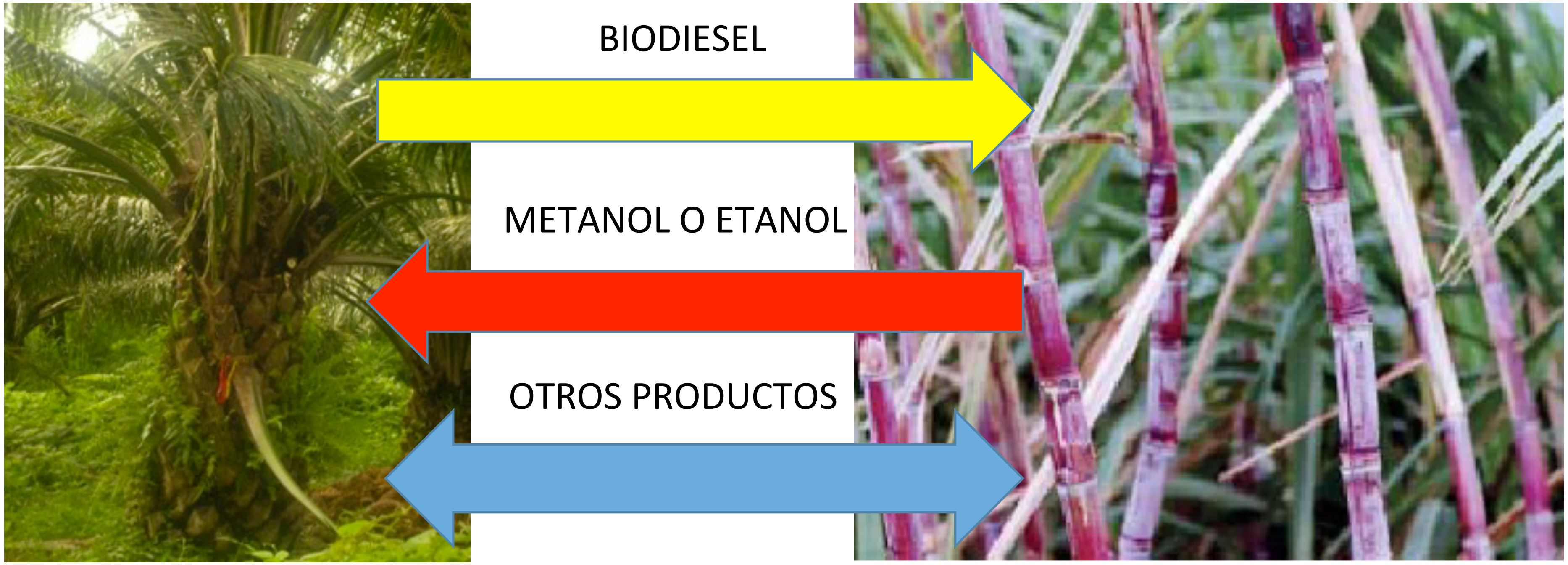
Relative values of sustainability indicators for the six biorefinery concepts

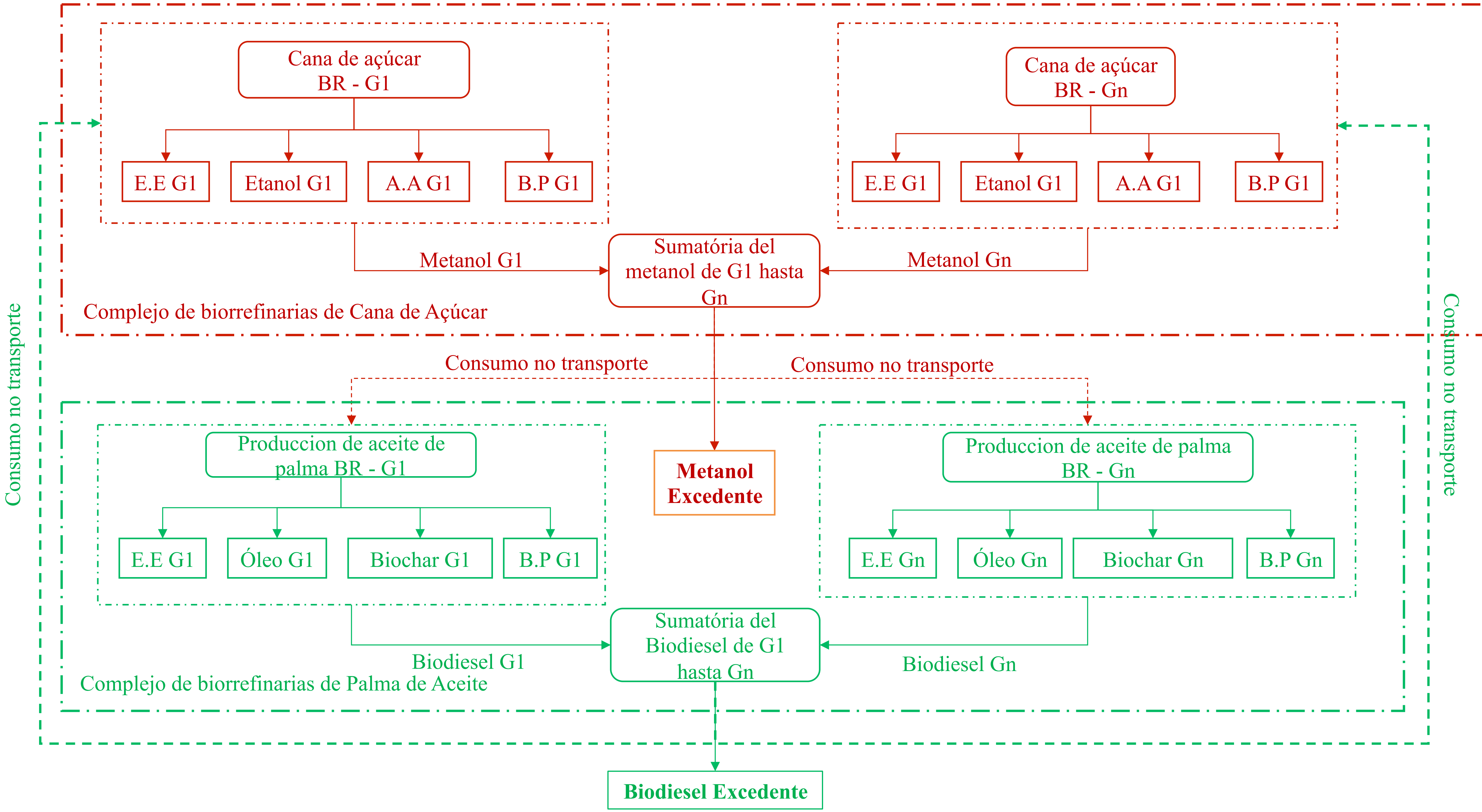


VIII- Posible interacción entre complejos de biorefinerias baseados en la palma de aceite y la caña de azucar



Posibles Ventajas:

- Reduccion del consumo de produtos de origen fóssil y com fuerte input energético.
- Mejoria de los indicadores de sostenibilidad.
- Reduccion de costos


Cana de açúcar BR - G1
E.E G1
Etanol G1
A.A G1
B.P G1
Cana de açúcar BR - Gn
E.E G1
Etanol G1
A.A G1
B.P G1
Metanol G1
Sumatória del metanol de G1 hasta Gn
Metanol Gn
Complejo de biorrefinarias de Cana de Açúcar
Consumo no transporte
Consumo no transporte
Consumo no transporte
Consumo no transporte
Produccion de aceite de palma BR - G1
Metanol Excedente
Produccion de aceite de palma BR - Gn
E.E G1
Óleo G1
Biochar G1
B.P G1
E.E Gn
Óleo Gn
Biochar Gn
B.P Gn
Sumatória del Biodiesel de G1 hasta Gn
Biodiesel G1
Biodiesel Gn
Complejo de biorrefinarias de Palma de Aceite
Biodiesel Excedente

COMENTARIOS Y RESULTADOS PRELIMINARES

COMENTARIOS

- El sector azucarero consume el 4 % del Diesel utilizado en Brasil
- El sector de biodiesel en Brasil importa metanol por valor de 250 millones de dolares.

RESULTADOS PRELIMINARES

- Aumento del NER de las biorefinerias de la caña de azucar hasta 19
- Aumento del NER de las biorefinerias de la palma de aceite hasta 8-9
- Reduccion de las emisiones de GEI en los dos complejos de refinerias em alrededor de 20 %.


MUITO OBRIGADO!!!
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