Table S1. LCI Scenario A: Acrolein from glycerol produced as a by-product of triglycerides trans-esterification

	Process name input	Amount	Unit
Input			
Cultivation phase	Rape seed conventional, at farm/DE U *	3.3E+01	kg
Oil production			
Inputs	Heat, natural gas, at industrial furnace >100kW/RER U *	2.3E+01	MJ
	Transport, freight, rail/RER U *	7.4E-02	tkm
	Transport, lorry >16t, fleet average/RER U *	1.2E-02	tkm
	Transport, lorry 3.5-16t, fleet average/RER U *	3.3E+00	tkm
	Oil mill/CH/I U *	1.1E-08	p
	Bentonite, at processing/DE U *	7.6E-02	kg
	Hexane, at plant/RER U *	3.7E-02	kg
	Phosphoric acid, industrial grade, 85% in H2O, at plant/RER U *	1.2E-02	kg
	Electricity, medium voltage, production UCTE, at grid/UCTE U *	1.4E+00	kWh
Outputs & Waste	Carbon dioxide, biogenic *	3.9E+01	kg
	Heat, waste *	1.6E+01	MJ
	Hexane *	3.6E-02	kg
	Treatment, sewage, from residence, to wastewater treatment, class 2/CH U *	8.8E-05	m^3
Triglycerides trans-esterification	Nitrogen, in air *	5.9E-02	kg
	Methanol, at regional storage/CH U *	1.7E+00	kg
	Sodium methoxide, at plant/GLO U *	2.9E-01	kg
	Hydrochloric acid, 30% in H_2O, at plant/RER U *	2.2E-01	kg
	Sodium hydroxide, 50% in H_2O, production mix, at plant/RER U *	6.3E-02	kg
	Compressed air, average generation, <30kW, 10 bar gauge, at compressor/RER U *	1.2E-01	Nm^3
	Steam, for chemical processes, at plant/RER U *	6.2E+00	kg
	Electricity, medium voltage, at grid/IT U *	3.6E-01	kWh
	Crude glycerol 84% **,i	2.1E+00	kg
	Biodiesel *,ii	1.7E+01	kg
Glycerol refining (84%→100%)	Nitrogen, in air *	9.5E-02	kg
	Sodium hydroxide, 50% in H_2O, production mix, at plant/RER U *	3.0E-03	kg
	Compressed air, average generation, <30kW, 10 bar gauge, at compressor/RER U *	7.6E-02	Nm^3
	Steam, for chemical processes, at plant/RER U *	3.3E+00	kg
	Natural gas, burned in power plant/IT U *	1.0E+00	kWh
	Electricity, medium voltage, at grid/IT U *	1.4E-01	kWh
Avoided products	Diesel, at refinery/RER U *	1.7E+01	kg

* Calculated on the basis of mass balance and data furnished by Spiga BD Srl.
** Calculated on the basis of mass balance.
i Not included in the inventory, yield conversion into acrolein is 100%.
ii This flow was included in the inventory indirectly (see "Avoided products" field).

Table S2. LCI Scenario B: Acrolein from glycerol produced as a by-product of triglycerides hydrolysis

	Process name input	Amount	Unit
Input			
Breeding phase	Beef (farm type 23) *	2.3E+00	kg
Tallow production	Tallow, at plant/CH U *	2.3E+01	kg
Hydrolysis process	Water, process, unspecified natural origin/kg *	1.4E+01	kg
	Compressed air, average generation, >30kW, 7 bar gauge, at compressor/RER U *	1.8E-02	Nm^3
	Steam, for chemical processes, at plant/RER U *	5.9E+00	kg
	Electricity, medium voltage, at grid/IT U *	4.6E-01	kWh
	Crude glycerol 20% **,i	2.1E+00	kg
	Crude fatty acids *, ii	2.0E+01	kg
Glycerol refining (20%→99.5%)	Water, cooling, unspecified natural origin/m^3 *	5.0E-01	m^3
	Compressed air, optimized generation, >30kW, 7 bar gauge, at compressor/RER U *	8.5E+00	Nm^3
	Steam, for chemical processes, at plant/RER U *	7.0E+00	Kg
	Electricity, medium voltage, at grid/IT U *	9.4E-02	kWh
Fatty acids refining	Water, cooling, unspecified natural origin/m^3 *	1.2E+00	m^3
	Compressed air, optimized generation, >30kW, 7 bar gauge, at compressor/RER U *	1.2E-01	Nm^3
	Steam, for chemical processes, at plant/RER U *	1.9E+01	kg
	Electricity, medium voltage, at grid/IT U *	6.2E-01	kWh
Avoided products	Rape oil, at oil mill/RER U *	2.1E+01	kg

* Calculated on the basis of mass balance and data furnished by SO.G.I.S. SpA.
** Calculated on the basis of mass balance.

ii Not included in the inventory, yield conversion into acrolein is 100%.
ii This flow was included in the inventory indirectly (see "Avoided products" field).

Table S3. LCI Glycerol dehydration to acrolein

	Process name input	Amount	Unit
Input	Water, cooling, unspecified natural origin/kg *	2.6E06	kg
	Water, process, unspecified natural origin/ kg *	5.2E03	kg
	Chemicals organic, at plant/GLO U **	1.2E-02	kg
	Argon *	2.5E+00	kg
	Chemical plant, organics/RER/I U **	4.0E-10	p
	Transport, freight, rail/RER U **	5.2E-01	tkm
	Transport, lorry >16t, fleet average/RER U **	8.6E-02	tkm
	Steam, for chemical processes, at plant/RER U *	5.4E+00	kg
	Steam, for chemical processes, at plant/RER U ***	3.7E+00	kg
	Natural gas, burned in industrial furnace > 100kW/ RER U *	1.2E+00	MJ
	Electricity, medium voltage, production FR, at grid/FR U *	3.7E-01	kWh
	Silicon *	3.8E-06	kg
	Tungsten *	3.0E-04	kg
	Titanium dioxide, production mix, at plant/RER U *	3.0E-04	kg
Air emissions	Carbon dioxide, fossil *	6.3E-01	kg
	Heat, waste **	6.8E+02	kJ
Avoided processes	Heat, unspecific, in chemical plant/RER U *	3.4E+02	kJ
	Electricity, production mix IT/IT U *	2.9E-02	kWh

* Calculated on the basis of mass balance and data furnished by patent (*US. Pat.*, 0 053 595 A1, 2013)
or internal report (Chem Systems – Process Evaluation/Research Planning (PERP program), *Acrylic Acid 08/09-3*, 2010.)
** Collected from Ecoinvent database.
*** Collected from literature (P.A. Holman, D.R. Shonnard, J.H. Holles, *Ind. Eng. Chem. Res.*, 2009, **48**, 6668-6674).

Table S4. LCI Acrolein production from propylene oxidation

	Process name input	Amount	Unit
Input	Water, cooling, unspecified natural origin/kg *	2.7E-05	kg
	Water, process, unspecified natural origin/ kg *	1.7E-04	kg
	Steam, for chemical processes, at plant/RER U *	6.0E-03	kg
	Natural gas, burned in industrial furnace > 100kW/ RER U *	7.0E+00	MJ
	Electricity, medium voltage, production FR, at grid/FR U *	1.6E+00	kWh
	Propylene, at plant/RER U *	9.9E-01	kg
	Chemical plant, organics/RER/I U **	4.0E-10	p
	Transport, freight, rail/RER U **	5.2E-01	tkm
	Transport, lorry >16t, fleet average/RER U **	8.6E-02	tkm
	Molybdenum ***	3.5E-04	kg
	Iron ***	4.1E-05	kg
	Bismuth ***	5.1E-05	kg
	Cobalt ***	1.3E-04	kg
	Potassium ***	9.6E-07	kg
	Silicon ***	1.3E-05	kg
Air emissions			
	Carbon dioxide, fossil *	7.8E-01	kg
Avoided processes	Heat, unspecific, in chemical plant/RER U *	1.9E+03	kJ
	Electricity, production mix IT/IT U *	1.7E-01	kWh

* Calculated on the basis of mass balance and internal report
(Chem Systems – Process Evaluation/Research Planning (PERP program), *Epichlorohydrine 99/00S11*, 2000.)
** Collected from Ecoinvent database.
*** Calculated on the basis of mass balance and data furnished by patent (*EU. Pat.*, 1 005 908 A2, 2000).

Table S5. Scenario A: percentage contribution of each life cycle stage in terms of Impacts and Avoided impacts

Impact category	Cultivation phase	Oil production	Triglycerides trans-esterification	Avoided glycerine combustion	Avoided diesel extraction	Glycerol refining (84% -> 100%)	Dehydration process
Impacts							
Climate Change	77	6	9	-	-	2	5
Terrestrial ecotoxicity	100	0	0	0	-	0	0
Agricultural land occupation	100	0	0	0	-	0	0
Metal depletion	87	4	6	-	-	0	3
Fossil fuel depletion	53	10	22	5	-	3	7
Avoided impacts							
Climate Change	-	-	-	8	92	-	-
Terrestrial ecotoxicity	-	-	-	-	100	-	-
Agricultural land occupation	-	-	-	-	100	-	-
Metal depletion	-	-	-	4	96	-	-
Fossil fuel depletion	-	-	-	-	100	-	-

Table S6. Scenario B: percentage contribution of each life cycle stage in terms of Impacts and Avoided impacts

Impact category	Breeding phase	Tallow production	Triglyceride hydrolysis	Glycerol refining (20%->99.5%)	Fatty Acids Purification	Avoided rape oil production	Dehydration process	Avoided glycerine combustion
Impacts								
Climate Change	72	16	2	2	5	-	3	-
Terrestrial ecotoxicity	4	29	8	12	24	-	12	10
Agricultural land occupation	100	0	0	0	0	-	0	0
Metal depletion	3	68	2	10	4	-	13	-
Fossil fuel depletion	17	46	5	6	14	-	7	5
Avoided impacts								
Climate Change	-	-	-	-	-	99	-	1
Terrestrial ecotoxicity	-	-	-	-	-	100	-	-
Agricultural land occupation	-	-	-	-	-	100	-	-
Metal depletion	-	-	-	-	-	100	-	0
Fossil fuel depletion	-	-	-	-	-	100	-	-

Table S7. Typical analyses of various types of glycerol produced at different industrial sites by triglycerides trans-esterification (extrapolated from *US Pat.*, 8 530 697 B2, 2013.)

	Diester Industries		
Site	Robbe	Saipol	Marl (RFA)
Production (kt/year)	10	25	15
Glycerol (wt %)	65	93	85
Water (wt %)	31	4	10
NGOM* (wt %)	1	1	0.5
Ash (wt %)	3 (Na_2SO_4)	2.5 (NaCl)	4.5 (NaCl)
Methanol (wt %)	0.3	0.2	< 0.01

*NGOM = non-glycerin organic matter: fatty acids, esters, other

Table S8. LCIA using crude instead of purified glycerol

Analysis method	Impact category	Unit	Scenario A	Scenario B
ReCiPe2008				
	Total Impact	Pt	8.5E+00	-4.0E+00
	Agricultural land occupation	species·yr	1.5E-06	-6.4E-07
	Terrestrial ecotoxicity	species·yr	1.4E-06	-1.7E-06
	Climate change Ecosystems	species·yr	3.6E-07	3.8E-07
	Climate change Human Health	DALY	5.4E-05	5.6E-05
	Fossil fuel depletion	$	-4.8E-01	1.5E-01
	Metal depletion	$	1.6E-01	-1.5E-01