Supplementary Information for:

Decarbonization Approaches for Ethylene Production: Comparative Techno-Economic and Life-Cycle Analysis

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22 pages, including 10 tables and 16 figures

Figure S1. Process configurations of Baseline case with stream numbers & information shown in Table S1.

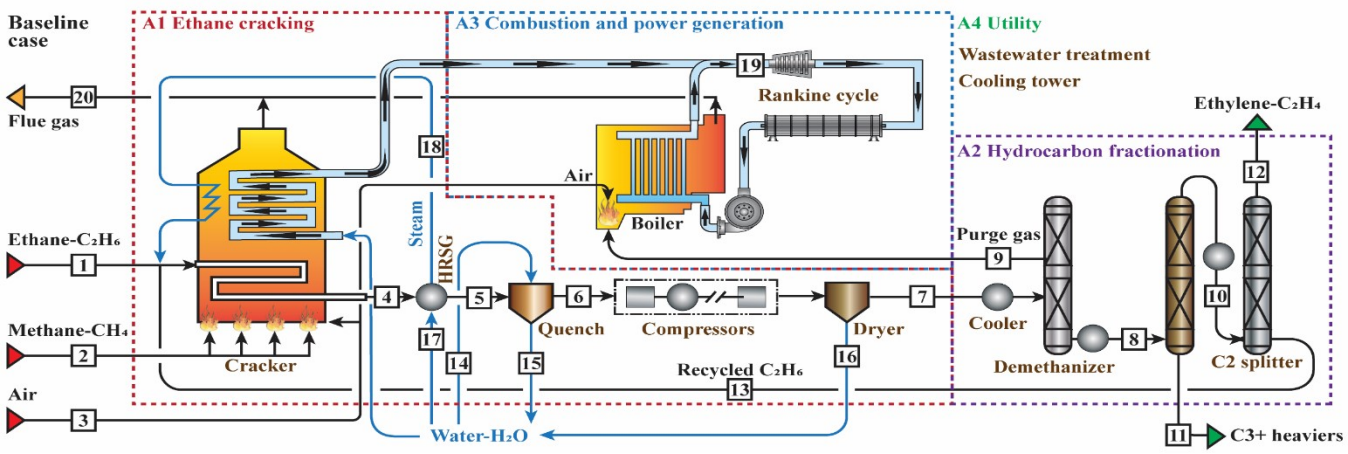

Figure S2. Screen copy of our Aspen Plus model for Baseline case: Main Flowsheet.

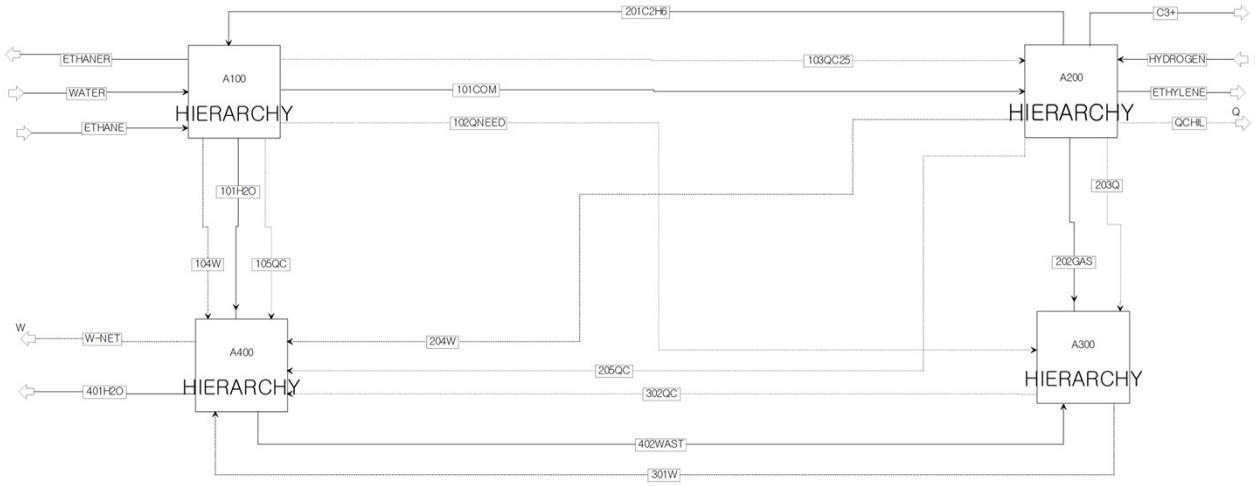

Figure S3. Screen copy of our Aspen Plus model for Baseline case: A1–A4 Flowsheet.

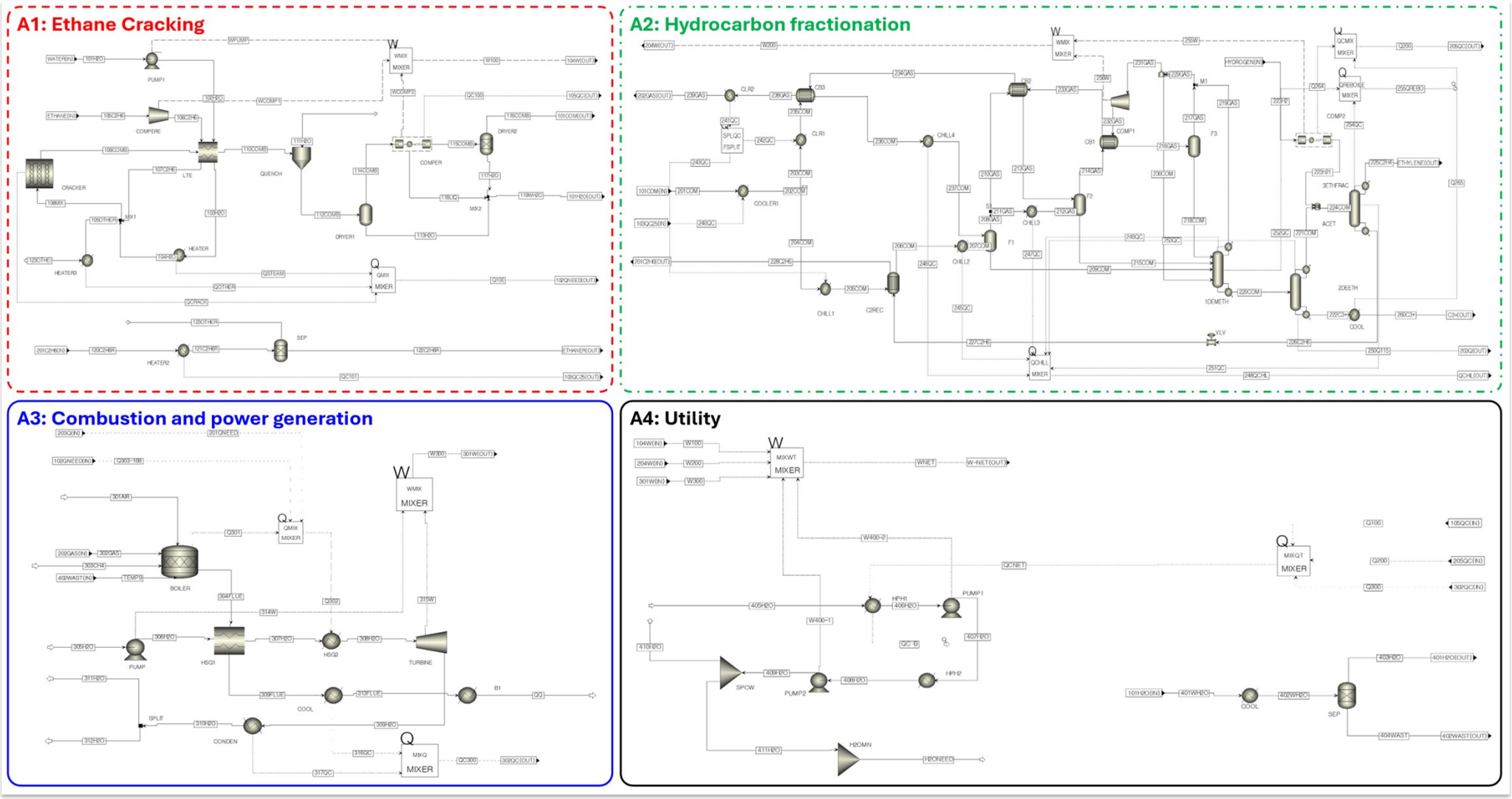

Figure S4. Process configurations of No external NG case with stream numbers & information shown in Table S2.

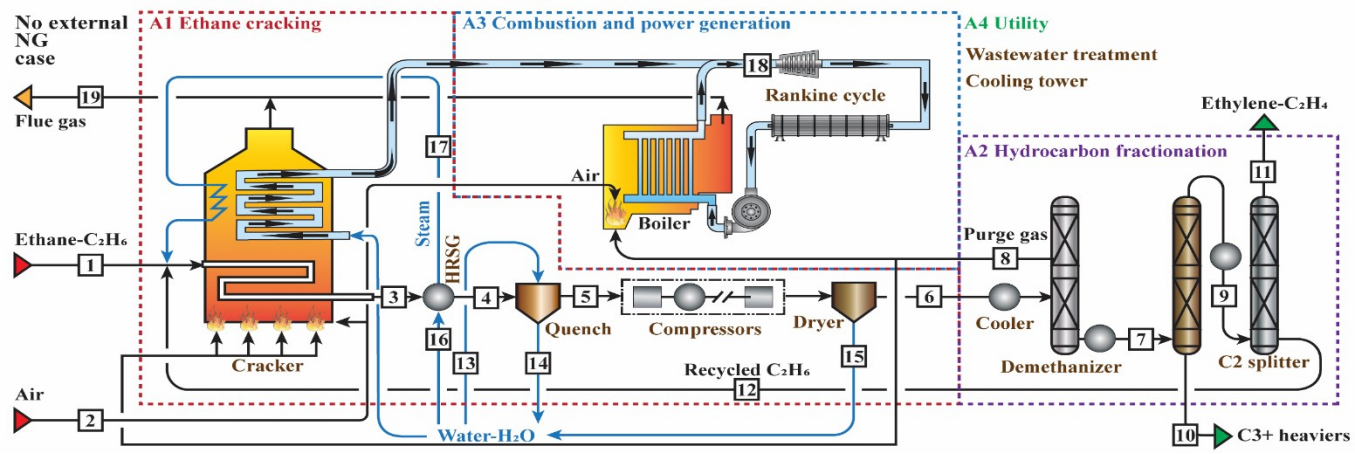

Figure S5. Screen copy of our Aspen Plus model for No external NG case: Main Flowsheet.

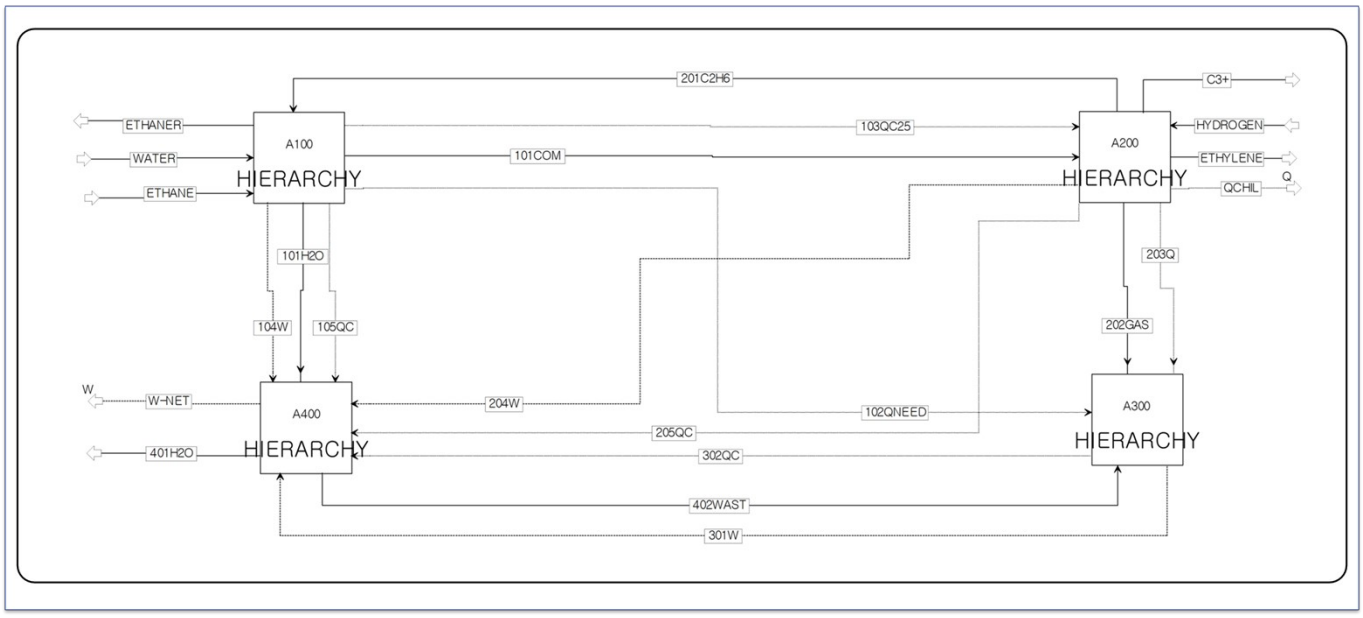

Figure S6. Screen copy of our Aspen Plus model for No external NG case: A1–A4 Flowsheet.

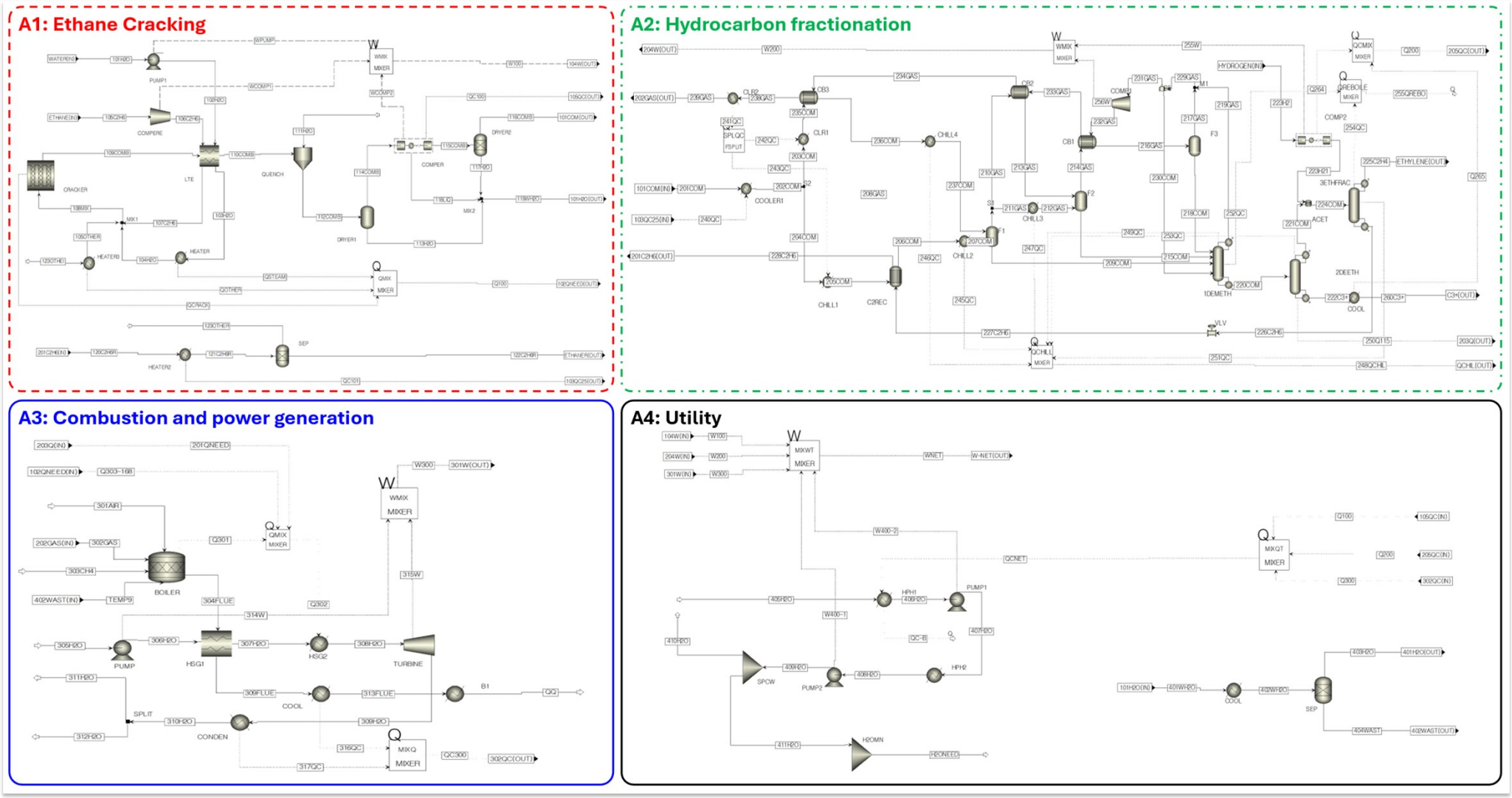

Figure S7. Process configurations of Electrical heating case with stream numbers & information shown in Table S3.

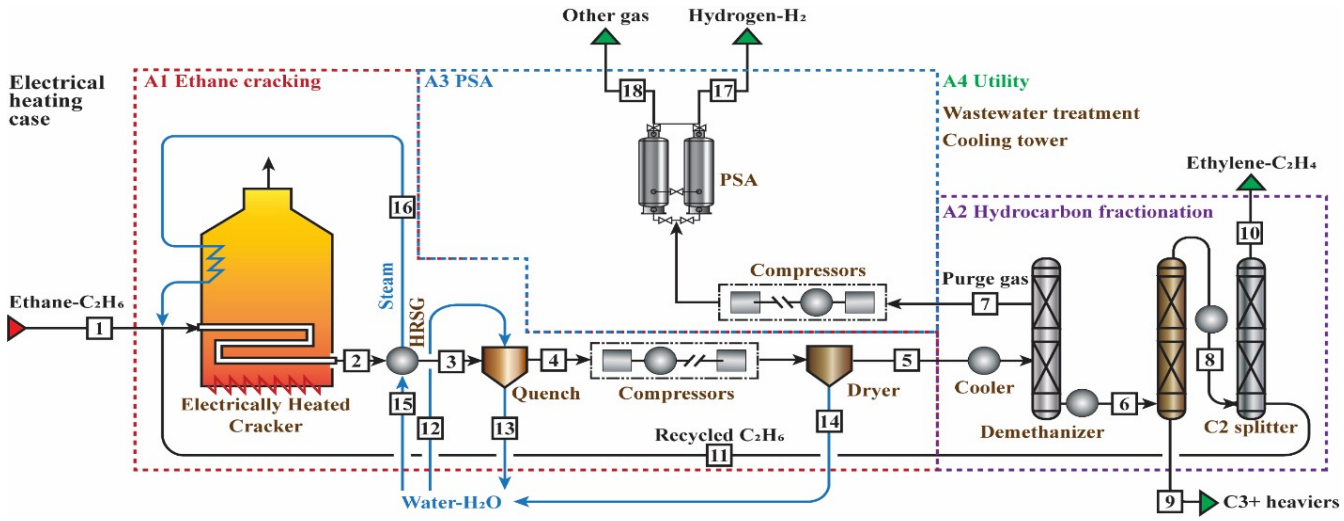

Figure S8. Screen copy of our Aspen Plus model for Electrical heating case: Main Flowsheet.

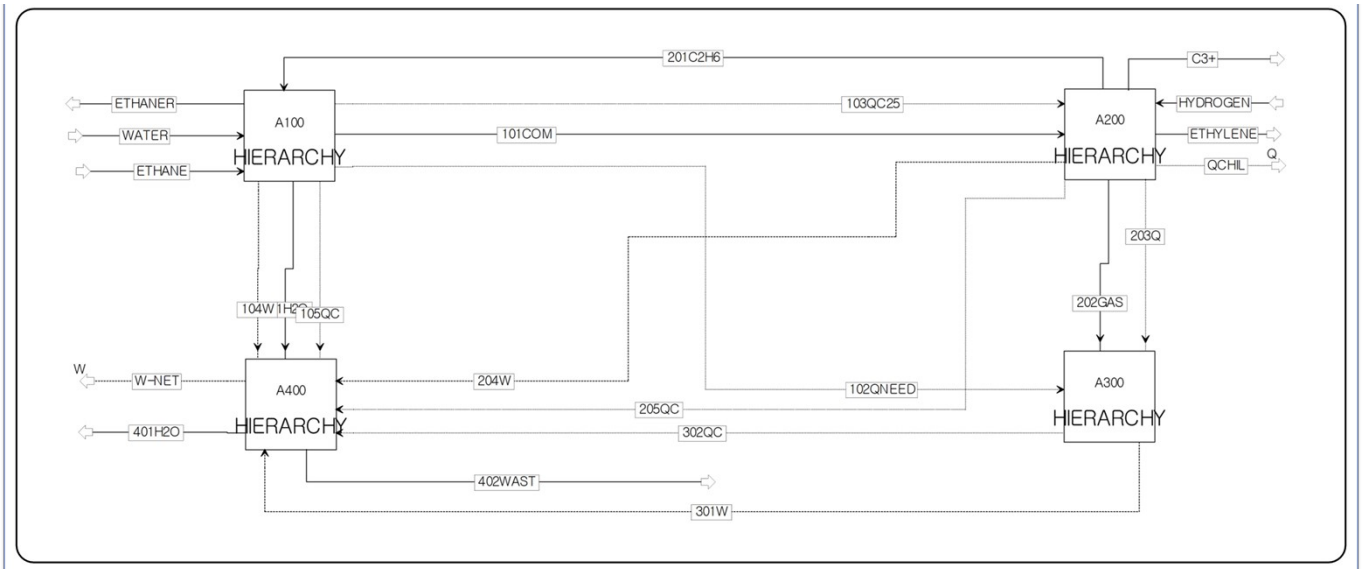

Figure S9. Screen copy of our Aspen Plus model for Electrical heating case: A1–A4 Flowsheet.

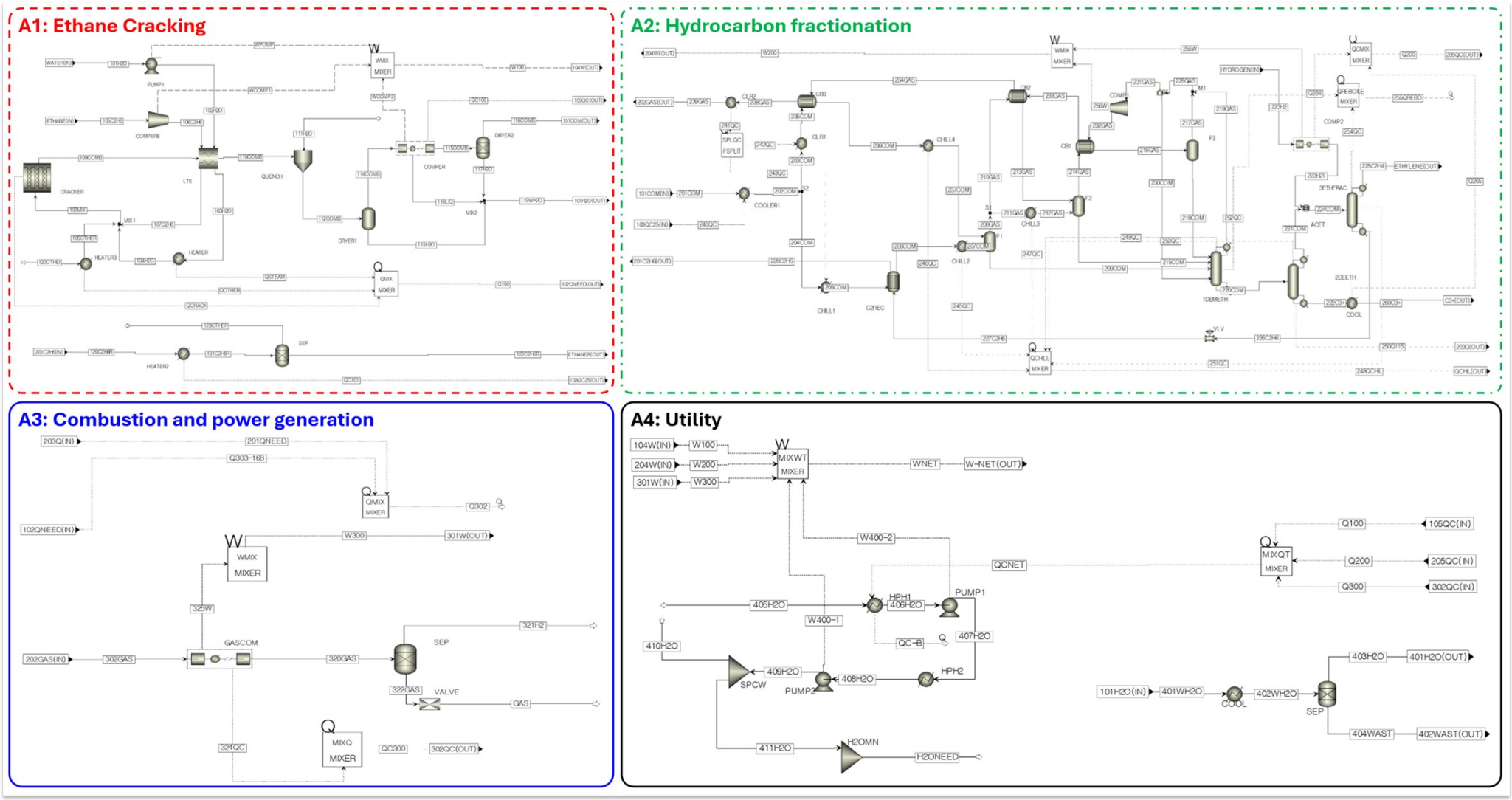

Figure S10. Process configurations of CCS H_2 combustion case with stream numbers & information shown in Table S4.

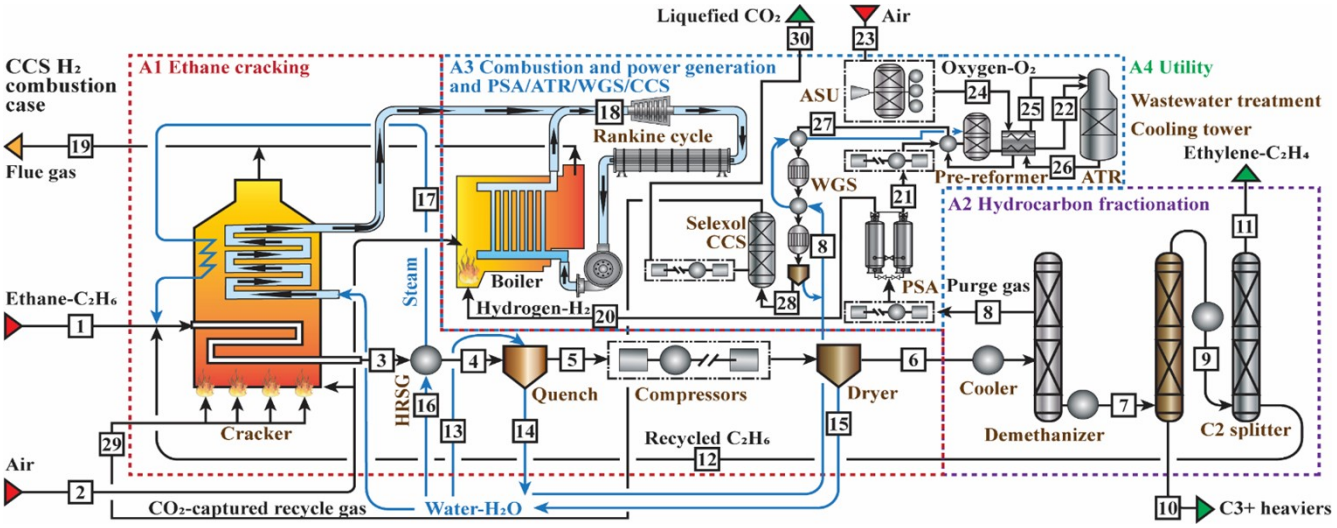

Figure S11. Screen copy of our Aspen Plus model for CCS H_2 combustion case: Main Flowsheet.

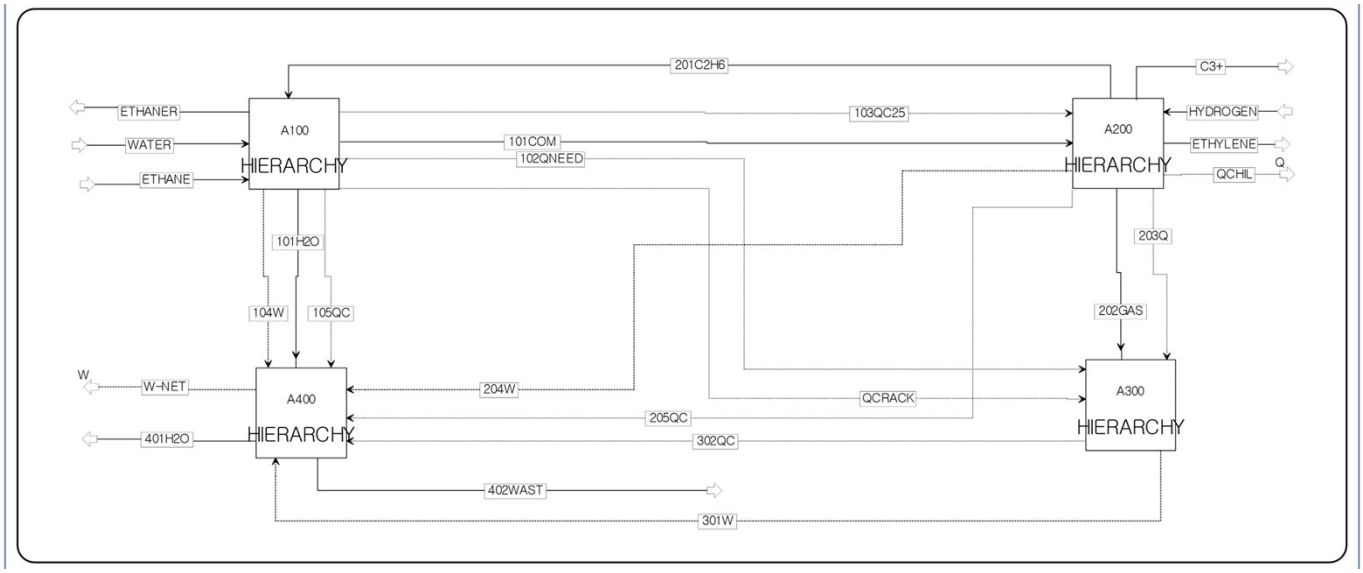

Figure S12. Screen copy of our Aspen Plus model for CCS H_2 combustion case: A1–A4 Flowsheet.

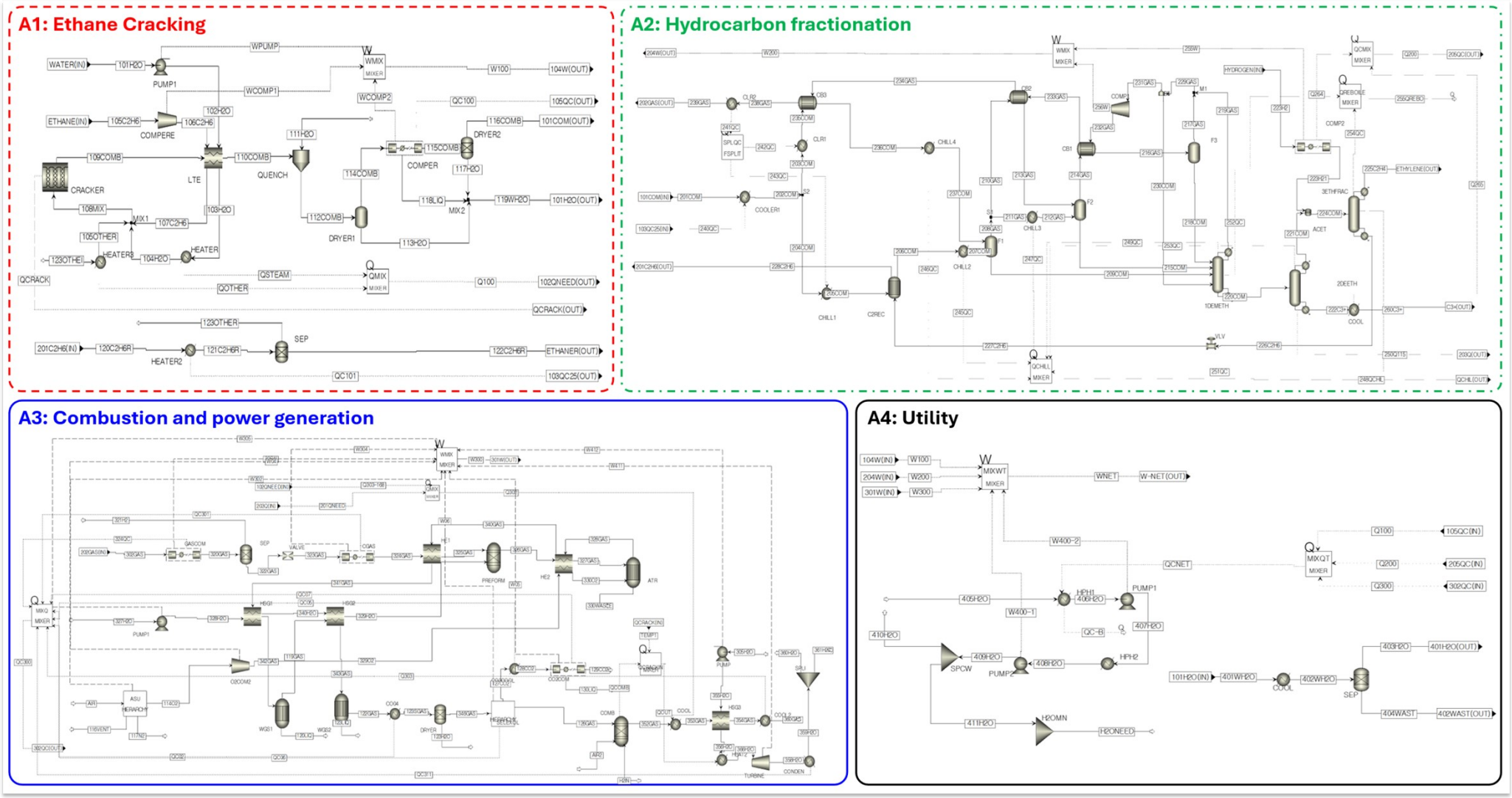

Figure S13. Effects of allocation methods on WTG GHG emissions (Assumption: using grid electricity, substitutes NG-SMR based gray hydrogen in the Electrical heating case, lower heating value (LHV) basis if energy allocation)

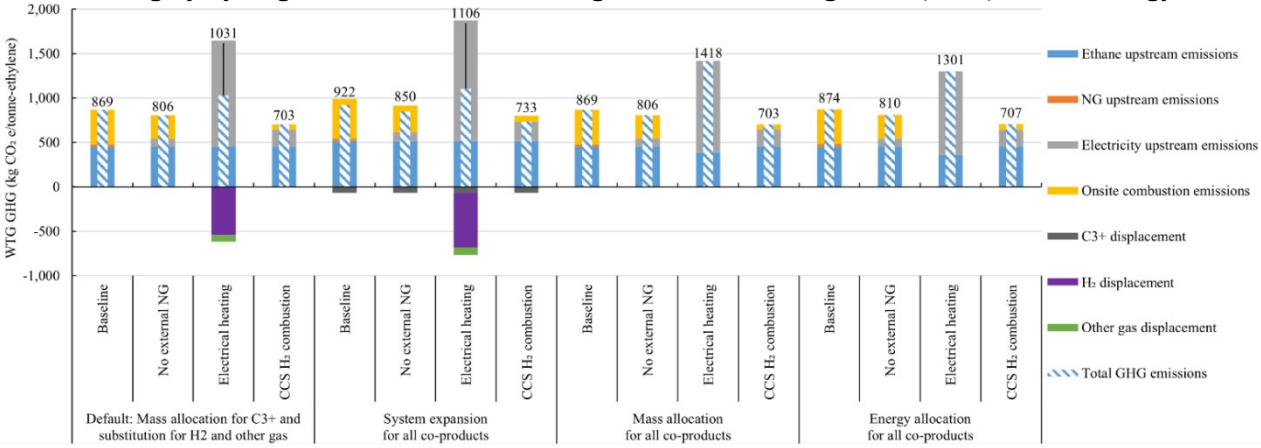

Figure S14. Assumption: renewable electricity, substitute NG-SMR based gray hydrogen

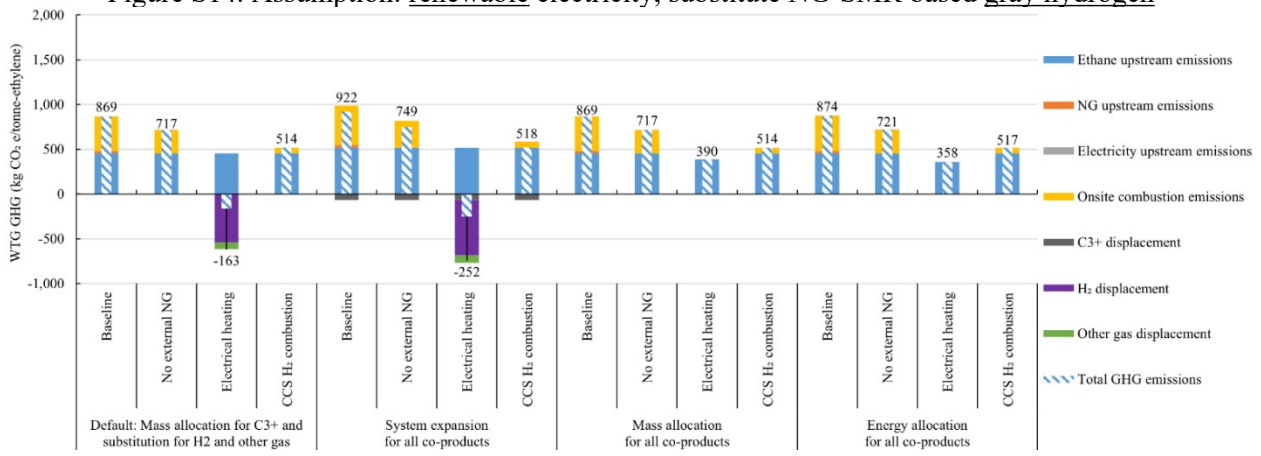

Figure S15. Assumption: renewable electricity, substitute NG-ATR+CCS based blue hydrogen

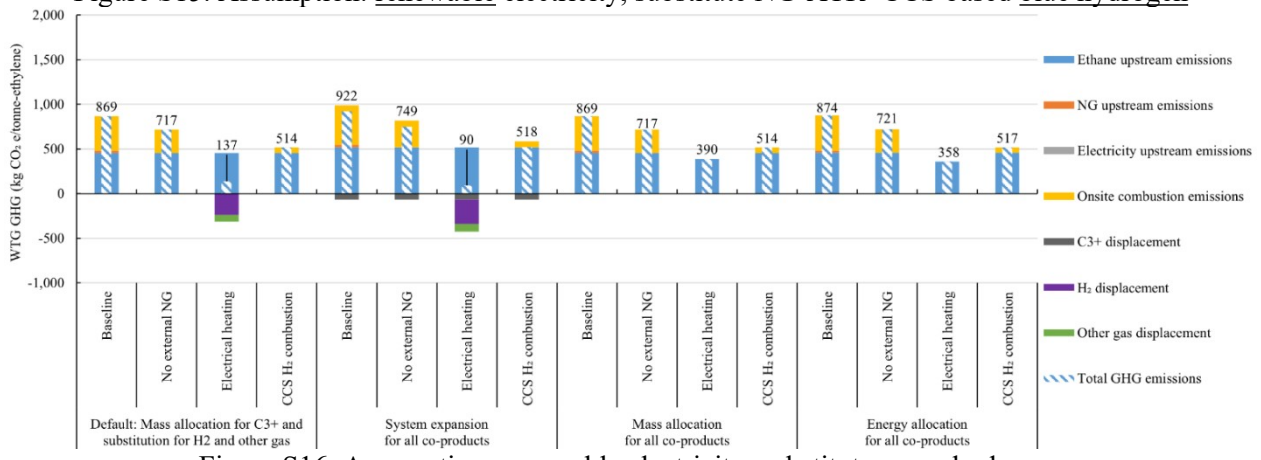

Figure S16. Assumption: renewable electricity, substitute green hydrogen

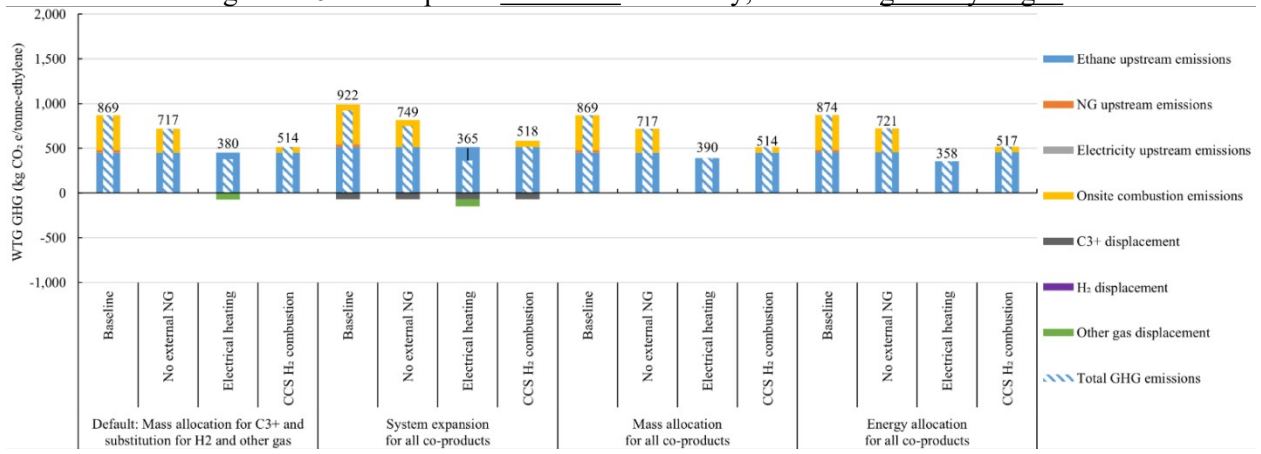

Table S1. Detailed stream information according to the stream number shown in Figure S1 for Baseline case.

Name	Unit	1	2	3	4	5	6	7	8	9	10
Temperature	ºC	25.0	25.0	25.0	850.0	200.0	30.0	43.0	3.0	13.0	-14.0
Pressure	Bar	1.0	1.0	1.0	2.2	2.2	2.1	38.0	34.5	4.5	23.4
Mass flow	kg/hr	220,979	5,920	676,995	295,168	295,168	225,138	221,498	200,391	21,107	184,653
Molar flow	kmol/hr	7,349	369	23,466	15,865	15,865	11,978	11,776	6,686	5,091	6,409
C2H6	mol %	100.00%	0.00%	0.00%	14.65%	14.65%	19.41%	19.74%	34.75%	0.03%	36.25%
C2H4	mol %	0.00%	0.00%	0.00%	25.90%	25.90%	34.30%	34.88%	60.96%	0.64%	63.59%
H2	mol %	0.00%	0.00%	0.00%	27.40%	27.40%	36.29%	36.91%	0.00%	85.39%	0.00%
CH4	mol %	0.00%	100.00%	0.00%	4.48%	4.48%	5.93%	6.03%	0.00%	13.94%	0.01%
C2H2	mol %	0.00%	0.00%	0.00%	0.02%	0.02%	0.02%	0.02%	0.04%	0.00%	0.04%
C3H6	mol %	0.00%	0.00%	0.00%	0.02%	0.02%	0.02%	0.02%	0.04%	0.00%	0.01%
C3H8	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%
C4H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H8	mol %	0.00%	0.00%	0.00%	1.70%	1.70%	2.25%	2.29%	4.04%	0.00%	0.10%
C4H10	mol %	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.00%	0.00%
C6H6	mol %	0.00%	0.00%	0.00%	0.07%	0.07%	0.09%	0.09%	0.16%	0.00%	0.00%
H2O	mol %	0.00%	0.00%	0.00%	25.77%	25.77%	1.69%	0.00%	0.00%	0.00%	0.00%
O2	mol %	0.00%	0.00%	21.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
N2	mol %	0.00%	0.00%	79.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CO2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	mol %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Name	**Unit**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Temperature	ºC	43.0	-35.9	25.0	15.0	30.0	43.2	25.0	263.4	25.0	25.0
Pressure	Bar	23.4	16.5	1.0	2.2	2.1	11.9	1.0	2.2	1.0	1.0
Mass flow	kg/hr	15,738	114,335	69,796	4,157,164	4,227,194	3,640	73,660	73,660	267,201	704,033
Molar flow	kmol/hr	277	4,075	2,321	230,758	234,645	202	4,089	4,089	14,832	26,753
C2H6	mol %	0.10%	0.09%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C2H4	mol %	0.00%	99.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
H2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CH4	mol %	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C2H2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C3H6	mol %	0.61%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C3H8	mol %	0.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H6	mol %	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H8	mol %	95.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H10	mol %	0.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C6H6	mol %	3.79%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
H2O	mol %	0.00%	0.00%	0.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	24.58%
O2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.84%
N2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	69.29%
CO2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.29%
Total	mol %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table S2. Detailed stream information according to the stream number shown in Figure S4 for No external NG case.

Name	Unit	1	2	3	4	5	6	7	8	9	10
Temperature	ºC	25.0	25.0	850.0	200.0	30.0	43.0	3.0	13.0	-14.0	43.0
Pressure	Bar	1.0	1.0	2.2	2.2	2.1	38.0	34.5	4.5	23.4	23.4
Mass flow	kg/hr	220,979	564,337	295,168	295,168	225,138	221,498	200,391	21,107	184,653	15,738
Molar flow	kmol/hr	7,349	19,561	15,865	15,865	11,978	11,776	6,686	5,091	6,409	277
C2H6	mol %	100.00%	0.00%	14.65%	14.65%	19.41%	19.74%	34.75%	0.03%	36.25%	0.10%
C2H4	mol %	0.00%	0.00%	25.90%	25.90%	34.30%	34.88%	60.96%	0.64%	63.59%	0.00%
H2	mol %	0.00%	0.00%	27.40%	27.40%	36.29%	36.91%	0.00%	85.39%	0.00%	0.00%
CH4	mol %	0.00%	0.00%	4.48%	4.48%	5.93%	6.03%	0.00%	13.94%	0.01%	0.00%
C2H2	mol %	0.00%	0.00%	0.02%	0.02%	0.02%	0.02%	0.04%	0.00%	0.04%	0.00%
C3H6	mol %	0.00%	0.00%	0.02%	0.02%	0.02%	0.02%	0.04%	0.00%	0.01%	0.61%
C3H8	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.10%
C4H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
C4H8	mol %	0.00%	0.00%	1.70%	1.70%	2.25%	2.29%	4.04%	0.00%	0.10%	95.11%
C4H10	mol %	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.00%	0.00%	0.29%
C6H6	mol %	0.00%	0.00%	0.07%	0.07%	0.09%	0.09%	0.16%	0.00%	0.00%	3.79%
H2O	mol %	0.00%	0.00%	25.77%	25.77%	1.69%	0.00%	0.00%	0.00%	0.00%	0.00%
O2	mol %	0.00%	21.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
N2	mol %	0.00%	79.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CO2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	mol %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Name	Unit	11	12	13	14	15	16	17	18	19
Temperature	ºC	-35.9	25.0	15.0	30.0	43.2	25.0	263.4	25.0	25.0
Pressure	Bar	16.5	1.0	2.2	2.1	11.9	1.0	2.2	1.0	1.0
Mass flow	kg/hr	114,335	69,796	4,157,164	4,227,194	3,640	73,660	73,660	185,708	585,454
Molar flow	kmol/hr	4,075	2,321	230,758	234,645	202	4,089	4,089	10,308	22,479
C2H6	mol %	0.09%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C2H4	mol %	99.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
H2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CH4	mol %	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C2H2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C3H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C3H8	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H8	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H10	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C6H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
H2O	mol %	0.00%	0.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	25.97%
O2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.83%
N2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	68.74%
CO2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.46%
Total	mol %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table S3. Detailed stream information according to the stream number shown in Figure S7 for Electrical heating case.

Name	Unit	1	2	3	4	5	6	7	8	9	10
Temperature	ºC	25.0	850.0	200.0	30.0	43.0	3.0	13.0	-14.0	43.0	-35.9
Pressure	Bar	1.0	2.2	2.2	2.1	38.0	34.5	4.5	23.4	23.4	16.5
Mass flow	kg/hr	220,979	295,168	295,168	225,138	221,498	200,391	21,107	184,653	15,738	114,335
Molar flow	kmol/hr	7,349	15,865	15,865	11,978	11,776	6,686	5,091	6,409	277	4,075
C2H6	mol %	100.00%	14.65%	14.65%	19.41%	19.74%	34.75%	0.03%	36.25%	0.10%	0.09%
C2H4	mol %	0.00%	25.90%	25.90%	34.30%	34.88%	60.96%	0.64%	63.59%	0.00%	99.90%
H2	mol %	0.00%	27.40%	27.40%	36.29%	36.91%	0.00%	85.39%	0.00%	0.00%	0.00%
CH4	mol %	0.00%	4.48%	4.48%	5.93%	6.03%	0.00%	13.94%	0.01%	0.00%	0.01%
C2H2	mol %	0.00%	0.02%	0.02%	0.02%	0.02%	0.04%	0.00%	0.04%	0.00%	0.00%
C3H6	mol %	0.00%	0.02%	0.02%	0.02%	0.02%	0.04%	0.00%	0.01%	0.61%	0.00%
C3H8	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.10%	0.00%
C4H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
C4H8	mol %	0.00%	1.70%	1.70%	2.25%	2.29%	4.04%	0.00%	0.10%	95.11%	0.00%
C4H10	mol %	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.00%	0.00%	0.29%	0.00%
C6H6	mol %	0.00%	0.07%	0.07%	0.09%	0.09%	0.16%	0.00%	0.00%	3.79%	0.00%
H2O	mol %	0.00%	25.77%	25.77%	1.69%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
O2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
N2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CO2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	mol %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Name	Unit	11	12	13	14	15	16	17	18
Temperature	ºC	25.0	15.0	30.0	43.2	25.0	263.4	43.0	39.0
Pressure	Bar	1.0	2.2	2.1	11.9	1.0	2.2	30.0	1.2
Mass flow	kg/hr	69,796	4,157,164	4,227,194	3,640	73,660	73,660	7,448	13,659
Molar flow	kmol/hr	2,321	230,758	234,645	202	4,089	4,089	3,695	1,396
C2H6	mol %	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.09%
C2H4	mol %	0.00%	0.00%	9.80E-07	0.00%	0.00%	0.00%	0.00%	2.34%
H2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	46.71%
CH4	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	50.86%
C2H2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C3H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C3H8	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H8	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H10	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C6H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
H2O	mol %	0.00%	100.00%	100.00%	100.00%	100.00%	100.00%	0.00%	0.00%
O2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
N2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CO2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	mol %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table S4. Detailed stream information according to the stream number shown in Figure S10 for CCS H_2 combustion case.

Name	**Unit**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Temperature	ºC	25.0	25.0	850.0	200.0	30.0	43.0	3.0	13.0	-14.0	43.0
Pressure	Bar	1.0	1.2	2.2	2.2	2.1	38.0	34.5	4.5	23.4	23.4
Mass flow	kg/hr	220,979	456,970	295,168	295,168	225,138	221,498	200,391	21,107	184,653	15,738
Molar flow	kmol/hr	7,349	15,836	15,865	15,865	11,978	11,776	6,686	5,091	6,409	277
C2H6	mol %	100.00%	0.00%	14.65%	14.65%	19.41%	19.74%	34.75%	0.03%	36.25%	0.10%
C2H4	mol %	0.00%	0.00%	25.90%	25.90%	34.30%	34.88%	60.96%	0.64%	63.59%	0.00%
H2	mol %	0.00%	0.00%	27.40%	27.40%	36.29%	36.91%	0.00%	85.39%	0.00%	0.00%
CH4	mol %	0.00%	0.00%	4.48%	4.48%	5.93%	6.03%	0.00%	13.94%	0.01%	0.00%
C2H2	mol %	0.00%	0.00%	0.02%	0.02%	0.02%	0.02%	0.04%	0.00%	0.04%	0.00%
C3H6	mol %	0.00%	0.00%	0.02%	0.02%	0.02%	0.02%	0.04%	0.00%	0.01%	0.61%
C3H8	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.10%
C4H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
C4H8	mol %	0.00%	0.00%	1.70%	1.70%	2.25%	2.29%	4.04%	0.00%	0.10%	95.11%
C4H10	mol %	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.00%	0.00%	0.29%
C6H6	mol %	0.00%	0.00%	0.07%	0.07%	0.09%	0.09%	0.16%	0.00%	0.00%	3.79%
H2O	mol %	0.00%	0.99%	25.77%	25.77%	1.69%	0.00%	0.00%	0.00%	0.00%	0.00%
O2	mol %	0.00%	20.74%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
N2	mol %	0.00%	77.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CO2	mol %	0.00%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CO	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
AR	mol %	0.00%	0.92%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CLYCOI	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	mol %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Name	**Unit**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Temperature	ºC	-35.9	25.0	15.0	30.0	43.2	25.0	263.4	25.0	43.0	43.0
Pressure	Bar	16.5	1.0	2.2	2.1	11.9	1.0	2.2	1.0	1.0	30.0
Mass flow	kg/hr	114,335	69,796	4,157,164	4,227,194	3,640	73,660	73,660	170,607	476,116	7,448
Molar flow	kmol/hr	4,075	2,321	230,758	234,645	202	4,089	4,089	9,470	19,176	3,695
C2H6	mol %	0.09%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C2H4	mol %	99.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
H2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
CH4	mol %	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C2H2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C3H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C3H8	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H8	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H10	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C6H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
H2O	mol %	0.00%	0.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	34.34%	0.00%
O2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

N2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	63.89%	0.00%
CO2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.93%	0.00%
CO	mol %	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
AR	mol %	0.00%	0.00%	0.00%	0.00%	200.00%	0.00%	0.00%	0.00%	0.83%	0.00%
CLYCOI	mol %	0.00%	0.00%	0.00%	0.00%	300.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	mol %	100.00%	100.00%	100.00%	100.00%	400.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Name	**Unit**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Temperature	ºC	43.0	700.0	25.0	174.8	700.0	1000.5	583.2	43.0	33.0	43.0
Pressure	Bar	30.0	33.0	1.0	28.5	28.5	28.3	28.3	27.8	30.0	153.0
Mass flow	kg/hr	13,659	32,843	60,669	13,902	13,902	46,744	46,744	38,327	11,697	26,526
Molar flow	kmol/hr	1,396	2,434	2,102	432	432	3,938	3,938	3,470	2,862	603
C2H6	mol %	0.09%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C2H4	mol %	2.34%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
H2	mol %	46.71%	24.55%	0.00%	0.00%	0.00%	54.80%	54.80%	76.83%	93.16%	0.00%
CH4	mol %	50.86%	31.82%	0.00%	0.00%	0.00%	0.86%	0.86%	0.97%	1.17%	0.07%
C2H2	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C3H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C3H8	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H8	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C4H10	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
C6H6	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
H2O	mol %	0.00%	43.49%	0.99%	0.00%	0.00%	24.90%	24.90%	0.14%	0.00%	0.00%
O2	mol %	0.00%	0.00%	20.74%	95.04%	95.04%	0.00%	0.00%	0.00%	0.00%	0.00%
N2	mol %	0.00%	0.00%	77.32%	1.78%	1.78%	0.20%	0.20%	0.22%	0.27%	0.00%
CO2	mol %	0.00%	0.12%	0.03%	0.00%	0.00%	4.10%	4.10%	19.31%	2.34%	99.92%
CO	mol %	0.00%	0.01%	0.00%	0.00%	0.00%	14.80%	14.80%	2.13%	2.58%	0.00%
AR	mol %	0.00%	0.00%	0.92%	3.18%	3.18%	0.35%	0.35%	0.40%	0.48%	0.01%
CLYCOI	mol %	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	mol %	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table S5. Molecular reaction scheme for ethane cracker. The kinetic data referenced from [1-5]

No.	Reactions	Pre-exponential Constant [s^{-1} or [a] $kmol^{-1}m^3s^{-1}$]	Activation Energy [kJ/mol]
1	$C_2H_6 \leftrightarrow C_2H_4 + H_2$	(Forward) 4.60×10^{13} (Reverse) 8.49×10^{8}	(Forward) 272.8 (Reverse) 136.5
2	$C_3H_6 \leftrightarrow C_2H_2 + CH_4$	(Forward) 9.81×10^{8} (Reverse) 5.87×10^{4}	(Forward) 154.5 (Reverse) 29.4
3	$C_2H_2 + C_2H_4 \rightarrow C_4H_6$	[a] 1.03×10^{12}	172.6
4	$C_2H_4 + C_4H_6 \rightarrow C_6H_6 + 2H_2$	[a] 8.30×10^{12}	144.6
5	$C_3H_8 \leftrightarrow C_3H_6 + H_2$	(Forward) 5.80×10^{10} (Reverse) 9.03×10^{5}	(Forward) 214.6 (Reverse) 93.5
6	$C_3H_8 + C_2H_4 \rightarrow C_2H_6 + C_3H_6$	[a] 2.50×10^{16}	247.1
7	$2C_3H_6 \rightarrow 3C_2H_4$	7.30×10^{12}	268.5
8	$2C_2H_6 \rightarrow C_3H_8 + CH_4$	3.80×10^{11}	273.0
9	$C_4H_{10} \leftrightarrow C_4H_8 + H_2$	(Forward) 1.60×10^{12} (Reverse) 1.78×10^{7}	(Forward) 260.9 (Reverse) 135.1
10	$C_2H_4 + C_2H_6 \rightarrow C_3H_6 + CH_4$	[a] 7.08×10^{13}	252.8
11	$C_3H_6 + C_2H_6 \rightarrow C_4H_8 + CH_4$	[a] 1.00×10^{17}	251.1
12	$C_3H_8 \rightarrow C_2H_4 + CH_4$	4.90×10^{10}	212.0
13	$2C_2H_6 \rightarrow C_2H_4 + 2CH_4$	6.37×10^{23}	530.0

Table S6. Total plant cost breakdown, installation factor and scaling exponent for Baseline case.

Reaction area	Major equipment name	Major equipment installed cost	Installation factor	Scaling exponent	References
A1 Ethane cracking process	Water pump	$ 13,154	3.10	0.80	[6]
	Ethane preheater	$ 11,098,183	2.47	0.60	[7]
	HRSG	$ 1,463,457	2.47	0.60	[8]
	Heater	$ 4,816,879	2.47	0.60	[7]
	Cracker	$ 370,332,924	2.47	0.67	[9]
	Quench	$ 12,030,723	4.63	0.70	[10]
	Ethane compressor	$ 7,199,401	2.47	0.80	[10]
	Syngas compressor	$ 35,294,253	2.47	0.80	[10]
	Dryer	$ 550,730	2.00	0.70	[8]
A2 Hydrocarbon fractionation	Chiller	$ 3,992,589	3.23	0.70	[8]
	Cooling recycler and cooler	$ 22,181	3.02	0.60	[11]
	Flasher separator	$ 291,969	3.02	0.60	[11]
	Heat exchanger	$ 2,908,179	3.71	0.00	[8]
	Syngas compressor	$ 1,198,112	2.47	0.80	[10]
	First de-methane separator unit	$ 2,962,789	2.47	0.65	[12]
	Second de-methane separator unit	$ 2,771,687	2.47	0.65	[12]
	Third ethylene separator unit	$ 12,330,702	2.47	0.65	[12]
	C3+ Coolers	$ 506,948	1.50	0.65	[13]
A3 Combustion and power generation	Boiler	$ 71,182,164	2.07	0.60	[6]
	Turbine/Generator	$ 34,308,161	2.07	0.60	[6]
	Hot Process Water Softener System	$ 194,473	2.07	0.60	[6]
	Deaerator	$ 760,440	2.07	0.60	[6]
A4 Utility	Cooling Towers	$ 30,597,844	1.38	0.78	[13]
	Accessory Electric plant	$ 6,077,318	1.38	0.65	[13]
	Wastewater Treatment Equipment	$ 13,139,010	1.44	0.00	[13]
Total	**Total**	**$ 626,044,269**			

Table S7. Total plant cost breakdown, installation factor and scaling exponent for No external NG case.

Reaction area	Major equipment name	Major equipment installed cost [$]	Installation factor	Scaling exponent	References
A1 Ethane cracking process	Water pump	$ 13,154	3.10	0.80	6
	Ethane preheater	$ 11,098,183	2.47	0.60	7
	HRSG	$ 1,463,457	2.47	0.60	8
	Heater	$ 4,816,879	2.47	0.60	7
	Cracker	$ 370,332,924	2.47	0.67	9
	Quench	$ 12,030,723	4.63	0.70	10
	Ethane compressor	$ 7,199,401	2.47	0.80	10
	Syngas compressor	$ 35,294,253	2.47	0.80	10
	Dryer	$ 550,730	2.00	0.70	8
A2 Hydrocarbon fractionation	Chiller	$ 3,992,589	3.23	0.70	8
	Cooling recycler and cooler	$ 22,181	3.02	0.60	11
	Flasher separator	$ 291,969	3.02	0.60	11
	Heat exchanger	$ 2,908,179	3.71	0.00	8
	Syngas compressor	$ 1,198,112	2.47	0.80	10
	First de-methane separator unit	$ 2,962,789	2.47	0.65	12
	Second de-methane separator unit	$ 2,771,687	2.47	0.65	12
	Third ethylene separator unit	$ 12,330,702	2.47	0.65	12
	C3+ Coolers	$ 506,948	1.50	0.65	13
A3 Combustion and power generation	Boiler	$ 57,222,447	2.07	0.60	6
	Turbine/Generator	$ 27,580,125	2.07	0.60	6
	Hot Process Water Softener System	$ 156,335	2.07	0.60	6
	Deaerator	$ 611,308	2.07	0.60	6
A4 Utility	Cooling Towers	$ 26,025,646	1.38	0.78	13
	Accessory Electric plant	$ 3,875,292	1.38	0.65	13
	Wastewater Treatment Equipment	$ 13,139,010	1.44	0.00	13
Total	**Total**	**$ 598,395,021**			

Table S8. Total plant cost breakdown, installation factor and scaling exponent for Electrical heating case.

Reaction area	Major equipment name	Major equipment installed cost	Installation factor	Scaling exponent	References
A1 Ethane cracking process	Water pump	$ 13,154	3.10	0.80	[6]
	Ethane preheater	$ 11,098,183	2.47	0.60	[7]
	HRSG	$ 1,463,457	2.47	0.60	[8]
	Heater	$ 4,816,879	2.47	0.60	[7]
	Cracker	$ 370,332,924	2.47	0.67	[9]
	Quench	$ 12,030,723	4.63	0.70	[10]
	Ethane compressor	$ 7,199,401	2.47	0.80	[10]
	Syngas compressor	$ 35,294,253	2.47	0.80	[10]
	Dryer	$ 550,730	2.00	0.70	[8]
A2 Hydrocarbon fractionation	Chiller	$ 3,992,589	3.23	0.70	[8]
	Cooling recycler and cooler	$ 22,181	3.02	0.60	[11]
	Flasher separator	$ 291,969	3.02	0.60	[11]
	Heat exchanger	$ 2,908,179	3.71	0.00	[8]
	Syngas compressor	$ 1,198,112	2.47	0.80	[10]
	First de-methane separator unit	$ 2,962,789	2.47	0.65	[12]
	Second de-methane separator unit	$ 2,771,687	2.47	0.65	[12]
	Third ethylene separator unit	$ 12,330,702	2.47	0.65	[12]
	C3+ Coolers	$ 506,948	1.50	0.65	[13]
A3 PSA	Pressure Swing Adsorption Unit	$ 18,348,708	2.47	0.60	[10]
	Compressor	$ 3,665,915	2.47	0.65	[10]
A4 Utility	Cooling Towers	$ 7,964,133	1.38	0.78	[13]
	Accessory Electric plant	$ 21,071,096	1.38	0.65	[13]
	Wastewater Treatment Equipment	$ 13,139,010	1.44	0.00	[13]
Total	**Total**	**$ 533,973,722**			

Table S9. Total plant cost breakdown, installation factor and scaling exponent for CCS H_2 combustion case.

Reaction area	Major equipment name	Major equipment installed cost	Installation factor	Scaling exponent	References
A1 Ethane cracking process	Water pump	$ 13,154	3.10	0.80	6
	Ethane preheater	$ 11,098,183	2.47	0.60	7
	HRSG	$ 1,463,457	2.47	0.60	8
	Heater	$ 4,816,879	2.47	0.60	7
	Cracker	$ 370,332,924	2.47	0.67	9
	Quench	$ 12,030,723	4.63	0.70	10
	Ethane compressor	$ 7,199,401	2.47	0.80	10
	Syngas compressor	$ 35,294,253	2.47	0.80	10
	Dryer	$ 550,730	2.00	0.70	8
A2 Hydrocarbon fractionation	Chiller	$ 3,992,589	3.23	0.70	8
	Cooling recycler and cooler	$ 22,181	3.02	0.60	11
	Flasher separator	$ 291,969	3.02	0.60	11
	Heat exchanger	$ 2,177,729	3.71	0.60	8
	Syngas compressor	$ 1,198,112	2.47	0.80	10
	First de-methane separator unit	$ 2,962,789	2.47	0.65	12
	Second de-methane separator unit	$ 2,771,687	2.47	0.65	12
	Third ethylene separator unit	$ 12,330,702	2.47	0.65	12
	C3+ Coolers	$ 506,948	1.50	0.65	13
A3 Combustion and power generation and PSA/ATR/WGS/CCS	Pressure Swing Adsorption Unit	$ 18,348,708	2.47	0.60	10
	Compressor	$ 6,303,329	2.47	0.65	10
	Heat exchanger	$ 7,303,434	3.71	0.60	8
	Pre-reformer	$ 776,030	1.50	0.70	13
	Autothermal Reformer	$ 2,425,117	1.50	0.70	13
	Air Blower	$ 147,044	1.38	0.65	13
	Air Separation Unit/Oxidant Compression	$ 45,754,351	1.20	0.70	13
	Water Gas Shift (WGS) Reactors	$ 4,037,642	1.44	0.65	13
	CO2 Glycol separation	$ 12,658,113	1.79	0.65	14
	Gas cooler	$ 1,732,400	3.71	0.65	8
	Dryer	$ 128,239	2.30	0.60	8
	O2 compressor	$ 2,073,831	2.47	0.80	10
	Water pump	$ 30,239	3.10	0.80	6
	Boiler	$ 33,767,283	2.07	0.60	6
	Turbine/Generator	$ 16,746,855	2.07	0.60	6
	Hot Process Water Softener System	$ 92,254	2.07	0.60	6
	Deaerator	$ 360,736	2.07	0.60	6
A4 Utility	Cooling Towers	$ 28,152,226	1.38	0.78	13
	Accessory Electric plant	$ 1,063,871	1.38	0.65	13
	Wastewater Treatment Equipment	$ 13,139,010	1.44	0.00	13
Total	**Total**	**$ 664,095,121**			

Table S10. Financial input and assumption.[15]

Parameter	Values
Operating Capacity Factor (%)	90.0
Plant Design Capacity (million tonnes per year)	1.00
Plant Output (million tonnes per year)	0.90
Reference Year	2019
Assumed Start-up year	2018
Length of Construction Period (years)	3
% of Capital Spent in 1st Year of Construction	8%
% of Capital Spent in 2nd Year of Construction	60%
% of Capital Spent in 3rd Year of Construction	32%
Start-up Time (years)	1
Plant Life (years) = Analysis Period	40
Depreciation Schedule Length (years)	20
Depreciation Type	MACRS
% Equity Financing	40
Interest Rate on Debt (%)	3.7
Debt Period (years)	Constant Debt
% of Fixed Operating Costs During Start-up (%)	75%
% of Revenues During Start-up (%)	50%
% of Variable Operating Costs During Start-up (%)	75%
Decommissioning costs (% of depreciable capital investment)	10%
Salvage value (% of total capital investment)	10%
Inflation rate (%)	1.9%
After-tax Real IRR (%)	8.0%
State Taxes (%)	6.0%
Federal Taxes (%)	21.0%
Total Tax Rate (%)	25.74%
Working Capital (% of yearly change in operating costs)	15%

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