

## BIOPROCESS CAPITAL COSTS

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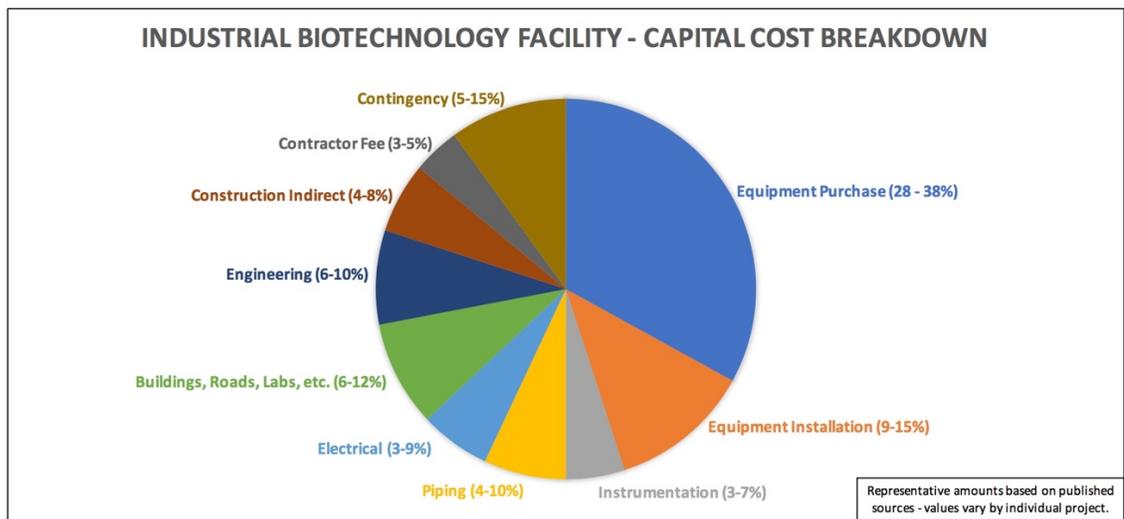
Discussion of biotechnology capital costs is often a controversial topic, on par with discussing politics at the Thanksgiving dinner table; why the facilities are so expensive and a disbelief of the forecasted costs. As a seasoned veteran in the battle, trust me when I tell you that the cost of a fully-constructed industrial biotechnology facility will be about 3 times the purchase cost of the major equipment. Similar to election day, just because the estimate is not the desired outcome, does not mean it is not reality. Let's explore:

**Back of the envelope** – In the early phases of project development there is a need to understand the order of magnitude capital cost of a proposed project. Quite simply, knowing whether a proposed facility will cost tens of millions or hundreds of millions will make a big difference in process development and fundraising efforts. This is accomplished by factor-based estimates, determining the major equipment required and multiplying by industry factors (known as Lang factors<sup>1</sup>) to determine an order of magnitude costs. They are determined from previously executed projects and compare total project cost to the cost to purchase major equipment. If a previous project had a total cost 3 times the cost of equipment purchase, it is a reasonable assumption a similar project will be 3 times the equipment cost.

**It's a secret** – The factored estimate approach seems easy, if you have accurate cost factors. The problem is, for emerging industries like industrial biotechnology, there is not a lot of publicly available documentation supporting them. You can often find them in public documents for more mature industries like pharmaceuticals (5 to 6 times) or petroleum refining (4 to 5 times), but not for emerging industries. I can tell you from personal experience that the Lang factor for industrial biotechnology range from 2.5 to 3.5 times the equipment cost and this is generally accepted by engineering firms and capital project groups, but unfortunately all the data to support this is based on proprietary information. NREL has published a series reports<sup>2</sup> on biorefinery economics that calculated detailed capital cost estimates and backs into Lang factors. While they are for proposed facilities and not actuals from completed projects, they are one of the best publicly available sources to support the range.

**It just can't cost that much** – a standard response I have received many times over the years by senior management who sincerely do not believe it can cost more to install equipment than to purchase it. I understand that it may not be intuitive to some, unfortunately the perspective is not backed by data. As noted in the paragraph above, installation factors from other industries are ABOVE the range I quote for industrial biotechnology. While the hopes of a plant only costing 50% more than the equipment (1.5 installation factor) is an admirable dream, it is unfortunately, a dream. The installed cost ranges for individual project components will vary, but for most industrial biotechnology projects, the chart below illustrates typical cost

percentages for primary project costs. While equipment purchase is a major component, it only represents about one-third of the total project cost.



**Everything I need to know I learned in ChemE 201** – The first and most basic chemical engineering class at most universities is material and energy balances, developing detailed analysis of what compounds go where in a chemical process and how much energy is added or removed along the way. It is the key starting point for any capital cost estimate and provides required project definition. Think of it this way, you cannot determine how much a car costs until you define what kind of car you plan to buy. Taking shortcuts in this area is a mistake and a well executed effort pays dividends down the road.

**Sizing the equipment is key** – When developing a factored capital cost estimate, the most important item is to determine the size (and thus cost) of the equipment. The key to doing this accurately is understanding flow rates, required separation efficiencies and working with vendors to select the right equipment. Data from the specific process is critical and should not be “assumed”. Guesstimating the equipment size will generate a factored cost estimate that provides limited value and inadequate accuracy to be relied upon.

Understanding the basic principles outlined above will provide a perspective that allows early-stage capital cost estimates to be used for key strategic value and not as an aspirational (and often unachievable) target.

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Note 1 – Lang Factors were introduced by H. J. Lang in Chemical Engineering magazine in 1947 as a method for estimating the total installation cost for plants and equipment.

Note 2 – NREL has published a series of Process Design and Economics studies on bio-based processes. The total cost estimates include calculation of projected Lang factor, see reports TP-5100-62498, TP-5100-60223 and TP-6A2-46588.