Table 1. Global Life Cycle Inventory data per section corresponding to the foreground system for the production of bio-ethanol and xylooligosaccharides. Data are reported per production batch.

INPUTS from TECHNOSPHERE	
Area 1	
Barley straw	37,108 kg
Brewer´s spent grain	37,108 kg
Electricity	157 (22.20)[a] kWh
Area 2	
Water	546,961 kg
High pressure steam	235,455 kg
Electricity	119 (16.83)[a] kWh
Area 3	
Low pressure steam	51,939 kg
Natural gas	678 kg
Electricity	68 (9.61)[b] kWh
Area 4	
Inoculum	0.20 kg
Oxygen	144 kg
Water	44,818
Glucose	223 kg
Peptone	163 kg
Malt extract	98 kg
Yeast extract	98 kg
Cellic CTec2 (enzymes)	1,237 kg
Electricity	50 (7.07)[b] kWh
Area 5	
Low pressure steam	37,550 kg
Electricity	156 (22.06)[a] kWh
OUTPUTS to TECHNOSPHERE	
Co-products	
Xylooligosaccharides	7,000 kg
Bio-ethanol	9,154 kg
Waste to treatment	
Wastewater to WWTP from Area 3	452,444 kg
Wastewater to WWTP from Area 5	158,228 kg
Solid waste to composting from Area 5	26,449 kg
OUTPUTS to ENVIRONMENT	
Emissions into air	
Steam (from Area 2 + Area 3 + Area 5)	7.27 t
CO_2 (from Area 4 + Area 5)	9.17 t
CO_2 (from Area 3)	1.31 t
CH_4 (from Area 3)	46.9 g
CO (from Area 3)	704 g
N_2O (from Area 3)	11.7 g
Particulates <2.5µm (from Area 3)	2.35 g
NO_x (from Area 3)	469 g

SO_2 (from Area 3)	12.9 g

Standard deviation is shown in parentheses (n=3). Different letters indicate significant differences ($p \leq 0.05$)

Table 2. Description of the Ecoinvent ® database version 3.2 processes considered for the background processes.

Input	Process / Source
Electricity	Electricity, medium voltage {ES}| market for | Alloc Rec, U
Heat	Heat, district or industrial, natural gas {CH}| market for heat, district or industrial, natural gas | Alloc Def, U
Steam	Steam, in chemical industry {GLO}| market for | Alloc Def, U
Water	Tap water {Europe without Switzerland}| market for | Alloc Rec, U
Inorganic chemicals	Chemical, inorganic {GLO}| market for chemicals, inorganic | Alloc Rec, U
Organic chemicals	Chemical, organic {GLO}| market for | Alloc Rec, U
Oxygen	Oxygen, liquid {RER}| market for | Alloc Def, U
Malt extract/Yeast extract	Yeast paste, from whey, at fermentation/CH U
Wastewater treatment	Wastewater, average {CH}| treatment of, capacity 5E9l/year | Alloc Rec, U
Solid waste management	Biowaste {RoW}| treatment of, composting | Alloc Def, U
Sensitivity analysis- Steam production	Heat, district or industrial, other than natural gas {CH}| heat production, hardwood chips from forest, at furnace 1000kW | Alloc Rec, U

Table 3. Impact assessment characterisation results corresponding to the biorefinery system under study. Results are reported per production batch (74.22 tonnes of lignocellulosic stream) as well as per kg of value product obtained (bio-ethanol and XOS).

Category	Per batch[a]	Per kg XOS	Per kg bio-ethanol[a]
AP	343 kg SO_2 eq	17.6 g SO_2 eq	24.0 g SO_2 eq
EP	68.5 kg PO_4^{-3} eq	3.00 g PO_4^{-3} eq	5.19 g PO_4^{-3} eq
GWP	88.2 t CO_2 eq	4.21 kg CO_2 eq	7.39 kg CO_2 eq
ODP	12.9 g CFC-11 eq	0.519 mg CFC-11 eq	1.01 mg CFC-11 eq
POP	19.4 kg C_2H_4 eq	897 mg C_2H_4 eq	1.43 g C_2H_4 eq
HTP	16.5 t 1,4-DB eq	734 g 1,4-DB eq	1.24 kg 1,4-DB eq
FEP	6.20 t 1,4-DB eq	347 g 1,4-DB eq	412 g 1,4-DB eq
MEP	1.17 Mg 1,4-DB eq	264 g 1,4-DB eq	127 kg 1,4-DB eq
TEP	43.8 kg 1,4-DB eq	182 mg 1,4-DB eq	4.65 g 1,4-DB eq

[a] Including enzymes production. Acronyms: AP - acidification potential; EP - eutrophication potential; GWP – global warming potential; ODP – ozone depletion potential; POP – photochemical oxidation potential; HTP – human toxicity potential; FEP – freshwater aquatic ecotoxicity potential; MEP - marine aquatic ecotoxicity potential; TEP - terrestrial ecotoxicity