

Supplementary Information for

**Prospects for Bioenergy with Carbon Capture & Storage (BECCS)
in the United States Pulp and Paper Industry**

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The nonlinear regression (Figure S1) is computed using the Gekko package in Python¹ and a total of 39 data sets (Table S1), with each set containing four data points: CO₂ flow rate, CO₂ capture rate, CO₂ concentration, and levelized cost of capturing CO₂. The Python code is based on a non-linear regression for predicting oil prices, which is available via APMonitor's open source repositories.² As shown in Figure S1, the nonlinear fit is acceptable with an R² correlation of 0.853. Of the 39 data sets used in the regression, 15 are from the bottom-up analysis conducted in this study, and the remaining 24 are derived from work published by Psarras et al.³ wherein techno-economic studies were conducted on CO₂ capture systems for power generation via 1) natural gas combined cycle (NGCC) with post-combustion monoethanolamine (MEA) chemisorption capture, 2) subcritical pulverized coal (PC) with post-combustion MEA chemisorption capture, and 3) integrated gasification combined cycle (IGCC) with a water gas shift reactor and Selexol unit. One data set from the bottom-up analysis (Mill 4, Steam + Lime Kiln Emissions) is not included in the regression because this particular scenario has a very low cost of CO₂ capture due to the lack of new boiler installation and no biomass consumption, thereby making it an outlier. All other data sets from the bottom-up analysis are included in the regression. The multivariate regression accounts for direct contact cooling of gases to condense water soluble components, but does not account for additional gas treating including desulfurization. The lack of additional gas treatment is deemed acceptable since gas streams at pulp and paper mills typically have concentrations of sulfur containing species (SO_x) acceptable to amine chemisorption.⁴

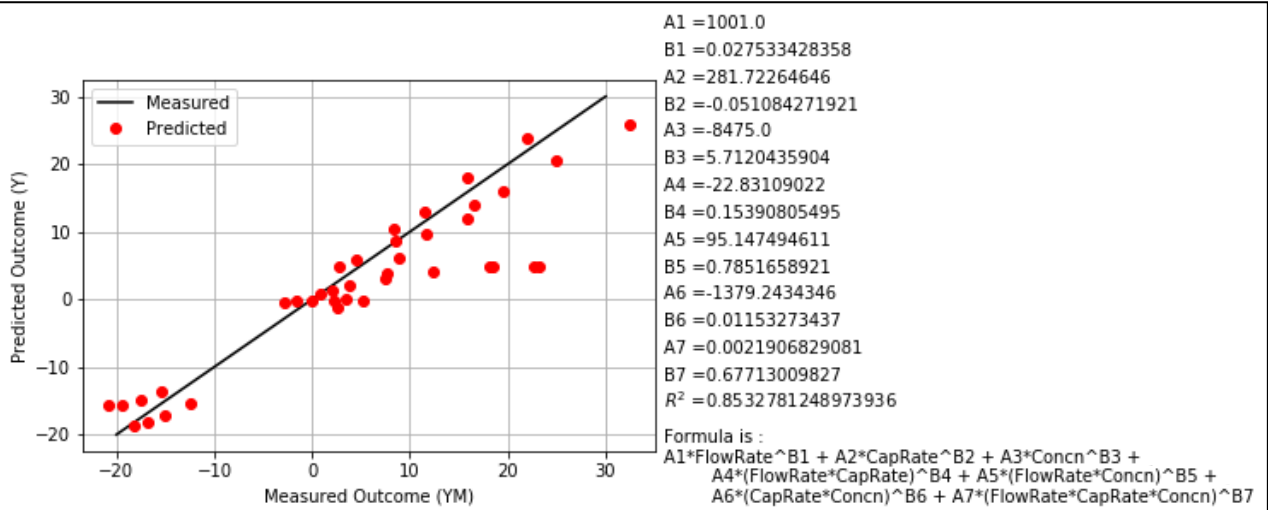


Figure S1. Nonlinear regression developed in Python to estimate costs of CO₂ capture for 205 pulp and paper mills across the US.

Flow_Rate	Capture_Rate	Concentration	Cost
3.13E+06	90%	37.7%	-20.7
2.06E+06	90%	13.6%	0.82
3.80E+06	70%	13.0%	4.45
3.13E+06	80%	37.7%	-19.4
3.12E+05	90%	18.3%	2.76
3.13E+06	70%	37.7%	-17.5
1.60E+06	90%	13.1%	2.01
1.53E+06	80%	37.7%	-16.9
3.13E+06	60%	37.7%	-15.3
7.05E+05	90%	20.8%	7.59
1.53E+06	70%	37.7%	-15.0
4.36E+06	90%	15.1%	-2.90
1.53E+06	60%	37.7%	-12.4
6.45E+05	90%	21.4%	12.3
3.80E+06	90%	13.0%	2.62
3.80E+06	80%	13.0%	3.79
3.37E+06	90%	14.9%	-1.67
1.53E+06	90%	37.7%	-18.2
9.51E+05	90%	13.0%	7.49
3.11E+06	90%	14.9%	3.50
3.80E+06	60%	13.0%	8.41
1.25E+06	90%	4.19%	8.49
3.41E+05	90%	18.3%	18.4
9.51E+05	80%	13.0%	8.88
3.16E+05	90%	18.8%	22.7
1.25E+06	80%	4.19%	11.5
3.10E+05	90%	18.6%	23.1
9.51E+05	70%	13.0%	11.7
6.26E+05	90%	4.19%	15.8
2.61E+06	90%	12.8%	-0.12
1.25E+06	70%	4.19%	15.9
4.01E+06	90%	15.1%	2.31
1.25E+06	60%	4.19%	22.0
2.61E+06	90%	12.7%	5.13
6.26E+05	80%	4.19%	19.6
6.26E+05	60%	4.19%	32.4
3.47E+05	90%	18.4%	18.0
6.26E+05	70%	4.19%	24.9
9.51E+05	60%	13.0%	16.5

Table S1. Data sets used to construct the multivariate regression for top-down, industry-wide cost estimation. Flow rate: t-CO₂/year | Capture rate: CO₂ captured/total CO₂ | Concentration: CO₂ mol% | Cost: USD/t-CO₂ in year 2026 with \$50/t-CO₂ tax credit applied.

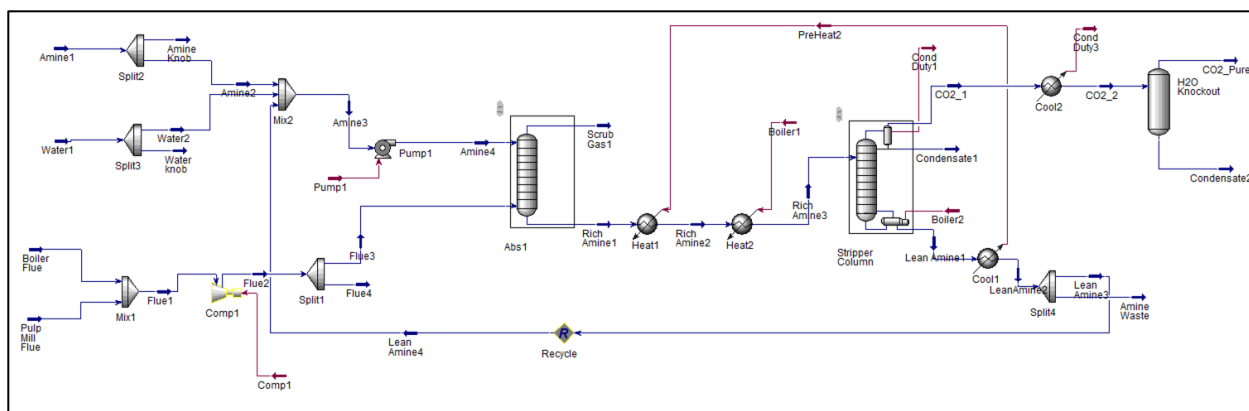


Figure S2. CO₂ Capture Amine System Model in Aspen Hysys

Table S2. Techno-economic summary of Mill 1, Baseline Scenario 1

Mill 1		
Baseline Scenario 1: Steam + Combined Emissions		
P&P Site Biomass Input (dry short t-biomass/day)		4225
CO ₂ capture capacity (kt-CO ₂ /y)		4005
CO ₂ capture rate (CO ₂ captured/CO ₂ input)		90%
Concentration of CO ₂ input (mol%)		15.1%
Biomass Input (dry short t-biomass/day)		3140
Biomass cost (\$/short t-biomass)	\$	60
Electricity cost (\$/kWh)	\$	0.07
LP steam cost (\$/t-steam)	\$	8.6
Reboiler Duty (GJ/tCO ₂)		3.5
Equipment Costs (2026\$)		Installed Capital Cost
Biomass Boiler		
Biomass Preprocessing	\$	39,149,860
Biomass Boiler	\$	110,191,339
Turbine/generator	\$	-
Boiler accessories + gas cleaning	\$	4,038,839
Amine Capture System		
Compressors	\$	38,479,067
Pumps	\$	11,337,909
Heat Exchangers	\$	28,120,818
Absorber Columns	\$	16,719,920
Stripper Column	\$	33,810,834
Water Knockout	\$	599,264
Indirect costs	\$	98,856,748
Contingency	\$	38,130,460
Total Installed Capital	\$	419,435,057
Capital Intensity (\$/t-CO ₂ -year)	\$	105
Levelized Capital Cost (CRF 8%) (\$/t-CO₂)	\$	9
Operating Costs (2026\$)		Annual cost (\$/y)
Biomass feedstock	\$	61,896,026
MEA Absorbent	\$	54,337,562
Cooling Water	\$	3,173,003
Electricity	\$	33,734,316
Low Pressure Steam	\$	(54)
Other O&M	\$	6,640,189
Fixed Costs	\$	12,353,588
Net Operating Costs	\$	172,134,630
Net Operating Costs (\$/t-CO₂)	\$	43
45Q Tax Credit (y2026) (\$/tCO ₂)	\$	50
Total Costs (w/ CRF 8%) (\$/t-CO₂)	\$	2

Table S3. Techno-economic summary of Mill 1, Baseline Scenario 2

Mill 1	
Baseline Scenario 2: Steam & Power + Combined Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	4225
CO2 capture capacity (kt-CO2/y)	4363
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	15%
Biomass Input (dry short t-biomass/day)	3932
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 45,819,715
Biomass Boiler	\$ 116,278,923
Turbine/generator	\$ 29,959,742
Boiler accessories + gas cleaning	\$ 4,726,925
Amine Capture System	
Compressors	\$ 40,850,295
Pumps	\$ 12,036,595
Heat Exchangers	\$ 29,853,731
Absorber Columns	\$ 17,750,265
Stripper Column	\$ 35,894,388
Water Knockout	\$ 636,193
Indirect costs	\$ 116,832,370
Contingency	\$ 45,063,914
Total Installed Capital	\$ 495,703,058
Capital Intensity (\$/t-CO2-year)	\$ 114
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 10
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 77,493,605
MEA Absorbent	\$ 59,183,562
Cooling Water	\$ 3,455,981
Electricity	\$ 8
Low Pressure Steam	\$ 366,774
Other O&M	\$ 7,170,388
Fixed Costs	\$ 13,605,713
Net Operating Costs	\$ 161,276,031
Net Operating Costs (\$/t-CO2)	\$ 37
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ (3)

Table S4. Techno-economic summary of Mill 1, Baseline Scenario 3

Mill 1	
Baseline Scenario 3: Steam + Lime Kiln Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	4225
CO2 capture capacity (kt-CO2/y)	316
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	18.8%
Biomass Input (dry short t-biomass/day)	247
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 6,610,627
Biomass Boiler	\$ 18,606,294
Turbine/generator	\$ -
Boiler accessories + gas cleaning	\$ 681,976
Amine Capture System	
Compressors	\$ 6,497,360
Pumps	\$ 438,616
Heat Exchangers	\$ 5,257,233
Absorber Columns	\$ 1,962,317
Stripper Column	\$ 5,195,355
Water Knockout	\$ 189,622
Indirect costs	\$ 15,903,790
Contingency	\$ 6,134,319
Total Installed Capital	\$ 67,477,510
Capital Intensity (\$/t-CO2-year)	\$ 214
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 19
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 4,876,510
MEA Absorbent	\$ 4,281,012
Cooling Water	\$ 752,633
Electricity	\$ 2,699,549
Low Pressure Steam	\$ (4)
Other O&M	\$ 523,151
Fixed Costs	\$ 3,800,124
Net Operating Costs	\$ 16,932,975
Net Operating Costs (\$/t-CO2)	\$ 54
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ 23

Table S5. Techno-economic summary of Mill 1, Baseline Scenario 4

Mill 1	
Baseline Scenario 4: Steam & Power + Lime Kiln Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	4225
CO2 capture capacity (kt-CO2/y)	347
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	18.4%
Biomass Input (dry short t-biomass/day)	318
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 7,881,360
Biomass Boiler	\$ 20,000,913
Turbine/generator	\$ 5,153,317
Boiler accessories + gas cleaning	\$ 813,069
Amine Capture System	
Compressors	\$ 6,950,284
Pumps	\$ 469,191
Heat Exchangers	\$ 5,623,709
Absorber Columns	\$ 2,099,108
Stripper Column	\$ 5,557,517
Water Knockout	\$ 202,841
Indirect costs	\$ 19,162,959
Contingency	\$ 7,391,427
Total Installed Capital	\$ 81,305,696
Capital Intensity (\$/t-CO2-year)	\$ 234
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 21
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 6,268,920
MEA Absorbent	\$ 4,713,619
Cooling Water	\$ 828,689
Electricity	\$ (2)
Low Pressure Steam	\$ (23,905)
Other O&M	\$ 580,055
Fixed Costs	\$ 4,027,147
Net Operating Costs	\$ 16,394,524
Net Operating Costs (\$/t-CO2)	\$ 47
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ 18

Table S6. Techno-economic summary of Mill 2, Baseline Scenario 1

Mill 2	
Baseline Scenario 1: Steam + Combined Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	5263
CO2 capture capacity (kt-CO2/y)	4,032
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	13%
Biomass Input (dry short t-biomass/day)	3162
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 39,334,782
Biomass Boiler	\$ 110,711,823
Turbine/generator	\$ -
Boiler accessories + gas cleaning	\$ 4,057,917
Amine Capture System	
Compressors	\$ 38,660,821
Pumps	\$ 64,048,312
Heat Exchangers	\$ 52,823,747
Absorber Columns	\$ 23,400,191
Stripper Column	\$ 20,602,663
Water Knockout	\$ 605,508
Indirect costs	\$ 123,986,017
Contingency	\$ 47,823,178
Total Installed Capital	\$ 526,054,958
Capital Intensity (\$/t-CO2-year)	\$ 130
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 12
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 62,314,110
MEA Absorbent	\$ 54,704,591
Cooling Water	\$ 3,067,235
Electricity	\$ 34,515,204
Low Pressure Steam	\$ (54)
Other O&M	\$ 6,685,041
Fixed Costs	\$ 14,104,013
Net Operating Costs	\$ 175,390,139
Net Operating Costs (\$/t-CO2)	\$ 43
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ 5

Table S7. Techno-economic summary of Mill 2, Baseline Scenario 2

Mill 2	
Baseline Scenario 2: Steam & Power + Combined Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	5263
CO2 capture capacity (kt-CO2/y)	4,442
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	13%
Biomass Input (dry short t-biomass/day)	4068
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 46,927,113
Biomass Boiler	\$ 119,089,223
Turbine/generator	\$ 30,683,827
Boiler accessories + gas cleaning	\$ 4,841,169
Amine Capture System	
Compressors	\$ 41,367,183
Pumps	\$ 68,531,866
Heat Exchangers	\$ 56,521,551
Absorber Columns	\$ 25,038,267
Stripper Column	\$ 22,044,905
Water Knockout	\$ 647,896
Indirect costs	\$ 145,492,550
Contingency	\$ 56,118,555
Total Installed Capital	\$ 617,304,106
Capital Intensity (\$/t-CO2-year)	\$ 139
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 12
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 80,182,988
MEA Absorbent	\$ 60,256,259
Cooling Water	\$ 3,378,512
Electricity	\$ (27)
Low Pressure Steam	\$ (330,024)
Other O&M	\$ 7,419,233
Fixed Costs	\$ 15,602,090
Net Operating Costs	\$ 166,509,030
Net Operating Costs (\$/t-CO2)	\$ 37
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ (0)

Table S8. Techno-economic summary of Mill 2, Baseline Scenario 3

Mill 2	
Baseline Scenario 3: Steam + Lime Kiln Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	5263
CO2 capture capacity (kt-CO2/y)	310
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	18.6%
Biomass Input (dry short t-biomass/day)	243
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 6,529,129
Biomass Boiler	\$ 18,376,910
Turbine/generator	\$ -
Boiler accessories + gas cleaning	\$ 673,568
Amine Capture System	
Compressors	\$ 6,417,259
Pumps	\$ 438,510
Heat Exchangers	\$ 5,256,080
Absorber Columns	\$ 1,961,844
Stripper Column	\$ 5,194,103
Water Knockout	\$ 189,577
Indirect costs	\$ 15,762,943
Contingency	\$ 6,079,992
Total Installed Capital	\$ 66,879,914
Capital Intensity (\$/t-CO2-year)	\$ 216
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 19
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 4,790,853
MEA Absorbent	\$ 4,205,815
Cooling Water	\$ 754,525
Electricity	\$ 2,653,428
Low Pressure Steam	\$ (4)
Other O&M	\$ 513,961
Fixed Costs	\$ 3,790,313
Net Operating Costs	\$ 16,708,891
Net Operating Costs (\$/t-CO2)	\$ 54
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ 23

Table S9. Techno-economic summary of Mill 2, Baseline Scenario 4

Mill 2	
Baseline Scenario 4: Steam & Power + Lime Kiln Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	5263
CO2 capture capacity (kt-CO2/y)	341
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	18.3%
Biomass Input (dry short t-biomass/day)	313
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 7,788,738
Biomass Boiler	\$ 19,765,861
Turbine/generator	\$ 5,092,755
Boiler accessories + gas cleaning	\$ 803,514
Amine Capture System	
Compressors	\$ 6,866,254
Pumps	\$ 469,191
Heat Exchangers	\$ 5,623,831
Absorber Columns	\$ 2,099,108
Stripper Column	\$ 5,557,517
Water Knockout	\$ 202,841
Indirect costs	\$ 18,994,364
Contingency	\$ 7,326,398
Total Installed Capital	\$ 80,590,373
Capital Intensity (\$/t-CO2-year)	\$ 236
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 21
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 6,163,939
MEA Absorbent	\$ 4,632,418
Cooling Water	\$ 831,057
Electricity	\$ (2)
Low Pressure Steam	\$ (25,143)
Other O&M	\$ 570,342
Fixed Costs	\$ 4,015,404
Net Operating Costs	\$ 16,188,016
Net Operating Costs (\$/t-CO2)	\$ 47
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ 18

Table S10. Techno-economic summary of Mill 3, Baseline Scenario 1	
Mill 3	
Baseline Scenario 1: Steam + Combined Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	7320
CO2 capture capacity (kt-CO2/y)	3,110
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	15%
Biomass Input (dry short t-biomass/day)	2438
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 32,793,928
Biomass Boiler	\$ 92,301,910
Turbine/generator	\$ -
Boiler accessories + gas cleaning	\$ 3,383,139
Amine Capture System	
Compressors	\$ 32,232,038
Pumps	\$ 2,937,532
Heat Exchangers	\$ 21,843,947
Absorber Columns	\$ 12,686,435
Stripper Column	\$ 27,626,824
Water Knockout	\$ 479,783
Indirect costs	\$ 79,199,937
Contingency	\$ 30,548,547
Total Installed Capital	\$ 336,034,019
Capital Intensity (\$/t-CO2-year)	\$ 108
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 10
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 48,056,605
MEA Absorbent	\$ 42,188,149
Cooling Water	\$ 4,001,875
Electricity	\$ 26,041,826
Low Pressure Steam	\$ (42)
Other O&M	\$ 5,155,500
Fixed Costs	\$ 10,984,357
Net Operating Costs	\$ 136,428,270
Net Operating Costs (\$/t-CO2)	\$ 44
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ 4

Table S11. Techno-economic summary of Mill 3, Baseline Scenario 2	
Mill 3	
Baseline Scenario 2: Steam & Power + Combined Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	7320
CO2 capture capacity (kt-CO2/y)	3,374
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	15%
Biomass Input (dry short t-biomass/day)	3023
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 38,122,553
Biomass Boiler	\$ 96,745,461
Turbine/generator	\$ 24,926,865
Boiler accessories + gas cleaning	\$ 3,932,859
Amine Capture System	
Compressors	\$ 34,124,666
Pumps	\$ 3,110,020
Heat Exchangers	\$ 23,126,599
Absorber Columns	\$ 13,431,368
Stripper Column	\$ 29,249,040
Water Knockout	\$ 507,955
Indirect costs	\$ 93,547,085
Contingency	\$ 36,082,447
Total Installed Capital	\$ 396,906,918
Capital Intensity (\$/t-CO2-year)	\$ 118
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 10
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 59,588,889
MEA Absorbent	\$ 45,771,106
Cooling Water	\$ 4,341,746
Electricity	\$ 11
Low Pressure Steam	\$ 471,313
Other O&M	\$ 5,513,686
Fixed Costs	\$ 11,983,734
Net Operating Costs	\$ 127,670,485
Net Operating Costs (\$/t-CO2)	\$ 38
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ (2)

Table S12. Techno-economic summary of Mill 3, Baseline Scenario 3	
Mill 3	
Baseline Scenario 3: Steam + Lime Kiln Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	7320
CO2 capture capacity (kt-CO2/y)	645
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	21%
Biomass Input (dry short t-biomass/day)	506
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 10,906,052
Biomass Boiler	\$ 30,696,215
Turbine/generator	\$ -
Boiler accessories + gas cleaning	\$ 1,125,107
Amine Capture System	
Compressors	\$ 10,719,188
Pumps	\$ 645,994
Heat Exchangers	\$ 7,924,913
Absorber Columns	\$ 2,781,819
Stripper Column	\$ 7,494,517
Water Knockout	\$ 219,608
Indirect costs	\$ 25,379,695
Contingency	\$ 9,789,311
Total Installed Capital	\$ 107,682,419
Capital Intensity (\$/t-CO2-year)	\$ 167
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 15
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 9,970,482
MEA Absorbent	\$ 8,752,931
Cooling Water	\$ 875,371
Electricity	\$ 5,460,210
Low Pressure Steam	\$ (9)
Other O&M	\$ 1,069,631
Fixed Costs	\$ 4,460,186
Net Operating Costs	\$ 30,588,802
Net Operating Costs (\$/t-CO2)	\$ 47
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ 12

Table S13. Techno-economic summary of Mill 3, Baseline Scenario 4

Mill 3	
Baseline Scenario 4: Steam & Power + Lime Kiln Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	7320
CO2 capture capacity (kt-CO2/y)	705
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	21%
Biomass Input (dry short t-biomass/day)	638
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 12,836,694
Biomass Boiler	\$ 32,576,305
Turbine/generator	\$ 8,393,419
Boiler accessories + gas cleaning	\$ 1,324,279
Amine Capture System	
Compressors	\$ 11,406,099
Pumps	\$ 687,391
Heat Exchangers	\$ 8,432,760
Absorber Columns	\$ 2,960,084
Stripper Column	\$ 7,974,783
Water Knockout	\$ 233,681
Indirect costs	\$ 30,388,923
Contingency	\$ 11,721,442
Total Installed Capital	\$ 128,935,861
Capital Intensity (\$/t-CO2-year)	\$ 183
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 16
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 12,584,572
MEA Absorbent	\$ 9,565,101
Cooling Water	\$ 956,595
Electricity	\$ 1
Low Pressure Steam	\$ 26,291
Other O&M	\$ 1,164,435
Fixed Costs	\$ 4,809,113
Net Operating Costs	\$ 29,106,109
Net Operating Costs (\$/t-CO2)	\$ 41
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ 8

Table S14. Techno-economic summary of Mill 4, Baseline Scenario 1	
Mill 4	
Baseline Scenario 1: Steam + Combined Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	3444
CO2 capture capacity (kt-CO2/y)	1,602
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	13%
Biomass Input (dry short t-biomass/day)	831
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 15,433,007
Biomass Boiler	\$ 43,437,799
Turbine/generator	\$ -
Boiler accessories + gas cleaning	\$ 1,592,124
Amine Capture System	
Compressors	\$ 20,259,413
Pumps	\$ 2,015,265
Heat Exchangers	\$ 14,881,627
Absorber Columns	\$ 9,298,772
Stripper Column	\$ 23,790,777
Water Knockout	\$ 343,208
Indirect costs	\$ 45,868,197
Contingency	\$ 17,692,019
Total Installed Capital	\$ 194,612,209
Capital Intensity (\$/t-CO2-year)	\$ 121
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 11
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 16,372,704
MEA Absorbent	\$ 21,732,188
Cooling Water	\$ 3,977,162
Electricity	\$ 13,457,879
Low Pressure Steam	\$ (0)
Other O&M	\$ 1,756,459
Fixed Costs	\$ 8,662,574
Net Operating Costs	\$ 65,958,967
Net Operating Costs (\$/t-CO2)	\$ 41
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ 2

Table S15. Techno-economic summary of Mill 4, Baseline Scenario	
2	
Mill 4	
Baseline Scenario 2: Steam & Power + Combined Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	3444
CO2 capture capacity (kt-CO2/y)	2,065
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	14%
Biomass Input (dry short t-biomass/day)	1856
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 27,094,799
Biomass Boiler	\$ 68,759,792
Turbine/generator	\$ 17,716,243
Boiler accessories + gas cleaning	\$ 2,795,196
Amine Capture System	
Compressors	\$ 24,199,011
Pumps	\$ 2,407,148
Heat Exchangers	\$ 17,775,474
Absorber Columns	\$ 11,106,990
Stripper Column	\$ 28,417,076
Water Knockout	\$ 409,948
Indirect costs	\$ 70,238,587
Contingency	\$ 27,092,026
Total Installed Capital	\$ 298,012,290
Capital Intensity (\$/t-CO2-year)	\$ 144
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 13
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 36,585,905
MEA Absorbent	\$ 28,012,212
Cooling Water	\$ 5,126,456
Electricity	\$ (5)
Low Pressure Steam	\$ (5,096,774)
Other O&M	\$ 3,385,249
Fixed Costs	\$ 10,360,138
Net Operating Costs	\$ 78,373,180
Net Operating Costs (\$/t-CO2)	\$ 38
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ 1

Table S16. Techno-economic summary of Mill 4, Baseline Scenario 3	
Mill 4	
Baseline Scenario 3: Steam + Lime Kiln Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	3444
CO2 capture capacity (kt-CO2/y)	183
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	21%
Biomass Input (dry short t-biomass/day)	0
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ -
Biomass Boiler	\$ -
Turbine/generator	\$ -
Boiler accessories + gas cleaning	\$ -
Amine Capture System	
Compressors	\$ 4,436,053
Pumps	\$ 243,056
Heat Exchangers	\$ 2,981,700
Absorber Columns	\$ 1,200,768
Stripper Column	\$ 3,705,667
Water Knockout	\$ 140,615
Indirect costs	\$ 4,447,751
Contingency	\$ 1,715,561
Total Installed Capital	\$ 18,871,172
Capital Intensity (\$/t-CO2-year)	\$ 103
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 9
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ -
MEA Absorbent	\$ 2,481,845
Cooling Water	\$ 530,697
Electricity	\$ 1,566,366
Low Pressure Steam	\$ (3,526,498)
Other O&M	\$ -
Fixed Costs	\$ 3,002,133
Net Operating Costs	\$ 4,054,542
Net Operating Costs (\$/t-CO2)	\$ 22
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ (19)

Table S17. Techno-economic summary of Mill 4, Baseline Scenario 4

Mill 4	
Baseline Scenario 4: Steam & Power + Lime Kiln Emissions	
P&P Site Biomass Input (dry short t-biomass/day)	3444
CO2 capture capacity (kt-CO2/y)	312
CO2 capture rate (CO2 captured/CO2 input)	90%
Concentration of CO2 input (mol%)	18%
Biomass Input (dry short t-biomass/day)	286
Biomass cost (\$/short t-biomass)	\$ 60
Electricity cost (\$/kWh)	\$ 0.07
LP steam cost (\$/t-steam)	\$ 8.6
Reboiler Duty (GJ/tCO2)	3.5
Equipment Costs (2026\$)	Installed Capital Cost
Biomass Boiler	
Biomass Preprocessing	\$ 7,313,067
Biomass Boiler	\$ 18,558,726
Turbine/generator	\$ 4,781,732
Boiler accessories + gas cleaning	\$ 754,442
Amine Capture System	
Compressors	\$ 6,445,250
Pumps	\$ 353,143
Heat Exchangers	\$ 4,332,184
Absorber Columns	\$ 1,744,625
Stripper Column	\$ 5,384,055
Water Knockout	\$ 204,303
Indirect costs	\$ 17,455,034
Contingency	\$ 6,732,656
Total Installed Capital	\$ 74,059,216
Capital Intensity (\$/t-CO2-year)	\$ 237
Levelized Capital Cost (CRF 8%) (\$/t-CO2)	\$ 21
Operating Costs (2026\$)	Annual cost (\$/y)
Biomass feedstock	\$ 5,633,286
MEA Absorbent	\$ 4,232,047
Cooling Water	\$ 904,945
Electricity	\$ 1
Low Pressure Steam	\$ (5,345,208)
Other O&M	\$ 521,241
Fixed Costs	\$ 3,908,179
Net Operating Costs	\$ 9,854,491
Net Operating Costs (\$/t-CO2)	\$ 32
45Q Tax Credit (y2026) (\$/tCO2)	\$ 50
Total Costs (w/ CRF 8%) (\$/t-CO2)	\$ 3

- 1 Gekko Python Package - Optimization suite, <https://gekko.readthedocs.io/en/latest/>.
- 2 APMonitor - Non-linear regression,
<https://apmonitor.com/me575/index.php/Main/NonlinearRegression>.
- 3 P. Psarras, S. Comello, P. Bains, P. Charoensawadpong, S. Reichelstein and J. Wilcox,
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- 4 K. Onarheim, S. Santos, P. Kangas and V. Hankalin, *Int. J. Greenh. Gas Control*, 2017,
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