

Part 8

Utilities in Aspen Plus





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 high pressure 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	xport Edit Input	Сору	Paste		
Require utility spe	ecifications for all utili	ty heat exchangers			
Name	Туре		Status	Description	Delete
🔊 New Utility		×			
Create a new utility	:	1			
U-1					
Copy from:					
<blank></blank>		-			
<blank></blank>		-			
LP Steam					
MP Steam					
HP Steam					
Hot Oil					
Fired Heat (1000)					
Fired Heat (2000)					
Ven Ulinh Temper	atura	_			

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	es water to be in d water to the c	n the simulation. omponents list?
	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
Utility type Ste	am	-					
Utility cost							
Purchase price			\$/kg	T			
Energy price		1.9e-06	\$/kJ	-			
Heating/Cooling value	alue						
Specify heating/	cooling value	Specify in	let/outlet condi	tions			
Heating/Cooling va	alue		kcal/kg	•			
Inlet temperature		125	С	-			
Outlet temperature		124	C	~			
Consistency check s	pecifications —						
Consistency check		Error		•			
Flow direction		Countercurrent		-			
Minimum approact	n temperature	10	с	•			



Specifications Specifications	Properties	Flash Options	Diagnostics	EO Options	Carbon Tracking	Comments
Inlet state variables		-Composition —				
Temperature	-	Basis Mol	e	-		
125 C	-	Compo	onent	Value		
Vapor fraction	-	► WATER				
1	~					
Outlet state variables						
Temperature	-					
124 C	-					
Vapor fraction	-					
0	-					

Aspen Tech 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	▼			
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 study 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	s EO O	ptions	🖉 Carbon Tracking	Comments
- Carbon tracking									
Calculate CO2 emissions									
CO2 emission fact	or data source	USER					•	•	
Ultimate fuel sour	ce	USER					~	•	
CO2 emission fact	or	7	8.65 I	kg/GJ	•				
CO2 energy source	e efficiency facto	r	1						
Fuel composition									
Basis Mole		-		Comp	onent	Value			
			► V	WATER					

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%, $Tbp = 56^{\circ}C$), methanol (38 mol%, $Tbp = 65^{\circ}C$), and *n*-butanol (35 mol%, $Tbp = 117^{\circ}C$) 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.

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) × Mai	in Flowsheet \times +					ה ב	Main Flowsheet ×	TOWER1 (Ra	dFrac) × 🕂				
Mixed CI Solid	NC Solid Flash Opt	tions EO Options	Costing	g Comments			Configuration	Streams	Pressure	Condenser	Reboiler	3-Phase	Comments
Specifications Flash Type State variables Temperature Pressure Vapor fraction Total flow basis Total flow rate	mperature 25 1 Mole 100	Pressure C • bar • kmol/hr •		Composition Mole-Frac Component WATER ACETONE ACETONE METHANOL BUTANOL	Value 27 38 35		Setup options — Calculation type Number of stages Condenser Reboiler Valid phases			Equilibrium Total Kettle Vapor-Liquid	15 💭	Stage V	/izard
Reference Temperatu Volume flow reference Component concentu	are emperature	erature		Total	100		Operating specific Reflux ratio Boilup ratio Free water reflux ra Design and specif	ations atio	• • rnals	Mole Mole 0	•	2.9 5.1 Feed Basi	* *

Configuration	Streams	🕜 Pro	essure	Condens	er 🕺 🥑 R	leboiler	3-Phase	Comments				
ed streams —												
Name	Stage			Convention								
S1		8	Above-St	tage								
S7		5	Above-St	taae								
			710076 31									
oduct streams -	Chara -		Dhase	-	Davia		<u></u>	Unite	<u> </u>	D-+:-		
oduct streams - Name	Stage		Phase	e	Basis		Flow	Units	Flow	Ratio	Feed Specs	
oduct streams - Name S2	Stage 1	Liqui	Phase	e N	Basis		Flow	Units kmol/hr	Flow	Ratio	Feed Specs Feed basis	
S2 S3	Stage 1 15	Liqui	Phase id id	e N	Basis ole ole		Flow	Units kmol/hr kmol/hr	Flow	Ratio	Feed Specs Feed basis Feed basis	
oduct streams - Name S2 S3 eudo streams -	Stage 1 15	Liqui	Phase id id	e N	Basis ole ole		Flow	Units kmol/hr kmol/hr	Flow	Ratio	Feed Specs Feed basis Feed basis	



Main Flowsheet × TOWER1 (RadFrad	c) × +	Ma	in Flowsheet $ imes$	PUMP (Pump)× [+		
Configuration Streams	Pressure Condenser OF	Reboiler	Specifications	Calculation O	ptions	Flash Options	ØUtility
		_ N	lodel ———				
View Top / Bottom	•	(Pump		🔘 Tu	rbine	
Top stage / Condenser pressure		P	ump outlet speci	ification ——			
Stage 1 / Condenser pressure	1 bar	•) Discharge pres	sure	20	bar	-
Stage 2 pressure (optional)) Pressure increa	ise		bar	Ŧ
Stage 2 pressure	bar	•	Dowor roquiroo			LAM	_
Condenser pressure drop	bar) Use performan	ice curve to det	ermine dis	scharge conditi	ons
Pressure drop for rest of column (opti	ional)						\mathbf{X}
Stage pressure drop	bar	- E	ficiencies				
Column pressure drop	bar	P	ump		Driv	ver	
Main Flowsheet × TOWER2 (RadFrac) × +		Main	Flowsheet × TOW	/ER1 (RadFrac) ×	Control Par	nel X TOWER2 (RadFrac) × 🕂
Configuration Streams Pressure Cond	denser @Reboiler 3-Phase Comments		onfiguration	itreams 🕜 Pressu	ire OCor	ndenser 🖉 Rebo	oiler 3-Phase
Setup options							Jiler J Huse
Calculation type Equilibrium	n •	View	Top / Botto	m	•		
Number of stages	12 🗟 Stage Wizard	Tor	stage / Condenser r				
Condenser Total		Sta	stage / condenser p		1 bar	-]
Reboiler Kettle	•	Sta	je i / condensei pre	ssure	I Dai		
Valid phases Vdpor-Liqu Convergence Standard	•	Sta	je 2 pressure (optior	nal)			
- Standard			tage 2 pressure		bar	•	
Operating specifications	- 61		ondenser pressure c	lrop	bar	Ŧ	
Reflux ratio Mole	- 0.1 - 64						
Eree water reflux ratio	0 Eeed Basis	Pres	sure drop for rest of	column (optional)			
			tage pressure drop		bar	•	
Design and specify column internals			olumn pressure dro	p	bar	~	
Configuration Streams OP	Pressure 🛛 🥑 Condenser 🗎 🥑 F	Reboiler 3-Phase	Comments				
Feed streams							
Name Stage	Convention						
3 5 9	ADDVE-SLUGE						
Product streams							
Name Stage	Phase Basis	Flow	Units	Flow Ratio	F	eed Specs	
▶ S5 1 Liqu	uid Mole		kmol/hr			Feed basis	
S6 12 Liqu	uid Mole		kmol/hr			Feed basis	
- Pseudo streams							
Name Pseudo Stream Type	Stage Internal Phase Rel	boiler Phase Reb Cond	oiler Pumpa litions ID	round Pumpar Condit	round tions	Flow	Units



	(RadFrac) × +				Main Flowsheet × TOWER3 (RadFrac) × +						
Configuration Stream	s 🛛 🥑 Pressure	Condenser OReb	ooiler 3-Phase Comm	ents	Configurat	ion 🛛 🕜 Streams	⊘ Pressure	Condenser	Reboiler		
Setup options					_						
Calculation type	Eq	uilibrium	•		View	Top / Bottom		•			
Number of stages			12 😴 Stage Wizard		- Top stage / C	ondenser pressure					
Condenser	Τα	ital	•		Stage 1 / Con	dansar pressure	20	har	_		
Reboiler	Ke	rttle	•		Stage 17 Con	denser pressure	20	Dar			
Valid phases	Va	1por-Liquid	•		- Stage 2 press	ure (optional) —					
Convergence	St	andard	•		Stage 2 pr	essure		bar	•		
Operating specifications					© stuge z pr						
Reflux ratio	- M	ole 🔹	2	~	Condenser	pressure drop		bar	Ŧ		
Boilup ratio	• M	ole 🔹	15	*	Pressure drop	for rest of column	(optional)				
Free water reflux ratio		0	Feed Basis		Stage pres	sure drop		bar	-		
					Column pr	assura dran		bar	-		
Design and specify column in	nternals				Column pr	essure urop		Dai			
Main Flowsheet × $>$	TOWER3 (Ra	dFrac) × 🕂									
Configuration	Streams	⊘ Pressure		Reboiler	3-Phase Comm	ents					
Eood strooms											
recu sucarns											
Name	Stage		Convention								
Name > S4	Stage	6 Above-Sta	Convention								
Name S4	Stage	6 Above-Sta	Convention age								
Name S4	Stage	6 Above-Sto	Convention age								
Name	Stage	6 Above-Sto	Convention Ige								
Name S4 Product streams	Stage	6 Above-Sto	Convention age	ie E		its Flow Pa	tio	Feed Spers			
Product streams Name S7	Stage Stage	6 Above-Sto	Convention age Bas Mole	is F	low Ur kmol/h	its Flow Ra	tio	Feed Specs			
Product streams S7 S8	Stage Stage 1	6 Above-Sto Phase Liquid	Convention age Bas Mole Mole	is Fi	low Ur kmol/h kmol/h	its Flow Ra	tio	Feed Specs Feed basis Feed basis			
Name > S4 Product streams Name S7 S8	Stage	6 Above-Stu Phase Liquid	Convention age Bas Mole Mole	is F	low Ur kmol/h kmol/h	its Flow Ra	tio I	Feed Specs Feed basis Feed basis			

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. 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 X PIIMP (Pump) X +		Main Flowsheet × PUMP (Pump) × TOWER1 (RadFrac) × +
		Configuration Streams Pressure Condenser Reboiler 3-Phase Comments
Specifications Calculation Options Flash Opti	ions 🔮 Utility Comments	Thermosiphon reboiler options
- Select utility for this block		O Specify reboiler outlet condition O Specify both flow and outlet condition
Utility ID U-2	•	Flow rate Outlet condition
U-1		Mole v kmol/hr v Temperature v C v
U-2	1 1 1 1 1 1 1 1 1 1	Coptional
U-3	Electrical Utility	Reboiler outlet pressure bar
U-4		Reboiler return feed convention Above-Stage
U-5		U-1 Low Pressure Steam, Inlet Temp=125 C, Outlet
U-6		NT-1 U-3
U-7		4 U-4 k I
<new></new>		

Main Flowsheet × PUMP (Pump) × TO	WER2 (RadFrac) × +		Main Flowsheet × PUMP (Pump) × TOWER3 (RadFrac) × +					
Configuration Streams Pres	sure Condenser Reboiler	B-Phase Comments	Configuration Streams Pres	ssure 🔇 Condenser 🔇 Reboiler	3-Phase Comments			
Thermosiphon reboiler options			Thermosiphon reboiler options					
Specify reboiler flow rate	Rebo	iler Wizard	Specify reboiler flow rate	Re	boiler Wizard			
O Specify reboiler outlet condition			O Specify reboiler outlet condition					
O Specify both flow and outlet condition			O Specify both flow and outlet condition	1				
Flow rate	Outlet condition		- Flow rate	Outlet condition				
Mole -	I/hr v Temperature	v	Mole -	ol/hr v Temperature	T			
	С	T			C v			
Optional			 Optional 					
Reboiler outlet pressure	bar 👻		Reboiler outlet pressure	bar	•			
Reboiler return feed convention	Above-Stage -		Reboiler return feed convention	Above-Stage	-			
Utility	U-3 •		Utility	U-4	•			
Paboilar configurations	U-1			U-1				
	U-2	3177 A	Reboiler configurations	U-2				
NT-1	U-3	Medium Pressure Steam, Inlet Temp=175 C,	NT-1	U-3	NT-2			
	-4 Outlet Temp=174 C, Pres=127 psia			U-4	High Pressure Steam. Inlet Temp=250 C. Outlet			
		K III		0-5				
	11.7	N. † '¥I		11.7	17.11.11			

Educational Institute for Equipment and Process Design

Results

Mai	Main Flowsheet × PUMP (Pump) - Results × +									
Su	mmary	Balance	Performance Curve	Utility Usa	ge	🕑 Status				
Utili	ity ID		U-2							
Utili	Utility duty		10.7499			kW 🗸				
Utili	Utility usage		10.7499			kW 🗸				
Utili	Utility cost		0.833121		\$/hr		•			
CO2	emissior	n rate		3.04374	kg/	/hr	•			

Main Flowsheet × TOWER1 (RadFrac) - Results × +										
Summary	Balanc	e Split Frac	tion	on Reboiler Utilities Stage Util		Stage Utilities	Status 🛇			
Condenser					Rel	poiler	U-1			
Duty					- Du	ty	3850.87	kW	-	
Usage				-		ige	6324.77	kg/hr	-	
Cost				-		st	26.34	\$/hr	•	
CO2 emission	n rate				- co	2 emission rate	911.541	kg/hr	-	
Pumpar	ound ut	ilities								
Decanter utilities										



Main Flowsheet × TOWER2 (RadFrac) - Results × +										
Summary	Balance	Split Fraction	n Reboiler	Utilities	Stage Utilities	Status 🔮				
Condenser		Reboiler U-3								
Duty				- Dut	ly.	2717.17	kW	•		
Usage				- Usa	ige	4807.38	kg/hr	•		
Cost				- Cost		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	ilities Stage Utilities 🛛 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									



References:

- 1.EIEPD members' experience
- 2. Aspen Plus build-in help
- 3.Learn Aspen Plus in 24 hr. by Thomas A. Adams II