Article

Blue Hydrogen Cogeneration as an Energy Vector for a Sustainable Future: A Case for Alberta, Canada

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S1. Technical Model Specifications

To understand the energy and material demands of the autothermal reforming process, the described process has been modeled in Aspen Plus. The Peng Robinson EOS model is primarily used in this model due to its adequate description of non-polar compounds, as well as hydrocarbon and light gas properties and interactions. For clarity, the process system will be broken down into the following categories:

1. Reformer subsystem including autothermal reformer and water gas shift reactors;
2. Hydrogen purification;
3. Oxy-fuel combustion and co-generation;
4. CO_2 conditioning;
5. Air separation unit.

S1.1 Reformer subsystem

The autothermal reactor is represented with two reactor models in series: an equilibrium reactor model for the combustion furnace and a rigorous plug flow model for the steam methane reforming reactions. The water gas shift reactors following them were also modeled with plug flow models, consisting of a high-temperature and low-temperature one. The rigorous plug flow models were specified as adiabatic, catalytic-packed bed reactors consisting of multiple reactor tubes. The number and length of tubes are selected to achieve a certain pressure drop and approach equilibrium conversion levels. The parameters used for the reactors are shown in Table S1.

Table S1: Reformer and water gas shift reactor model specifications

Reactor	**Autothermal Reformer**	**High-Temperature Water Gas Shift**	**Low-Temperature Water Gas Shift**
Aspen Block Model	Rstoic + Rplug	RPlug	RPlug
Reactor type	Adiabatic reactor	Adiabatic reactor	Adiabatic reactor
Catalyst	8.7 %-Ni / $MgAl_2O_4$	89%-Fe / Cr_2O_3	42%-Cu / 47%-Zn / Al_2O_3
Catalyst particle density [kg/m^3]	1970	2000	5904
Catalyst voidage	0.42	0.5	0.5
Pressure drop [bar]	0.5	0.5	0.5
Shape	Raschig rings	Raschig rings	Raschig rings
Dimensions [m]	0.015 x 0.015 x 0.15	0.015 x 0.015 x 0.15	0.015 x 0.015 x 0.15
Tube diameter [m]	0.1	0.1	0.1
Reactor inlet pressure [bar]	9	8.5	8
Feed temperature [C]	Varies based on steam flow rate	300	150

The associated kinetics for the nickel-catalyzed reactions used in this work are shown in **Error! Reference source not found.**; they were developed by Numaguchi and Kikuchi [1] and are widely adopted in steam methane reformer studies operating at 1 – 25.5 bars and containing negligible H_2 in the feed.

Table S2: Steam methane reformer kinetic equations

Reaction (i)	**Rate Equation [kmol/kg-cat.s]**	**k_{oi} [kmol/kg-cat.s]**	**E_i [kJ/mol]**
SMR-NK	$r_i = \frac{k_i\left(p_{CH_4}p_{H_2O} - \frac{p_{H_2}^3 p_{CO}}{K_{eq_1}}\right)}{p_{H_2O}^{1.596}}$	2.62E+02 bar^{-1}	106.9
WGS-NK	$r_i = k_i\left(p_{CO} - \frac{p_{H_2}p_{CO_2}}{p_{H_2O}K_{eq_2}}\right)$	2.45E-01 bar$^{0.5}$	54.5
$where\ k_i = k_{oi}\exp\left(-\frac{E_i}{RT}\right), p_k\ is\ the\ partial\ pressure\ of\ component\ k$			

The kinetics of the water gas shift reactions over iron- and copper-based catalysts, derived by Adams [2], are shown in **Error! Reference source not found.**.

Table S3: Water gas shift reaction kinetics

Reaction (i)	**Rate Equation [kmol/kg-cat.s]**	**k_{oi} [kmol/kg-cat.s]**	**E_i [kJ/mol]**
HT-WGS	$r_i = d_{cat}(1-\theta)F_{press}k_i \times y_{CO}^{0.9}y_{H_2O}^{0.31}y_{CO_2}^{-0.156}y_{H_2}^{-0.05}\left(1 - \frac{y_{CO_2}y_{H_2}}{y_{CO}y_{H_2O}K_{eq_2}}\right)$	3.126e+04	88.0
LT-WGS	$r_i = d_{cat}(1-\theta)F_{press}k_i \times \left(y_{CO}y_{H_2O} - \frac{y_{CO_2}y_{H_2}}{K_{eq_2}}\right)$	8.222e+01	47.4
$where\ F_{press} = P\{atm\}^{0.5-\frac{P\{atm\}}{250}}, k_i = k_{oi}\exp\left(-\frac{E_i}{RT}\right), y_k\ is\ the\ mole\ fraction\ of\ compoenent\ k$			

The equilibrium constants for the steam methane reforming reaction is shown in Equation (S1) [3]:

$$K_{eq_1} = \exp(177.94 - 29.56\ln(T\ \{K\})) \quad \text{(S1)}$$

The equilibrium constants for the water gas shift reaction, as repeatedly used in the literature [4], is given in Equation (S2):

$$K_{eq_2} = \exp\left(-4.33 + \frac{4577.8}{T\ \{K\}}\right) \quad \text{(S2)}$$

To cool the synthesis gas for the water gas shift reactors after the reformer, the heat is recovered using heat exchangers that simultaneously preheat the feedwater for steam generation in the cogeneration section. The autothermal reformer is made from a special nickel–iron–chromium alloy material, Incoloy 825, to accommodate the elevated temperatures and the highly reducing environment [5, 6]. Stainless steel SS316L is used in all other equipment within the reforming subsystem for its resistance to corrosion and hydrogen embrittlement.

S1.2 Hydrogen purification

The outlet stream from the water gas shift reactors is purified to produce hydrogen and the recycled flue gas in a multi-bed cyclic pressure swing adsorption (PSA) unit. For the material balance, PSA is modeled as a dummy separation block with two product streams—H_2 product stream and a tail gas stream. The H_2 product stream is specified with 81% recovery for H_2 and 0% for the other components [7].

The sizing for the PSA unit is based on Praxair PSA Patent [7], which has a similar feed composition to the feed in this study. This is a 12-step and 4-bed process designed to achieve 81.6% recovery of H_2 using three adsorbent layers. From this patent, the adsorbent amounts in each train needed to handle a given amount of hydrogen are given in **Error! Reference source not found.**:

Table S4: PSA Sorbent requirements and bulk density [7],

Adsorbent	**Layer from bottom of bed**	**Adsorbent amount [kg per tonne/day H_2]**	**Bulk Density [kg/m^3]**
Alumina	1	470.75	850
Activated carbon	2	2229.93	460
Ca-X Zeolite	3	146.39	685

The alumina sorbent is selective for water in the synthesis gas. The activated carbon is highly selective for the CH_4, and the zeolite handles any remaining CO_2 in the feed. All equipment involved in hydrogen purification are made from stainless steel SS316L for its resistance to hydrogen embrittlement. Other process conditions for the PSA unit are given in **Error! Reference source not found.**:

Table S5: PSA H_2 separation specifications

Cycle time [s]	600
High Pressure [bar]	11.72
Low Pressure [bar]	1.327
Feed Temperature [C]	40
Pressure drop [bar]	0.5
Hydrogen recovery	81.6%
Feed flux [kmol/s/m^2]	6.5E-02
Diameter [m]	5
Length [m]	10

Based on the total mass of sorbent and the dimensions of the columns, the number of 4-bed trains needed to handle the feed volume without exceeding the recommended feed flux is evaluated using Equation (S3):

$$N_{trains} = ceiling\left(\frac{\sum_{n=\#\ of\ sorbents}^{s} \frac{m_s}{\rho_{b_s}}}{V_{column}}\right) \quad \text{(S3)}$$

The tail gas could be subjected to another train of PSA units to reach up to 96% recovery, which we did not consider here. Otherwise, the tail gas is compressed to the selected fuel gas pressure in 4-stage compressors modeled with intercoolers and water knockout drums. The compressed product is recycled as fuel for the oxy-fuel furnace.

S1.3 Oxy-fuel combustion and co-generation

The oxy-fuel burner is modeled with an equilibrium reactor that accounts for methane and hydrogen combustion reactions. A 5% pressure drop from the feed pressure is specified in this unit [1]. A calculator block is used to deliver high-purity oxygen in stoichiometric amounts to the hydrogen and methane in the fuel gas. A design specification block is used to control the water to achieve an outlet stack gas temperature of 1200^{o}C. This temperature constraint is due to the construction material limitations, as operating

temperatures exceeding 1200°C demand proprietary fabrication from ceramic oxides and advanced materials that make for prohibitive costs [5], [8].

The stack gas is then fed to a gas turbine, modeled as an isentropic turbine model with 90% isentropic efficiency. The gas turbine expands the stack gas to 10 bar to ensure the stack gas outlet pressure can be utilized in the TEG dehydration. The turbine stack gas is then used to generate superheated steam at 800°C in a heat exchanger for the reformer. Due to elevated temperatures, the material used in the combustion burners, turbine, and heat exchanger is Incoloy 825, a nickel superalloy commonly recommended for gas turbine parts [5, 6].

The lower-pressure stack gas is delivered to a waste heat recovery steam generator that consists of an economizer, an evaporator, and a superheater; all heat exchangers are used to generate superheated steam at 220°C and 20 bar. The feedwater mass flow rate is set using a design specification to meet an evaporator pinch temperature of 10°C (the temperature difference between the waste gas leaving the evaporator and the steam temperature). An approach temperature of 10°C between the economizer outlet feedwater and the saturated steam temperature is also assumed. The specification for each equipment is shown in **Error! Reference source not found.**.

Table S6: Heat recovery steam generator equipment specifications

Unit	Specification
Boiler feedwater Pump	Pressure outlet = 21 bar
Economizer	Cold stream outlet temperature = 202 C; Cold Stream Pressure drop = 0.5 bar; Hot Stream Pressure drop = 0.25 bar
Evaporator	Cold stream outlet vapor fraction = 0.5; Cold Stream Pressure drop = 0 bar; Hot Stream Pressure drop = 0.25 bar
Steam Drum	Pressure = 20 bar; Duty = 0 W
Superheater	Cold stream outlet temperature = 220 C; Cold Stream Pressure drop = 0.25 bar; Hot Stream Pressure drop = 0.25 bar
Stack Gas Cooler	Hot stream outlet temperature = 40 C; Hot Stream Pressure drop = 0.25 bar

S1.4 CO_2 conditioning

The stack gas is first cooled to 40°C in a shell and tube heat exchanger, and water is condensed out in a flash unit. The remaining water is removed in a scrubber where the gas makes contact with triethylene glycol (TEG). The HYGLYCO equation of the state model is used in this section, which has been fitted for glycol fluids. Aspen RADFRAC blocks were used to model the absorber, still drum, and stripping column. The equilibrium stage model is considered sufficient for the absorber where physical absorption occurs and the stripping columns where the high temperature leads to a fast equilibrium approach. The Aspen Plus built-in interactive column sizing is used to measure the three columns for an 80% approach to flooding and to prevent entrainment.

Recalling that the maximum amount of water permitted in the CO_2 pipeline is 160 mg/Sm^3, this is equivalent to a dew point of -18.4°C at 8 bar. To achieve the level of separation needed, 99.65 wt.% TEG lean solvent is needed to depress the dewpoint from 40°C to -18.4°C. The amount of the H_2O-lean TEG is set by a design specification algorithm to meet the maximum water requirement. After water absorption, the H_2O-rich TEG is depressurized to atmospheric pressure and fed to the top of the still column. In the still column, the

distillate flow rate is varied to ensure the reboiler temperature is 200°C. This is done to achieve the maximum concentration of TEG in the lean solvent without reaching the degradation temperature of 206.5°C. At 200°C in an atmospheric still column, the maximum TEG mass concentration achievable is 98.4%, so a stripping column with dry nitrogen is used to recover more water from the solvent. The vapors from both regeneration columns are cooled to 30°C and subjected to condensers to separate the stripping gas for recycling and wastewater for treatment. To make up for the solvent losses, fresh 99.5 wt% TEG solvent is pumped into the system.

The hot H_2O-lean TEG stream is used within a heat exchanger to preheat the H_2O-rich TEG solvent, which leaves the scrubber at 40 – 50°C. This heat exchanger is specified such that the outlet hot and cold streams come out within 10°C from each other. An extra cooler is used to cool the lean solvent to 40°C for recycling.

The equipment material used in this section is carbon steel. A summary of the design specifications for all columns is provided in Table S7.

Table S7: Triethylene glycol dehydration column and design specifications

	Absorber	**Still**	**Stripper**
Top Pressure [bar]	8	1	1
Packing type	MELLAPAK 125 X	MELLAPAK 125 X	MELLAPAK 125 X
No of Equilibrium stages	5	5	5
Condenser temperature [C]	None	108	None
Reboiler temperature [C]	None	200	None

The dried CO_2 stream is then further compressed in a 4-stage compressor unit with intercooling to generate a dense phase fluid at 185 bars. The intercoolers that cool the compressor output to 40°C are included for the first three stages with water knockouts.

S1.5 Air separation unit

The air separation unit is not modeled but the electricity consumption is specified as 0.54 kWh/kg O_2 to produce 99.5% purity oxygen at 6.6 bar based on a rigorous modeling estimate of large-scale ASU by Young et al. [9]. This value is corroborated by reported performance in Air Liquide commercial ASU units [10]. The process is designed to take advantage of the operating pressure of ASU.

S1.6 Ancillary units

The rotating equipment in this study, pumps and compressors, are represented with isentropic models with isentropic efficiency of 75% and motor efficiency of 97% [11]. In the costing, each sized pump and compressor is assigned a spare for redundancy and reliability.

The heat exchangers are shortcut models set up with outlet stream vapor or temperature specifications, as well as a thermal energy balance (Q = U x A x LMTD). The surface area (A) is estimated using an overall heat transfer coefficient (U) of 800 W/m^2-K. A pressure drop of 0.5 bar is assumed in liquid and saturated vapor handling exchangers.

Piping and control instrumentation are not modeled but are accounted for, along with installation factor, in the costing for each unit.

The utilities specified in the model are electricity and cooling water at 20°C. The electricity is externally generated and delivered. Cooling water production using cooling towers and water purification, performed on-site, is not modeled but accounted for in outside battery limit (OSBL) costs. All steam required is generated within the process using the heat recovery steam generators.

S2. Capital Costing Indices

Index Type	Reference
Equipment cost	Chemical Engineering Magazine
Chemical	Statistics Canada. Industrial product price index

S3. Regression Model Building

The complete ANOVA results for the regression model:

a) Specific Cost.

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	4	11.436023	2.85901	109.3091
Error	13	0.340018	0.02616	**Prob > F**
C. Total	17	11.776041		<.0001*

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	3.6143963	0.132245	27.33	<.0001*
Fuel Pressure (bar)	0.0058274	0.003315	1.76	0.1022
O2/CH4 Ratio	-3.623184	0.186745	-19.40	<.0001*
(Fuel Pressure (bar)-23.5)*(O2/CH4 Ratio-0.45)	-0.043789	0.016239	-2.70	0.0183*
(O2/CH4 Ratio-0.45)*(O2/CH4 Ratio-0.45)	9.1892094	1.293807	7.10	<.0001*

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Fuel Pressure (bar)	1	1	0.0808380	3.0907	0.1022
O2/CH4 Ratio	1	1	9.8455949	376.4292	<.0001*
Fuel Pressure (bar)*O2/CH4 Ratio	1	1	0.1901906	7.2716	0.0183*
O2/CH4 Ratio*O2/CH4 Ratio	1	1	1.3193995	50.4449	<.0001*

b) Specific Emissions.

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	18.329839	3.05497	87.3645
Error	11	0.384650	0.03497	**Prob > F**

Source	DF	Sum of Squares	Mean Square	F Ratio
C. Total	17	18.714489		<.0001*

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	6.9335825	0.177345	39.10	<.0001*
Fuel Pressure (bar)	0.0065463	0.003833	1.71	0.1157
O2/CH4 Ratio	-3.738198	0.215926	-17.31	<.0001*
(Fuel Pressure (bar)-23.5)*(O2/CH4 Ratio-0.45)	-0.059963	0.018776	-3.19	0.0086*
Pressure Ratio	-0.150494	0.014972	-10.05	<.0001*
(O2/CH4 Ratio-0.45)*(Pressure Ratio-6)	0.4795144	0.073347	6.54	<.0001*
(O2/CH4 Ratio-0.45)*(O2/CH4 Ratio-0.45)	12.297233	1.495982	8.22	<.0001*

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Fuel Pressure (bar)	1	1	0.102015	2.9174	0.1157
O2/CH4 Ratio	1	1	10.480596	299.7184	<.0001*
Fuel Pressure (bar)*O2/CH4 Ratio	1	1	0.356638	10.1989	0.0086*
Pressure Ratio	1	1	3.533176	101.0399	<.0001*
O2/CH4 Ratio*Pressure Ratio	1	1	1.494571	42.7409	<.0001*
O2/CH4 Ratio*O2/CH4 Ratio	1	1	2.362843	67.5713	<.0001*

c) Net-Specific Electricity Consumption.

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	31.327598	6.26552	49.4681
Error	12	1.519894	0.12666	**Prob > F**
C. Total	17	32.847492		<.0001*

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	8.6469958	0.290825	29.73	<.0001*
O2/CH4 Ratio	-1.854599	0.410947	-4.51	0.0007*
Pressure Ratio	-0.389349	0.038159	-10.20	<.0001*
(O2/CH4 Ratio-0.45)*(Pressure Ratio-6)	1.2003151	0.139592	8.60	<.0001*
(O2/CH4 Ratio-0.45)*(O2/CH4 Ratio-0.45)	8.370587	2.847122	2.94	0.0124*
(Pressure Ratio-6)*(Pressure Ratio-6)	0.0375285	0.018331	2.05	0.0632

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Fuel Pressure (bar)	1	1	0.102015	2.9174	0.1157
O2/CH4 Ratio	1	1	10.480596	299.7184	<.0001*

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Fuel Pressure (bar)*O2/CH4 Ratio	1	1	0.356638	10.1989	0.0086*
Pressure Ratio	1	1	3.533176	101.0399	<.0001*
O2/CH4 Ratio*Pressure Ratio	1	1	1.494571	42.7409	<.0001*
O2/CH4 Ratio*O2/CH4 Ratio	1	1	2.362843	67.5713	<.0001*

d) Specific Natural Gas Consumption.

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	45.934780	7.65580	809.1394
Error	11	0.104078	0.00946	**Prob > F**
C. Total	17	46.038858		<.0001*

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	6.4345849	0.09225	69.75	<.0001*
Fuel Pressure (bar)	0.0252946	0.001994	12.69	<.0001*
O2/CH4 Ratio	-6.966555	0.112319	-62.02	<.0001*
(Fuel Pressure (bar)-23.5)*(O2/CH4 Ratio-0.45)	-0.095893	0.009767	-9.82	<.0001*
Pressure Ratio	0.0363339	0.007788	4.67	0.0007*
(O2/CH4 Ratio-0.45)*(Pressure Ratio-6)	-0.268606	0.038153	-7.04	<.0001*
(O2/CH4 Ratio-0.45)*(O2/CH4 Ratio-0.45)	20.278131	0.778168	26.06	<.0001*

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Fuel Pressure (bar)	1	1	1.523083	160.9743	<.0001*
O2/CH4 Ratio	1	1	36.399662	3847.072	<.0001*
Fuel Pressure (bar)*O2/CH4 Ratio	1	1	0.912078	96.3973	<.0001*
Pressure Ratio	1	1	0.205944	21.7662	0.0007*
O2/CH4 Ratio*Pressure Ratio	1	1	0.468971	49.5655	<.0001*
O2/CH4 Ratio*O2/CH4 Ratio	1	1	6.425041	679.0610	<.0001*

Table S8 shows the derived regression model and two criteria describing their fit.

Table S8: Regression models and summary of fit.

Model	R^2	ANOVA P-value
$Specific\ Cost = 3.61\ (\pm 0.132) + 0.00583(\pm 0.00331) * Fuel\ Pressure\ \{bar\} - 3.62(\pm 0.187) * O_2\|CH_4 ratio - 0.0438\ (\pm 0.0162) * (Fuel\ Pressure\ \{bar\} - 23.5) * (O_2\|CH_4\ ratio - 0.45) + 9.19\ (\pm 1.29) * (O_2\|CH_4\ ratio - 0.45) * (O_2\|CH_4\ ratio - 0.45)$	0.971	<0.0001

$Specific\ Emissions = 6.93\ (\pm 0.177) + 0.0655(\pm 0.00383) * Fuel\ Pressure\ \{bar\} - 3.74\ (\pm 0.216) * O_2\|CH_4\ ratio - 0.150\ (\pm 0.0150)\ \ Turbine\ pressure\ ratio - 0.060\ (\pm 0.0188) * (Fuel\ Pressure\ \{bar\} - 23.5) * (O_2\|CH_4\ ratio - 0.45) +\ 12.3\ (\pm 1.50) * (O_2\|CH_4\ ratio - 0.45) * (O_2\|CH_4\ ratio - 0.45) + 0.480\ (\pm 0.0733) * (O_2\|CH_4\ ratio - 0.45) * (Turbine\ Pressure\ Ratio - 6)$	0.979	<0.0001
$Net\ Specific\ Electricity\ Consumption = 8.66\ (\pm 0.324) - 0.337(\pm 0.0318) * Turbine\ pressure\ ratio - 1.85(\pm 0.459) * O_2\|CH_4 ratio + 1.20\ (\pm 0.156) * (O_2\|CH_4\ ratio - 0.45) * (Turbine\ Pressure\ Ratio - 6) + 8.37\ (\pm 3.18) * (O_2\|CH_4\ ratio - 0.45) * (O_2\|CH_4\ ratio - 0.45) + 0.0375\ (\pm 0.0183) * (Turbine\ Pressure\ ratio - 6) * (Turbine\ Pressure\ ratio - 6)$	0.938	<0.0001
$Specific\ Natural\ Gas\ Consumption = 6.43\ (\pm 0.092) + 0.0253(\pm 0.00199) * Fuel\ Pressure\ \{bar\} - 6.97\ (\pm 0.112) * O_2\|CH_4\ ratio + 0.0363\ (\pm 0.00779) *\ Turbine\ pressure\ ratio - 0.0959\ (\pm 0.00977) * (Fuel\ Pressure\ \{bar\} - 23.5) * (O_2\|CH_4\ ratio - 0.45) + 20.3\ (\pm 0.778) * (O_2\|CH_4\ ratio - 0.45) * (O_2\|CH_4\ ratio - 0.45) - 0.269\ (\pm 0.0382) * (O_2\|CH_4\ ratio - 0.45) * (Turbine\ Pressure\ Ratio - 6)$	0.998	<0.0001

S4. Process Flow Diagram.

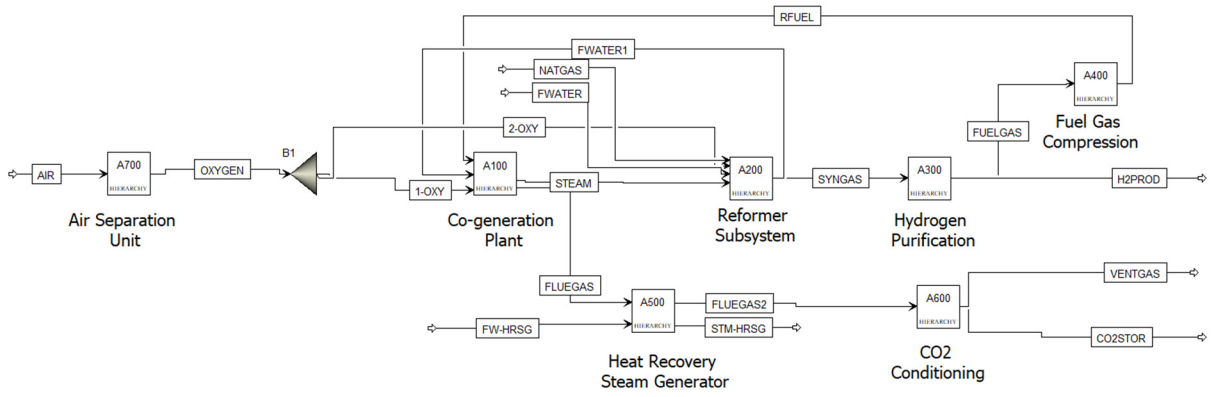


Figure S1: Overall Flowsheet.

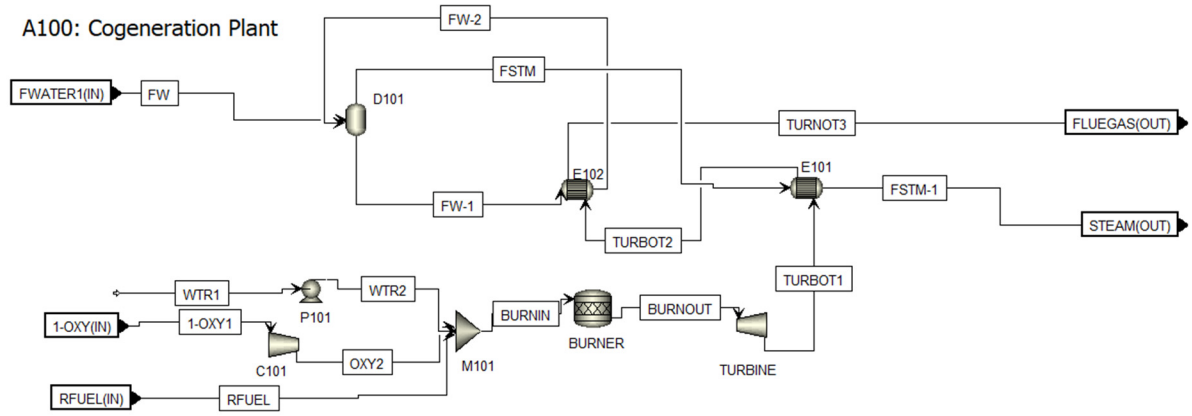


Figure S2: A100—Cogeneration Plant.

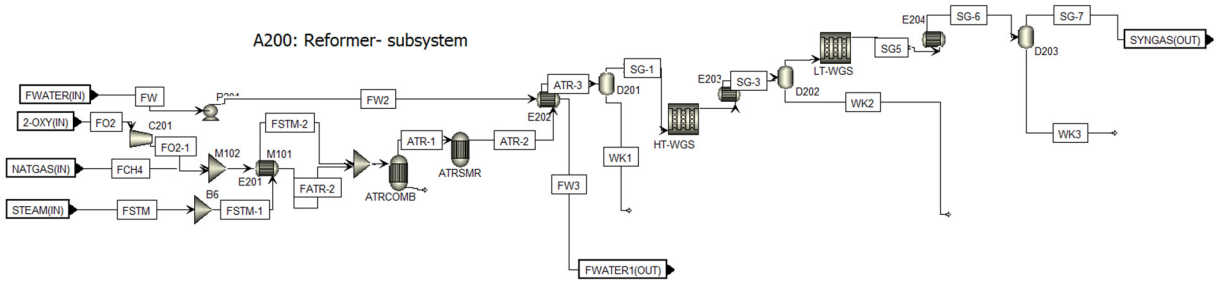


Figure S3: A200—Reformer Subsystem.

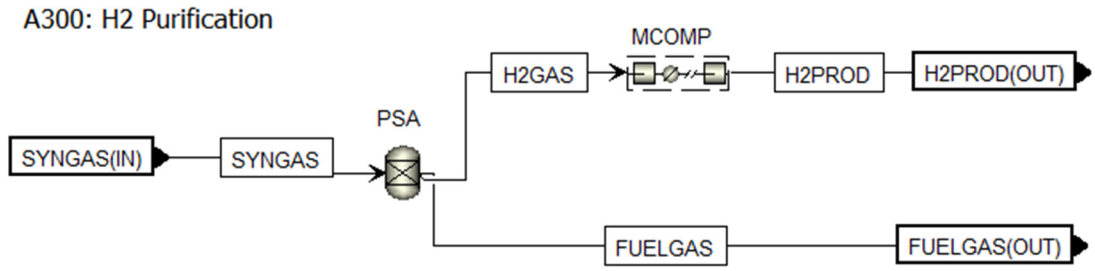


Figure S4: A300—Hydrogen Purification.

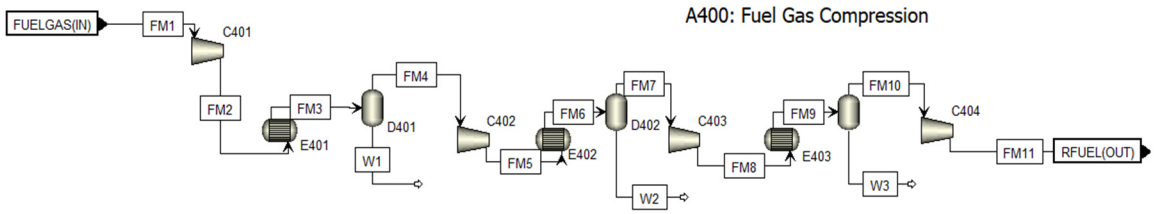


Figure S5: A400—Fuel Gas Compression.

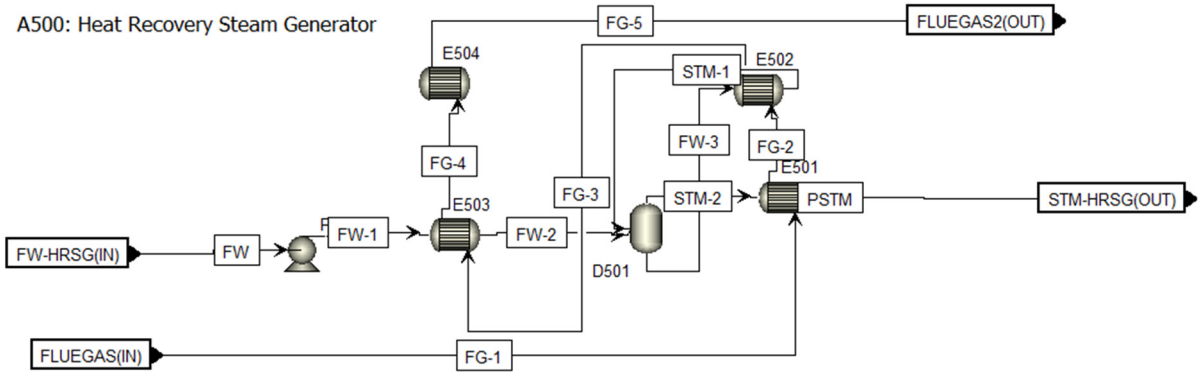


Figure S6:A600—Heat Recovery Steam Generator.

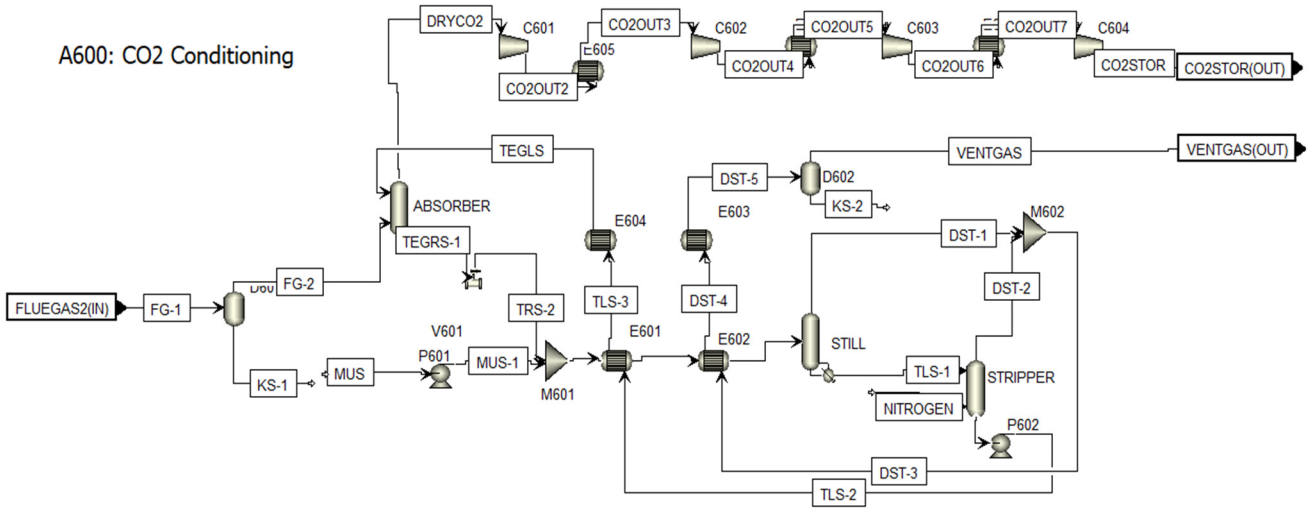


Figure S7: A600—CO2 Conditioning

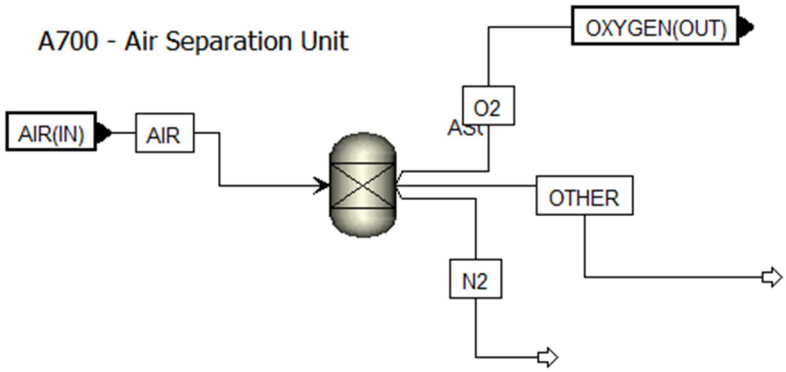


Figure S8: A700—Air Separation Unit.

S5. Raw Data

Table S9: Cost-Optimal Scenario—35 bar natural gas supply pressure.

Stream Name	Units	1-OXY	2-OXY	AIR	CO2 STOR	FLUEGAS	FLUE GAS2	FUELGAS	FW-HRSG	FWATER	FWATER1	H2PROD	NATGAS	OXYGEN	RFUEL	STEAM	STM-HRSG	SYNGAS	VENT GAS
Description																			
From		B1	B1		A600	A100	A500	A300			A200	A300		A700	A400	A100	A500	A200	A600
To		A100	A200	A700		A500	A600	A400	A500	A200	A100		A200	B1	A100	A200		A300	
Stream Class		CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN
Maximum Relative Error																			
Cost Flow	$/sec																		
MIXED Substream																			
Phase		Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase		Vapor Phase	Liquid Phase	Liquid Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase
Temperature	C	1.50E+01	1.50E+01	1.50E+01	7.04E+01	3.09E+02	4.00E+01	3.00E+01	2.00E+01	1.50E+01	2.73E+02	4.00E+01	1.50E+01	1.50E+01	9.85E+01	8.00E+02	2.20E+02	3.00E+01	4.00E+01
Pressure	bar	1.00E+00	1.00E+00	1.00E+00	1.85E+02	1.00E+01	9.00E+00	1.20E+00	1.00E+00	1.00E+00	3.55E+01	1.00E+02	3.50E+01	1.00E+00	5.27E+01	3.55E+01	1.98E+01	3.20E+01	1.00E+00
Molar Vapor Fraction		1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	5.25E-01	1.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Molar Liquid Fraction		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.75E-01	0.00E+00	1.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Molar Solid Fraction		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mass Vapor Fraction		1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	7.14E-01	1.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Mass Liquid Fraction		0.00E+00	0.00E+00	0.00E+00	5.88E-07	0.00E+00	2.86E-01	0.00E+00	1.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mass Solid Fraction		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Molar Enthalpy	J/kmol	-3.03E+05	-3.03E+05	-3.00E+05	-3.66E+08	-2.94E+08	-3.25E+08	-2.45E+08	-2.88E+08	-2.89E+08	-2.35E+08	5.05E+05	-7.67E+07	-3.03E+05	-2.43E+08	-2.13E+08	-2.36E+08	-1.01E+08	-4.99E+07
Mass Enthalpy	J/kg	-9.48E+03	-9.48E+03	-1.03E+04	-8.95E+06	-9.80E+06	-1.09E+07	-8.38E+06	-1.60E+07	-1.60E+07	-1.30E+07	2.51E+05	-4.55E+06	-9.48E+03	-8.32E+06	-1.18E+07	-1.31E+07	-7.64E+06	-1.74E+06
Molar Entropy	J/kmol-K	-9.17E+02	-9.17E+02	-3.77E+03	-4.52E+04	-5.88E+03	-8.33E+04	-1.41E+04	-1.69E+05	-1.71E+05	-5.51E+04	-3.69E+04	-1.15E+05	-9.17E+02	-1.15E+04	-2.75E+04	-5.33E+04	-1.97E+04	-3.11E+03
Mass Entropy	J/kg-K	-2.87E+01	-2.87E+01	-1.30E+02	-1.10E+03	-1.96E+02	-2.78E+03	-4.82E+02	-9.40E+03	-9.48E+03	-3.06E+03	-1.83E+04	-6.82E+03	-2.87E+01	-3.95E+02	-1.52E+03	-2.96E+03	-1.49E+03	-1.08E+02
Molar Density	kmol/cum	4.18E-02	4.18E-02	4.18E-02	1.11E+01	2.09E-01	6.79E-01	4.77E-02	5.54E+01	5.57E+01	8.81E-01	3.66E+00	1.61E+00	4.18E-02	1.77E+00	4.01E-01	5.25E-01	1.27E+00	3.84E-02

Stream Name	Units	1-OXY	2-OXY	AIR	CO2 STOR	FLUEGAS	FLUE GAS2	FUELGAS	FW-HRSG	FWATER	FWATER1	H2PROD	NATGAS	OXYGEN	RFUEL	STEAM	STM-HRSG	SYNGAS	VENTGAS
Mass Density	kg/cum	1.34E+00	1.34E+00	1.21E+00	4.53E+02	6.24E+00	2.03E+01	1.39E+00	9.99E+02	1.00E+03	1.59E+01	7.39E+00	2.71E+01	1.34E+00	5.18E+01	7.22E+00	9.46E+00	1.68E+01	1.10E+00
Enthalpy Flow	Watt	-1.63E+05	-3.86E+05	-2.58E+06	-8.17E+08	-1.26E+09	-1.39E+09	-7.54E+08	-7.18E+06	-1.69E+09	-1.37E+09	-2.22E+06	-1.53E+08	-5.48E+05	-7.48E+08	-1.24E+09	-5.99E+06	-7.55E+08	-9.85E+05
Average MW		3.20E+01	3.20E+01	2.90E+01	4.09E+01	2.99E+01	2.99E+01	2.92E+01	1.80E+01	1.80E+01	1.80E+01	2.02E+00	1.68E+01	3.20E+01	2.92E+01	1.80E+01	1.80E+01	1.32E+01	2.86E+01
Mass Flows	kg/hr	6.18E+04	1.46E+05	8.98E+05	3.29E+05	4.62E+05	4.62E+05	3.24E+05	1.62E+03	3.79E+05	3.79E+05	3.18E+04	1.21E+05	2.08E+05	3.24E+05	3.79E+05	1.64E+03	3.56E+05	2.03E+03
CH4	kg/hr	0.00E+00	0.00E+00	0.00E+00	1.33E+02	1.33E+02	1.33E+02	8.86E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E+05	0.00E+00	8.86E+02	0.00E+00	0.00E+00	8.86E+02	5.74E-03
CO2	kg/hr	0.00E+00	0.00E+00	0.00E+00	3.23E+05	3.24E+05	3.24E+05	2.93E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.47E+02	0.00E+00	2.93E+05	0.00E+00	0.00E+00	2.93E+05	2.61E+02
H2O	kg/hr	0.00E+00	0.00E+00	0.00E+00	2.66E+01	1.33E+05	1.33E+05	6.29E+02	1.62E+03	3.79E+05	3.79E+05	0.00E+00	0.00E+00	0.00E+00	3.52E+02	3.79E+05	1.64E+03	6.29E+02	9.23E+01
CO	kg/hr	0.00E+00	0.00E+00	0.00E+00	3.21E+03	3.21E+03	3.21E+03	2.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.14E+04	0.00E+00	0.00E+00	2.14E+04	1.29E-01
H2	kg/hr	0.00E+00	0.00E+00	0.00E+00	1.08E+03	1.08E+03	1.08E+03	7.18E+03	0.00E+00	0.00E+00	0.00E+00	3.18E+04	9.83E+00	0.00E+00	7.18E+03	0.00E+00	0.00E+00	3.90E+04	1.00E-02
O2	kg/hr	6.18E+04	1.46E+05	2.08E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E+01	2.08E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N2	kg/hr	0.00E+00	0.00E+00	6.78E+05	8.04E+02	8.03E+02	8.03E+02	8.03E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.03E+02	0.00E+00	8.03E+02	0.00E+00	0.00E+00	8.03E+02	1.68E+03
TEG	kg/hr	0.00E+00	0.00E+00	0.00E+00	1.08E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.13E-03
AR	kg/hr	0.00E+00	0.00E+00	1.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C2H6	kg/hr	0.00E+00	0.00E+00	0.00E+00	1.09E-03	1.09E-03	1.09E-03	7.30E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.49E+03	0.00E+00	7.30E-03	0.00E+00	0.00E+00	7.30E-03	1.15E-07
C3H8	kg/hr	0.00E+00	0.00E+00	0.00E+00	2.19E-08	2.19E-08	2.19E-08	1.46E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.18E+02	0.00E+00	1.46E-07	0.00E+00	0.00E+00	1.46E-07	9.14E-12
N-BUT-01	kg/hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Fractions																			
CH4		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00
CO2		0.00	0.00	0.00	0.98	0.70	0.70	0.90	0.00	0.00	0.00	0.00	0.01	0.00	0.91	0.00	0.00	0.82	0.13
H2O		0.00	0.00	0.00	0.00	0.29	0.29	0.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.05
CO		0.00	0.00	0.00	0.01	0.01	0.01	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.06	0.00
H2		0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	1.00	0.00	0.00	0.02	0.00	0.00	0.11	0.00
O2		1.00	1.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
N2		0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.83
TEG		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AR		0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C2H6		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
C3H8		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00

Stream Name	Units	1-OXY	2-OXY	AIR	CO2 STOR	FLUEGAS	FLUE GAS2	FUELGAS	FW-HRSG	FWATER	FWATER1	H2PROD	NATGAS	OXYGEN	RFUEL	STEAM	STM-HRSG	SYNGAS	VENT GAS
N-BUT-01		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Volume Flow	cum/hr	46258.16016	109556.7419	742278.7876	724.7829933	74008.75568	22716.676	232680.1717	1.61699342	377.4107341	23873.68339	4310.577095	4464.282368	155814.902	6251.668214	52463.14943	173.7487771	21139.05475	1848.506633

Table S10: Cost-Optimal Scenario—12 bar natural gas supply pressure.

Stream Name	Units	1-OXY	2-OXY	AIR	CO2 STOR	FLUE GAS	FLUE GAS2	FUEL GAS	FW-HRSG	FWATER	FWATER1	H2PROD	NATGAS	OXYGEN	RFUEL	STEAM	STM-HRSG	SYNGAS	VENT GAS
Description																			
From		B1	B1		A600	A100	A500	A300			A200	A300		A700	A400	A100	A500	A200	A600
To		A100	A200	A700		A500	A600	A400	A500	A200	A100		A200	B1	A100	A200		A300	
Stream Class		CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN
Maximum Relative Error																			
Cost Flow	$/sec																		
MIXED Substream																			
Phase		Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase		Vapor Phase	Liquid Phase	Liquid Phase		Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase
Temperature	C	1.50E+01	1.50E+01	1.50E+01	5.65E+01	2.78E+02	4.00E+01	3.00E+01	2.00E+01	1.50E+01	1.90E+02	4.00E+01	1.50E+01	1.50E+01	9.85E+01	8.00E+02	2.20E+02	3.00E+01	4.00E+01
Pressure	bar	1.00E+00	1.00E+00	1.00E+00	1.85E+02	1.00E+01	9.00E+00	1.20E+00	1.00E+00	1.00E+00	1.25E+01	1.00E+02	1.20E+01	1.00E+00	5.27E+01	1.25E+01	1.98E+01	9.04E+00	1.00E+00
Molar Vapor Fraction		1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	4.74E-01	1.00E+00	0.00E+00	0.00E+00	9.00E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Molar Liquid Fraction		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.26E-01	0.00E+00	1.00E+00	1.00E+00	1.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Molar Solid Fraction		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mass Vapor Fraction		1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	6.86E-01	1.00E+00	0.00E+00	0.00E+00	9.00E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Mass Liquid Fraction		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-01	0.00E+00	1.00E+00	1.00E+00	1.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mass Solid Fraction		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Molar Enthalpy	J/kmol	-3.03E+05	-3.03E+05	-3.00E+05	4.00E+08	-3.03E+08	3.36E+08	-2.56E+08	-2.88E+08	2.89E+08	-2.41E+08	-5.05E+05	-7.62E+07	-3.03E+05	-2.54E+08	-2.13E+08	-2.36E+08	-1.03E+08	-5.57E+07
Mass Enthalpy	J/kg	-9.48E+03	-9.48E+03	-1.03E+04	9.10E+06	-1.00E+07	1.11E+07	-8.70E+06	-1.60E+07	1.60E+07	-1.34E+07	-2.51E+05	-4.52E+06	-9.48E+03	-8.61E+06	-1.18E+07	-1.31E+07	-7.89E+06	-1.93E+06
Molar Entropy	J/kmol-K	-9.17E+02	-9.17E+02	-3.77E+03	5.79E+04	-1.24E+04	9.29E+04	-6.98E+03	-1.69E+05	1.71E+05	-5.92E+04	-3.69E+04	-1.05E+05	-9.17E+02	-1.85E+04	-1.86E+04	-5.33E+04	-1.19E+04	-3.39E+03
Mass Entropy	J/kg-K	-2.87E+01	-2.87E+01	-1.30E+02	1.32E+03	-4.10E+02	3.07E+03	-2.37E+02	-9.40E+03	9.48E+03	-3.29E+03	-1.83E+04	-6.22E+03	-2.87E+01	-6.28E+02	-1.03E+03	-2.96E+03	-9.12E+02	-1.18E+02
Molar Density	kmol/cum	4.18E-02	4.18E-02	4.18E-02	1.55E+01	2.21E-01	7.57E-01	4.77E-02	5.54E+01	5.57E+01	3.84E-01	3.66E+00	5.17E-01	4.18E-02	1.78E+00	1.40E-01	5.25E-01	3.59E-01	3.84E-02
Mass Density	kg/cum	1.34E+00	1.34E+00	1.21E+00	6.82E+02	6.69E+00	2.29E+01	1.41E+00	9.99E+02	1.00E+03	6.92E+00	7.39E+00	8.72E+00	1.34E+00	5.27E+01	2.53E+00	9.46E+00	4.69E+00	1.11E+00

Stream Name	Units	1-OXY	2-OXY	AIR	CO2 STOR	FLUE GAS	FLUE GAS2	FUEL GAS	FW-HRSG	FWATER	FWATER1	H2PROD	NATGAS	OXYGEN	RFUEL	STEAM	STM-HRSG	SYNGAS	VENT GAS
Enthalpy Flow	Watt	-1.81E+05	-3.67E+05	-2.58E+06	-8.65E+08	-1.39E+09	-1.54E+09	-8.44E+08	-1.11E+07	-1.49E+09	-1.24E+09	-2.47E+06	-1.57E+08	-5.48E+05	-8.32E+08	-1.10E+09	-9.19E+06	-8.44E+08	-1.07E+06
Average MW		3.20E+01	3.20E+01	2.90E+01	4.39E+01	3.02E+01	3.02E+01	2.94E+01	1.80E+01	1.80E+01	1.80E+01	2.02E+01	1.68E+01	3.20E+01	2.95E+01	1.80E+01	1.80E+01	1.31E+01	2.89E+01
Mass Flows	kg/hr	6.88E+04	1.40E+05	8.98E+05	3.42E+05	5.00E+05	5.00E+05	3.50E+05	2.50E+03	3.35E+05	3.35E+05	3.54E+04	1.25E+05	2.08E+05	3.48E+05	3.35E+05	2.52E+03	3.85E+05	2.00E+03
CH4	kg/hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E+05	0.00E+00	1.07E+03	0.00E+00	0.00E+00	1.07E+03	0.00E+00
CO2	kg/hr	0.00E+00	0.00E+00	0.00E+00	3.41E+05	3.41E+05	3.41E+05	3.36E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.82E+02	0.00E+00	3.36E+05	0.00E+00	0.00E+00	3.36E+05	3.00E+02
H2O	kg/hr	0.00E+00	0.00E+00	0.00E+00	1.92E+01	1.58E+05	1.58E+05	2.16E+03	2.50E+03	3.35E+05	3.35E+05	0.00E+00	0.00E+00	0.00E+00	3.92E+02	3.35E+05	2.52E+03	2.16E+03	9.06E+01
CO	kg/hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.92E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.92E+03	0.00E+00	0.00E+00	1.92E+03	0.00E+00
H2	kg/hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.99E+03	0.00E+00	0.00E+00	0.00E+00	3.54E+04	1.02E+01	0.00E+00	7.99E+03	0.00E+00	0.00E+00	4.34E+04	0.00E+00
O2	kg/hr	6.88E+04	1.40E+05	2.08E+05	2.93E+01	2.93E+01	2.93E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E+01	2.08E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.65E-03
N2	kg/hr	0.00E+00	0.00E+00	6.78E+05	8.33E+02	8.33E+02	8.33E+02	8.33E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.33E+02	0.00E+00	8.33E+02	0.00E+00	0.00E+00	8.33E+02	1.61E+03
TEG	kg/hr	0.00E+00	0.00E+00	0.00E+00	1.05E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.97E-03
AR	kg/hr	0.00E+00	0.00E+00	1.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C2H6	kg/hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.22E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.84E+03	0.00E+00	5.22E-03	0.00E+00	0.00E+00	5.22E-03	0.00E+00
C3H8	kg/hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.68E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.44E+02	0.00E+00	6.68E-08	0.00E+00	0.00E+00	6.68E-08	0.00E+00
N-BUT-01	kg/hr	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mass Fractions																			
CH4		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.07E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.01E-01	0.00E+00	3.08E-03	0.00E+00	0.00E+00	2.79E-03	0.00E+00
CO2		0.00E+00	0.00E+00	0.00E+00	9.97E-01	6.83E-01	6.83E-01	9.60E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.84E-03	0.00E+00	9.65E-01	0.00E+00	0.00E+00	8.72E-01	1.50E-01
H2O		0.00E+00	0.00E+00	0.00E+00	5.61E-05	3.16E-01	3.16E-01	6.19E-03	1.00E+00	1.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-03	1.00E+00	1.00E+00	5.62E-03	4.52E-02
CO		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.49E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.52E-03	0.00E+00	0.00E+00	4.99E-03	0.00E+00
H2		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.29E-02	0.00E+00	0.00E+00	0.00E+00	1.00E+00	8.14E-05	0.00E+00	2.30E-02	0.00E+00	0.00E+00	1.13E-01	0.00E+00
O2		1.00E+00	1.00E+00	2.32E-01	8.55E-05	5.85E-05	5.85E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.50E-05	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E-06
N2		0.00E+00	0.00E+00	7.56E-01	2.44E-03	1.67E-03	1.67E-03	2.38E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.65E-03	0.00E+00	2.40E-03	0.00E+00	0.00E+00	2.16E-03	8.05E-01
TEG		0.00E+00	0.00E+00	0.00E+00	3.07E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.82E-07
AR		0.00E+00	0.00E+00	1.24E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C2H6		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.85E-02	0.00E+00	1.50E-08	0.00E+00	0.00E+00	1.36E-08	0.00E+00

Stream Name	Units	1-OXY	2-OXY	AIR	CO2 STOR	FLUE GAS	FLUE GAS2	FUEL GAS	FW-HRSG	FWATER	FWATER1	H2PROD	NATGAS	OXYGEN	RFUEL	STEAM	STM-HRSG	SYNGAS	VENT GAS
C3H8		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.91E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.94E-03	0.00E+00	1.92E-13	0.00E+00	0.00E+00	1.74E-13	0.00E+00
N-BUT-01		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Volume Flow	cum/hr	5.15E+04	1.04E+05	7.42E+05	5.01E+02	7.48E+04	2.19E+04	2.49E+05	2.50E+00	3.34E+02	4.84E+04	4.80E+03	1.44E+04	1.56E+05	6.60E+03	1.32E+05	2.67E+02	8.20E+04	1.81E+03

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