Supplemental Information

The complete simulation comprises of four sections; the Air Separation Unit (ASU), the Combustion Boiler Section (CBS), the Balance of Plant (BOP), and the CO_2 Compression and Purification Unit (CO_2CPU) as shown in Figure 1.

SI-1 Air Separation Unit (ASU)

Figure S-1 shows the Aspen Plus simulation of the ASU section. Air at 1 bar and 25 °C (AIR) is provided to the ASU and compressed to 5.6 bar in a three-stage compressor (C-101) during which some of the H_2O present is condensed out of the system. The compression heat of the remaining stream (ASU-1) is removed through a water-cooled column (V-101), which further dries the stream before passing through a separator (V-102) to remove any remaining H_2O, CO_2 and other impurities (Fu and Gundersen, 2013). Compressed dry air (ASU-5) then passes through the first heat exchanger (HX-1) where it is cooled to its dew point of -173.8 °C before passing through a high-pressure distillation column (T-101). T-101 separates N_2 (ASU-8-1) at 99% purity, which is sent back to HX-1 to provide cooling. The O_2 (ASU-10-1), along with the remaining distillate (ASU-9-1), then pass through the second heat exchanger (HX-2) where further cooling takes place before the low-pressure distillation column (T-102). T-102 produces O_2 (ASU-14-1) at 95% purity and N_2 (ASU-13-1), which is sent back through HX-2 and HX-1 to provide cooling as well. After heat recovery, the N_2 streams, now ASU-8-4 and ASU-13-3, are mixed and vented into the atmosphere at ambient conditions, as stream N2OUT. As for ASU-14-1, it passes through HX-1 where it is heated to 11°C, at 1 bar, generating a stream (O2) with 95% O_2, 3% Ar and 2% N_2, which is sent as O2INLET to R-101-1 where it reacts with the fuel (coal or petcoke).

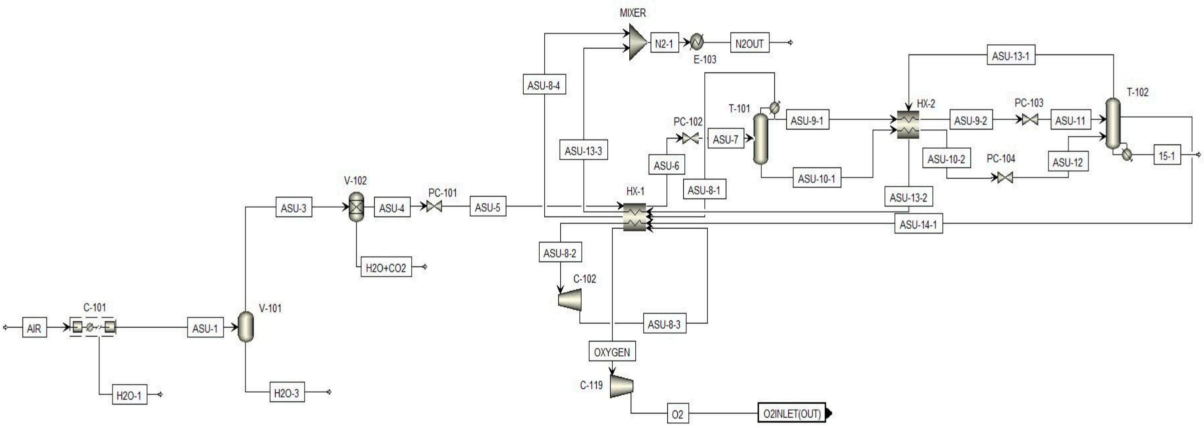

Figure S-1. Aspen Plus Simulation Flowsheet of the ASU.

SI-2 Balance of Plant (BOP):

The BOP is largely comprised of the steam cycle in which heat is converted into steam which then turns turbines to generate electric power. The BOP (Figure S-2) consists of three high-pressure turbines (HPT), two intermediate-pressure turbines (IPT) and five low-pressure turbines (LPT), which provide steam to preheat the feed water passing through the four feedwater heaters (FWH). In addition, there is a deaerator, a condenser and pumps. Feed water (SC-1) is fed from the condenser (E-117) to the pump (P-102) where it is discharged at 17.2 bar and 38.5 °C. Instead of going through a FWH, the discharge (SC-2-1) first goes through a heat exchanger (E-105) where it is heated to 86 °C (SC-2-1-2) using the latent heat of GAS-2, instead of extracting steam from the LPTs, C-114, C-115, C-116 and C-117. 2-1-2 then goes into the first FWH (E-118) before entering the deaerator (SC-DEAR) at 9.5 bar and 161.7 °C. The feed water from the deaerator (SC-6) then goes through another pump (P-103) and is discharged at 290 bar and 167 °C. Then, the discharge (SC-7-1) goes through the remaining FWHs (E-114, E-115 and E-116) before entering the boiler at 289 bar and 264 °C (SC-8). The feed water is heated to steam through R-101-3 before entering the first HPT (C-108) at 599°C, at 242 bars (SC-9-1). Following C-108, are two HPTs (C-109 and C-110) after which the steam (SC-9-7) is reheated through R-101-3 to at 621 °C and 45 bars (SC-9-8). SC-9-8 then enters the IPTs, C-111 and C-112, where part of the exhaust steam from C-112 (SC-15) is used to drive the boiler feed turbine drive. The remaining steam (SC-9-13) enters the LPT (C-113) at 10 bar and 381 °C and goes through the remaining LPTs (C-114 to C-117). The steam exits the LPTs at 0.07 bar and 42 °C (SC-9-22) and, along with the boiler feed turbine drive exhaust (SC-16), all seal and gland steam condensate (SC-17) and make-up feed water (MAKE-UP), enters E-117 to be recycled back as feed water. It should be noted that steam from the turbines is extracted to pre-heat the feed water as it passes through the FWHs. In addition, in Figure S-2, FGD-HEAT account for the amount of energy that would have been allocated to an FGD if it were included in the simulation, instead of SO2-SEP.

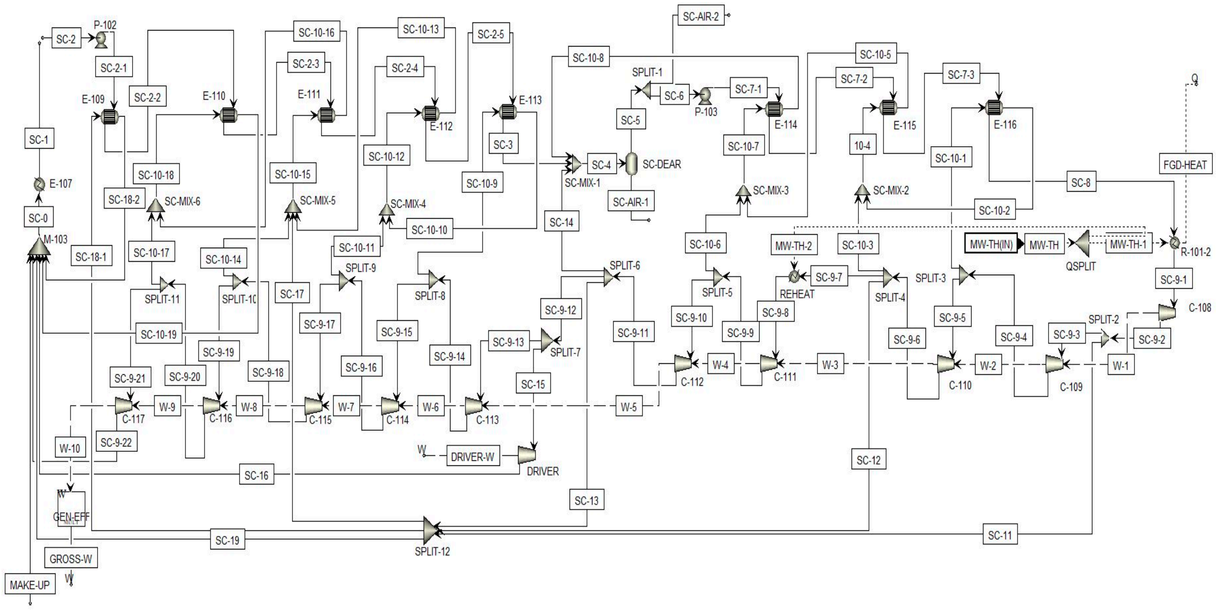

Figure S-2. Aspen Plus Simulation Flowsheet of the BOP.

SI-3: CO_2 Capture and Purification Unit (CO_2CPU)

The portion of the flue gas that is not recycled (FLUE-GAS) is sent to the CO_2CPU (Figure S-3). FLUE-GAS enters multi-stage compression with intercooling, at 1 bar and 64 °C, which compresses the stream up to 30 bar, while cooling it to 35 °C. The resulting flue gas (CPU-12-2) then enters a dryer (V-109) removing any remaining H_2O to avoid the formation of ice, before entering the first heat exchanger (HX-3) as CPU-13 and the following flash separator (V-111) as CPU-14. V-111 outputs CPU-15, which is separated into CPU-17 and CPU-18, and CPU-16. CPU-18 is expanded to 15 bar, reducing its temperature to -38 °C, and is then flashed through V-110, separating it into CPU-28, which is redirected back into HX-3 to provide cooling, and CPU-29, which is pumped (P-101) back to 30 bar (CPU-30) before mixing with CPU-16. CPU-17 goes into the second heat exchanged (HX-4) and then into a flash separator (V-112). V-112 separates the impurities into CPU-20 and the CO_2 into CPU-21. CPU-20 goes back through HX-4 and HX-3 and is released into the atmosphere after being expanded to 1 bar and heated to 23 °C as CPU-23-3. CPU-21 then provides cooling to HX-4 and HX-3, before going through C-108 where it is compressed to 110 bar (CPU-34-2). The mixture of CPU-16 and CPU-30 is also high in CO_2 and provides cooling to HX-3 as well, before being compressed by C-109 to 110 bar (CPU-35-2). The streams CPU-34-2 and CPU-35-2 are mixed and cooled to 43 °C through E-119, which produced CO2 at over 96% purity, ready for further compression and transportation for reuse or storage, while also recovering over 96% of the CO2 initially found in FLUE-GAS.

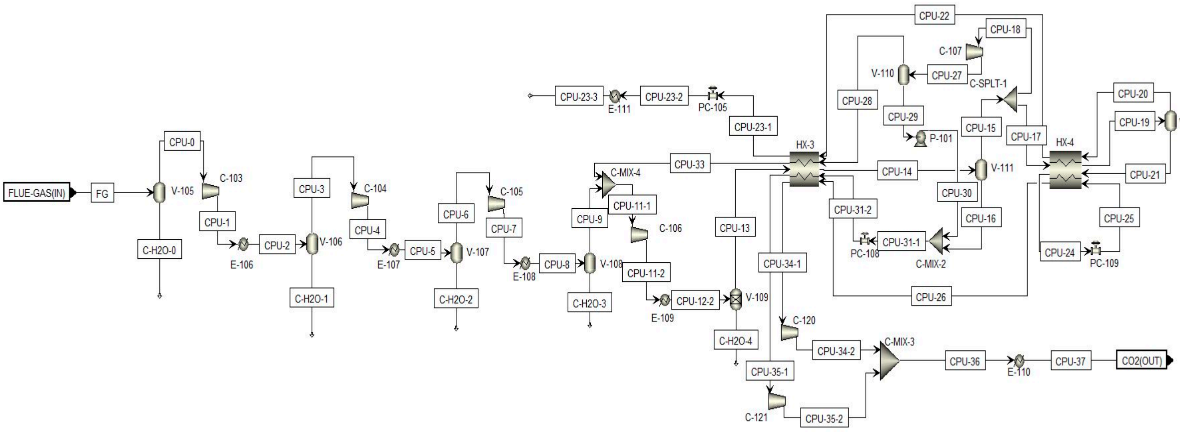

Figure S-3. Aspen Plus Simulation Flowsheet of the CO_2CPU.

The economic assessment of the plant required details pertaining to size of and materials of the unit For brevity, the details about the materials used for process equipment are given here in Table S-1. In general, stainless steel is chosen over carbon steel whenever there is a potentially corrosive stream passing through the equipment. That is why the majority of the equipment are made of stainless steel. Since the BOP only contains water and steam, most of the BOP equipment are made of carbon steel.

Table S-1. Equipment Description and Material of Construction for ASU, CBS, BOP and CO_2CPU.

	Equipment	Flowsheet	Description	Material of Construction
Compressors and Turbines	C-101	ASU	Centrifugal Compressor	Stainless Steel
	C-102	ASU	Axial Gas Turbine	Stainless Steel
	C-103	CO2CPU	Centrifugal Compressor	Stainless Steel
	C-104	CO2CPU	Centrifugal Compressor	Stainless Steel
	C-105	CO2CPU	Centrifugal Compressor	Stainless Steel
	C-106	CO2CPU	Centrifugal Compressor	Stainless Steel
	C-107	CO2CPU	Axial Gas Turbine	Stainless Steel
	C-108	BOP	Axial Gas Turbine	Carbon Steel
	C-109	BOP	Axial Gas Turbine	Carbon Steel
	C-110	BOP	Axial Gas Turbine	Carbon Steel
	C-111	BOP	Axial Gas Turbine	Carbon Steel
	C-112	BOP	Axial Gas Turbine	Carbon Steel
	C-113	BOP	Axial Gas Turbine	Carbon Steel
	C-114	BOP	Axial Gas Turbine	Carbon Steel
	C-115	BOP	Axial Gas Turbine	Carbon Steel
	C-116	BOP	Axial Gas Turbine	Carbon Steel
	C-117	BOP	Axial Gas Turbine	Carbon Steel
	C-118	BOP	Axial Gas Turbine	Carbon Steel
	C-119	ASU	Centrifugal Compressor	Stainless Steel
	C-120	CO2CPU	Axial Gas Turbine	Stainless Steel

	C-121	CO2CPU	Axial Gas Turbine	Stainless Steel

Table S-1. Equipment Description and Material of Construction for ASU, CBS, BOP and CO_2CPU (cont'd).

	Equipment	Flowsheet	Description	Material of Construction
Heat Exchangers	E-103	ASU	Fixed Tube Sheet	Carbon Steel for Shell Side Stainless Steel for Tube Side
	E-105	CBS	Floating Head	Stainless Steel
	E-106	CO2CPU	Fixed Tube Sheet w/ ammonia	Stainless Steel
	E-107	CO2CPU	Fixed Tube Sheet w/ ammonia	Stainless Steel
	E-108	CO2CPU	Floating Head w/ ammonia	Stainless Steel
	E-109	CO2CPU	Floating Head w/ ammonia	Stainless Steel
	E-110	CO2CPU	Floating Head	Carbon Steel on Shell Side Stainless Steel on Tube Side
	E-111	CO2CPU	Fixed Tube Sheet	Carbon Steel on Shell Side Stainless Steel on Tube Side
	E-114	BOP	Floating Head	Carbon Steel
	E-115	BOP	Floating Head	Carbon Steel

	E-116	BOP	Floating Head	Carbon Steel
	E-117	BOP	Floating Head	Carbon Steel
	HX-1	ASU	Plate-Fin	Stainless Steel
	HX-2	ASU	Plate-Fin	Stainless Steel
	HX-3	CO2CPU	Plate-Fin	Stainless Steel
	HX-4	CO2CPU	Plate-Fin	Stainless Steel
Pumps	P-101	CO2CPU	Centrifugal Pump	Stainless Steel
	P-102	BOP	Centrifugal Pump	Carbon Steel
	P-103	BOP	Centrifugal Pump	Carbon Steel
Reactor	R-101-1	CBS	Boiler w/ heat exchanger tube bundles	Stainless Steel

Table S-1. Equipment Description and Material of Construction for ASU, CBS, BOP and CO_2CPU (cont'd).

	Equipment	**Flowsheet**	**Description**	**Material of Construction**
Process Vessels	T-101	ASU	Distillation Tower w/ 2-in. pall rings	Stainless Steel
	T-102	ASU	Distillation Tower w/ 2-in. pall rings	Stainless Steel
	V-101	ASU	Flash Drum	Stainless Steel
	V-102	ASU	Adsorber w/ activated alumina	Stainless Steel
	V-104	CBS	Flash Drum	Stainless Steel
	V-105	CO2CPU	Flash Drum	Stainless Steel
	V-106	CO2CPU	Flash Drum	Stainless Steel

	V-107	CO2CPU	Flash Drum	Stainless Steel
	V-108	CO2CPU	Flash Drum	Stainless Steel
	V-109	CO2CPU	Dryer w/ activated alumina	Stainless Steel
	V-110	CO2CPU	Flash Drum	Stainless Steel
	V-111	CO2CPU	Flash Drum	Stainless Steel
	V-112	CO2CPU	Flash Drum	Stainless Steel