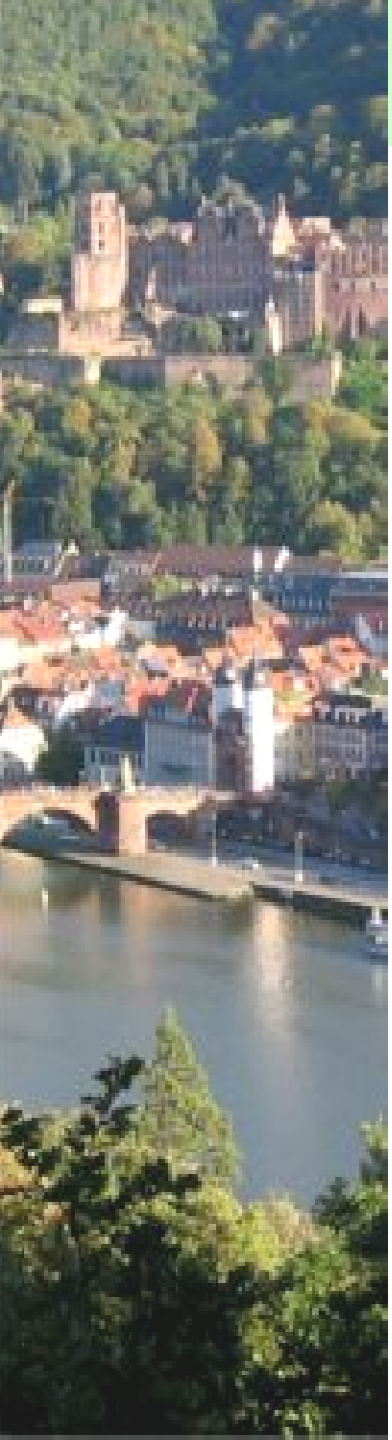


GBEP
Global Bioenergy Partnership

ifeu

GBEP
Capacity Building Workshop on GHG LCA and Policy Applications
Tokyo - 15 November 2011

How to measure GHG emissions from bioenergy production and use: field measurements and calculators

Horst Fehrenbach IFEU Germany

in cooperation with

Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

sponsored by

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Umwelt Bundes Amt
Für Mensch und Umwelt

OVERVIEW

Introduction

Part 1:

Major issues in the 10 steps of the GBEP methodological framework for GHG LCA

Part 2:

Different approaches to conducting LCA of bioenergy

Part 3:

Human and institutional capacity required to conduct LCA

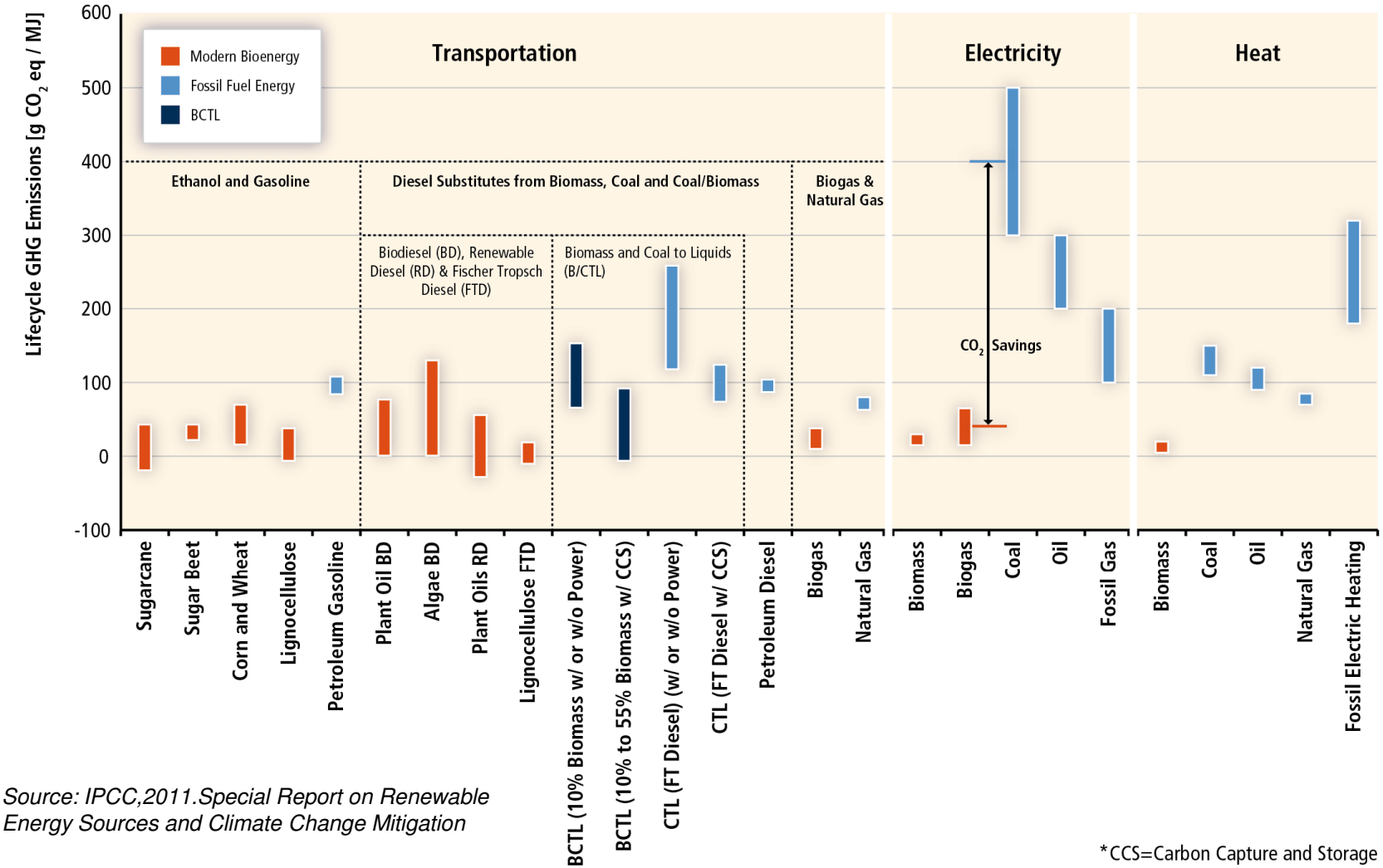
Part 4:

Quick overview of policy and other applications

Conclusions

Introduction

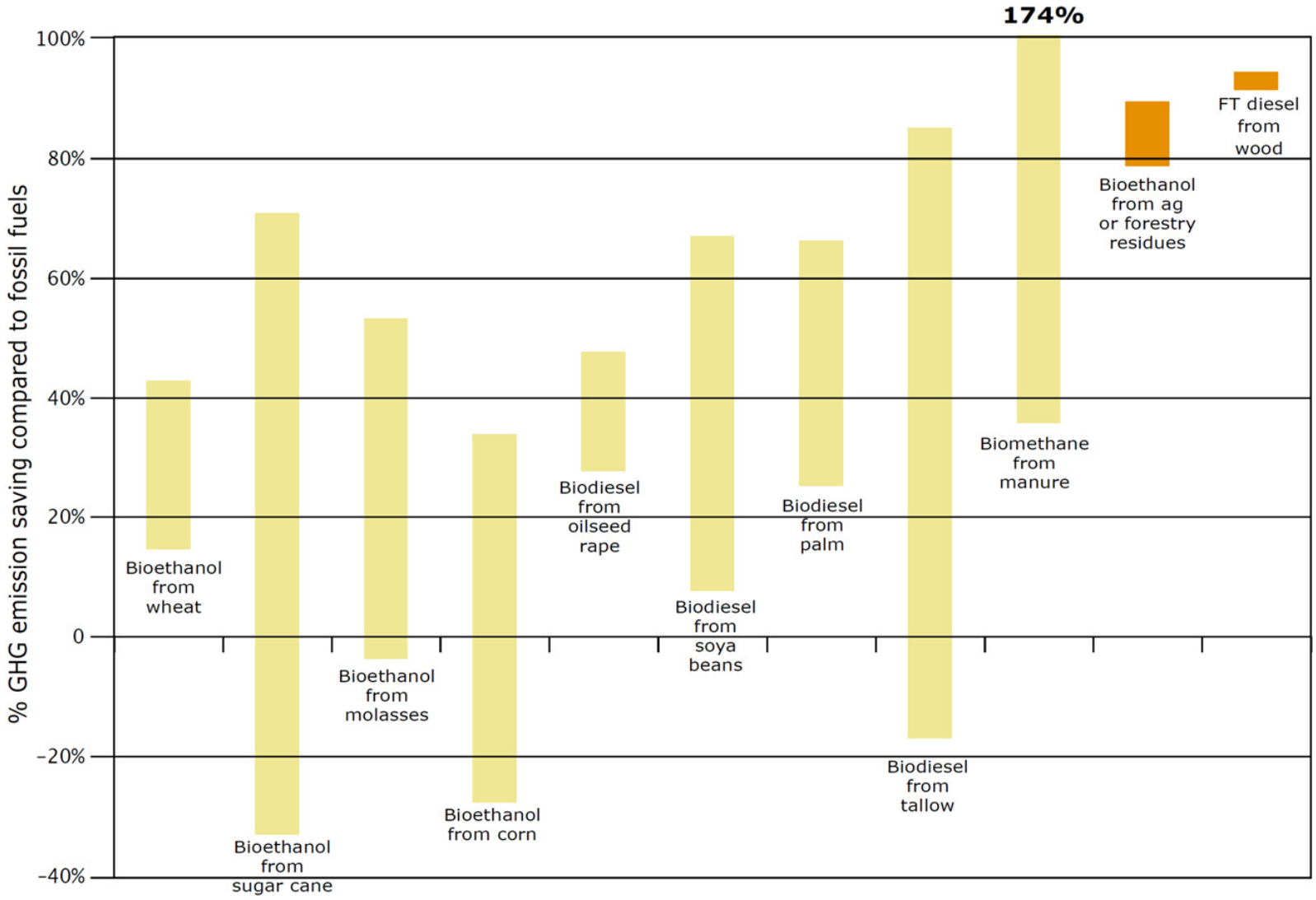
Ranges of GHG emissions per unit energy output (MJ) from major modern bioenergy chains compared to current and selected advanced fossil fuel energy systems
(land use related net changes in carbon stocks and land management impacts are excluded)



Source: IPCC,2011.Special Report on Renewable Energy Sources and Climate Change Mitigation

*CCS=Carbon Capture and Storage

Estimated GHG savings of current biofuel



Note: current technologies are shown in yellow, advanced technologies in orange

Source: Renewable Fuel Agency, 2008. The Gallagher Review of the indirect effects of biofuels production

10-step framework

Key questions of this part

→ *Which steps embed the **major sources** of emissions and sinks and mitigation potential?*

→ *Which steps are connected with **major methodological choices** and their potential impacts on results*

10-step framework

1. GHGs covered
2. Source of biomass
3. Land use change
4. Biomass feedstock production
5. Transport of biomass
6. Processing into fuel
7. By-products and co-products
8. Transport of fuel
9. Fuel Use
10. Comparison with replaced fuel

All steps are essential!
However
some are major
some are minor
sources by trend

mostly major
case by case
mostly minor

Step 1: GHGs covered

The user is asked to provide Global Warming Potential values and/or a clear reference for the GHGs included in the analysis. IPCC SAR values are assumed unless otherwise indicated. This is necessary to ensure consistency between reports and the repeatability of reported calculations.

	IPCC 1995	IPCC 2001	IPCC 2007
CO_2	1	1	1
CH_4	21	23	25
N_2O	310	296	298

Table TS.2. *Lifetimes, radiative efficiencies and direct (except for CH_4) global warming potentials (GWP) relative to CO_2. {Table 2.14}*

Industrial Designation or Common Name (years)	Chemical Formula	Lifetime (years)	Radiative Efficiency ($W\ m^{-2}\ ppb^{-1}$)	Global Warming Potential for Given Time Horizon: SAR‡ (100-yr)	20-yr	100-yr	500-yr
Carbon dioxide	CO_2	See below[a]	[b]1.4×10^{-5}	1	1	1	1
Methane[c]	CH_4	12[c]	3.7×10^{-4}	21	72	25	7.6
Nitrous oxide	N_2O	114	3.03×10^{-3}	310	289	298	153
Substances controlled by the Montreal Protocol							
CFC-11	CCl_3F	45	0.25	3,800	6,730	4,750	1,620
CFC-12	CCl_2F_2	100	0.32	8,100	11,000	10,900	5,200
CFC-13	$CClF_3$	640	0.25		10,800	14,400	16,400
CFC-113	CCl_2FCClF_2	85	0.3	4,800	6,540	6,130	2,700
CFC-114	$CClF_2CClF_2$	300	0.31		8,040	10,000	8,730
CFC-115	$CClF_2CF_3$	1,700	0.18		5,310	7,370	9,990
Halon-1301	$CBrF_3$	65	0.32	5,400	8,480	7,140	2,760
Halon-1211	$CBrClF_2$	16	0.3		4,750	1,890	575
Halon-2402	$CBrF_2CBrF_2$	20	0.33		3,680	1,640	503
Carbon tetrachloride	CCl_4	26	0.13	1,400	2,700	1,400	435
Methyl bromide	CH_3Br	0.7	0.01		17	5	1
Methyl chloroform	CH_3CCl_3	5	0.06		506	146	45
HCFC-22	$CHClF_2$	12	0.2	1,500	5,160	1,810	549
HCFC-123	$CHCl_2CF_3$	1.3	0.14	90	273	77	24
HCFC-124	$CHClFCF_3$	5.8	0.22	470	2,070	609	185
HCFC-141b	CH_3CCl_2F	9.3	0.14		2,250	725	220
HCFC-142b	CH_3CClF_2	17.9	0.2	1,800	5,490	2,310	705
HCFC-225ca	$CHCl_2CF_2CF_3$	1.9	0.2		429	122	37
HCFC-225cb	$CHClFCF_2CClF_2$	5.8	0.32		2,030	595	181
Hydrofluorocarbons							
HFC-23	CHF_3	270	0.19	11,700	12,000	14,800	12,200
HFC-32	CH_2F_2	4.9	0.11	650	2,330	675	205
HFC-125	CHF_2CF_3	29	0.23	2,800	6,350	3,500	1,100
HFC-134a	CH_2FCF_3	14	0.16	1,300	3,830	1,430	435
HFC-143a	CH_3CF_3	52	0.13	3,800	5,890	4,470	1,590
HFC-152a	CH_3CHF_2	1.4	0.09	140	437	124	38
HFC-227ea	CF_3CHFCF_3	34.2	0.26	2,900	5,310	3,220	1,040
HFC-236fa	$CF_3CH_2CF_3$	240	0.28	6,300	8,100	9,810	7,660
HFC-245fa	$CHF_2CH_2CF_3$	7.6	0.28		3,380	1030	314
HFC-365mfc	$CH_3CF_2CH_2CF_3$	8.6	0.21		2,520	794	241
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	15.9	0.4	1,300	4,140	1,640	500
Perfluorinated compounds							
Sulphur hexafluoride	SF_6	3,200	0.52	23,900	16,300	22,800	32,600
Nitrogen trifluoride	NF_3	740	0.21		12,300	17,200	20,700
PFC-14	CF_4	50,000	0.10	6,500	5,210	7,390	11,200
PFC-116	C_2F_6	10,000	0.26	9,200	8,630	12,200	18,200

Step 2: source of biomass

Significance:

Use of waste/residue avoids feedstock production

However use of waste/residue can cause emissions due to the loss of carbon stocks.

Methodological issues:

Distinction between waste and non-waste bioenergy

→ The user is asked to specify the definition of “waste” biomass to ensure transparency at this critical point.

Step 2: source of biomass

„A range of studies has shown that where feedstock is produced without land-use change (either direct or indirect) most biofuels achieve net GHG savings.

Current biodiesel technologies generally achieve a 40 - 50% saving compared to that of conventional diesel. The range of savings from current bioethanol technologies is much wider, from -20% to 80% depending upon: feedstock, rates of fertiliser application; type of other energy source (coal, gas or biomass); heat and power source (simple boiler, CHP or advanced turbine) and the specific use of co-products.“

Source: Renewable Fuel Agency,
2008. The Gallagher Review of the indirect effects of biofuels production

Step 3: Land use change

3a. Direct LUC:

Significance:

if DLUC is given, it is mostly a major source or sink.

Within the majority of cases DLUC might not be given.

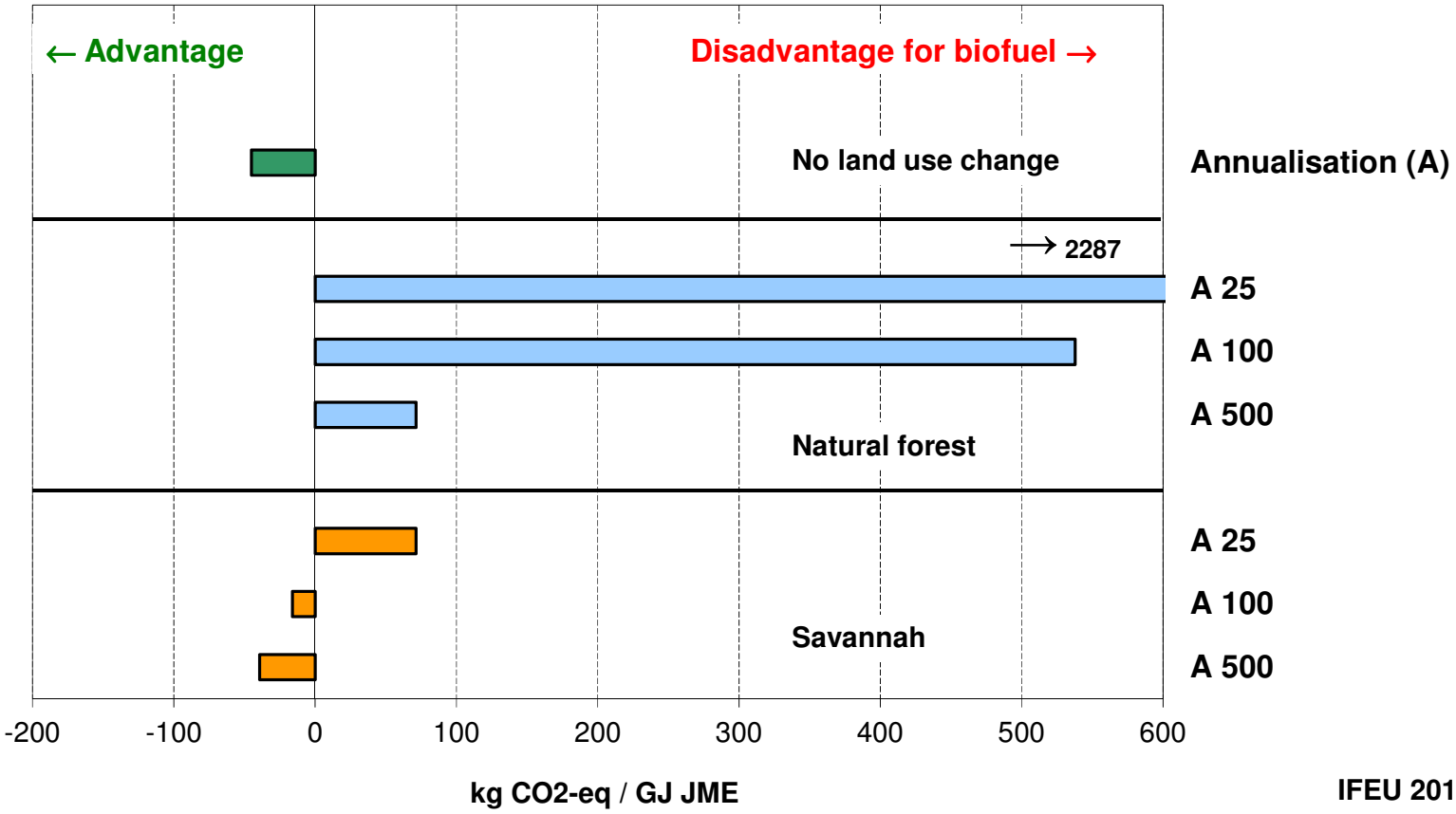
Methodological issues:

- Data availability (on-site nearly unfeasible → rely on IPCC tier 1)
- Temporal aspect (reference year; annualization)
- Land categories (change of status; forest = forest)
- Degraded land (definition?)

Step 3: Land use change

3a. Direct LUC: example

Jatropha FAME for different options in terms of land use change and annualisation



IFEU 2011

Step 3: Land use change

3b. indirect LUC:

Significance:

Within the range of published approaches in many cases a major source (in few cases a sink).

Methodological issues:

There is a plenty of

→ to be tackled separately within the ILUC workstream.

Step 4: Biomass feedstock production

Significance:

One of the major sources.
(fertilizer production, N_2O emissions, land machines).

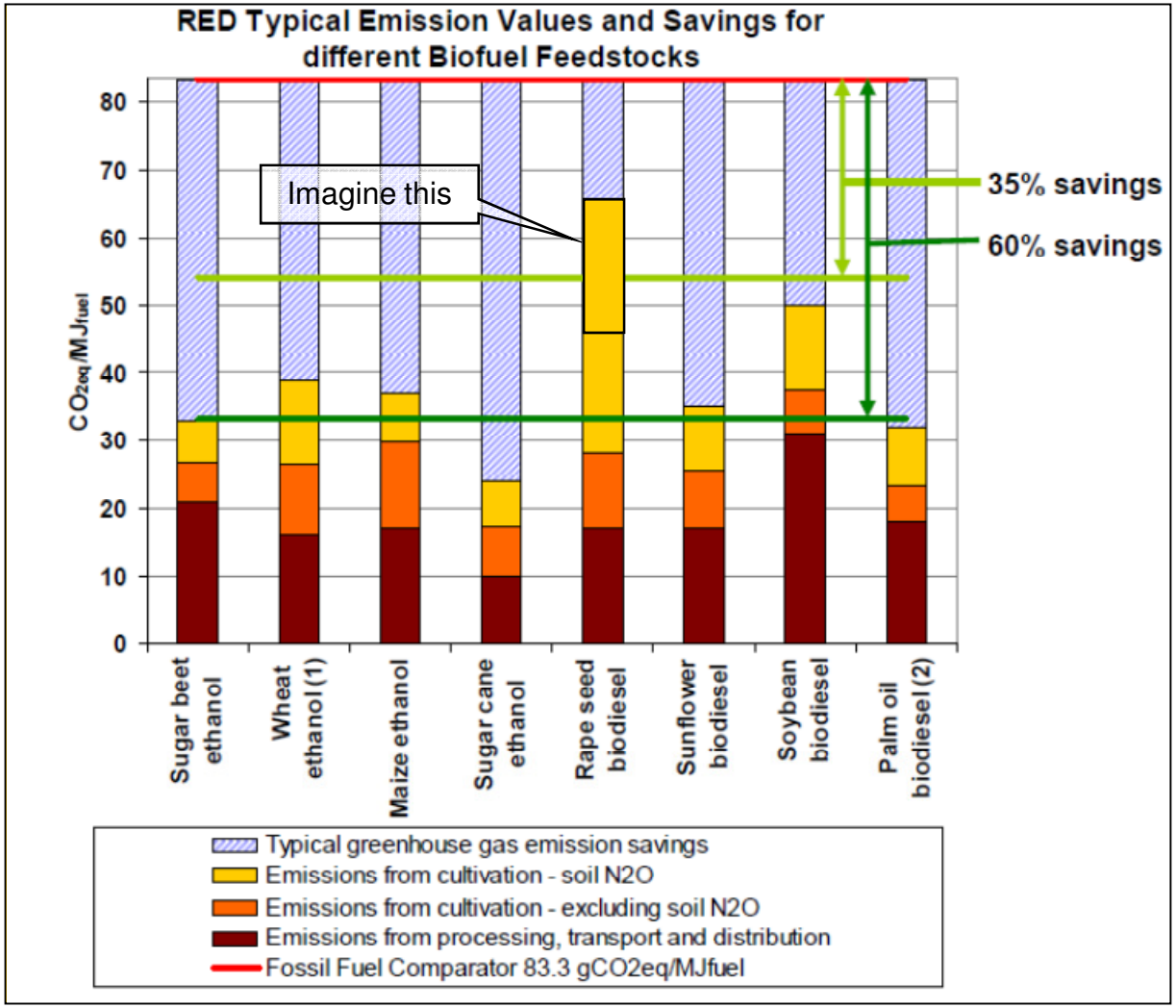
Methodological issues:

- Data for N-fertilizer are key
- given that upstream production chains are embodied.
  (applies also for step 6)
- N_2O emission modeling has relevant impact on results
- Crop rotation systems
- Soil management – how to include good practice
  (long term aspect)

Step 4: Biomass feedstock production

Major source N_2O emissions:

Method under discussion, some approaches lead to values >x2



Source: Köble, R. 2011 JRC
slightly modified by IFEU

Step 5 & 8: transport of biomass and fuel

Significance:

In most cases only minor contributions are related to transport processes (<10% of the life cycle result). Extended truck transports (some 100 km) plus far transcontinental shipping can enhance the relevance.

Methodological issues:

- Return run considered (empty or loaded)

Step 6: processing into fuel

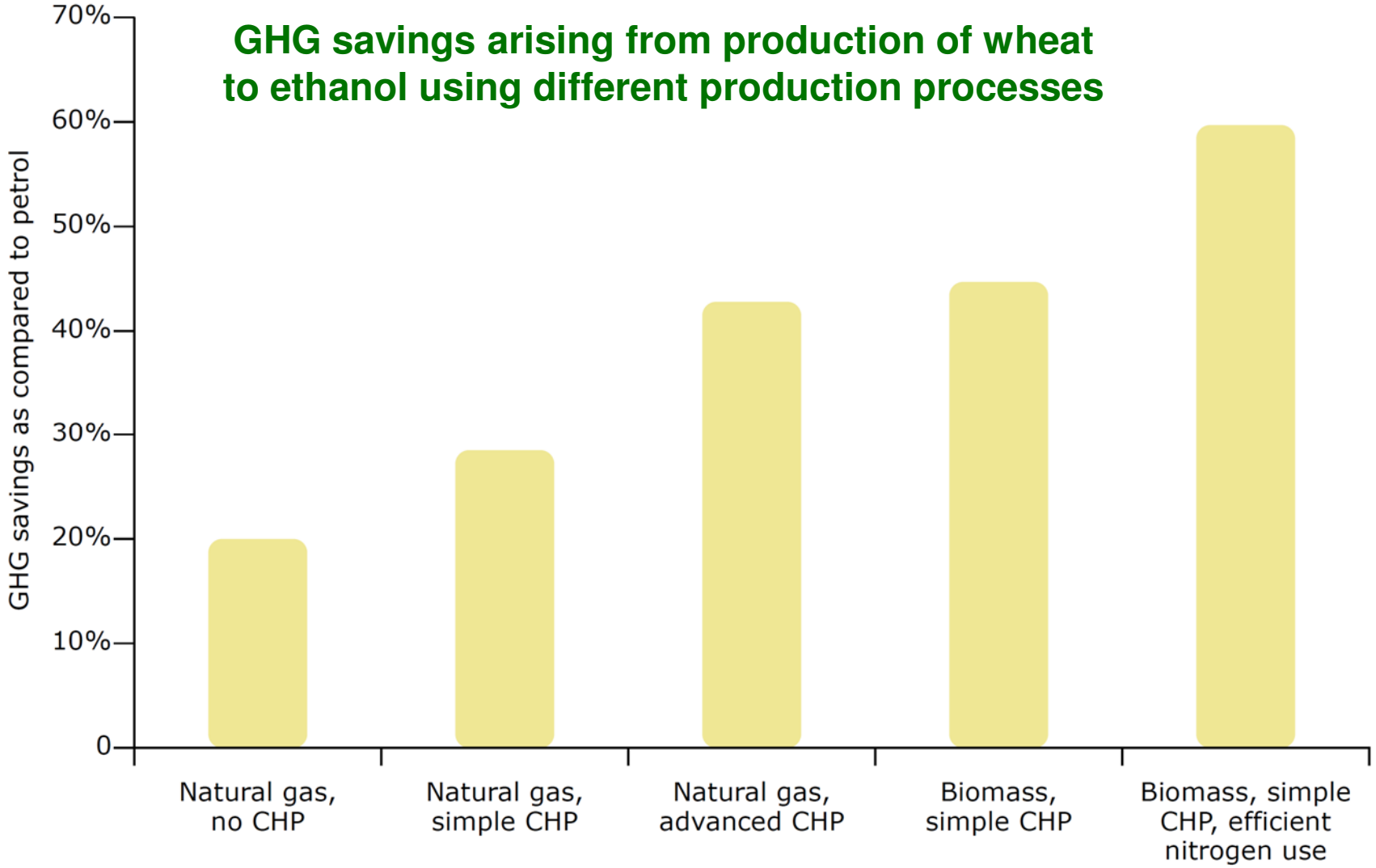
Significance:

Depends strongly on the degree and nature of the processing and on type of fuel for process energy (fossil, non-fossil) as well as energy efficiency.

Methodological issues:

- System modelling – simplification (eg. “black box”) vs. complex modelling.
- Cut-off rule to limit the amount of inputs to be regarded
- Treatment of process waste (downstream)

Part 1: The GBEP methodology framework



Source: Renewable Fuel Agency, 2008. The Gallagher Review of the indirect effects of biofuels production

Step 7: by-products and co-products

Significance:

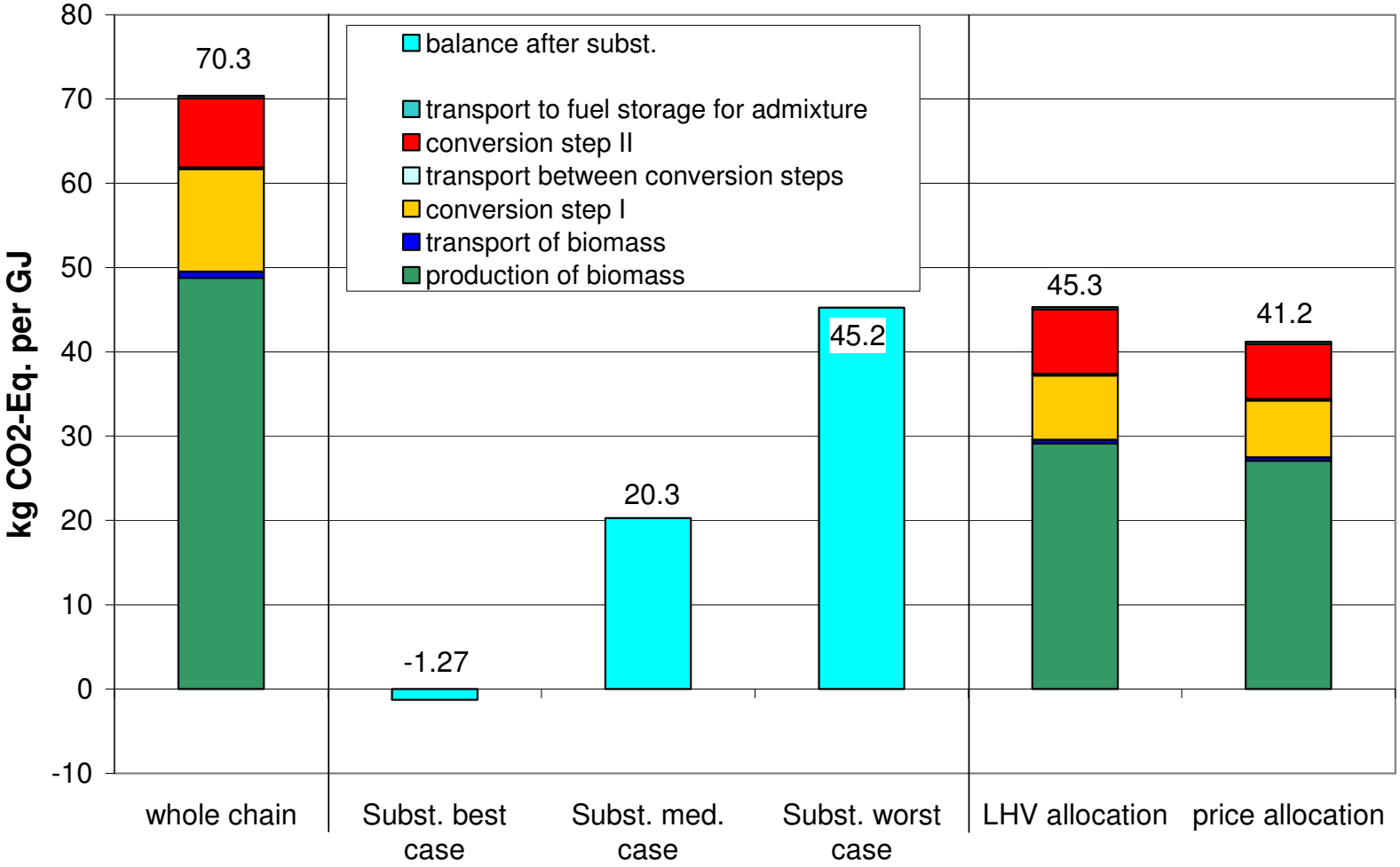
Depends on quantity and quality of by-/co-product.

Methodological issues:

- Choice of general approach (allocation, substitution).
- System boundary (point of allocation or substitution)
- Line between by-/co-product and waste/residue? (see also step 2)

Step 7: by-products and co-products

Example: RME, diverse approaches for glycerine



Step 9: use of fuel

Significance:

Important because this defines the functional unit of bioenergy.
Maybe be not a major source for transport fuel (+/- identical use efficiency).
Can be major source for stationary use

Methodological issues:

- transport fuel: tailpipe gas (non-CO_2 GHG) considered? data?
- Stationary use:
  - CHP considered?
  - non-CO_2 GHG emissions considered?

Step 10: Comparison with replaced fuel

Significance:

Crucial aspect! Represents the whole life cycle for the substituted system.

Methodological issues:

- Identification of the replaced fuel system.
- Timeline, attributional/consequential approaches.
- How to minimize inconsistencies between bioenergy system (1-9) and replaced system (10).

Part 2:
Different approaches to conduct an LCA of bioenergy

Key content in this part

→ *Different **methods** for calculating lifecycle emissions, with different **levels of data** requirements and country capacity*

→ *Data requirements and **potential sources** of data for LCA of bioenergy*

Part 2: Different approaches to conduct LCA of bioenergy

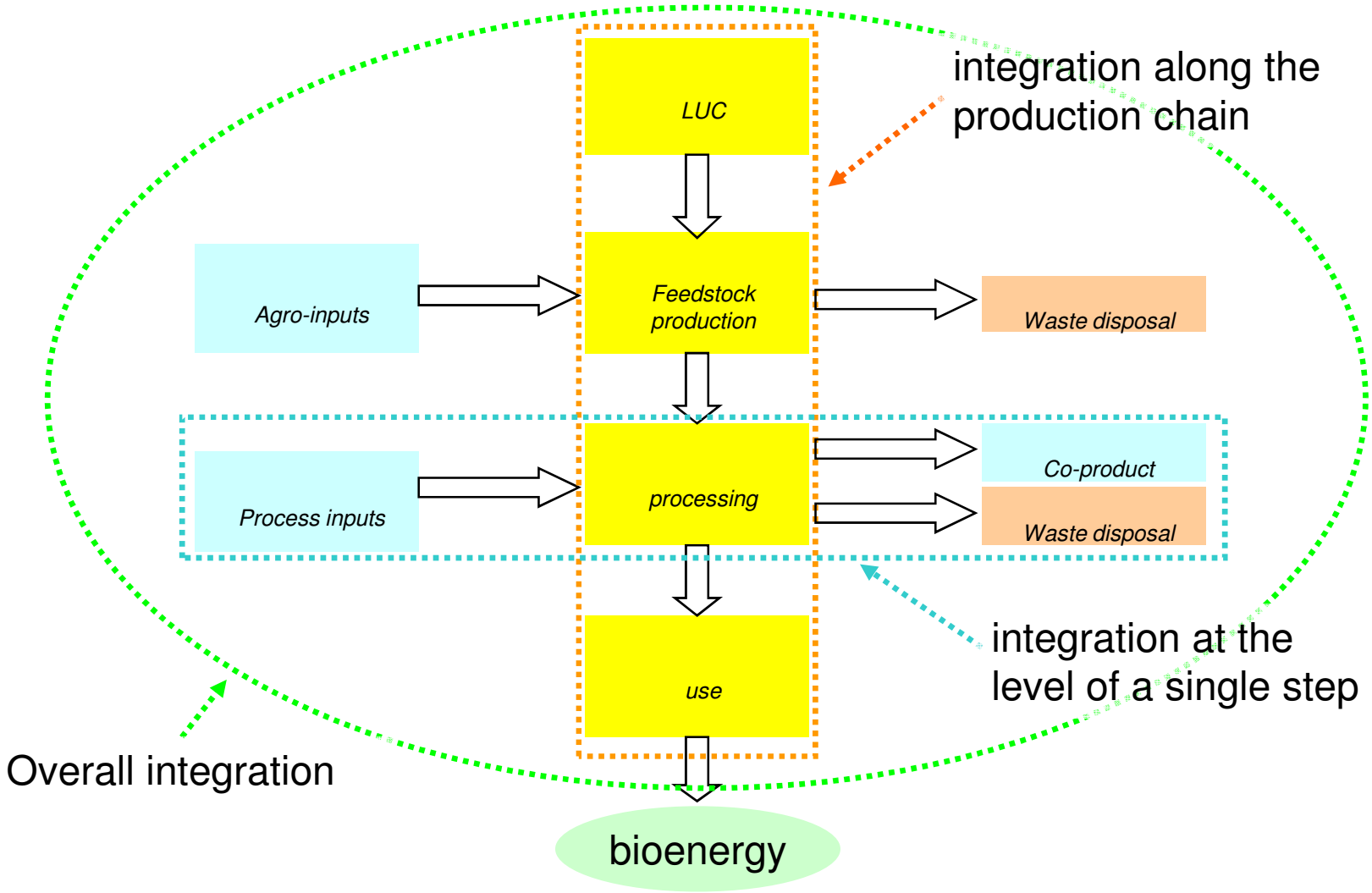
LCA work is data work
There are different levels of data

→ *direct (field) measurements, meaning actual values*

→ *Activity data referring to rough typology of processes to be combined with default emission factors (e.g. IPCC or other databases)*

→ *Data from integrated calculator tools offering pre-calculated values at different degrees of specification.*

an LCA for bioenergy encloses various levels



Part 2: Different approaches to conduct LCA of bioenergy

Measured field data:

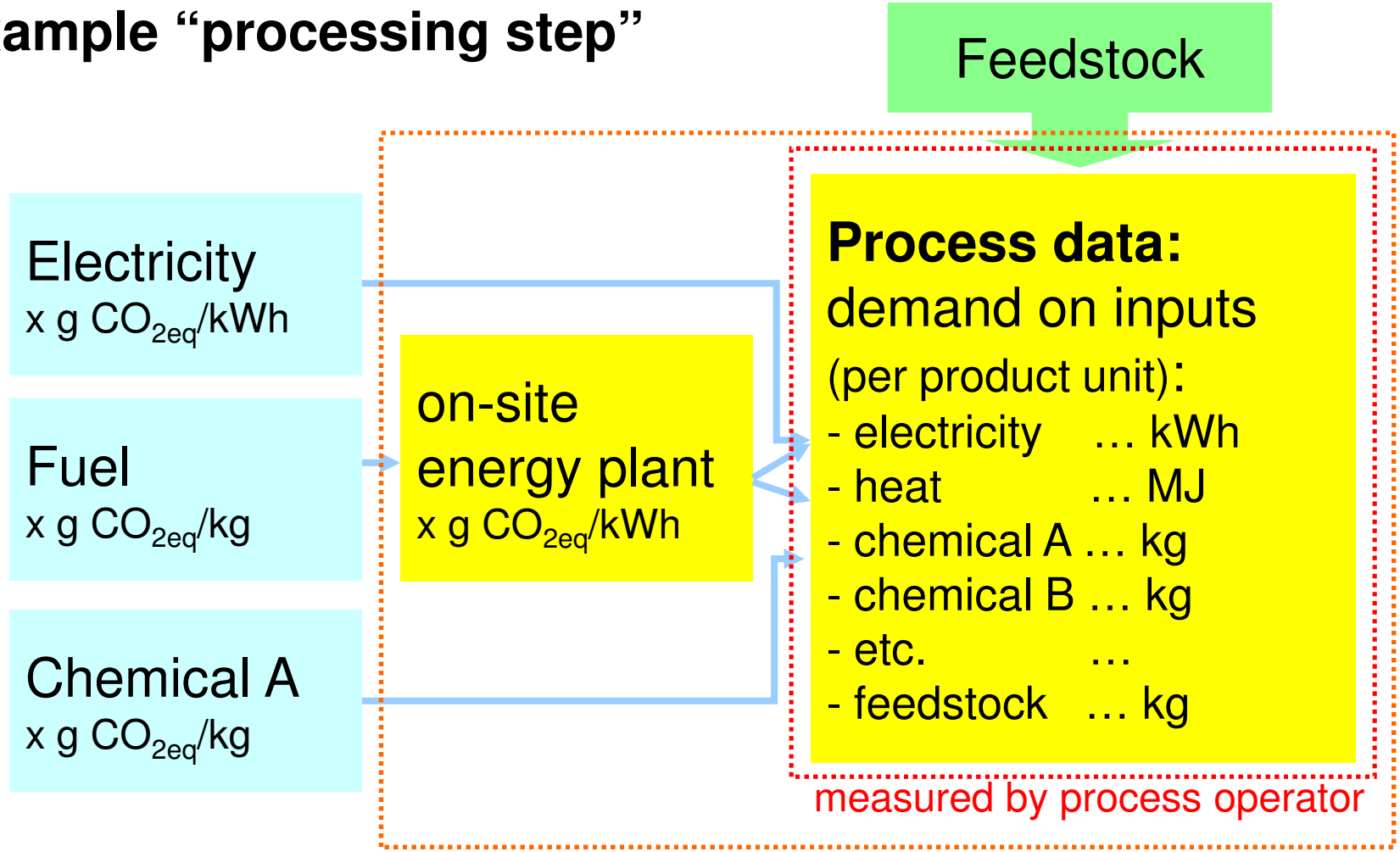
- **rarely cover a whole life cycle**
- **refer to a single step in principle**

e.g. biomass feedstock production:
field data on yield and agro-inputs (fertilizers …)

e.g. land use change:
Field data for LUC-derived C stock changes based on satellite images/remote sensing

e.g. processing:
example

Measured field data
Example "processing step"



Combining activity data and appropriate emission factors

→ might be a sensible compromise between actuality and referring to broader averages
(e.g. based on statistical data)

→ might not cover the number of processes since the categories of acivitities are to generic

→ Still requires the final overall chain integration

→ Existing emission factors mostly refer to „Northern“ conditions and might not be appropriate for (sub-) tropical production.
→ need to have measured data for the South.

Data from integrated calculator tools offering pre-calculated values:

→ There is a number of such calculators around, all designed to enable operators to perform GHG calculations for bioenergy.

→ Some refer directly to legal regulations (RED, LCFS)

→ Some offer high flexibility, some offer widely integrated pre-calculated results

EXAMPLES

Calculator tools for bioenergy:

→ **EU-RED related:**
- BioGrace (initiated by research institutes)
- RSB-EU (stakeholder driven)
- RTFO-Tool (UK)
- BioNachTHG (DE)
- Calcugei (ES)

→ **Other legal relations:**
- GREET-Model (→ Californian LCFS)
- EMPA-Model (Swiss regulation)

→ **"independent" Tools:**
- RSB general tool,
- GEF-biofuel GHG calculator

Part 2: Different approaches to conduct LCA of bioenergy

GBEP Global Bioenergy Partnership

ifeu

BIOGRACE Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe

www.biograce.net Intelligent Energy Europe

About Directory

Production of Ethanol from Sugarbeet (steam from NG boiler) Version 4b - Public

Overview Results

All results in g $CO_{2,eq}$ / $MJ_{Ethanol}$	Non- allocated results	Allocation factor	Allocated results	Total	Actual/ Default	Default values RED Annex V.D
Cultivation e_{ec}				11,5	A	12
Cultivation of sugarbeet	16,16	71,3%	**11,52**			11,54
Processing e_p				26,4	A	26
Ethanol plant	37,03	71,3%	**26,40**			26,42
Transport e_{td}				2,3	A	2
Transport of sugarbeet	1,11	71,3%	**0,79**			0,84
Transport of ethanol	1,10	100,0%	**1,10**			1,10
Filling station	0,44	100,0%	**0,44**			0,44
Land use change e_l	0,0	71,3%	0,0	0,0		0
Bonus (restored degraded lar	0,0	100,0%	0,0	0,0		0
e_{sca} + e_{ccr} + e_{ccs}	0,0	100,0%	0,0	0,0		0
Totals	**55,8**			**40,3**		**40**

Allocation factors	
Ethanol plant	
71,3% to ethanol	
28,7% to Sugar beet pulp	

Emission reduction	
Fossil fuel reference (petrol)	
	83,8 g $CO_{2,eq}$/MJ
GHG emission reduction	
	52%

Calculations in this Excel sheet……

- ☐ ~~strictly follow the methodology as given in Directives 2009/28/EC and 2009/30/EC~~
- ☑ follow JEC calculations by using GWP values 25 for CH4 and 298 for N2O

As explained in "About" under "Inconsistent use of GWP's"

When using this GHG calculation tool, **the BioGrace calculation rules must be respected.**
The rules are included in the zip file in which you downloaded this tool. The rules are also available at www.BioGrace.net

Calculation per phase

Track changes: OFF

Cultivation of sugarbeet			Quantity of product	Calculated emissions				Info	
Yield			**Yield**	**Emissions per MJ ethanol**				**per kg sugarbeet**	**per ha, year**
Sugar beet	68.860	kg ha^{-1} $year^{-1}$	280.605 $MJ_{Sugar\ beet}$ ha^{-1} $year^{-1}$	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$	g $CO_{2,eq}$	kg $CO_{2,eq}$
Moisture content	75,0%		1,000 MJ / $MJ_{Sugarbeet,\ input}$						
			0,451 $kg_{Sugarbeet}/MJ_{ethanol}$						
Energy consumption									
Diesel	6.331	MJ ha^{-1} $year^{-1}$		3,64	0,00	0,00	3,64	8,06	554,8
Agro chemicals									
N-fertiliser (kg N)	119,7	kg N ha^{-1} $year^{-1}$		2,22	0,01	0,01	4,64	10,28	708,0
Manure	0,0	kg N ha^{-1} $year^{-1}$		0,00	0,00	0,00	0,00	0,00	0,0
CaO-fertiliser (kg CaO)	400,0	kg CaO ha^{-1} $year^{-1}$		0,31	0,00	0,00	0,34	0,75	52,0
K_2O-fertiliser (kg K_2O)	134,9	kg K_2O ha^{-1} $year^{-1}$		0,47	0,00	0,00	0,51	1,13	78,1
P_2O_5-fertiliser (kg P_2O_5)	59,7	kg P_2O_5 ha^{-1} $year^{-1}$		0,38	0,00	0,00	0,40	0,88	60,5
Pesticides	1,30	kg ha^{-1} $year^{-1}$		0,08	0,00	0,00	0,09	0,21	14,3
Seeding material									
Seeds- sugarbeet	6	kg ha^{-1} $year^{-1}$		0,09	0,00	0,00	0,14	0,31	21,3
Field N_2O emissions	3,27	kg ha^{-1} $year^{-1}$		0,00	0,00	0,02	6,40	14,17	975,6
Field N_2O emissions can be calculated in the sheet N2O emissions IPCC			**Total**	**7,19**	**0,01**	**0,03**	**16,16**	**35,79**	**2464,7**
			Result			g $CO_{2,eq}$ / $MJ_{Ethanol}$	**16,16**		

Part 2: Different approaches to conduct LCA of bioenergy

Final draft version 2 November 2011

Biofuel GreenHouse Gas Calculator

Directory | About | Background data | Lookup table | Diagrams | References

Biodiesel from palm oil

	Setting 19	Setting 20	Setting 21	Setting 22	Setting 23	Setting 24	User-defined
	Indonesia Smallholders Intermediate inputs No POME use **2010**	**Indonesia** Plantation High inputs No POME use **2010**	**Colombia** Smallholders Intermediate inputs No POME use **2010**	**Malaysia** Plantation High inputs No POME use **2010**	**Indonesia** Plantation High inputs POME use **2020**	**Malaysia** Plantation High inputs POME use **2020**	**2020**
Overview results							
Land use change							
Direct land use change in [g CO_2eq / MJ_{FAME}]	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Indirect land use change in [g CO_2eq / MJ_{FAME}]	24,7	23,2	21,1	18,6	17,7	17,7	17,7
Cultivation							
Cultivation of FFBs in [g CO_2eq / MJ_{FAME}]	11,9	14,8	11,4	13,2	11,5	11,5	11,5
Processing							
Oil mill in [g CO_2eq / MJ_{FAME}]	30,6	30,6	29,4	27,3	0,6	0,6	0,6
Biodiesel plant in [g CO_2eq / MJ_{FAME}]	11,1	11,1	10,0	11,0	11,1	11,0	11,0
Transports							
FFB to oil mill in [g CO_2eq / MJ_{FAME}]	2,5	2,5	2,4	2,3	2,0	2,0	2,0
Palm oil to biodiesel plant in [g CO_2eq / MJ_{FAME}]	0,3	0,3	0,3	0,3	0,3	0,3	0,3
FAME to filling station in [g CO_2eq / MJ_{FAME}]	0,6	0,6	0,6	0,6	0,6	0,6	0,6
GHG emissions allocated in [g CO_2eq / MJ_{FAME}]	**81,7**	**83,2**	**75,2**	**73,1**	**43,7**	**43,6**	**43,6**
GHG emissions allocated in [kg CO_2eq / $ha_{oil\ palm}$]	**9.159**	**9.906**	**9.882**	**10.148**	**6.497**	**6.478**	**6.478**
Fossil fuel comparator in [g CO_2eq / $MJ_{fossil\ fuel}$]	**83,8**	**83,8**	**83,8**	**83,8**	**83,8**	**83,8**	**83,8**
GHG savings in [g CO_2eq / MJ_{FAME}]	**2,1**	**0,6**	**8,6**	**10,7**	**40,1**	**40,2**	**40,2**
GHG savings in [kg CO_2eq / $ha_{oil\ palm}$]	**236**	**76**	**1.136**	**1.483**	**5.948**	**5.967**	**5.967**
GHG emission reduction in [%]	**2,5%**	**0,8%**	**10,3%**	**12,8%**	**47,8%**	**47,9%**	**47,9%**

Input data per step

STEP 1 - GHG emissions from land use changes	
Do direct land use changes occur (only user-defined)?	
If land use changes occur, go to sheet 'LUC' and calculate respective GHG emission. Enter emissions manually in line 38.	
Which emissions arose from direct land use changes (only user-defined)?	
	k

Part 2: Different approaches to conduct LCA of bioenergy

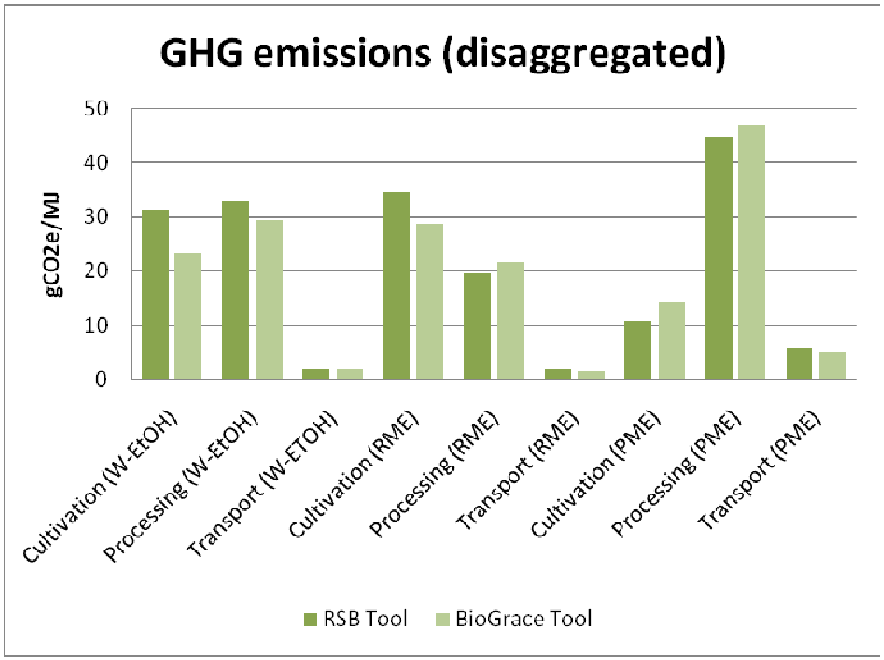
Conclusion at this step:

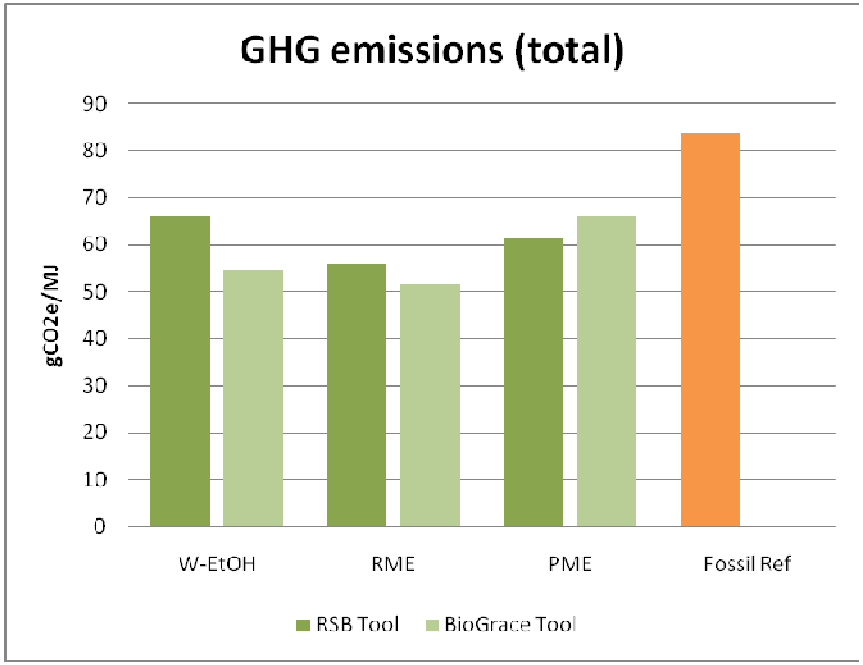
→ **Measured field data are always very welcome <u>BUT</u> they will always refer to a selected part of the chain which needs to be integrated including a number of data.**

→ **Flexible calculator tools may incorporate measured field data, while they facilitate the chain integration.**

→ **However the calculator tools are not harmonized (just some of them are),**
hence results vary between the tools.

Comparison of RSB-RED tool and BioGrace tool





W-EtOH: ethanol from wheat
RME: rapeseed oil methylester (Biodiesel from rapeseed oil)
PME: palm oil methylester (Biodiesel from palm oil)

Source: Hennecke et al. 2011

Data requirements and potential sources of data for LCA of bioenergy

Requirement in general:

→ data shall be fit for purpose, i.e.:

- well documented and transparent (particularly measurements)
- They have to be reliable and taken from recognized sources (particularly background data)
- Consistent with the overall methodological set-up (e.g. in terms of GHG coverage, allocations, system boundaries etc.)

Exemplary data bases:

→ **International:**
- IPCC (→ carbon stocks for LUC; emission factors)
- FAOSTAT (→ agricultural systems)
- CORINAIR (→ generic, also transport and industrial systems)

→ **Proposed by national (community) initiatives**
- ELCD (EU)
- US LCI (US)
- PROBAS (DE)
- BioGrace Standard values (if recognized by EU Commission)

→ **From research institutions**
- ECOINVENT (CH)
- GEMIS (DE)

→ From industrial institutions
- IFS (fertilizer data)

Part 3:
Human and institutional capacity required to conduct an LCA

Part 3: Human and institutional capacity required to conduct LCA

At first this is a question of the goal and scope: what is the purpose of the LCA and its results?

GHG value for legal support scheme e.g. EU RED, LCFS	GHG value for policy decision support e.g. GBEP (IND1) applic.	GHG value for research reasons
Requires watertight unambigous rules and data	Requires a reasonable set of rules and guidance	Shall refer to the ISO Standards 14040/44 or 14067
Rulemaker in charge to provide framework and „tools“	Policy makers could make reference to existing framework or „tools“	Scientists should be capable enough …

Part 3: Human and institutional capacity required to conduct LCA

Capacity needed for LCA in policy decision support:

Institutional capacities:

→ Responsible Authority (who is in charge? Who ist the driver?)

→ Include environmental Departments (if other department is the driver)

→ use existing capacities in environmental and climate change issues

→ Get connected with other GHG related national reporting systems (synergies)

→ Created – promote Networks – getting relevant stakeholders (companies, NGO, research) involved

Part 3: Human and institutional capacity required to conduct LCA

Capacity needed for LCA in policy decision support:

Human capacities:

→established capacity centers at national level such as:

→University Institutes
→national research laboratories
→independant experts or institutes
(→associated external corporation partners)

} Have to cover expertise in LCA, how to get to data how to work on data

→Administrative office responsible for the issue.

→Responsible officer

- needs to have basic understanding of LCA, GHG calculation,
- general aspects on data handling.
- basics about the calculator tool (in case there is one in place)

Part 4:
Overview of policy and other applications

- legal regulations requiring GHG LCA for bioenergy
- Voluntary systems
- Others

Part 4: Overview of policy and other applications

There are a number of legal regulations in place requiring GHG LCA for bioenergy

- EU RED/FQD (each consignment – default or actual values)
- US RFS2 (EPA manages the calculations)
- Californian LCFS (CARB manages the calculations),
- German law, (under EU RED but slightly modified)
- UK RTFO (under EU RED but earlier started with reporting system)
- Switzerland

- Many countries are about to introduce something (at least at voluntary level)

Part 4: Overview of policy and other applications

There are a some (voluntary) certification systems in place including a GHG LCA for bioenergy

- RSB (RED related and also general)
- ISCC (RED related)
- RTRS (RED related and also general)
- Bonsucro (RED related and also general)
- GGL Green Gold Label (driven by energy industry)
- US system

- not a system but standards:
  - prEN 16214 (RED related)
  - ISO 13065
  - NTA 8080 (Dutch Standard, RED related)
- not to forget: IEA Bioenergy Task 38 Tool

Last not least: international support schemes like

- **the CDM process**
  at least GHG mitigation performance in a more qualitative sense to achieve carbon finance through CDM through climate funds
  UNFCCC scheme for biofuel from degraded land

- **The GEF**
  intention to include GHG information within a project screening tool;
  objective: to enable the GEF and its *Implementing Agencies* (IA) to assess on the basis of the *Project Identification Forms* (PIF) if a biofuel project meets the *Global Environmental Benefits* (GEB) and additional benefits

CONCLUSIONS (1)

The GBEP-10-step framework includes the essential components of a GHG LCA for bioenergy

It does NOT
- provide "ready-to-use" schemes;
- determine on methods;
- provide data (or refer to a specific databank).
The applicant is supposed to be skilled in LCA

However it offers a common ground of major/minor working items facilitating a consistent building up of capacities for partners at global scale.

CONCLUSIONS (2)

Capacitity building options:

Supporting a partner

- **to strenghten its human and institutional capacities** (experts, adminstrative level),
- **to identify the demand for GHG calc. for bioenergy** (own policy goals, compliance with other schemes if wishful)
- **and to develop a GHG assessment approach according to his needs**
- **to make use of existing data, schemes or tools** (as long as appropriate and compliant with own goals)
- **to identify data gaps and how fill such.**

THANK YOU FOR LISTENING

horst.fehrenbach@ifeu.de

www.ifeu.de

in cooperation with Öko-Institut e.V. Institut für angewandte Ökologie Institute for Applied Ecology

sponsored by Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Umwelt Bundes Amt Für Mensch und Umwelt