Carbon and Sustainability Reporting Within the Renewable Transport Fuel Obligation

New fuel chains

Office of the Renewable Fuels Agency

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New default fuel chains

Contents

1. Spent sulphite liquor to ethanol

Fuel chain summary

	Carbon intensity [kg CO2 / t ethanol]			
Module	**Canada hard wood**	**Sweden hard wood**	**Canada soft wood**	**Sweden soft wood**
1 – Conversion	2854	2854	918	918
2 – Liquid fuel transport and storage	50	111	50	111
3 – Liquid fuel transport and storage	80	0	80	0
4 – Liquid fuel transport and storage	91	16	91	16
TOTAL	3075	2981	1139	1045

Spent sulphite liquor to ethanol - selected default options

Stage	Module	Input	Options
1	Conversion	Fuel emissions factor	Coal, Natural gas, Heavy fuel oil, Biomass
2	Liquid fuel transport and storage	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping
3	Liquid fuel transport and storage	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping
4	Liquid fuel transport and storage	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping

Spent sulphite liquor to ethanol - Default fuel chain

Stage 1 - Conversion

Description	Bioethanol plant							
Basic data								
Plant yield	[t bioethanol / t waste sulphite liquor]	*value*	(z1)					
Conversion Inputs					Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t bioethanol)	
Ammonia	[MJ/t biodiesel]	*value*	x		*value*	=	*calculation*	1
Fuel	[MJ/t biodiesel]	*value*	x		*value*	=	*calculation*	2
Co-products	**Description**	**Treatment**						
None								
Totals							Emissions ($kgCO_{2e}$/t bioethanol)	
Module total						1 + 2 =	*calculation*	3
Contribution to fuel chain						3 =	*calculation*	Stage_1

Stage 2 - Liquid fuel transport and storage

Description	From port to bioethanol plant							
Transport distance	[km]	*value*	dist_3					
Fuel consumption	[MJ/t-km]	*value*	FC_3					
Totals					Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t bioethanol)	
Module total	[MJ/t feedstock]	*value*	x		*value*	=	*calculation*	4
Contribution to fuel chain						4 =	*calculation*	Stage_2

Stage 3 - Liquid fuel transport and storage

Description	From biodiesel plant to refinery / blending facility							
Transport distance	[km]	*value*	dist_4					
Fuel consumption	[MJ/t-km]	*value*	FC_4					
Totals					Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t bioethanol)	
Module total	[MJ/t biodiesel]	*value*	x		*value*	=	*calculation*	5
Contribution to fuel chain						5 =	*calculation*	Stage_3

Stage 4 - Liquid fuel transport and storage

Description	From biodiesel plant to refinery / blending facility							
Transport distance	[km]	*value*	dist_4					
Fuel consumption	[MJ/t-km]	*value*	FC_4					
Totals				Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t bioethanol)		
Module total	[MJ/t biodiesel]	*value*	x	*value*	=	*calculation*	6	
Contribution to fuel chain					6 =	*calculation*	Stage_4	

Spent sulphite liquor to ethanol - Default value tables

Stage / Input	**Units**	**Feedstock country of origin / type of wood used**			
		Sweden – hard wood	**Canada – hard wood**	**Sweden – soft wood**	**Canada – soft wood**
Stage 1 – Conversion					
Plant yield	[t bioethanol / t spent sulphite liquor]	0.002	0.002	0.005	0.005
Ammonia*	[kg / t bioethanol]	1000	1000	200	200
Fuel input	[MJ / t bioethanol]	7000	7000	7000	7000
Fuel type		Natural gas			
Stage 2 – Liquid fuel transport and storage					
Transport distance	[km]	400	840	400	840
Fuel consumption	[MJ/t-km]	1.46	1.53	1.46	1.53
Fuel type		Diesel			
Stage 3 – Liquid fuel transport and storage					
Transport distance	[km]	4900	0	4900	0
Fuel consumption	[MJ/t-km]	0.19	0	0.19	0
Fuel type		Diesel		Diesel	
Stage 4 – Liquid fuel transport and storage					

Stage / Input	Units	Feedstock country of origin / type of wood used			
		Sweden – hard wood	Canada – hard wood	Sweden – soft wood	Canada – soft wood
Transport distance	[km]	5200	890	5200	890
Fuel consumption	[MJ/t-km]	0.2	0.2	0.2	0.2
Fuel type		HFO	HFO	HFO	HFO

* Ammonia has an emissions factor of 2.42 kg CO_2e / kg.

References

Helle, S. University of Northern British Colombia (2008). Personal Communication

JRC/Eucar/Concawe (2007) WTT report Appendix 1, p.57

2. Soya beans to ME biodiesel

Fuel chain summary

	Carbon intensity [kg CO_2 / t biodiesel]
	Spain
1 – Crop production	2034
2 – Drying and storage	75
3 – Feedstock transport	147
4 – Conversion (crushing)	-1059
5 – Feedstock transport	0
6 – Feedstock transport	44
7 – Conversion (transesterification)	471
8 – Liquid fuel transport	0
TOTAL	**1712**

Selected default options

See current version of Technical Guidance, Part 2 – page 71-72.

Default fuel chain

See current version of Technical Guidance, Part 2 – page 73-76.

Soya beans to ME biodiesel - Default value tables

Stage / Input	Units	Feedstock country of origin

		Spain
Stage 1 – Crop Production		
Yield @ traded moisture content	[t/ha.a]	2.57
Moisture content	%	13
N fertiliser	[kg N/ha.a]	14
Type of N fertiliser		Ammonium nitrate
P fertiliser	[kg P_2O_5/ha.a]	6
Type of P fertiliser		MAP
K fertiliser	[kg K_2O/ha.a]	6
Pesticides	[kg/ha.a]	1.31
Electricity	[kWh/ha.a]	11.0
Diesel fuel consumption	[litres/ha.a]	75.6
Stage 2 – Drying and storage		
Moisture removed	%	2
Fuel for heating	[MJ/t soy]	138
Fuel type		Diesel
Electricity	[MJ/t soy]	15
Stage 3 – Feedstock Transport		
Transport distance	[km]	200
Fuel consumption	[MJ/t-km]	1.53

Stage / Input	**Units**	**Feedstock country of origin**
		Spain
Fuel type		Diesel
Stage 4 – Conversion		
Yield	[t soy oil/t soy]	0.17
Natural gas	[MJ/t soy oil]	5447
Electricity imported	[MJ/t soy oil]	1476
Co-products	Description	
Co-product 1:	Soymeal sold as animal feed	
Quantity of soy meal produced & sold as animal feed	[t soy meal/t soy oil]	4.32
Credit	[kgCO_2e/t soy meal]	-373
Stage 5 – Feedstock Transport		
Transport distance	[km]	0
Fuel consumption	[MJ/t-km]	0
Fuel type		None
Stage 6 – Feedstock Transport		
Transport distance	[km]	2640
Fuel consumption	[MJ/t-km]	0.2

Stage / Input	**Units**	**Feedstock country of origin**
		Spain
Fuel type		HFO
Stage 7 – Conversion		
Yield	[t biodiesel / t soy oil]	0.95
Natural gas	[MJ/t biodiesel]	1690
Electricity imported	[MJ/t biodiesel]	335
Methanol	kg/t biodiesel	113
Potassium hydroxide	kg/t biodiesel	26
Co-products		
Co-product 1	Crude glycerine	
Quantity of crude glycerine	[t glycerine/t biodiesel]	0.1
Market value of glycerine	[£/t glycerine]	345
Co-product 2:	Potassium sulphate	
Quantity of potassium sulphate	[t potassium sulphate /t biodiesel]	0.04
Market value of potassium sulphate	[£/t potassium sulphate]	75
Primary product: biodiesel		
Market value of biodiesel	[£/t biodiesel]	340

Stage / Input	Units	Feedstock country of origin
		Spain
Allocation factor	%	90
Stage 8 – Liquid fuel transport and storage		
Transport distance	[km]	0
Fuel consumption	[MJ/t-km]	0

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3. Sunflower to ME biodiesel

Fuel chain summary

	Carbon intensity [kg CO_2 / t biodiesel]					
	Argentina	**China**	**France**	**Russian Fed.**	**Ukraine**	**USA**
1 – Crop production	698	1802	1933	2334	2122	1933
2 – Drying and storage	66	77	62	68	68	73
3 – Feedstock transport	309	36	87	17	14	4
4 – Feedstock transport	0	94	0	18	0	0
5 – Conversion (crushing)	-486	-442	-503	-481	-480	-459
6 – Feedstock transport	199	328	7	124	111	23
7 – Feedstock transport	0	0	0	0	0	116
8 – Conversion (transesterification)	471	471	471	471	471	471
9 – Liquid fuel transport and storage	0	0	0	0	0	0
TOTAL	**1257**	**2366**	**2057**	**2551**	**2306**	**2161**

Sunflower to ME biodiesel - Selected default options

Stage	Module	Input	Options
1	Crop production	Nitrogen fertiliser emissions factor	Ammonium nitrate (AN), Ammonium sulphate (AS), Urea, Calcium nitrate (CN), Urea, Ammonium nitrate (UAN), NPK (Urea / TSP / MOP)
1	Crop production	Phosphorus fertiliser emissions factor	Triple superphosphate (TSP), Rock phosphate, Mono ammonium phosphate (MAP)
2	Drying and storage	Fuel emissions factor	Diesel, Heavy fuel oil, Coal, Natural gas
3, 4	Feedstock transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping
5	Conversion (crushing)	Fuel emissions factor	Coal, Natural gas, Heavy fuel oil, Biomass
6, 7	Feedstock transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping
8	Conversion (transesterification)	Fuel emissions factor	Coal, Natural gas, Heavy fuel oil, Biomass
9	Liquid fuel transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping

Sunflower to ME biodiesel -Default fuel chain

Stage 1 - Crop Production

Description	Cultivation and harvesting of sunflower seeds						
Basic Data							
	Units						
Yield @ traded moisture content	[t/ha.a]	*value*	Y				
Traded moisture content	%	*value*					
Soil Emissions							
				Emissions co-efficient [$kgCO_{2e}$/ha]		Total Emissions ($kgCO_{2e}$/t sunflower seeds)	
N2O emissions	[total kg N/ha.a]	*N_FERT*	x	*6.163*	÷ Y =	*calculation*	1
Farming Inputs							
		Mass of input		Emissions co-efficient [$kgCO_{2e}$/kg nutrient]		Total emissions	
N fertiliser	[kg nutrient/ha.a]	*value (N_FERT)*	x	*value*	÷ Y =	*calculation*	2
P fertiliser (P2O5)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	3
K fertiliser (K2O)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	4
Lime (CaO)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	5
				Emissions co-efficient [$kgCO_{2e}$/kg]			
Pesticides	[kg/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	6
Machinery Inputs							
Diesel fuel consumption	[litres/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	7
Totals						Total Emissions ($kgCO_{2e}$/t sunflower seeds)	
Module total					1 + 2 + 3 + 4 + 5 + 6 + 7 =	*calculation*	8
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					8 ÷ z1 ÷ z2 × AF=	*calculation*	Stage_1

Stage 2 - Drying and storage

Description	Drying and storage of sunflower seeds						
Basic Data							
Moisture removed	% by weight	*value*					
Drying and storage inputs				Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t sunflower seed)	
Fuel for heating	[MJ/t sunflower seeds]	*value*	x	*value*	=	*calculation*	9
Electricity	[MJ/t sunflower seeds]	*value*	x	*value*	=	*calculation*	10
Totals						Emissions ($kgCO_{2e}$/t sunflower seed)	
Module total					9 + 10 =	*calculation*	11
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					11 ÷ z1 ÷ z2 × AF =	*calculation*	Stage_2

Stage 3 - Feedstock Transport

Description	From farm to sunflower seed crusher						
				Emissions factor [kgCO2e/MJ]			
Transport distance	[km]	*value*	dist_1				
Fuel consumption	[MJ/t-km]	*value*	FC_1				
Totals						Emissions ($kgCO_{2e}$/t sunflower seed)	
Module total	[MJ/t sunflower seed]	*value*	x	*value*	=	*calculation*	12
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					12 ÷ z1 ÷ z2 × AF =	*calculation*	Stage_3

Stage 4 - Feedstock Transport

Description	From farm to sunflower seed crusher						
				Emissions factor [kgCO2e/MJ]			
Transport distance	[km]	*value*	dist_2				
Fuel consumption	[MJ/t-km]	*value*	FC_2				
Totals						Emissions ($kgCO_{2e}$/t sunflower seed)	
Module total	[MJ/t sunflower seed]	*value*	x	*value*	=	*calculation*	13
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					13 ÷ z1 ÷ z2 × AF =	*calculation*	Stage_4

Stage 5 - Conversion

Description	Oil extraction						
Basic Data							
Plant yield	[t sunflower oil / t sunflower seed]	*value*	z1				
Conversion Inputs							
				Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t biodiesel)	
Natural gas	[MJ/t sunflower oil]	*value*	x	*value*	=	*calculation*	14
Electricity imported	[MJ/t sunflower oil]	*value*	x	*value*	=	*calculation*	15
Co-products	**Description**	**Treatment**					
Co-product 1:	sunflower cake - sold as animal feed	Substitution					
Co-products treated by substitution							
Co-product 1: sunflower cake							
				Credit [$kgCO_{2e}$/t sunflower cake]			
- substitutes US soy meal (soybeans crushed in EU)							
Quantity of sunflower cake produced & sold as animal feed	[t sunflower cake / t sunflower oil]	*value*	x	*value*	=	*calculation*	16
Totals							
Module total					14 + 15 + 16 =	*calculation*	17
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					17 ÷ z2 × AF =	*calculation*	Stage_5

Stage 6 - Feedstock Transport

Description	From extraction facility to biodiesel plant							
				Emissions factor [kgCO2e/MJ]				
Transport distance	[km]	*value*	dist_3					
Fuel consumption	[MJ/t-km]	*value*	FC_3					
Totals						Emissions ($kgCO_{2e}$/t sunflower oil)		
Module total	[MJ / t sunflower oil]	*value*	x	*value*	=	*calculation*	18	
Contribution to fuel chain					18 ÷ z2 × AF =	*calculation*	Stage_6	

Stage 7 - Feedstock Transport

Description	From extraction facility to biodiesel plant							
				Emissions factor [kgCO2e/MJ]				
Transport distance	[km]	*value*	dist_4					
Fuel consumption	[MJ/t-km]	*value*	FC_4					
Totals						Emissions ($kgCO_{2e}$/t sunflower oil)		
Module total	[MJ / t sunflower oil]	*value*	x	*value*	=	*calculation*	19	
Contribution to fuel chain					19 ÷ z2 × AF =	*calculation*	Stage_7	

Stage 8 - Conversion

Description	Biodiesel plant							
Basic data								
Plant yield	[t biodiesel / t sunflower oil]	*value*	(z2)					
				Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t biodiesel)		
Conversion Inputs								
Natural gas	[MJ/t biodiesel]	*value*	x	*value*	=	*calculation*		20
Electricity imported	[MJ/t biodiesel]	*value*	x	*value*	=	*calculation*		21
				Emissions factor (kgCO2e/kg)				
Methanol	kg/t biodiesel	*value*	x	*value*	=	*calculation*		22
Potassium hydroxide	kg/t biodiesel	*value*	x	*value*	=	*calculation*		23
Co-products	**Description**	**Treatment**						
Co-product 1:	Crude glycerine sold as chemical	Allocation - by market value						
Co-product 2:	Potassium sulphate	Allocation - by market value						
Co-products treated by allocation by market value								
				Market value [£ / t glycerine]				
Co-product 1: Glycerine								
Quantity of crude glycerine produced	[t glycerine / t biodiesel]	*value*	x	*value*	=	*calculation*		24
				Market value [£ / t potassium sulphate]				
Co-product 2: Potassium sulphate								
Quantity of potassium sulphate produced and sold as chemical	[t potassium sulphate / t biodiesel]	*value*		*value*	=	*calculation*		25
				Market value [£ / t biodiesel]				
Primary product: biodiesel								
Market value of biodiesel				*value*	=	*calculation*		26
Total market value of products								
Total market value	[£ / t biodiesel]				24 + 25 + 26 =	*calculation*		27
Allocation factor (%age of emissions attributable to biodiesel)	%				26 ÷ 27 =	*calculation*		AF
						Total Emissions [$kgCO_{2e}$/t biodiesel]		
Totals								
Module total					(20 + 21 + 22 + 23) x AF =	*calculation*		28
Contribution to fuel chain					28 =	*calculation*		Stage_8

Stage 9 - Liquid fuel transport and storage

Description	From biodiesel plant to refinery / blending facility							
Transport distance	[km]	*value*	dist_4					
Fuel consumption	[MJ/t-km]	*value*	FC_4					
				Emissions factor [kgCO2e/MJ]		Total Emissions [$kgCO_{2e}$/t biodiesel]		
Totals								
Module total	[MJ/t biodiesel]	*value*	x	*value*	=	*calculation*		29
Contribution to fuel chain					29 =	*calculation*		Stage_9

Sunflower to ME biodiesel -Default value tables

Stage / Input	Units	Feedstock country of origin					
		Argentina	**China**	**France**	**Russian Federation**	**Ukraine**	**USA**
Stage 1 – Crop production							
Yield @ traded moisture content	[t/ha.a]	1.8	1.6	2.3	1.0	1.1	2.3
Traded moisture content	%	9	9	9	9	9	9
N fertiliser	[kg N /ha.a]	25	80	130	60	60	25
Type of N fertiliser		AN	AN	AN	AN	AN	AN
P fertiliser	[kg P_2O_5/ha.a]	5	30	80	60	60	10
Type of P fertiliser		TSP	TSP	TSP	TSP	TSP	TSP
K fertiliser	[kg K_2O/ha.a]	2	50	180	50	50	10
Lime	[kg CaO/ha.a]	271	271	271	271	271	271
Pesticides	[kg/ha.a]	0.28	0.28	0.28	0.28	0.28	0.28
Diesel fuel consumption	[litres/ha.a]	66	66	66	66	66	66

Stage / Input	Units	Feedstock country of origin					
		Argentina	**China**	**France**	**Russian Federation**	**Ukraine**	**USA**
Stage 2 – Drying and storage							
Moisture removed	% by weight	3	3	3	3	3	3
Fuel for heating	[MJ/t sunflower]	318	318	318	318	318	318
Fuel type		Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Electricity	[MJ/t sunflower]	35	35	35	35	35	35
Stage 3 – Feedstock Transport							
Transport distance	[km]	900	100	300	50	400	100
Fuel consumption	[MJ/t-km]	1.8	1.89	1.53	1.82	0.19	0.19
Fuel type		Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Stage 4 – Feedstock Transport							
Transport distance	[km]	0	1500	0	500	0	0

Stage / Input	**Units**	**Feedstock country of origin**					
		Argentina	**China**	**France**	**Russian Federation**	**Ukraine**	**USA**
Fuel consumption	[MJ/t-km]	0	0.33	0	0.19	0	0
Fuel type		Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Stage 5 – Conversion							
Plant yield	[t sunflower oil / t sunflower seed]	0.43	0.43	0.43	0.43	0.43	0.43
Natural gas	[MJ/t sunflower oil]	1986	1986	1986	1986	1986	1986
Electricity imported	[MJ/t sunflower oil]	337	337	337	337	337	337
Co-product 1: Sunflower cake – sold as animal feed							
Quantity of sunflower cake	[t rape meal / t sunflower oil]	1.32	1.32	1.32	1.32	1.32	1.32
Credit for co-product 1	[kgCO_2e/t sunflower cake]	-501	-501	-501	-501	-501	-501
Stage 6 – Feedstock Transport							

Stage / Input	**Units**	**Feedstock country of origin**					
		Argentina	**China**	**France**	**Russian Federation**	**Ukraine**	**USA**
Transport distance	[km]	12000	19800	450	7500	6700	1500
Fuel consumption	[MJ/t-km]	0.2	0.2	0.2	0.2	0.2	0.19
Fuel type		HFO	HFO	HFO	HFO	HFO	Diesel
Stage 7 – Feedstock Transport							
Transport distance	[km]	0	0	0	0	0	7000
Fuel consumption	[MJ/t-km]	0	0	0	0	0	0.2
Fuel type		None	None	None	None	None	HFO
Stage 8 – Conversion							
Plant yield	[t biodiesel / t sunflower oil]	0.95	0.95	0.95	0.95	0.95	0.95
Natural gas	[MJ/t biodiesel]	1690	1690	1690	1690	1690	1690
Electricity imported	[MJ/t biodiesel]	335	335	335	335	335	335
Methanol	kg/t biodiesel	113	113	113	113	113	113

Stage / Input	**Units**	**Feedstock country of origin**					
		Argentina	**China**	**France**	**Russian Federation**	**Ukraine**	**USA**
Potassium hydroxide	kg/t biodiesel	26	26	26	26	26	26
Co-products							
Co-product 1	Crude glycerine						
Quantity of crude glycerine	[t glycerine/ t biodiesel]	0.1	0.1	0.1	0.1	0.1	0.1
Market value of glycerine	[£/t glycerine]	345	345	345	345	345	345
Co-product 2:	Potassium sulphate						
Quantity of potassium sulphate	[t potassium sulphate /t biodiesel]	0.04	0.04	0.04	0.04	0.04	0.04
Market value of potassium sulphate	[£/t potassium sulphate]	75	75	75	75	75	75
Primary product: biodiesel							
Market value of biodiesel	[£/t biodiesel]	340	340	340	340	340	340

Stage / Input	Units	Feedstock country of origin					
		Argentina	**China**	**France**	**Russian Federation**	**Ukraine**	**USA**
Allocation factor	%	90	90	90	90	90	90
Stage 9 – Liquid fuel transport and storage							
Transport distance	[km]	0	0	0	0	0	0
Fuel consumption	[MJ/t-km]	0	0	0	0	0	0
Fuel Type		None	None	None	None	None	None

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4. Coconut to ME biodiesel

Fuel chain summary

	Carbon intensity [kg CO_2/t biodiesel]		
	India	**Philippines**	**Indonesia**
1 – Crop production	697	802	625
2 – Conversion	0	0	0
3 – Feedstock transport	6	31	88
4 – Feedstock transport	0	0	0
5 – Conversion (crushing)	-27	-75	-41
6 – Feedstock transport	20	0	0
7 – Feedstock transport	199	298	248
8 – Conversion (transesterification)	471	471	471
9 – Liquid fuel transport and storage	0	0	0
TOTAL	**1366**	**1527**	**1347**

Coconut to ME biodiesel - Selected default options

Stage	Module	Input	Options
1	Crop production	Nitrogen fertiliser emissions factor	Ammonium nitrate (AN); Ammonium sulphate (AS); Urea, Calcium nitrate (CN); Urea, Ammonium nitrate (UAN); NPK (Urea / TSP / MOP)
1	Crop production	Phosphorus fertiliser emissions factor	Triple superphosphate (TSP), Rock phosphate, Mono ammonium phosphate (MAP)
3, 4	Feedstock transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping
5	Conversion (crushing)	Fuel emissions factor	Coal, Natural gas, Heavy fuel oil, Biomass
6, 7	Feedstock transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping
8	Conversion (transesterification)	Fuel emissions factor	Coal, Natural gas, Heavy fuel oil, Biomass
9	Liquid fuel transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping

Coconut to ME biodiesel - Default fuel chain

Stage 1 - Crop Production

Description	Cultivation and harvest of coconuts						
Basic Data							
	Units						
Yield of coconuts	[t/ha.a]	*value*	Y				
Soil Emissions							
				Emissions co-efficient [$kgCO_{2e}$/ha]		Total emissions	
N2O emissions	[total kg N/ha.a]	*N_FERT*	x	*6.163*	÷ Y =	*calculation*	1
Farming Inputs							
		Mass of input		Emissions co-efficient [$kgCO_{2e}$/kg nutrient]		Total emissions	
N fertiliser	[kg nutrient/ha.a]	*value (N_FERT)*	x	*value*	÷ Y =	*calculation*	2
P fertiliser (P2O5)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	3
K fertiliser (K2O)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	4
Mg fertiliser (MgO)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	5
NPK fertiliser	[kg fertiliser/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	6
				Emissions co-efficient [$kgCO_{2e}$/kg]			
Pesticide	[kg/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	7
Machinery and transport Inputs							
				Emissions factor ($kgCO_{2e}$/l)			
Replant and production	[litres/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	8
Harvest and collection	[litres/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	9
Totals						Emissions ($kgCO_{2e}$/t coconuts)	
Module total				1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 =		*calculation*	10
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain				10 ÷ z1 ÷ z2 ÷ z3 × AF_1		*calculation*	Stage_1

Stage 2 - Drying and storage

Description	Pre-drying of coconuts							
Basic Data								
Moisture removed	% by weight	*value*						
Drying and storage inputs				Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t coconuts)		
Fuel for heating	[MJ/t pre-dried coconut]	*value*	x	*value*	=	*calculation*		11
Electricity	[MJ/t pre-dried coconut]	*value*	x	*value*	=	*calculation*		12
Totals						Emissions ($kgCO_{2e}$/t coconuts)		
Module total					11 + 12 =	*calculation*		13
						Total Emissions [$kgCO_{2e}$/t biodiesel]		
Contribution to fuel chain					13 ÷ z1 ÷ z2 ÷ z3 × AF_1 =	*calculation*		Stage_2

Stage 3 - Conversion

Description	Removal of coconut meat from shells							
Basic Data								
Coconut meat	[t meat / t coconut]	*value*	z1					
Extraction inputs				Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t coconut meat)		
Fuel for process heat	[MJ / t coconut meat]	*value*	x	*value*	=	*calculation*		14
Electricity	[MJ / t coconut meat]	*value*	x	*value*	=	*calculation*		15

Co-products	**Description**	**Treatment**
Co-product 1:	Coconut shells	Considered within system boundaries
Co-product 2:	Coir	Treated by market value allocation: market value of coir is likely to be close to zero; yield of coir is likely to be less than 0.1 tonne / tonne coconut oil. Hence market value allocation would attribute very close to 100% of emissions to the copra.

Stage 4 - Drying and storage

Description	Drying and storage of copra						
Basic Data							
Moisture removed	% by weight	*value*					
				Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t copra)	
Drying and storage inputs							
Fuel for heating	[MJ/t copra]	*value*	x	*value*	=	*calculation*	16
Electricity	[MJ/t copra]	*value*	x	*value*	=	*calculation*	17
						Emissions ($kgCO_{2e}$/t copra)	
Totals							
Module total					16 +17 =	*calculation*	18
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					18 ÷ z2 ÷ z3 × AF_1 =	*calculation*	Stage_4

Stage 5 - Feedstock Transport

Description	Transport of copra to a crushing mill						
				Emissions factor [kgCO2e/MJ]			
Transport distance	[km]	*value*	dist_1				
Fuel consumption	[MJ/t-km]	*value*	FC_1				
						Emissions ($kgCO_{2e}$/t copra)	
Totals							
Module total	[MJ/t copra]	*value*	x	*value*	=	*calculation*	19
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					19 ÷ z2 ÷ z3 × AF_1 =	*calculation*	Stage_5

Stage 6 - Feedstock Transport

Description	Transport of copra to a crushing mill						
				Emissions factor [kgCO2e/MJ]			
Transport distance	[km]	*value*	dist_2				
Fuel consumption	[MJ/t-km]	*value*	FC_2				
						Emissions ($kgCO_{2e}$/t copra)	
Totals							
Module total	[MJ/t copra]	*value*	x	*value*	=	*calculation*	20
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					20 ÷ z2 ÷ z3 × AF_1 =	*calculation*	Stage_6

Stage 7 - Conversion

Description	Crushing of copra to coconut oil						
Basic Data							
Palm oil mill yield	[t coconut oil / t copra]	*value*	z2				
						Emissions ($kgCO_{2e}$/t coconut oil)	
Extraction Inputs							
Fuel for process heat	[MJ/t coconut oil]	*value*	x	*value*	=	*calculation*	21
Electricity for process	[MJ/t coconut oil]	*value*	x	*value*	=	*calculation*	22
Co-products	**Description**	**Treatment**					
Co-product 1:	Copra cake	Substitution					
Co-products treated by substitution							
Co-product 1: rape meal							
- substitutes US soy meal				Credit [$kgCO_{2e}$/t copra cake]			
Quantity of copra cake produced & sold as animal feed	[t copra cake / t coconut oil]	*value*	x	*value*	=	*calculation*	23
Totals							
Module total					21 + 22 + 23 =	*calculation*	24
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					24 ÷ z3 × AF_1 =	*calculation*	Stage_7

Stage 8 - Feedstock Transport

Description	Transport of coconut oil from mill to port						
				Emissions factor [kgCO2e/MJ]			
Transport distance	[km]	*value*	dist_3				
Fuel consumption	[MJ/t-km]	*value*	FC_3				
						Emissions ($kgCO_{2e}$/t CPO)	
Totals							
Module total	[MJ/t CPO]	*value*	x	*value*	=	*calculation*	25
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					25 ÷ z3 × AF_1 =	*calculation*	Stage_8

Stage 9 - Feedstock Transport

Description	Transport of coconut oil from port to biodiesel plant						
				Emissions factor [kgCO2e/MJ]			
Transport distance	[km]	*value*	dist_4				
Fuel consumption	[MJ/t-km]	*value*	FC_4				
						Emissions ($kgCO_{2e}$/t CPO)	
Totals							
Module total	[MJ/t CPO]	*value*	x	*value*	=	*calculation*	26
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					26 ÷ z3 × AF_1 =	*calculation*	Stage_9

Stage 10 - Conversion

Description	Biodiesel plant							
Basic data								
Biodiesel plant yield	[t biodiesel / t coconut oil]	*value*	z3					
				Emissions factor [kgCO2e/MJ]			Emissions ($kgCO_{2e}$/t biodiesel)	
Conversion Inputs								
Natural gas	[MJ/t biodiesel]	*value*	x	*value*	=		*calculation*	27
Electricity imported	[MJ/t biodiesel]	*value*	x	*value*	=		*calculation*	28
				Emissions factor (kgCO2e/kg)				
Methanol	kg/t biodiesel	*value*	x	*value*	=		*calculation*	29
Potassium hydroxide	kg/t biodiesel	*value*	x	*value*	=		*calculation*	30

Co-products	**Description**	**Treatment**
Co-product 1:	Crude glycerine sold as chemical	Allocation - by market value
Co-product 2:	Potassium sulphate	Allocation - by market value

Co-products treated by allocation by market value

				Market value [£ / t glycerine]				
Co-product 1: crude glycerine								
Quantity of crude glycerine produced	[t glycerine / t biodiesel]	*value*	x	*value*	=		*calculation*	31
				Market value [£ / t potassium sulphate]				
Co-product 2: Potassium sulphate								
Quantity of potassium sulphate produced and sold as chemical	[t potassium sulphate / t biodiesel]	*value*		*value*	=		*calculation*	32
				Market value [£ / t biodiesel]				
Primary product: biodiesel								
Market value of biodiesel				*value*	=		*calculation*	33
Total market value of products								
Total market value	[£ / t biodiesel]						*calculation*	34
Allocation factor (%age of emissions attributable to biodiesel)	%					33 ÷ 34 x 100 =	*calculation*	AF_1
							Total Emissions ($kgCO_{2e}$/t biodiesel]	
Totals								
Module total						(27 + 28 + 29 + 30) x AF_1 =	*calculation*	35
Contribution to fuel chain						35 =	*calculation*	Stage_10

Stage 11 - Liquid fuel transport and storage

Description	Transport from biodiesel plant to refinery / blending facility		
Transport distance	[km]	*value*	dist_5
Fuel consumption	[MJ/t-km]	*value*	FC_5

							Total Emissions ($kgCO_{2e}$/t biodiesel]	
Totals								
Module total	[MJ/t biodiesel]	*value*	x	*value*	=		*calculation*	36
Contribution to fuel chain						36 =	*calculation*	Stage_11

Coconut to ME biodiesel - Default value tables

Stage / Input	Units	Feedstock country of origin		
		India	Philippines	Indonesia
Stage 1 – Crop Production				
Yield of coconuts (i.e. flesh, shell but no husk)	[t/ha.a]	4.93	4.36	6.03
N fertiliser	[kg N/ha.a]	63	55	70
Type of N fertiliser		Urea	Urea	Urea
P fertiliser	[kg P_2O_5/ha.a]	20	17	22
Type of P fertiliser		Rock	Rock	Rock
K fertiliser	[kg K_2O/ha.a]	23	20	25
Pesticides	[kg/ha.a]	3	3	3
Diesel fuel consumption	[litres/ha.a]	25	25	25
Stage 2 – Conversion				
Yield of copra from coconut	[t copra / t coconut]	0.252	0.223	0.249
Fuel used	[MJ/t copra]	0	0	0
Fuel type		None	None	None
Stage 3 – Feedstock Transport				
Transport distance	[km]	27	140	200
Fuel consumption	[MJ/t-km]	1.94	1.8	1.8

Stage / Input	**Units**	**Feedstock country of origin**		
		India	**Philippines**	**Indonesia**
Fuel type		Diesel	Diesel	Diesel
Stage 4 – Conversion				
Yield	[t coconut oil /t copra]	0.67	0.67	0.67
Natural gas	[MJ /t coconut oil]	0	0	0
Electricity imported	[MJ /t coconut oil]	403.2	403.2	403.2
Co-products	Description			
Co-product 1:	Coconut cake sold as animal feed			
Quantity of soy meal produced & sold as animal feed	[t coconut cake /t coconut oil]	0.552	0.552	0.552
Credit	[kgCO_2e /t coconut cake]	-236	-236	-236
Stage 5 – Feedstock Transport				
Transport distance	[km]	1300	0	0
Fuel consumption	[MJ/t-km]	0.19	0	0
Fuel type		Diesel	None	None
Stage 6 – Feedstock Transport				
Transport distance	[km]	12000	18000	15000

Stage / Input	**Units**	**Feedstock country of origin**		
		India	**Philippines**	**Indonesia**
Fuel consumption	[MJ/t-km]	0.2	0.2	0.2
Fuel type		HFO	HFO	HFO
Stage 7 – Conversion				
Yield	[t biodiesel / t soy oil]	0.95	0.95	0.95
Natural gas	[MJ/t biodiesel]	1690	1690	1690
Electricity imported	[MJ/t biodiesel]	335	335	335
Methanol	kg/t biodiesel	113	113	113
Potassium hydroxide	kg/t biodiesel	26	26	26
Co-products				
Co-product 1	Crude glycerine			
Quantity of crude glycerine	[t glycerine /t biodiesel]	0.1	0.1	0.1
Market value of glycerine	[£/t glycerine]	345	345	345
Co-product 2:	Potassium sulphate			
Quantity of potassium sulphate	[t potassium sulphate /t biodiesel]	0.04	0.04	0.04
Market value of potassium sulphate	[£/t potassium sulphate]	75	75	75
Primary product: biodiesel				

Stage / Input	Units	Feedstock country of origin		
		India	Philippines	Indonesia
Market value of biodiesel	[£/t biodiesel]	340	340	340
Allocation factor	%	90.07	90.07	90.07
Stage 8 – Liquid fuel transport and storage				
Transport distance	[km]	0	0	0
Fuel consumption	[MJ/t-km]	0	0	0
Fuel type		None	None	None

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5. Jatropha to ME biodiesel

Fuel chain summary

	Carbon intensity [kg CO_2/t biodiesel]
	India
1 – Crop production	392
2 – Conversion	0
3 – Drying and storage	0
4 – Feedstock transport	14
5 – Feedstock transport	0
6 – Conversion (crushing)	41
7 – Feedstock transport	20
8 – Feedstock transport	199
9 – Conversion (transesterification)	461
10 – Liquid fuel transport and storage	0
TOTAL	**1137**

Jatropha to ME biodiesel - Selected default options

Stage	Module	Input	Options
1	Crop production	Nitrogen fertiliser emissions factor	Ammonium nitrate (AN); Ammonium sulphate (AS); Urea, Calcium nitrate (CN); Urea Ammonium nitrate (UAN); NPK (Urea / TSP / MOP)
1	Crop production	Phosphorus fertiliser emissions factor	Triple superphosphate (TSP), Rock phosphate, Mono ammonium phosphate (MAP)
3	Drying and storage	Fuel emissions factor	Coal, Natural gas, Heavy fuel oil, Biomass
4, 5	Feedstock transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping
6	Conversion (crushing)	Fuel emissions factor	Coal, Natural gas, Heavy fuel oil, Biomass
7, 8	Feedstock transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping
9	Conversion (transesterification)	Fuel emissions factor	Coal, Natural gas, Heavy fuel oil, Biomass
10	Liquid fuel transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping

Stage 1 - Crop Production

Description	Cultivation and harvest of jatropha fruit						
Basic Data							
	Units						
Yield of jatropha fruit	[t/ha.a]	*value*	Y				
Soil Emissions							
				Emissions co-efficient [$kgCO_{2e}$/ha]		Total emissions	
N2O emissions	[total kg N/ha.a]	*N_FERT*	x	*6.163*	÷ Y =	*calculation*	1
Farming Inputs							
				Emissions co-efficient [$kgCO_{2e}$/kg nutrient]			
		Mass of input				Total emissions	
N fertiliser	[kg nutrient/ha.a]	*value (N_FERT)*	x	*value*	÷ Y =	*calculation*	2
P fertiliser (P2O5)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	3
K fertiliser (K2O)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	4
				Emissions co-efficient [$kgCO_{2e}$/kg]			
Pesticide	[kg/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	5
Machinery and transport Inputs							
				Emissions factor ($kgCO_{2e}$/l)			
Replant and production	[litres/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	6
Harvest and collection	[litres/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	7
Totals						Emissions ($kgCO_{2e}$/t FFB)	
Module total					1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 =	*calculation*	8
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					10 ÷ z1 ÷ z2 ÷ z3 × AF_1	*calculation*	Stage_1

Stage 2 - Conversion

Description	Seed separation from fruit							
Basic Data								
Seed yield	[t seeds / t fruit]	*value*	z1					
Energy inputs for seed separation					Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t jatropha seeds)	
Fuel for process	[MJ/t seeds]	*value*		x	*value*	=	*calculation*	9
Electricity	[MJ/t seeds]	*value*		x	*value*	=	*calculation*	10
Co-products	**Description**	**Treatment**						
Co-product 1:	Fruit husks	Considered within system boundaries						
Totals							Emissions ($kgCO_{2e}$/t jatropha oil)	
Module total						11 + 12 =	*calculation*	11
							Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain						13 ÷ z2 ÷ z3 × AF_1 =	*calculation*	Stage_2

Stage 3 - Drying and storage

Description	Seed separation and drying and storage of seeds							
Drying - Basic Data								
Moisture removed	% by weight	*value*						
Drying and storage inputs					Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t copra)	
Fuel for heating	[MJ/t seeds]	*value*		x	*value*	=	*calculation*	12
Electricity	[MJ/t seeds]	*value*		x	*value*	=	*calculation*	13
Totals							Emissions ($kgCO_{2e}$/t copra)	
Module total						14 + 15 =	*calculation*	14
							Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain						16 ÷ z2 ÷ z3 × AF_1 =	*calculation*	Stage_3

Stage 4 - Feedstock Transport

Description	Transport of dried jatropha seeds to crushing plants							
					Emissions factor [kgCO2e/MJ]			
Transport distance	[km]	*value*	dist_1					
Fuel consumption	[MJ/t-km]	*value*	FC_1					
Totals							Emissions ($kgCO_{2e}$/t FFB)	
Module total	[MJ/t FFB]	*value*		x	*value*	=	*calculation*	15
							Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain						17 ÷ z2 ÷ z3 × AF_1 =	*calculation*	Stage_4

Stage 5 - Feedstock Transport

Description	Transport of dried jatropha seeds to crushing plants							
				Emissions factor [kgCO2e/MJ]				
Transport distance	[km]	*value*	dist_2					
Fuel consumption	[MJ/t-km]	*value*	FC_2					
Totals							Emissions ($kgCO_{2e}$/t FFB)	
Module total	[MJ/t FFB]	*value*	x	*value*	=		*calculation*	16
							Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					18 ÷ z2 ÷ z3 × AF_1 =		*calculation*	Stage_5

Stage 6 - Conversion

Description	Processing jatropha seeds to extract oil							
Basic Data								
Jatropha oil yield	[t jatropha oil / t seeds]	*value*	z2					
							Emissions ($kgCO_{2e}$/t jatropha oil)	
Extraction Inputs				Emissions factor [kgCO2e/MJ]				
Fuel for process	[MJ/t jatropha oil]	*value*	x	*value*	=		*calculation*	17
Electricity	[MJ/t jatropha oil]	*value*	x	*value*	=		*calculation*	18
				Emissions factor [kgCO2e/MJ]				
Co-products	**Description**	**Treatment**						
Co-product 1:	jatropha cake	Considered within system boundaries						
							Emissions ($kgCO_{2e}$/t jatropha oil)	
Totals								
Module total					19 + 20 + 21 =		*calculation*	19
							Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					22 ÷ z3 × AF_1 =		*calculation*	Stage_6

Stage 7 - Feedstock Transport

Description	Transport of jatropha oil from the crusher to the port							
				Emissions factor [kgCO2e/MJ]				
Transport distance	[km]	*value*	dist_3					
Fuel consumption	[MJ/t-km]	*value*	FC_3					
							Emissions ($kgCO_{2e}$/t jatropha oil)	
Totals								
Module total	[MJ/t jatropha oil]	*value*	x	*value*	=		*calculation*	20
							Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					23 ÷ z3 × AF_1 =		*calculation*	Stage_7

Stage 8 - Feedstock Transport

Description	Transport of jatropha oil from the port to the biodiesel plant							
					Emissions factor [kgCO2e/MJ]			
Transport distance	[km]	*value*	dist_4					
Fuel consumption	[MJ/t-km]	*value*	FC_4					
							Emissions ($kgCO_{2e}$/t jatropha oil)	
Totals								
Module total	[MJ/t jatropha oil]	*value*		x	*value*	=	*calculation*	21
							Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain						24 ÷ z3 × AF_1 =	*calculation*	Stage_8

Stage 9 - Conversion

Description	Biodiesel plant							
Basic data								
Biodiesel plant yield	[t biodiesel / t jatropha oil]	*value*	z3					
					Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t biodiesel)	
Conversion Inputs								
Natural gas	[MJ/t biodiesel]	*value*		x	*value*	=	*calculation*	22
Electricity imported	[MJ/t biodiesel]	*value*		x	*value*	=	*calculation*	23
					Emissions factor (kgCO2e/kg)			
Methanol	kg/t biodiesel	*value*		x	*value*	=	*calculation*	24
Potassium hydroxide	kg/t biodiesel	*value*		x	*value*	=	*calculation*	25
Co-products	**Description**	**Treatment**						
Co-product 1:	Crude glycerine sold as chemical	Allocation - by market value						
Co-product 2:	Potassium sulphate	Allocation - by market value						
Co-products treated by allocation by market value								
					Market value [£ / t glycerine]			
Co-product 1: crude glycerine								
Quantity of crude glycerine produced	[t glycerine / t biodiesel]	*value*		x	*value*	=	*calculation*	26
					Market value [£ / t potassium sulphate]			
Co-product 2: Potassium sulphate								
Quantity of potassium sulphate produced and sold as chemical	[t potassium sulphate / t biodiesel]	*value*			*value*	=	*calculation*	27
					Market value [£ / t biodiesel]			
Primary product: biodiesel								
Market value of biodiesel					*value*	=	*calculation*	28
Total market value of products								
Total market value	[£ / t biodiesel]					29 + 30 + 31 =	*calculation*	29
Allocation factor (%age of emissions attributable to biodiesel)	%					31 ÷ 32 x 100 =	*calculation*	AF_1
							Total Emissions [$kgCO_{2e}$/t biodiesel]	
Totals								
Module total						(25 + 26 + 27 + 28) x AF_1 =	*calculation*	30
Contribution to fuel chain						33 =	*calculation*	Stage_9

Stage 10 - Liquid fuel transport and storage

Description	Transport from biodiesel plant to refinery / blending facility							
Transport distance	[km]	*value*	dist_5					
Fuel consumption	[MJ/t-km]	*value*	FC_5					
Totals							Total Emissions [$kgCO_{2e}$/t biodiesel]	
Module total	[MJ/t biodiesel]	*value*	x	*value*	=		*calculation*	31
Contribution to fuel chain						34 =	*calculation*	Stage_10

Jatropha to ME biodiesel - Default value tables

Stage / Input	**Units**	**Feedstock country of origin**
		India
Stage 1 – Crop Production		
Yield @ traded moisture content	[t/ha.a]	2.270
N fertiliser	[kg N/ha.a]	26
Type of N fertiliser		Urea
P fertiliser	[kg P_2O_5/ha.a]	11.55
Type of P fertiliser		Rock
P fertiliser	[kg P_2O_5/ha.a]	27
Type of P fertiliser		Rock
K fertiliser	[kg K_2O/ha.a]	56.95
Pesticides	[kg/ha.a]	0
Diesel fuel consumption	[litres/ha.a]	0
Stage 2 – Conversion		

Stage / Input	**Units**	**Feedstock country of origin**
		India
Yield of seeds	[t seeds / t fruit]	0.740
Fuel for process	[MJ/t seeds]	0
Fuel type		None
Electricity	[MJ/t seeds]	0
Stage 3 – Drying and storage		
Fuel consumption	[MJ/t seeds]	0
Fuel type		None
Electricity	[MJ/t seeds]	0
Stage 4 – Feedstock transport		
Transport distance	[km]	27
Fuel consumption	[MJ/t-km]	1.94
Fuel type		Diesel
Stage 5 – Feedstock Transport		
Transport distance	[km]	0
Fuel consumption	[MJ/t-km]	0
Fuel type		None
Stage 6 – Conversion		
Yield	[t biodiesel	0.313

Stage / Input	**Units**	**Feedstock country of origin**
		India
	/ t jatropha oil]	
Fuel for process	[MJ/t biodiesel]	0
Fuel type		None
Electricity imported	[MJ/t biodiesel]	170
Co-products		
Co-product 1	Jatropha cake – considered within system boundaries	
Stage 7 – Feedstock transport		
Transport distance	[km]	1300
Fuel consumption	[MJ/t-km]	0.19
Fuel type		Diesel
Stage 8 – Feedstock transport		
Transport distance	[km]	12000
Fuel consumption	[MJ/t-km]	0.2
Fuel type		HFO
Stage 9 – Conversion		
Yield	[t biodiesel /t jatropha oil]	0.95
Fuel for process	[MJ/t biodiesel]	1521

Stage / Input	**Units**	**Feedstock country of origin**
		India
Fuel type		Natural gas
Electricity imported	[MJ/t biodiesel]	335
Methanol	[kg/t biodiesel]	113
Potassium hydroxide	[kg/t biodiesel]	26
Co-products		
Co-product 1	Crude glycerine	
Quantity of crude glycerine	[t glycerine /t biodiesel]	0.1
Market value of glycerine	[£/t glycerine]	345
Co-product 2:	Potassium sulphate	
Quantity of potassium sulphate	[t potassium sulphate /t biodiesel]	0.04
Market value of potassium sulphate	[£/t potassium sulphate]	75
Primary product: biodiesel		
Market value of biodiesel	[£/t biodiesel]	340
Allocation factor	%	90.07
Stage 9 – Liquid fuel transport and storage		

Stage / Input	**Units**	**Feedstock country of origin**
		India
Transport distance	[km]	0
Fuel consumption	[MJ/t-km]	0
Fuel type		None

6. HVO biodiesel

Calculation of default values for HVO biodiesel from the new vegetable oils (i.e. sunflower, jatropha & coconut) follows the same approach taken in the existing technical guidance – see, for example, Part 2 – page 105.

7. Co-processed HVO biodiesel

Fuel chain summary: CHVO from Rapeseed oil

	Carbon intensity [kg CO_2 / t biodiesel]								
Module	**Australia**	**Canada**	**Finland**	**France**	**Germany**	**Poland**	**Ukraine**	**UK**	**USA**
1 - Crop production	2262	2168	2227	1862	1870	1726	2373	2276	3732
2 - Drying and storage	0	76	78	73	83	88	80	83	85
3 - Feedstock transport	26	128	34	102	102	102	73	34	33
4 – Feedstock transport	811	0	0	0	0	0	104	0	0
5 – Conversion (crushing)	-549	-573	-566	-589	-545	-528	-548	-548	-537
6 – Feedstock transport	40	93	71	33	49	61	58	44	27
7 - Feedstock transport	0	0	0	0	0	0	0	0	122
8 – Conversion (hydrogenation)	511	511	511	511	511	511	511	511	511
9 – Liquid fuel transport	40	40	40	40	40	40	40	40	40
TOTAL	**3141**	**2443**	**2395**	**2032**	**2110**	**2000**	**2691**	**2440**	**4013**

Fuel chain summary: CHVO from Soy oil

	Carbon intensity [kg CO_2 / t biodiesel]				
Module	**Argentina**	**Brazil**	**USA**	**Canada**	**Spain**
1 - Crop production	2138	2413	2816	2704	2380
2 - Drying and storage	85	80	71	84	88
3 - Feedstock transport	335	1522	82	82	172
4 – Conversion (crushing)	-1288	-1377	-1152	-1312	-1239
5 – Feedstock transport	0	0	27	18	0
6 - Feedstock transport	200	181	122	93	7
7 – Conversion (hydrogenation)	511	511	511	511	511
8 – Liquid fuel transport	40	40	40	40	40
TOTAL	**2021**	**3370**	**2517**	**2220**	**1959**

Fuel chain summary: CHVO from Palm oil

	Carbon intensity [kg CO_2 / t biodiesel]	
Module	**Indonesia**	**Malaysia**
1 - Crop production	366	403
2 – Feedstock transport	13	13
3 – Conversion (palm oil extraction)	609	609
4 – Feedstock transport	74	46
5 – Conversion (palm oil refining)	137	128
6 - Feedstock transport	266	250
7 – Conversion (hydrogenation)	511	511
8 – Liquid fuel transport	40	40
TOTAL	**2016**	**2000**

Fuel chain summary: CHVO from Sunflower oil

	Carbon intensity [kg CO_2 / t biodiesel]					
Module	**Argentina**	**China**	**France**	**Russian Fed.**	**Ukraine**	**USA**
1 - Crop production	817	2109	2262	2731	2483	2262
2 - Drying and storage	77	90	73	80	80	85
3 - Feedstock transport	362	42	102	20	16	5
4 – Feedstock transport	0	110	0	21	0	0
5 – Conversion (crushing)	-569	-517	-589	-563	-562	-537
6 - Feedstock transport	200	334	33	77	61	27
7 – Feedstock transport	0	0	0	0	0	122
8 – Conversion (hydrogenation)	511	511	511	511	511	511
9 – Liquid fuel transport and storage	40	40	40	40	40	40
TOTAL	**1438**	**2719**	**2432**	**2917**	**2629**	**2515**

Fuel chain summary: CHVO from Coconut oil

	Carbon intensity [kg CO_2/t biodiesel]		
Module	**India**	**Philippines**	**Indonesia**
1 - Crop production	731	816	939
2 - Drying and storage	0	0	0
3 - Feedstock transport	103	7	36
4 – Feedstock transport	0	0	0
5 – Conversion (crushing)	-48	-32	-88
6 – Feedstock transport	0	24	0
7 - Feedstock transport	266	186	306
8 – Conversion (hydrogenation)	511	511	511
9 – Liquid fuel transport	40	40	40
TOTAL	**1603**	**1552**	**1744**

Fuel chain summary: CHVO from Jatropha oil

	Carbon intensity [kg CO_2 / t biodiesel]
Module	**India**
1 - Crop production	459
2 – Conversion	0
3 – Drying and storage	0
4 – Feedstock transport	16
5 – Feedstock transport	0
6 – Conversion (crushing)	48
7 - Feedstock transport	24
8 – Feedstock transport	186
9 – Conversion (hydrogenation)	511
10 – Liquid fuel transport and storage	40
TOTAL	**1284**

Fuel chain summary: CHVO from Tallow

	Carbon intensity [kg CO_2 / t biodiesel]		
Module	**Denmark**	**UK**	**USA**
1 - Feedstock transport	37	7	27
2 – Feedstock transport	48	44	122
3 – Conversion (hydrogenation)	511	511	511
4 – Liquid fuel transport	40	40	40
TOTAL	**636**	**602**	**700**

Co-processed HVO biodiesel - Default fuel chain

The example given below is for the production of Co-processed HVO from rapeseed oil. Stages 1-5 are identical to the fuel chain given for OSR to ME biodiesel.

Stage 6 - Feedstock Transport

Description	From extraction facility to hydrogenation plant							
					Emissions factor [kgCO2e/MJ]			
Transport distance	[km]	*value*	dist_3					
Fuel consumption	[MJ/t-km]	*value*	FC_3					
Totals							Emissions ($kgCO_{2e}$/t rapeseed oil)	
Module total	[MJ / t rapeseed oil]	*value*	x	*value*	=		*calculation*	19
Contribution to fuel chain						19 ÷ z2 =	*calculation*	Stage_6

Stage 7 - Conversion

Description	Hydrogenation plant							
Basic data								
Plant yield	[t HVO biodiesel / t rapeseed oil]	*value*	(z2)					
Conversion Inputs					Emissions factor [kgCO2e / MJ]		Emissions [$kgCO_{2e}$/t HVO diesel]	
Natural gas	[MJ/t HVO biodiesel]	*value*	x		*value*	=	*calculation*	20
Electricity	[MJ/t HVO biodiesel]	*value*	x		*value*	=	*calculation*	21
Totals							Total Emissions [$kgCO_{2e}$/t HVO biodiesel]	
Module total						20 + 21 =	*calculation*	22
Contribution to fuel chain						22 =	*calculation*	Stage_7

Stage 8 - Liquid fuel transport and storage

Description	From HVO biodiesel plant to refinery / blending facility							
Transport distance	[km]	*value*	dist_4					
Fuel consumption	[MJ/t-km]	*value*	FC_4					
Totals					Emissions factor [kgCO2e/MJ]		Total Emissions [$kgCO_{2e}$/t HVO biodiesel]	
Module total	[MJ/t HVO biodiesel]	*value*	x		*value*	=	*calculation*	23
Contribution to fuel chain						23 =	*calculation*	Stage_8

Co-processed HVO biodiesel - Default value fuel tables

The conversion stage for all countries and all vegetables oils will be identical and so only one default value is shown below for each of the inputs in the conversion stage

Stage / Input	Units	Default value
Stage – Conversion		
Plant yield	[t CHVO/t biodiesel]	0.902
Fuel input*	[MJ/t CHVO biodiesel]	7000
Fuel type		Natural gas
Electricity imported	[MJ/t CHVO biodiesel]	231
Heavy Fuel Oil input	[MJ/t CHVO biodiesel]	572

* Includes natural gas used to produce hydrogen.

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JEC (2008) quoting GEMIS, version 4.1.3.2: http://www.oeko-institut.org/service/gemis/index/htm

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8. Oil seed rape (OSR) to pure plant oil

Fuel chain summary

	Carbon intensity [kg CO_2 / t biodiesel]								
Module	**Australia**	**Canada**	**Finland**	**France**	**Germany**	**Poland**	**Ukraine**	**United Kingdom**	**United States**
1 - Crop production	2039	1955	2008	1678	1685	1556	2139	2052	3364
2 - Drying and storage	0	69	71	66	75	79	72	75	77
3 - Feedstock transport	23	115	31	92	92	92	65	31	29
4 – Feedstock transport	731	0	0	0	0	0	93	0	0
5 – Conversion (crushing)	-494	-517	-510	-531	-491	-476	-494	-494	-484
6 – Liquid fuel transport and storage	9	91	35	8	11	26	0	0	25
7 – Liquid fuel transport and storage	0	0	0	0	0	0	0	0	122
TOTAL	2308	1713	1635	1313	1372	1277	1875	1664	3133

Oil seed rape (OSR) to pure plant oil - Selected default options

Stage	Module	Input	Options
1	Crop production	Nitrogen fertiliser emissions factor	Ammonium nitrate (AN); Ammonium sulphate (AS); Urea, Calcium nitrate (CN); Urea, Ammonium nitrate (UAN); NPK (Urea / TSP / MOP)
1	Crop production	Phosphorus fertiliser emissions factor	Triple superphosphate (TSP); Rock phosphate; Mono ammonium phosphate (MAP)
2	Drying and storage	Fuel emissions factor	Diesel, Heavy fuel oil, Coal, Natural gas
3, 4	Feedstock transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping
5	Conversion (crushing)	Fuel emissions factor	Coal, Natural gas, Heavy fuel oil, Biomass
6,7	Liquid fuel transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping

Stage 1 - Crop Production

Description	Cultivation and harvesting of oilseed rape						
Basic Data							
	Units						
Yield @ traded moisture content	[t/ha.a]	*value*	Y				
Traded moisture content	%	*value*					
Soil Emissions							
				Emissions co-efficient [$kgCO_{2e}$/ha]		Total Emissions ($kgCO_{2e}$/t OSR)	
N2O emissions	[total kg N/ha.a]	*N_FERT*	x	*6.163*	÷ Y =	*calculation*	1
Farming Inputs							
		Mass of input		Emissions co-efficient [$kgCO_{2e}$/kg nutrient]		Total emissions	
N fertiliser	[kg nutrient/ha.a]	*value (N_FERT)*	x	*value*	÷ Y =	*calculation*	2
P fertiliser (P2O5)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	3
K fertiliser (K2O)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	4
Lime (CaO)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	5
				Emissions co-efficient [$kgCO_{2e}$/kg]			
Pesticides	[kg/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	6
Machinery Inputs							
Diesel fuel consumption	[litres/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	7
Totals						Total Emissions ($kgCO_{2e}$/t OSR)	
Module total					1 + 2 + 3 + 4 + 5 + 6 + 7 =	*calculation*	8
						Total Emissions [kgCO2e/t pure plant oil]	
Contribution to fuel chain					8 ÷ z1 =	*calculation*	Stage_1

Stage 2 - Drying and storage

Description	Drying and storage of oilseed rape						
Basic Data							
Moisture removed	% by weight	*value*					
				Emissions factor [kgCO2e/MJ]		Emissions ($kgCO_{2e}$/t OSR)	
Drying and storage inputs							
Fuel for heating	[MJ/t OSR]	*value*	x	*value*	=	*calculation*	9
Electricity	[MJ/t OSR]	*value*	x	*value*	=	*calculation*	10
Totals						Emissions ($kgCO_{2e}$/t OSR)	
Module total					9 + 10 =	*calculation*	11
						Total Emissions [$kgCO_{2e}$/t biodiesel]	
Contribution to fuel chain					11 ÷ z1 =	*calculation*	Stage_2

Stage 4 - Feedstock Transport

Description	From farm to oilseed crusher							
				Emissions factor [kgCO2e/MJ]				
Transport distance	[km]	*value*	dist_2					
Fuel consumption	[MJ/t-km]	*value*	FC_2					
						Emissions ($kgCO_{2e}$/t OSR)		
Totals								
Module total	[MJ/t OSR]	*value*	x	*value*	=	*calculation*	13	
						Total Emissions [kgCO2e/t pure plant oil]		
Contribution to fuel chain					13 ÷ z1 =	*calculation*	Stage_4	

Stage 5 - Conversion

Description	Oil extraction							
Basic Data								
Plant yield	[t rapeseed oil / t oilseed rape]	*value*	z1					
Conversion Inputs								
				Emissions factor [kgCO2e/MJ]		Emissions (kgCO2e/t pure plant oil)		
Natural gas	[MJ/t rapeseed oil]	*value*	x	*value*	=	*calculation*	14	
Electricity imported	[MJ/t rapeseed oil]	*value*	x	*value*	=	*calculation*	15	
Co-products	**Description**	**Treatment**						
Co-product 1:	Rape meal - sold as animal feed	Substitution						
Co-products treated by substitution								
Co-product 1: rape meal								
- substitutes US soy meal (soybeans crushed in EU)				Credit [$kgCO_{2e}$/t rape meal]				
Quantity of rape meal produced & sold as animal feed	[t rape meal / t rapeseed oil]	*value*	x	*value*	=	*calculation*	16	
Totals								
Module total					14 + 15 + 16 =	*calculation*	17	
						Total Emissions [kgCO2e/t pure plant oil]		
Contribution to fuel chain					17 =	*calculation*	Stage_5	

Stage 6 - Liquid fuel transport and storage

Description	From crusher to duty point							
				Emissions factor [kgCO2e/MJ]				
Transport distance	[km]	*value*	dist_3					
Fuel consumption	[MJ/t-km]	*value*	FC_3					
						Emissions ($kgCO_{2e}$/t rapeseed oil)		
Totals								
Module total	[MJ / t rapeseed oil]	*value*	x	*value*	=	*calculation*	18	
Contribution to fuel chain					18 =	*calculation*	Stage_6	

Stage 7 - Liquid fuel transport and storage

Description	From extraction facility to blending facility							
				Emissions factor [kgCO2e/MJ]				
Transport distance	[km]	*value*	dist_4					
Fuel consumption	[MJ/t-km]	*value*	FC_4					
Totals						Emissions ($kgCO_{2e}$/t rapeseed oil)		
Module total	[MJ / t rapeseed oil]	*value*	x	*value*	=	*calculation*	19	
Contribution to fuel chain					19 =	*calculation*	Stage_7	

Stage 8 - Liquid fuel transport and storage

Description	Transport from pure plant oil plant to refinery / blending facility							
Transport distance	[km]	*value*	dist_5					
Fuel consumption	[MJ/t-km]	*value*	FC_5					
Totals						Total Emissions [kgCO2e/t pure plant oil]		
Module total	[MJ/t pure plant oil]	*value*	x	*value*	=	*calculation*	20	
Contribution to fuel chain					20 =	*calculation*	Stage_8	

Oil seed rape (OSR) to pure plant oil - Default value fuel tables

Stage / Input	Units	Feedstock country of origin								
		Australia	**Canada**	**Finland**	**France**	**Germany**	**Poland**	**Ukraine**	**United Kingdom**	**USA**
Stage 1 – Crop production										
Yield @ traded moisture content	[t/ha.a]	1.19	1.46	1.30	3.18	3.44	2.38	1.12	3.03	1.56
Traded moisture content	%	9	9	9	9	9	9	9	9	9
N fertiliser	[kg N /ha.a]	61	75	67	155	170	102	60	185	150
Type of N fertiliser		AN	AN	AN	AN	AN	AN	AN	AN	AN
P fertiliser	[kg P_2O_5 /ha.a]	16	20	18	45	45	35	15	45	120
Type of P fertiliser		TSP	TSP	TSP	TSP	TSP	TSP	TSP	TSP	TSP
K fertiliser	[kg K_2O /ha.a]	12	15	13	80	90	44	12	48	80

Stage / Input	Units	Feedstock country of origin								
		Australia	**Canada**	**Finland**	**France**	**Germany**	**Poland**	**Ukraine**	**United Kingdom**	**USA**
Lime	[kg CaO /ha.a]	271	271	271	271	271	271	271	271	271
Pesticides	[kg/ha.a]	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Diesel fuel consumption	[litres /ha.a]	66	66	66	66	66	66	66	66	66
Stage 2 – Drying and storage										
Moisture removed	% by weight	0	3	3	3	3	3	3	3	3
Fuel for heating	[MJ /t OSR]	0	318	318	318	318	318	318	318	318
Fuel type		None	Diesel							
Electricity	[MJ /t OSR]	0	35	35	35	35	35	35	35	35
Stage 3 – Feedstock										

Stage / Input	Units	Feedstock country of origin								
		Australia	**Canada**	**Finland**	**France**	**Germany**	**Poland**	**Ukraine**	**United Kingdom**	**USA**
Transport										
Transport distance	[km]	300	3000	100	300	300	300	1700	100	100
Fuel consumption	[MJ/t-km]	0.38	0.19	1.53	1.53	1.53	1.53	0	1.53	1.46
Fuel type		Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Stage 4 – Feedstock Transport										
Transport distance	[km]	18000	0	0	0	0	0	2300	0	0
Fuel consumption	[MJ/t-km]	0.2	N/A	N/A	N/A	N/A	N/A	0.2	N/A	N/A
Fuel type		HFO	N/A	N/A	N/A	N/A	N/A	HFO	N/A	N/A
Stage 5 – Conversion										
Plant yield	[t rapeseed oil /t oilseed rape]	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43

Stage / Input	**Units**	**Feedstock country of origin**								
		Australia	**Canada**	**Finland**	**France**	**Germany**	**Poland**	**Ukraine**	**United Kingdom**	**USA**
Natural gas	[MJ/t rapeseed oil]	1986	1986	1986	1986	1986	1986	1986	1986	1986
Electricity imported	[MJ/t rapeseed oil]	337	337	337	337	337	337	337	337	337
Co-product 1: Rape meal – sold as animal feed		Substitutes US soy meal (soybeans crushed in EU)								
Quantity of rape meal	[t rape meal/t rapeseed oil]	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Credit for co-product 1	[kgCO_2e/t rape meal]	-504	-504	-504	-504	-504	-504	-504	-504	-504
Stage 6 – Liquid fuel transport and storage										
Transport distance	[km]	500	5200	2000	450	650	1500	0	0	1500

Stage / Input	Units	Feedstock country of origin								
		Australia	**Canada**	**Finland**	**France**	**Germany**	**Poland**	**Ukraine**	**United Kingdom**	**USA**
Fuel consumption	[MJ/t-km]	0.2	0.2	0.2	0.2	0.2	0.2	0	0	0.19
Fuel Type		HFO	HFO	None	HFO	HFO	HFO	None	None	HFO
Stage 7 – Liquid fuel transport and storage										
Transport distance	[km]	0	0	0	0	0	0	0	0	7000
Fuel consumption	[MJ/t-km]	0	0	0	0	0	0	0	0	0.2
Fuel Type		None	None	None	None	None	None	None	None	HFO

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9. Soy to pure plant oil

Fuel chain summary

	Carbon intensity [kg CO_2 / t pure plant oil]			
	Argentina	**Brazil**	**Canada**	**USA**
1 – Crop production	1927	2175	2438	2538
2 – Drying and storage	77	72	76	64
3 – Feedstock transport	302	1372	74	74
4 – Conversion (crushing)	-1161	-1241	-1182	-1037
5 – Liquid fuel transport	0	0	16	25
6 – Liquid fuel transport	227	175	105	122
TOTAL	**1372**	**2553**	**1527**	**1786**

Soy to pure plant oil - Selected default options

Stage	Module	Input	Options
1	Crop production	Nitrogen fertiliser emissions factor	Ammonium nitrate (AN); Ammonium sulphate (AS); Urea, Calcium nitrate (CN); Urea ammonium nitrate (UAN); NPK (Urea / TSP / MOP)
1	Crop production	Phosphorus fertiliser emissions factor	Triple superphosphate (TSP); Rock phosphate; Mono ammonium phosphate (MAP)
2	Drying and storage	Fuel emissions factor	Diesel, Heavy fuel oil, Coal,

Stage	Module	Input	Options
			Natural gas
3	Feedstock transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping
4	Conversion (crushing)	Fuel emissions factor	Coal, Natural gas, Heavy fuel oil, Biomass
5	Liquid fuel transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping
6	Liquid fuel transport	Transport mode fuel efficiency	Truck (by geographic region), Rail (by geographic region), Shipping

Soy to pure plant oil - Default fuel chain

Stage 1 - Crop Production

Description	Cultivation and harvesting of soy						
Basic Data							
	Units						
Yield @ traded moisture content	[t/ha.a]	*value*	Y				
Moisture content	%	*value*					
Soil Emissions							
				Emissions factor ($kgCO_{2e}$/ha)		Total Emissions (kgCO2e/t soy)	
N2O emissions	[total kg N/ha.a]	*N_FERT*		*6.163*	÷ Y =	*calculation*	1
Farming Inputs							
				Emissions co-efficient [$kgCO_{2e}$/kg]		Total Emissions (kgCO2e/t soy)	
N fertiliser	[kg nutrient/ha.a]	*value (N_FERT)*	x	*value*	÷ Y =	*calculation*	2
P fertiliser (P2O5)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	3
K fertiliser (K2O)	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	4
				Emissions co-efficient [$kgCO_{2e}$/kg nutrient]			
Pesticides	[kg nutrient/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	5
Electricity	[kWh/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	6
Machinery Inputs							
Diesel fuel consumption	[litres/ha.a]	*value*	x	*value*	÷ Y =	*calculation*	7
Totals						Emissions (kgCO2e/t soy)	
Module total					1 + 2 + 3 + 4 + 5 + 6 + 7 =	*calculation*	8
						Total Emissions [kgCO2e/t pure plant oil]	
Contribution to fuel chain					8 ÷ z1 =	*calculation*	Stage_1

Stage 2 - Drying and storage

Description	Drying of soy						
Basic Data							
Moisture removed	%	*value*					
Drying and storage inputs				Emissions factor [kgCO2e/MJ]			
Diesel	[MJ/t soy]	*value*	x	*value*	=	*calculation*	9
Electricity	[MJ/t soy]	*value*	x	*value*	=	*calculation*	10
Totals						Emissions (kgCO2e/t soy)	
Module total					9 + 10 =	*calculation*	11
						Total Emissions [kgCO2e/t pure plant oil]	
Contribution to fuel chain					11 ÷ z1 =	*calculation*	Stage_2

Stage 3 - Feedstock Transport

Description	From drying and storage facility to oil extraction plant							
				Emissions factor [kgCO2e/MJ]				
Transport distance	[km]	*value*	dist_1					
Fuel consumption	[MJ/t-km]	*value*	FC_1					
Totals						Emissions (kgCO2e/t soy)		
Module total	[MJ/t]	*value*	x	*value*	=	*calculation*	12	
						Total Emissions [kgCO2e/t pure plant oil]		
Contribution to fuel chain					12 ÷ z1 =	*calculation*	Stage_3	

Stage 4 - Conversion

Description	Oil extraction						
Basic Data							
Plant yield	[t soy oil / t soy]	*value*	z1				
				Emissions factor [kgCO2e/MJ]		Emissions (kgCO2e/t pure plant oil)	
Conversion Inputs							
Natural gas	[MJ/t soy oil]	*value*	x	*value*	=	*calculation*	13
Electricity imported	[MJ/t soy oil]	*value*	x	*value*	=	*calculation*	14
Co-products	**Description**	**Treatment**					
Co-product 1:	Soy meal - sold as animal feed	Substitution					
Co-products treated by substitution							
Co-product 1: soy meal							
- substitutes EU wheat				Credit [$kgCO_{2e}$/t soy meal]			
Quantity of soy meal produced & sold as animal feed	[t soy meal / t soy oil]	*value*	x	*value*	=	*calculation*	15
Totals							
Module total					13 + 14 + 15 =	*calculation*	16
						Total Emissions [kgCO2e/t pure plant oil]	
Contribution to fuel chain					16 =	*calculation*	Stage_4

Stage 5 - Liquid fuel transport and storage

Description	From crusher to duty point							
				Emissions factor [kgCO2e/MJ]				
Transport distance	[km]	*value*	dist_2					
Fuel consumption	[MJ/t-km]	*value*	FC_2					
Totals						Emissions (kgCO2e/t soy oil)		
Module total	[MJ/t soy oil]	*value*	x	*value*	=	*calculation*	17	
						Total Emissions [kgCO2e/t pure plant oil]		
Contribution to fuel chain					17 =	*calculation*	Stage_5	

Stage 6 - Liquid fuel transport and storage

Description	From crusher to duty point							
					Emissions factor [kgCO2e/MJ]			
Transport distance	[km]	*value*	dist_3					
Fuel consumption	[MJ/t-km]	*value*	FC_3					
							Emissions (kgCO2e/t soy oil)	
Totals								
Module total	[MJ/t soy oil]	*value*	x		*value*	=	*calculation*	18
							Total Emissions [kgCO2e/t pure plant oil]	
Contribution to fuel chain						18 =	*calculation*	Stage_6

Soy to pure plant oil - Default value tables

Stage / Input	Units		Feedstock country of origin			
		Argentina	Brazil	Canada	Spain	USA
Stage 1 – Crop Production						
Yield @ traded moisture content	[t/ha.a]	2.54	2.54	2.28	2.57	2.60
Moisture content	%	13	13	13	13	13
N fertiliser	[kg N/ha.a]	10	10	25	14	24
Type of N fertiliser		Urea	Urea	Urea	AN	AN
P fertiliser	[kg P_2O_5/ha.a]	5	50	50	6	100
Type of P fertiliser		MAP	MAP	MAP	MAP	TSP
K fertiliser	[kg K_2O/ha.a]	3	60	85	6	55
Pesticides	[kg/ha.a]	1.31	1.31	1.31	1.31	1.31
Electricity	[kWh/ha.a]	11.00	11.00	0	11.0	11.00
Diesel fuel consumption	[litres/ha.a]	75.6	75.6	75.6	75.6	75.6

Stage / Input	Units		Feedstock country of origin			
		Argentina	Brazil	Canada	Spain	USA
Stage 2 – Drying and storage						
Moisture removed	%	2	2	2	2	2
Fuel for heating	[MJ/t soy]	138	138	138	138	138
Fuel type		Diesel	Diesel	Diesel	Diesel	Natural gas
Electricity	[MJ/t soy]	15	15	15	15	15
Stage 3 – Feedstock Transport						
Transport distance	[km]	330	1500	100	200	100
Fuel consumption	[MJ/t-km]	1.8	1.8	1.46	1.53	1.46
Fuel type		Diesel	Diesel	Diesel	Diesel	Diesel
Stage 4 – Conversion						
Yield	[t soy oil/t soy]	0.17	0.17	0.17	0.17	0.17
Natural gas	[MJ/t soy oil]	5447	5447	5447	5447	5447

Stage / Input	**Units**		**Feedstock country of origin**			
		Argentina	**Brazil**	**Canada**	**Spain**	**USA**
Electricity imported	[MJ/t soy oil]	1476	1476	1476	1476	1476
Co-products	Description		Treatment			
Co-product 1:	Soymeal sold as animal feed		Substitutes for EU wheat			
Quantity of soy meal produced & sold as animal feed	[t soy meal/t soy oil]	4.32	4.32	4.32	4.32	4.32
Credit	[kgCO_2e/t soy meal]	-373	-373	-373	-373	-373
Stage 5 – Liquid Fuel Transport						
Transport distance	[km]	0	0	1000	0	1500
Fuel consumption	[MJ/t-km]	0	0	0.19	0	0.19
Fuel type		None	None	Diesel	None	Diesel
Stage 6 – Liquid Fuel Transport						
Transport distance	[km]	13000	10000	6000	2640	7000

Stage / Input	**Units**		**Feedstock country of origin**			
		Argentina	**Brazil**	**Canada**	**Spain**	**USA**
Fuel consumption	[MJ/t-km]	0.2	0.2	0.2	0.2	0.2
Fuel type		HFO	HFO	HFO	HFO	HFO