Electronic Supplementary Material

Techno-economic comparison of three technologies for pre-combustion CO_2 capture from a lignite-fired IGCC

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1 Further details on results of the process modelling

Further details on the results of the process modelling in the base case (~85% CO_2 capture) are presented for each CO_2 capture technology considered in this study. These results include stream characteristics as well as equipment power and cooling duty.

1.1 Rectisol-based CO_2 capture process

A more detailed process flow diagram of the Rectisol-based CO_2 capture process is presented in Figure S1, corresponding stream characteristics and power balance are presented in respectively Tables S1 and S2.

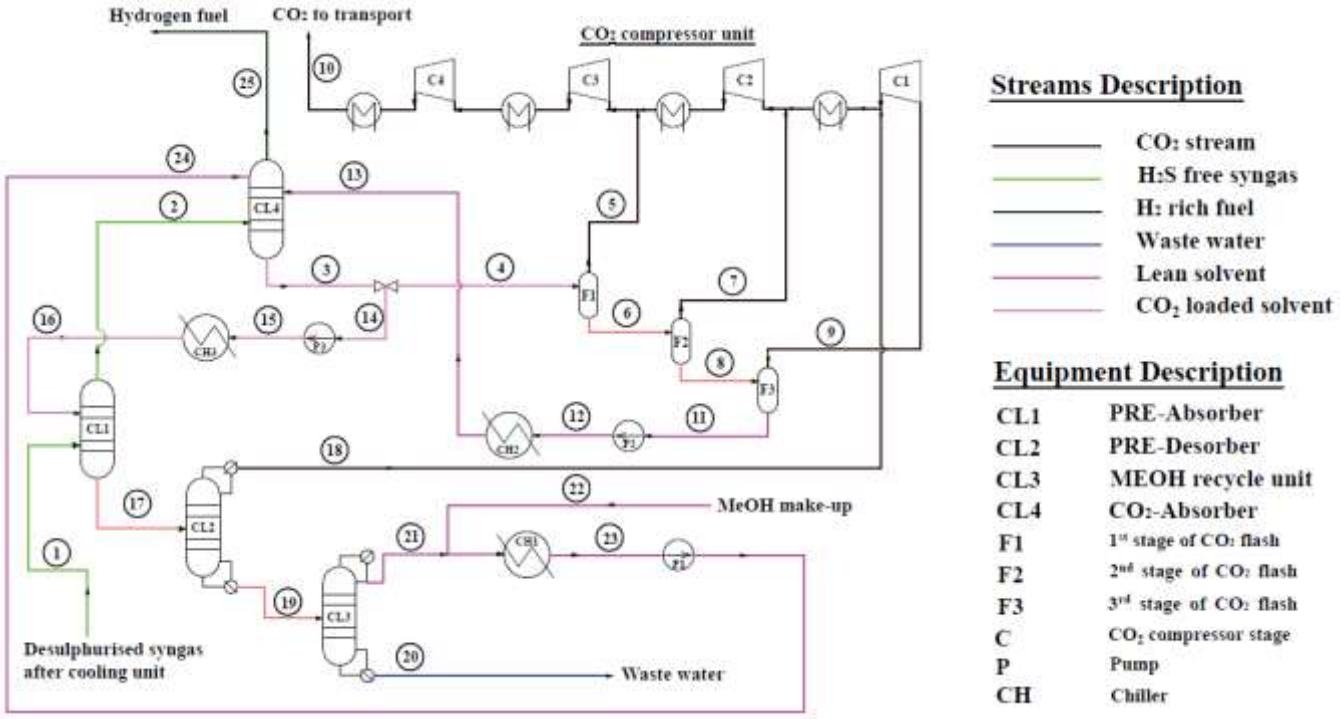

Figure S1: Process flow diagram of the Rectisol-based CO_2 capture process including stream and equipment tags

Table S1: Stream characteristics along the Rectisol-based CO_2 capture process

Stream no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Molar Flow /10^3 kmol.h^{-1}	11.99	12.02	32.49	32.37	0.95	31.42	2.22	29.20	1.02	4.20	28.18	28.18	28.18	0.13	0.13	0.13	0.10	0.01	0.09	0.00	0.08	0.03	0.11	0.11	7.81
Mass Flow /kg.s^{-1}	67.93	68.22	304.5	303.3	11.28	292.0	27.12	264.9	12.42	50.95	252.5	252.5	252.5	1.20	1.20	1.20	0.91	0.13	0.77	0.02	0.75	0.24	0.99	0.99	17.19
Temperature / ℃	6.6	3.4	-2.9	-2.9	-5.4	-5.4	-13.5	-13.5	-17.5	30.0	-17.5	-17.0	-20.0	-2.9	-2.8	-20.0	4.2	6.8	122.8	144.2	93.7	20.0	-20.0	-19.7	-18.4
Pressure /bar	27.9	27.0	26.6	26.6	8.0	8.0	3.0	3.0	1.0	110	1.0	30.0	29.9	26.6	31.0	31.0	27.0	7.0	7.0	4.0	3.0	30.0	3.0	29.0	26.5
Molar composition /%mol																									
H_2	53.5	53.3	0.1	0.1	2.0	0	0	0	0	0.4	0	0	0	0.1	0.1	0.1	0.1	0.5	0	0	0	0	0	0	81.8
CO_2	38.7	38.7	14.3	14.3	95.4	11.9	99.4	5.2	98.9	98.4	1.8	1.8	1.8	14.3	14.3	14.3	10.8	97.9	0	0	0	0	0	0	6.5
N_2	5.9	5.9	0.1	0.1	1.8	0	0.1	0	0	0.4	0	0	0	0.1	0.1	0.1	0	0.4	0	0	0	0	0	0	8.8
CO	1.1	1.1	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7
Ar	0.8	0.8	0	0	0.3	0	0	0	0	0.1	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	1.2
H_2O	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	4.2	0	4.7	99.8	0	0	0	0	0
MeOH	0	0.2	85.5	85.5	0.3	88.1	0.5	94.7	1.0	0.6	98.1	98.1	98.1	85.5	85.5	85.5	84.9	0.8	95.3	0.2	100	100	100	100	0

Table 1: Power balance of the Rectisol-based CO_2 capture process

	Power requirement /MW
Solvent pump 1 (P1)	0.004
Solvent pump 2 (P2)	1.18
Solvent pump 3 (P3)	0.001
CO_2 compression stage 1 (C1)	1.00
CO_2 compression stage 2 (C2)	2.85
CO_2 compression stage 3 (C3)	5.26
CO_2 compression stage 4 (C4)	4.80
Total	15.09

1.2 Low-temperature based CO_2 process

A more detailed process flow diagram of the low-temperature based CO_2 capture process is presented in Figure , corresponding stream characteristics and power balance are presented in respectively Tables S3 and S4.

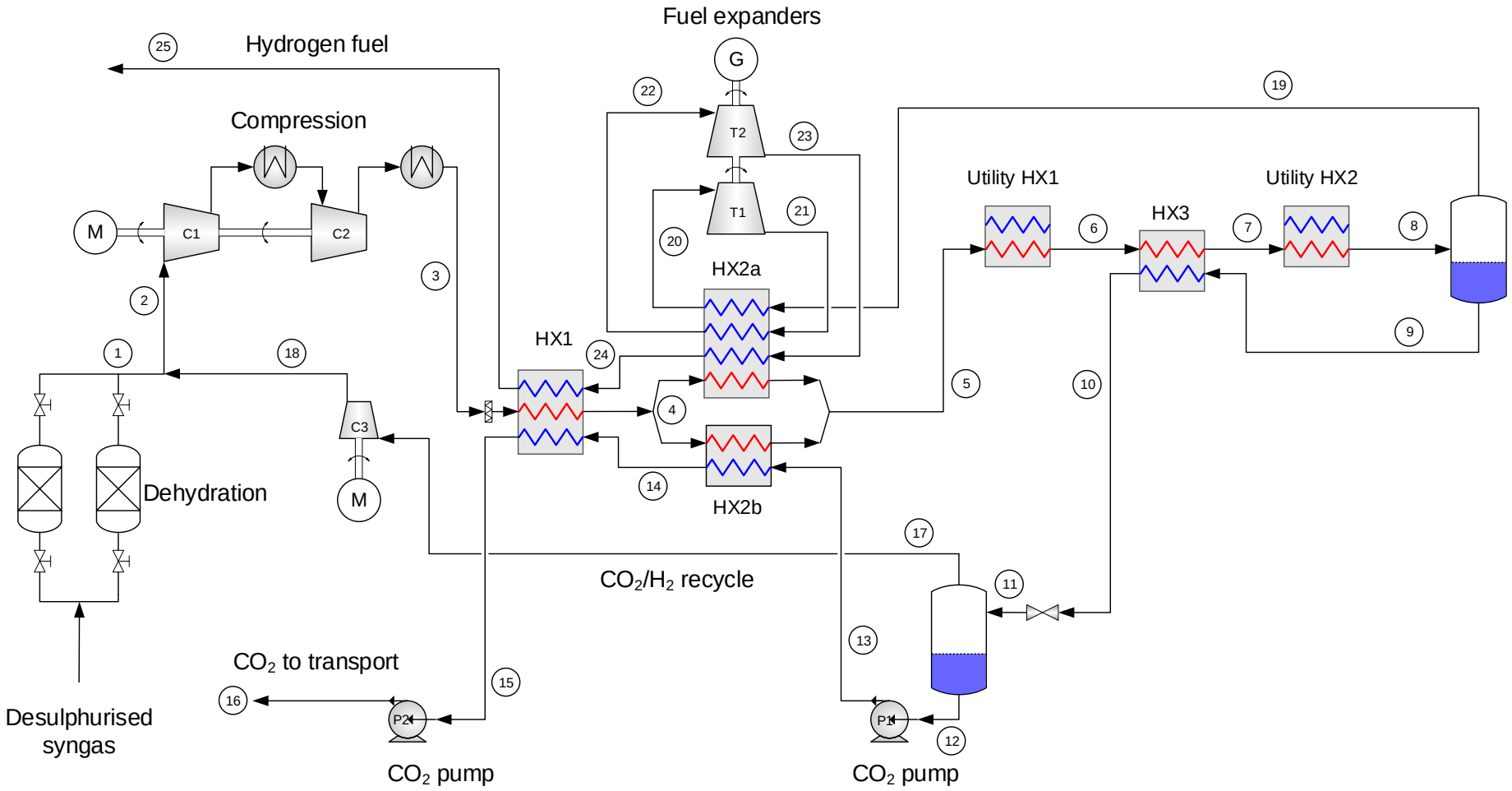

Figure S2: Process flow diagram of the low-temperature based CO_2 capture process including stream and equipment tags

Table 2: Stream characteristics along the low-temperature based CO_2 capture process

Stream no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Molar Flow /10^3 kmol.h^{-1}	12.00	12.57	12.57	12.57	12.57	12.57	12.57	12.57	4.48	4.48	4.48	3.92	3.92	3.92	3.92	3.92	0.56	0.56	8.09	8.09	8.09	8.09	8.09	8.09	8.09
Mass Flow /kg.s^{-1}	67.98	73.38	73.38	73.38	73.38	73.38	73.38	73.38	53.19	53.19	53.19	47.82	47.82	47.82	47.82	47.82	5.37	5.37	20.19	20.19	20.19	20.19	20.19	20.19	20.19
Temperature / ℃	30.0	30.6	30.0	6.9	-30.1	-39.2	-42.8	-55.2	-55.2	-42.2	-55.2	-55.2	-51.1	-8.9	1.5	7.5	-55.2	43.5	-55.2	0.9	-55.6	0.9	-55.2	-29.0	1.5
Pressure /bar	27.7	27.7	104.7	104.4	104.1	103.8	103.5	103.2	103.2	102.2	8.1	8.1	90.0	89.0	88.0	150.0	8.1	28.0	103.2	102.9	40.4	40.1	15.6	15.3	15.0
Molar composition /%mol																									
H_2	53.50	51.94	51.94	51.94	51.94	51.94	51.94	51.94	2.43	2.43	2.43	0.05	0.05	0.05	0.05	0.05	18.97	18.97	79.36	79.36	79.36	79.36	79.36	79.36	79.36
CO_2	38.70	40.03	40.03	40.03	40.03	40.03	40.03	40.03	95.75	95.75	95.75	99.73	99.73	99.73	99.73	99.73	68.15	68.15	9.17	9.17	9.17	9.17	9.17	9.17	9.17
N_2	5.90	6.03	6.03	6.03	6.03	6.03	6.03	6.03	1.21	1.21	1.21	0.12	0.12	0.12	0.12	0.12	8.77	8.77	8.70	8.70	8.70	8.70	8.70	8.70	8.70
CO	1.10	1.13	1.13	1.13	1.13	1.13	1.13	1.13	0.25	0.25	0.25	0.03	0.03	0.03	0.03	0.03	1.81	1.81	1.62	1.62	1.62	1.62	1.62	1.62	1.62
Ar	0.80	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.35	0.35	0.35	0.07	0.07	0.07	0.07	0.07	2.31	2.31	1.15	1.15	1.15	1.15	1.15	1.15	1.15

Table S4: Electrical power balance of the low-temperature based CO_2 capture process

	Power Requirement /MW
1st compressor stage (C1)	7.39
2nd compressor stage (C2)	7.34
Recirculation compressor (C3)	0.48
Liquid CO2 pump (P1)	0.45
End-product CO2 pump (P2)	0.41
H2 fuel turbine 1 (T1)	-3.21
H2 fuel turbine 2 (T2)	-3.23
Auxiliary refrigeration for Utility HX1	1.70
Auxiliary refrigeration for Utility HX2	2.56
Total	13.90

1.3 CO_2-selective membrane-based CO_2 capture process

A more detailed process flow diagram of the CO_2 capture processes based on the CO_2-selective membranes A and B are respectively presented in Figures S3 and S4. For the process based on membrane A, the corresponding stream characteristics and power balance are presented in respectively Tables S5 and S6, while this information is available in Tables S7 and S8 for the process based on membrane B.

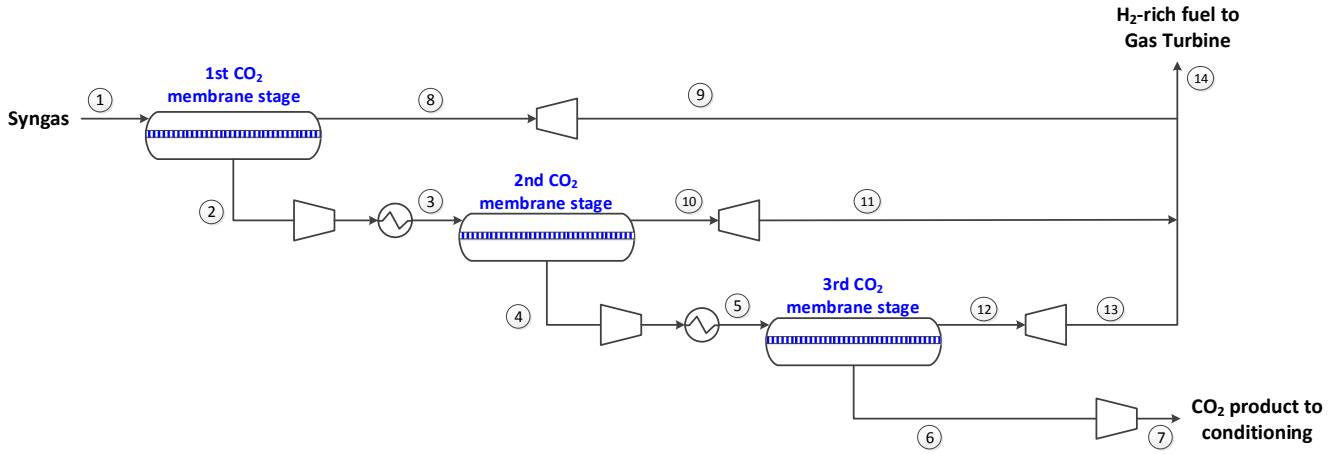

Figure S3: Process flow diagram of the CO_2 capture process based on the CO_2-selective membrane A including stream tags

Table S5: Stream characteristics along the CO_2 capture process based on the CO_2-selective membrane A

Stream no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Molar Flow /10^3 kmol.h^{-1}	12.03	6.84	6.84	5.00	5.00	4.27	4.27	5.04	5.04	1.80	1.80	0.72	0.72	7.57
Mass Flow /kg.s^{-1}	68.00	58.09	58.09	53.17	53.17	49.96	49.96	9.91	9.91	4.92	4.92	3.21	3.21	18.05
Temperature / ℃	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	-15.9	30.0	-15.8	30.0	-14.1	-15.7
Pressure /bar	28.0	1.6	28.3	2.1	28.3	1.8	150.0	28.0	14.0	28.3	14.0	28.3	14.0	14.0
Molar composition /%mol														
H_2	53.41	30.32	30.32	12.94	12.94	4.35	4.35	83.40	83.40	77.15	77.15	63.11	63.11	79.98
CO_2	38.64	65.17	65.17	85.14	85.14	95.00	95.00	4.19	4.19	11.36	11.36	27.49	27.49	8.12
N_2	5.89	3.34	3.34	1.43	1.43	0.48	0.48	9.20	9.20	8.51	8.51	6.96	6.96	8.82
CO	1.08	0.61	0.61	0.26	0.26	0.09	0.09	1.69	1.69	1.56	1.56	1.28	1.28	1.62
Ar	0.80	0.45	0.45	0.19	0.19	0.07	0.07	1.25	1.25	1.16	1.16	0.95	0.95	1.20
Other*	0.18	0.10	0.10	0.04	0.04	0.01	0.01	0.28	0.28	0.26	0.26	0.21	0.21	0.27

* H_2O,HCL, COS, CH_4, etc.

Table S6: Electrical power balance and membrane area of the CO_2 capture process based on the CO_2-selective membrane A

	Power requirement /MW	Membrane area /m^2
1st membrane stage	-1.95	8 920
Retentate expander	*-1.95*	
2nd membrane stage	19.09	3 710
Feed compressor	*19.78*	
Retentate expander	*-0.70*	
3rd membrane stage	13.58	1 939
Feed compressor	*13.30*	
Retentate expander	*-0.28*	
CO_2 conditioning	14.84	
Total	45.56	14 569

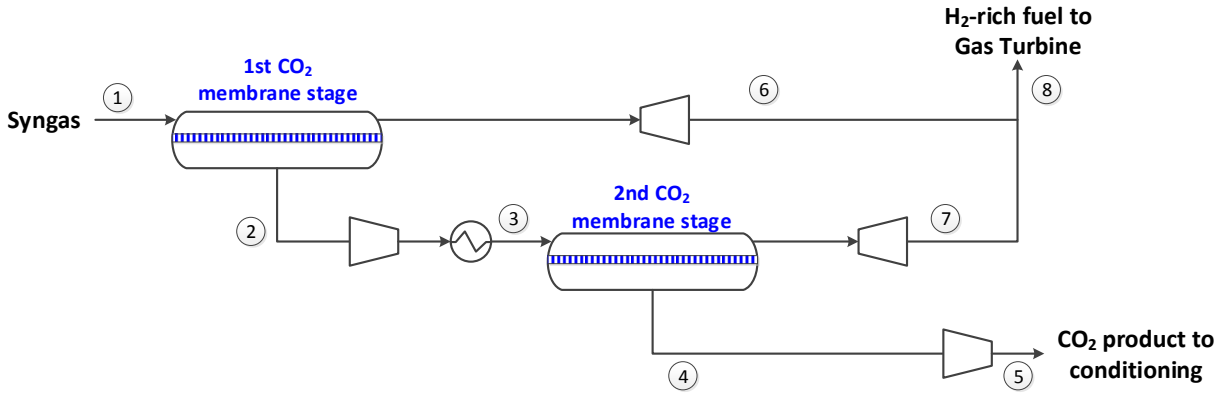

Figure S4: Process flow diagram of the CO_2 capture process based on the CO_2-selective membrane B including stream tags

Table S7: Stream characteristics along the CO_2 capture process based on the CO_2-selective membrane B

Stream no.	1	2	3	4	5	6	7	8
Molar Flow /10^3 kmol.h^{-1}	12.03	5.32	5.32	4.05	4.05	6.37	1.26	7.63
Mass Flow /kg.s^{-1}	68.00	54.93	54.93	49.73	49.73	13.07	5.20	18.27
Temperature / ℃	30.0	30	30	30	30	-15.8	-14.1	-15.6
Pressure /bar	28.0	3.8	28.1	2.3	150	14	14	14
Molar composition /%mol								
H_2	53.41	17.34	17.34	1.15	1.15	82.78	67.17	80.20
CO_2	38.64	80.08	80.08	98.68	98.68	4.90	22.84	7.86
N_2	5.89	1.91	1.91	0.13	0.13	9.13	7.41	8.84
CO	1.08	0.35	0.35	0.02	0.02	1.67	1.36	1.62
Ar	0.80	0.26	0.26	0.02	0.02	1.24	1.01	1.20
Other*	0.18	0.06	0.06	0.00	0.00	0.28	0.23	0.27

* H_2O,HCL, COS, CH_4, etc.

Table S8: Electrical power balance and membrane area of the CO_2 capture process based on the CO_2-selective membrane B

	Power requirement /MW	Membrane area /m^2
1st membrane stage	-2.47	9 373
Retentate expander	*-2.47*	
2nd membrane stage	10.50	903
Feed compressor	*10.98*	
Retentate expander	*-0.49*	
CO_2 conditioning	14.83	
Total	22.86	10 276