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Municipal Solid Waste (MSW) to Liquid Fuels Synthesis, Volume 2: A Techno-economic Evaluation of the Production of Mixed Alcohols

SB Jones
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April 2009

Pacific Northwest NATIONAL LABORATORY

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Summary

Biomass is a renewable energy resource that can be converted into liquid fuel suitable for transportation applications and thus help meet the Energy Independence and Security Act renewable energy goals (U.S. Congress 2007). However, biomass is not always available in sufficient quantity at a price compatible with fuels production. Municipal solid waste (MSW) on the other hand is readily available in large quantities in some communities and is considered a partially renewable feedstock. Furthermore, MSW may be available for little or no cost.

This report provides a techno-economic analysis of the production of mixed alcohols from MSW and compares it to the costs for a wood based plant. In this analysis, MSW is processed into refuse derived fuel (RDF) and then gasified in a plant co-located with a landfill. The resulting syngas is then catalytically converted to mixed alcohols. At a scale of 2000 metric tons per day of RDF, and using current technology, the minimum ethanol selling price at a 10% rate of return is approximately $1.85/gallon ethanol (early 2008 $). However, favorable economics are dependent upon the toxicity characteristics of the waste streams and that a market exists for the by-product scrap metal recovered from the RDF process.

Acknowledgment

The authors thank DOE's biomass program for funding this work and acknowledge the modeling work performed by the National Renewable Energy Laboratory (NREL), which serves as the basis for the gasification and syngas conditioning portion of the models.

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1.0 Introduction

Biomass is a renewable domestic resource that has the potential to make a significant impact on domestic fuel supplies. However, due to the disperse nature of biomass, its cost rises with the quantity collected. Thus capital cost economies of scale can be difficult to achieve. Municipal solid waste (MSW) is an important biomass containing resource that remains largely untapped in the United States. Some landfills have installed landfill gas recovery systems or employ waste-to-energy via combustion and/or refuse derived fuel production. However, these uses represent only a portion of the nation's waste and generally have low efficiency. Using MSW as a fuel feedstock takes advantage of existing collection infrastructure and extends landfill life. In some locations using this feedstock could take advantage of existing sorting infrastructure (i.e., Material Recover Facilities or MRFs), thus reducing costs. It also provides a domestic source of feedstock for fuel and captures energy value that is otherwise literally buried. Importantly, it does not compete for food or cultivatable land and may be available for low or even negative fees. According to the Energy Information Agency, on average, fifty-six percent of MSW can be classified as biogenic and therefore can be considered partially renewable (EIA 2007).

This report analyzes the use of MSW to produce mixed alcohols via gasification using existing technologies and compares those results to a biomass based system. The MSW plant is assumed to be co-located with a landfill. Sensitivities to fees, return on investment, and technology improvements are discussed. The process model and cost models used in this work are based upon previous analysis (Aden 2005, Phillips 2007, Zhu 2009) and employs similar methodology.

2.0 Process Design Basis and Modeling

A simplified block diagram for the MSW to ethanol process is shown in Figure 2-1. In this system, MSW is first separated to remove recyclables and shredded and milled to reduce its size. It is then dried prior to gasification to synthesis gas. Then syngas is sent to a tar reformer and a scrubber. Syngas free of tars and particulates is sent to a sulfur removal unit to remove sulfur compounds. Then clean syngas is sent to a steam reformer to convert methane to hydrogen and carbon monoxide and to adjust the H_2/CO ratio to that required by the mixed alcohols synthesis. The syngas is then compressed and sent to mixed alcohol synthesis. The product stream is cooled and the unconverted syngas and gaseous products are separated from the product liquid. The liquid product is dried in a molecular sieve and fractioned into ethanol and higher alcohols. Steam generated in the processes is collected and sent to the steam cycle for power generation. Process steam is extracted from the turbines for use in the gasifier, steam reformer and various process heaters. The entire process is assumed to be co-located with a landfill of suitable size. The reference biomass based process is the same as the MSW process, without the physical separation step.

The base case assumes existing technology for the gas cleanup section (tar cracking and steam reforming) and the mixed alcohols production (Spath 2005, Aden 2005, Zhu 2009). The future 2012 goal case (Phillips 2007) gas cleanup and alcohol production are included as sensitivity.

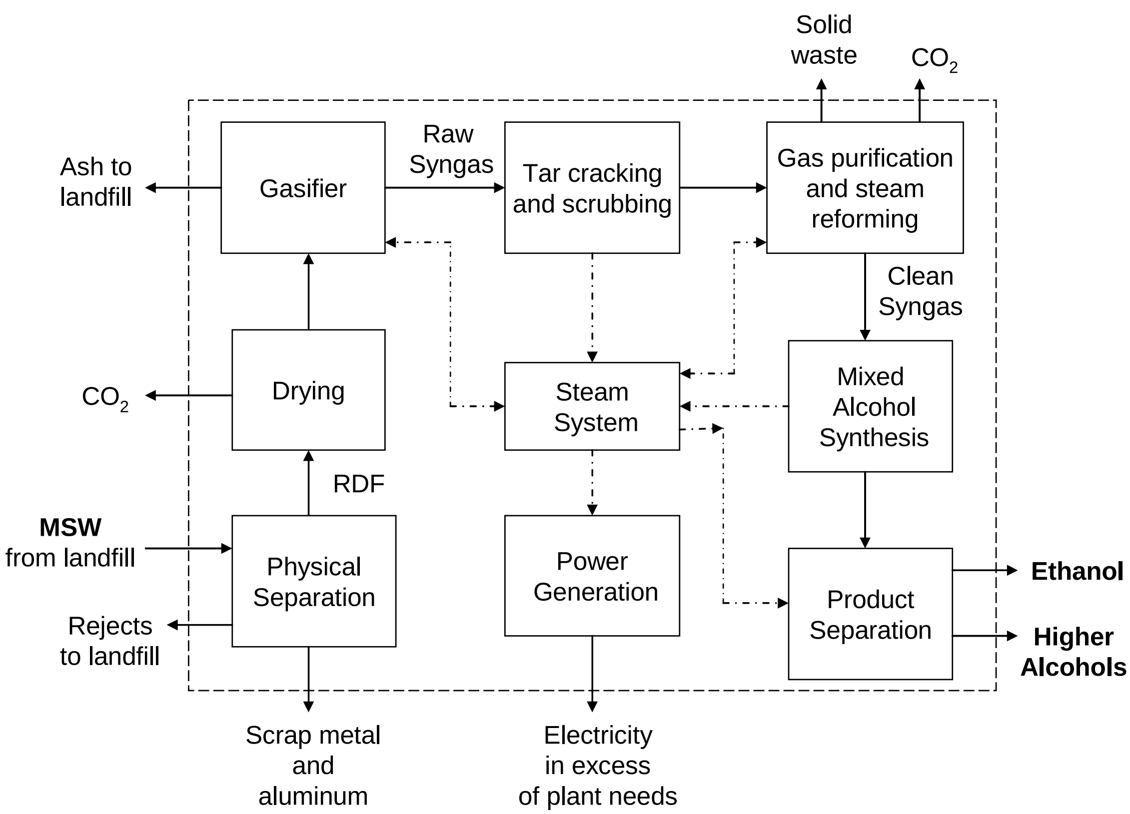

Figure 2-1 Process Diagram of the MSW to Ethanol Process

2.1 Process Design Basis

The gasifier feed rate is assumed to be 2000 metric tones/day of dry feed (2205 short tons per day). The MSW to ethanol process consists of nine main areas. Each area is described in the follow paragraphs.

2.1.1 Physical Separation

Raw MSW contains a large amount of non-combustible material, and therefore requires pre-processing before sending it to a gasifier. The pre-processing must be able to meet the requirements of the gasifier and be flexible enough to handle MSW variability. This flexibility must be in terms of the type of material handled and its frequency of delivery.

The pre-processing area is assumed to be similar to a Refuse Derived Fuel (RDF) facility. Some recyclables and non-combustibles are removed from the MSW to make a higher heating value product that is sized appropriately for gasification. The RDF separation equipment is located in an enclosed area. The building contains front end loaders, stockpiling areas, cranes, shredders, a ferrous magnet to remove scrap iron, an eddy current separator to capture aluminum, screens to separate by size, air classifiers to separate by weight, a series of conveyor belts and product storage areas. A simplified block diagram is shown in Figure 2-2.

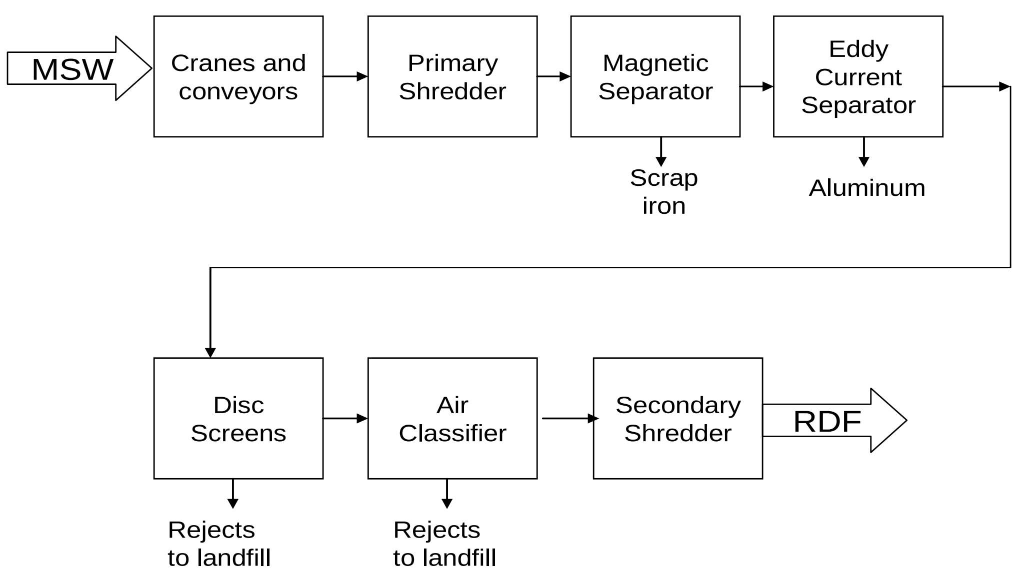

Figure 2-2 Process Diagram of the MSW to Ethanol Process

Reject material contains broken glass, dirt and material too small to collect for the gasifier as well as some combustible material. Reject material plus recovered scrap metal is assumed to be 20% of the MSW feed rate. The rejects are returned to the landfill, while the scrap metal is stockpiled for sale. The RDF material retains significant mineral matter, resulting greater than 10% ash content.

The RDF facility is expected to operate on a schedule similar to that of the waste collection. For large municipalities, this could mean a twenty-four hour, seven days per week operation. Smaller facilities may only collect waste five days per week. Since the gasifier operates continuously at a feed rate of 2205 dry short tons per day (TPD), the RDF facility must run at a higher rate if it operates at less than round the clock. Table 2-1 shows the MSW feed rates required for various combinations of shifts per day and loss to meet 2205 dry short tons per day of RDF on a continuous basis. The term “loss” refers to the recovered metals and the reject material in the MSW that is not recovered in the RDF and is sold as scrap metal or returned to the landfill. It is assumed that the RDF facility in this study operates six days per week on two eight hour shifts per day at 20% loss, thus requiring an MSW feed rate of 200 short tons per hour (TPH). Two trains of 100 TPH MSW will allow flexibility to handle variations in MSW rates and equipment maintenance.

Table 2-1 Example Operating Schedules for RDF Production

MSW Tons/hr	Shifts /day	Hours /shift	MSW Tons /day	Operating days /week	MSW Tons /week	MSW TPD continuous	MSW conversion to RDF		
							75%	80%	85%
143	3	8	3432	6	20,592	2942	**2206**	2353	2500
134	3	8	3216	6	19,296	2757	2067	**2205**	2343
126	3	8	3024	6	18,144	2592	1944	2074	**2203**
214	2	8	3424	6	20,544	2935	**2201**	2348	2495
201	2	8	3216	6	19,296	2757	2067	**2205**	2343
189	2	8	3024	6	18,144	2592	1944	2074	**2203**
429	1	8	3432	6	20,592	2942	**2206**	2353	2500
402	1	8	3216	6	19,296	2757	2067	**2205**	2343
378	1	8	3024	6	18,144	2592	1944	2074	**2203**

2.1.2 Drying

The feedstock (either RDF or biomass) at a moisture content of 50 wt% is fed at a rate of 2205 dry TPD. The biomass is assumed to be delivered at the correct size for gasification. The wet feed is dried in rotary dryers to a moisture content of 12 wt%. The dried feed is then conveyed to the gasifier.

2.1.3 Gasification

The indirectly-heated gasifier contains both a gasifier and a combustor. Dried feedstock is fed into a low-pressure indirectly heated gasifier. Steam extracted from the steam cycle is sent to the gasifier to fluidize the bed and to supply a portion of the heat required for the gasifier. The gasifier is mainly heated by circulating olivine particles between the gasifier and the separate combustor. Char and ash formed in the gasifier is carried out of the gasifier along with the olivine, separated in a series of cyclones and sent to the fluidized bed combustor, where air is used to burn the char, thereby reheating the olivine. The heat balance in the gasifier is achieved by adjusting air to the combustor, and the olivine circulation rate.

The indirectly-heated gasifier is modeled using the correlations reported in Spath, *et al.* (2005). The correlations are based on data from the Battelle-Columbus Laboratory (BCL) process development unit (PDU) gasifier. The RDF data are from the BCL PDU running on RDF as reported in Paisley, *et al.* (1990). These data are summarized in Table 2-2. Economics for both RDF and Biomass are included in this report.

Table 2-2 RDF and Biomass Feedstock Quality and Gasifier Conditions

	RDF	Biomass (Poplar)
Feedstock analysis, % dry basis		
volatile matter	79.6	83.8
fixed carbon	10.0	15.3
ash	10.5	0.92
carbon	45.5	51.0
hydrogen	5.8	6.1
nitrogen	0.3	0.2
sulfur	0.2	0.1
oxygen (by difference)	37.8	42.3
BTU/lb, dry basis	7621	8671
Moisture Content, % wet	50%	50%
Gasifier temp, °C (°F)	822 (1511)	870 (1598)
Feed moisture, %	12	12
Gasifier press, psig	8	8
Steam rate, lb/lb dry feedstock	0.398	0.398
Combustor temp, °C (°F)	943 (1730)	995 (1823)
Combustor press, psig	8	8
Dry syngas composition, vol%		
hydrogen	17.6	24.0
carbon monoxide	38.8	42.4
carbon dioxide	9.3	12.8
methane	15.6	15.4
ethane	1.0	0.3
ethylene	16.7	4.4
acetylene	0.4	0.4
benzene	0.3	0.1
naphthalene	0.5	0.2
H_2/CO ratio	0.45	0.57
Product gas HHV, btu/scf (dry)	663	468

Note the higher ash content and lower heating value of RDF as compared to the wood. The ash from the RDF gasifier is assumed to be non-hazardous, but will likely require testing in the same way that ash from MSW incineration must be tested. Non-hazardous ash from incinerators can be returned to the landfill or used in roads and parking lots, depending upon local restrictions. (EPA 2008) However, some states regulate ash based on scale. For example, Washington State requires ash deposition to an ash monofill by plants processing more than 12 TPD of MSW (WAC 173-306-200).

2.1.4 Tar reforming and gas scrubbing

During gasification, a relatively small fraction of the feedstock is converted into tars consisting mostly of aromatic and poly-aromatic type hydrocarbons. The raw gas from the cyclone in the gasifier section is sent to a catalytic tar cracker, which is assumed to be a bubbling fluidized bed reactor. A portion of the tar, methane, and other light hydrocarbons in the raw gas are converted to CO and H_2. The gasifier also produces a small amount of NH_3 from the nitrogen in the biomass, which is then converted in the tar cracker to N_2 and H_2. The conversion percentage for each compound is reported in Spath, *et al*., (2005) and represents the state of technology. The gas enters the tar reformer at the gasifier outlet temperature and exits the reformer at 751°C (1,383°F). The syngas is further cooled to 150°C (300°F) and sent to a wet scrubber to remove other impurities, such as particulates, NH_3, and some residual tars.

RDF is expected to contain variable amounts of chlorides depending upon the amount of plastics such as polyvinyl chloride in the MSW stream. Halides are assumed to be removed in the particulate scrubber by the addition of lime.

2.1.5 Gas purification and steam reforming

The scrubbed syngas is compressed to 450 psia in preparation for gas purification. Mercury and sulfur are the main contaminants that must be removed prior to stream reforming.

The RDF material potentially contains mercury which becomes volatile in the gasifier (Parsons 2002). Mercury in MSW mainly comes from fluorescent bulbs and its concentration can be as high 6000 ppb (EPA 1997). Carbon beds are an effective means of mercury removal from syngas (Parsons 2002) and a series of fixed bed carbon vessels are assumed. The spent carbon containing adsorbed mercury is disposed of as hazardous waste.

A liquid phase oxidation (LO-CAT) process followed by a ZnO bed is used to remove sulfur. The LO-CAT process is assumed to remove the sulfur to a concentration of 10 ppm H_2S, and then the ZnO bed polishes the syngas to less than 1 ppmv (Spath, *et al.* 2005).

Syngas leaving the ZnO bed is sent to a steam reformer to convert the remaining methane and light hydrocarbons to additional syngas and to adjust the H_2:CO ratio via the water-gas shift reaction. The main steam reforming reactions are:

$$C_nH_m + nH_2O \leftrightarrow (n+m/2)H_2 + nCO \quad (1)$$

$$CO + H_2O \leftrightarrow CO_2 + H_2 \quad (2)$$

Before the syngas is sent to the steam reformer, it is mixed with high temperature steam and compressed carbon dioxide (from the amine system as discussed below). Reactions take place between 800 and 900°C

(1472 and 1652°F). The H_2: CO ratio is adjusted to approximately 1.2, as required by the mixed alcohol synthesis reaction. The converted syngas passes through several heat exchangers to recover heat by generating saturate high pressure steam and superheated high pressure steam. The cooled syngas from reforming process is further cooled by air cooling and cooling water. The cooled syngas is further sent to an amine unit to remove most of the CO_2 which is a diluent in the high pressure synthesis system. The clean syngas is compressed to 2000 psi and sent to the mixed alcohol synthesis section. The steam reformer is fired with off-gas from the mixed alcohol synthesis.

2.1.6 Mixed alcohol synthesis

The mixed alcohol synthesis involves multiple reactions with different pathways to various alcohols and hydrocarbons. The overall stoichiometric reaction for higher alcohol synthesis is:

$$nCO + 2nH_2 \rightarrow C_nH_{2n+1}OH + (n-1)H_2O \qquad (3)$$

where the value of "n" typically ranges from 1 to 6. Hydrocarbon synthesis takes place according to a similar reaction scheme. While the stoichiometry of these reactions suggests an optimum H_2/CO ratio approximately 2, the optimal ratio is closer to 1.0 if the catalyst is significantly active for the water-gas shift reaction. This study assumes a modified Fischer-Tropsch catalyst (K/Co/MoS catalyst) that reflects the current state of technology, and thus represents a scenario that might be obtainable today. A description of this catalyst can be found in Aden et al, (2005).

Clean syngas at 2000 psi is preheated to 299°C (570°F) in a feed-product exchanger. The mixed alcohol reactor is assumed to be of a fixed bed tubular design, with catalyst in the tubes and steam raised in the shell. The product gas is partially cooled against the inlet compressed syngas, followed by further cooling to condense the alcohols and water. Most of unconverted syngas is recycled to the stream reformer. The methanol product is recycled back to the mixed alcohol synthesis reactor to increase the conversion efficiency. The liquid alcohols are then sent to the alcohol separation and purification processes. Methanol purge and product gas purge streams are combined and sent to the fuel gas system. The assumed mixed alcohol synthesis reaction conditions and per pass conversions for are shown in Table 2-3. The specific conversions of CO in each of the main reactions are set in order to reach catalyst performance targets consistent with those of Aden, et al. (2005).

Table 2-3 Mixed Alcohol Synthesis Assumptions

Parameter	Values
Temperature (°F)	570
Pressure (psia)	2000
H_2/CO Ratio	1.2
CO_2 inlet concentration	0.2 mol%
Gas hourly space velocity, v/h/v	3000
CO + H_2 Reactions	**Mole % CO Conversion per pass**
$CO + H_2O \rightarrow CO_2 + H_2$	13%
$CO + 3\ H_2 \rightarrow CH_4 + H_2O$	4.5%
$2\ CO + 4\ H_2 \rightarrow C_2H_6 + H_2O$	0.5%
CO + H_2 → Methanol	4.1%
2 CO + 4 H_2 → Ethanol + H_2O	11.4%
3 CO + 6 H_2 → Propanol + 2 H_2O	3%
4 CO + 8 H_2 → n-Butanol + 3 H_2O	1%
5 CO + 10 H_2 → n-Pentanol + 4H_2O	0.5%
Methanol Recycle Reactions	**Mole % Recycled Methanol Conversion**
Methanol + CO + 2 H_2 → Ethanol + H_2O	58%
Methanol + 2 CO + 4H_2 → Propanol + 2 H_2O	7%
Methanol + 3 CO + 6 H_2 → n-Butanol + 3 H_2O	4.5%
Methanol + 4 CO + 8 H_2 → n-Pentanol + 4H_2O	2%

The large heat release from the exothermic mixed alcohol reactor is removed by vaporizing boiler feed water on the shell side of the reactor. The high pressure steam is sent to the steam cycle and power recovery section for electric power generation.

2.1.7 Product separation and purification

The raw mixed alcohol product from the synthesis step is dried with a molecular sieve. The dried product is then distilled into a methanol stream that is recycled to the synthesis reactor, a purified ethanol stream and a higher alcohol stream. The higher alcohol product contains propanol and higher boiling alcohols.

2.1.8 Power generation

Saturated steam is generated by cooling the process streams in the gasifier, steam reformer and mixed alcohol synthesis areas. Saturated steam is superheated in the steam reformer section then sent to a steam turbine to generate power for the plant and to provide process steam for use in the system.

2.2 Analysis Approach

The process simulation was developed in CHEMCAD and the capital and operating costs were assembled in an EXCEL spreadsheet. A discounted cash flow analysis is used to estimate the ethanol selling price.

3.0 Simulation and Economic Assumptions

The main assumptions for the performance and cost models are described in this section.

3.1 Simulation Assumptions

Table 3-1 shows the main assumptions for the biomass and MSW simulations. The main difference is in the composition of the feedstocks.

Table 3-1 Process Model Assumptions

Parameter	**Biomass Case**	**MSW Case**
% MSW in RDF	Not applicable	80%
Dryer		
Feed inlet moisture, wt%	50	50
Outlet moisture, wt%	12	12
Gasifier		
Pressure, psi	23	23
Temperature, °C (°F)	822 (1511)	870 (1598)
Bone dry feed, metric ton/d	2000	2000
Tar Reformer, T, °C (°F)**/ P, psi**	751 (1383) / 23	751 (1383) / 23
Steam Reforming		
Temperature, °C (°F)	900 (1652)	900 (1652)
Pressure, psia	435	435
H_2:CO in reformed syngas	2.1	2.1
Mixed alcohol Synthesis and Purification		
Temperature, °C (°F)	299 (570)	299 (570)
Pressure, psia	2000	2000
Methanol Recycle, %	90	90
Steam System		
Pressure, psia	800	800
Superheat temperature, °C (°F)	538 (1000)	538 (1000)

3.2 Economic Assumptions

Figure 3-1 plots the total capital investment required for an RDF facility as taken from various literature sources (source dates are listed in the legend) and converted to January 2008 dollars using the Chemical Engineering Index (CEI 2008). Included in each sources estimate are all direct and indirect capital costs to provide sufficient equipment to produce RDF from MSW and recover recyclables. The estimates also include scales, a processing building and all site work. Note that the trend of the capital investment increase is almost linear with the increase in plant scale. RDF facilities typically have multiple lines to accommodate equipment maintenance and variable processing rates and therefore have little economy of scale.

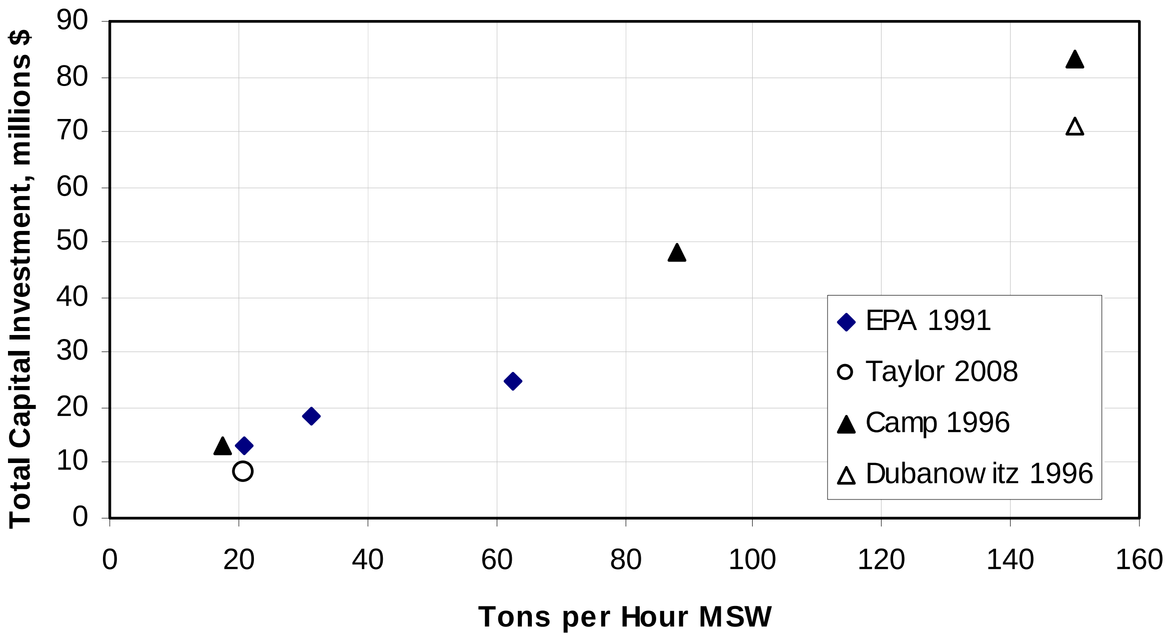

Figure 3-1 RDF Facility Scale vs. Total Capital Investment

The capital investment for the rest of the mixed alcohols plant is determined from a cost rollup of the specific equipment needed for each area of the plant (e.g. dryer, gasifier, heat recovery, mixed alcohol reactor). Most of the base equipment costs for the gas purification and conditioning and the steam cycle and power generation sections of the plant come from Spath, *et al.* (2005). The estimation of the equipment costs for the indirectly heated gasifier is based on Hamelinck and Faaij (2002). The equipment costs for mercury removal is from Parsons (2002). The mixed alcohol synthesis and product separation equipment is sized using the heat and material balances, and the associated equipment costs come from APSEN ICARUS.

All capital costs are reported in January 2008 dollars. The total capital investment for the mixed alcohol plant excluding the RDF facility is factored from installed equipment costs using the factors shown in Table 3-2. The capital investment for the RDF facility is added to the capital investment for the remainder of the plant to determine the total capital required.

Table 3-2 Total Project Investment Assumptions

Total Purchased Equipment Cost for Mixed Alcohols Portion of the Plant (TPEC)	100% of TPEC
Purchased Equipment Installation	39%
Instrumentation and Controls	26%
Piping	31%
Electrical Systems	10%
Buildings (including services)	29%
Yard Improvements	12%
Total Installed Cost (TIC)	247%
Indirect Costs	
Engineering	32%
Construction	34%
Legal and Contractors Fees	23%
Project Contingency	37%
Total Indirect	126%
Capital Investment for the Mixed Alcohols Portion of the Plant	373%

Table 3-3 lists the assumptions used to estimate the production costs. The minimum ethanol selling price (MESP) was determined using a discounted cash flow rate of return analysis similar to that used in Phillips *et al*. 2007. The MESP is the selling price of the fuel that makes the net present value of the process equal to zero for a specified discounted cash flow rate of return over a 20 year plant life. A sensitivity analysis was conducted to determine the effect of different financial and operating assumptions on the MESP.

Table 3-3 Economic Assumptions

	Value used in model, 2008 basis	Units or Basis	Reference
Raw Materials			
Hybrid poplar chips	60	\$/dry short ton	Aden, 2008
Olivine makeup	207	\$/short ton	Phillips, *et al.* 2007*
Ash disposal	34	\$/short ton	Valkenburg, *et al.* 2008
Tar cracker catalyst	6.15	\$/lb	Phillips, *et al.*, 2007*
Reformer catalyst	21.9	\$/lb	SRI PEP 2007*
Mixed alcohol catalyst	5.25	\$/lb	Phillips, *et al.* 2007
Carbon	8.34	\$/1b	Parsons, 2002*
By-Products			
Scrap metal	0.2	\$/lb	USFN 2008
Scrap aluminum	1.0	\$/lb	Thompson 2008
Higher alcohol value	1.15	\$/gallon	Phillips, *et al.* 2007
Sulfur	40	\$/ton	Phillips, *et al.* 2007*
Waste By-Products			
Waste water treatment	2.47	\$/100 ft^3	Phillips, *et al.* 2007*
Hazardous waste disposal	500	\$/ton	Parsons, 2002
Non-hazardous waste disposal	34	\$/ton	Valkenburg, *et al.* 2008
Utilities			
Cooling water	168	¢/1000 gal	Phillips, *et al.* 2007*
Electricity	6.27	¢/kWh	EIA 2008, industrial price
Stream Factor	90%		estimated
MACRS Depreciation, yrs	7		Phillips, *et al.* 2007
Plant life, yrs	20		Phillips, *et al.* 2007
Construction Period 1st 6 months expenditure Next 12 months expenditure Last 12 months expenditure	2.5 years 8% 60% 32%		Phillips, *et al.* 2007
Start-up time Revenues Variable Costs Fixed Costs	6 months 50% 75% 100%		Phillips, *et al.* 2007
Working Capital	5% of Total Capital Investment		Phillips, *et al.* 2007
Land	6% of Total Purchased Equipment Cost (taken as 1st year construction expense)		Phillips, *et al.* 2007
Internal Rate of Return	10%		Phillips, *et al.* 2007
* Reference value escalated to early 2008 dollars using the producer price index			

4.0 Results and Analysis

This section describes the main performance and cost simulation results for each scenario.

4.1 Performance Results

Table 4-1 shows the main performance results for the MSW case and compares it to the same process fed only with biomass. Both cases produce higher alcohols and sulfur as by-products. The mixed alcohol yield is lower for the MSW case due to the higher fraction of inorganic material in the RDF than in the wood. Both processes also generate electricity in excess of the plant's needs. Additionally, the MSW based process recovers metals that can be sold as scrap. On the other hand, the MSW case produces more waste streams, although one could argue that the wastes are a fraction of the total MSW waste to begin with, and thus a net gain to the landfill in terms of landfill usage. The non-hazardous MSW waste stream consists of ash, MSW in the materials separation pre-processing area that is not recovered metals or RDF, and spent olivine. However, the spent carbon beds contain mercury and therefore must be disposed of as hazardous waste.

Table 4-1 Main Performance Analysis Results

Case	MSW Case	Biomass Case
Feedstock		
Wood chips or MSW, dry million lb/y	1930 MSW; 1,447 RDF	1,447 Wood chips
Products		
Ethanol, mmgal/y	27	36
Propanol and high alcohols, million gal/y	9	12
Sulfur, lb/y	81,600	35,200
Recyclable scrap aluminum, million lb/y	110	0
Recyclable scrap iron, million lb/y	25	0
Yields		
Ethanol, gal/ton dry feedstock	28 MSW basis; 38 RDF basis	50
Higher alcohols, gal/ton dry feedstock	9 MSW basis; 13 RDF basis	17
Waste Products		
Hazardous waste, lb/y	80,000	0
Total Non-hazardous solid waste, million lb/y	390	22.5
Ash, million lb/y	152	19
Spent olivine, million lb/y	3	3.5
MSW rejects, million lb/y	235	0
Net Power for export, MW	9.3	3.2

4.2 Economic Results

Table 4-2 shows the capital cost breakdown for each section of the plant. The RDF facility amounts to almost a quarter of the required investment. Gasification and syngas cleanup make up the bulk of the rest of the costs. Improved and simplified syngas cleanup and improved mixed alcohols synthesis is an ongoing area of research. It is expected that costs for these areas will decrease with time. Reduction in capital and improved yields are addressed in the sensitivity section.

Table 4-2 Capital Costs for the MSW and Biomass Cases

	MSW Case		**Biomass Case**	
Million gallons/year ethanol	27		36	
Capital Costs	Million $	% of Total	Million $	% of Total
RDF production	$105	23%	$0	
Feedstock drying	$40	9%	$39	11%
Gasification, tar reforming, scrubbing	$67	15%	$56	16%
Syngas conditioning	$164	37%	$167	49%
Mixed alcohol synthesis	$20	4%	$21	6%
Mixed alcohol separation	$9	2%	$11	3%
Steam system and power generation	$34	8%	$39	11%
Remainder off-site battery limits	$9	2%	$9	3%
Total Capital Investment	$449		$343	
Project investment/annual gallon ethanol	16		9	

Table 4-3 shows the operating cost breakdown for both cases. The MSW case assumes that the plant is co-located with a municipal waste landfill and that the MSW feedstock is free. This case also assumes that the non-hazardous waste is returned to the landfill for no fee. The MSW case has lower variable costs than the biomass case due to no feedstock cost and additional by-product credits from the sale of the recyclables. The fixed costs for the MSW case are higher, mainly due to the larger work force needed to produce the RDF material. The gasification and mixed alcohol production areas are assumed to be highly automated and require fewer operators per unit than does the labor intensive RDF facility. Waste treatment costs are relatively low for both cases. Disposal of the mercury laden spent carbon is not a large cost factor for the MSW case. The higher capital costs for the MSW case are more than offset by the lower operating costs. The base MSW case selling price of $1.85 per gallon of ethanol falls within the selling price of ethanol over the past year. Ethanol prices from June 2007 to October 2008 have fluctuated up and down between $1.60 and $2.50/gallon (ICIS 2008). However, a 10% internal rate of return on investment may not be sufficiently high to make this economically attractive to investors. Sensitivities to return on capital are explored in the next section.

Table 4-3 Economic Results for the MSW and Biomass Cases

	MSW Case	**Biomass Case**
Million gallons/year ethanol	27	36
Operating Costs	$/gal	$/gal
Raw materials		
Feedstock (MSW or Biomass)	0.00	1.19
Catalysts & Chemicals	0.10	0.09
By-product credits		
Higher alcohols	-0.39	-0.39
Scrap Aluminum	-0.86	0.00
Scrap Iron	-0.58	0.00
Electricity sold to grid	-0.17	-0.04
Waste treatment or Disposal		
Gasifier ash	0.000	0.01
MSW rejects	0.000	0.00
Spent carbon	0.0001	0.00
Waste water treatment	0.026	0.02
Total variable cost, $/gal ethanol	-1.86	0.87
Fixed costs, $/gal ethanol	0.87	0.51
Capital depreciation, $/gal ethanol	0.82	0.47
Average income tax, $/gal ethanol	0.56	0.33
Average return on investment (10% IRR)	1.46	0.86
Estimated Selling Price (10% IRR), $/gal ethanol	1.85	3.05

4.3 Sensitivity Analysis

A sensitivity analysis was conducted to investigate the effects of different cost assumptions such as return on investment, MSW fee, and by-product credits.

4.3.1 Effect of MSW Fee and Return on Investment

According to a 2004 survey, as reported in Valkenburg *et al*. 2008, tipping fees vary widely across the country, from a low of $24.06 per ton in the south to $70.06 per ton in the Northeast, with the average of approximately $34.29/ton nationwide. Tipping fees for MSW that was incinerated averaged about $61.64 nationwide. Thus there is precedent for increasing tipping fees to offset capital costs, assuming the local market will bear the cost increase. Figure 4-1 shows how varying the tipping fee affects the minimum ethanol selling price at a 10% IRR.

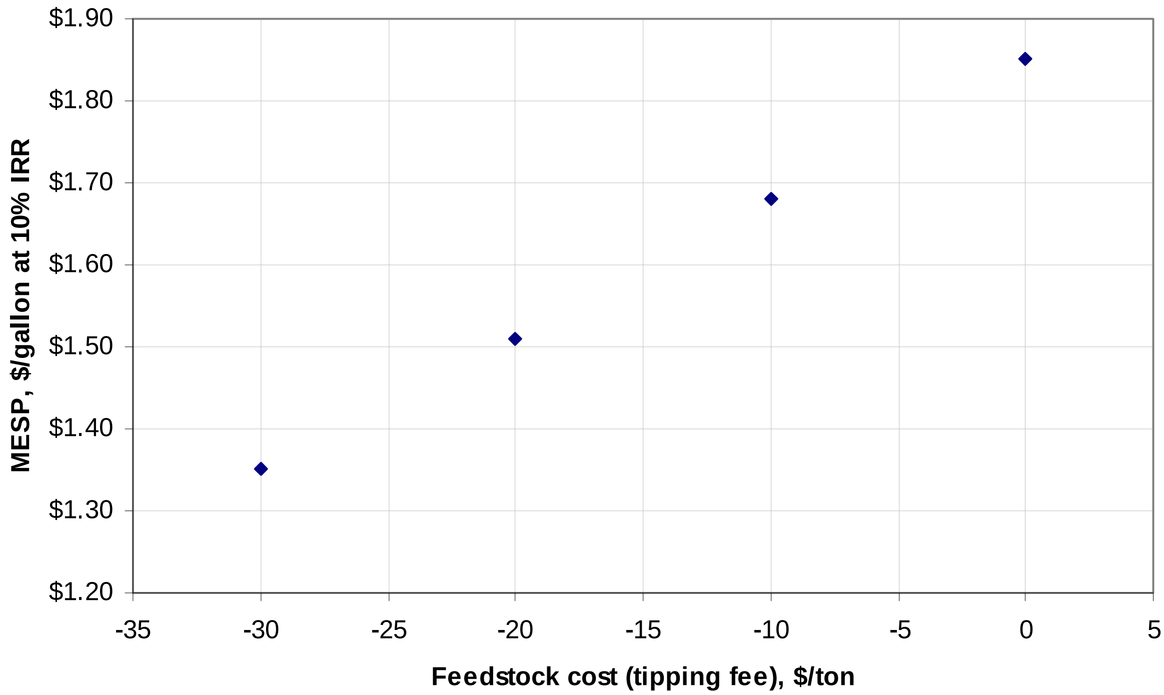

Figure 4-1 Effect of Tipping Fee on MESP

Recall that the tipping fee is the cost charged by the landfill to waste generators; a tipping fee of $30/ton is the same as a feedstock cost of -$30/ton. Increasing the tipping fee from $0 to $30 per ton is worth approximately $0.50/gallon of ethanol.

Figure 4-2 expands Figure 4-1 to show the effects of increasing the return rate. This plot shows several things:

- Even with a negative feedstock cost, the MSW case can at best return about 10% of the capital before the selling price of ethanol exceeds $2.00/gallon.

- As shown previously in Table 4-2, the RDF facility significantly increases the capital cost of the MSW plant compared to the biomass (wood) plant. The MSW case and the biomass (wood) case MESP overlap when the IRR is approximately 20%. This is mainly due to the tradeoff between higher capital and lower feedstock cost for the MSW case as compared with the lower capital and higher feedstock costs for the biomass case. Above an IRR of 20%, the higher capital costs for the MSW case offset the gains made by low or no feedstock cost.

- There do not appear to be incentives to decrease the scale of the plant from 2205TPD RDF, as this is likely to increase production costs and thus lower the return on investment.

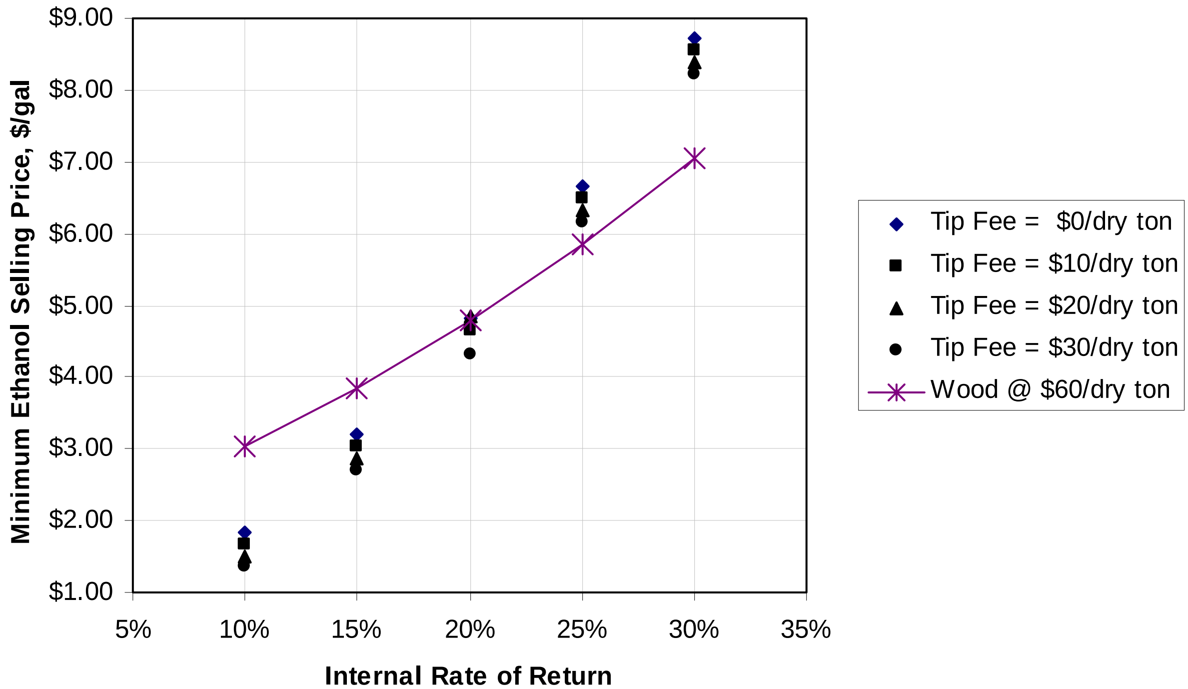

Figure 4-2 Effect of Tipping Fee on MESP at Different Rates of Return

4.3.2 Effect of RDF Operating Schedule and MSW and By-Product Value

Figure 4-3 shows the effect of selected operating variables. They are shown as cost differences with the base case assumptions of 2205 TPD MSW, 10% IRR, and no cost for the MSW. The top two bars show the sensitivity to RDF processing schedules. The base case assumes that the RDF plant processes MSW on two eight-hour shifts/day for six days per week, while the gasifier and alcohol synthesis systems operate continuously. The base case also assumes that 80% of the MSW is recovered as RDF. Forty cents per gallon could be saved by continuous 24 hour per day, seven day per week RDF processing. This is mostly due to the smaller capital investment for the RDF plant. Maintaining the same operating schedule as the base case, but with only 75% recovery of MSW as RDF increases costs by about twenty cents per gallon.

The middle three bars show the effect of fees. In the base case, the MSW is assumed to be free of charge and the waste generated in the RDF plant is landfilled at no additional cost. As noted previously, mercury in the MSW is assumed to be part of the RDF and captured post gasification in a carbon bed. The carbon bed is then disposed of as hazardous waste. If the reject MSW material (glass and fines) in the RDF plant contains significant amounts of mercury, say from broken fluorescent bulbs, then that material might be re-classified as hazardous. Disposal of the MSW reject material as hazardous waste increases the ethanol selling price by over two dollars per gallon. While this may not be a likely scenario, it does illustrate the need to sample and test waste materials for proper disposal.

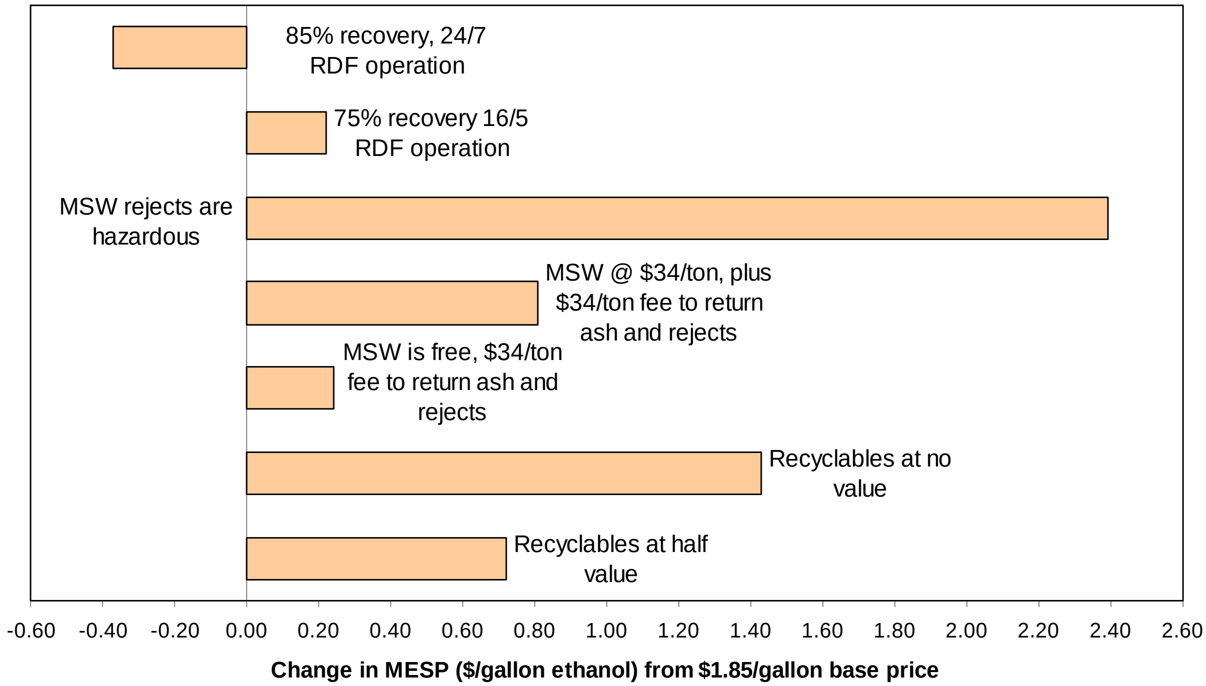

Figure 4-3 MESP Sensitivity to Process and Operating Changes

If the facility is not owned by the landfill, but still adjacent to it, then the landfill may charge a fee for providing the MSW and fees to return the rejected solids. This is just the opposite of the tipping fee case presented in the previous section. In the tipping fee case, the landfill charges the waste generators to leave the MSW, and thus the feedstock itself is potentially income generating. This time, rather than a negative cost feedstock, the mixed alcohol plant must purchase the MSW from the landfill. Assuming that +$34/ton is charged for the MSW to the RDF plant and another +$34/ton is charge to return the waste generated in RDF production, then the cost of ethanol rises by about $1.40/gallon. If the landfill does not charge a fee for the MSW, but does require payment for ash rejects, then the selling price increases by about twenty cents per gallon (as shown in the bottom bar)

The lowest two bars show the effects of by-products on MESP. Reclaiming and selling scrap iron and aluminum (noted as recyclables on the chart) is important for process economics. Over one dollar per gallon is lost if the recyclables have no value (again assuming that the MSW is obtained at no cost to the RDF plant).

4.3.3 Effect of Technology Improvements

The conservative mixed alcohol case represents a scenario that might be possible to implement today. However, as shown in Figure 4-2, the economics are attractive only at about 10% IRR. Technology improvements can help reduce the capital cost and improve the overall economics. Thus the goal case thermo-chemical mixed alcohol process as described in Phillips *et al.* (Phillips 2007) was analyzed assuming MSW with RDF processing. As described in that report, improvements to the tar reformer, elimination of the steam reformer, simplified syngas conditioning and improved mixed alcohol catalyst yields reduce the capital and operating costs. A comparison between the main assumption differences and main results for the conservative MSW case and the goal MSW case are shown in Table 4-4. Assumptions not shown are the same as those listed in Table 3-1.

Table 4-4 MSW Conservative and MSW Goal Cases Comparison

Assumption Differences	**MSW Conservative Case**	**MSW Goal Case**
Tar Cracker/Reformer, T, °C (°F) / P, psi	751 (1383) / 23	889 (1633) /2 3
Steam Reforming	Yes	No
Steam System		
Pressure, psia	800	850
Superheat temperature, °C (°F)	538 (1000)	482 (900)
Mixed Alcohol Synthesis		
Temperature, °C (°F)	299 (570)	299 (570)
Pressure, psi	2000	900
Methanol Recycle, %	90%	97%
Liquid Hourly Space Velocity, v/v/h	3000	6000
Catalyst life, years	1	5
Feedstock Cost, $/short ton	0	0
Performance Results		
Products		
Ethanol, mmgal/y	27	42
Propanol and high alcohols, million gal/y	9	7
Yields		
Ethanol, gal/ton dry feedstock	28 MSW basis; 38 RDF basis	44 MSW basis; 55 RDF basis
Higher alcohols, gal/ton dry feedstock	9 MSW basis; 13 RDF basis	8 MSW basis; 12 RDF basis
Net power for export. MW	9	3
Cost Results		
Capital cost, millions $ (2008 basis)	$449	$313
Operating Costs, $/gal ethanol		
Raw materials	0.10	0.04
Waste disposal	0.03	0.00
By-product credits	-1.83	-1.03
Electricity	-0.17	-0.04
Fixed costs	0.87	0.44
Depreciation	0.82	0.37
Average income tax	0.56	0.25
Average return on investment	1.47	0.68
Minimum ethanol selling price, $/gal (10% IRR)	1.85	0.71

As can be seen in Figure 4-4, improved economics allow selling prices of less than $2/gallon without a tipping fee for a 20% rate of return if these improvements were available today. Higher returns on investment can be had by increasing the tipping fee. The wood case represents the goal case at a feedstock cost of $60/ton.

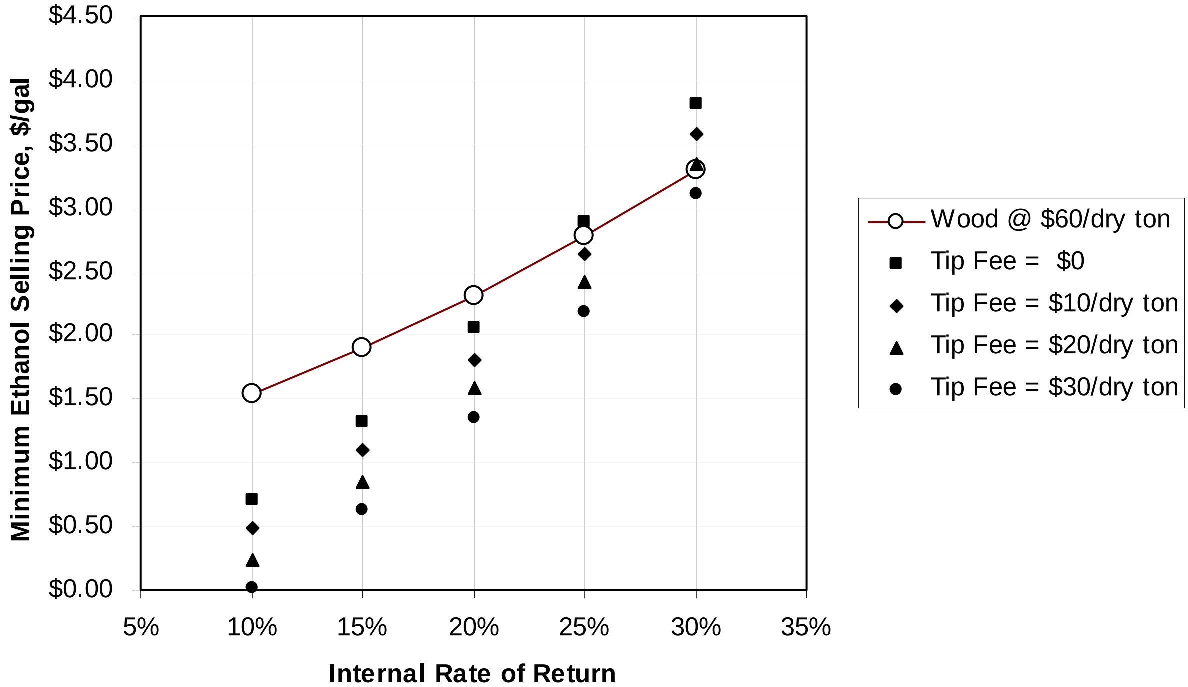

Figure 4-4 Effect of Improved Technology

5.0 Conclusions and Recommendations

A techno-economic analysis of an MSW to ethanol process via gasification was conducted. The base case assumes that the MSW is obtained at zero cost and that the metals are recovered and sold as a by-product. The base case process is based on currently available technology for syngas cleanup and mixed alcohols synthesis. The results of this study provide information about the main performance and economics for the systems. Sensitivity analysis was also conducted to investigate the effects of key assumptions on ethanol selling prices.

The capital required to produce mixed alcohols from MSW rather than from biomass is higher, due to the need to process the MSW into RDF. However, landfill-based operations offer the opportunity for zero or negative cost feedstock which offset the cost higher capital cost. The simulation results showed that the estimated ethanol selling price of $1.85/gallon (early 2008 dollars, 10% return on investment) for the indirectly-heated gasifier system, and assuming that the by-product metals are sold at a profit. $1.85/gallon is competitive with early 2008 ethanol market prices, thus this process might be implemented today using existing technology. Other conclusions are as follows:

- The sale of RDF plant recyclables are a necessary part of an economic operation.
- Returns on investment of greater than 10% may be achieved by technological improvements in the syngas cleanup and mixed alcohol synthesis steps. In particular, implementing the 2012 time-frame improvements outlined in Phillips et al. (Phillips 2008) reduce the MESP by half.
- Waste streams from the process need to be tested for toxicity.

In addition, further work is needed to clarify the effect of MSW variability on RDF quality and gasifier operation. It would be useful to determine the economics of more mature products from MSW generated syngas, in particular, methanol, Fischer-Tropsch fuels, gasoline, synthetic natural gas as well as alternate means of processing besides gasification.

MSW is a potentially valuable, partially renewable feedstock that has been under utilized. This study provides potential research areas for process improvement.

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Appendix A. Heat and Material Balance for the Biomass Reference Case

Figure A-1 Process Flow Diagram for the Biomass Reference Case

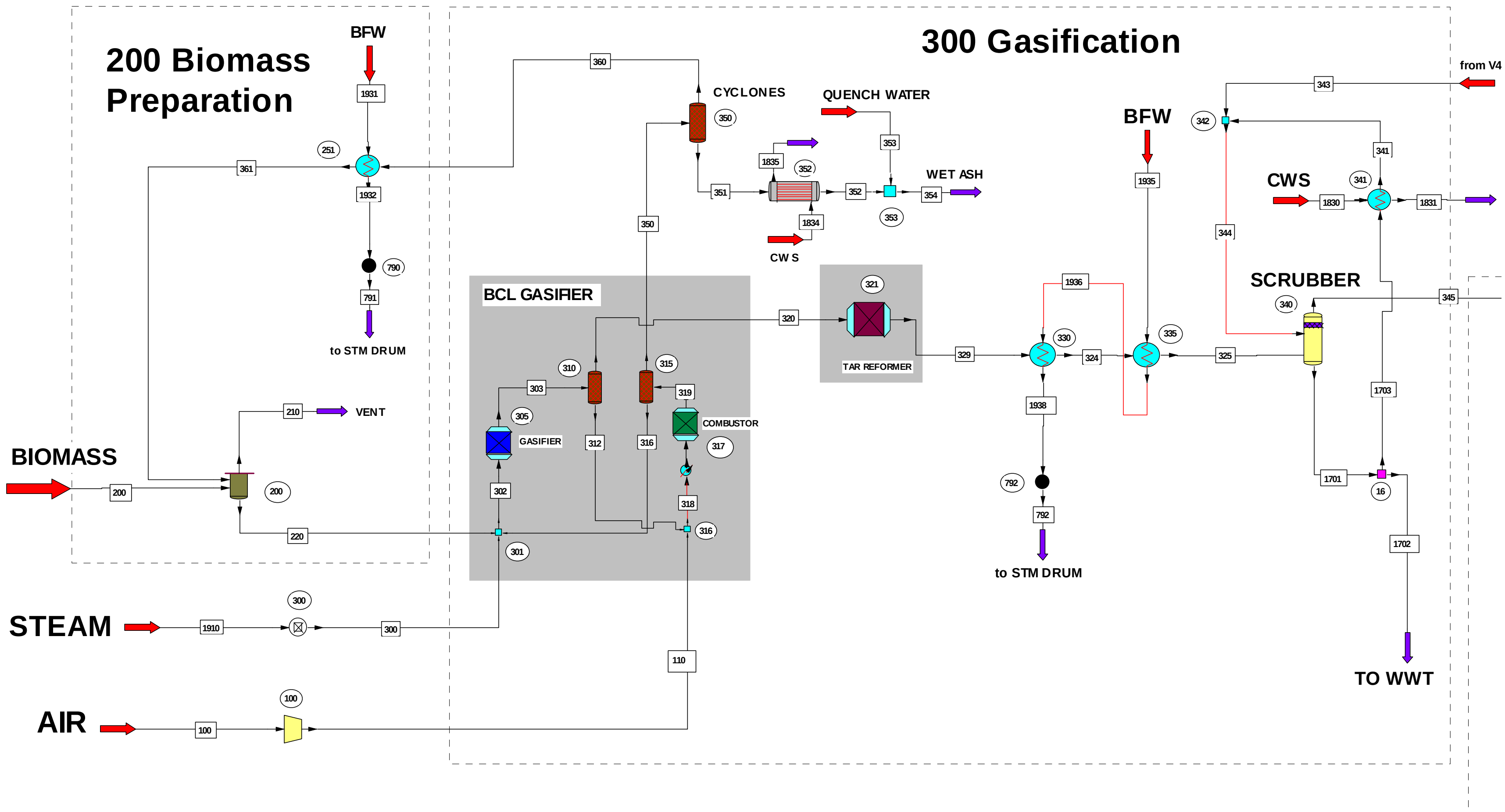

Figure A-1 Process Flow Diagram for the Biomass Reference Case (cont.)

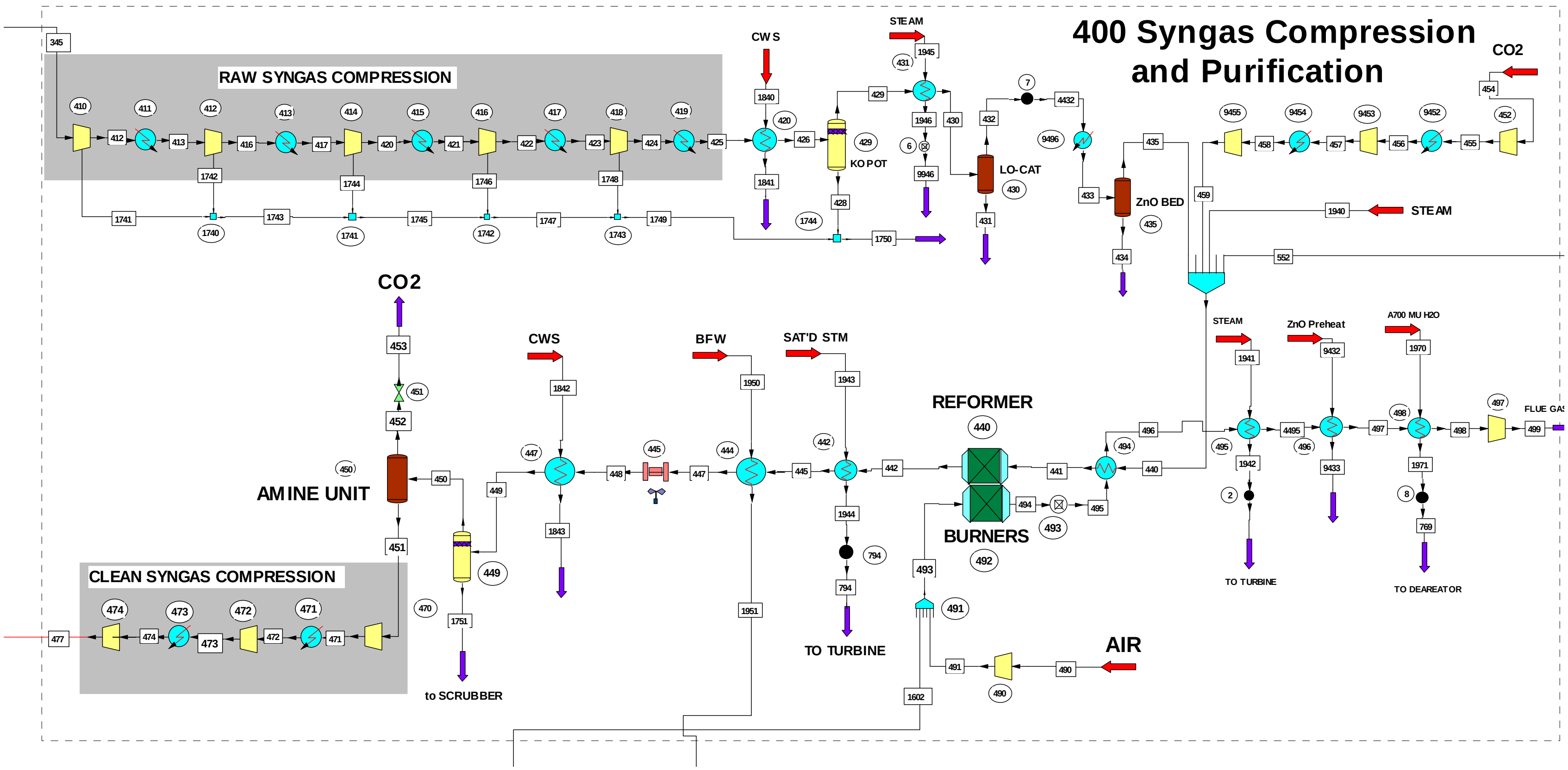

Figure A-1 Process Flow Diagram for the Biomass Reference Case (cont.)

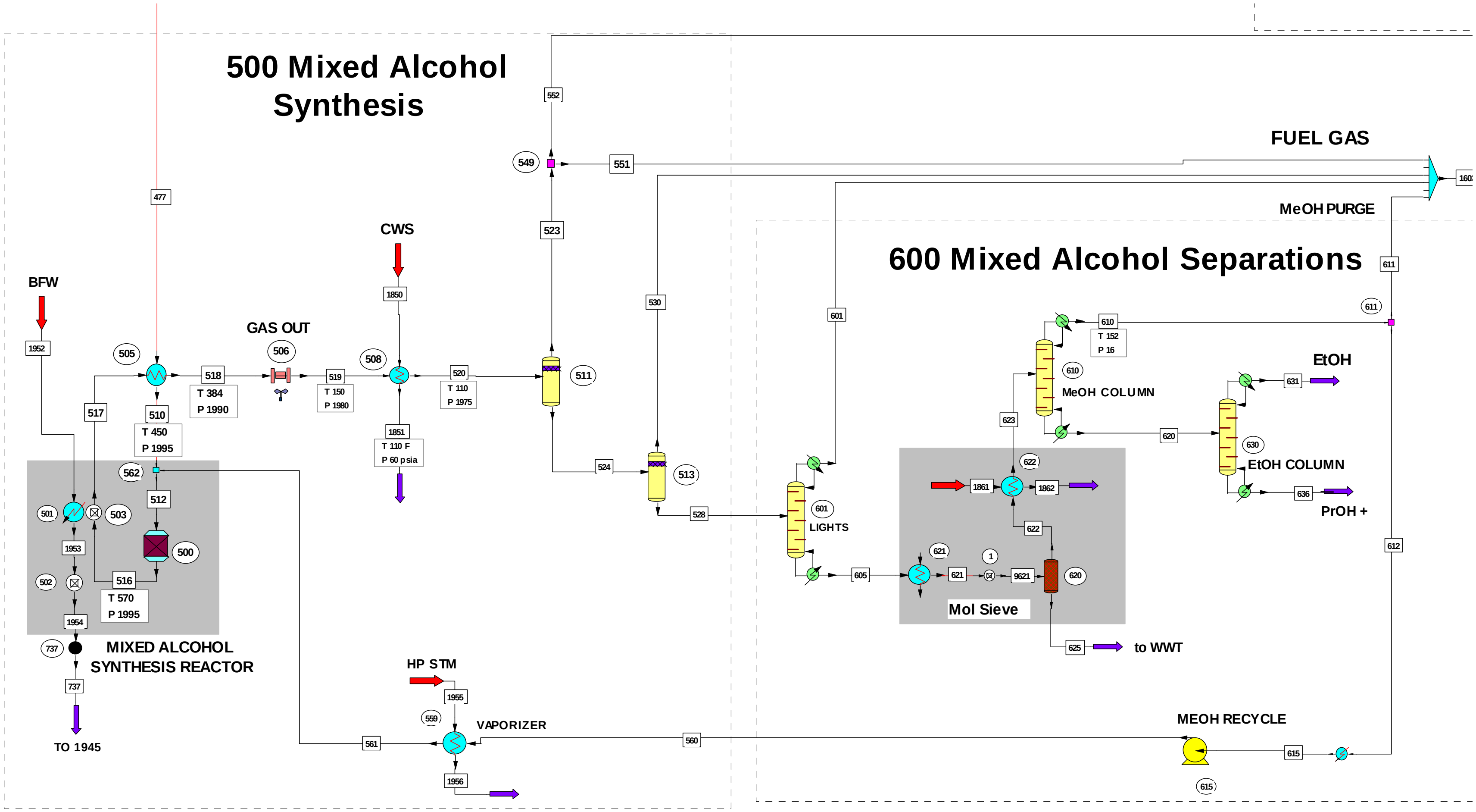

Figure A-1 Process Flow Diagram for the Biomass Reference Case (cont.)

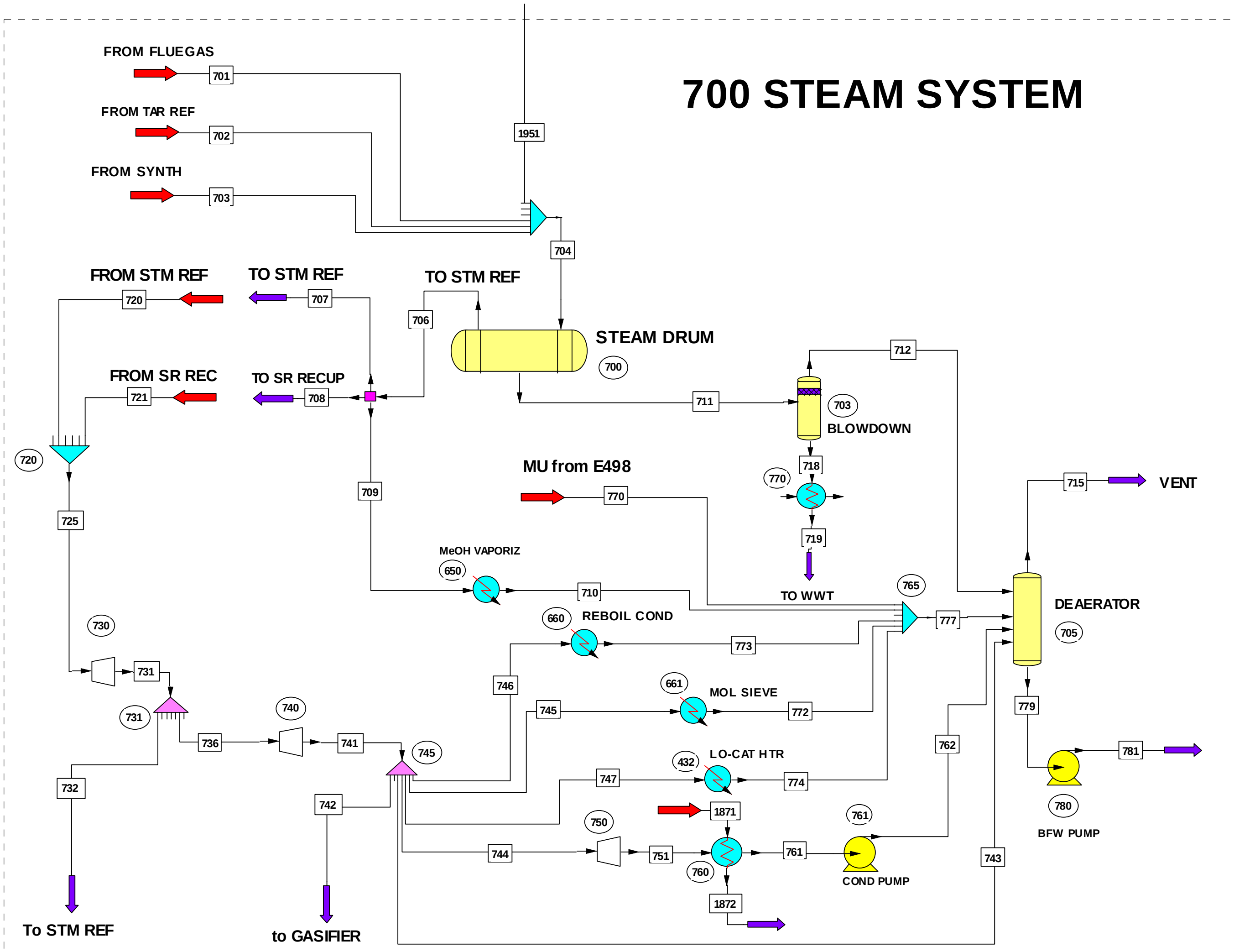

Table A-1 Stream Results for the Biomass Reference Case

Stream No.	5	100	110	200	210	220	300	302	303	312	316	318	319	320	324
Stream Name		AIR		BIOMASS	VENT								Syngas		
Temp F	1611.079	90	184.7633	60	225.2196	220	260	1737.218	1598	1598	1823	1523.3	1823	1598	464.2304
Pres psia	22	14.696	22	25	22	22	25	22	23	23	22	22	22	23	19
Enth MMBtu/h	-8518.2	-47.987	-38.01	-1692.5	-1470.1	-559.18	-416.82	-9151.3	-9341.2	-8670.1	-8175.3	-8708.1	-8509.2	-671.07	-756.76
Vapor mass fraction	1	1	1	0	1	0	1	0.33736	1	1	0	1	1	1	1
Total lb/h	5418386	430413	430413	367437.4	628558	204132	73119.59	5228696	5228662	4987973	4951445	5418386	5418387	240689.4	240689.1
Flowrates in lb/h															
Oxygen	102708.3	97654.13	97654.13	0	11292.91	0	0	0	5054.145	5054.145	0	102708.3	11292.91	0	0
Nitrogen	318713.3	318713.3	318713.3	0	318689	0	0	0	0	0	0	318713.3	318689	0	204.734
Argon	5435.613	5435.613	5435.613	0	5435.613	0	0	0	0	0	0	5435.613	5435.613	0	0
Carbon	27500.24	0	0	0	0	0	0	0	27500.24	27500.24	0	27500.24	0.0012	0	0
Hydrogen	2282.96	0	0	0	0.0009	0	0	0	5461.737	2282.96	0	2282.96	0.0009	3178.778	6370.468
Carbon Monoxide	0	0	0	0	0	0	0	0	78075.38	0	0	0	0	78075.38	98480.85
Carbon Dioxide	212.2069	212.2069	212.2069	0	100981	0	0	0	37202.6	0	0	212.2069	100981	37202.59	37202.6
Methane	0	0	0	0	0	0	0	0	16283.21	0	0	0	0	16283.21	13026.57
Acetylene	0	0	0	0	0	0	0	0	701.6728	0	0	0	0	701.6727	350.8364
Ethylene	0	0	0	0	0	0	0	0	8060.712	0	0	0	0	8060.713	4030.356
Ethane	0	0	0	0	0	0	0	0	579.8716	0	0	0	0	579.8715	57.9872
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	8397.746	8397.746	8397.746	183718.8	192107.1	20413.18	73119.59	93532.76	93532.76	0	0	8397.746	28801.52	93532.77	80408.71
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	161.5833	0	0	0	0	161.5833	161.5833
Ammonia	0	0	0	0	0	0	0	0	355.6206	0	0	0	0	355.6205	106.6862
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	4951445	0	0	0	0	0	0	4951445	4951445	4951445	4951445	4951445	4951445	0	0
Calcium Oxide	1690.211	0	0	0	0	0	0	0	1690.211	1690.211	0	1690.211	1690.222	0	0
Benzene	0	0	0	0	0	0	0	0	639.3002	0	0	0	0	639.3002	191.7901
Naphthalene	0	0	0	0	0	0	0	0	1917.901	0	0	0	0	1917.901	95.8951
Hybrid Pop NREL	0.0041	0	0	183718.6	0	183718.6	0	183718.6	0.0041	0.0041	0	0.0041	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	52.0559	0	0	0	0	0	0	0	52.0559	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	325	329	341	343	344	345	350	351	352	353	354	360	361	412	413
Stream Name				from V449				ASH		QUENCH '	WET ASH				
Temp F	250.8848	1383	110	110	109.9997	118.317	1823	1823	300	60	137.5378	1823	1750	253.0462	140
Pres psia	18	20	15	415	15	15	22	22	22	14.7	14.7	22	22	28	28
Enth MMBtu/h	-778.95	-651	-66654	-253.51	-66907	-435.29	-333.87	-7.5742	-8.1505	-5.1321	-13.283	-326.3	-336.8	-425.53	-434.68
Vapor mass fraction	1	1	0.002532	0	0.002522	1	1	0	0	0	0	1	1	1	0.99495
Total lb/h	240689.1	240689.1	9826158	37319.66	9863478	178568.7	466942.3	1690.224	1690.224	750.0001	2440.224	465252.1	465252.1	178568.7	178568.7
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	11292.91	0	0	0	0	11292.91	11292.91	0	0
Nitrogen	204.734	204.734	0.0907	0	0.0907	204.733	318689	0	0	0	0	318689	318689	204.733	204.733
Argon	0	0	0	0	0	0	5435.613	0	0	0	0	5435.613	5435.613	0	0
Carbon	0	0	0	0	0	0	0.0012	0.0012	0.0012	0	0.0012	0	0	0	0
Hydrogen	6370.468	6370.468	4.0767	0	4.0767	6370.427	0.0009	0	0	0	0	0.0009	0.0009	6370.427	6370.427
Carbon Monoxide	98480.85	98480.85	64.4907	0	64.4907	98480.19	0	0	0	0	0	0	0	98480.19	98480.19
Carbon Dioxide	37202.6	37202.6	17673.67	0	17673.67	36987.35	100981	0	0	0	0	100981	100981	36987.35	36987.35
Methane	13026.57	13026.57	13.5323	0	13.5323	13026.43	0	0	0	0	0	0	0	13026.43	13026.43
Acetylene	350.8364	350.8364	0.3639	0	0.3639	350.8326	0	0	0	0	0	0	0	350.8326	350.8326
Ethylene	4030.356	4030.356	13.0743	0	13.0743	4030.222	0	0	0	0	0	0	0	4030.222	4030.222
Ethane	57.9872	57.9872	0.0641	0	0.0641	57.9865	0	0	0	0	0	0	0	57.9865	57.9865
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	80408.71	80408.71	9801370	37319.66	9838689	18585	28801.52	0	0	750.0001	750.0001	28801.52	28801.52	18585	18585
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	161.5833	161.5833	108.8491	0	108.8491	160.6335	0	0	0	0	0	0	0	160.6335	160.6335
Ammonia	106.6862	106.6862	6909.775	0	6909.775	27.2479	0	0	0	0	0	0	0	27.2479	27.2479
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	1690.222	1690.222	1690.222	0	1690.222	0	0	0	0
Benzene	191.7901	191.7901	0.2888	0	0.2888	191.787	0	0	0	0	0	0	0	191.787	191.787
Naphthalene	95.8951	95.8951	0.0851	0	0.0851	95.8941	0	0	0	0	0	0	0	95.8941	95.8941
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	52.0559	0	0	0	0	52.0559	52.0559	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	416	417	420	421	422	423	424	425	426	428	429	430	431	432	433
Stream Name															
Temp F	274.5935	140	195.4107	140	209.0953	140	231.2065	140	110	110	110	120	120	120	707
Pres psia	54	54	109.5	109.5	220	220	465	465	465	465	465	465	445	445	445
Enth MMBtu/h	-423.96	-443.82	-416.31	-432.43	-381.76	-394.84	-364.62	-377.55	-380.31	-48.377	-331.94	-331.28	0	-331.26	-291.04
Vapor mass fraction	1	0.94457	1	0.9317	1	0.95183	1	0.9609	0.9575	0	1	1	0	1	1
Total lb/h	178568.7	178568.7	176201.6	176201.6	170321.2	170321.2	167569.5	167569.5	167569.5	7121.836	160447.6	160447.6	0	160447.6	160447.6
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	204.733	204.733	204.733	204.733	204.733	204.733	204.733	204.733	204.733	0	204.733	204.733	0	204.733	204.733
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	6370.427	6370.427	6370.427	6370.427	6370.427	6370.427	6370.426	6370.426	6370.426	0	6370.426	6370.426	0	6370.426	6370.426
Carbon Monoxide	98480.19	98480.19	98480.19	98480.19	98480.19	98480.19	98480.19	98480.19	98480.19	0	98480.19	98480.19	0	98480.19	98480.19
Carbon Dioxide	36987.35	36987.35	36987.35	36987.35	36987.35	36987.35	36987.35	36987.35	36987.35	0	36987.35	36987.35	0	36987.35	36987.35
Methane	13026.43	13026.43	13026.43	13026.43	13026.43	13026.43	13026.43	13026.43	13026.43	0	13026.43	13026.43	0	13026.43	13026.43
Acetylene	350.8326	350.8326	350.8326	350.8326	350.8326	350.8326	350.8326	350.8326	350.8326	0	350.8326	350.8326	0	350.8326	350.8326
Ethylene	4030.222	4030.222	4030.222	4030.222	4030.222	4030.222	4030.222	4030.222	4030.222	0	4030.222	4030.222	0	4030.222	4030.222
Ethane	57.9865	57.9865	57.9865	57.9865	57.9865	57.9865	57.9865	57.9865	57.9865	0	57.9865	57.9865	0	57.9865	57.9865
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	18585	18585	16217.9	16217.9	10337.51	10337.51	7585.755	7585.755	7585.755	7121.836	463.9131	463.9131	0	463.9131	463.9131
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	160.6335	160.6335	160.6335	160.6335	160.6335	160.6335	160.6335	160.6335	160.6335	0	160.6335	160.6335	0	160.6335	160.6335
Ammonia	27.2479	27.2479	27.2479	27.2479	27.2479	27.2479	27.2479	27.2479	27.2479	0	27.2479	27.2479	0	27.2479	27.2479
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	191.787	191.787	191.787	191.787	191.787	191.787	191.787	191.787	191.787	0	191.787	191.787	0	191.787	191.787
Naphthalene	95.8941	95.8941	95.8941	95.8941	95.8941	95.8941	95.8941	95.8941	95.8941	0	95.8941	95.8941	0	95.8941	95.8941
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	434	435	440	441	442	445	447	448	449	450	451	452	453	454	455
Stream Name												CO2		CO2	
Temp F	707.0002	707	459.8756	930.0002	1652	1170.387	300.0607	150	110	110	120	120	57.4546	60	316.1531
Pres psia	682	682	450	445	430	430	430	430	427.5	427.5	422.5	422.5	22	22	100
Enth MMBtu/h	-0.01686	-290.95	-1947.7	-1828.7	-1527	-1663	-1927.1	-2042.1	-2056.9	-1236.2	-432.73	-803.75	-803.75	-609.7	-601
Vapor mass fraction	1	1	1	1	1	1	0.92981	0.80342	0.79916	1	1	0.995	0.99766	1	1
Total lb/h	160.6335	160287	601582.1	601582	601582	601582	601582	601582	601582	480759	272761.6	207997.1	207997.1	158436	158436
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	204.733	667.2862	667.2863	680.811	680.811	680.811	680.811	680.811	680.811	680.811	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	6370.426	13637.61	13637.61	19134.34	19134.34	19134.34	19134.34	19134.34	19134.34	19134.34	0	0	0	0
Carbon Monoxide	0	98480.19	191381.6	191381.6	235921.5	235921.5	235921.5	235921.5	235921.5	235921.4	235921.4	0	0	0	0
Carbon Dioxide	0	36987.35	226418.7	226418.7	208683.4	208683.4	208683.4	208683.4	208683.4	208683.4	2086.822	206596.6	206596.6	158436	158436
Methane	0	13026.43	27171.88	27171.89	14917.88	14917.88	14917.88	14917.88	14917.88	14917.88	14917.88	0	0	0	0
Acetylene	0	350.8326	350.8344	350.8345	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0	0	0	0
Ethylene	0	4030.222	4030.67	4030.67	0.6849	0.6849	0.6849	0.6849	0.6849	0.6849	0.6849	0	0	0	0
Ethane	0	57.9865	469.5271	469.5272	1.5415	1.5415	1.5415	1.5415	1.5415	1.5415	1.5415	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	0	463.9131	135730.5	135730.4	122223.7	122223.7	122223.7	122223.7	122223.7	1400.485	0	1400.485	1400.48	0	0
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	160.6335	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	27.2479	34.2377	34.2377	17.6516	17.6516	17.6516	17.6516	17.6516	17.6516	17.6516	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	191.787	191.7869	191.787	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	95.8941	95.8941	95.8941	0	0	0	0	0	0	0	0	0	0	0
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0.0618	0.0618	0.2912	0.2912	0.2912	0.2912	0.2912	0.2912	0.2912	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	492.663	492.6631	0.1196	0.1196	0.1196	0.1196	0.1196	0.1196	0.1196	0	0	0	0
Ethanol	0	0	792.6373	792.6376	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	87.9436	87.9436	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	19.1715	19.1715	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	8.9839	8.9839	0	0	0	0	0	0	0	0	0	0	0

Stream No.	456	457	458	459	471	472	473	474	477	490	491	493	494	495	496
Stream Name										AIR					To LOCAT
Temp F	150	317.6949	150	256.3384	235.4644	150	277.7088	150	270.7586	60	124.5558	111.9801	1800	1800	1032.189
Pres psia	100	250	250	450	700	700	1200	1200	2000	14.696	20	16	16	16	14
Enth MMBtu/h	-607	-601.26	-607.55	-604.12	-416.99	-428.73	-411	-428.8	-411.63	-1.7701	4.8091	-166.6	-470.27	-470.27	-589.22
Vapor mass fraction	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total lb/h	158436	158436	158436	158436	272761.6	272761.6	272761.6	272761.6	272761.6	421657.2	421657.2	498803.3	498803.5	498803.5	498803.5
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	98210	98210	98210	12717.52	12717.52	12717.52
Nitrogen	0	0	0	0	680.811	680.811	680.811	680.811	680.811	323447.3	323447.3	323666	323651	323651	323651
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	19134.34	19134.34	19134.34	19134.34	19134.34	0	0	3434.957	0.0013	0.0013	0.0013
Carbon Monoxide	0	0	0	0	235921.4	235921.4	235921.4	235921.4	235921.4	0	0	44032.44	0.028	0.028	0.028
Carbon Dioxide	158436	158436	158436	158436	2086.822	2086.822	2086.822	2086.822	2086.822	0	0	19273.77	112381	112381	112381
Methane	0	0	0	0	14917.88	14917.88	14917.88	14917.88	14917.88	0	0	6844.954	0.0003	0.0003	0.0003
Acetylene	0	0	0	0	0.0031	0.0031	0.0031	0.0031	0.0031	0	0	0.0012	0.0005	0.0005	0.0005
Ethylene	0	0	0	0	0.6849	0.6849	0.6849	0.6849	0.6849	0	0	0.2364	0.0005	0.0005	0.0005
Ethane	0	0	0	0	1.5415	1.5415	1.5415	1.5415	1.5415	0	0	223.0892	0.0006	0.0006	0.0006
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	0	0	0	0	0	0	0	0	0	0	0	126.0698	50003	50003	50003
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	17.6516	17.6516	17.6516	17.6516	17.6516	0	0	10.6638	0.0003	0.0003	0.0003
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0.2912	0.2912	0.2912	0.2912	0.2912	0	0	0.2293	0.0005	0.0005	0.0005
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	51.0227	51.0227	51.0227
Methanol	0	0	0	0	0.1196	0.1196	0.1196	0.1196	0.1196	0	0	2293.303	0.0006	0.0006	0.0006
Ethanol	0	0	0	0	0.0001	0.0001	0.0001	0.0001	0.0001	0	0	609.9102	0.0009	0.0009	0.0009
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	59.8768	0.0011	0.0011	0.0011
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	12.3067	0.0014	0.0014	0.0014
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	5.6418	0.0016	0.0016	0.0016

Stream No.	497	498	499	510	512	516	517	518	519	520	523	524	528	530	551
Stream Name	FLUE GAS						GAS OUT					TO WWT			
Temp F	469.7888	280	297.8397	450	451.0664	570	570	383.6532	150	110	110.2585	110.2585	101.7292	101.7292	110.2585
Pres psia	14	14	15	1995	1995	1995	1995	1990	1980	1975	1975	1975	35	35	1975
Enth MMBtu/h	-668.94	-694.37	-692.01	-386.4	-418.49	-580.02	-580.02	-605.26	-657.23	-664.53	-454.55	-209.97	-193.71	-16.261	-145.46
Vapor mass fraction	1	1	1	1	1	1	1	1	0.78186	0.76503	1	0	0	1	1
Total lb/h	498803.5	498803.5	498803.5	272761.6	284142.6	284144.6	284144.6	284144.6	284144.6	284144.6	217274.2	66870.41	62228.29	4642.12	69527.73
Flowrates in lb/h															
Oxygen	12717.52	12717.52	12717.52	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	323651	323651	323651	680.811	681.2112	681.211	681.211	681.211	681.211	681.211	680.2254	0.9856	0.0024	0.9832	217.6721
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0.0013	0.0013	0.0013	19134.34	19130.62	10702.14	10702.14	10702.14	10702.14	10702.14	10687.04	15.1045	0.0318	15.0728	3419.852
Carbon Monoxide	0.028	0.028	0.028	235921.5	235887.4	136934	136934	136934	136934	136934	136619.8	314.1132	1.2259	312.8874	43718.33
Carbon Dioxide	112381	112381	112381	2086.822	2086.908	50269.07	50269.07	50269.07	50269.07	50269.07	45581.32	4687.747	986.0571	3701.69	14586.02
Methane	0.0003	0.0003	0.0003	14917.89	14910.61	20990.42	20990.42	20990.42	20990.42	20990.42	20802.15	188.2663	3.3535	184.9128	6656.688
Acetylene	0.0005	0.0005	0.0005	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0028	0.0002	0	0.0002	0.0009
Ethylene	0.0005	0.0005	0.0005	0.6849	0.6844	0.6844	0.6844	0.6844	0.6844	0.6844	0.6589	0.0256	0.0023	0.0233	0.2108
Ethane	0.0006	0.0006	0.0006	1.5415	1.5403	634.6297	634.6297	634.6297	634.6297	634.6297	605.2066	29.4231	3.3546	26.0685	193.6661
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	50003	50003	50003	0	0	7281.481	7281.481	7281.481	7281.481	7281.481	226.5492	7054.934	7001.711	53.2222	72.4957
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0.0003	0.0003	0.0003	17.6516	17.6536	17.6537	17.6537	17.6537	17.6537	17.6537	10.2791	7.3745	5.0573	2.3172	3.2893
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0.0005	0.0005	0.0005	0.2912	0.2912	0.2912	0.2912	0.2912	0.2912	0.2912	0.0909	0.2002	0.1813	0.0189	0.0291
Nitric Oxide	51.0227	51.0227	51.0227	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0.0006	0.0006	0.0006	0.1196	11398.28	14312.07	14312.07	14312.07	14312.07	14312.07	724.5045	13587.57	13465.86	121.7069	231.8414
Ethanol	0.0009	0.0009	0.0009	0.0001	27.1554	31646.65	31646.65	31646.65	31646.65	31646.65	1165.643	30481.02	30280.96	200.0588	373.0058
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0.0011	0.0011	0.0011	0	0.2859	6557.749	6557.749	6557.749	6557.749	6557.749	129.3288	6428.421	6409.961	18.4592	41.3852
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0.0014	0.0014	0.0014	0	0	2747.122	2747.122	2747.122	2747.122	2747.122	28.1934	2718.929	2715.644	3.2848	9.0219
1-Pentanol	0.0016	0.0016	0.0016	0	0	1369.51	1369.51	1369.51	1369.51	1369.51	13.2117	1356.298	1354.884	1.414	4.2277

Stream No.	552	560	561	601	605	610	611	612	615	620	621	622	623	625	631
Stream Name						MeOH	MeOH PUI	MeOH RECYCLE				Mixed OH		to WWT	EtOH
Temp F	110.2585	167.2547	480	136.2132	194.8936	152.0138	152.0138	152.0138	152.0138	197.9772	193.9325	193.9326	187.4027	193.9326	176.7088
Pres psia	1975	2000	1995	23	26.7	16	16	16	16	22	26.7	23	23	23	16
Enth MMBtu/h	-309.1	-35.947	-32.154	-5.6871	-183.46	-40.074	-4.0074	-36.067	-36.067	-96.767	-157.24	-132.03	-136.85	-46.917	-76.788
Vapor mass fraction	1	0	1	1	0	0	0	0	0	0	1	0.2243	2.85E-06	0	0
Total lb/h	147746.4	11425.6	11425.6	1706.739	60521.55	12695.11	1269.511	11425.6	11425.6	40825.07	60521.55	53520.18	53520.18	7001.335	30393.73
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	462.5533	0	0	0.0024	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	7267.187	0	0	0.0318	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	92901.45	0	0	1.2259	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	30995.3	0	0	986.0571	0	0	0	0	0	0	0	0	0	0	0
Methane	14145.46	0	0	3.3535	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0.0019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0.448	0	0	0.0023	0	0	0	0	0	0	0	0	0	0	0
Ethane	411.5405	0	0	3.3546	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	154.0534	0	0	0.3518	7001.359	0	0	0	0	0	7001.359	0	0	7001.335	0
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	6.9898	0	0	5.0573	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0.0618	0	0	0.1813	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	492.6631	11398.16	11398.16	673.2924	12792.57	12664.62	1266.462	11398.16	11398.16	127.9357	12792.57	12792.56	12792.56	0	127.7901
Ethanol	792.6373	27.1553	27.1553	33.8283	30247.13	30.1726	3.0173	27.1553	27.1553	30216.97	30247.13	30247.14	30247.14	0	30201.85
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	87.9436	0.2859	0.2859	0.0007	6409.961	0.3176	0.0318	0.2859	0.2859	6409.638	6409.961	6409.955	6409.955	0	64.0946
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	19.1715	0	0	0	2715.644	0	0	0	0	2715.64	2715.644	2715.64	2715.64	0	0
1-Pentanol	8.9839	0	0	0	1354.884	0	0	0	0	1354.882	1354.884	1354.882	1354.882	0	0

Stream No.	636	701	702	703	704	706	707	708	709	710	711	712	715	718	719
Stream Name	PrOH +	FROM FL	FROM TA	FROM SYNTH		TO STM R	TO STM R	TO SR RECUP					VENT		TO WWT
Temp F	230.5994	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5755	236.9942	526.5755	200
Pres psia	19	860	860	860	860	860	860	860	860	860	860	860	30	860	860
Enth MMBtu/h	-20.195	-60.648	-738.52	-932.53	-3256	-3219.3	-2468.7	-717.75	-32.91	-36.81	-36.695	0	0	-36.695	-38.749
Vapor mass fraction	0	0.99	0.99	0.98971	0.98991	1	1	1	1	0.001037	0	1	1	0	0
Total lb/h	10431.33	10675.7	130000	164146	573150	567369	435075	126494	5800	5800	5781.162	0	0	5781.162	5781.162
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	0	10675.7	130000	164146	573150	567369	435075	126494	5800	5800	5781.162	0	0	5781.162	5781.162
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0.1456	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	15.119	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	6345.543	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	2715.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	1354.882	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	720	721	725	731	732	736	737	741	742	743	744	745	746	747	751
Stream Name	FROM STI	FROM SR REC			To STM REF		TO 1945		to GASIFIE	TO REBOI	TO MOL SIEVE				
Temp F	1000	1000	1000	840.662	840.662	840.662	526.5776	366.3953	366.3953	366.3953	366.3953	366.3953	366.3953	366.3953	115.5419
Pres psia	850	850	850	450	450	450	860	35	35	35	35	35	35	35	1.5
Enth MMBtu/h	-2334.2	-678.21	-3012.4	-3053.7	-734.35	-2319.3	-932.53	-2411.1	-413.15	-104.53	-660.77	-152.56	-1076.4	-3.7509	-681.05
Vapor mass fraction	1	1	1	1	1	1	0.98971	1	1	1	1	1	1	1	0.93746
Total lb/h	435348	126493.8	561842	561842	135113	426729	164146	426729	73120	18500	116945	27000	190500	663.8382	116945
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	435348	126493.8	561842	561842	135113	426729	164146	426729	73120	18500	116945	27000	190500	663.8382	116945
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	761	762	769	770	772	773	774	777	779	781	791	792	794	1602	1701
Stream Name				MU from E	MOL SIEV	REBOIL COND				BFW				FUEL GAS	TO WWT
Temp F	115.5419	115.6498	178.7597	178.7597	259.3462	259.3462	259.3462	226.8287	236.9942	240.2726	526.5776	526.5776	1000	71.4942	118.317
Pres psia	1.5	30	60	60	35	35	35	30	30	880	860	860	850	16	15
Enth MMBtu/h	-793.74	-793.72	-1438.1	-1438.1	-179.11	-1264.4	-4.4089	-2922.8	-3821.1	-3819.2	-60.648	-738.52	-2334.2	-171.41	-67250
Vapor mass fraction	0	0	0	0	0.009411	0.00564	0.001	0	0	0	0.99	0.99	1	1	0
Total lb/h	116945	116945	213884	213884	27000	190500	663.8382	437848	573293	573293	10675.7	130000	435348	77146.09	9925413
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	218.6577	0.0916
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	3434.957	4.1179
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	44032.44	65.1421
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	19273.77	17852.19
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	6844.954	13.669
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0012	0.3676
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2364	13.2064
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	223.0892	0.0647
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	116945	116945	213884	213884	27000	190500	663.8382	437848	573293	573293	10675.7	130000	435348	126.0698	9900374
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	109.9485
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	10.6638	6979.57
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2917
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.086
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2293	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	2293.303	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	609.9102	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	59.8768	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	12.3067	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	5.6418	0

Stream No.	1702	1703	1741	1742	1743	1744	1745	1746	1747	1748	1749	1750	1751	1830	1831
Stream Name									TO WWT		to WWT	TO DEARE	to SCRUB	CWS	
Temp F	118.317	118.317	253.0462	274.5935	0	195.4107	195.4109	209.0953	205.1707	231.2065	211.696	171.8389	110	90	110
Pres psia	15	15	28	54	0	109.5	109.5	220	109.5	465	109.5	109.5	427.5	60	60
Enth MMBtu/h	-672.5	-66577	0	0	0	-15.876	-15.876	-39.36	-55.236	-18.357	-73.593	-121.97	-820.73	-26023	-25947
Vapor mass fraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total lb/h	99254.12	9826158	0	0	0	2367.09	2367.09	5880.385	8247.476	2751.756	10999.23	18121.07	120823.2	3819701	3819701
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0.0009	0.0907	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0.0412	4.0767	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0.6514	64.4907	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	178.5219	17673.67	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0.1367	13.5323	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0.0037	0.3639	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0.1321	13.0743	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0.0006	0.0641	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	99003.73	9801370	0	0	0	2367.09	2367.09	5880.385	8247.476	2751.756	10999.23	18121.07	120823.2	3819701	3819701
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	1.0995	108.8491	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	69.7957	6909.775	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0.0029	0.2888	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0.0009	0.0851	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	1834	1835	1840	1841	1842	1843	1850	1851	1861	1862	1871	1872	1910	1931	1932
Stream Name	CWS		CWS		CWS		CWS						STEAM	BFW	to STM DR
Temp F	90	110	90	110	90	110	90	110	90	110	90	110	260	237	526.5776
Pres psia	60	60	65	65	65	65	65	60	60	60	65	65	25	860	860
Enth MMBtu/h	-196.29	-195.71	-941.89	-939.13	-5031.6	-5016.9	-2485.9	-2478.6	-1183.8	-1179	-62829	-62716	-416.82	-71.155	-60.648
Vapor mass fraction	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0.99
Total lb/h	28811.37	28811.37	138253.4	138253.4	738555	738555	364879	364879	173765	173765	9232755	9232755	73119.59	10675.7	10675.7
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	28811.37	28811.37	138253.4	138253.4	738555	738555	364879	364879	173765	173765	9232755	9232755	73119.59	10675.7	10675.7
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	1935	1936	1938	1940	1941	1942	1943	1944	1945	1946	1950	1951	1952	1953	1954
Stream Name	BFW	MP STEAM	to STM DR	STEAM	STEAM	TO TURBINE			STEAM		BFW	TO STM D	BFW		
Temp F	237	400	526.5776	715.0002	525.2153	1000	525.2153	1000	366.3939	259.3462	237	526.5776	237	526.5776	526.5776
Pres psia	860	860	860	450	850	850	850	850	35	35	860	860	860	860	860
Enth MMBtu/h	-866.47	-844.28	-738.52	-743.52	-717.71	-678.21	-2470.1	-2334.2	-3.7505	-4.4085	-1788.5	-1524.3	-1094.1	-932.53	-932.53
Vapor mass fraction	0	0	0.99	1	1	1	1	1	1	0.001	0	0.99	0	0.98971	0.98971
Total lb/h	130000	130000	130000	135112.5	126493.8	126493.8	435348	435348	663.7736	663.7736	268328.3	268328.3	164146	164146	164146
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	130000	130000	130000	135112.5	126493.8	126493.8	435348	435348	663.7736	663.7736	268328.3	268328.3	164146	164146	164146
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	1834	1835	1840	1841	1842	1843	1850	1851	1861	1862	1871	1872	1910	1931	1932
Stream Name	CWS		CWS		CWS		CWS						STEAM	BFW	to STM DR
Temp F	90	110	90	110	90	110	90	110	90	110	90	110	260	237	526.5776
Pres psia	60	60	65	65	65	65	65	60	60	60	65	65	25	860	860
Enth MMBtu/h	-196.29	-195.71	-941.89	-939.13	-5031.6	-5016.9	-2485.9	-2478.6	-1183.8	-1179	-62829	-62716	-416.82	-71.155	-60.648
Vapor mass fraction	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0.99
Total lb/h	28811.37	28811.37	138253.4	138253.4	738555	738555	364879	364879	173765	173765	9232755	9232755	73119.59	10675.7	10675.7
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	28811.37	28811.37	138253.4	138253.4	738555	738555	364879	364879	173765	173765	9232755	9232755	73119.59	10675.7	10675.7
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Pop NREL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix B. Heat and Material Balance for the MSW Case

Figure B-1 Process Flow Diagram for the MSW Case

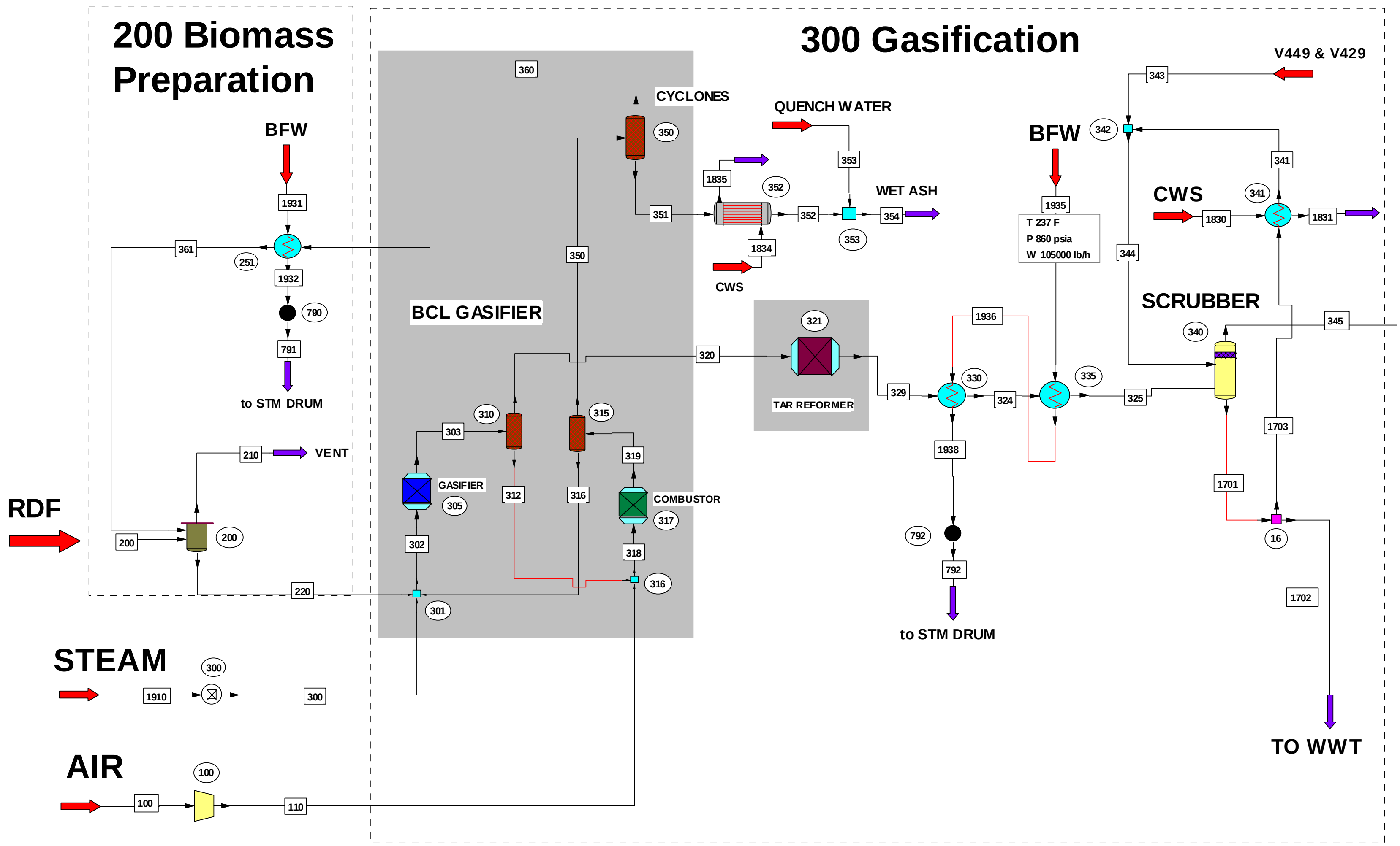

Figure B-1 Process Flow Diagram for the MSW Case (cont.)

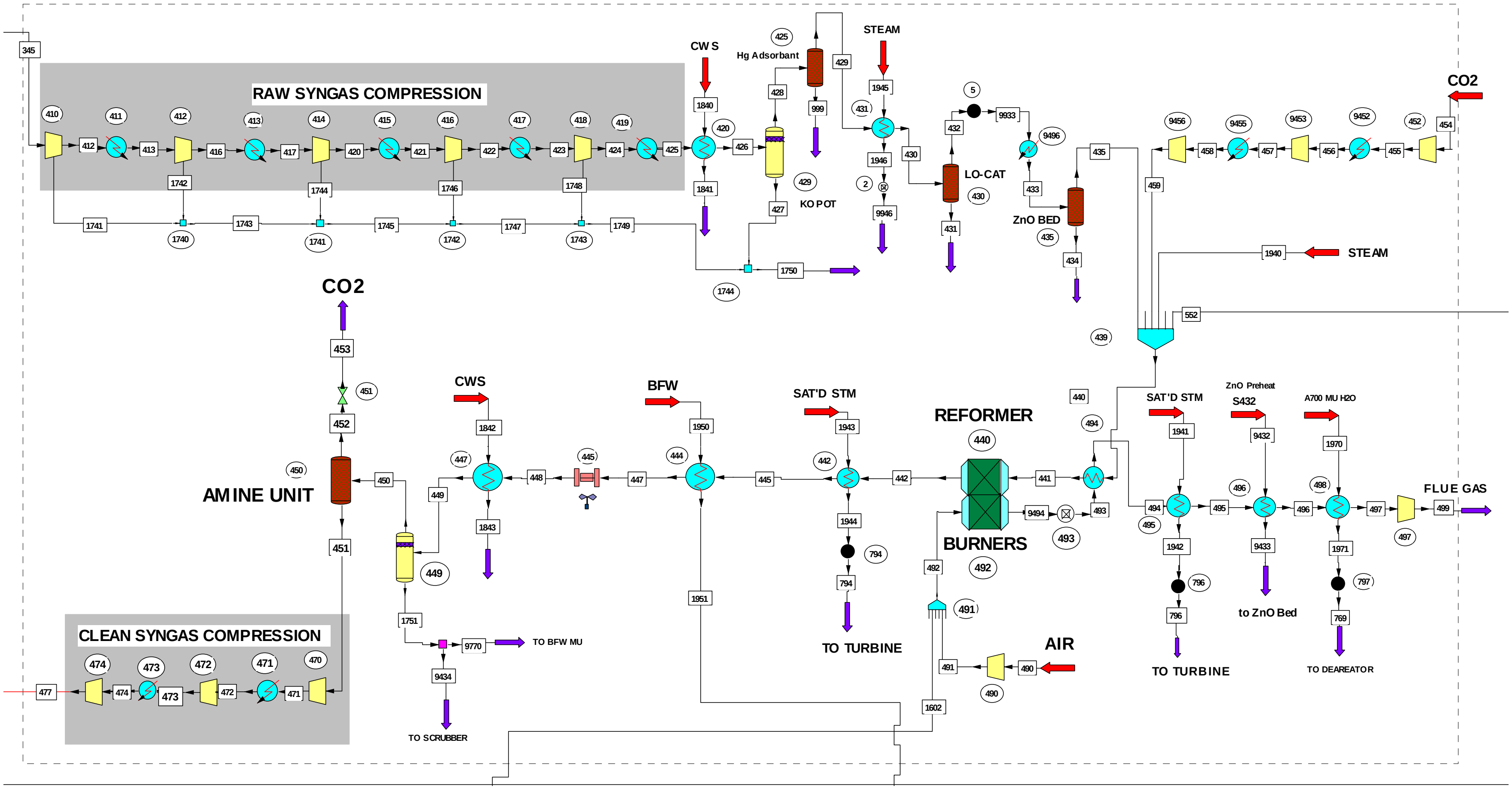

Figure B-1 Process Flow Diagram for the MSW Case (cont.)

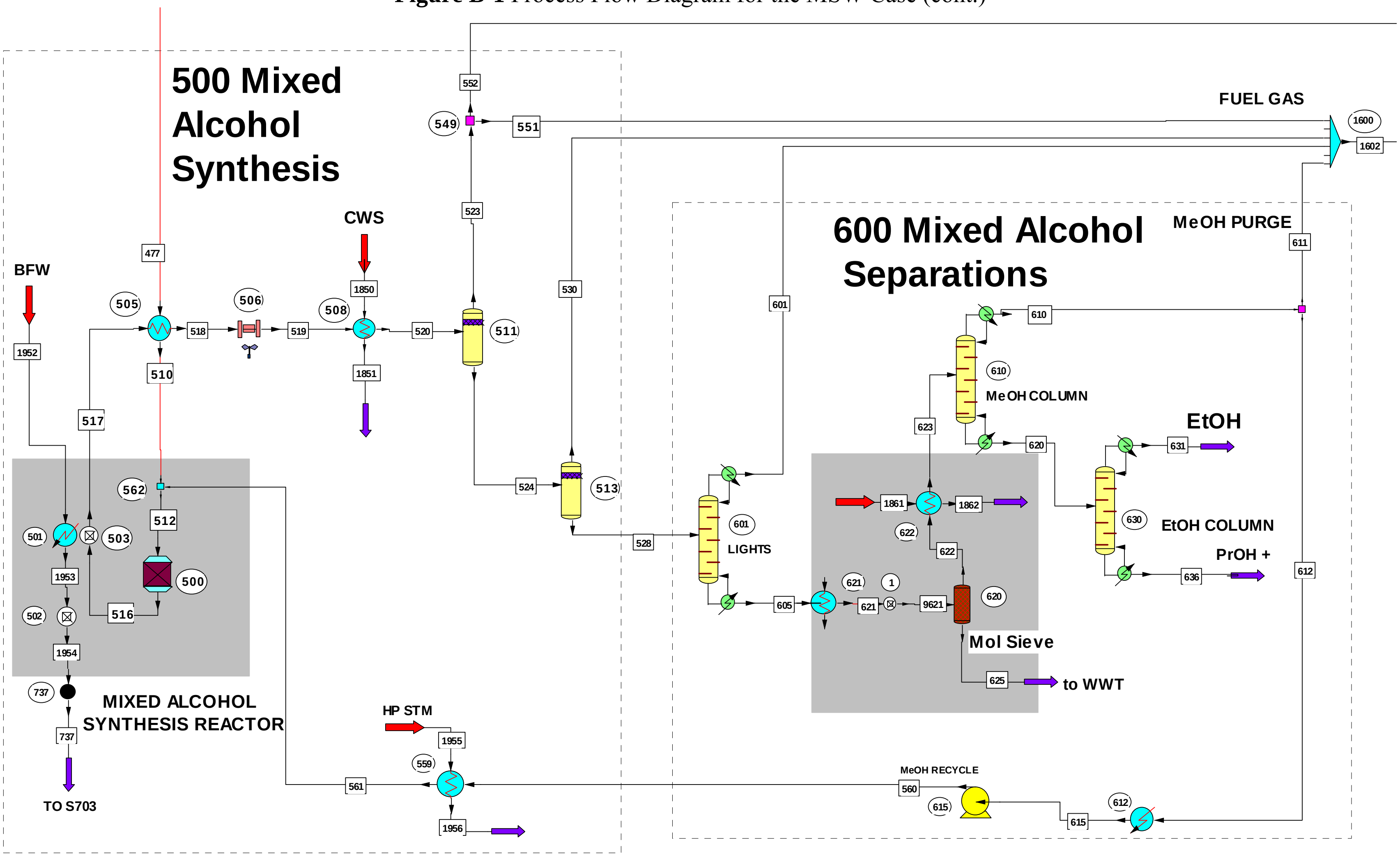

Figure B-1 Process Flow Diagram for the MSW Case (cont.)

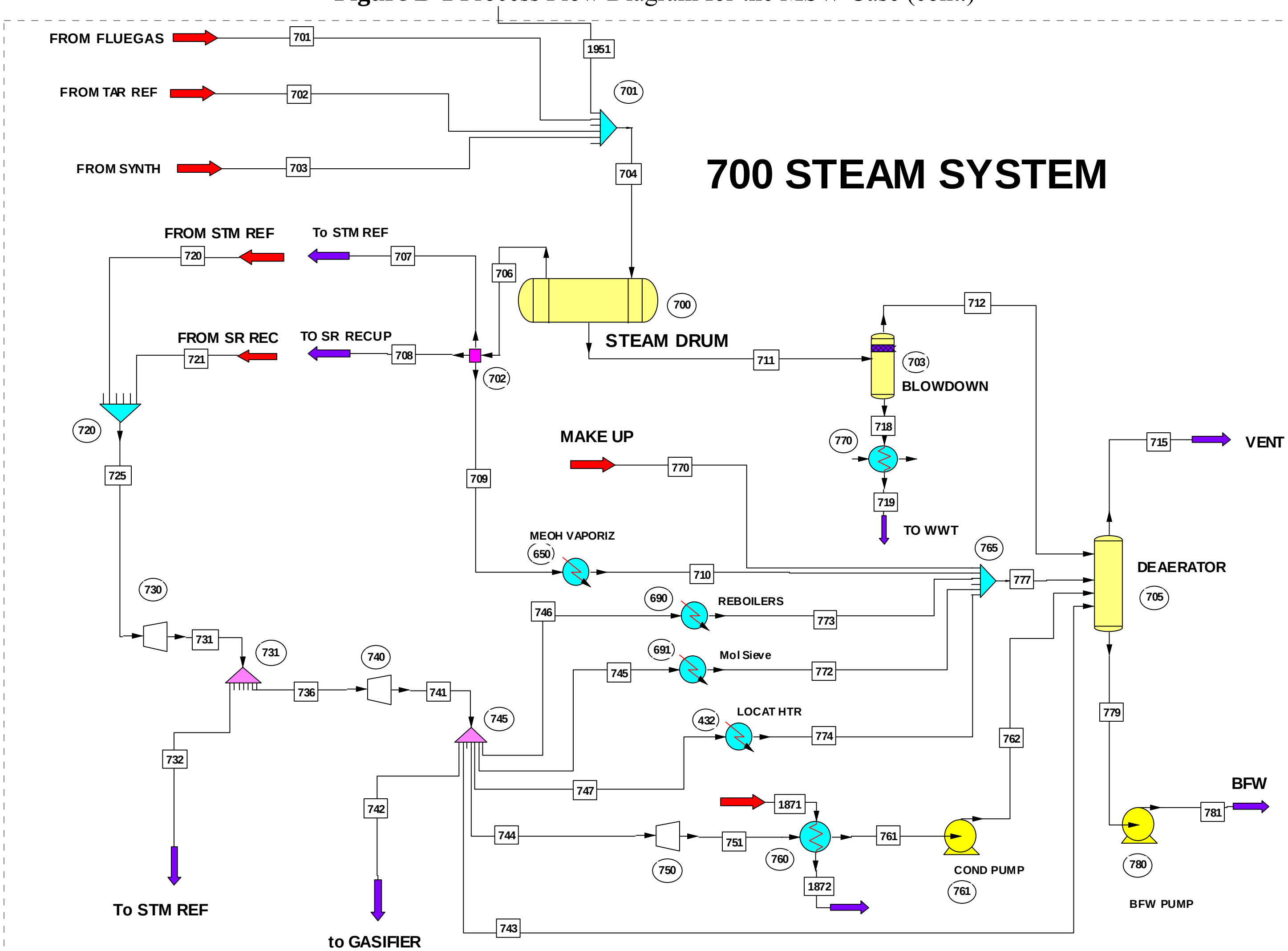

Table B-1 Steam Results for the MSW Case

Stream No.	100	110	200	210	220	300	302	303	312	316	318	319	320	324	325
Stream Name	AIR		RDF	VENT								Syngas			
Temp F	60	172.5231	60	304.7456	220	259.3482	1661.5451	1511	1511	1730	1432.019	1730	1511	462.4696	249.0378
Pres psia	14.696	30	25	23	23	35	23	23	23	23	23	23	23	19	18
Enth MMBtu/h	-71.027	-50.695	-1853	-1746.7	-721.28	-417.08	-11319	-11320	-10777	-10181	-10827	-10828	-543.26	-583.54	-601.47
Vapor mass fraction	0.99137	1	0	1	0	1	1	1	1	0	1	1	1	1	1
Total lb/h	555001	555001	367435.188	795754	204130.703	73119.7656	6277250.5	6277251	6096737	6000000	6651737.5	6651739.5	180513.516	180513.109	180513.109
Flowrates in lb/h															
Oxygen	125921.063	125921.063	0	16851.8438	0	0	0	32906.8516	32906.8516	0	158828	16851.8438	0	0	0
Nitrogen	410968.219	410968.219	0	410945	0	0	0	0	0	0	410968.219	410945	0	392.5347	392.5347
Argon	7009.0005	7009.0005	0	7009.0005	0	0	0	0	0	0	7009.0005	7009.0005	0	0	0
Carbon	0	0	0	0	0	0	0	40123.7344	40123.7344	0	40123.7305	0.0015	0	0	0
Hydrogen	0	0	0	0.0005	0	0	0	5699.1343	4416.0098	0	4416.0098	0.0005	1283.1241	5422.354	5422.354
Carbon Monoxide	0	0	0	0	0	0	0	39389.8164	0	0	0	0	39389.8164	67260.8438	67260.8438
Carbon Dioxide	273.6321	273.6321	0	147297.656	0	0	0	14855.46	0	0	273.6321	147297.656	14855.46	14855.46	14855.46
Methane	0	0	0	0	0	0	0	9054.3818	0	0	0	0	9054.3818	7243.5059	7243.5059
Acetylene	0	0	0	0	0	0	0	398.3862	0	0	0	0	398.3862	199.1931	199.1931
Ethylene	0	0	0	0	0	0	0	17005.373	0	0	0	0	17005.373	8502.6865	8502.6865
Ethane	0	0	0	0	0	0	0	1041.9557	0	0	0	0	1041.9557	104.1956	104.1956
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	10828.5596	10828.5596	183717.547	213600	20413.0703	73119.7656	93532.8359	93532.8359	0	0	10828.5596	50295.5	93532.8359	75607.2188	75607.2188
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	397.3538	0	0	0	0	397.3538	397.3538	397.3538
Ammonia	0	0	0	0	0	0	0	681.8284	0	0	0	0	681.8284	204.5485	204.5485
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	6000000	6000000	6000000	6000000	6000000	6000000	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	19290.3516	19290.3516	0	19290.3496	19290.4082	0	0	0
Benzene	0	0	0	0	0	0	0	718.251	0	0	0	0	718.251	215.4753	215.4753
Naphthalene	0	0	0	0	0	0	0	2154.7529	0	0	0	0	2154.7529	107.7377	107.7377
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	50.1734	0	0	0	0	0	0	0	50.1734	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RDF	0	0	183717.625	0	183717.625	0	183717.625	0	0	0	0	0	0	0	0

Stream No.	329	341	343	344	345	350	351	352	353	354	360	361	412	413	416
Stream Name			V449 & V429				ASH		QUENCH W/	WET ASH					
Temp F	1383	110	110	109.9994	118.6996	1730	1730	300	60	212.0109	1730	1450	253.7146	140	272.2724
Pres psia	20	15	415	15	15	23	23	23	14.7	14.7	23	23	28	28	54
Enth MMBtu/h	-498.12	-66129	-253.51	-66383	-254.29	-647.04	-86.863	-93.021	-5.1321	-98.153	-560.18	-614.95	-247.14	-254	-246.15
Vapor mass fraction	1	0.0046978	0	0.0046794	1	1	0	0	0	0.33858	1	1	1	0.99327	1
Total lb/h	180513.109	9760903	37319.6602	9798222	118171.734	651740	19290.4082	19290.4082	750.0001	20040.4082	632449	632449	118171.734	118171.734	118171.734
Flowrates in lb/h															
Oxygen	0	0	0	0	0	16851.8438	0	0	0	0	16851.8438	16851.8438	0	0	0
Nitrogen	392.5347	0.2354	0	0.2354	392.5323	410945	0	0	0	0	410945	410945	392.5323	392.5323	392.5323
Argon	0	0	0	0	0	7009.0005	0	0	0	0	7009.0005	7009.0005	0	0	0
Carbon	0	0	0	0	0	0.0015	0.0015	0.0015	0	0.0015	0	0	0	0	0
Hydrogen	5422.354	4.7008	0	4.7007	5422.3066	0.0005	0	0	0	0	0.0005	0.0005	5422.3066	5422.3066	5422.3066
Carbon Monoxide	67260.8438	59.6037	0	59.6037	67260.2344	0	0	0	0	0	0	0	67260.2344	67260.2344	67260.2344
Carbon Dioxide	14855.46	29694.6875	0	29694.6914	14548.0752	147297.656	0	0	0	0	147297.656	147297.656	14548.0752	14548.0752	14548.0752
Methane	7243.5059	10.1854	0	10.1854	7243.4019	0	0	0	0	0	0	0	7243.4019	7243.4019	7243.4019
Acetylene	199.1931	0.2868	0	0.2868	199.1902	0	0	0	0	0	0	0	199.1902	199.1902	199.1902
Ethylene	8502.6865	37.3303	0	37.3303	8502.3047	0	0	0	0	0	0	0	8502.3047	8502.3047	8502.3047
Ethane	104.1956	0.1556	0	0.1556	104.194	0	0	0	0	0	0	0	104.194	104.194	104.194
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	75607.2188	9716314	37319.6602	9753634	13727.6865	50295.5	0	0	750.0001	750.0001	50295.5	50295.5	13727.6865	13727.6865	13727.6865
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	397.3538	956.1025	0	956.1025	387.4926	0	0	0	0	0	0	0	387.4926	387.4926	387.4926
Ammonia	204.5485	13825.0391	0	13825.0391	61.1072	0	0	0	0	0	0	0	61.1072	61.1072	61.1072
Hydrogen Chloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	19290.4082	19290.4082	19290.4082	0	19290.4082	0	0	0	0	0
Benzene	215.4753	0.4609	0	0.4609	215.4706	0	0	0	0	0	0	0	215.4706	215.4706	215.4706
Naphthalene	107.7377	0.1397	0	0.1397	107.7363	0	0	0	0	0	0	0	107.7363	107.7363	107.7363
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	50.1734	0	0	0	0	50.1734	50.1734	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	417	420	421	422	423	424	425	426	427	428	429	430	431	432	433
Stream Name															
Temp F	140	195.4259	140	209.108	140	231.2095	140	110	110	110	110	120	120	120	707
Pres psia	54	109.5	109.5	220	220	465	465	465	465	465	455	455	445	445	445
Enth MMBtu/h	-260.68	-239.67	-251.46	-214.38	-223.94	-201.82	-211.25	-213.28	-35.361	-177.92	-177.91	-177.43	-0.10025	-177.36	-148.05
Vapor mass fraction	0.9376	1	0.92429	1	0.94641	1	0.95643	0.95175	0	1	1	1	0	1	1
Total lb/h	118171.734	116309.711	116309.711	112006.781	112006.781	109992.469	109992.469	109992.469	5306.8062	104685.656	104685.656	104685.656	61.0737	104624.586	104624.586
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	392.5323	392.5323	392.5323	392.5323	392.5323	392.5323	392.5323	392.5323	0.0018	392.5304	392.5304	392.5304	0	392.5304	392.5304
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	5422.3066	5422.3066	5422.3066	5422.3066	5422.3066	5422.3066	5422.3066	5422.3066	0.0108	5422.2959	5422.2959	5422.2959	0	5422.2959	5422.2959
Carbon Monoxide	67260.2344	67260.2344	67260.2344	67260.2344	67260.2344	67260.2344	67260.2344	67260.2344	0.3159	67259.9141	67259.9141	67259.9141	0	67259.9141	67259.9141
Carbon Dioxide	14548.0752	14548.0742	14548.0742	14548.0723	14548.0723	14548.0723	14548.0723	14548.0723	1.7083	14546.3652	14546.3652	14546.3652	0	14546.3652	14546.3652
Methane	7243.4019	7243.4019	7243.4019	7243.4019	7243.4019	7243.4019	7243.4019	7243.4019	0.1385	7243.2627	7243.2627	7243.2627	0	7243.2627	7243.2627
Acetylene	199.1902	199.1902	199.1902	199.1902	199.1902	199.1902	199.1902	199.1902	0.0265	199.1637	199.1637	199.1637	0	199.1637	199.1637
Ethylene	8502.3047	8502.3047	8502.3047	8502.3037	8502.3037	8502.3037	8502.3037	8502.3037	0.703	8501.6016	8501.6016	8501.6016	0	8501.6016	8501.6016
Ethane	104.194	104.194	104.194	104.194	104.194	104.194	104.194	104.194	0.0125	104.1815	104.1815	104.1815	0	104.1815	104.1815
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	13727.6865	11865.6709	11865.6709	7562.7437	7562.7437	5548.4297	5548.4297	5548.4297	5209.1787	339.2523	339.2523	339.2523	0	339.2523	339.2523
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	387.4926	387.4926	387.4926	387.4925	387.4925	387.4925	387.4925	387.4925	0.1328	387.3598	387.3598	387.3598	0	387.3598	387.3598
Ammonia	61.1072	61.1072	61.1072	61.1072	61.1072	61.1072	61.1072	61.1072	0.0335	61.0737	61.0737	61.0737	61.0737	0	0
Hydrogen Chloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	215.4706	215.4706	215.4706	215.4706	215.4706	215.4706	215.4706	215.4706	5.2171	210.2535	210.2535	210.2535	0	210.2535	210.2535
Naphthalene	107.7363	107.7363	107.7363	107.7363	107.7363	107.7363	107.7363	107.7363	89.3262	18.4101	18.4101	18.4101	0	18.4101	18.4101
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	434	435	440	441	442	445	447	448	449	450	451	452	453	454	455
Stream Name												CO2		CO2	
Temp F	707	707	468.9732	900	1652	1155.3776	300.0074	150	110	110	120	120	57.2347	60	316.1526
Pres psia	682	682	450	445	430	430	430	430	427.5	427.5	422.5	422.5	22	22	100
Enth MMBtu/h	-0.04066	-147.95	-1847	-1752.4	-1485.8	-1606.4	-1853.9	-1950.4	-1963.4	-1116.4	-318.22	-798.47	-798.47	-762.12	-751.25
Vapor mass fraction	1	1	1	1	1	1	0.88387	0.77007	0.76623	1	1	0.99634	0.99895	1	1
Total lb/h	387.3598	104237.227	533428	533428	533428	533428	533428	533428	533428	408726.344	201888.734	206837.609	206837.609	198045	198045
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	392.5304	965.5877	965.5877	956.4749	956.4749	956.4749	956.4749	956.4749	956.4749	956.4749	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	5422.2959	10511.9482	10511.9482	14833.0586	14833.0586	14833.0586	14833.0586	14833.0586	14833.0576	14833.0576	0	0	0	0
Carbon Monoxide	0	67259.9141	128707.758	128707.758	176995.125	176995.125	176995.125	176995.125	176995.125	176995.125	176995.125	0	0	0	0
Carbon Dioxide	0	14546.3652	233360.594	233360.594	207796.297	207796.297	207796.297	207796.297	207796.297	207796.297	2077.9683	205718.328	205718.328	198045	198045
Methane	0	7243.2627	14122.8584	14122.8584	7008.3682	7008.3682	7008.3682	7008.3682	7008.3682	7008.3682	7008.3682	0	0	0	0
Acetylene	0	199.1637	199.1642	199.1642	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0	0	0	0
Ethylene	0	8501.6016	8501.7246	8501.7246	0.2139	0.2139	0.2139	0.2139	0.2139	0.2139	0.2139	0	0	0	0
Ethane	0	104.1815	376.0543	376.0543	0.4389	0.4389	0.4389	0.4389	0.4389	0.4389	0.4389	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	0	339.2523	135551.422	135551.422	125820.68	125820.68	125820.68	125820.68	125820.68	1119.2845	0	1119.2845	1119.2869	0	0
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	387.3598	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	5.8146	5.8146	16.797	16.797	16.797	16.797	16.797	16.797	16.797	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	210.2535	210.2535	210.2535	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	18.4101	18.4101	18.4101	0	0	0	0	0	0	0	0	0	0	0
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0.0371	0.0371	0.2021	0.2021	0.2021	0.2021	0.2021	0.2021	0.2021	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	316.2478	316.2478	0.0746	0.0746	0.0746	0.0746	0.0746	0.0746	0.0746	0	0	0	0
Ethanol	0	0	506.4705	506.4705	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	55.838	55.838	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	12.14	12.14	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	5.6754	5.6754	0	0	0	0	0	0	0	0	0	0	0
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	456	457	458	459	471	472	473	474	477	490	491	492	493	494	495
Stream Name										AIR				To LOCAT&ZnO	
Temp F	150	317.6958	150	256.3385	236.1337	150	278.5218	150	271.5315	60	124.5558	112.3454	1800	1099.1305	753.4954
Pres psia	100	250	250	450	700	700	1200	1200	2000	14.696	20	16	16	14	14
Enth MMBtu/h	-758.75	-751.58	-759.43	-755.14	-306.39	-315.21	-301.9	-315.24	-302.35	-1.522	4.135	-148.4	-415.2	-509.72	-553.33
Vapor mass fraction	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total lb/h	198045	198045	198045	198045	201888.734	201888.734	201888.734	201888.734	201888.734	362548.563	362548.563	432050	432050	432050	432050
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	84442.6797	84442.6797	84442.6797	11010.9072	11010.9072	11010.9072
Nitrogen	0	0	0	0	956.4749	956.4749	956.4749	956.4749	956.4749	278106	278106	278489.313	278478	278478	278478
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	14833.0576	14833.0576	14833.0576	14833.0576	14833.0576	0	0	3405.0361	0.0012	0.0012	0.0012
Carbon Monoxide	0	0	0	0	176995.125	176995.125	176995.125	176995.125	176995.125	0	0	41200.3203	0.0246	0.0246	0.0246
Carbon Dioxide	198045	198045	198045	198045	2077.9683	2077.9683	2077.9683	2077.9683	2077.9683	0	0	17461.6094	98743.8594	98743.8594	98743.8594
Methane	0	0	0	0	7008.3682	7008.3682	7008.3682	7008.3682	7008.3682	0	0	4690.6763	0.0003	0.0003	0.0003
Acetylene	0	0	0	0	0.0011	0.0011	0.0011	0.0011	0.0011	0	0	0.0005	0.0004	0.0004	0.0004
Ethylene	0	0	0	0	0.2139	0.2139	0.2139	0.2139	0.2139	0	0	0.0904	0.0004	0.0004	0.0004
Ethane	0	0	0	0	0.4389	0.4389	0.4389	0.4389	0.4389	0	0	203.5968	0.0004	0.0004	0.0004
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	0	0	0	0	0	0	0	0	0	0	0	66.4548	43773.25	43773.25	43773.25
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	16.797	16.797	16.797	16.797	16.797	0	0	10.9824	0.0003	0.0003	0.0003
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0.2021	0.2021	0.2021	0.2021	0.2021	0	0	0.165	0.0004	0.0004	0.0004
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	44.0383	44.0383	44.0383
Methanol	0	0	0	0	0.0746	0.0746	0.0746	0.0746	0.0746	0	0	1686.7837	0.0005	0.0005	0.0005
Ethanol	0	0	0	0	0.0001	0.0001	0.0001	0.0001	0.0001	0	0	342.8955	0.0007	0.0007	0.0007
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	37.2493	0.0008	0.0008	0.0008
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	8.0933	0.001	0.001	0.001
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	3.7836	0.0011	0.0011	0.0011
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	496	497	499	510	512	516	517	518	519	520	523	524	528	530	551
Stream Name	FLUE GAS						GAS OUT					TO WWT			
Temp F	510.6381	280	297.8182	450	451.0915	570	570	384.1223	150	110	110.2502	110.2502	110.2502	110.2502	110.2502
Pres psia	14	14	15	1995	1995	1995	1995	1990	1980	1975	1975	1975	1975	1975	1975
Enth MMBtu/h	-582.63	-609.5	-607.45	-283.68	-308.14	-429.72	-429.72	-448.39	-487.36	-492.79	-333.89	-158.9	-158.9	0	-133.56
Vapor mass fraction	1	1	1	1	1	1	1	1	0.77735	0.76051	1	0	0	1	1
Total lb/h	432050	432050	432050	201888.734	210582.625	210584.063	210584.063	210584.063	210584.063	210584.063	160055.422	50528.6328	50528.6328	0	64022.1836
Flowrates in lb/h															
Oxygen	11010.9072	11010.9072	11010.9072	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	278478	278478	278478	956.475	956.4749	956.4749	956.4749	956.4749	956.4749	956.4749	955.0955	1.3794	1.3794	0	382.0382
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0.0012	0.0012	0.0012	14833.0586	14833.0576	8494.6875	8494.6875	8494.6875	8494.6875	8494.6875	8482.7539	11.9344	11.9344	0	3393.1018
Carbon Monoxide	0.0246	0.0246	0.0246	176995.125	176995.094	102648.141	102648.141	102648.141	102648.141	102648.141	102413.047	235.0997	235.0997	0	40965.2188
Carbon Dioxide	98743.8594	98743.8594	98743.8594	2077.9683	2077.9683	38230.8398	38230.8398	38230.8398	38230.8398	38230.8398	34615.3867	3615.4543	3615.4543	0	13846.1553
Methane	0.0003	0.0003	0.0003	7008.3687	7008.3662	11570.2715	11570.2715	11570.2715	11570.2715	11570.2715	11466	104.2797	104.2797	0	4586.3965
Acetylene	0.0004	0.0004	0.0004	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.001	0.0001	0.0001	0	0.0004
Ethylene	0.0004	0.0004	0.0004	0.2139	0.2139	0.2139	0.2139	0.2139	0.2139	0.2139	0.2058	0.0081	0.0081	0	0.0823
Ethane	0.0004	0.0004	0.0004	0.4389	0.4389	475.4695	475.4695	475.4695	475.4695	475.4695	453.1212	22.3483	22.3483	0	181.2485
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	43773.25	43773.25	43773.25	0	0	5526.8784	5526.8784	5526.8784	5526.8784	5526.8784	166.1309	5360.7461	5360.7461	0	66.4524
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0.0003	0.0003	0.0003	16.797	16.797	16.797	16.797	16.797	16.797	16.797	9.691	7.1059	7.1059	0	3.8764
Hydrogen Chloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0.0004	0.0004	0.0004	0.2021	0.2021	0.2021	0.2021	0.2021	0.2021	0.2021	0.0618	0.1403	0.1403	0	0.0247
Nitric Oxide	44.0383	44.0383	44.0383	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0.0005	0.0005	0.0005	0.0746	8672.9873	10773.2061	10773.2061	10773.2061	10773.2061	10773.2061	527.0796	10246.125	10246.125	0	210.8318
Ethanol	0.0007	0.0007	0.0007	0.0001	20.8168	23846.5332	23846.5332	23846.5332	23846.5332	23846.5332	844.1176	23002.4082	23002.4082	0	337.647
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0.0008	0.0008	0.0008	0	0.2151	4936.3354	4936.3354	4936.3354	4936.3354	4936.3354	93.0634	4843.271	4843.271	0	37.2254
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0.001	0.001	0.001	0	0	2073.8054	2073.8054	2073.8054	2073.8054	2073.8054	20.2333	2053.5718	2053.5718	0	8.0933
1-Pentanol	0.0011	0.0011	0.0011	0	0	1034.2206	1034.2206	1034.2206	1034.2206	1034.2206	9.459	1024.7612	1024.7612	0	3.7836
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	552	560	561	601	605	610	611	612	615	620	621	622	623	625	631
Stream Name		MeOH RECYCLE				MeOH	MeOH PURG	MeOH RECYCLE				Mixed OH		to WWT	EtOH
Temp F	110.2502	167.2084	480	84.2883	194.8814	152.0141	152.0141	152.0141	152.0141	197.947	201.8105	201.8105	187.3736	201.8105	176.7085
Pres psia	1975	2000	1995	23	26.7	16	16	16	16	22	26.7	23	23	23	16
Enth MMBtu/h	-200.33	-27.353	-24.466	-15.934	-139.72	-30.493	-3.0493	-27.444	-27.444	-73.487	-119.57	-93.378	-103.99	-35.881	-58.387
Vapor mass fraction	1	0.0003125	1	1	0	0	0	0	0	0	1	0.67884	1.75E-06	0	0
Total lb/h	96033.2734	8693.9443	8693.9443	4512.9829	46015.6484	9659.9404	965.994	8693.9443	8693.9443	30995.0215	46015.6484	40655	40655	5360.7534	23110.4844
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	573.0573	0	0	1.3794	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	5089.6528	0	0	11.9344	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	61447.832	0	0	235.0997	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	20769.2324	0	0	3615.4543	0	0	0	0	0	0	0	0	0	0	0
Methane	6879.5952	0	0	104.2797	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0.0006	0	0	0.0001	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0.1235	0	0	0.0081	0	0	0	0	0	0	0	0	0	0	0
Ethane	271.8728	0	0	22.3483	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	99.6786	0	0	0.0025	5360.7437	0	0	0	0	0	5360.7437	0	0	5360.7534	0
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	5.8146	0	0	7.1059	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0.0371	0	0	0.1403	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	316.2478	8672.9131	8672.9131	512.2948	9733.8291	9636.5713	963.6571	8672.9131	8672.9131	97.2767	9733.8291	9733.8477	9733.8477	0	97.166
Ethanol	506.4705	20.8167	20.8167	2.9355	22999.4727	23.1297	2.313	20.8167	20.8167	22976.373	22999.4727	22999.502	22999.502	0	22964.8906
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	55.838	0.2151	0.2151	0	4843.271	0.239	0.0239	0.2151	0.2151	4843.0371	4843.271	4843.2759	4843.2759	0	48.4271
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	12.14	0	0	0	2053.5718	0	0	0	0	2053.5737	2053.5718	2053.5737	2053.5737	0	0
1-Pentanol	5.6754	0	0	0	1024.7612	0	0	0	0	1024.7623	1024.7612	1024.7623	1024.7623	0	0
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	636	701	702	703	704	706	707	708	709	710	711	712	715	718	719
Stream Name	PrOH +	FROM FLUE	FROM TAR I	FROM SYNTH			To STM REF	TO SR RECUP					VENT		TO WWT
Temp F	230.6059	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	233.9624	526.5776	150
Pres psia	19	860	860	860	860	860	860	860	860	860	860	860	30	860	860
Enth MMBtu/h	-15.264	-316.11	-596.49	-701.44	-3042.5	-3008.8	-2191.7	-792.39	-24.683	-27.583	-33.679	-3.96E-05	0	-33.679	-35.83
Vapor mass fraction	0	0.99	0.99	0.99043	0.99009	1	1	1	1	0.0095721	0	1	1	0	0
Total lb/h	7884.5376	55644.2734	105000	123479.414	535571	530265	386267	139648	4350.0005	4350.0005	5305.981	0.007	0	5305.9736	5305.9736
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	0	55644.2734	105000	123479.414	535571	530265	386267	139648	4350.0005	4350.0005	5305.981	0.007	0	5305.9736	5305.9736
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0.1108	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	11.4814	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	4794.6099	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	2053.5737	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	1024.7623	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	636	701	702	703	704	706	707	708	709	710	711	712	715	718	719
Stream Name	PrOH +	FROM FLUE(	FROM TAR I	FROM SYNTH			To STM REF	TO SR RECUP					VENT		TO WWT
Temp F	230.6059	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	526.5776	233.9624	526.5776	150
Pres psia	19	860	860	860	860	860	860	860	860	860	860	860	30	860	860
Enth MMBtu/h	-15.264	-316.11	-596.49	-701.44	-3042.5	-3008.8	-2191.7	-792.39	-24.683	-27.583	-33.679	-3.96E-05	0	-33.679	-35.83
Vapor mass fraction	0	0.99	0.99	0.99043	0.99009	1	1	1	1	0.0095721	0	1	1	0	0
Total lb/h	7884.5376	55644.2734	105000	123479.414	535571	530265	386267	139648	4350.0005	4350.0005	5305.981	0.007	0	5305.9736	5305.9736
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	0	55644.2734	105000	123479.414	535571	530265	386267	139648	4350.0005	4350.0005	5305.981	0.007	0	5305.9736	5305.9736
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0.1108	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	11.4814	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	4794.6099	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	2053.5737	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	1024.7623	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	720	721	725	731	732	736	737	741	742	743	744	745	746	747	751
Stream Name	FROM STM I	FROM SR REC			To STM REF		TO S703		to GASIFIER		TO MOL SIEVE				
Temp F	1000	1000	1000	840.6619	840.6619	840.6619	526.5776	366.397	366.397	366.397	366.397	366.397	366.397	366.397	115.5419
Pres psia	850	850	850	450	450	450	860	35	35	35	35	35	35	35	1.5
Enth MMBtu/h	-2071	-748.74	-2819.8	-2858.4	-734.35	-2124.1	-701.44	-2208.2	-413.15	-94.359	-754.33	-129.96	-813.64	-2.719	-777.48
Vapor mass fraction	1	1	1	1	1	1	0.99043	1	1	1	1	1	1	1	0.93747
Total lb/h	386270.031	139648.406	525918.438	525918.438	135113	390805.438	123479.414	390805.438	73120	16700	133504.219	23000	144000	481.211	133504.219
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	386270.031	139648.406	525918.438	525918.438	135113	390805.438	123479.414	390805.438	73120	16700	133504.219	23000	144000	481.211	133504.219
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	761	762	769	770	772	773	774	777	779	781	791	792	794	796	999
Stream Name			TO DEAREA	MAKE UP	MOL SIEVE	REBOIL COND				BFW					
Temp F	115.5419	115.6686	185.6402	185.6402	250.3853	259.3462	250.3853	231.0757	233.9624	237.2776	526.5776	526.5776	1000	1000	110
Pres psia	1.5	35	60	60	30	35	30	30	30	890	860	860	850	850	455
Enth MMBtu/h	-906.13	-906.11	-1434.3	-1434.3	-150.11	-955.64	-3.2004	-2570.9	-3571.3	-3569.5	-316.11	-596.49	-2071	-748.74	0
Vapor mass fraction	0	0	0	0	0.13252	0.006452	0.001	0	0	0	0.99	0.99	1	1	0
Total lb/h	133504.219	133504.219	213536	213536	23000	144000	481.211	385367.219	535572	535572	55644.2734	105000	386270.031	139648.406	0
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	133504.219	133504.219	213536	213536	23000	144000	481.211	385367.219	535572	535572	55644.2734	105000	386270.031	139648.406	0
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	1602	1701	1702	1703	1741	1742	1743	1744	1745	1746	1747	1748	1749	1750	1751
Stream Name	FUEL GAS	TO WWT									TO WWT		to WWT	TO DEAREA	to SCRUBBE
Temp F	75.4944	118.6996	118.7001	118.7001	253.7146	272.2724	0	195.4259	195.4258	209.108	204.9788	231.2095	211.4502	171.9244	110
Pres psia	16	15	15	15	28	54	0	109.5	109.5	220	109.5	465	109.5	109.5	427.5
Enth MMBtu/h	-152.54	-66730	-667.23	-66055	0	0	0	-12.489	-12.489	-28.801	-41.29	-13.438	-54.728	-90.088	-847.07
Vapor mass fraction	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total lb/h	69501.1563	9860562	98595	9760903	0	0	0	1862.0194	1862.0194	4302.9282	6164.9473	2014.3109	8179.2583	13486.0625	124701.398
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	383.4176	0.2378	0.0024	0.2354	0	0	0	0	0	0	0	0	0	0.0018	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	3405.0361	4.7488	0.0475	4.7008	0	0	0	0	0	0	0	0	0	0.0108	0
Carbon Monoxide	41200.3203	60.2127	0.6021	59.6037	0	0	0	0	0	0	0	0	0	0.3159	0
Carbon Dioxide	17461.6094	30002.0762	299.9464	29694.6875	0	0	0	0	0	0	0	0	0	1.7083	0
Methane	4690.6763	10.2895	0.1029	10.1854	0	0	0	0	0	0	0	0	0	0.1385	0
Acetylene	0.0005	0.2898	0.0029	0.2868	0	0	0	0	0	0	0	0	0	0.0265	0
Ethylene	0.0904	37.7117	0.3771	37.3303	0	0	0	0	0	0	0	0	0	0.703	0
Ethane	203.5968	0.1572	0.0016	0.1556	0	0	0	0	0	0	0	0	0	0.0125	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	66.4548	9815512	98144.5938	9716314	0	0	0	1862.0194	1862.0194	4302.9282	6164.9473	2014.3109	8179.2583	13388.4365	124701.398
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	965.9637	9.6576	956.1025	0	0	0	0	0	0	0	0	0	0.1328	0
Ammonia	10.9824	13968.4805	139.6469	13825.0391	0	0	0	0	0	0	0	0	0	0.0335	0
Hydrogen Chloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0.4656	0.0047	0.4609	0	0	0	0	0	0	0	0	0	5.2171	0
Naphthalene	0	0.1412	0.0014	0.1397	0	0	0	0	0	0	0	0	0	89.3262	0
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0.165	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	1686.7837	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	342.8955	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	37.2493	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	8.0933	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	3.7836	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	1830	1831	1834	1835	1840	1841	1842	1843	1850	1851	1861	1862	1871	1872	1910
Stream Name	CWS		CWS		CWS		CWS		CWS						STEAM
Temp F	90	110	90	110	90	110	90	110	90	110	90	110	90	110	259.3482
Pres psia	60	60	60	60	65	65	65	65	65	60	60	60	65	60	35
Enth MMBtu/h	-25113	-25039	-2097.5	-2091.3	-690.94	-688.92	-4435.2	-4422.2	-1849.9	-1844.5	-2604.6	-2594	-43820	-43691	-417.08
Vapor mass fraction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total lb/h	3686166	3686166	307872	307872	101418.43	101418.43	651012.188	651012.188	271534	271534	382314	382314	6431974	6431974	73119.7656
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	3686166	3686166	307872	307872	101418.43	101418.43	651012.188	651012.188	271534	271534	382314	382314	6431974	6431974	73119.7656
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	1931	1932	1935	1936	1938	1940	1941	1942	1943	1944	1945	1946	1950	1951	1952
Stream Name	BFW	to STM DRUI	BFW	MP STEAM	to STM DRUI	STEAM	SAT'D STM	TO TURBINE			STEAM	to TURBINE	BFW	TO STM DRU	BFW
Temp F	237	526.5776	237	400	526.5776	715.0002	525.2153	1000	525.2153	1000	366.401	259.3462	237	526.5776	237
Pres psia	860	860	860	860	860	450	850	850	850	850	35	35	860	860	860
Enth MMBtu/h	-370.88	-316.11	-699.84	-681.92	-596.49	-743.52	-792.35	-748.74	-2191.6	-2071	-2.7189	-3.1959	-1675.9	-1428.4	-823.01
Vapor mass fraction	0	0.99	0	0	0.99	1	1	1	1	1	1	0.001	0	0.99	0
Total lb/h	55644.2734	55644.2734	105000	105000	105000	135112.5	139648.406	139648.406	386270.031	386270.031	481.1948	481.1948	251447	251447	123479.414
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	55644.2734	55644.2734	105000	105000	105000	135112.5	139648.406	139648.406	386270.031	386270.031	481.1948	481.1948	251447	251447	123479.414
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stream No.	1931	1932	1935	1936	1938	1940	1941	1942	1943	1944	1945	1946	1950	1951	1952
Stream Name	BFW	to STM DRUI	BFW	MP STEAM	to STM DRUI	STEAM	SAT'D STM	TO TURBINE			STEAM	to TURBINE	BFW	TO STM DR(	BFW
Temp F	237	526.5776	237	400	526.5776	715.0002	525.2153	1000	525.2153	1000	366.401	259.3462	237	526.5776	237
Pres psia	860	860	860	860	860	450	850	850	850	850	35	35	860	860	860
Enth MMBtu/h	-370.88	-316.11	-699.84	-681.92	-596.49	-743.52	-792.35	-748.74	-2191.6	-2071	-2.7189	-3.1959	-1675.9	-1428.4	-823.01
Vapor mass fraction	0	0.99	0	0	0.99	1	1	1	1	1	1	0.001	0	0.99	0
Total lb/h	55644.2734	55644.2734	105000	105000	105000	135112.5	139648.406	139648.406	386270.031	386270.031	481.1948	481.1948	251447	251447	123479.414
Flowrates in lb/h															
Oxygen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Monoxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethylene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Propane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	55644.2734	55644.2734	105000	105000	105000	135112.5	139648.406	139648.406	386270.031	386270.031	481.1948	481.1948	251447	251447	123479.414
Sulphur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbonyl Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Sulfide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenChloride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hybrid Poplar Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sulfur Dioxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen Cyanide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitric Oxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopropanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Propanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isobutanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-Butanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Pentanol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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