

Bioenergy GHG Emission Balances including Direct and Indirect Land Use Change Effects

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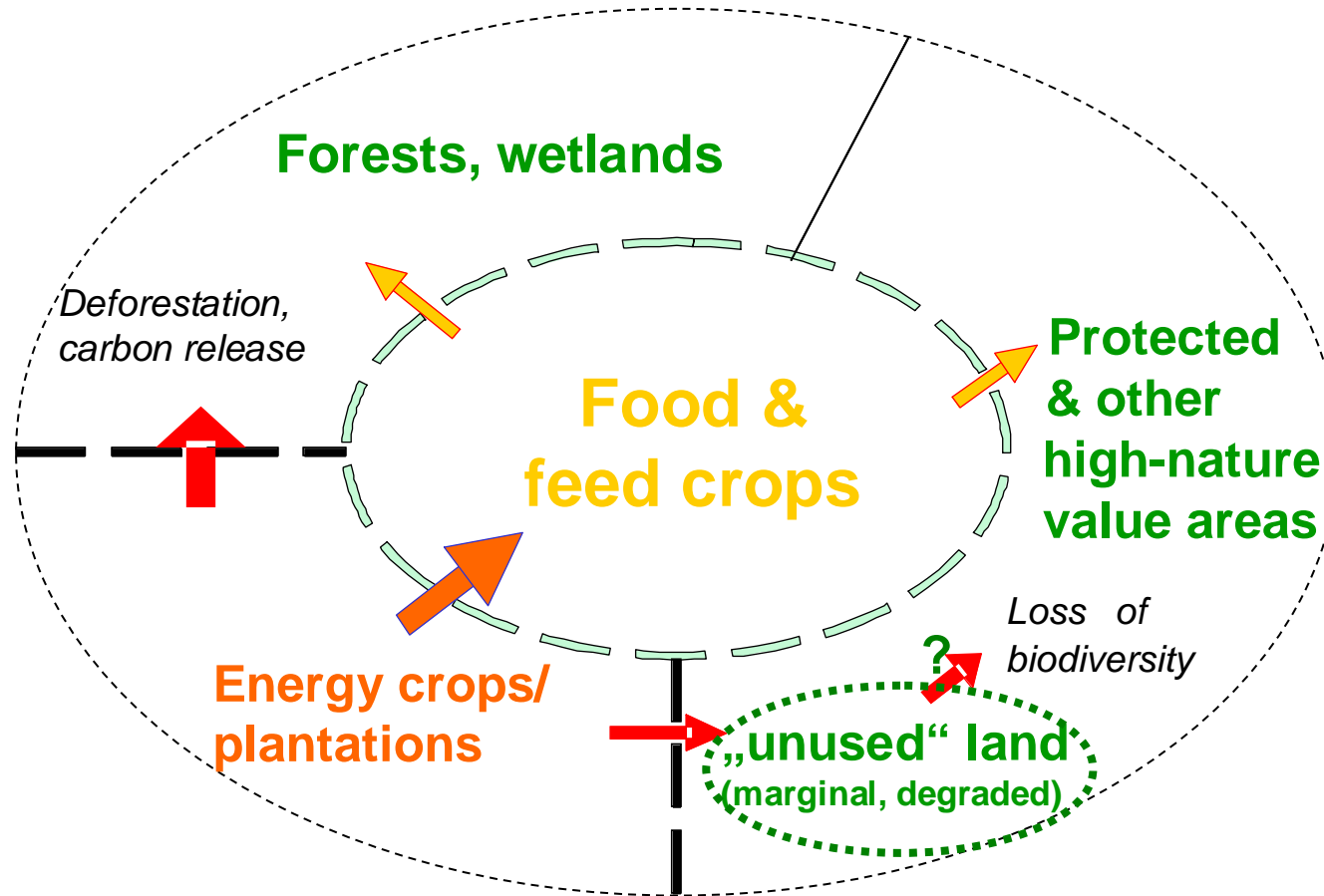


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- **Bioenergy life cycle GHG emission more or less understood:**
 - Uncertainty in N_2O (fertilizer for cultivation) and CH_4 (for biomethane)
 - Data variation in cropping (yield, fertilizer), conversion and background systems (electricity, process heat)
- **But land use change (LUC) impacts need consideration:**
 - GHG from direct + indirect land use changes
 - **Net result** can be positive or negative

Indirect Effects (Displacement)



Source: based on Girard (GEF-STAP Biofuels Workshop, New Delhi 2005)

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GHG from indirect LUC

- **Displacement = generic problem of restricted system boundaries**
 - Accounting problem of partial analysis (only biofuels, no explicit modeling of agro + forestry sectors)
 - All incremental land uses imply indirect effects
- **Analytical and political implications**
 - Analysis: which displacement when & where?
 - Policy: which instruments? Partial certification schemes do not help, but have „spill-over“ effects
- **Future global GHG regime with cap for all sectors & countries: no leakage = no indirect effects!**

The iLUC Factor Approach (1)

- ...assumes that potential release of CO₂ from LUC caused by displacement is function of land used to produce agro products for exports, as displacement “works” via trade flows**
- ...takes into account key countries trading agro-products being subject to displacement which can impact different land with different C stocks**
- ...argues that trading countries are potentially incited to increase food/feed production to “balance” markets if increased feedstock production for biofuels displaces previous food/feed producing land**

The iLUC Factor Approach (2)

- ...is deterministic and describes average impacts
- ... shares of displaced land for food/feed derived from share of land used in each country for agro commodity exports (country-specific yields, FAO data)
- ...share of land use in export countries determined using key commodity (rape, maize, palm, soy, wheat) in Brazil (BR), European Union (EU), Indonesia (ID), and United States of America (US)
- ...shares of land potentially affected derived from share of land used for selected commodity exports + assumptions on which LUC will be most likely (e.g. grassland to maize)
- ...IPPC-based LUC factors for C releases coupled with regional land use shares of each agro commodity
- ...from that, average CO₂ emission factor per ha of displaced land is derived, and discounted over time horizon of 20 years

The iLUC Factor Approach (3)

Calculated theoretical global average iLUC factor: 20 t CO₂/ha/year – if displacement risk would be 100%. Real risk lower (biofuel feedstocks from set-aside/abandoned land, intensification etc.)

Indicative values for iLUC factor (reflecting order of magnitude) for

- “low” level, assuming 25% of all non-zero risk biofuels are subject to theoretical full iLUC factor = 5 t of CO₂/ha/year
- “medium” level, i.e. 50% of all non-zero risk feedstocks are subject to theoretical full iLUC factor = 10 t of CO₂/ha/year, and
- “maximum” level, representing a 75% share* of non-zero risk biofuel feedstocks = 15 t of CO₂/ha/year

Translating the iLUC factor to a given biofuel, divide by fuel-specific yield → energy-specific emission factor (t CO₂/GJ_{biofuel}).

*= maximum case is not 100% of theoretical iLUC factor as in the longer-term, 25% of all biofuels come from yield increases (average 1% per year until 2030)

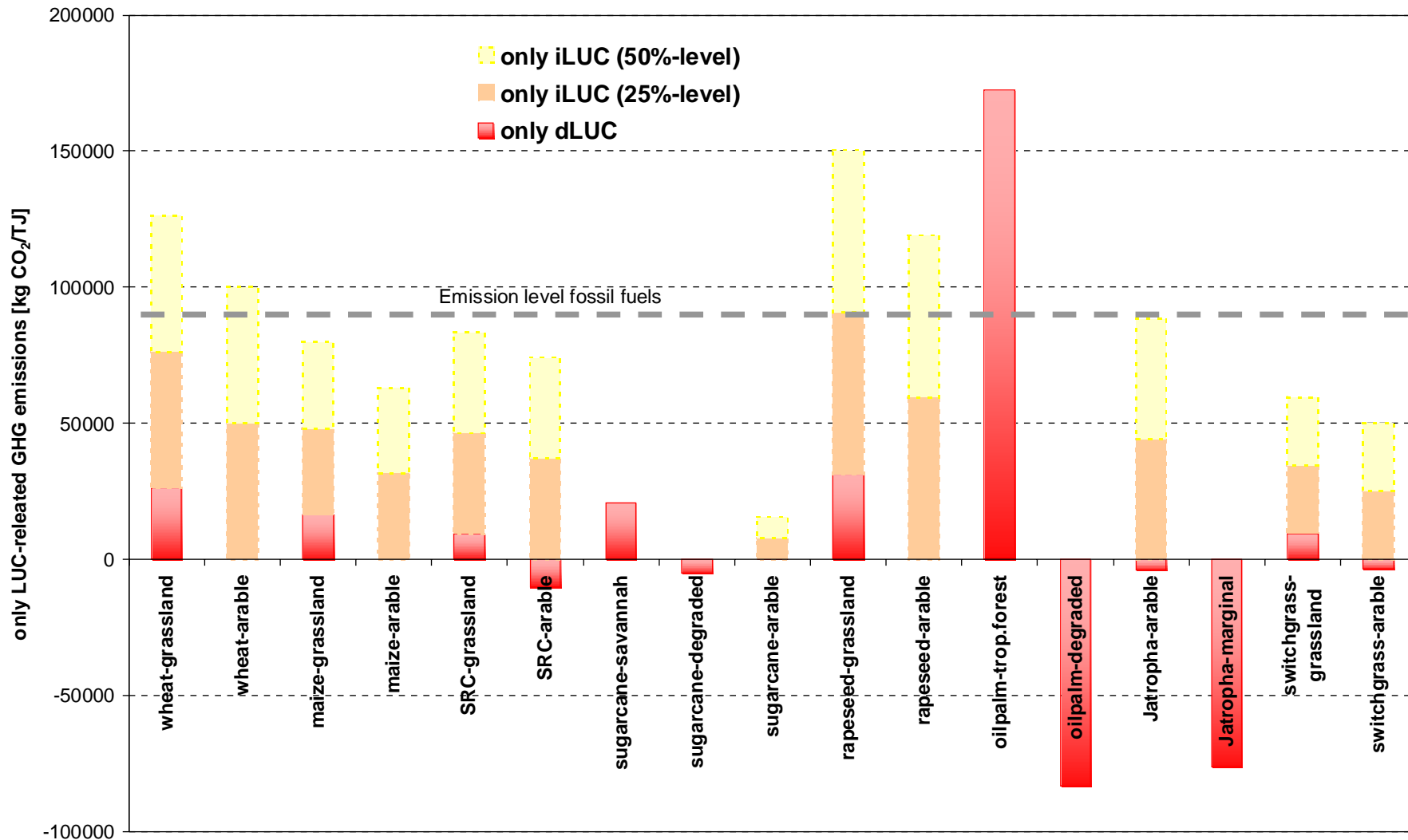
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Direct + Indirect GHG from LUC



Data only for LUC-induced GHG emissions, excluding life-cycles

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Indirect GHG: “iLUC Factor“

Accounting for CO₂ from indirect LUC using the “iLUC factor“ for the GHG balance of biofuels*

biofuel route, life-cycle	kg CO _{2eq} /GJ with iLUC factor			relative to fossil diesel/gasoline,		
	including conversion/by-products, without direct LUC			including conversion/by-products		
	max	med	low	max	med	low
Rapeseed to FAME, EU	260	188	117	201%	118%	35%
palmoil to FAME, ID	84	64	45	-3%	-25%	-48%
soybean oil to FAME, Brazil	101	76	51	17%	-12%	-41%
sugarcane to EtOH, Brazil	48	42	36	-44%	-52%	-59%
maize to EtOH, US	129	101	72	50%	17%	-16%
wheat to EtOH, EU	144	110	77	67%	28%	-11%
SRC/SG to BtL, EU	109	75	42	26%	-13%	-51%
SRC/SG to BtL, Brazil, tropical	34	25	17	-61%	-71%	-80%
SRC/SG to BtL, Brazil, savanna	59	42	25	-32%	-51%	-71%

SRC = short-rotation coppice; SG= switchgrass; BtL = biomass-to-liquid, i.e. Fischer-Tropsch synthetic diesel

*= By-product allocation using lower heating value; iLUC factor is zero for residues/wastes and for biocrops from unused/degraded lands

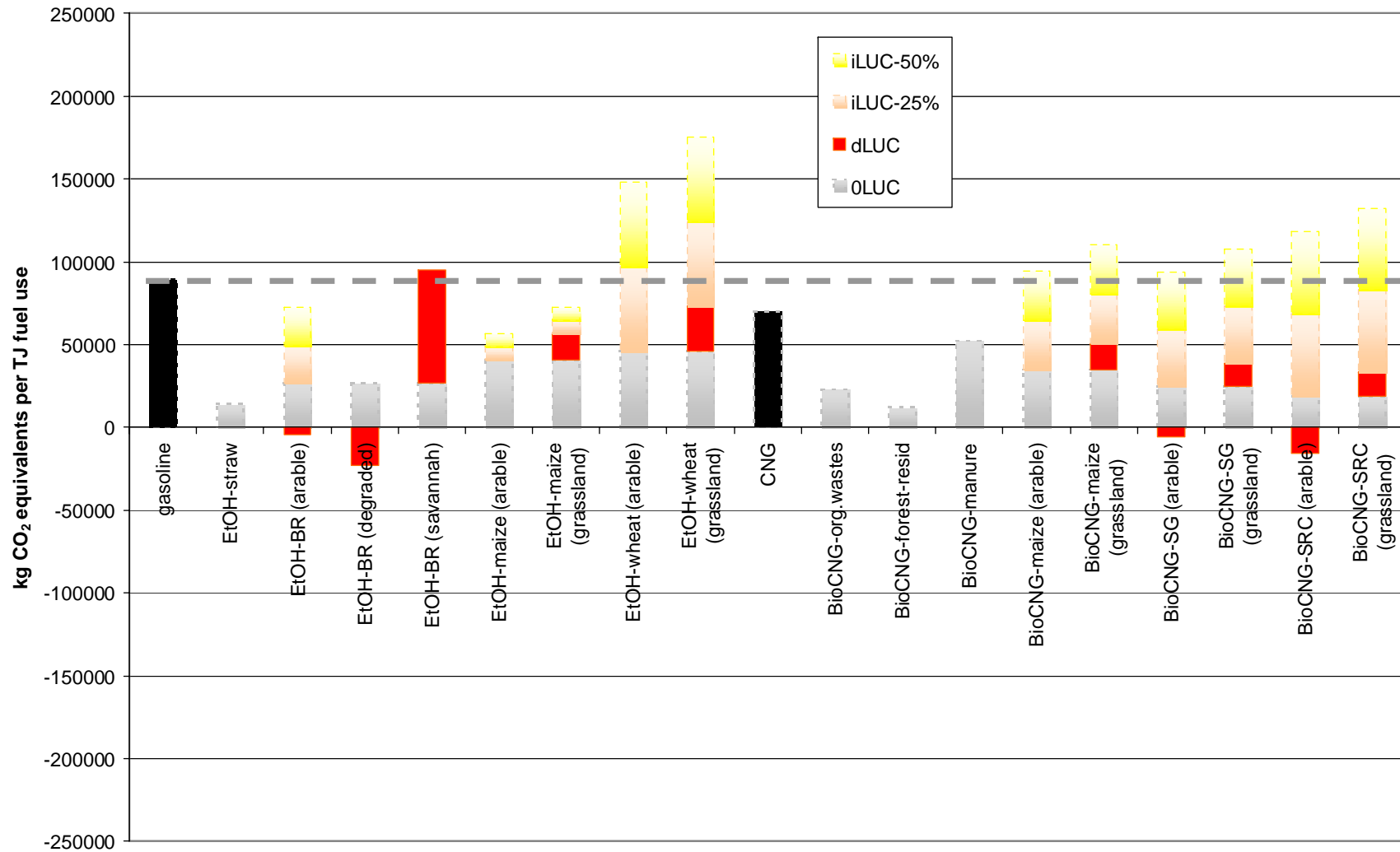
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Total GHG: Biofuels (1)

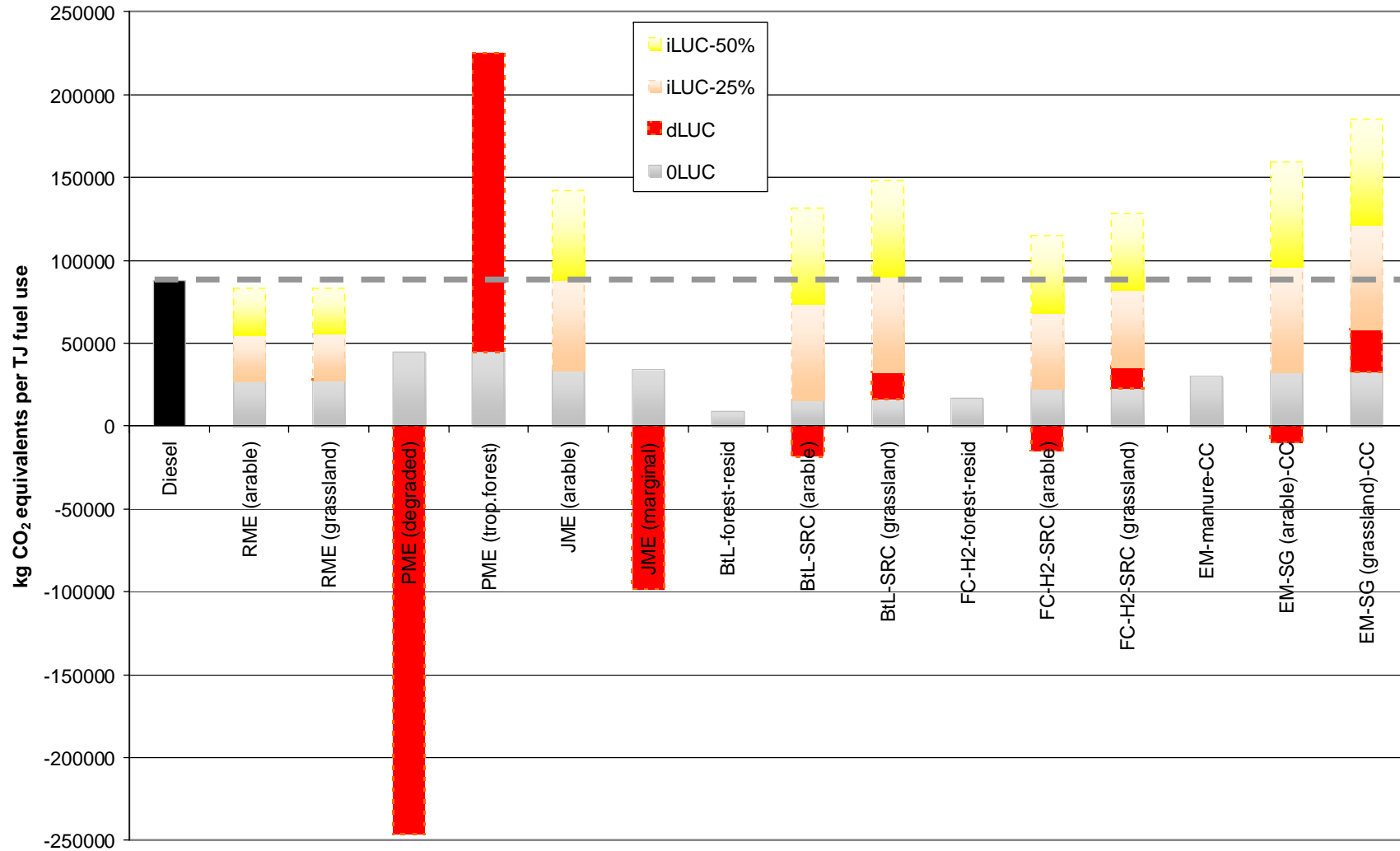


data from GEMIS 4.5; GHG emissions from life-cycles + LUC, allocation by LHV

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Total GHG: Biofuels (2)



data from GEMIS 4.5; GHG emissions from life-cycles + LUC, allocation by LHV

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Conclusions

- GHG emissions from direct and indirect LUC **effect all uses of bioenergy** – electricity, heat, and transport fuels (also electricity for transport)
- GHG emissions of **direct** LUC relevant for C-rich soils; low impact for arable and some for grassland – but **indirect** effects!
- Risk hedging: favor residues/wastes, and unused/degraded land → **caution**: potential negative biodiversity and social tradeoffs