Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Table S1 Environmental Results of Alternative Jet Fuel LCA studies (2008-2018). Numbers in red indicate scenarios worse than aviation production from crude oil: 85 g CO_2e/MJ.

Year	Author/Recovery	Output/Pathway	Feedstock group	Feedstock Scenario	GWP (g CO2e/MJ)
2008	**Wong[9]**	**MSc thesis**			
	Crude extraction	Crude refining	CO	Energy: Low: Jet A 98.0% RE	83.0
				Energy: Baseline: Jet A 93.5 RE	85.0
				Energy: High: Jet A 88.0%	92.2
				Energy: Low: ULS Jet A 93.5 RE	84.9
				Energy: Baseline: ULS Jet A 91.5 RE	86.7
				Energy: High: ULS Jet A 86% RE	92.8
	Surface bitumen mining	Syncrude refining	UCO	Energy: Low: Can. Oil sands	96.8
				Energy: Baseline: Can. Oil sands	99.7
				Energy: High: Can. Oil sands	114.8
	In-situ processing	Syncrude refining	UCO	Energy: Low: Can. Oil sands	102.9
				Energy: Baseline: Can. Oil sands	108.2
				Energy: High: Can. Oil sands	140.3
	In-situ conversion	Shale oil refining	UCO	Energy: Low: Oil shale 25% Rec. CC	83.3
				Energy: Base: Oil shale 25% Rec WCC	121.6
				Energy: High: Oil shale 0% Rec WCC	142.2
	Bituminous coal mining	Gasifier/FTJ	C	Energy: Low: Coal 60% PE WCC	158.7
	Illinois #6 coal mining			Energy: Baseline: Coal 50% PE WCC	194.8
	Lignite coal mining			Energy: High: Coal 40% PE WCC	268.6
	Bituminous coal mining			Energy: Low: Coal 58.1% PE CC	81.3
	Illinois #6 coal mining			Energy: Baseline: Coal 48.3% PE CC	91.0
	Lignite coal mining			Energy: High: Coal	130.8
	Extraction		NG	Energy: Low: Natural Gas 62% PE CC	87.3
				Energy: Base: Natural Gas 63% PE WCC	100.4
				Energy: High: Natural Gas 60% PE WCC	102.5
	Farm and extraction		B 2nd	Energy: Corn stover	5.4
				Energy: Forest residue	11.6
				Energy: Herbaceous biomass	6.9
		HRJ/HEFA	B 1st	Energy: Low: Soy: 110 (bu/ha) WLU	29.9
				Energy: Low: Soy: 110 (bu/ha) LU	90.4
				Energy: Baseline: Soy: 103 (bu/ha) WLU	35.2
				Energy: Baseline: Soy: 103 (bu/ha) LU	253.8
				Energy: High: Soy: 98 (bu/ha) WLU	50.8
				Energy: High: Soy: 98 (bu/ha) LU	600.3
			B 2nd	Energy: Low: Palm: 27.5 (ton/ha) WLU	21.9
				Energy: Low: Palm: 27.5 (ton/ha) LU	32.1
				Energy: Base: Palm: 24.6 (ton/ha) WLU	26.2
				Energy: Base: Palm: 24.6 (ton/ha) LU	139.0
				Energy: High: Palm: 21.6 (ton/ha) WLU	31.5
				Energy: High: Palm: 21.6 (ton/ha) LU	648.8
2009	**Vera Morales and Shafer[12]**	**Public report**			
	Crude extraction	Crude refining	CO	Jet A1	85.0
	Bitumen mining	Syncrude refining	UCO	Oll sands	100.3
	In-situ conversion	Shale oil refining		Shale Oil	155.2
	Coal mining	Gasifier/FTJ	C	Coal WCC	185.7
				Coal CC	85.9
	Extraction		NG	Natural Gas WCC	95.2
				Natural Gas CC	76.2
	Farm and extraction		B 2nd	Cellulosic biomass (Average)	12.8
	Cult. via wastewater	HRJ/HEFA	B 3rd	Microalgae Pure CO_2 CC	31.0
				Microalgae Flue gas CC	20.0
				Microalgae Pure CO_2 WCC	86.0
				Microalgae Flue gas WCC	86.0
	Crude extraction	Crude refining	CO	Low: Jet A Straight Run (US)	80.7
				Baseline: Jet A (Average)	87.5
				High: Jet A (Nigeria)	109.3
				ULS Jet A	89.1
	Bitumen mining	Syncrude refining	UCO	Oil sands	102.7
	In-situ conversion	Shale oil refining		Oil shale	121.5
	Coal mining (Average U.S)	Gasifier/FTJ	C	Coal WCC	194.8
				Coal CC	97.2
2010	**Stratton[13]**	**MSc thesis**			
	Crude extraction	Crude refining	CO	Jet A	88.0

Table S1 (Continued)

Year	Author/Recovery	Output/Pathway	Feedstock group	Feedstock Scenario	GWP (g CO2e/MJ)
					80.7
	Crude extraction	Crude refining	CO	Jet A	87.5
					109.3
	Crude extraction	Crude refining	CO	ULS	89.1
	Surface bitumen mining	Syncrude refining	UCO	Oil sands	102.7
	In-situ conversion	Shale oil refining		Oil shale	121.5
	Coal mining	Gasifier/FTJ	C	Coal WCC	194.8
				Coal CC	97.2
	Coal mining and farming		C, B 2nd	Low: Coal w/s.grass (40%) WSC	12.4
				Baseline: Coal w/s.grass (25%) WSC	56.9
				High: Coal w/s.grass (10%) WSC	99.8
				Low: Coal w/switchgrass (40%) SC	6.9
				Baseline: Coal w/switchgrass (25%) SC	53.0
				High: Coal w/switchgrass (10%) SC	97.8
				Baseline: Coal w/switchgrass (25%) WCC	163.0
				Coal w/switchgrass (70%) WCC and biomass	87.5
	Farming and extraction	HRJ/HEFA	B 2nd	Baseline: Palm (No land use)	30.1
				Baseline: Palm (9.6 CO_2e/MJ land use)	39.8
				Baseline: Palm (135.8 CO_2e/MJ land use)	166
				Baseline: Palm (667.9 CO_2e/MJ land use)	698
			B 1st	Low: Rapeseed 2.79 WLU	39.8
				Baseline: Rapeseed 3.35 WLU	54.9
				High: Rapeseed 3.89 WLU	75.9
				Low: Rapeseed 2.79 LU	78.2
				Baseline: Rapeseed 3.35 LU	97.9
				High: Rapeseed 3.89 LU	128.5
			B 2nd	Low: Jatropha 1000 kg/ha/yr	31.8
				Baseline: Jatropha 2500 kg/ha/yr	39.4
				High: Jatropha 5000 kg/ha/yr	45.1
	Cult. via wastewater		B 3rd	Low: Algae: 40 (g/m^2/day) Displacement	14.1
				Baseline: Algae 40 (g/m^2/day) Displacement	50.7
				High: Algae 25 (g/m^2/day) Displacement	193.2
	Farming and extraction		B 2nd	Low: Salicornia 17614 kg/ha/yr WSC	30.5
				Baseline: Salicornia 16247 kg/ha/yr WSC	47.7
				High: Salicornia 14880 kg/ha/yr WSC	66.1
				Low: Salicornia 17614 kg/ha/yr SC	-19.2
				Baseline: Salicornia 16247 kg/ha/yr SC	5.8
				High: Salicornia 14880 kg/ha/yr SC	32.2
		Gasifier/FTJ		Switchgrass	17.7
				Switchgrass	-2.0
2010	**Bailis and Baka[14]**	**Journal article**			
	Crude extraction	Crude refining	CO	Jet A	88.0
	Farming and extraction	HRJ/HEFA	B 2nd	Jatropha: EA	40.0
				Jatropha: Mass based allocation	33.0
				Disp.: Jatropha: Seedcake and husk unused	63.0
				Disp.: Jatropha: Seedcake and husk fertiliser	40.0
				Disp.: Jatropha: Seedcake and husk boiler fuel	-134
2010	**Kinsel**	**Thesis**			
	Coal mining and farming	Gasifier/FTJ	C, B 2nd	0% Switchgrass, without CCS, 50% credit	28.5
				8% Switchgrass, without CCS	23.8
				8% Switchgrass, without CCS, 50% credit	22. 8
				15% Switchgrass, without CCS, 50% credit	21.3
				30% Switchgrass, without CCS, 50% credit	18.0
				100% Switchgrass, without CCS, 50% credit	12.8
				0% Switchgrass, without CCS, 50% credit	13.2
				8% Switchgrass, with CCS, 50% credit	12.3
				15% Switchgrass, with CCS, 50% credit	11.5
				30% Switchgrass, with CCS, 50% credit	9.7
				100% Switchgrass, with CCS, 50% credit	6.6
2010	**Shonnard et al[15]**	**Journal article**			

Table S1 (Continued)

Year	Author/Recovery	Output/Pathway	Feedstock group	Feedstock Scenario	GWP (g CO2e/MJ)
	Crude extraction	Crude refining	CO	Jet A	89.6
	Farming and extraction	HRJ/HEFA	B 2nd	Camelina: EA (base case)	22.36
				Camelina: Mass allocation	20.18
				Camelina: Displacement allocation	-17.0
2011	**Skone et al[16]**	**Public report**			
	Crude extraction	Crude refining	CO	Jet A	87.4
	Coal mining	Gasifier/FTJ	C	0% Switchgrass, Iron FT unallocated	120.6
				0% Switchgrass, Iron FT EA	84.9
				0% Switchgrass, Iron FT displacement	98.2
	Coal mining and farming	Gasifier/FTJ	C, B 2nd	16% Switchgrass, Iron FT unallocated	105.6
				16% Switchgrass, Iron FT EA	82.6
				16% Switchgrass, Iron FT displacement	83.0
				31% Switchgrass, Iron FT unallocated	90
	Coal mining and farming	Gasifier/FTJ	C, B 2nd	31% Switchgrass, Iron FT EA	80.3
				31% Switchgrass, Iron FT displacement	67.2
				14% Switchgrass, Cobalt FT unallocated	105.9
				14% Switchgrass, Cobalt FT EA	83.0
				14% Switchgrass, Cobalt FT displacement	86.1
				14% Switchgrass, Cobalt FT unallocated Optimal	99.5
				14% Switchgrass, Cobalt FT EA Optimal	83.2
				14% Switchgrass, Cobalt FT disp. Optimal	87.8
				0% Switchgrass, Iron FT SAS unallocated	93.6
				0% Switchgrass, Iron FT SAS EA	86.5
				0% Switchgrass, Iron FT SAS EA displaced	86
				16% Switchgrass, Iron FT SAS unallocated	78.6
				16% Switchgrass, Iron FT SAS EA	78.6
				16% Switchgrass, Iron FT SAS displacement	70.9
				31% Switchgrass, Iron FT SAS unallocated	63.0
				31% Switchgrass, Iron FT SAS EA	70.3
				31% Switchgrass, Iron FT SAS displacement	55.2
				14% Switchgrass, Cobalt FT SAS unallocated	81.1
				14% Switchgrass, Cobalt FT SAS EA	80
				14% Switchgrass, Cobalt FT SAS displacement	75
				14% Switchgrass, Cobalt FT SAS opt. unalloc.	81.2
				14% Switchgrass, Cobalt FT SAS opt. EA	80.7
				14% Switchgrass, Cobalt FT SAS opt disp.	79.6
2011	**Agustinata et al**	**Journal article**			
	Crude extraction	Crude refining	CO	Jet A	92.4
	Cult. via wastewater	HRJ/HEFA	B 2nd	Market: Camelina	75
			B 3rd	Market: Algae	85
	Farm and extraction	Gasifier/FTJ	B 2nd	Market: Corn Stover	25
				Market: Switchgrass	78
				Market: Short rotation woody crops	45
2012	**Handler et al[18]**	**Journal article**			
	Crude extraction	Crude refining	CO	Jet A	88.5
	Cult. via wastewater	HRJ/HEFA	B 3rd	Low: Microalgae	53.8
				Baseline: Microalgae	127.9
				High: Microalgae	476.0
2012	**Carter[19]**	**MSc thesis**			
	Crude extraction	Crude refining	CO	Jet A	87.5
	Horiz. Serpentine Tube PBR	HRJ/HEFA	B 3rd	Low: Microal., Dry, Displacement and energy	145
				Baseline: Microal., Dry, Displaced and energy	397
				High: Microal., Dry, Displaced and energy	1010
				Low: Microal., Wet, Displaced and energy	99.6
				Baseline: Microal., Wet, Displace and energy	202
				High: Microalgae, Wet, Displaced and energy	637
				Baseline: Microalgae, Wet, Displaced and ECA.	2020
	Open Raceway Pond			Low: Microal., Dry, Displacement and energy	54
				Low: Microal., Dry, Displacement and energy	63
				Baseline: Microal., Dry, Displaced and energy	95
				Baseline: Microal., Dry, Displaced and energy	227
				High: Microalgae, Wet, Displaced and energy	387

Table S1 (Continued)

Year	Author/Recovery	Output/Pathway	Feedstock group	Feedstock Scenario	GWP (g CO2e/MJ)
	Open Raceway Pond	HRJ/HEFA	B 3rd	High: Microalgae, Wet, Displaced and energy	703
				Low: Microalgae, Wet, Displaced and energy	8.9
				Baseline: Microalgae, Wet, Displaced and ECA	31
				Low-B: Microalgae, Wet, Displaced and energy	35.3
				Baseline: Microal., Wet, Displace and energy	41
				Low-A: Microal., Wet, Displaced and energy	46
				Baseline: Microal., Wet, Displace and energy	47
				High: Microalgae, Wet, Displaced and energy	329
	Vertical Flat Panel PBR			Low: Microal., Dry, Displacement and energy	74.7
				Baseline: Microal., Dry, Displaced and energy	249
				High: Microalgae, Dry, Displaced and energy	676
				Low: Microalgae, Wet, Displaced and energy	29
				Baseline: Microal., Wet, Displace and energy	54
	Vert. Serpentine Tube PBR			High: Microalgae, Wet, Displaced and energy	303
				Low: Microal., Dry, Displacement and energy	147
				Baseline: Microal., Dry, Displaced and energy	426
				High: Microal., Dry, Displaced and energy	1020
				Low: Microalgae, Wet, Displaced and energy	101
				Baseline: Microal. Wet, Displace and energy	231
				High: Microalgae, Wet, Displaced and energy	646
2012	**Elgowainy et al[20]**	**Public report**			
	Crude extraction	Crude refining	CO	Mass: Jet A (U.S.)	88.1
	Bitumen mining	Syncrude refining	UCO	Mass: Oil sands	101
	Crude ext. and Bitumen mining	Mixed refining	UCO	Mass: Crude Mix	87
	Extraction	Gasifier/FTJ	NG	Mass: Natural Gas	115
	Coal mining		C	Mass: Coal WCC	225
				Mass: Coal CC	105
	Coal mining and farming		C, B 2nd	Mass: Coal and cellulosic biomass (average)	140
	Farm and extraction	Pyrolysis	B 2nd	Mass: Corn stover	40
		HRJ/HEFA	B 1st	Mass: Soybean	25
		Gasifier/FTJ	B 2nd	Mass: Cellulosic biomass (average)	10
	Cult. via wastewater	HRJ/HEFA	B 3rd	Mass: Algae	25
2013	**Han et al[21]**	**Journal article**			
	Crude extraction	Crude refining	CO	Jet A 98% RE	88.1
	Coal Mining and farming	Gasifier/FTJ	C, B 2nd	20% corn stover WCC	150.6
				20% corn stover CC	61.8
	Farm and extraction	HRJ/HEFA	B 2nd	Jatropha	51.9
			B 1st	Rapeseed	51.9
			B 2nd	Camelina	44.0
			B 1st	Soybean	37.8
			B 2nd	Palm	32.5
		Pyrolysis		Corn stover: Biochar power generation	28.1
				Corn stover: Biochar in soil for CC discounting	21.1
		Gasifier/FTJ		Corn stover	9.6
2013	**Ou et al[22]**	**Journal article**			
	Crude extraction	Crude refining	CO	Jet A (China)	93.5
	Open Raceway Pond (China)	HRJ/HEFA	B 3rd	Baseline: Microalgae	159
				Low: Microalgae	46.7
				High: Microalgae	851.9
2013	**Fan et al[23]**	**Journal article**			
	Crude extraction	Crude refining	CO	Jet A	88.1
	Farm and extraction	HRJ/HEFA	B 2nd	Pennycress: EA	32.7
				Pennycress: ECA	44.9
				Pennycress: Displacement	-18.3
				Pennycress: +50% Nitrogen content: EA	43.4
				Pennycress: -50% Nitrogen content: EA	21.9
				Pennycress: +50% Nitrogen content: MVA	59.7
				Pennycress: -50% Nitrogen content: MVA	30.0
				Pennycress: +50% Nitrogen content disp.	27.4
				Pennycress: - 50% Nitrogen content disp.	-45.7
				Pennycress: Integrated H_2:product EA	26.4
				Pennycress: Integrated H_2:product MVA	38.6
				Pennycress: Integrated H_2:product DA	-24.6

Table S1 (Continued)

Year	Author/Recovery	Output/Pathway	Feedstock group	Feedstock Scenario	GWP (g CO2e/MJ)
2014	**Fortier et al[24]**	**Journal article**			
	Crude extraction	Crude refining	CO	Jet A	88.1
	Cult. via wastewater	HTL	B 3rd	Refinery HTL, solar drying to 5.7% solids	131.9
				Refinery HTL, centrifuge to 10% solids	86.5
				WWTP HTL, solar drying to 5.7% solids	39.3
				WWTP HTL, centrifuge to 10% solids	35.2
				Refinery HTL optimized case	54.2
				WWTP HTL optimized case	21.2
2014	**Li and Mupondwa[25]**	**Journal article**			
	Crude extraction	Crude refining	CO	Jet A	88
	Farm and extraction	HRJ/HEFA	B 2nd	Low: Camelina	3.0
				Average: Camelina	14.1
				High: Camelina	31.0
2014	**Cox et al[26]**	**Journal article**			
	Crude extraction	Crude refining	CO	Jet A	88.1
	Farm and extraction	HRJ/HEFA	B 1st	Sugarcane molasses: SE/Displacement	80.0
				Sugarcane molasses ECA/Market	20.2
			B 2nd	Pongamia: SE/Displacement	44.7
				Pongamia: ECA/Market	44.7
	Cult. via wastewater		B 3rd	Microalgae: SE/Displacement	22.7
				Microalgae: ECA/Market	33.8
2014	**Seber et al[111]**	**Journal article**			
	Render and recycle	HRJ/HEFA	B 2nd	Low: Yellow grease	16.8
				Baseline: Yellow grease	19.4
				High: Yellow grease	21.4
	Slaughtering and rendering	HRJ/HEFA	B 2nd	Low: Tallow Refinery 1	25.7
				Baseline: Tallow Refinery 1	29.8
				High: Tallow Refinery 1	37.5
				Low: Tallow Refinery 2	67.1
				Baseline: Tallow Refinery 2	75.1
				High: Tallow Refinery 2	83.9
				Lowest: Tallow Refinery 1 ECA	26.6
				Highest: Tallow Refinery 1 ECA	31.1
				Lowest: Tallow Refinery 2 ECA	60.9
				Highest: Tallow Refinery 2 ECA	80.5
2014	**Staples et al[27]**	**Journal article**			
	Crude extraction	Crude refining	CO	Jet A	90.0
	Farm and extraction	Advanced Fermentation/StJ	B 1st	Low: Sugarcane ECA and displacement	-27.0
				Baseline: Sugarcane ECA	12.7
				High: Sugarcane ECA and displacement	19.7
				Low: Corn grain ECA and displacement	47.6
				Baseline: Corn grain ECA	62.6
				High: Corn grain ECA and displacement	117.5
			B 2nd	Low: Switchgrass ECA and displacement	11.7
				Baseline: Switchgrass ECA	37.4
				High: Switchgrass ECA and displacement	89.9
			B 1st	Sugarcane: displacement	-4.9
				Corn grain: displacement	65.6
			B 2nd	Switchgrass: displacement	37.4
2014	**Moreira et al[28]**	**Journal article**			
	Farm and extraction	HRJ/HEFA	B 1st	Displacement: Sugarcane: LUC 50 kWh/t	8.5
				Displacement: Sugarcane: LUC 96 kWh/t	24.7
				Displacement: Sugarcane: 7 billion litres LUC	13.7
2015	**Conelley et al[29]**	**Journal article**			
	Cult. via wastewater	HTL	B 3rd	Algae: Industrial CO_2	43.6
				Algae: Industrial CO_2 multiplier	129.6
				Algae: Extracted CO_2	43.6
				Algae: Extracted CO_2 multiplier	213.6
2015	**Lokesh et al[30]**	**J. article**			
	Crude extraction	Crude refining	CO	Jet A	106.1
	Farm and extraction	HRJ/HEFA	B 2nd	Camelina: ALCEmB WCC	101.5
				Camelina: ALCEmB CC	31.4

Table S1 (Continued)

Year	Author/Recovery	Output/Pathway	Feedstock group	Feedstock Scenario	GWP (g CO2e/MJ)
	Farm and extraction	HRJ/HEFA	B 2nd	Camelina: Adapted from literature WCC	34.2
	Cult. via wastewater	HRJ/HEFA	B 3rd	Microalgae: ALCEmB WCC	112.0
				Microalgae: ALCEmB CC	40.1
				Microalgae: Adapted from literature CC	42.0
	Farm and extraction	HRJ/HEFA	B 2nd	Jatropha: ALCEmB WCC	108.5
				Jatropha: ALCEmB CC	38.0
				Jatropha: Adapted from the literature CC	39.7
2016	**Budsberg et al[31]**	**J. article**			
	Crude extraction	Crude refining	CO	Jet A	93.0
	Farm and extraction	HRJ/HEFA	B 2nd	Poplar: Nat. gas steam reforming	66.0
				Poplar: Nat. gas steam reforming: hog fuel/L	60.0
				Poplar: Lignin gasification	73.0
				Poplar: Lignin (hydrogen), hog fuel: heat/steam	32.0
2016	**Guo et al[32]**	**J. article**			
	Cult. via wastewater	HRJ/HEFA	B 3rd	Microal.: Chlorella 10% lipid, 75% N recovery	31.9
				Microal.: Chlorella 20% lipid, 75% N recovery	37.9
				Microal.: Chlorella 30% lipid, 75% N recovery	41.7
				Microal.: Chlorella 40% lipid, 75% N recovery	44.6
				Microal.: Chlorella 50% lipid, 75% N recovery	47.1
				Microal.: Chlorella 60% lipid, 75% N recovery	49.2
				Microal.: Chlorella 10% lipid, 50% N recovery	46.8
				Microal.: Chlorella 20% lipid, 50% N recovery	55.7
				Microal.: Chlorella 30% lipid, 50% N recovery	61.3
				Microal.: Chlorella 40% lipid, 50% N recovery	65.6
				Microal.: Chlorella 50% lipid, 50% N recovery	69.2
				Microal.: Isochrysis 10% lipid, 75% N recov.	21.4
				Microal.: Isochrysis 20% lipid, 75% N recov.	29.5
				Microal.: Isochrysis 30% lipid, 75% N recov.	36.9
				Microalgae: Isochrysis 40% lipid, 75% N recov.	44.1
				Microalgae: Isochrysis 50% lipid, 75% N recov.	51.1
				Microalgae: Isochrysis 10% lipid, 50% N recov.	31.5
				Microalgae: Isochrysis 20% lipid, 50% N recov.	43.4
				Microalgae: Isochrysis 30% lipid, 50% N recov.	54.3
				Microalgae: Isochrysis 40% lipid, 50% N recov.	64.9
				Microalgae: Isochrysis 60% lipid, 75% N recov.	58.1
				Microalgae: Isochrysis 50% lipid, 50% N recov.	75.2
				Microalgae: Isochrysis 60% lipid, 50% N recov.	85.4
				Microalgae: Nannochloropsis 10% lip., 75% N	23.5
				Microalgae: Nannochloropsis 20% lip., 75% N	32.9
				Microalgae: Nannochloropsis 30% lip., 75% N	39.2
				Microalgae: Nannochloropsis 40% lip., 75% N	44.1
				Microalgae: Nannochloropsis 50% lip., 75% N	48.4
				Microalgae: Nannochloropsis 60% lip., 75% N	52.2
				Microalgae: Nannochloropsis 10% lip., 50% N	34.6
				Microalgae: Nannochloropsis 20% lip., 50% N	48.4
				Microalgae: Nannochloropsis 30% lip., 50% N	57.6
				Microalgae: Nannochloropsis 40% lip., 50% N	64.9
				Microalgae: Nannochloropsis 50% lip., 50% N	71.2
				Microalgae: Nannochloropsis 60% lip., 50% N	76.8
2016	**Suresh[34]**	**MSc thesis**			
	Crude extraction	Crude refining	CO	Jet A	90
	Recycle and process	Gasifier/FTJ	B 2nd	Baseline[a]: MSW Energy	32.8
				Baseline[a]: MSW Displacement	28.7
				Low: MSW, 0% Non biogenic comp.	-66.3
				High: MSW, 65% Non biogenic comp.	64.0
				Low: MSW, WM Credit: 603 $kgCO_2e/t$	-24.9
				High: MSW, WM Credit: -23 $kgCO_2e/t$	57.9
				Low: MSW, plant scale: 3k; tpd: 52%	31.5
				High: MSW, plant scale: 7k; tpd: 34%	43.9

Table S1 (Continued)

Year	Author/Recovery	Output/Pathway	Feedstock group	Feedstock Scenario	GWP (g CO2e/MJ)
	MSW Recycle and process	Gasifier/FTJ	B 2nd	Low: MSW, transport: 10 miles	30.7
				High: MSW, transport: 70 miles	42.9
		Plasma Gasifier/FTJ		Baseline: MSW Energy	62.3
				Baseline: MSW Displacement	38.1
				Low: MSW Non-biogenic: 0%	-52.0
				High: MSW Non-biogenic: 65%	99.3
				Low: MSW, WM credit: 603 $kgCO_2e/t$	-8.6
				High: MSW, WM credit: -23	96.8
				Low: MSW, PS: 1k; FY: 37%	57.2
				High: MSW, PS: 3k; FY: 60%	96.8
				Low: MSW, Transport: 10	59.7
				High: MSW, Transport: 70	74.8
		Gasifier/ATJ		Baseline: MSW Energy allocation	52.7
				Baseline: MSW Displacement allocation	27.4
				Low: MSW Non-biogenic: 0%	-115.5
				High: MSW N. bioge65%	104.2
				Low: MSW, WM credit: 603	-51.8
				High: MSW, WM credit: -23	97.9
				Low: MSW, Plant scale: 3k; Fuel yield: 48%	35.3
				High: MSW, Plant scale: 3k; Fuel yield: 24%	67.3
				Low: MSW, Transport: 10	48.4
				High: MSW, Transport: 70	67.3
2016	**Ukaew et al**	**J. article**			
	Crude extraction	Crude refining	CO	Jet A	88.0
	Canola Farm and extraction	HEFA/HRJ	B 1st	Canola: Displacement, $470	-12.0
				Displacement, $480	2.0
				Displacement, $490	12.0
				Displacement, $500	19.0
				Displacement, $520	26.0
				Displacement, $550	26.0
				Displacement, $600	21.0
				Energy, $470	36.0
				Energy, $480	42.0
				Energy, $490	45.0
				Energy, $500	48.0
				Energy, $520	50.0
				Energy, $550	51.0
				Energy, $600	49.0
				Market, $470	33.0
				Market, $480	37.0
				Market, $490	41.0
				Market, $500	43.0
				Market, $520	46.0
				Market, $550	46.0
				Market, $600	44.0
				Displacement, $470, H2 Integration	-14.0
				Displacement, $480, H2 Integration	1
				Displacement, $490, H2 Integration	10
				Displacement, $500, H2 Integration	18
				Displacement, $520, H2 Integration	24
				Displacement, $550, H2 Integration	25
				Displacement, $600, H2 Integration	19
				Energy, $470, H2 Integration	27
				Energy, $480, H2 Integration	33
				Energy, $490, H2 Integration	38
				Energy, $500, H2 Integration	41
				Energy, $520, H2 Integration	44
				Energy, $550, H2 Integration	44
				Energy, $600, H2 Integration	41
				Market, $470, H2 Integration	25

Table S1 (Continued)

Year	Author/Recovery	Output/Pathway	Feedstock group	Feedstock Scenario	GWP (g CO2e/MJ)
	Farm and extraction	HEFA/HRJ	B 1st	Market, $480, H2 Integration	32
				Market, $490, H2 Integration	36
				Market, $500, H2 Integration	39
				Market, $520, H2 Integration	42
				Market, $550, H2 Integration	42
				Market, $600, H2 Integration	40
2017	**Crossin**	**J. article**			
	Farm and extraction	HEFA/HRJ	B 2nd	Mallee Eucalypt: Displacement	48
				Mallee Eucalypt: Mass	47.1
2017	**De Jong et al**	**J. article**			
	Render and recycle	HEFA/HRJ	B 2nd	Yellow grease: Energy	27
				Yellow grease: Energy and Displacement	27
	Farm and extraction			Jatropha: Energy	55
				Jatropha: Energy and Displacement	22
				Camelina: Energy	47
				Camelina: Energy and Displacement	44
				Camelina: Mass	37
				Camelina: Market	47
		Gasifier/FTJ		Willow: Energy	9
				Willow: Energy and Displacement	0
				Poplar: Energy	9
				Poplar: Energy and Displacement	0
				Corn Stover: Energy	13
				Corn stover: Energy and Displacement	4
				Forest residues: Energy	6
				Forest residues: Energy and Displacement	-3
		Pyrolysis		Forest residues in situ: Energy	18
				Forest residues in situ: Energy and Disp.	18
				Forest residues ex situ: Energy	20
				Forest residues ex situ: Energy and Disp.	20
				Forest residues in situ: Energy	22
				Forest residues in situ: Energy and Disp.	22
				Forest residues ex situ: Energy	40
				Forest residues ex situ: Energy and Disp.	37
		Adv. Ferment./ATJ	B 1st	Corn: Energy	55
				Corn: Energy and Displacement	71
				Corn Stover: Energy	35
				Corn Stover: Energy and Displacement	22
				Sugar cane: Energy	26
				Sugar cane: Energy and Displacement	22
		Adv. Ferment./STJ		Sugar cane increased blend level: Energy	72
				Sugar cane "……." Energy and Displacement	75
				Sugar cane: 10% blend level Energy	44
				Sugar cane: 10% blend level Energy and Disp.	45
2017	**Han et al[33]**	**J. article**			
	Crude extraction	Crude refining	CO	Jet A	85
	Farm and extraction	Adv. Ferment./ATJ	B 1st	Corn: Integrated, Energy allocation	72.0
				Corn, Distributed, U.S. Average Energy alloc.	78.0
				Corn: Distributed Dry mill w/ extract. Energy.	75.0
	Farm and extraction	Adv. Ferment./ATJ	B 1st	Corn: Distributed Dry mill w/o extract. Energy	75.0
			B 2nd	Corn stover: Integrated, Energy allocation	23.0
				Corn stover: Integrated, Displacement	12.0
		Various/STJ		Corn stover: Distributed, Energy allocation	28.0
				Corn stover: Biological, Energy allocation	35.0
				Corn stover: Biological, Displacement	25.0
				Corn stover. Catalytic, Energy allocation	61.0
				Corn stover: Catalytic, In-Situ H_2, Energy.	35.0
				Corn stover: Catalytic, Displacement	56.0
				Corn stover: Catalytic, H_2 Gasification, Energy.	25.0
				Corn stover. Catalytic, External H_2, Energy.	61.0
2018	**Capaz et al**	**Conference**			
	Farm and extraction	Adv. Ferment./ATJ	B 2nd	Sugarcane and Straw: 1G, Energy alloc.	25.2

Table S1 (Continued)

Year	Author/Recovery	Output/Pathway	Feedstock group	Feedstock Scenario	GWP (g CO2e/MJ)
	Farm and extraction	Adv. Ferment./ATJ	B 2nd	Sugarcane and Straw: 1G, Economic alloc.	24.3
				Sugarcane and Straw: 2Gh, Energy alloc.	20.2
				Sugarcane and Straw: 2Gh, Economic alloc.	20.0
				Sugarcane and Straw: 1G-2Gh, Energy alloc.	21.9
				Sugarcane and Straw: 1G-2Gh, Economic alloc.	20.9
				Sugarcane and Straw: 2Gs Energy alloc.	8.4
				Sugarcane and Straw: 2Gs, Economic alloc.	8.2
				Sugarcane and Straw: 1G-2Gs Energy alloc.	18.0
				Sugarcane and Straw: 1G-2Gs, Economic alloc.	17.6
				Sugarcane and Straw: 1G-2Gh, Economic alloc.	-64.2
				Sugarcane and Straw: 2Gs Energy alloc.	-67.2
				Sugarcane and Straw: 2Gs, Economic alloc.	-13.2
				Sugarcane and Straw: 1G-2Gs Energy alloc.	-21.9
				Sugarcane and Straw: 1G-2Gs, Economic alloc.	-1.5
2018	**Ganguly et al**	**J. article**			
	Recovery and transport	Adv. Ferment./STJ	B 2nd	Wood residue: 50% avoided slash pile burning	19.4
2018	**Klein et al**	**J. article**			
	Farm and extraction	HRJ/HEFA	B 2nd	Market: Palm oil	22.3
				Market: Palm oil (Macauba)	17.3
			B 1st	Market: Soybean	16.9
		Gasifier/FTJ		Market: Sugarcane	9.4
			B 1st/2nd	Market: Sugarcane and Eucalyptus	9.3
		Adv. Ferment./ATJ	B 2nd	Market: 1G EtOH	20.7
				Market: 1G2G EtOH	24.8
				Market: Isobutanol	17.7
2018	**Olcay et al[35]**	**J. article**			
	Crude extraction	Crude refining	CO	Jet A	84.6
	Felling and transport	Steam/APPJ	B 2nd	Baseline: Red maple, Biorefinery 1, G	64.0
				Red maple: Biorefinery 1, Coke oven gas	52.6
				Red maple: Biorefinery 1, Ethanol	47.3
				Red maple: Biorefinery 1, Methanol	73.7
		Catalytic/APPJ		Red maple: Biorefinery 1, Naptha	43.2
		Gasification/APPJ		Red maple: Biorefinery 1, Coal	83.3
				Red maple: Biorefinery 1, Coke	84.3
				Red maple: Biorefinery 1, Switchgrass	49.9
		Water split/APPJ		Red maple: Biorefinery 1, H_2O Thermo/Nucl.	50.3
				Red maple: Biorefinery 1, H_2O Electro/Nucl.	44.1
				Red maple: Biorefinery 1, H_2O Electro/Solar	43.5
				Red maple: Biorefinery 1, H_2O Electro/Grid	97.1
	Felling and transport	Steam/APPJ	B 2nd	Red maple: Biorefinery 2	63.8
				Red maple: Biorefinery 3	69.6
				Red maple: Biorefinery 4	38.8
				Red maple: Biorefinery 5	66.4
				Red maple: Biorefinery 6	63.2
				Red maple: Biorefinery 7	62.2
2018	**Pierobon et al**	**J. article**			
	Recovery and transport	Adv. Ferment./STJ	B 2nd	Forest resi: mass allocation (100% slash pile)	26.9
				Forest residue: mass allocation (50% slash pile)	34.0
				Forest residue: sys. Expansion (100% slash pile)	29.1
				Forest residue: sys. Expansion (50% slash pile)	34.0
2018	**Michailos et al**	**J. article**			
	Crude extraction	Petroleum	CO	Crude Oil	87.5
	Farm and extraction	Adv. Ferment./STJ	B 2nd	Baseline: Sugarcane bagasse:	46.2
				Sugarcane bagasse: Max. metabolic efficiency	37
2018	**Neuling and Kaltschmitt et al**	**J. article**			
	Crude extraction	Petroleum	CO	Crude Oil	87.5
	Extraction	Adv. Ferment./ATJ	B 2nd	Wheat Straw with Bio-methane	30.4
				Wheat Straw with Natural gas	31.6
				Wheat Grain	70.3
	Recovery	Digestion/FT		German Substrate Mix	71.5
				Manure	38.0
	Farm and extraction	Gasification/FTJ		Wheat Straw	38.2

Table S1 (Continued)

Year	Author/Recovery	Output/Pathway	Feedstock group	Feedstock Scenario	GWP (g CO2e/MJ)
	Gasification/FTJ	HEFA/HRJ	B 2nd	Willow Jatropha Oil Palm Oil	32.4 73.5 52.0

APPJ = Aqueous Phase Processing; CO = Crude oil; UCO=Unconventional crude oil; C = Coal; ECA = Economic Allocation; NG = Natural Gas; B = Biomass; EA: Energy allocation; HTL = Hydrothermal liquefaction; L = Lignin; WCC = with carbon capture; MSW=Municipal Solid Waste; PE = Process Efficiency; WCC = Without carbon capture; CC – With carbon capture; WWTP = Wastewater treatment plant; LG-HF = Lignin gasification w/hog fuel; SE = System expansion