

# How to Value your Intermediate Streams

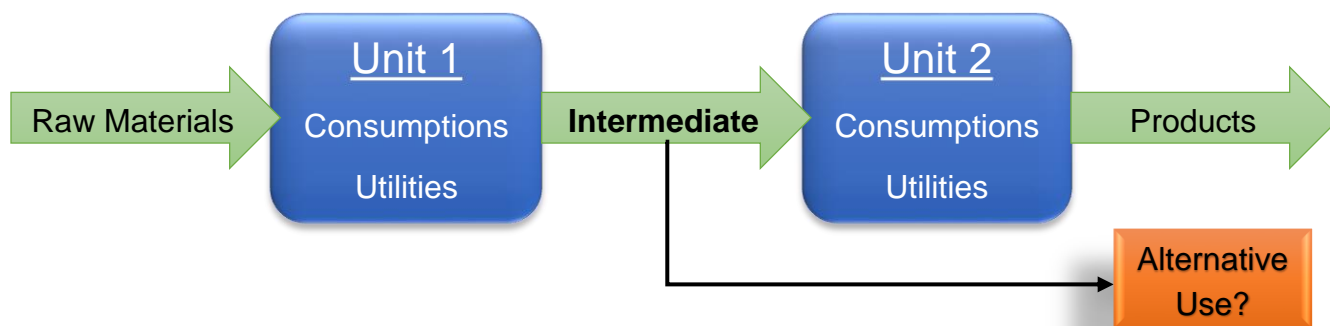


Figure 1 Multi-Step Process with Raw Materials, Intermediates, and Products

Many commercial chemicals are made in multiple sequential steps with intermediate streams that generally don't have other uses. For example,

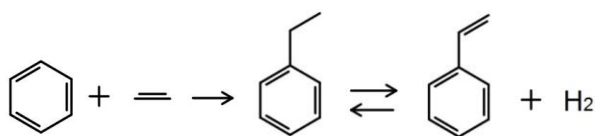


Figure 2 Benzene Alkylation with Ethylene to make Ethylbenzene (EB) followed by Dehydrogenation to make Styrene Monomer (SM)

- Roughly 30 million metric tonnes of ethylbenzene (EB) are made annually to support the demand for styrene (SM) (Platts, 2017). A small fraction of EB is used in solvents and other applications (ICIS, 2010)

Perhaps you're considering an alternative use for part or even all of that intermediate stream. This article will show you how to calculate a value for that intermediate stream.

Also, some byproduct streams from large facilities contain blends of components, each with its own chemical value. For example,

- "*Crude C4s*" from olefin plants and *catalytic butanes and butenes* ("Cat-BB's") from refineries are processed to recover components such as butadiene, 1-butene, and isobutylene that are used in polymers, fuels, and other chemical intermediates. See Figure 3 below. In common terminology for recovery of components in an olefin unit C4 stream, the term "Raff-I" refers to the raffinate after butadiene is recovered using an extraction solvent.

The same techniques of valuing intermediate streams can be used to determine a value for components in a stream or the entire stream itself.

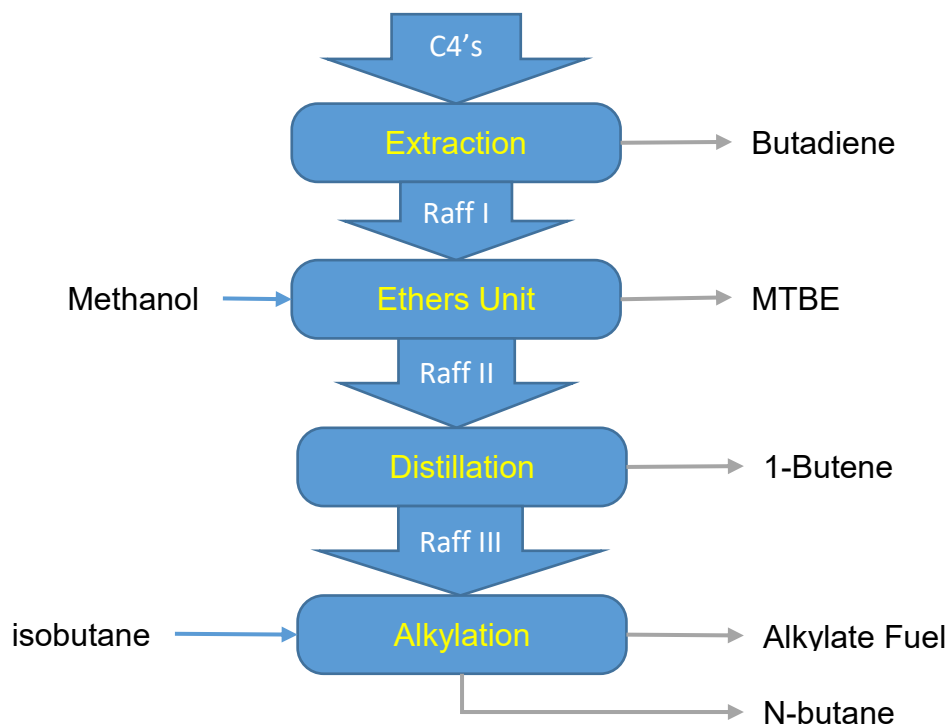


Figure 3 C4 Value Chain: A Possible Arrangement of Recovery Units

## Imputed Value

The term “imputed value” is often applied to an intermediate with little or no market commercial trade of its own, other than to be converted into a saleable finished good. Thus, in the case of styrene, EB’s imputed value is tied to its potential to become styrene.

Sometimes the choice of final product isn’t so clear. In the case of the Crude C4 example, the contained linear butenes (1-butene, cis-2-butene, trans-2-butene) have a number of possible end-games:

- Recover 1-butene for polyethylene (LLDPE) co-monomer. Optionally, isomerize unrecovered 2-butenes to 1-butene, an equilibrium reaction, and recover more 1-butene.
- Send 1- and 2-butenes to alkylation as a motor fuel component.
- Isomerize and react 1- and 2-butenes with ethylene to make propylene.

The determination of which final product will carry the imputed value of the intermediate stream depends on the company, the assets available, and market conditions at the time.

## Working Backwards

You have probably determined the cost of production for a product based on raw material consumptions and prices, utilities, by-product credits, and the like. The imputed value of an intermediate stream is done by working backwards one unit at a time. We'll use the ethylbenzene (EB) example here, as shown in Figure 4 below.

Start with the market price of the finished material (styrene monomer (SM) in this case, taken as 55¢/lb). Determine the consumptions and pricing for any other raw materials, catalyst, and utilities to convert the intermediate EB into product SM. Also include credits for any byproducts. Working backwards, subtract the contributions of each line item, other than EB, from the chosen price for SM. This leaves the value of EB as 53¢/lb SM. Divide by the consumption of EB to SM to get 50¢/lb EB.

### What about fixed costs?

Fixed costs include labor, maintenance, taxes, insurance and the like associated with running the unit regardless of its volume output. Consider two scenarios which might prompt an interest in calculating the value of an intermediate stream:

- Scenario 1: Taking a slip stream from an existing unit for an alternative use. In this case, the existing unit is already seeing fixed costs to make the product, and any intermediate stream feeding the unit should carry its share of those costs. In this case, **don't subtract fixed costs** from the final product price to get the intermediate value. Doing so would unfairly credit the intermediate and "cheat" the existing unit of fixed costs credits it would receive.
- Scenario 2: Considering a new, alternative process/product for the entire intermediate. In this case, the conventional unit converting intermediate to product has not been built, and a new use and process unit is under consideration. **Do subtract fixed costs** based on a conventional unit of current commercial scale, as this is presumably the best alternative to the new process under consideration.

## Conclusion

We've shown how to calculate the imputed value of an intermediate stream in a series of process units, using the conventional styrene process as an example, by working backwards through a cost of production calculation.

When looking at alternative uses for intermediate streams, it is important to compare the cash margins on those alternatives against the conventional route.

		8/25/2017		by: <u>Process Evaluations LLC</u>	
<b>Imputed Value of Ethylbenzene as Styrene Precursor</b>					
			<u>Unit Price</u>	<u>Consumption</u>	<u>Cost</u>
<u>reference</u>	<u>Raw Materials</u>	<u>units</u>	<u>¢/unit</u>	<u>unit / lb Styrene</u>	<u>¢/lb Styrene</u>
1	Ethylbenzene	lb	50.2	1.057	53.1
3	Catalyst				1.0
					<b>54.1</b>
	<b><u>Utilities</u></b>				
1,3	Steam	lb	1.10	2.6	2.8
1,3	Cooling water	gal	0.015	25.7	0.4
1,3	Fuel	MMBTU	500	0.0002	0.1
					<b>3.3</b>
	<b><u>Coproducts</u></b>				
2,3	Hydrogen	lb	62.1	0.019	-1.2
1,3	B/T Byproduct	lb	40.0	0.029	-1.2
					<b>-2.4</b>
<b>Styrene Market Price</b>					<b>55.0</b>
<b>Step by Step Instructions:</b>					
Step 1: Set a styrene market price which will determine the ethylbenzene (EB) value					
Step 2: Set consumptions of all raw materials, byproducts, and utilities					
Step 3: Set prices for raw materials (other than ethylbenzene) and utilities					
Step 4: Calculate the contribution of items in Step2 and 3 to the variable cost of styrene					
Step 5: Calculate the Ethylbenzene value, as ¢ / lb styrene, by taking the styrene market price (step 1) minus items above. The ethylbenzene (EB) imputed value, ¢ / lb EB, is the EB value (¢ / lb styrene) divided by the consumption of EB, lb EB / lb styrene.					
<b>references</b>					
1	For consumptions: Robert A. Meyers, <u>Handbook of Petrochemical Production Processes</u> (2005, McGraw-Hill), Table 11.2.3				
2	Prices roughly indicative of \$5/MMBTU natural gas as fuel. Hydrogen value assumed at twice its fuel value				
3	Catalyst cost and B/T (Benzene/Toluene) byproduct are arbitrarily chosen for this example.				

Figure 4 Worked Example for Ethylbenzene Value based on Styrene