

Lifecycle greenhouse gas footprint and minimum selling price of renewable diesel and jet fuel from fermentation and advanced fermentation production technologies

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Electronic supplementary information

This supplementary information (SI) includes tabular inputs and results pertaining to the calculation of the lifecycle greenhouse (GHG) footprint and minimum selling price (MSP) of producing renewable middle distillate (MD) fuels via fermentation and advanced fermentation (AF) production technologies.

Stepwise lifecycle GHG emissions from AF MD fuel production

Table S1: Lifecycle GHG footprint broken out by lifecycle step for sugar cane, corn grain and switchgrass AF MD. We assume that process heat and electric power co-produced from biomass co-firing (in the sugar cane and switchgrass AF pathways) goes first to satisfying the feedstock-to-platform chemical utility requirements, and if excess process heat and power are remaining, then to satisfying platform chemical upgrading utility requirements. All values in gCO₂e/MJ_{MD}.

		Biomass credit	Feedstock cultivation	Feedstock T&D	Feedstock to platform chemical conversion	Platform chemical to drop-in fuel upgrading	Fuel T&D	Fuel combustion	Total
Sugar cane AF	Low	-70.4	3.1	0.6	0.0	2.5	0.5	70.5	6.8
	Base	-70.4	4.9	1.0	0.0	6.2	0.5	70.5	12.7
	High	-70.4	5.9	1.1	0.0	12.1	0.5	70.5	19.7
Corn grain AF	Low	-70.4	26.2	1.9	13.3	5.6	0.5	70.5	47.6
	Base	-70.4	28.9	2.1	15.6	15.4	0.5	70.5	62.6
	High	-70.4	45.0	3.3	26.9	41.7	0.5	70.5	117.5
Switchgrass AF	Low	-70.4	11.1	1.3	1.8	2.6	0.5	70.5	17.3
	Base	-70.4	17.6	2.1	10.9	6.2	0.5	70.5	37.4
	High	-70.4	39.7	4.7	40.2	4.6	0.5	70.5	89.8

Direct land use change (LUC) emissions calculation and sources

Table S2: Low, baseline and high direct LUC emissions estimates for sugar cane, corn grain and switchgrass AF.

		Original land use type	LUC carbon debt	Biomass yield	Biomass to AF MD (alloc. factors incl)	LUC carbon debt amortized over 30 years	Lifecycle GHG footprint including direct LUC
			[MgCO ₂ /ha]	[Mg/ha]	[kg _{rawfeed} /MJ _{fuel}]	[gCO ₂ /MJ _{fuel}]	[gCO ₂ /MJ _{fuel}]
Sugar cane AF	Low	Cerrado wooded ¹	165 ¹	83.3 ²	0.31	20.2	27.0
	Base			75.7 ²	0.49	35.4	48.1
	High			68.0 ²	0.58	46.7	66.4
Corn grain AF	Low	Central grassland ¹	134 ¹	11.3 ²	0.10	38.4	86.0
	Base			9.4 ²	0.11	51.2	113.8
	High			7.4 ²	0.17	100.7	218.2
Switchgrass AF	Low	Abandoned cropland ¹	6 ¹	18.8 ³	0.12	1.3	18.6
	Base			12.9 ³	0.19	2.9	40.3
	High			7.0 ³	0.43	12.2	102.0

Minimum selling price (MSP) calculation

Table S3: MSP modeling process inputs and product streams for low, baseline and high scenarios for sugar cane, corn grain and switchgrass AF MD production. All parameters are provided an annual basis.

		Process inputs					Products							
		Make-up water	Electric power	Natural gas	Feedstock	Enzyme, yeast and preprocessing chemical costs	DDGS co-production	Electric power co-production	Heavy oil	Light ends	Naphtha	Jet	Diesel	Total fuel production
		[10 ³ m ³ /yr]	[GWh/yr]	[TJ/yr]	[kt/yr]	[1000 \$/yr]	[kt/yr]	[GWh/yr]			[10 ³ m ³ /yr]			
Sugar cane AF	Low	2641	0	443	4379	3028	0	644	0	0	0	378	0	378
	Base	2275	0	673	3979	2751	0	205	0	23	5	33	171	233
	High	1619	0	632	2264	1566	0	99	0	19	10	60	28	116
Corn grain AF	Low	643	189	2254	1603	15202	519	0	0	0	0	378	0	378
	Base	941	137	2529	1074	10185	348	0	0	23	5	33	171	233
	High	966	139	2666	789	7484	256	0	5	0	21	73	18	116
Switchgrass AF	Low	1679	0	774	1538	74570	0	111	0	0	0	378	0	378
	Base	1051	125	673	1455	70535	0	0	0	23	5	33	171	233
	High	1067	233	253	1662	80587	0	0	5	0	21	73	18	116

Table S4: MSP results broken out by capital cost (CapEx), feedstock operating costs (Feedstock OpEx) and non-feedstock operating costs (Non-feedstock OpEx). All values in 2012 USD/liter_{MD}.

		CapEx	Feedstock OpEx	Non-feedstock OpEx	Total MSP
Sugar cane AF	Low	0.28	0.21	0.12	0.61
	Base	0.52	0.80	0.24	1.56
	High	0.75	1.49	0.38	2.63
Corn grain AF	Low	0.24	0.43	0.17	0.84
	Base	0.39	1.06	0.30	1.75
	High	0.70	2.30	0.65	3.65
Switchgrass AF	Low	0.56	0.12	0.42	1.09
	Base	1.10	0.38	0.82	2.30
	High	3.00	1.24	2.06	6.30

References

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