Supporting information

Substances	Amount	Unit
Inputs		
Naphtha	2.22E+01	t
Energy	2.00E+02	GJ
Co-products		
Ethylene	7.00E+00	t
Propylene	3.22E+00	t
Aromatics and C4	2.89E+00	t
CH_4	3.00E+00	t
H_2	2.22E-01	t
Other	2.44E+00	t
Outputs		
Losses&blackflows	2.44E+00	t
CO_2	1.33E+01	t
Allocation to be applied	4.5	%

Tab. S1 Naphtha cracking LCI to 1t of BD.

Substances	Amount	Unit
Inputs		
Ethanol[i]	2.06E+00	t
Electricity	9.86E-01	GJ
Cooling water	7.00E+01	t
Steam	2.66E+00	t
Co-products		
Fuel (Methane)	1.40E-01	t
Diethyl Ether	3.81E-02	t
Acetaldehyde	2.26E-01	t
Outputs		
CO_2	9.06E-03	t
Allocation to be applied	48.0	%

Tab. S2 Lebedev process LCI to 1t of BD.

Substances	Amount	Unit
Inputs		
Ethanol[i]	3.75E+00	t
Electricity	7.74E-01	GJ
Cooling water	5.00E+01	t
Steam	2.20E+00	t
Co-products		
Ethylene	8.51E-02	t
Butene	9.56E-02	t
n-Butanol	2.77E-02	t
Butyraldehyde	3.00E-03	t
Crothyl alcohol	1.92E-02	t
Outputs		
CO_2	2.10E+00	t
Allocation to be applied	38.0	%

Tab. S3 Ostromisslensky process LCI to 1t of BD.

[i]As described in the manuscript several alternatives to simulate ethanol production were considered depending on which country is chosen as supplier:

- United States - a **100%** *Ethanol, 95% in H_2O, from corn, at distillery/US U*
- Brazil - a **100%** *Ethanol, 95% in H_2O, from sugar cane, at fermentation plant/BR U*
- Europe – **1/6** *Ethanol, 95% in H_2O, from corn, at distillery/US U*, **1/6** Ethanol, 95% in *H_2O*, from rye, at distillery/RER U, **1/3** Ethanol, 95% in *H_2O*, from sugar beets, at fermentation plant/CH U and **1/3** Ethanol from wheat, Europe (inventory reported below).

Process input	Amount	Unit
Wheat grains conventional, Barrois, at farm/FR U	2.5	kg
Chemicals organic, at plant/GLO U	0.02	kg
Water, unspecified natural origin/kg	0.31	kg
Electricity, production mix RER/RER U	0.1	kWh
Heat, unspecific, in chemical plant/RER U	5.1	MJ
Transport, lorry >16t, fleet average/RER U	0.27	tkm

Tab. S4 LCI for 1 kg of ethanol from EU wheat.

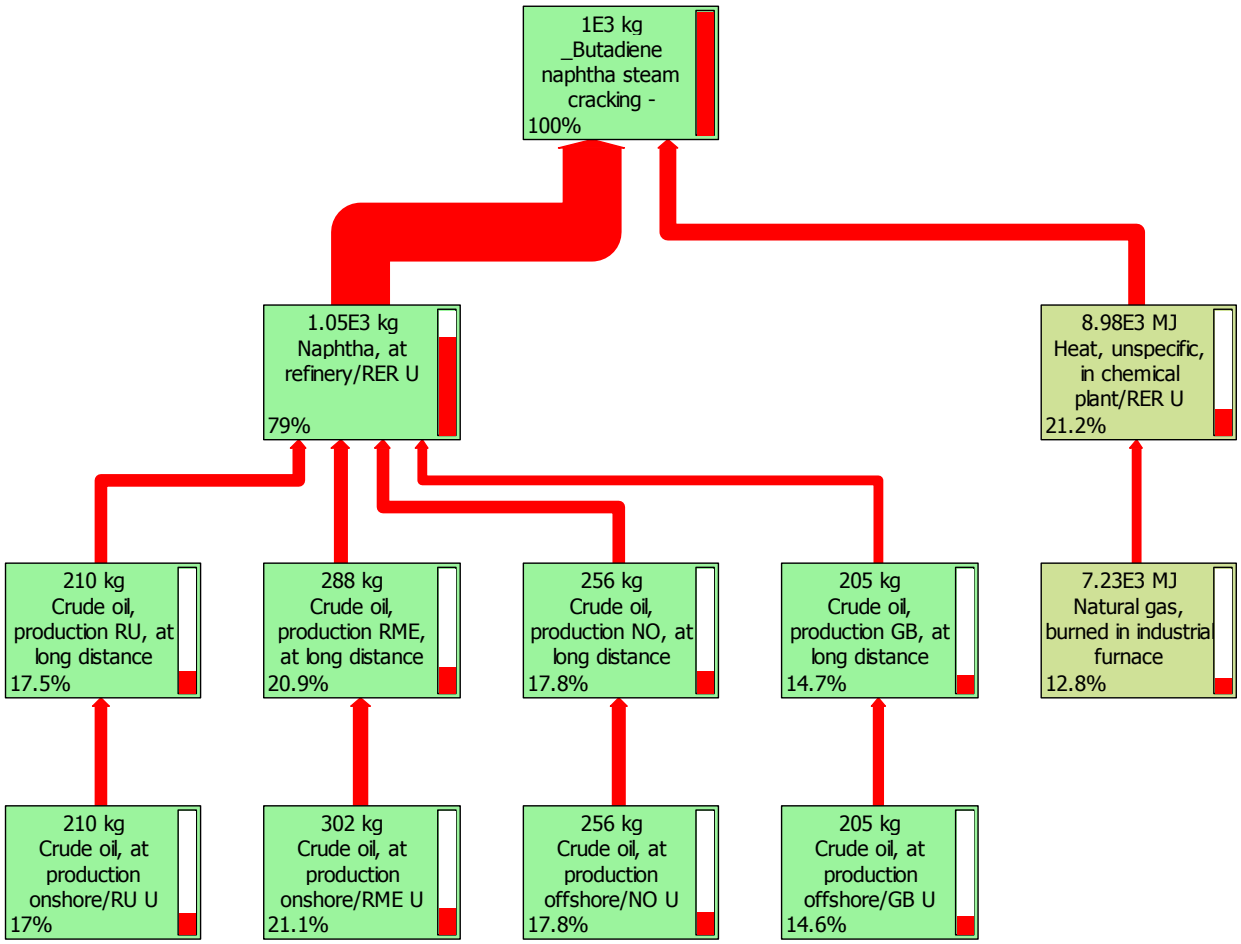

Fig. S1 Cumulative contribution to CED for naphtha cracking route to BD.

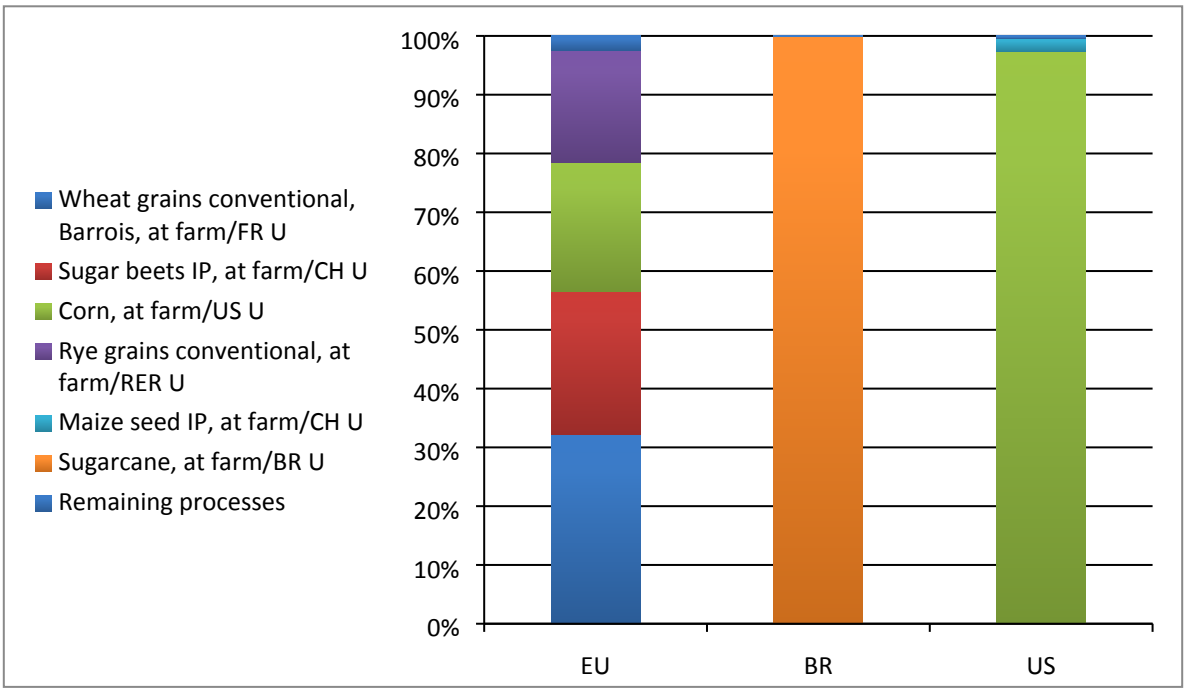

Fig. S2 CED contribution to the renewable biomass category for the unconventional BD routes.

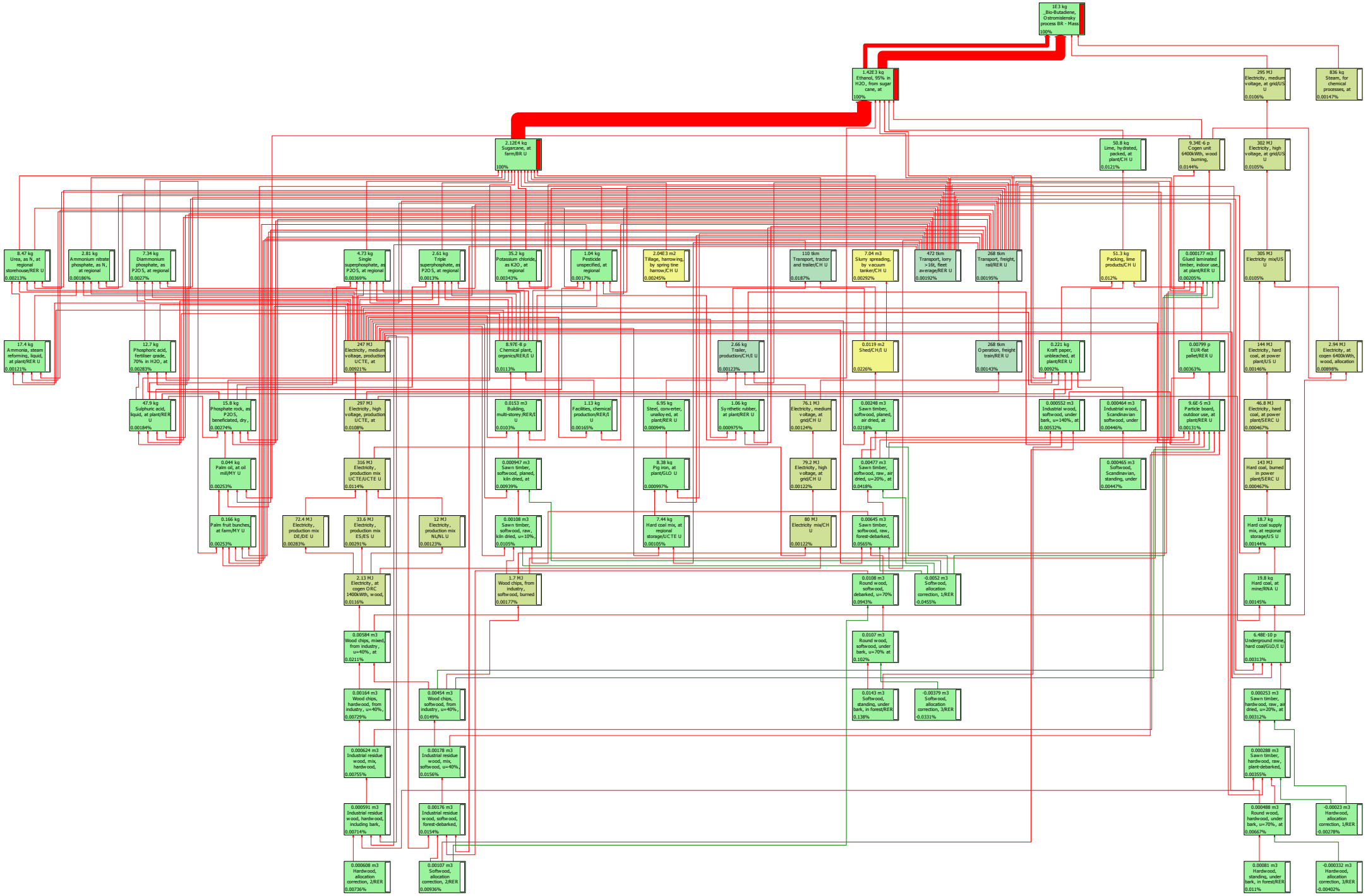

Fig. S3 CED contribution to the renewable biomass category for the unconventional BD route in Brazil, using network tool.

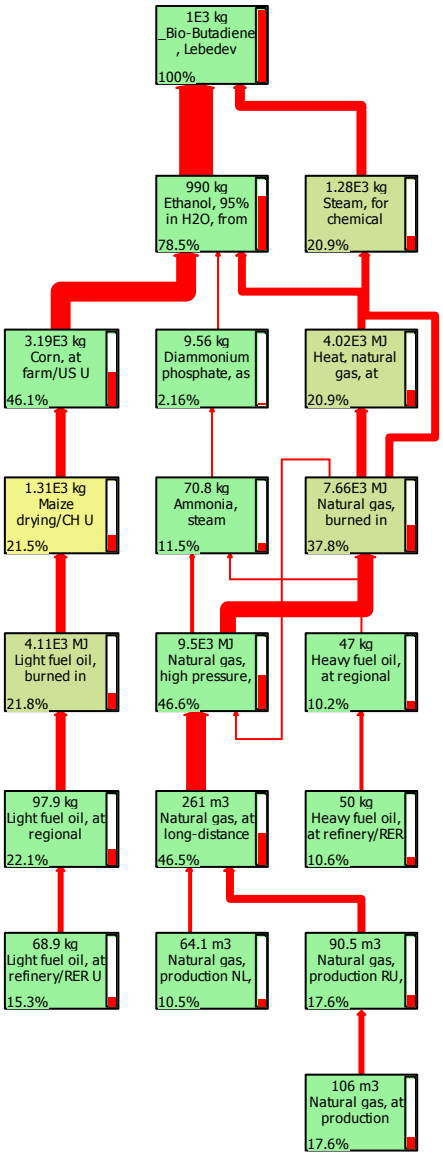

Fig. S4 CED contribution to the non-renewable fossil category, using network tool: Lebedev process in the United States.

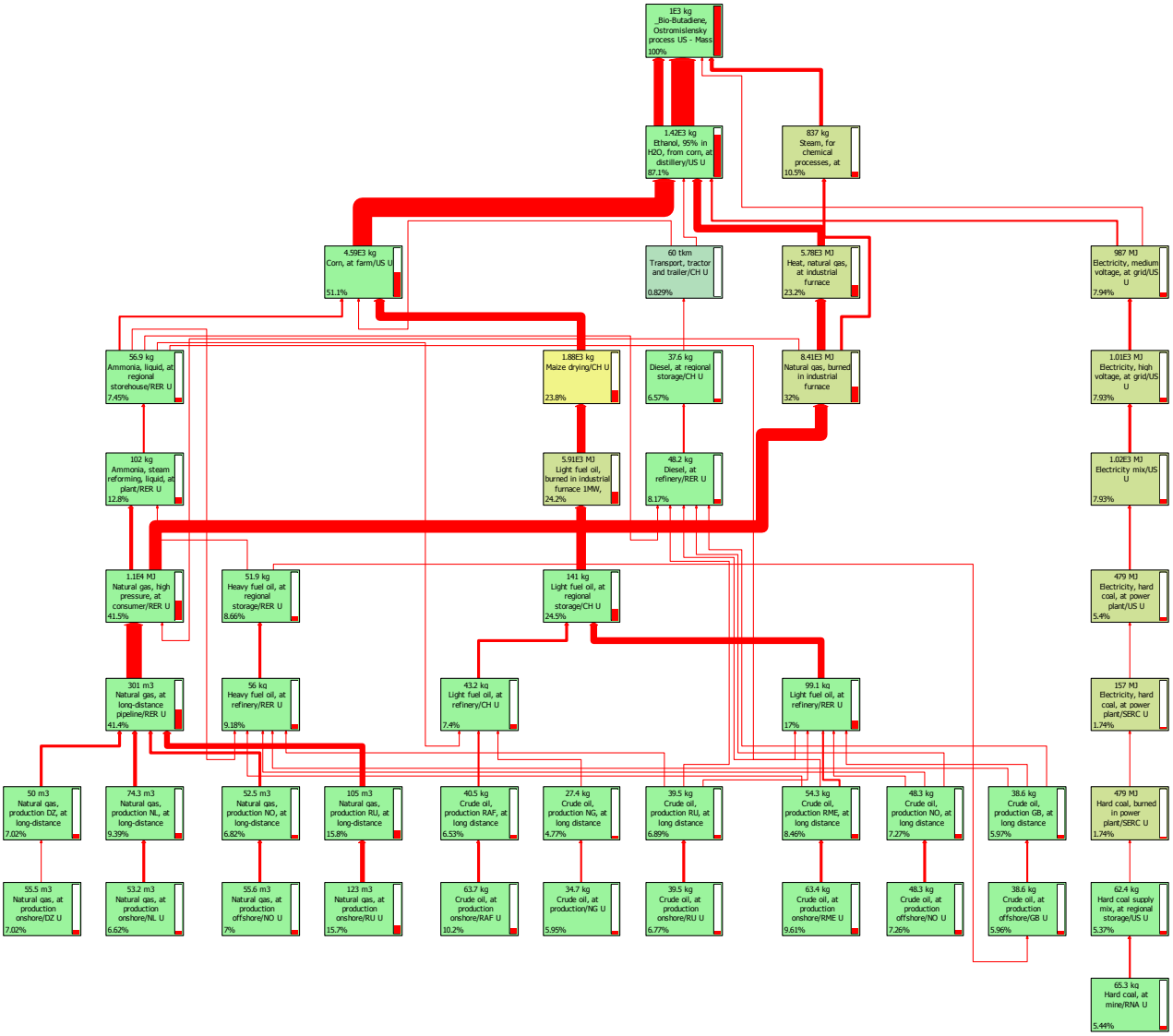

Fig. S5 CED contribution to the non-renewable fossil category, using network tool: Ostromisslensky process in the United States.

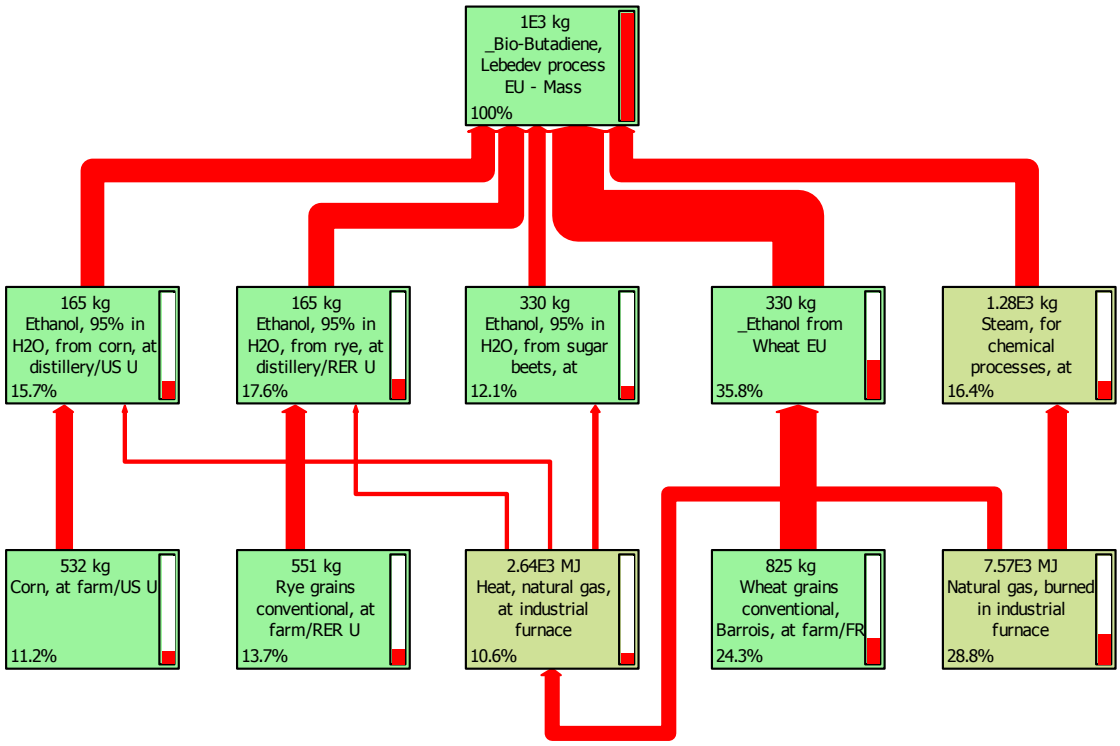

Fig. S6 GWP contribution through network tool for the Lebedev process in Europe.

BD, naphthta cracking	Bio- BD, Lebedev (EU)	Bio- BD, Lebedev (BR)	Bio- BD, Lebedev (US)	Bio- BD, Ostromiss lensky (EU)	Bio- BD, Ostromiss lensky (BR)	Bio- BD, Ostromiss lensky (US)	Bio-BD, Lebedev (EU) at 2023
2.13	2.04	1.04	2.30	3.62	2.18	4.00	1.49

Tab. S5 Results from the cradle-to-gate carbon footprint for each scenario in terms of t CO_2 eq.

BD, naphthta cracking	Bio- BD, Lebedev (EU)	Bio- BD, Lebedev (BR)	Bio- BD, Lebedev (US)	Bio- BD, Ostromisslensky (EU)	Bio- BD, Ostromisslensky (BR)	Bio- BD, Ostromisslensky (US)
5.12	12.63	19.95	28.57	16.81	27.34	39.73

Tab. S6 Results from the cradle-to-gate water consumption in m^3 per ton of BD.

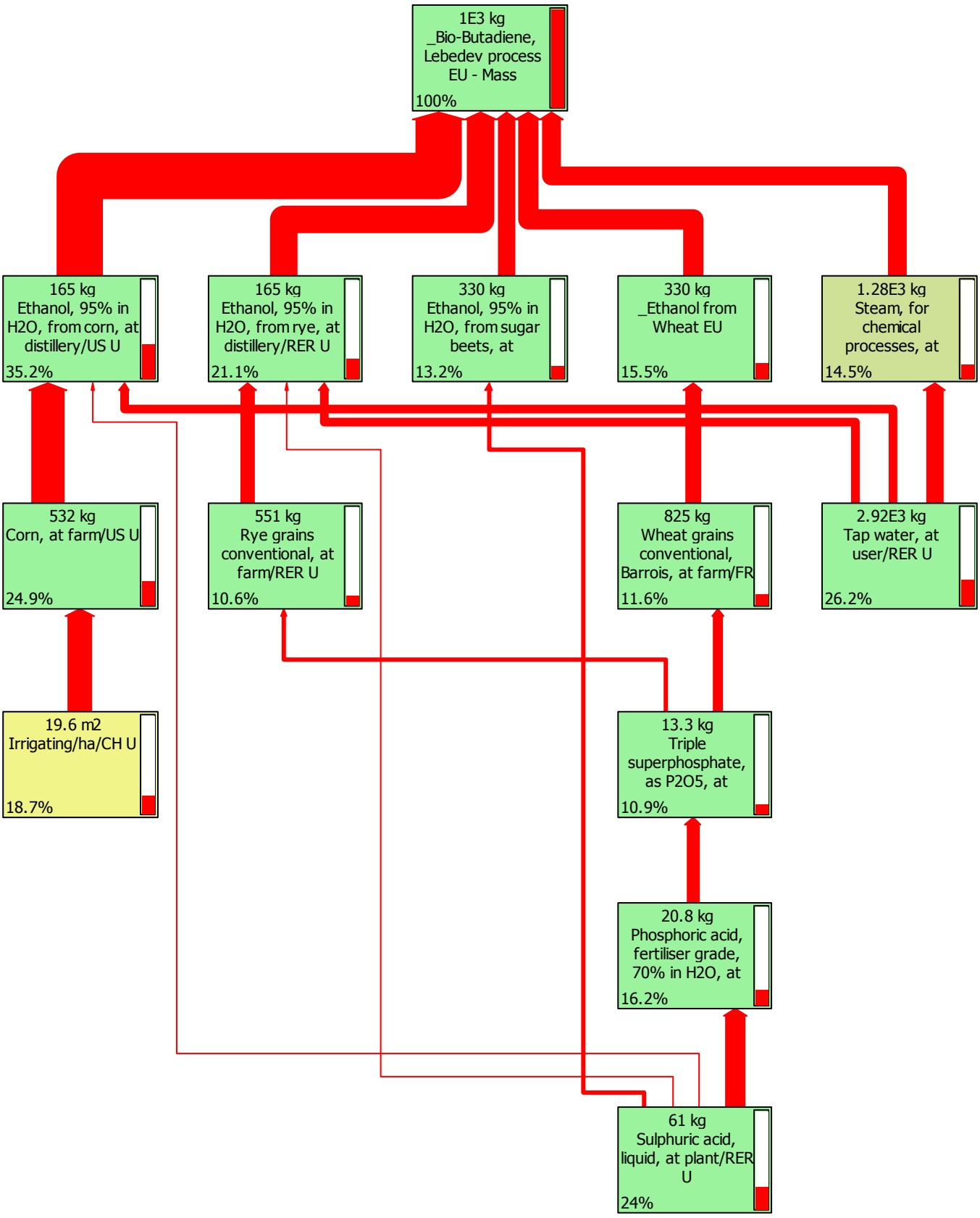

Fig. S7 Contribution to water depletion through network tool for the Lebedev process in Europe.

Impact categories - Pt	BD, naphthta cracking	Bio- BD, Lebedev (EU)	Bio- BD, Lebedev (BR)	Bio- BD, Lebedev (US)	Bio- BD, Ostromisslensky (EU)	Bio- BD, Ostromisslensky (BR)	Bio- BD, Ostromisslensky (US)	Bio-BD, Ostromisslensky (US)-NO 100% bio
Climate change	7.38E+01	7.31E+01	3.46E+01	8.23E+01	1.30E+02	7.45E+01	1.43E+02	1.59E+02
Particu. matter formation	1.39E+01	2.29E+01	2.04E+01	2.35E+01	3.25E+01	2.89E+01	3.33E+01	3.42E+01
Terrestrial ecotoxicity	9.28E-03	5.22E+00	5.29E+00	1.21E+00	7.51E+00	7.61E+00	1.74E+00	1.22E+00
Agricul. land occupation	1.60E-02	2.78E+01	1.67E+01	1.90E+01	4.00E+01	2.39E+01	2.73E+01	1.92E+01
Fossil fuel depletion	1.56E+02	4.60E+01	1.92E+01	5.58E+01	5.84E+01	1.98E+01	7.25E+01	1.22E+02
Tot	2.43E+02	1.77E+02	9.76E+01	1.84E+02	2.68E+02	1.55E+02	2.78E+02	3.36E+02

Tab. S7 Results from the ReCiPe aggregation procedure into single-score eco-indicator.

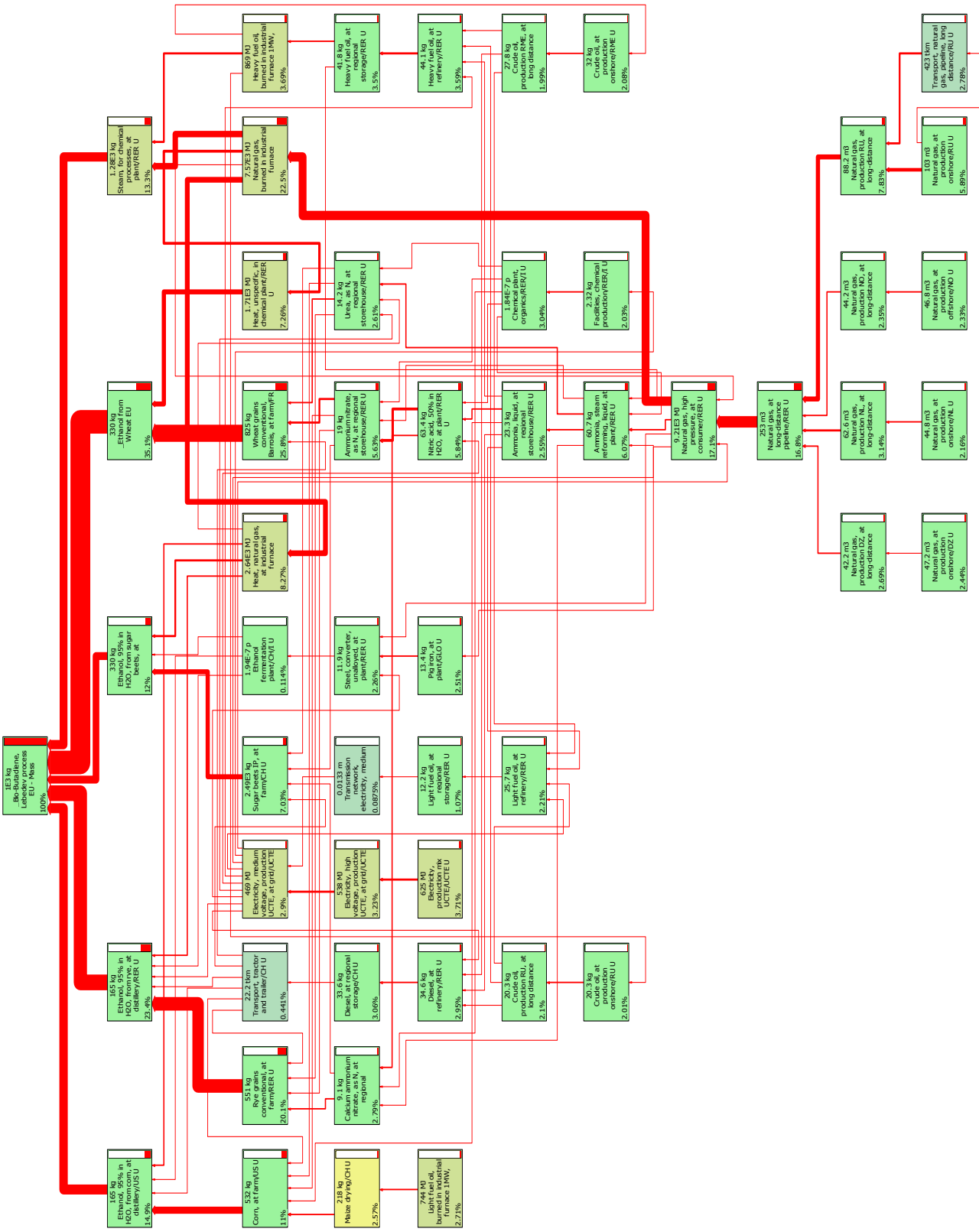

Fig. S8 Contribution to the ReCiPe single-score using network tool for the Lebedev process in Europe.

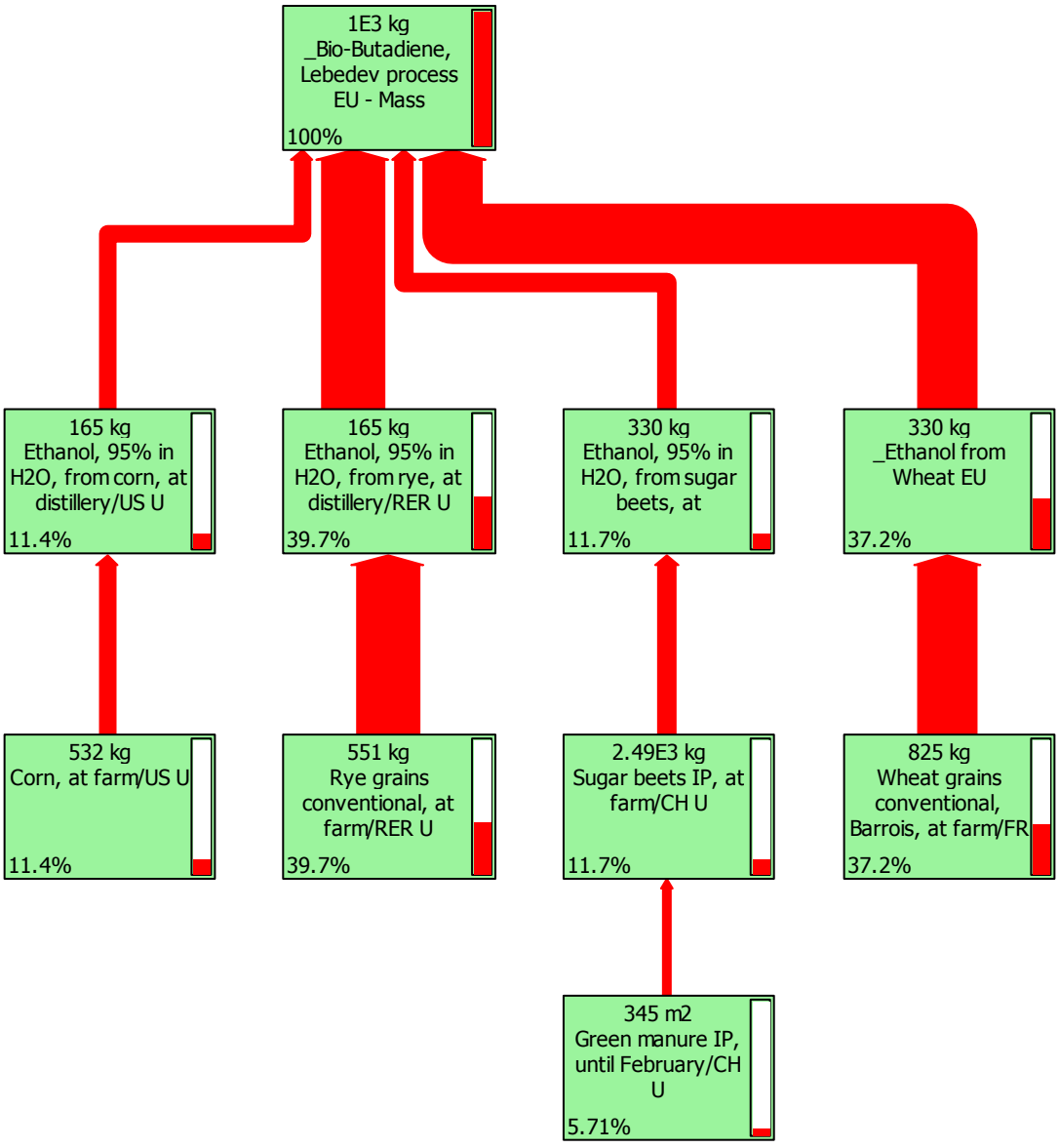

Fig. S9 Contribution to the agricultural land occupation through network tool for the Lebedev process in Europe.

Contribution to PMF	BD, naphthta cracking	Bio- BD, Lebedev (EU)	Bio- BD, Lebedev (BR)	Bio- BD, Lebedev (US)	Bio- BD, Ostromisslensky (EU)	Bio- BD, Ostromisslensky (BR)	Bio- BD, Ostromisslensky (US)
Process Energy	30%	6%	7%	6%	5%	5%	5%
Naphtha prduction	70%	0%	0%	0%	0%	0%	0%
Ethanol production	0%	94%	93%	94%	95%	95%	95%

Tab. S8 Contribution to PMF impact category.