Factors That Raise the Cost of a Pilot Plant

Process systems typically have two types of cost. The first category of costs: upfront capital required to design and build the process. The second category; operating costs, which include everything needed to run the plant on location. Raw materials, electricity, water and man power are all examples of typical operating costs.

This article will focus on factors that affect the upfront capital costs. Especially for a pilot plant, capital costs tend to drive most decision since a pilot module has shorter required run time and smaller product output.

Listed below are a few of the bigger factors that will affect your final price for any pilot plant. These explanations will be short and gloss over some of the more esoteric issues that complicate things, but they are also a good jumping off point for understanding what drives costs on a pilot plant project.
Pilot Plant Cost Factors:

- **Application complexity** – a more complex process has more equipment requirements, engineering design and modeling, and more complicated programming. Each of these drives up cost but will be required to make the pilot process system work properly.

- **Process Conditions** – High temperatures and high pressures also drive price up. The more difficult or unusual the process conditions, the higher cost will be. Examples of situations that will drive up temperature and pressure costs include high viscosity fluids, particulates/slurries, non-Newtonian fluids, and degree of difficulty of separation (if required).

- **Flammables** – This is really a process condition but is a big enough deal it has its own bullet. Flammability changes relief sizing and electrical classification which in turn effects instrumentation cost.

- **Instrumentation** – A primary reason to build a pilot plant is to gather enough data to build a production facility and you need instrumentation to gather this data. Instrumentation costs can rival other equipment costs (and in special cases, surpass it) so knowing what parameters are critical is vital. Additional instrumentation also requires more engineering time to specify and program.

- **Flow Rate** – Overall throughput of the unit also drives cost. The higher the flow rate, the larger the required piping, vessels and instrumentation sizes. Larger piping and instrumentation cost more. A 4-inch diameter pipe is dramatically more expensive than ½ inch.

- **Number of Pieces of Equipment** – More equipment means higher costs. This is one is pretty intuitive. More equipment means more money spent on purchasing equipment, and more engineering time specifying equipment and design layouts.

- **Major Equipment Types** – Some pieces of equipment are relatively expensive and can end up driving a sizeable portion of the overall cost. For example, specialty items that have very few manufacturers, compressors, mills, other large rotating equipment are almost all relatively expensive.
- **Materials of Construction** – Will this system be built out of mild carbon steel or does the whole thing need to be glass with lined pipe? Certain chemicals and processes will require more expensive materials of construction to remain safe and keep product contaminant free. Materials of construction have a large effect on piping, vessel, and instrumentation cost. There are some basic rules of thumb for the price difference here. These price ratios are rough but can help get you in the neighborhood.

- **Available Utilities** – Depending what utilities are already on site can allow you to use cheaper alternative equipment and or not have to have skid mounted utilities. If no or few utilities exist, these will need to be built into the pilot skid or added on-site.

- **Site Readiness** – Is there an existing concrete pad with electrical hookups and utilities? If not concrete and civil work should be taken into account. One advantage of a modular pilot plant design is that custom skids can often be designed to fit into small existing spaces.

All of these factors can affect your costs and must be considered. There are a few other items that add to the cost of a project but are unavoidable for a project to be successful.

- **Project Management** – It’s easy to forget cost associated with project management when you are totaling your other expenses but it is probably the most vital money spent on any project. The project manager’s job is to ensure that everyone else has everything they need to keep things moving forward and that the schedule and budget stay on track.

- **Craft Labor** – Setting the equipment, bolting the piping together, wiring the instrumentation and the thousand other tasks required for any construction project are easy to underestimate and are almost as expensive as the equipment itself.

- **Procurement** – Specifying every detail of a vessel, (ex. nozzle orientation, nozzle sizing, piping hookups, pump requirements, etc.,) is a detailed and difficult process. Procurement can be a critical timeline factor. If done wrong equipment won’t be available when you need it due to long leads times and the project will quickly fall behind schedule.
Putting together an accurate cost estimate for a pilot plant is non-trivial but getting a rough order of magnitude estimate can help to see if this project is in the ballpark of what is reasonable.

The cost of a pilot plant is a small fraction of what a full production system will cost, and should be viewed as an engineering investment. You can either spend money eliminating unknowns before you build a commercial scale system, or you can spend it fixing problems and dialing in the engineering during design build of the larger system. Are you willing to risk having to rework your whole hundred-million-dollar production plant just to save a little money early on?

Similarly, the design work to estimate the pilot plant cost should land around 1-5% of the overall total cost of the pilot plant project. Doing this work on the front end helps turn your unknowns into knowns and gives confidence the overall project will be successful.

**Seven Ways to Reduce the Cost of a Pilot Plant**

Securing funding for your pilot plant project can often be the single biggest hurdle to moving forward. Pilot plant testing allows you to properly vet your process, but the more capital required to build a test system the more difficult is to get approval. Alternately, if you skimp on the funding, you may build a pilot unit that doesn’t return enough data to make it a useful endeavor.

There are things you can do to bring down the cost of your pilot plant project but still get the valuable information you need to vet your technology. The top seven things to consider are:

1. **Can you shift any capital costs to operating costs?** Is it an operating or a capital expense? Since a pilot module is a temporary operation, you could certainly get away with less automation and more manual intervention. This can mean fewer automatic valves or removing automated solids handling equipment in lieu of an operator with a shovel.
Just be careful not to sacrifice the robustness of your overall system. People can be inconsistent and could potential introduce a new source of process upsets, increased transient states, or required startups & shutdowns.

2. **Can you reduce MOC (Materials of Construction) costs?** Reducing materials of construction cost is another way to bring down your overall expenditure. You might be able to get away with something that just has a ‘good’ or ‘fair’ rating, depending on the particulars of your process. Obviously, the best way to confidently make this call is coupon testing at lab scale. Putting coupons in your pilot can bring savings in a production scale facility because you will have more certainty about what will and won’t work.

3. **Can you change your throughput requirements?** There is a very important balance that must be struck when deciding on the production rate of your pilot plant between cost and the certainty it will accurately reflect the full production plant. A 1000:1 difference is too big to give much confidence in most situations whereas a 2:1 ratio would give an immense amount of confidence but would be a waste of money. Good engineering judgement and cost benefit analysis are critical when making this choice. Knowing which unit operations are most likely to change with scale and how to combat this is key and where a professional can help.

4. **Is there a more suitable site?** If you can locate your pilot plant on a site with existing utilities it is almost always an excellent call. It is doubly so if required draw materials already exist for your process. One word of caution here; remember to check your air & water permits, especially if your process might alter an existing permit.

5. **Does all your instrumentation serve a specific purpose?** Identify what instrumentation matters and trim back as much as possible. If the data gathered won’t change any design decisions or refine any selections, it might not be worth the cost to gather it. It is a natural thing to want as
much instrumentation as you can get on your pilot plant but that must be balanced with cost. Knowing which measurements are critical and which fall into the ‘just nice to know’ category is imperative.

6. **Does your project fit with a compressed modular build schedule?** Modular fabrication can reduce cost through off-site construction at a process system fabrication plant, which helps compress project timeline, ensure quality production-like construction inside a controlled environment, and reduce OSHA exposure hours. Read more about [advantages to modular fabrication](#) here.

7. **Are you reinventing the wheel?** Don’t waste time testing parts of the process that are clearly established. For example, if the hypothetical process will revolutionize coffee brewing, don’t worry about how the trees are grown. Focus only on the parts required to test your technology.

    If a portion of your production facility is a mature, well understood technology then excluding it makes sense. This can be everything from having bulk tanks of CO2 instead of scrubbing flue gas, burning syngas instead of feeding it into a second process, or not purifying your final product.

    This always works better for downstream processes rather than one that feeds another unit operation. I always recommend running this by both your pilot plant design team and your internal technology stakeholders to make sure you aren’t removing critical processing steps.

This is certainly not an exhaustive or fool proof list to make a pilot plant more affordable, but ideas to get you started. Take this advice and combine it with good engineering sense about your own technology, expertise from a pilot plant designer, and common sense.

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