

Part 8

Utilities in Aspen Plus





Objectives:

1.Learn to use different pressure change elements such as pumps, valves, pipe segments.

2.Become familiar with pages and Tabs of each element and how to fill in the required inputs.

3.Get to know the critical conditions and its causes for each pressure change elements.

4.Learn to use Sensitivity in Aspen Plus

5.Learn to use Design Specs in Aspen Plus

- 6.Understand pressure level heuristics for compressors and turbines
- 7.Understand the difference between heat, material, and work streams



UTILITIES

In this tutorial, you will use the Utilities feature. This is basically a convenient way of tracking the costs and amounts of utilities that your plant requires. These include electricity, different types of steam, different types of cooling, fuels, refrigerants, and others. Basically, you create your own list of utilities available to your plant, along with appropriate temperature ranges and costs of use. Then, for units such as heat exchangers, pumps, compressors, etc., you simply select in each block which utility you are going to use. Then, Aspen Plus will figure out how much of that utility you need and how much it costs.

What Are Utilities?

Most everyday people understand what "utilities" are since they routinely pay utility bills as a part of living expenses. The term has a very similar meaning in a chemical engineering context. When a chemical process consumes a utility, it is essentially "purchasing" heating, cooling, refrigeration, or electricity from some other provider, even though that provider may just be another business unit of the same company. In practice, other services may be considered utilities, such as waste removal, water treatment, pressurized air, high-purity oxygen, process water, or solvents of various kinds. However, in Aspen Plus, "utilities" refer only to energy services: heating, cooling, and electricity. Conceptually, utilities are provided "on demand" and are not directly integrated into your chemical process. A chemical process designer is not often concerned with exactly how those utilities are provided; the designer instead determines what utility is needed and how much. It is important to understand that when you are purchasing utilities like steam, cooling water, or refrigeration, you are not actually purchasing the actual steam, water, or refrigerant-you instead purchase the heating or cooling service they provide. For example, when you purchase highpressure steam as a utility, you are really only purchasing the latent heat it carries. In fact, your chemical plant would normally have a condensate return line where the used, condensed steam (still hot and at high pressure) returns to the steam generation plant. If you buy refrigeration utility, you are only buying the service of removing low-temperature thermal energy from your plant (making it colder). This is why utility accounting uses a cost-per-unit-energy framework, because you are only purchasing the energy.

Defining Utilities

To use utilities in Aspen Plus, you must first define what utilities are available for you to purchase. Start with a blank simulation in Aspen Plus, preferably with the Chemicals with Metric Units template. You can define a utility in the Utilities folder under the Simulation tab (or click Process Utilities in the Economics ribbon). Click New to make a new utility, and call it something meaningful (see Figure 6.1). Let's make LPS (low-pressure steam).



New Exp	ort Edit Input	Сору Р.	Paste		
			usice)		
Require utility specif	fications for all utility he	at exchangers			
A Name	Туре		Status	Description	Delete
🔊 New Utility		×			
Create a new utility:		1			
U-1					
Copy from:					
<blank></blank>		-			
<blank></blank>		A			
LP Steam		_			
MP Steam					
HP Steam					
Hot Oil					
Fired Heat (1000)					
Fired Heat (2000)					
Very High Temperatu	re	-			

In the Copy Form, choose LP Steam. Aspen Plus comes with default prices and settings for LPS. These are heuristics which may or may not be correct for your plant, and you'll see the actual numbers show up in the Specifications and Inlet/Outlet tab once you choose LP Steam and select OK. Note also that if you have not added water to your components list, you will be prompted to do so (do it).

Aspen Plus		×
This change requir Do you want to ad		
	Yes	No

These numbers are very convenient, but are they right? The energy prices given here are \$1.9×10-6 per kJ, which is \$1.9 per GJ.

	Specifications	⊘Inlet/Outlet	Properties	Flash Options	Diagnostics	EO Options	🕝 Carbon Tracking	Comments
1	Jtility type	team	-					
	Utility cost							
	Purchase price	•		\$/kg	~			
	Energy price		1.9e-06	\$/kJ	-			
	Heating/Cooling	value						
	Specify heating		Specify in	let/outlet condi	tions			
	Heating/Cooling	value		kcal/kg	-			
	Inlet temperature		125	С	-			
	Outlet temperatu	re	124	С	-			
	- Consistency checl	k specifications –						
	Consistency check		Error		•			
	Flow direction		Countercurrent		-			
	Minimum approa	ch temperature	10	c	-			



Specifications	✓Inlet/Outlet	Properties	Flash Options	Diagnostics	EO Options	Carbon Tracking	Comments
Inlet state variable	s		-Composition -]		
Temperature		-	Basis Mo	le	-		
125	c	•	Comp	onent	Value		
Vapor fraction		•	VATER .				
1		T					
Outlet state variab	les						
Temperature		-					
124	с	-					
Vapor fraction		-					
0		-					

AspenTech sometimes updates these numbers, but of course the prices will be different for each specific circumstance and point in time.³ The bottom line is that it will vary with the price of energy. At the same time, there are differences in the temperature/pressure ranges of the steams between Aspen Plus's default and heuristics given in other sources. There is no standard! Essentially, each plant will have access to steam levels depending on the other plants that sit nearby. For example, a company with lots of different processes on-site may have standard steam lines for that location. Or, individual plants may have custom steam pressure lines which are optimized to some particular values. My point is, don't just blindly go with the default numbers.

Now I've said that, let's blindly go with the default numbers since we're just learning how to use the tool and are less concerned about what the numbers actually are. In the Inlet/Outlet tab, you'll notice that the vapor fraction is defined as 1 for the inlet and 0 for the outlet. This means that heat is provided by condensing steam (this is normal). As mentioned in earlier tutorials, Aspen Plus uses a convention that if you *specify* vapor fraction = 1 or vapor fraction = 0 in an input form, that means you are defining that the inlet is exactly saturated vapor at the dew point or the outlet is exactly saturated liquid at the bubble point. The temperatures are given, so the pressures will be computed from this information. The outlet is defined to have a slightly lower temperature than the inlet so that the outlet will have a slightly lower pressure than the inlet. In the event that you wanted superheated steam or subcooled liquid, you would enter the temperature and pressure combination instead of a temperature and vapor pressure combination. Usually, real systems superheat and subcool by a few degrees as a safety margin.

Notice that there is a Carbon Tracking tab. This is a new feature that can help with sustainability analyses. On this tab, you'll see that by default it chose a U.S. Environmental Protection Agency rule for computing the amount of global warming potential (measured in CO2 equivalents). It also selected natural gas combustion to produce the heat to make the steam, and an efficiency of 85%. Aspen Plus has a default number for the average composition of natural gas and its

heat of combustion. It takes the amount of steam duty you need and then divides that by 0.85 to determine the total natural gas combustion duty that is required to produce it (so only 85% of the chemical energy from the natural gas is used to make steam via combustion, the rest is assumed lost as waste heat). Then it assumes that all the carbon atoms in the natural gas end up as CO2, and then outputs that number. So Aspen Plus computes the *total direct emissions* for this utility, but does not account for the CO2 that was emitted in order to produce the natural gas and pipeline it across the country and into your plant.



Now, go ahead and add a utility for electricity, using the default. We are going to add our own electric utility that assumes the electric power is produced by a coal power plant with a solvent-based CO2 capture system on it.

ſ	🔊 New Utility	×	
	Create a new utility:		
	U-2		
	Copy from:		
l	<blank></blank>	-	
l	MP Steam Generation	A	
l	HP Steam Generation		L
ŀ	Refrigerant 1		H
	Refrigerant 2		L
	Refrigerant 3		Ľ
	Refrigerant 4		
L	Very Low Temperature	-	L
	Electricity		1
ſ	EI	lectrical Utility	

Specifications	Inlet/Outlet	Properties	Flash Options	Diagnostics	EO Options	Garbon Tracking	Comments
Utility type	ectricity		•				
Utility cost							
Purchase price		0.0775	\$/kWhr	-			
Heating/Cooling	value						
Specify heating	g/cooling value	O Specify	inlet/outlet cor	nditions			
Heating/Cooling	value		kcal/kg	T			
Inlet temperature			С	T			
Outlet temperatu	re		С	T			
Consistency check	k specifications -						
Consistency check	k	Error		T			
Flow direction		Countercurren	nt	~			
Minimum approa	ch temperature		1 C	Ŧ			
Utility side film o	pefficient for ene	ergy analysis –					
Specify		0	Calculate from	properties			
	kcal/hr-sqm-K	- Vi	scosity:		сP	-	
		-			i		



The default electricity setting in Aspen Plusassumes classic power plants with no CO2 capture, at a rather typical price of about 8 cents per kWh. However, there is a power plant by SaskPower in Saskatchewan, Canada which is the first of its kind to implement CO2 capture at a meaningful scale from coal, which has about 80% lower emissions per kWh than traditional pulverized coal. Of course, it is more expensive than classic power plants without CO2 capture. According to the U.S. Department of Energy (document DOE/NETL-2007/1281), we can predict that the prices for this type are higher, at 13.2 cents per kWh (in the United States), after adjusting for inflation. So make the change in the Specifications tab. Similarly, the CO2 emissions should also be changed since they are much lower. A recent life cycle analysis study4 determined that the total cradle-tograve life cycle emissions for a power plant of this new type should be about 78.65 kg of CO2 equivalent per GJ of electricity. That includes the construction of the power plant, the mining and transport of the coal, the construction and use of the CO2 capture, pipeline and storage system, and even the electricity transmission losses from connecting the power plant to your plant. So it's a much better number to use than what Aspen Plus has because it includes more of the life cycle. Anyway, enter this number by setting the CO2 emission data factor source to USER, typing the number into the CO2 emissions factor box, and setting the efficiency factor to 1.0 since the efficiency factor is already included in the 78.65 kg/GJ number.

Specifications	Inlet/Outlet	Properties	Flash (Options	Diagnostic	EO Option	5	Carbon Tracking	Comments			
Carbon tracking –												
Calculate CO2 emissions												
CO2 emission factor data source USER -												
Ultimate fuel sour	ce	USER					-					
CO2 emission fact	or	7	8.65 k	cg/GJ	-							
CO2 energy source	e efficiency facto	r	1									
- Fuel composition												
Basis Mole		-		Compo	onent	Value						
			> V	VATER	_							

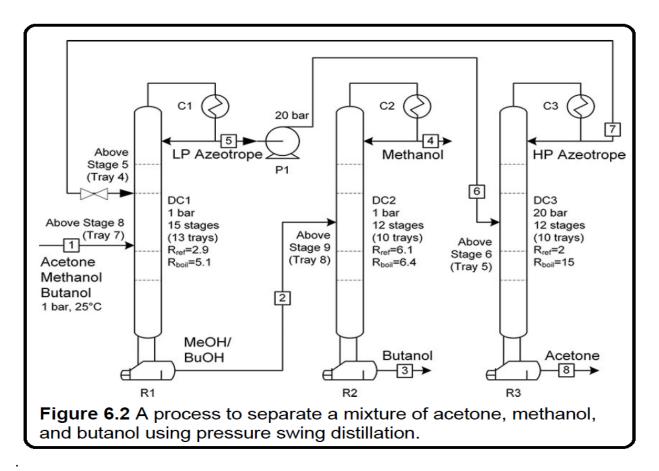
Finally, add utilities for medium- and high-pressure steam, and for boiler feedwater (BFW) streams at low, medium, and high pressure, using the defaults in Aspen Plus. Note that the BFW defaults are "Steam Generation" items. They are basically backward versions of the corresponding steam utility and actually make money and "consume" CO2 instead of costing money because the energy price and CO2 efficiency is negative. It is an accounting trick. The idea is that it prevents the cost of steam and the emission of CO2 somewhere else by making it here. Also, note the temperature ranges of these utilities for later. For example, cooling water comes in at 20°C and comes out at 25°C, which is rather generous but we'll go with it. It also has a temperature approach maximum of 5°C by default. That means that for countercurrent flow, the coldest anything can get is 25°C (cold in = $20^{\circ}C + 5^{\circ}C = 25^{\circ}C$). If you violate this by assigning the utility where it shouldn't be used (your heat exchanger comes too close to temperature crossover or actually does crossover, as discussed in Tutorial 4), Aspen Plus will throw you an error.5



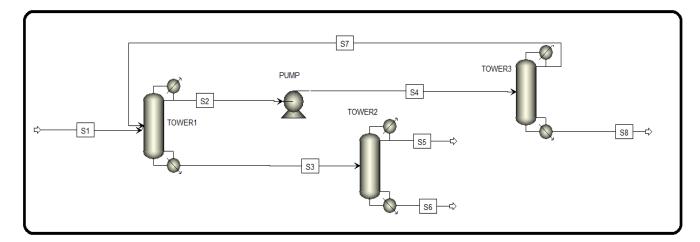
Using Utilities

Ok, let's see how utilities are used in the software. In this example, we are going to separate a 100 kmol/hr mixture of acetone (27 mol%, *T*bp = 56°C), methanol (38 mol%, *T*bp = 65°C), and *n*-butanol (35 mol%, *T*bp = 117°C) at 25°C and 1 bar that we get after a biofuel production process. Acetone and methanol form a low boiling azeotrope at 55°C, so we're going to use pressure swing distillation again (see Tutorial 2).

The process shown in Figure 6.2 can be used, with all of the remaining design parameters given. Simulate this process in Aspen Plus. You should be able to do this, given what you already know. Remember, it is better to get one block working at a time before adding another one, and get all three columns working without recycle first before connecting the final recycle stream. When it is finished, you should be able to get at least 98 mol% purity in each of the three product streams. Assume the distillation columns and their supporting reboilers and condensers are at constant pressure throughout. Use RADFRAC for the distillation columns of course and the NRTL-RK property package. Remember the best practices we learned from earlier tutorials: *change the property package first before adding the chemicals!* (butanol is *n*-butanol). Go back to check and make sure that the binary parameters come from the VLERK database and not the VLE-IG one! Do this by looking at the Source drop-downs of the different chemical pairs under the Input tab of the Properties | Parameters | Binary Interaction | NRTL-1 form.







S1 (MATERIAL) × Main Flowsheet × +				Main Flowsheet × TOWER1 (Rad	lFrac) × +		
Mixed CI Solid NC Solid Flash Op	otions EO Options Cost	ing Comments		Configuration Streams	Pressure Condenser	Reboiler 3-Phase Comm	ents
State variables Temperature 25 Pressure 1 Vapor fraction Total flow basis Mole • Total flow rate 100	Pressure	Composition Mole-Frac Component Value WATER ACETONE METHANOL BUTANOL	ие 27 38 35	Setup options Calculation type Number of stages Condenser Reboiler Valid phases Convergence	Equilibrium Total Kettle Vapor-Liquid Standard	15 🖉 Stage Wizard	
Solvent Reference Temperature Volume flow reference temperature Component concentration reference temp C	perature	Total	100	Operating specifications Reflux ratio Boilup ratio Free water reflux ratio Design and specify column intern	 Mole Mole 0 	2.9 5.1 Feed Basis	Y

Configuration	Streams	🕜 Pre	essure	Condenser	🛛 🥝 Reboil	er 3-Phase	Comments				
ed streams —											
Name	Stage			Convention							
S1		8 /	Above-St	age							
S7		5	Above-St	age							
	Chara		Dhara		Davia		Unite	flam f	Detie	Food Server	
oduct streams - Name	Stage		Phase		Basis	Flow	Units	Flow F	Ratio	Feed Specs	
	-	Liqui		Mol		Flow	Units kmol/hr	Flow F	Ratio	Feed Specs Feed basis	
Name	1	Liquid	id		е	Flow		Flow F	Ratio		
S2	1		id	Mol	е	Flow	kmol/hr	Flow F	Ratio	Feed basis	



Main Flowsheet × TOWER1 (RadFrac	c) × (+	\square	Main Flowsheet ×	PUMP (Pump) × [+		
Configuration Streams	Pressure 🛛 🖉 Condenser 🖉	Reboiler	Specifications	Calculation O	ptions	Flash Options	Otility
			C Model				
View Top / Bottom	•		Pump		🔘 Tu	rbine	
Top stage / Condenser pressure			CPump outlet speci	ification ——			
Stage 1 / Condenser pressure	1 bar	-	Oischarge pres		20	bar	-
Stage 2 pressure (optional)			 Pressure increa Pressure ratio 	ise		bar	Ŧ
Stage 2 pressure	bar	•					
Condenser pressure drop	bar	•	 Power required Use performan 		ermine dis	kW scharge conditi	ions 🞑
Pressure drop for rest of column (option	onal)						×
Stage pressure drop	bar	-	Efficiencies				
Column pressure drop	bar	-	Pump		Driv	ver	
Main Flowsheet × TOWER2 (RadFrac) × +			Main Flowsheet × TOW	/ER1 (RadFrac) ×	Control Par	nel X TOWER2 (RadFrac) 🗙 🕂
Configuration Streams Pressure Conde	lenser @Reboiler 3-Phase Comment	its	♥ Configuration ♥ S	itreams 🛛 📀 Press	ure 🕜 Cor	ndenser 🛛 🥑 Reb	oiler 3-Phase
Setup options						1.	
Calculation type Equilibrium			View Top / Botto	т	•		
Number of stages	12 😧 Stage Wizard		Top stage / Condenser p	oressure			
Condenser Total			Stage 1 / Condenser pre		1 bar		
Reboiler Kettle Valid phases Vapor-Liqu	id 🗸		Stuge 17 condenser pre				
Convergence Standard	•		Stage 2 pressure (option	nal)			
Operating specifications			Stage 2 pressure		bar	•	
Operating specifications Reflux ratio Mole	• 6.1	-	Condenser pressure d	lrop	bar	T	
Boilup ratio Mole	▼ 6.4		Pressure drop for rest of	column (ontional)			
Free water reflux ratio	0 Feed Basis		 Stage pressure drop 	column (optional)	bar	•	
Design and specify column internals			Column pressure drop	n	bar	~	
Design and specify column internals				μ	Ddi	-	
Configuration Streams OP	ressure 🛛 🥑 Condenser 🗋 🥝	Reboiler 3-P	hase Comments				
Feed streams							
Name Stage	Convention						
► S3 9	Above-Stage						
Product streams							
Name Stage	Phase Basis	s Flow	v Units	Flow Ratio	F	eed Specs	
▶ S5 1 Liqu	iid Mole		kmol/hr			Feed basis	
S6 12 Liqu	Mole		kmol/hr			Feed basis	
Pseudo streams							
Name Pseudo Stream Type	Stage Internal Phase Re	eboiler Phase	Reboiler Pumpa Conditions ID			Flow	Units



Main Flowsheet × TOWER3 (Rac	dFrac) × +					Main Fl	lowsheet ×	TOWER3 (F	RadFrac) ×	+	
Configuration Streams	O Pressure		ooiler 3-Pha	se Comments		⊘ Co	nfiguration	Streams	s 🛛 📀 Pressur	re 🕜 Condenser	Reboiler
Setup options							_	1			1
Calculation type	Equ	illibrium	•			View	Тор	/ Bottom		•	
Number of stages	_		12 😧 🛛 Sta	ge Wizard		~ Top s	tage / Con	denser pressure	e		
Condenser	Tot			•			-	nser pressure		20 bar	•
Reboiler	Ket			•		Stage	r / conde	liser pressure		20 04	•
Valid phases		por-Liquid		•		Stage	2 pressure	(optional) —			
Convergence	Sta	ndard		•		_	age 2 press			bar	•
Operating specifications								essure drop		bar	
Reflux ratio	- Mo	le 🔹	2		Ŧ	000	nuenser pr	essure drop		Dai	
Boilup ratio	- Mo	le 🔹	15		T	Pressu	ure drop fo	r rest of colum	n (optional)		
Free water reflux ratio		0	Feed	Basis		State	age pressur	e drop		bar	•
Design and specify column inter						0.00	lumn press	ure dron		bar	
	WER3 (Rad	dFrac) × +	Conde	nser 🛛 🥑 Reb	oiler 3	3-Phase	Comment	ts			
Name	Stage		Conventic	'n							
▶ S4		6 Above-Sto	зде								
Product streams											
Name	Stage	Phase		Basis	FI	ow	Units	Flow F	Ratio	Feed Specs	
> S7		Liquid		Mole			kmol/hr			Feed basis	
► S8	12	Liquid		Mole			kmol/hr			Feed basis	
Pseudo streams						1					
Name P	seudo Stre Type	am Stage	Internal	Phase Reboi	ler Phase	Rebo Condit		umparound ID	Pumparound Conditions	Flow	Units

Ok, let's go back and assign utilities to the process units. Each block has a different way of doing this. For example, in the Pump, there is a Utility tab, where you select which of the utilities that you created to be used with it (see Figure 6.3). In the RADFRAC blocks, you can find the utility specification in the Condenser (see Figure 6.4) and Reboiler tabs (Figure 6.5), respectively, at the bottom.

Go through and choose the correct utilities for each. You can use your simulation results to help you select. Remember not to violate the second law of thermodynamics! Remember, use BFW for cooling whenever you can because you'll generate steam instead of paying for cooling! Rerun the simulation. You can check the utility results in the block's results form, in the Utility tab or similarly named. Note: When selecting utilities, you generally want to

choose the cheapest utility that does the job. Suppose for example, you need to deliver 1.2 GJ/hr of heat to a stream that you want to heat up to 150°C. Your choices may include LPS (available at 125°C), MPS (175°C), HPS (250°C), and Fired Heat (e.g., inside a furnace with a minimum of 400°C). In this case, you cannot use LPS because it is not hot enough, so rule that out. MPS will



work because it is 25°C hotter than your maximum needed heating temperature, which is well above the 5–10°C approach temperature we often assume (see Tutorial 4 for more about approach temperatures). HPS and Fired Heat are even hotter and can also be used, but they are more expensive per GJ. (The default in Aspen Plus for HPS is \$2.5/GJ but MPS is only \$2.2/GJ.) So we select MPS because it is cheaper, with a total cost of \$2.64/hr.

Note: Although Aspen Plus lets you select Electricity as the utility for almost any heat exchanger, this is very rarely the actual utility used in practice. Electric heaters (e.g., using resistors or actually shocking the target directly) are usually special cases only.

Main Flowsheet × PUMP (Pump) × +		Main Flowsheet × PUMP (Pump) × TC	OWER1 (RadFrac) × +	
		Configuration Streams Pre	essure 🖉 Condenser 🥝 Reboile	r 3-Phase Comments
Specifications Calculation Options Flash Option	ns 🔇 Utility Comments	Thermosiphon reboiler options		
Select utility for this block		© Specify reboiler flow rate O Specify reboiler outlet condition O Specify both flow and outlet conditio		Reboiler Wizard
Utility ID U-2		Flow rate	Outlet condition	
U-1		Mole • km	iol/hr • Temperature	C
U-2		Optional		
U-3	Electrical Utility	Reboiler outlet pressure	bar	•
U-4		Reboiler return feed convention Utility	Above-Stage	-
U-5		Reboiler configurations	U-1	Low Pressure Steam, Inlet Temp=125 C, Outlet
U-6		NT-1	U-2 U-3	Temp=124 C
U-7		Å I	U-4 U-5	i I
<new></new>		└──₭`ャ╢ ┍	U-6 U-7	K.+W

Main Flowsheet × PUMP (Pump) × TO	VER2 (RadFrac) × +	Main Flowsheet	Main Flowsheet × PUMP (Pump) × TOWER3 (RadFrac) × +					
Configuration Streams Pres	sure Condenser Reboiler 3-Phase Comme	nents Oconfiguration	on 🔇 Streams 🔇 Pressure 🔇	Condenser 🔮 Reboiler	3-Phase Comments			
Thermosiphon reboiler options Specify reboiler flow rate Specify reboiler outlet condition Specify both flow and outlet condition	Reboiler Wizard	Specify reb Specify reb	reboiler options	Reb	iviler Wizard			
Flow rate	/hr Outlet condition Temperature C	Flow rate	v kmol/hr v	Outlet condition Temperature	•			
Optional		Optional —						
Reboiler outlet pressure	bar 👻	Reboiler outlet	pressure	bar				
Reboiler return feed convention	Above-Stage -	Reboiler return	feed convention Above-Sta	age				
Utility	U-3 ·	Utility	U-4	•				
Reboiler configurations	U-1 U-2 U-3 Medium Pressure	re Steam, Inlet Temp=175 C,	gurations U-1 U-2 IT-1 U-3		NT-2			
		74 C, Pres=127 psia	U-4 U-5 U-6		High Pressure Steam, Inlet Temp=250 C, Outlet Temp=249 C, Pres=572 psia			

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Results

Main Flowsheet × PUMP (Pump) - Results × +								
Sumr	nary	Balance	Performance Curve	Utility Usage 🛛 Status				
Utility	ID		U-2					
Utility	duty		10.7499			kW 🗸		
Utility	Utility usage		10.7499			kW 🗸		
Utility	Utility cost		0.833121			\$/hr •		
CO2 er	CO2 emission rate		3.04374			kg/hr 🔹		

Main Flowsheet × TOWER1 (RadFrac) - Results × +										
Summary	Balan	ce Split Fi	raction	Reboiler	r Utilities Stage Utilities		Status 🖉			
Condenser					Ret	ooiler	U-1			
Duty					- Dut	Jy	3850.87	kW	-	
Usage					- Usage		6324.77	kg/hr	-	
Cost				- Cost		26.34	\$/hr	•		
CO2 emission	n rate				- CO	2 emission rate	911.541	kg/hr	-	
Pumparo	ound ut	tilities								
Decanter utilities										



Main Flowsheet × TOWER2 (RadFrac) - Results × +										
Summary	Balance	Split Fraction	n Reboiler	Utilities	Stage Utilities	Status 🔮				
Condenser			Reboiler U-3							
Condenser Duty Usage Cost CO2 emission				- Dut	ly.	2717.17	kW	•		
Usage				- Usa	ige	4807.38	kg/hr	•		
Cost				 Cos 	it	21.52	\$/hr	•		
CO2 emission	n rate			- CO	2 emission rate	643.183	kg/hr	•		

Main Flowsheet × TOWER3 (RadFrac) - Results × +										
Summary Balar	nce Split Fract	ion Reboiler	Utilities	Stage Utilities	Status	Status				
Condenser			Reb	oiler	U-4					
Duty			- Dut	у	2236.97	kW	-			
Usage			- Usa	ge	4683.87	kg/hr	-			
Cost			- Cos	t	20.1327	\$/hr	-			
CO2 emission rate			- co2	2 emission rate	529.514	kg/hr	-			
Pumparound u	utilities									
🕑 Decanter utilit	ies									