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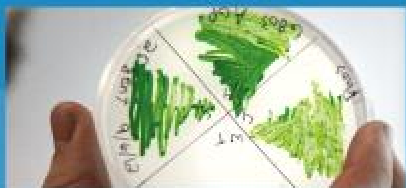




Tools for the GHG assessment of biofuels

Patrick Lamers, Helena Chum

Understanding Climate Change Effects of Forest Biomass and Bioenergy Systems – Workshop

Angers, France, November 7th, 2017

Context

IEA Bioenergy

Inter-Task project "Measuring, governing and gaining support for sustainable bioenergy supply chains"

Objective 1.
Measuring sustainability
Task 38: Lead (Annette Cowie)
Task 39 & 40: Contributors

Comparison of tools for assessing GHG emissions savings of biofuels

CTBE, Brazil: L. Pereira, O. Cavalett, A. Bonomi,
NREL, USA: Y. Zhang, E. Warner, H. Chum

CTBE Laboratório Nacional de Ciência e Tecnologia do Bioetanol

NREL National Renewable Energy Laboratory

Submitted to *Renewable & Sustainable Energy Reviews*

U.S. Department of Energy | Energy Efficiency & Renewable Energy

Motivation & Goal

- Motivation: Differences in results between LCA tools have decreased the credibility of measuring compliance with GHG emissions reduction targets in countries regulating CO_2 emissions.

- Goal: identify the main differences and commonalities in methodological structures, calculation procedures, and assumptions in LCA models used to assess GHG emissions of biofuels.

Main Regulatory Differences

U.S. Federal

Biofuel pathways have emission reductions = or > than threshold

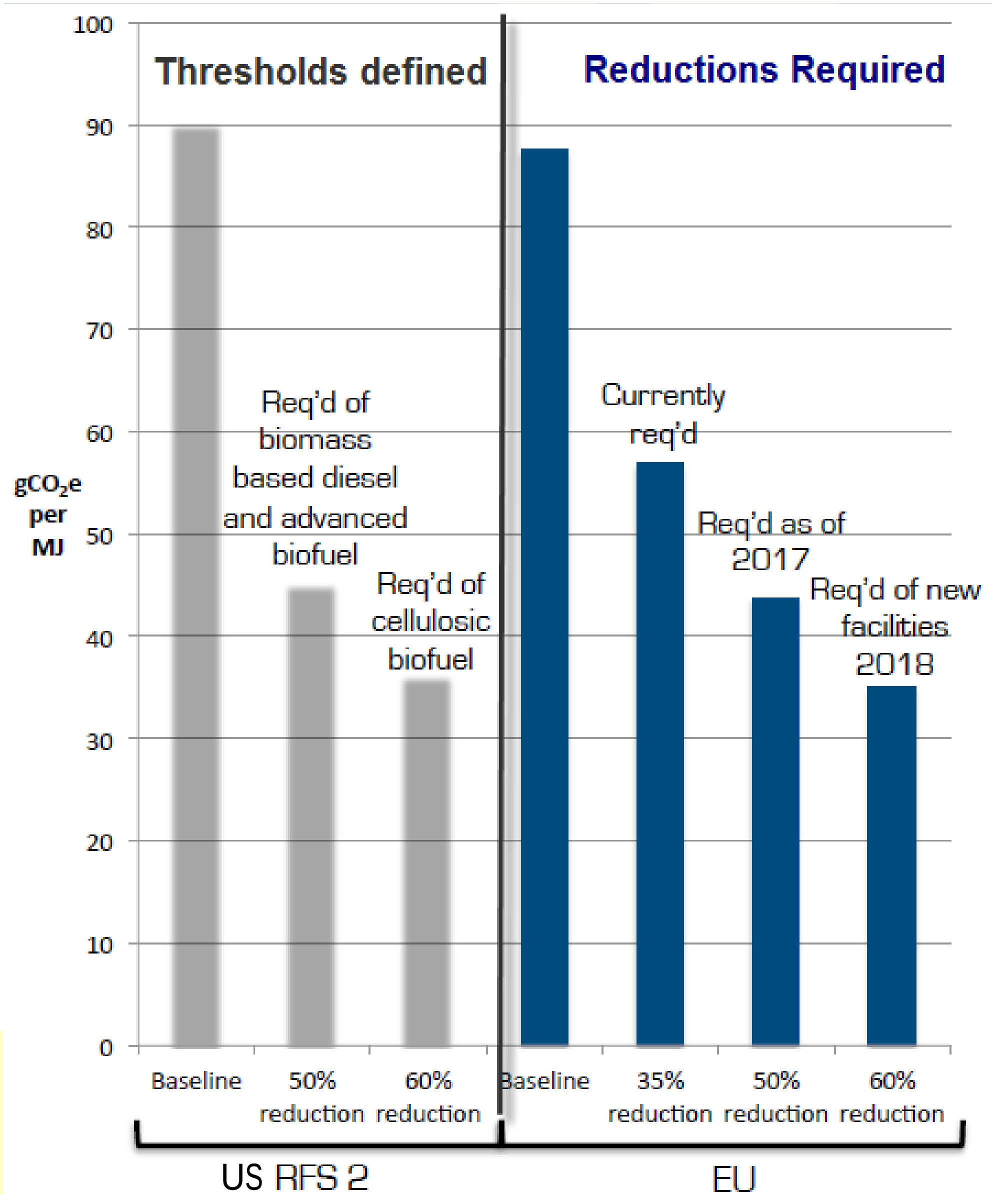
Pathway approval to access RINs

Accounts for volumes not emissions

National GHG net emissions assess transport sector reductions

LCA assessment crosses IPCC sectors

*California LCFS calculates biofuel carbon intensities



EU-RED/FQD

Harmonized/ Standardized GHG accounting to avoid data cherry-picking by operators

Min. reductions to access support schemes

BioGrace1 implements defined values to be used in calculations

Operators can use own operations data

Reductions are tracked and audited to improve the program

Grain ethanol

The models and their main characteristics

Parameters	BioGrace	GHGenius	GREET
Developed for regulatory purpose	Yes	No	No
Type of LCA	Attributional	Attributional	Attributional
Upstream life cycle data	JRC database	Internal	Internal
Default allocation method	Energy (RED)	Substitution	Energy (Elec) Substitution (DDGS)
GWP method	2001(RED)	2001, 2007	2007
Land-use change (LUC)	C stocks	none	CCLUB
Gasoline baseline (gCO2eq/MJ)	**83.8**	**95.0**	**90.2**
Default ethanol GHG (gCO2eq/MJ)			
Sugarcane (% reduction)	24.0 (71%)	43.3 (54%)	25.3 (72%)
Corn (% reduction)	43.6 (48%)	64.2 (32%)	67.8 (25%)
Wheat (% reduction)	69.9 (13%)	71.0 (25%)	-

No LUC
LHV values
Default allocation

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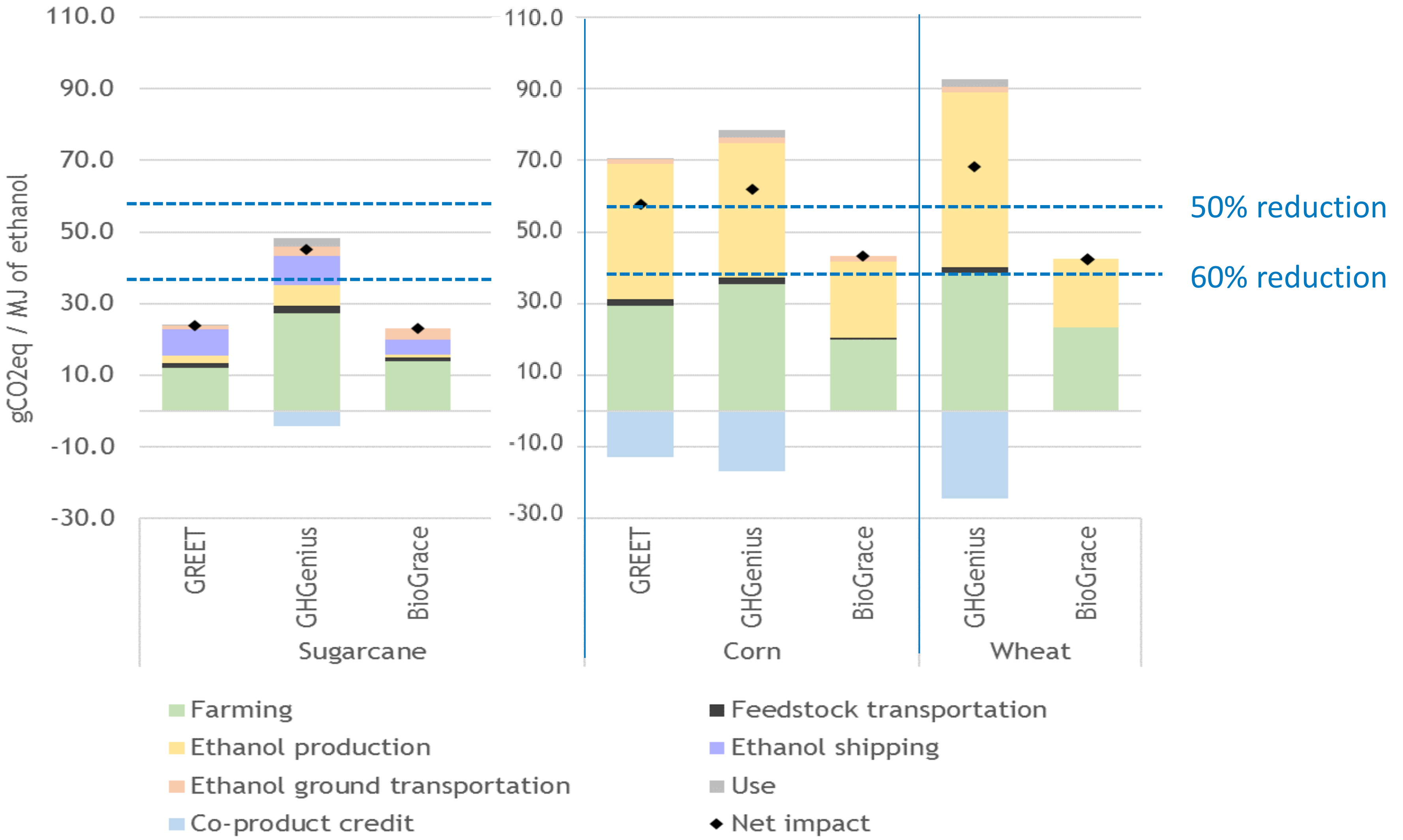
Scope

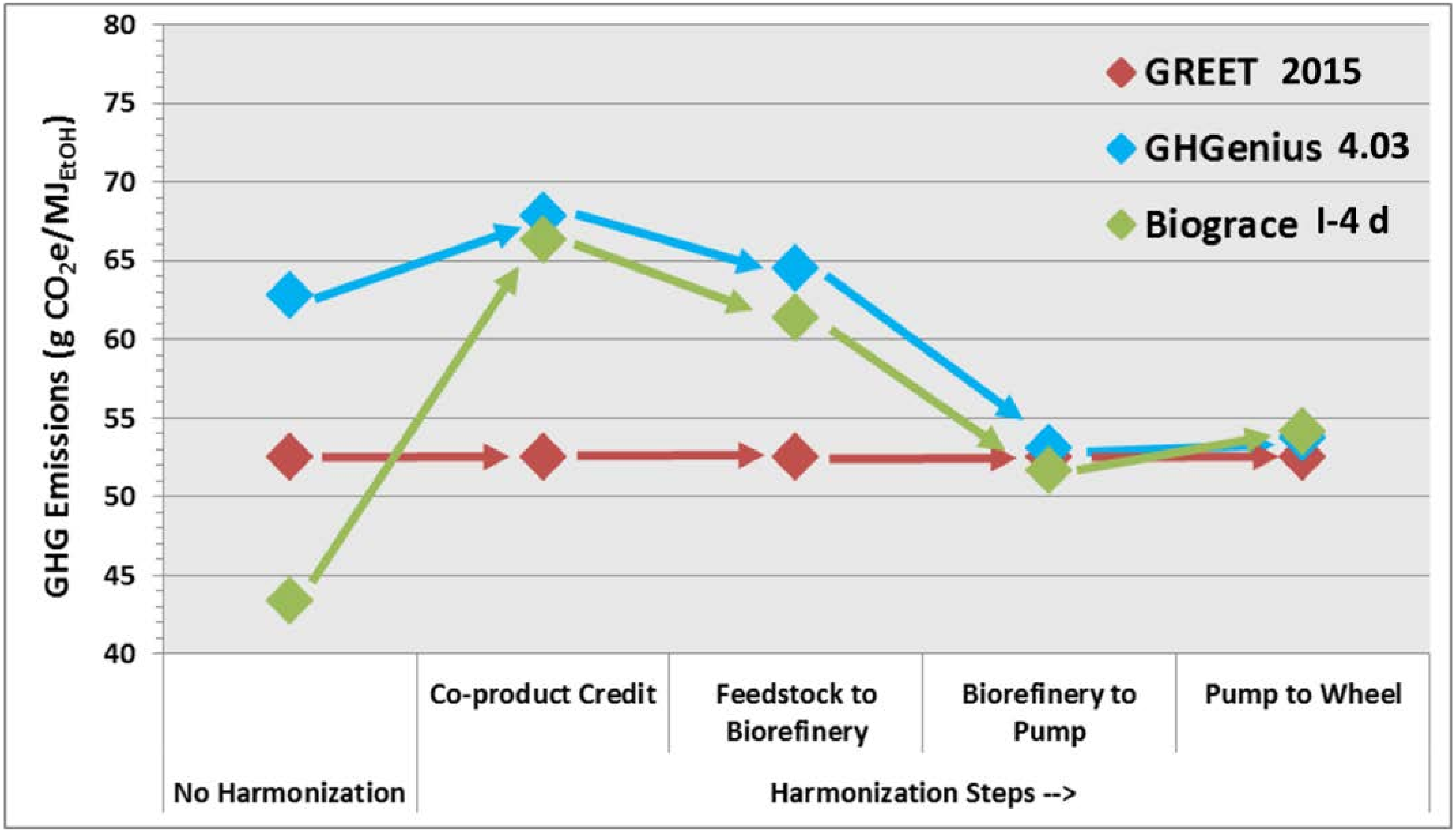
- Reference: GREET
- Harmonize assumptions in GHGenius & BioGrace1*
  - Global Warming Potential (GWP)
  - Yields (i.e., feedstock, fuel, and co-products)
  - Field N_2O and lime CO_2 emission factors (EF)
  - Agricultural inputs (e.g., nitrogen and their GHG EF)
  - Fuel conversion process chemicals and their GHG EF
  - Direct fossil energy use in feedstock and fuel production
  - Physical properties (e.g., lower heating value of EtOH)
  - Transportation modes, travel distances & fuel use intensity

*In some cases, absent components (due to minimum threshold) of the LCA were added to BioGrace1 (e.g., process chemicals).

Commercial ethanol default allocations



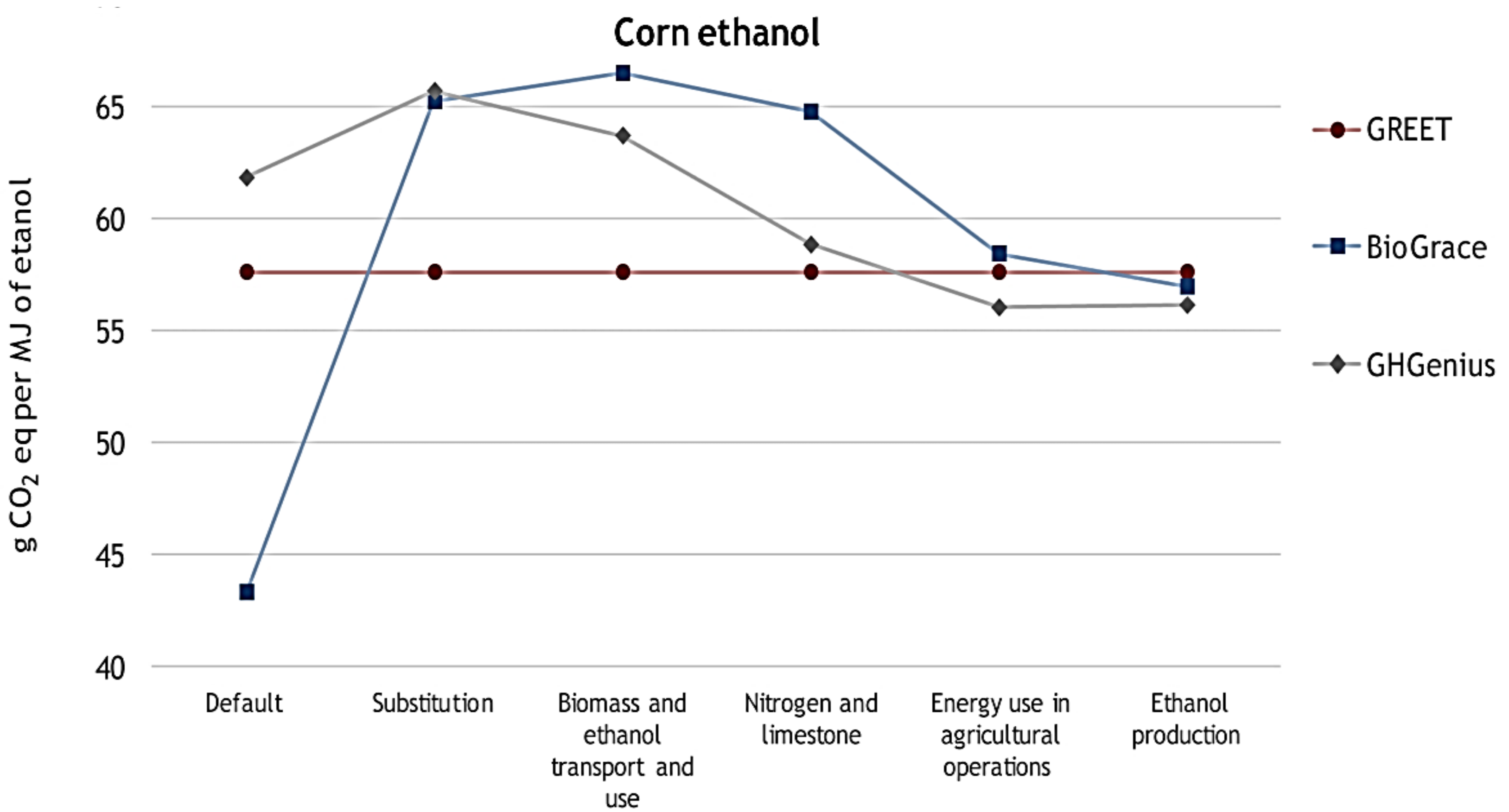
Well to Wheel harmonization (NREL)



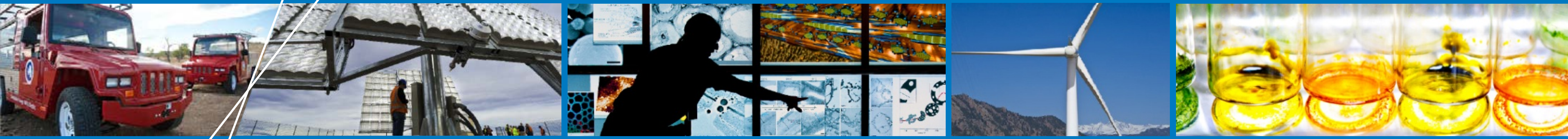
- Well to wheel
- Reference: GREET
- Average U.S. Dry mills only

- Steps based on ease of separation from the spreadsheets to test the methodology
- Source: NREL

Well To Wheel harmonization (CTBE)



- Well To Wheel
- Reference: GREET
- Average ethanol produced in the U.S.
- Includes dry mills with and without corn oil extraction and wet mills
- Non-food corn oil used for biodiesel
- Steps based on detailed analysis to identify major components in the LCA
- Source: CTBE



Sugarcane ethanol

Three models plus a reference

	GREET	BioGrace 1	GHGenius	VSB
Origin	US	EU	Canada	Brazil
Developer	ANL	IFEU (EU harmonization)	S&T2 Consultants	CTBE
Model version	2016	4d	4.03a	2015
Developed for regulatory use?/Open source?	No/Yes	Yes/Yes	No/Yes (dated)	No/No
Regulatory schemes	Used by RFS2, CA-LCFS	EU-RED Implementation	Used by LCFS (AB and BC)	No
Functional unit	Service (km, mile) Energy (Btu, MJ)	Energy (MJ)	Service (km) Energy (MJ)	Service (km) Energy (MJ)

Harmonize three models against VSB (Virtual Sugarcane Biorefinery):
Use VSB data (most up to date) and apply to the other three

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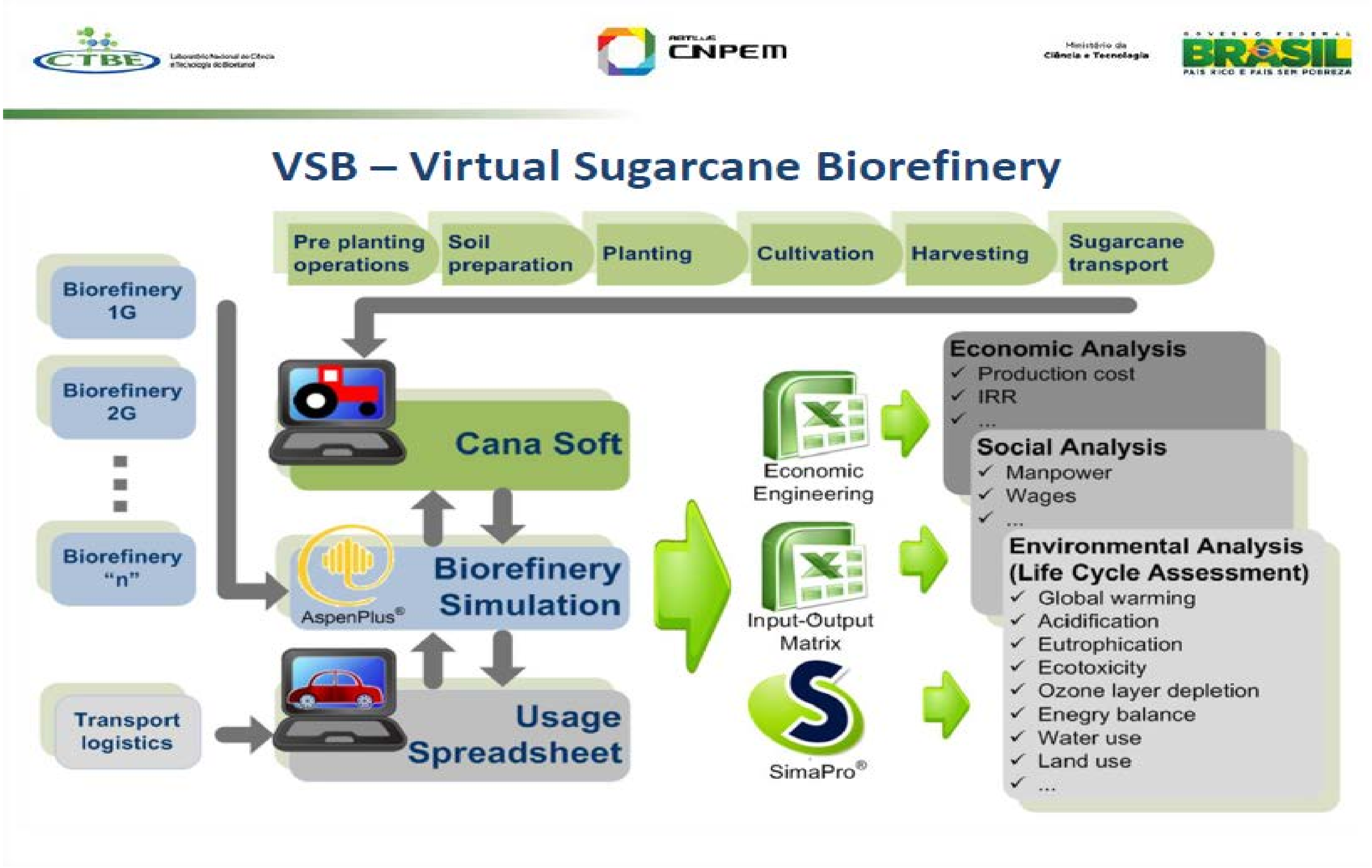
CTBE context



Bonomi, MA, Cavalett, O, Cunha, MP, Lima, MAP, Editors. 2016. Virtual Biorefinery. An Optimization Strategy for Renewable Carbon Valorization. Green Energy and Technology ISBN 978-3-319-26045-7 (eBook) 319 pp.

Key differences

Agricultural	GREET	BioGrace1	GHGenius	VSB
	Projected literature	Conditions for (EU) export		Actual average
Straw burning (%)	14%	100%	0%	18.4%
Limestone application (kg per tonne of sugarcane)	5.2	5.3	11.7	5.0
Limestone impact (g CO_2eq per kg of limestone)	236.0	129.5	790.0	131.6
Diesel (L per tonne of sugarcane)	1.1	0.8	2.9	1.9
Diesel impact (g CO_2eq per MJ of diesel)	90.2	87.6	116.4	81.6
N fertilizer application (g N per tonne of sugarcane)	800	910	1077	1230
N_2O emission fator (%)	1.220%	1.325%	1.575%	1.460%
N fertilizer manufacturing impact (g CO_2eq per kg of N)	4.48	5.88	3.51	3.35
Industrial				
Sulfuric acid (g per L of ethanol)	-	16.06	7.40	4.94
Lime (g per L of ethanol)	10.85	17.97	11.00	7.48

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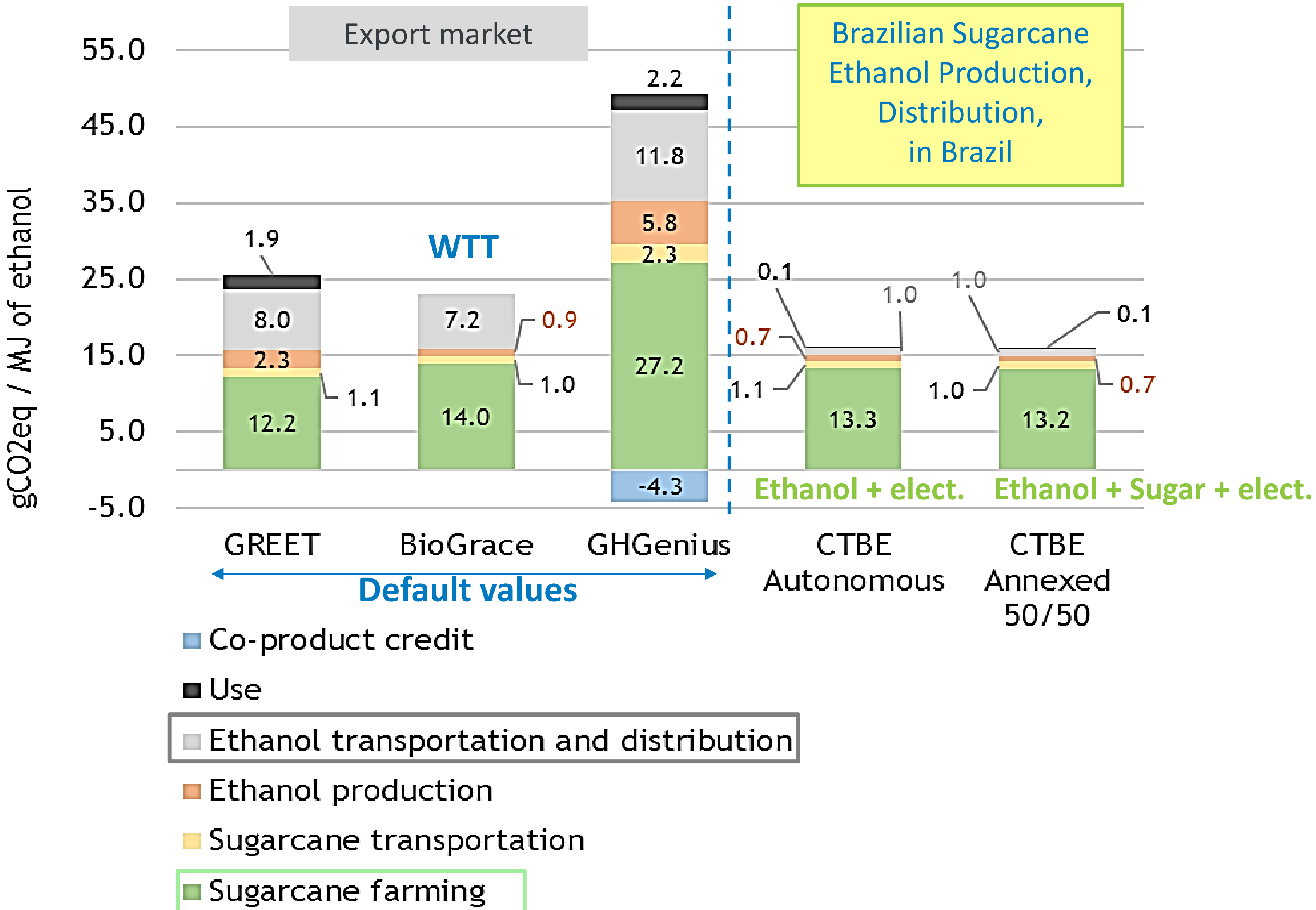
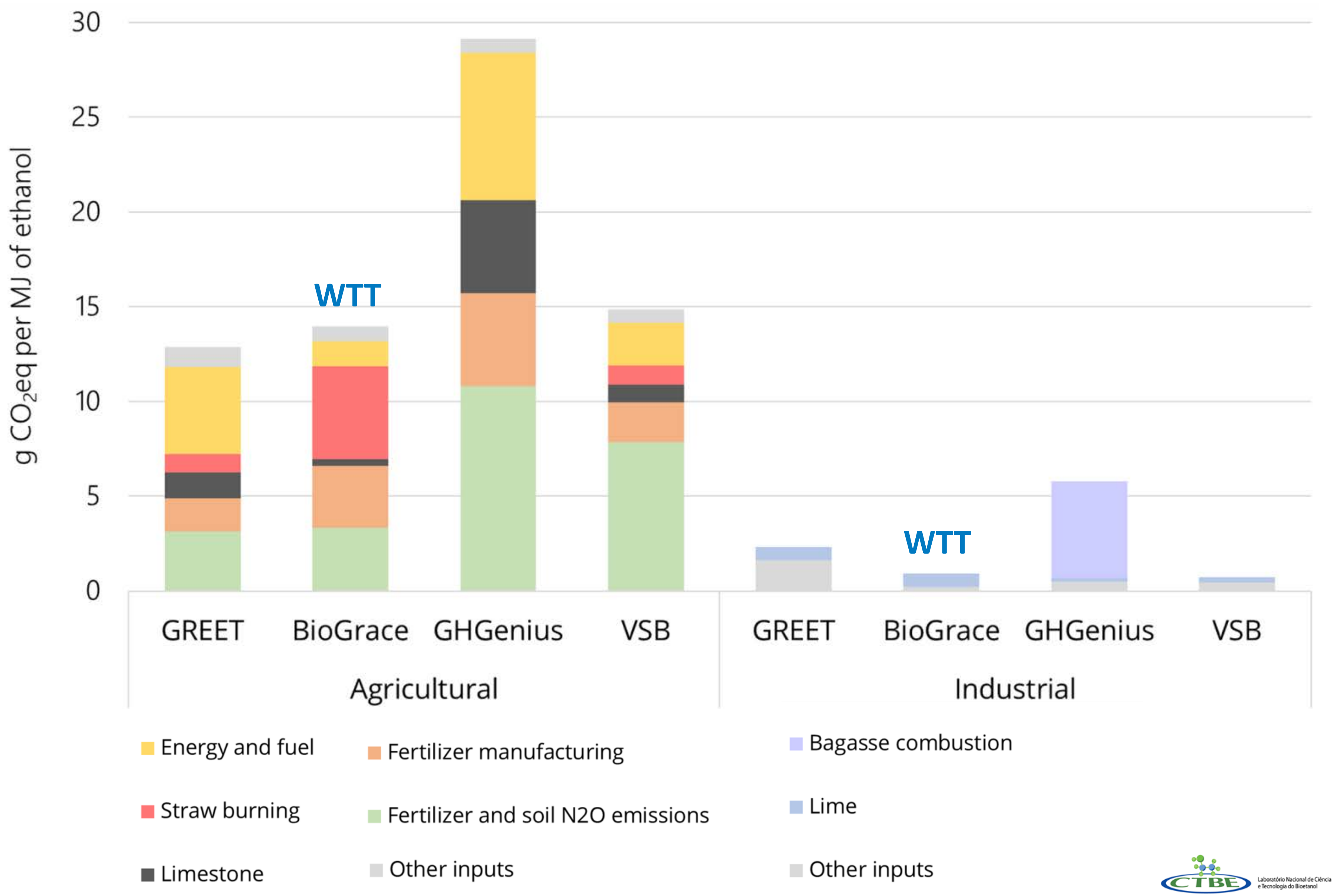
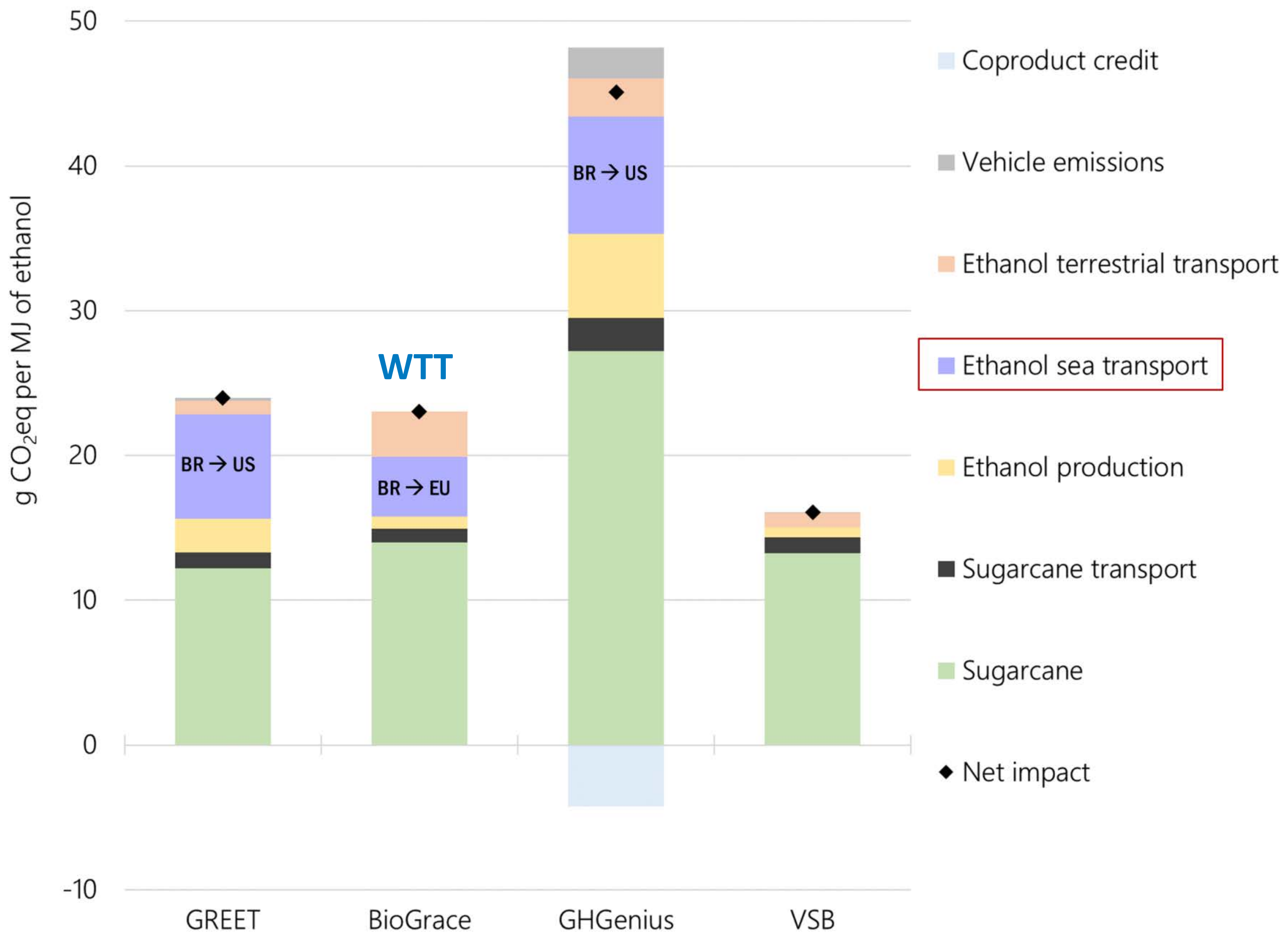
Default emissions summary (WTT & WTW)



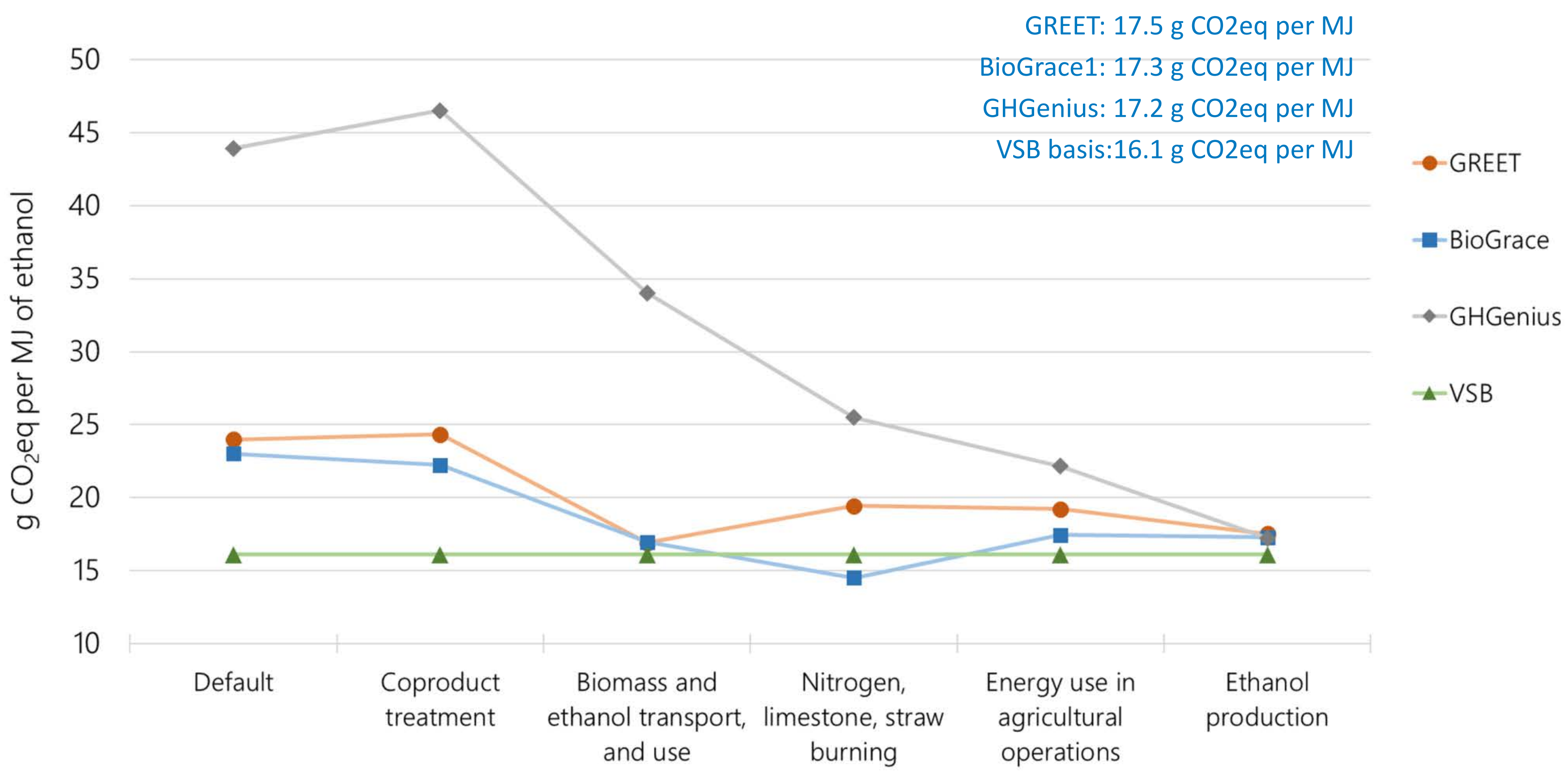
Emissions by category (WTT & WTW)



Consolidated comparison (WTT & WTW)



WTW harmonization



Upon harmonizing: 8% maximum variation

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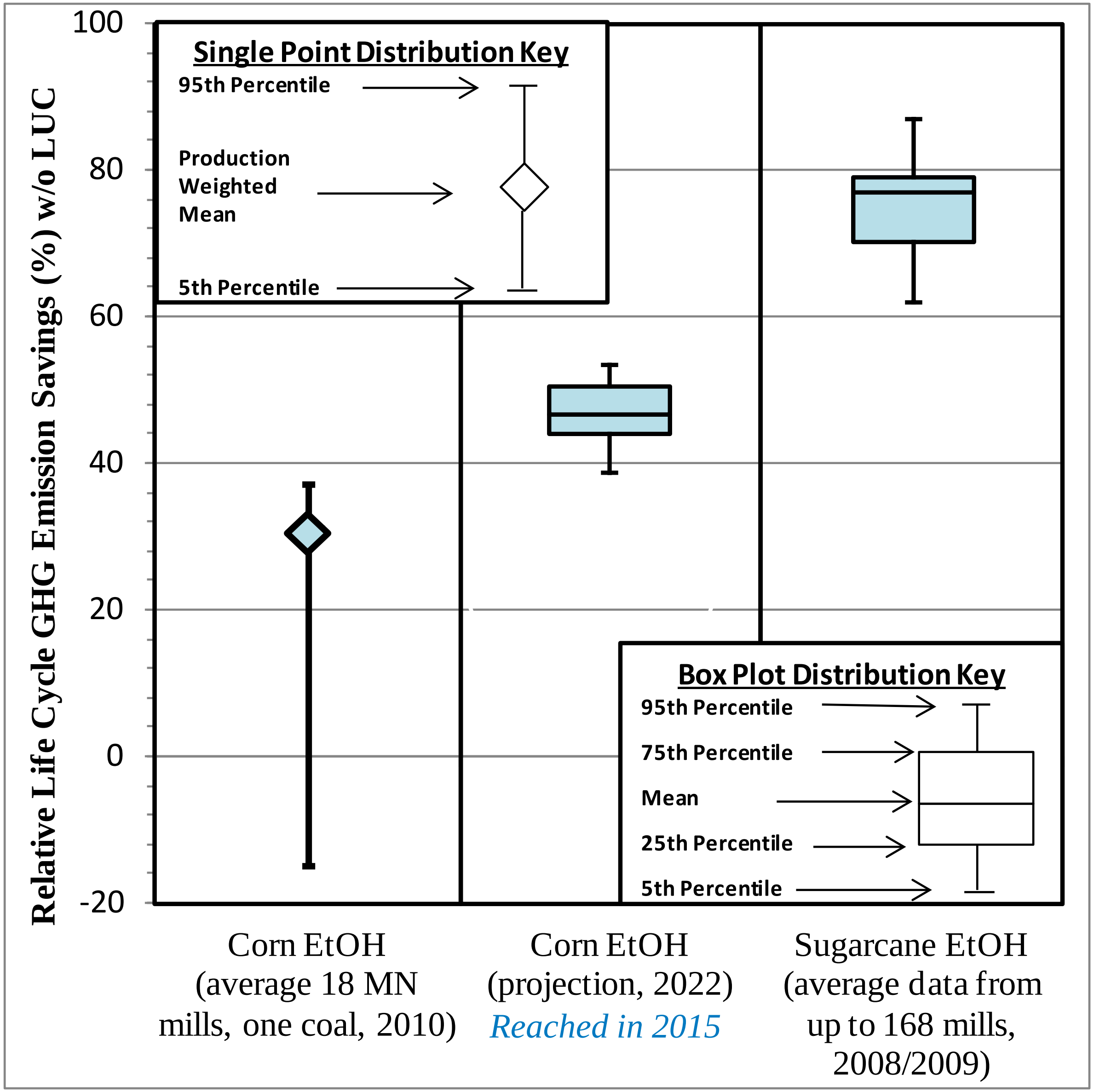
Benchmarking the two industries



A comparison of commercial ethanol production systems from Brazilian sugarcane and US corn

Helena L. Chum[1], Ethan Warner[1,*], Joaquim E.A. Seabra[2] and Isaias C. Macedo[2]

Article first published online: 10 OCT 2013

DOI: 10.1002/bbb.1448

Issue

Biofuels, Bioproducts and Biorefining

Volume 8, Issue 2, pages 205–223, March/April 2014

Brazil (center south):
50% mechanized harvest
in 2008/2009; 100% by 2020?

EPA: Brazilian ethanol meets Advanced Biofuels threshold with 50% reduction of GHG emissions including Land Use Change

U.S. dry mills with energy efficient technologies can meet EU RED I requirement (35% reduction) but will not be able to meet RED II proposal (70% reduction)

See also: http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/2011_events/Workshop_on_GHG_LCA_Tokyo_15Nov2011/4._Seabra.pdf

Conclusions – commercial ethanol

- Different regulatory bases and reporting requirements for biofuels (e.g., EU-RED and US-RFS2)
- LCA tools generate similar GHG emission values given the same assumptions and data
- GHGenius public version of 2013 produces largest default variation (as data is from 2008-2010)
- BioGrace1 is the EU regulatory calculator and not a model to investigate emissions from pathways
- GREET and GHGenius update the respective underlying country energy system changes

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