EMPA

Materials Science & Technology

Update and harmonization of the bioenergy inventories

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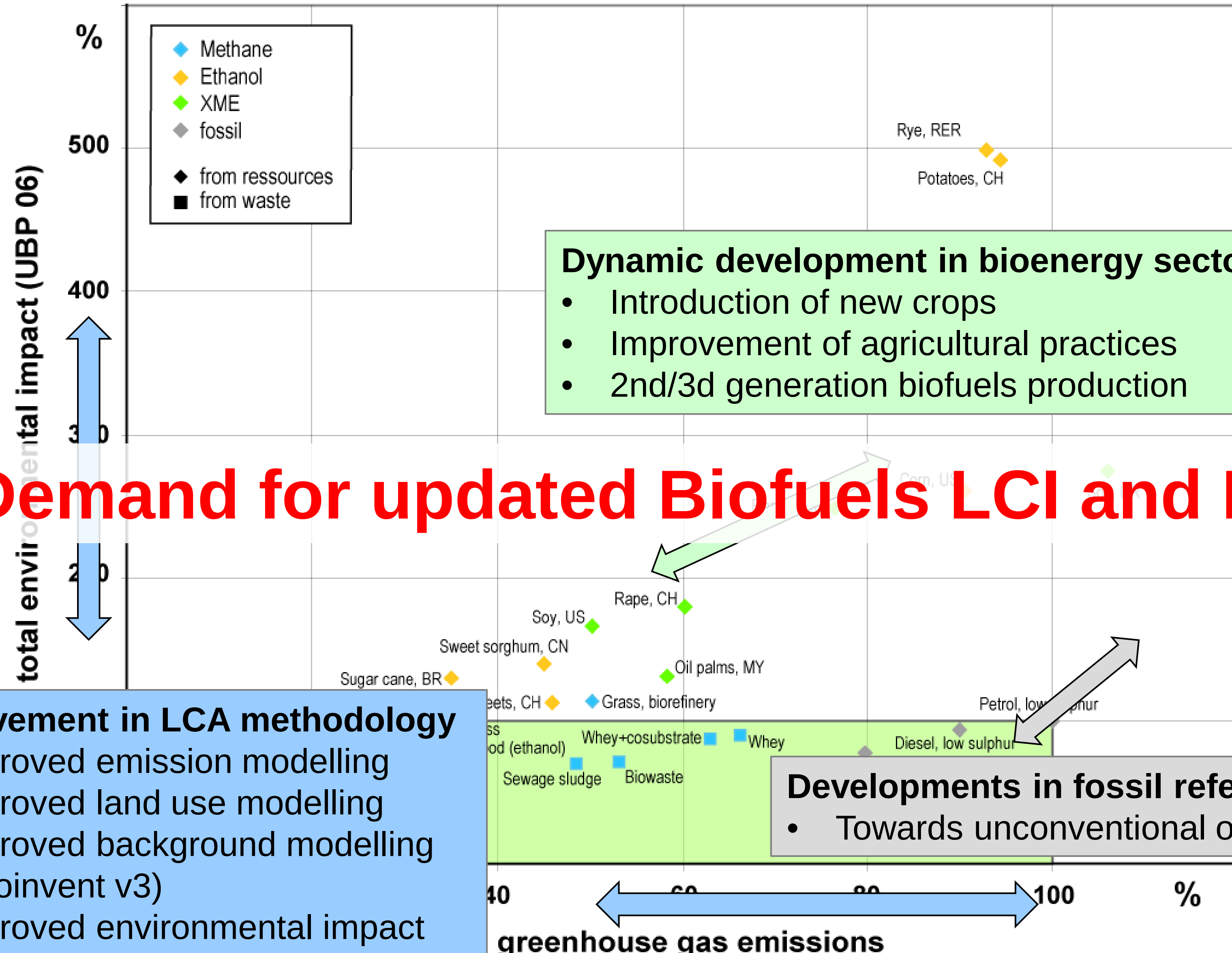
Discussion forum LCA, Bern-Ittigen, 23rd April 2012

Motivation?



Dynamic development in bioenergy sector
- Introduction of new crops
- Improvement of agricultural practices
- 2nd/3d generation biofuels production

→ Demand for updated Biofuels LCI and LCA

Improvement in LCA methodology
- Improved emission modelling
- Improved land use modelling
- Improved background modelling (Ecoinvent v3)
- Improved environmental impact assessment

Developments in fossil reference
- Towards unconventional oils

Goals of the project

- Overall goal: provide better and updated inventories and impact assessment as a discussion and decision basis
- Content: integrate
  - New modelling of N-emissions and of GHG-emissions from land use change
  - New inventories (crops, conversion technologies, fossil reference)
  - New assessment methods

Summary of changes for biofuel calculations

Life cycle stage	Inventories	Change
Cultivation	All	Harmonization of N-emission calculations
	Oil palm, soybeans, sugarcane, jatropha	New LUC calculations
	Palm fruit CO, sugarcane CO, alfalfa, jatropha	New crop inventories
Fossil oil production	Oil sand	New inventories
Processing	Methane pathways Jatropha biodiesel	New inventories
Operation	All inventories	Update of EURO 3 inventories (update of consumption and emission profiles)

ReCiPe Midpoints & USEtox results per v.km

	Midpoint impact category	GWP	FOSS	WAT DEP	ODP	MDP	ACID	FW-EUT	M-EUT	NLT	AGR LO	URB	POF	PMF	ION	ECOT OX	TOX CAN	TOX N-C
	Unit	$kg\ CO_2$-eq	kg oil eq	m^3	kg CFC-11 eq	kg Fe eq	$kg\ SO_2$ eq	kg P eq	kg N eq	m^2	m^2a	m^2a	kg NMVOC	kg PM10 eq	kg U235 eq	CTUe	CTUh	CTUh
Biodiesel	Rape seed ME IP/CH	64%	51%	108%	43%	131%	409%	204%	11298%	55%	29999%	165%	125%	233%	129%	19342%	353%	1226%
	Rape seed ME EXT/CH	64%	51%	101%	47%	131%	583%	173%	13398%	54%	34775%	166%	128%	289%	128%	4580%	373%	1259%
	Rape seed ME conv/DE	52%	47%	115%	31%	135%	166%	197%	1854%	48%	25529%	115%	120%	156%	110%	14208%	342%	1224%
	Rape seed ME conv/FR	64%	50%	130%	36%	136%	370%	264%	7694%	51%	32004%	108%	121%	223%	111%	140267%	377%	1301%
	Soybean ME BR	258%	39%	113%	27%	114%	163%	286%	6255%	5554%	44543%	111%	219%	431%	103%	960215%	1945%	1522%
	Soybean ME US	43%	38%	105%	24%	111%	129%	253%	5475%	43%	35293%	108%	128%	129%	105%	11257%	343%	1277%
	Jatropha ME EXT/IN	-68%	40%	393%	27%	119%	470%	1005%	9152%	8726%	231846%	110%	176%	440%	110%	1647%	1436%	1237%
	Jatropha ME INT/IN	44%	71%	2082%	47%	170%	1485%	528%	5944%	2763%	72052%	115%	161%	679%	142%	2229%	712%	1245%
	Jatropha ME fence/AFR	-4%	29%	80%	17%	100%	93%	148%	948%	35%	29466%	101%	85%	102%	102%	125%	329%	1213%
	Jatropha ME EXT/AFR	-216%	30%	86%	18%	101%	127%	417%	5866%	35%	183636%	102%	99%	157%	103%	242%	562%	1218%
	Palm fruit ME MY	101%	36%	1898%	23%	117%	182%	137%	5021%	1735%	7191%	107%	138%	219%	119%	27398%	677%	1313%
	Palm fruit ME CO	26%	35%	235%	23%	107%	152%	217%	575%	53%	7144%	105%	124%	161%	99%	18459%	428%	1250%
Ethanol	Sugarcane molasses BR	36%	30%	258%	24%	113%	288%	163%	2834%	44%	16812%	107%	375%	232%	102%	38208%	7405%	4252%
	Sugar cane ETOH BR	37%	33%	365%	25%	117%	275%	158%	2306%	47%	13504%	107%	326%	228%	104%	30633%	5970%	3416%
	Sugar cane ETOH CO	39%	33%	9176%	23%	117%	283%	134%	1637%	45%	11226%	107%	198%	246%	101%	54812%	240%	67%
	Maize ETOH US	84%	71%	350%	54%	141%	320%	335%	4959%	87%	19204%	196%	125%	213%	134%	174958%	363%	456%
	Rye ETOH CONV/RER	94%	67%	237%	56%	171%	366%	390%	22471%	74%	66612%	144%	146%	247%	143%	147989%	266%	102%
	Sugar beet ETOH IP/CH	38%	35%	121%	25%	110%	151%	117%	1793%	39%	4867%	105%	73%	115%	120%	8393%	147%	36%
	Sweet sorghum ETOH CN	40%	38%	3049%	26%	134%	243%	227%	659%	50%	9140%	110%	129%	231%	137%	64413%	272%	208%
	Wheat ETOH US	103%	77%	2499%	56%	192%	514%	1199%	4133%	89%	114251%	124%	178%	322%	146%	50156%	178%	103%
	Wheat ETOH CONV/DE	83%	60%	206%	50%	161%	250%	253%	4899%	67%	37319%	143%	127%	192%	137%	21306%	194%	64%
	Wheat ETOH CONV/ES	107%	78%	289%	62%	210%	328%	494%	14470%	71%	71490%	129%	183%	269%	146%	7186%	174%	71%
	Wheat ETOH CONV/FR	87%	61%	211%	55%	154%	534%	316%	14290%	67%	38553%	109%	123%	282%	132%	29419%	193%	61%
CH_4	Methane , Alfalfa grass	69%	28%	163%	20%	118%	203%	189%	437%	38%	14735%	101%	58%	118%	222%	123%	40%	41%
	Methane, sewage sludge	43%	43%	109%	31%	105%	66%	115%	79%	48%	116%	102%	59%	70%	184%	31%	33%	36%
	Methane, wood chips	22%	23%	85%	15%	106%	65%	97%	70%	48%	7463%	111%	60%	70%	111%	44%	18%	41%
	Methane, cattle slurry	28%	29%	111%	20%	135%	85%	122%	98%	45%	400%	112%	79%	97%	167%	41%	24%	49%
Foss	Fossil diesel, low-sulfur	84%	86%	95%	85%	98%	102%	96%	116%	99%	95%	99%	102%	117%	97%	118%	425%	1213%
	Fossil gasoline, low-sulfur	3.2E-01	1.1E-01	1.1E-03	5.1E-08	1.7E-02	6.1E-04	4.0E-05	2.5E-05	7.6E-05	1.3E-03	9.9E-03	8.2E-04	2.5E-04	6.0E-02	5.4E-04	2.2E-11	1.2E-10
	Natural gas	80%	95%	80%	77%	98%	72%	91%	71%	84%	94%	98%	66%	72%	108%	30%	23%	33%
F	Diesel, SCO	91%	101%	22375%	19%	98%	163%	99%	117%	689%	97%	221%	90%	172%	96%	82%	436%	1214%
	Gasoline, SCO	108%	117%	25040%	23%	100%	178%	105%	101%	778%	102%	236%	85%	166%	99%	58%	112%	100%

<60% of fossil reference value

< 95% of fossil reference value

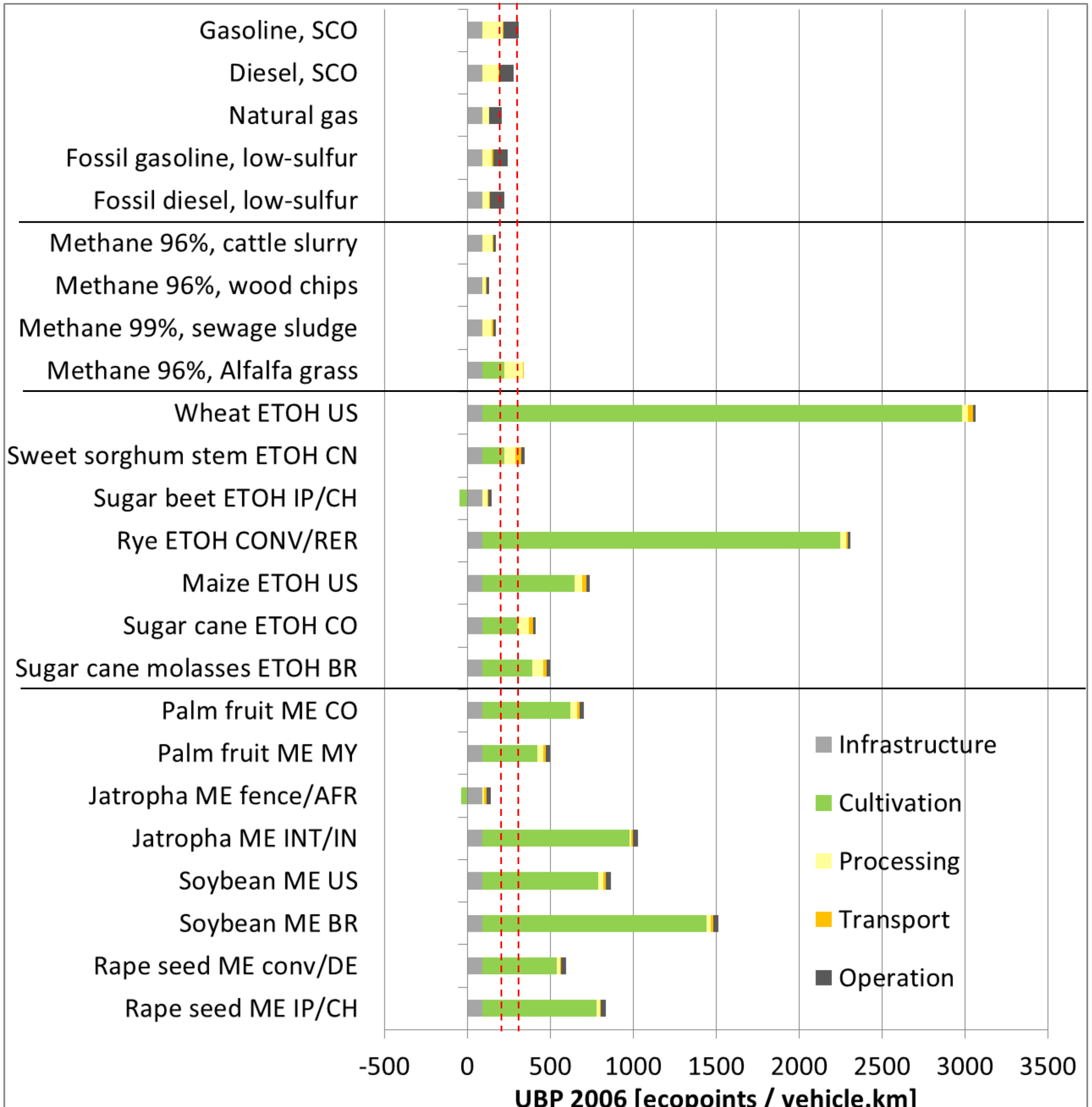
95%-105% of fossil reference value

>105% of fossil reference value

> 140% of fossil reference value

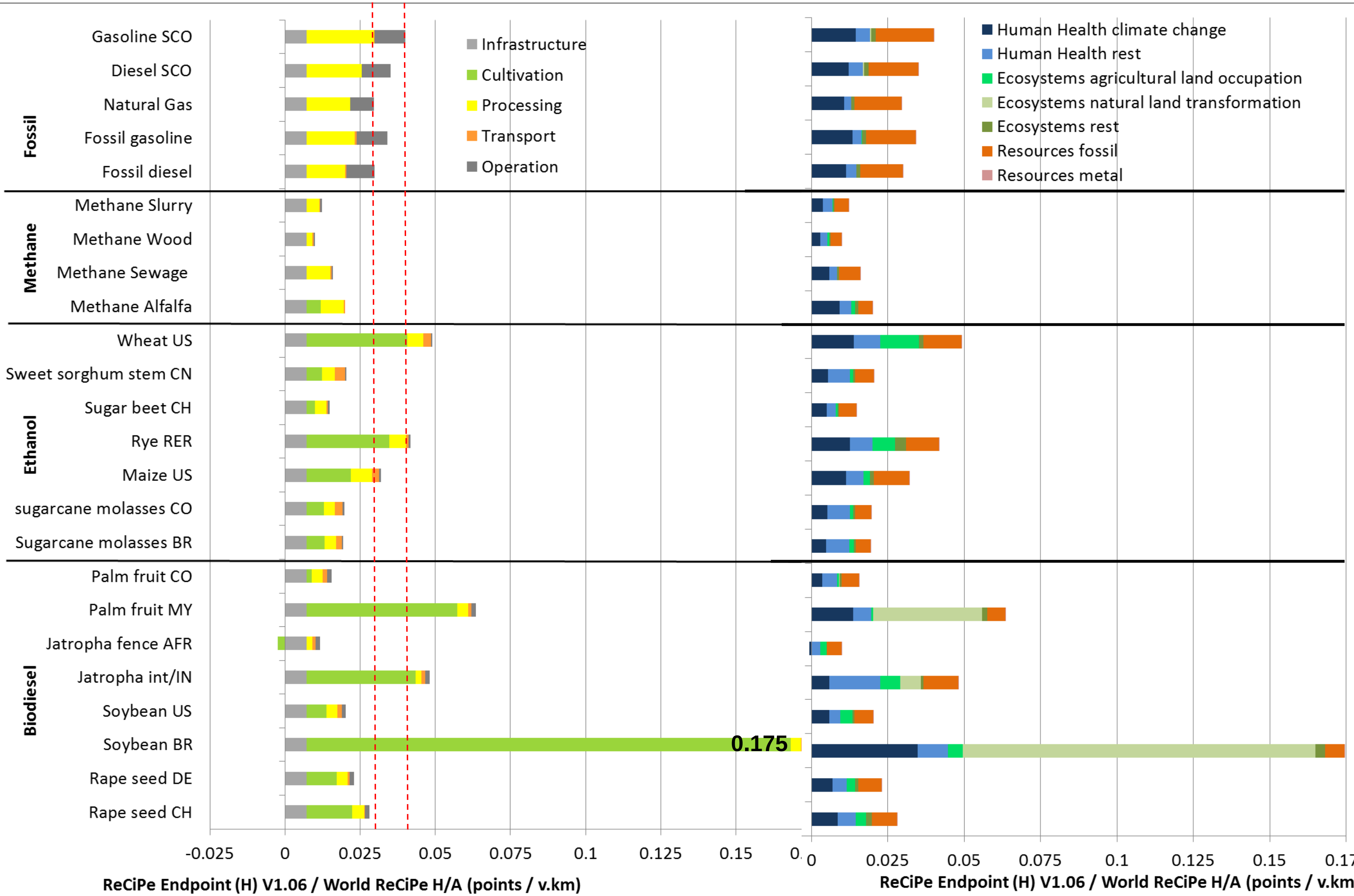
> 1000% of fossil reference value

Results Swiss ecological scarcity method (selected pathways)

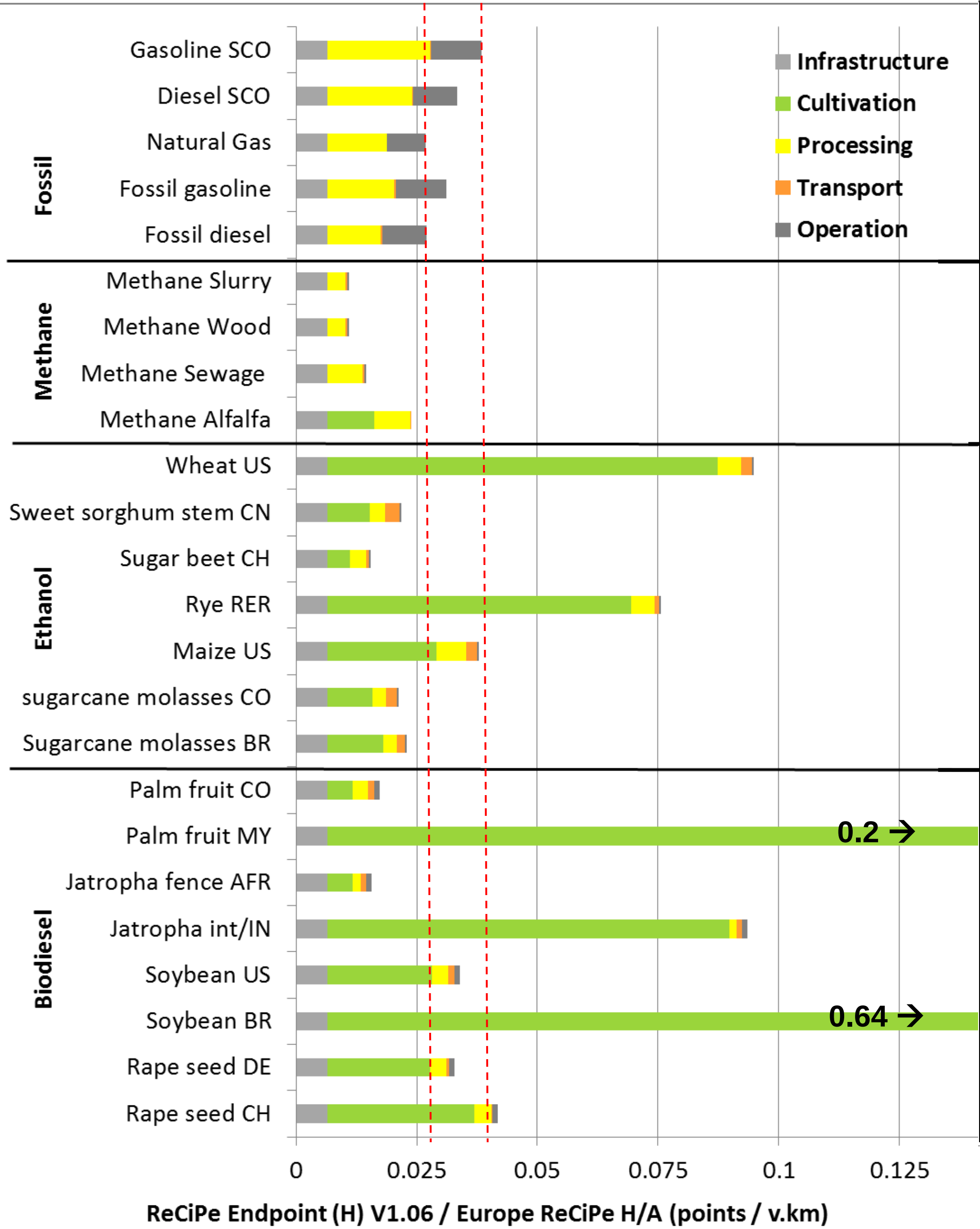


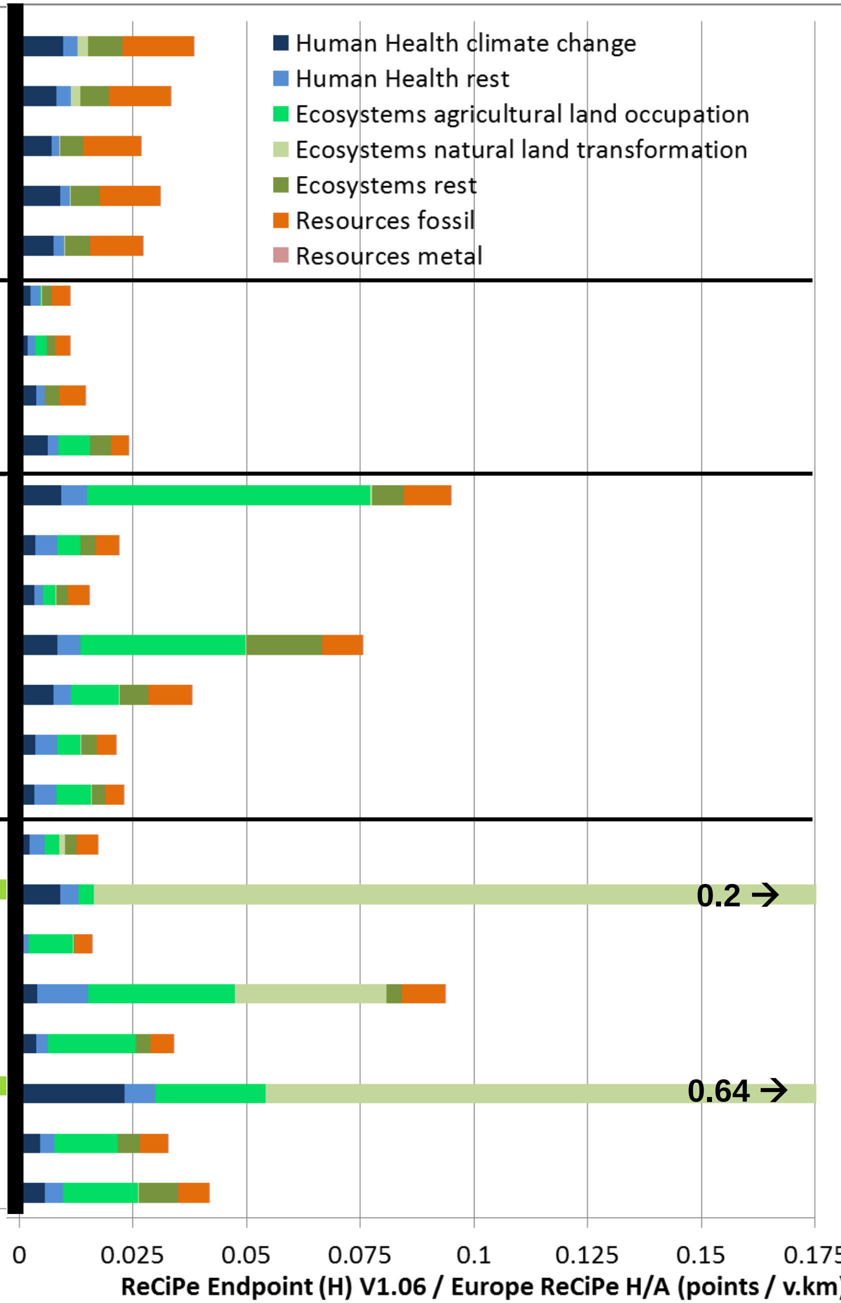
- High variability among the biofuels
- Agricultural step is very important
- Results very much influenced by nitrate and heavy metals
- Few biofuels better than reference, even SCO

ReCiPe Endpoint World (H/A) results

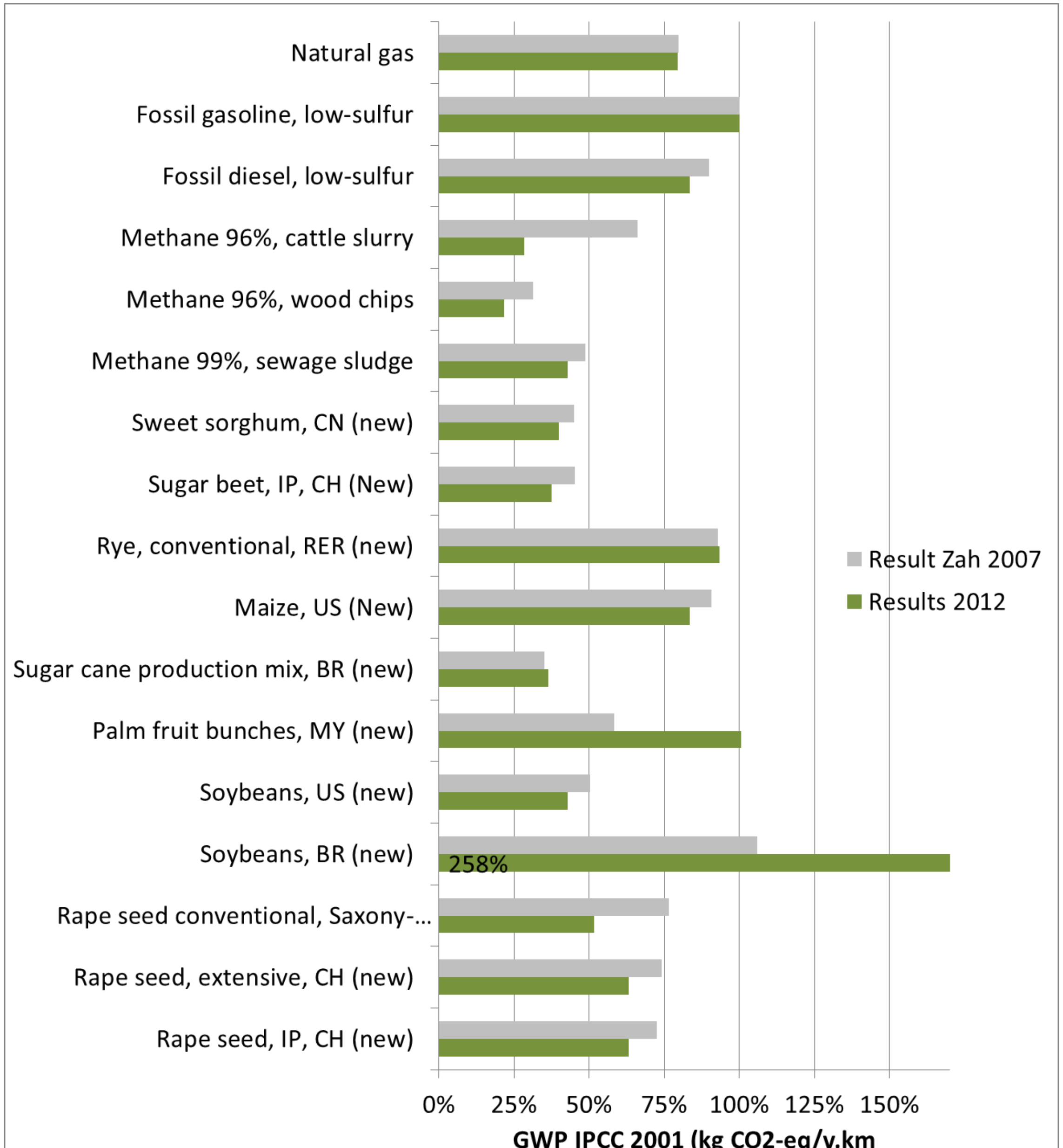


ReCiPe Endpoints Europe (H/A)



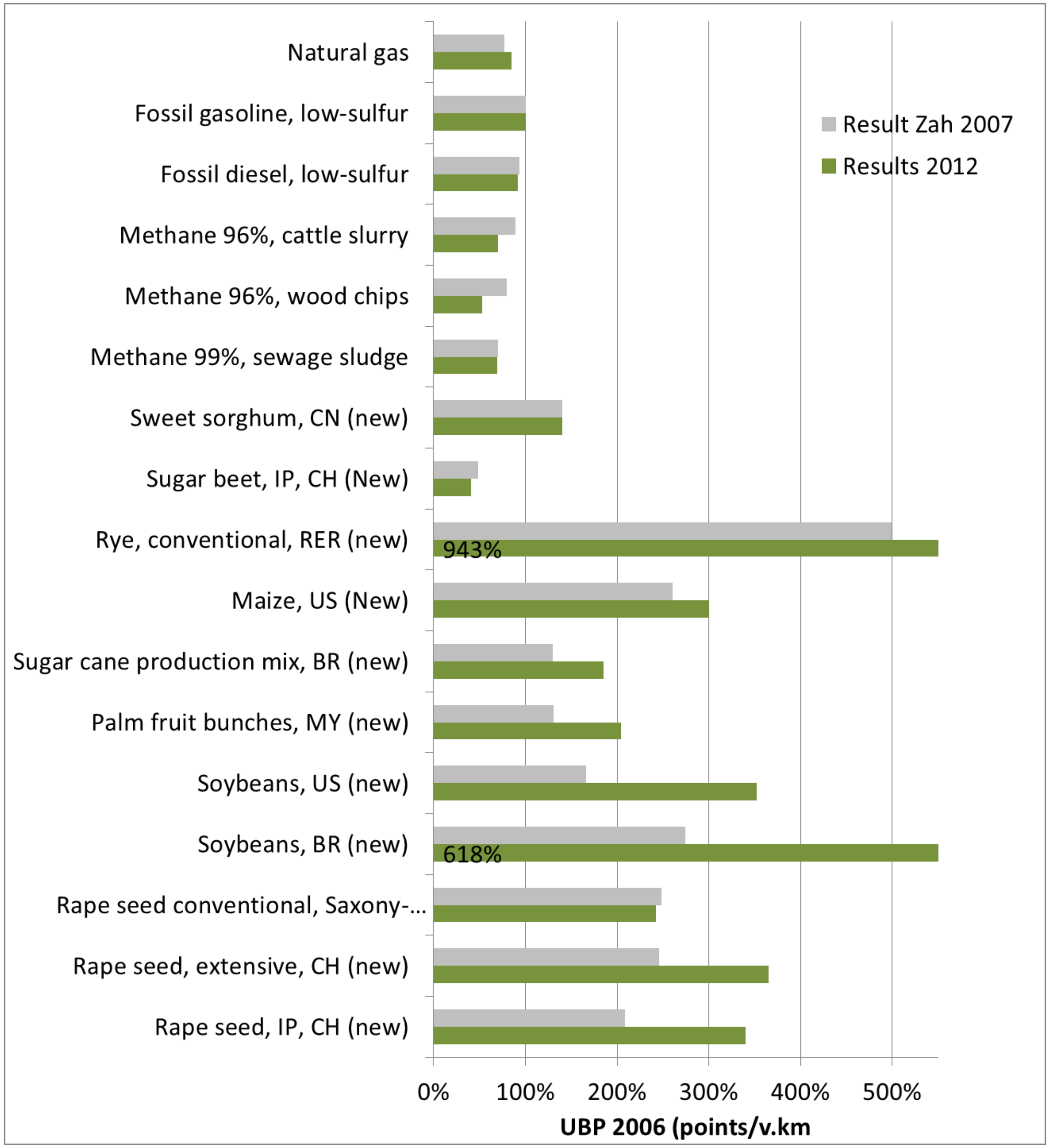


Comparison with 2007 results – GWP 100a IPCC 2001



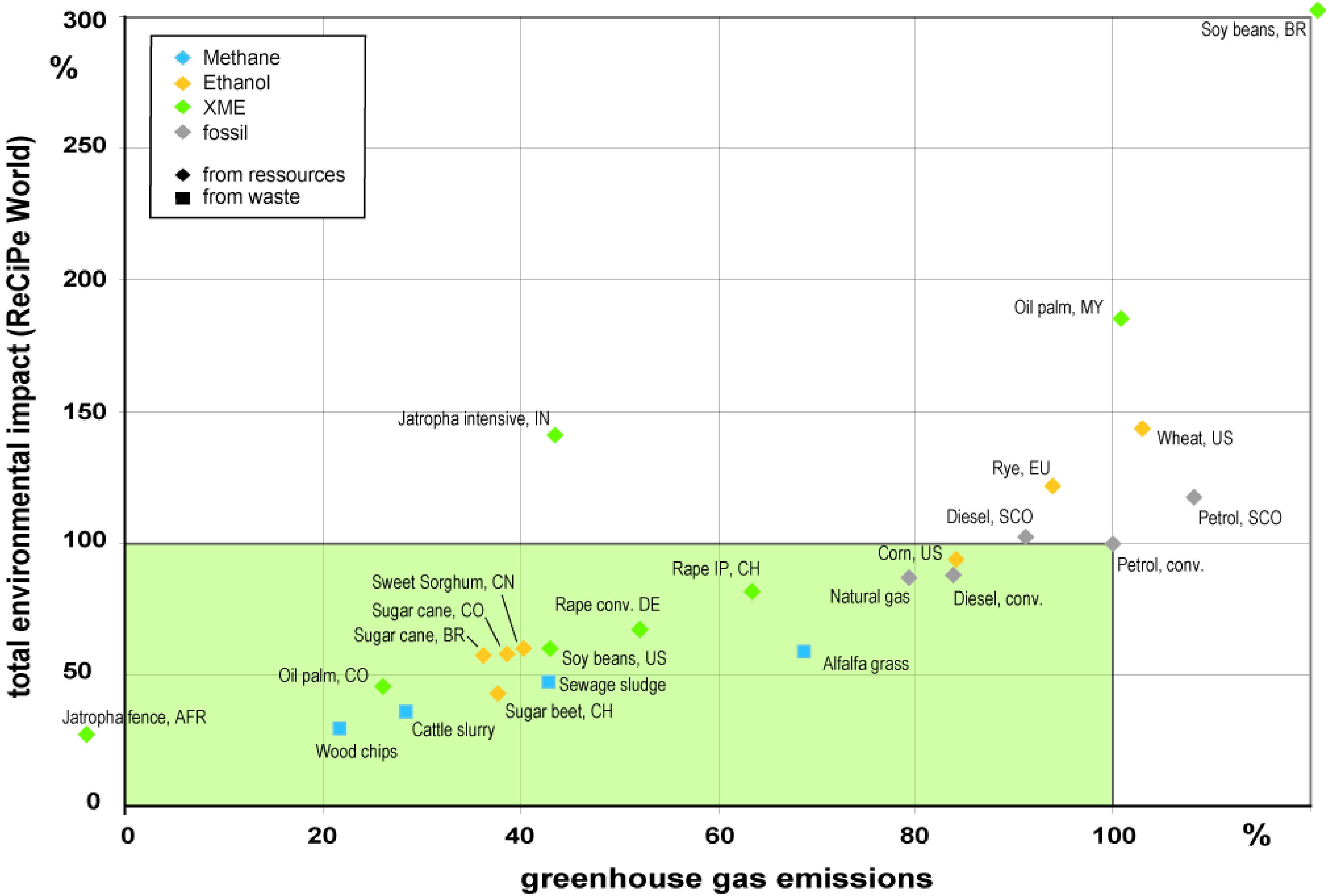
- Results Zah et al. In general higher values
- Changes in N-emissions → 2007 lower values (except for sugarcane, with higher N2O)
- Changes in LUC emissions → higher GWP for palm & soybean
- New/optimized processes in methane production

Comparison with 2007 results – UBP 2006



- Update of nitrate emissions (rye, soybean US & BR)
- Update of LUC calculations (Soybean BR, Palm fruit MY)
- New methanisation processes for slurry and wood

GHG emissions vs. total environmental impact



Outcomes: Trends in **inventories**

- **Trends in Feedstock and Process Development**
  - Environmental profile of **new crops** depends a lot on cultivation methods and land use change
  - Improvements in **methane technologies** → trend to reduction in GHG

- **Trends in fossil fuel**
  - Environmental profile of oil sands (even without assessment of tailings) shows higher impacts than conventional oil
  - Impacts of production are buffered by emissions in use

Outcomes: Trends in **methodology development**

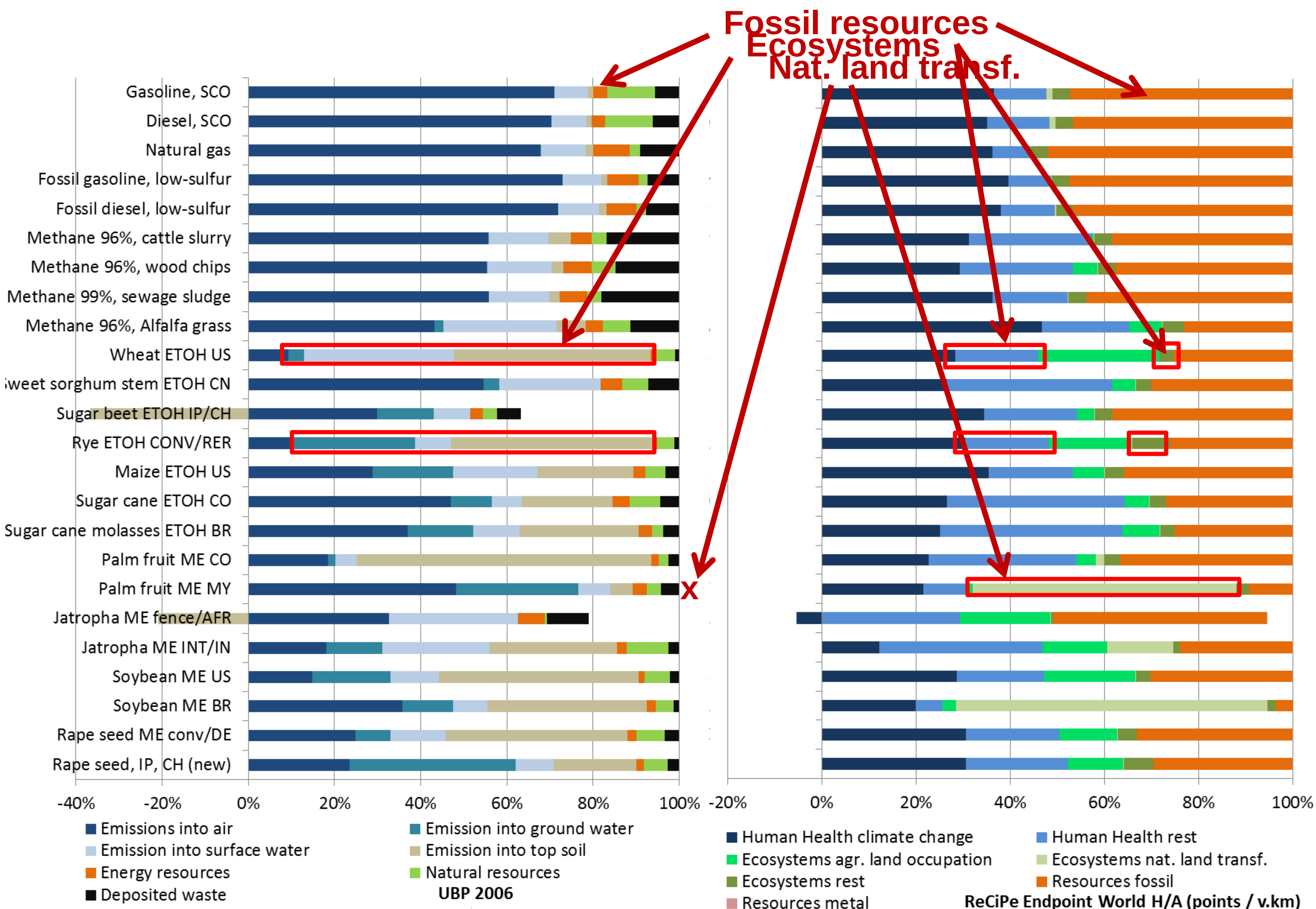
- **Inventory modelling**
  - Overestimation of N_2O and underestimation of nitrate in the past
  - Underestimation of land use change emissions until now

- **IPCC factors**
  - New factors lead to lower results even if nitrate emissions are higher (factor for nitrate volatilization 3x lower)
  - Modelling of N_2O still very uncertain

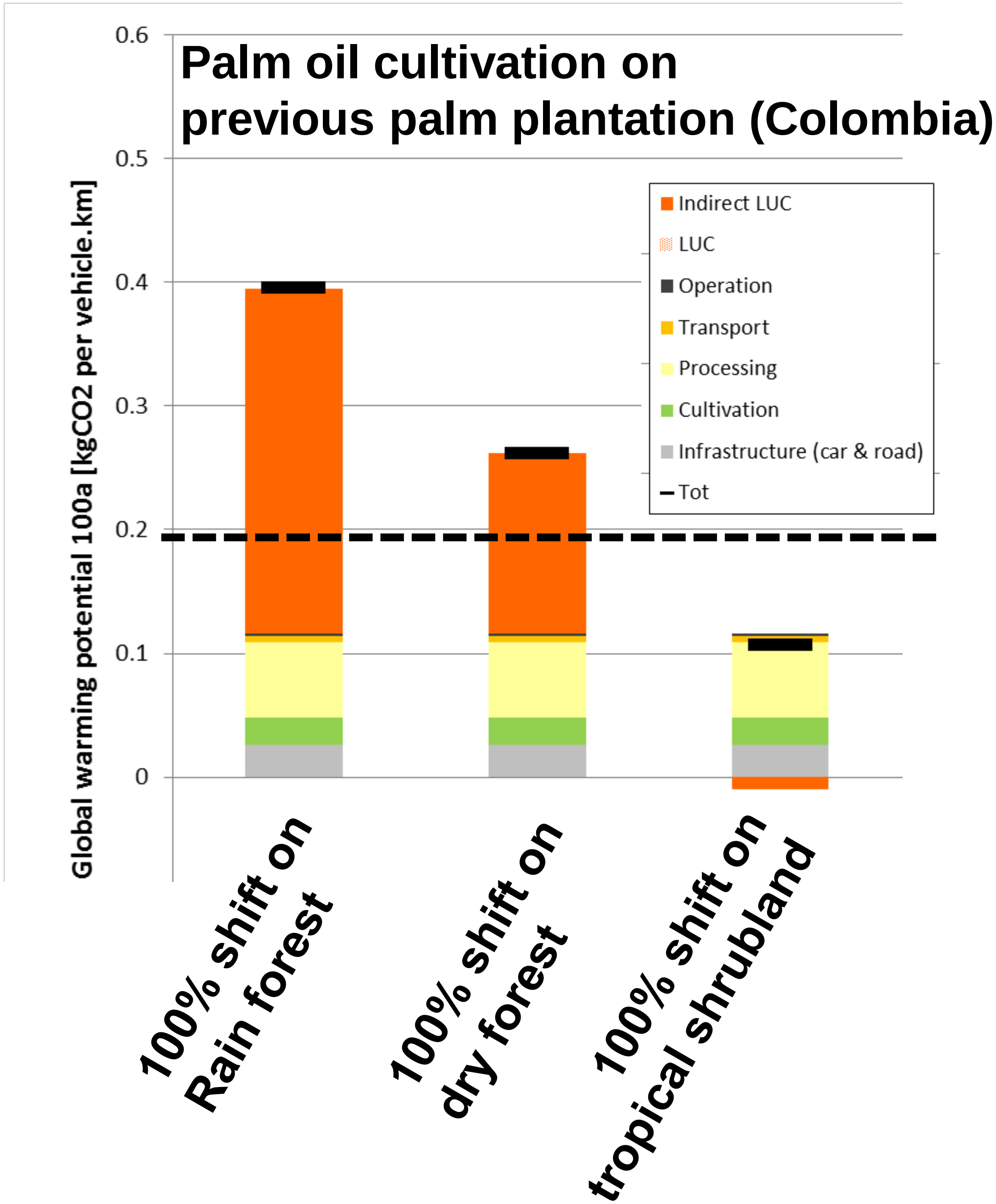
Impact assessment: two methods – two outcomes?

- All methods agree on
  - Importance of the agricultural phase
  - High variability of biofuel pathways
  - Importance of LUC
  - Methane from waste as a preferable option
- Midpoints indicator only favourable for biofuels with respect to GWP, fossil depletion, ozone depletion, natural land transformation (where no LUC)
- Endpoint methods → different models & weightings
  - UBP: nitrate, heavy metal, phosphate, N_2O
  - ReCiPe: fossil depletion, climate change, natural land transformation

Comparison environmental profiles UBP vs. ReCiPe



Indirect effects?



- Accounting of LUC might provoke growing of feedstocks on agricultural land while displacing food crops (EU / World)
- iLUC can obliterate GHG reduction
- Development of approach for iLUC in ecoinvent v3
- Assessment indirect land use emissions still very controversial

Conclusions

- Biofuels allow the **reduction of fossil fuel use and climate change impacts** but with the risk of shifting impacts and creating new environmental problems
- The study confirms the high diversity in the impact patterns of biofuel pathways and therefore the necessity of **assessing biofuel projects with specific data**
- If biofuel feedstocks are grown on agricultural land, measures preventing **indirect effects (iLUC)** must be taken
- **Potential for biofuels with no LUC and no iLUC is assumed to be limited**

Acknowledgements

Funding: Bundesamt für Energie

Project partners:

ART: Thomas Nemecek, Julian Schnetzer

PSI: Christian Bauer, Andrew Simons

EMPA: Simon Gmünder, Martin Lehmann, Jürgen Reinhardt, Rainer Zah

Doka Ökobilanzen: Gabor Doka

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Thank you for your attention!
Questions?

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