

Supplementary Materials

MR and Main Oven

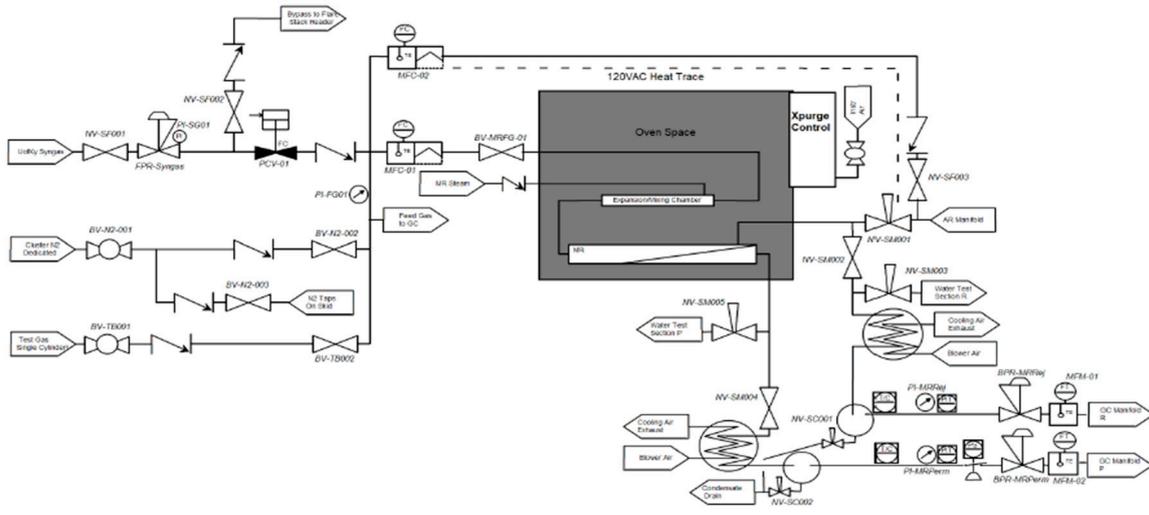


Figure S1: P&ID of the MR and the main oven.

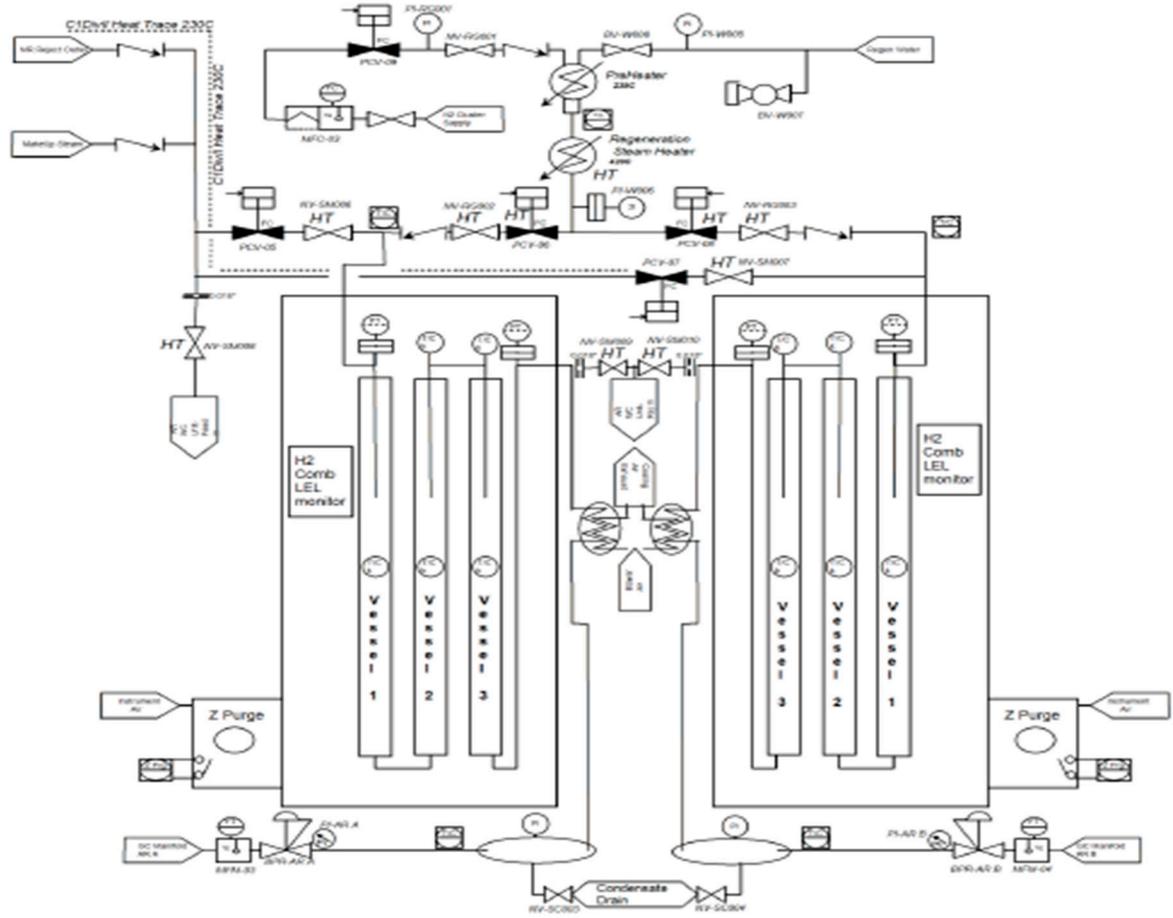


Figure S2: P&ID of the AR component.

Table S1: AR design parameters and operating conditions (adsorption/regeneration),

Length [']	5
Diameter ["]	2.5
Heat Transfer Coefficient of Vessel [W/m ² *K]	227
AR Vessel Wall Temperature [K]	523 (Ads.)/673 (Reg)
P [bar]	25
Feed T [K]	523 (Ads.)/673 (Reg)
Density of Catalyst [kg/m ³]	592.68
Density of Adsorbent [kg/m ³]	1,780
Catalyst Pellet Void Fraction [-]	0.35561
Adsorbent Pellet Void Fraction [-]	0.5
Mean Pore Diameter of Catalyst [m]	6.3*10 ⁻⁹
Mean Pore Diameter of Adsorbent [m]	6.3*10 ⁻⁷
Catalyst/Adsorbent Bed Void Fraction [-]	0.4717
Feed (Regeneration Cycle)	
100% steam	
Flow Rate [scfm]	2.5 - 10
Feed (Adsorption Cycle)	
Composition (Molar Ratios)	
CO ₂ /CO	1.2
H ₂ /CO	1.05
H ₂ O/CO	2
Flow rate [scfm]	2.5
AR Fixed-Bed Composition	
W _{ads} [kg]	2.72
W _{cat} [kg]	1.75
W _{ads} /W _{cat}	1.55
Pellet Diameter ["]	0.25

Table S2: AR adsorption test-run parameters.

	Value	Unit
AR Test Feed		
Pressure (Avg.)	16.35	bar
Temperature (Avg.)	517	K
Feed Mole Fraction: CO ₂ N ₂	0.3, 0.7	-

Flow Rate (Avg.)	0.326	scfm
AR Configuration		
AR Vessel Length (3 AR in Series, Each 5 ft long)	15	ft
AR Vessel Diameter	2.5	in
Packing Density (Catalyst)	568	kg/m ³
Packing Density (Adsorbent)	1700	kg/m ³
Adsorbent Pellet Pore Diameter	23.07	nm
Max. Adsorbent Loading/Train (3 AR in Series)	1639	g
Wads/Wcat	8	-

Table S3: MR-AR IGCC plant performance summary.

Performance Summary		
	Case B5B	MR-AR
Combustion Turbine Power, MWe	464	464
Sweet Gas Expander, MWe	3	3
Steam Turbine Power, MWe	274	274
Total Gross Power, MWe	741	741
Air Separation Unit Main Air Compressor, kWe	71,280	71,280
Air Separation Unit Booster Compressor, kWe	5,610	5,610
Nitrogen Compressors, kWe	36,580	36,580
CO ₂ Compression, kWe	31,670	9,327
Acid Gas Removal, kWe	11,550	2,950
Balance of Plant, kWe	28,080	28,977
Total Auxiliaries, MWe	185	155
Net Power, MWe	556	586
HHV Net Plant Efficiency (%)	33.7%	35.5%
HHV Net Plant Heat Rate, kJ/kWh (Btu/kWh)	10,675 (10,118)	10,131 (9,603)
HHV Cold Gas Efficiency, %	79.0%	79.0%
HHV Combustion Turbine Efficiency, %	36.4%	36.4%
LHV Net Plant Efficiency (%)	35.0%	36.8%
LHV Net Plant Heat Rate, kJ/kWh (Btu/kWh)	10,296 (9,759)	9,772 (9,262)
LHV Cold Gas Efficiency, %	75.7%	75.7%
LHV Combustion Turbine Efficiency, %	42.8%	42.8%
Steam Turbine Cycle Efficiency, %	43.1%	43.1%
Steam Turbine Heat Rate, kJ/kWh (Btu/kWh)	8,356 (7,920)	8,356 (7,920)

Condenser Duty, GJ/hr (MMBtu/hr)	1,555 (1,474)	1,555 (1,474)
AGR Cooling Duty, GJ/hr (MMBtu/hr)	147 (140)	147 (140)
As-Received Coal Feed, kg/hr (lb/hr)	218,895 (482,580)	218,895 (482,580)
HHV Thermal Input, kWt	1,649,926	1,649,926
LHV Thermal Input, kWt	1,591,374	1,591,374
Raw Water Withdrawal, (m ³ /min)/MW _{net} (gpm/MW _{net})	0.037 (9.9)	0.034 (9.0)
Raw Water Consumption, (m ³ /min)/MW _{net} (gpm/MW _{net})	0.030 (7.9)	0.026 (6.9)
O ₂ :As-Received Coal	0.760	0.760

Table S4: MR-AR plant LCOE breakdown.

	MR-AR		Baseline	
Net Power Production (MWe)	586		556	
Component	Value, \$/MWh	Percentage	Value, \$/MWh	Percentage
Capital	64.1	46%	75.2	49%
Fixed	25.8	19%	27.2	18%
Variable	19.4	14%	19.3	13%
Fuel	21.4	15%	22.5	15%
Total (Excluding T&S)	130.7	N/A	144.2	N/A
CO ₂ T&S	8.2	6%	8.1	5%
Total (Including T&S)	138.9	N/A	152.3	N/A

Table S5: MR-AR plant LCOE breakdown with N₂ sale @ \$30/ton, with/without N₂ compression.

	MR-AR		Baseline	
With N₂ Compression				
Net Power Production (MWe)	586		556	
Component	Value, \$/MWh	Percentage	Value, \$/MWh	Percentage
Capital	64.1	59%	75.2	49%
Fixed	25.8	24%	27.2	18%
Variable	19.4	18%	19.3	13%
Fuel	21.4	20%	22.5	15%
N ₂ sales @ \$30/ton (with N ₂ Compression)	-29.5	-27%	N/A	N/A
Total (Excluding T&S) [with N₂ Compression]	101.2	N/A	144.2	N/A

CO ₂ T&S	8.2	8%	8.1	5%
Total (Including T&S) [with N₂ Compression]	109.5	N/A	152.3	N/A
Without N₂ compression				
Net Power Production (MWe)	623		N/A	
Capital	60.4	59%	N/A	N/A
Fixed	24.3	24%	N/A	N/A
Variable	18.3	18%	N/A	N/A
Fuel	20.1	20%	N/A	N/A
N ₂ sales @ \$30/ton (no N ₂ Compression)	-27.8	-27%	N/A	N/A
Total (Excluding T&S) [no N₂ Compression]	95.3	N/A	N/A	N/A
CO ₂ T&S	7.7	8%	N/A	N/A
Total (Including T&S) [no N₂ Compression]	103.0	N/A	N/A	N/A

Table S6: MR-AR plant LCOE breakdown with Ar sales @ \$4.0/kg, with/without N₂ compression, and a 20% and 7% increase in ASU capital cost and fixed operating cost, respectively.

	MR-AR		Baseline	
With N₂ Compression				
Net Power Production (MWe)	586		556	
Component	Value, \$/MWh	Percentage	Value, \$/MWh	Percentage
Capital	64.5	89%	75.2	49%
Fixed	27.6	38%	27.2	18%
Variable	19.4	27%	19.3	13%
Fuel	21.4	29%	22.5	15%
Ar sales @ \$4.0/kg (with N ₂ Compression)	-68.3	-94%	N/A	N/A
Total (Excluding T&S) [with N₂ Compression]	64.6	N/A	144.2	N/A
CO ₂ T&S	8.2	11%	8.1	5%
Total (Including T&S) [with N₂ Compression]	72.9	N/A	152.3	N/A
Without N₂ Compression				
Net Power Production (MWe)	623		N/A	
Capital	60.7	89%	N/A	N/A
Fixed	26.0	38%	N/A	N/A
Variable	18.3	27%	N/A	N/A

Fuel	20.1	29%	N/A	N/A
Ar sales @ \$4.0/kg (no N ₂ Compression)	-64.2	-94%	N/A	N/A
Total (Excluding T&S) [no N₂ Compression]	60.8	N/A	N/A	N/A
CO ₂ T&S	7.7	11%	N/A	N/A
Total (Including T&S) [no N₂ Compression]	68.6	N/A	N/A	N/A