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Project Viability: The Case for Techno-Economic Models

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Introduction

Techno-Economic Models can be used early in the development process to 1) determine if the project has potential to be viable, 2) to make more efficient uses of available resources and 3) to increase the odds of the project being viable.

First there is no process that is either viable or not, it is only when the process is used in a project with real world constraints and challenges than the concept of profitability or viability can be even addressed. The discussion below is make inside of that constraint and any reference to a process being viable/profitable is meant to be in the context of a real world project.

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Making Economics Analysis part of Process Development

The journey to develop a metallurgical process is typically long and difficult. The schematics below can serve as a road map of the major steps required in this journey. The most often neglected part of this journey is economic analysis which is typically not done with any rigor until the development is nearly (thought to be) complete. There are two huge problems with this approach:

- Large amounts of resources can be spent on developing processes that have little economic potential
- The opportunity to adjust the process to make it eventually more profitable in the Conceptual Phase of Process Development (the least expensive phase) are missed.

The Role of Techno-Economic Modeling in Process Development

I advocate developing a techno-economic model concurrently with the development of the chemical process. The initial model can use stoichiometric chemistry to estimate profitability; such a model will be optimistic by its very nature. As knowledge of the process chemistry grows, the subroutines defining the unit operations can evolve in sophistication. The goal of the model is to use all information available to predict the performance of the process in a commercial setting and then tie that performance to the economics in a dynamic case by case basis. In complicated system, some thermo-dynamics maybe be used or programs like Met Sim can be used to obtain an understanding of the system which can used to modify the techno-economic model to make it more reliable. An example of a Techno-Economic Model can be seen by following this link.

The goal of the modeling is to quickly identify which unit operations have the most impact on the bottle line and to focus resources there. As the process grows into a project, the role of the model is to identify not only what internal process variables impact viability but what external project parameters impact performance including (1) the cost of raw materials, (2) value of products, (3) tariffs, taxes, and other fees, (4) regulatory and environmental requirements, costs, etc., (5) local labor rules, and (6) energy costs.

MV has extensive experience with developing Techno-Economic Models that run on VBA (Visual Basic for Applications) with outputs to Excel. Developing such models require an understanding of the metal chemistry, process engineering, good software skills, and a good grasp of finances. Of course, because VBA programming is driven by subroutines, each model built makes the next model easier.

The Process of Developing a Metallurgical Process

The process of developing a chemical/metallurgical process can be divided into three somewhat arbitrary stages:

- The Conceptual Stage
- The Pilot Plant Stage
- The Commercialization or Engineering Phase

The Conceptual Stage of Process Development

The standard process of developing a metallurgical process is to propose several flowsheets based on past experience of the researchers and wealth of processes available in the literature. Then a flowsheet is picked, usually based on the “gut” and biases of the researchers. What follows is extensive laboratory work to establish what works as expected and what doesn’t. Years of work and millions of dollars can be spent on this approach. Once the process is mostly working then an economic analysis is done on what is perceived to be the “best” flowsheet.

An alternative is to proposed several flowsheets and then answer the question, “if they work well” can a profitable process/project be built. Again, we are back to techno-economic models to pre-screen the best processes and to identify which steps in the process must work well for the process/project to be viable.

This method of process development is depicted in *the Process of Process Development*, Figure 1. The goal is to link the results of the laboratory work directly to the economic outcome. For example, the typical approach tends to equate “a high leaching recovery” with better economics, instead of more direct measures like dollars of acid per ton of recovered metal. More direct measurements of success result when an appropriate techno-economic model is being used. The goal is to direct the laboratory work in a way that the unit costs of the products are minimized while maximizing the revenues per unit of raw material. To put it another way, ***the role of the techno-economic model is to provide information that enables the team to maximize the gross profits of a project.***

The biggest potential for enhancing the economic performance of a project is in the Conceptual Phase. Using a model to estimate future economic performance enables an efficient use of resources both for this stage of the project and for the project as a whole.

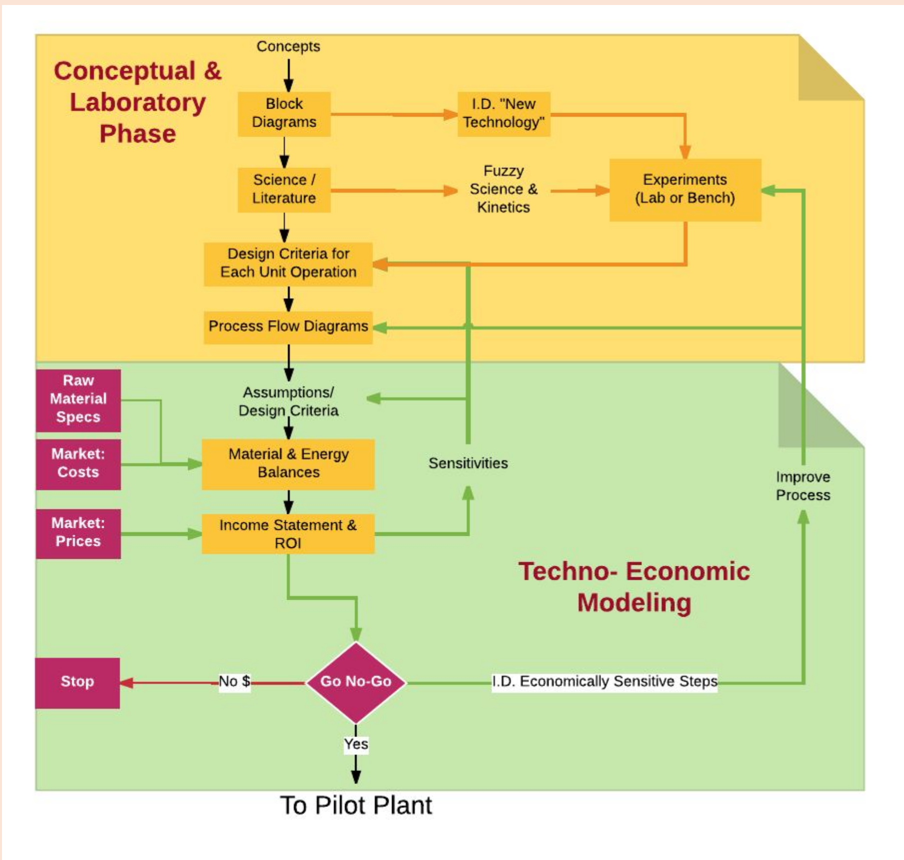

Figure 1. Using Techno-Economic Models to make the "Process of *Process Development*" more efficient.

The Role of the Techno-Economic Model in the Pilot Plant

The role of the techno-economic model during the pilot plant comes in two areas: 1) when performance of the pilot plant is different, usually less efficient but not always, than the laboratory results, the model allows the impact on the economics to be evaluated in nearly real time and to take corrective actions accordingly. And 2) it allows differences in performance of different pieces of equipment doing the same job (say a belt filter versus a filter press) to be evaluated in terms of its economic impact on the project. Of course, such analysis even with a good model takes time and effort, but the payoff is immediate and decisions are based on overall project economics instead of sub-optimizations of unit operations.

In Figure 2, a typical decision chart is shown to insure that the pilot plant accomplishes its objectives. Some **typical pilot plant objectives follow**:

1. To show the process produces marketable products by producing large samples for potential customers of those products.
    a. A sub goal would be to get off-take agreements for products based on pilot plant samples.
    b. A second sub-goal would be to show the process remains viable with significant changes in plant feedstock.
    c. If the product is off-spect, make engineering changes.
    d. Evaluate the impact of off-spec products and/or changes to the process on plant economics via the techno-economic model.
2. To verify the performance of key plant equipment especially any custom made equipment.
    a. Scale up data for all key equipment.
    b. Energy consumption per unit of throughput for energy intensive steps.
    c. Specific data according to the function of that equipment (for example, leaching efficiency as a function of key process data for a leach tank / agitator).
3. Verification that materials of construction are adequate
    a. by recording with high quality pictures of all process equipment especially surfaces that come in contact with process fluids and solids.
    b. by measurement and documentation of corrosion/erosion of plant equipment
    c. by the placement of corrosion coupons of materials of construction that are both more active and more noble than the actual alloys used. These results can then be used to reduce costs by choosing a less expensive alloy or a more expensive alloy if the material in the pilot plant did not perform.
4. To demonstrate that the process as a whole is robust and can work at near the designed throughput.
    a. Typically this is shown by demonstrating the design capacity can be met over an extended time period, say a month, while producing on-spec products.
    b. Third party verification of the pilot plant's performance is very important in the engineering and financing stage of the project. Data to show a "new

process" is robust to investors is essential.

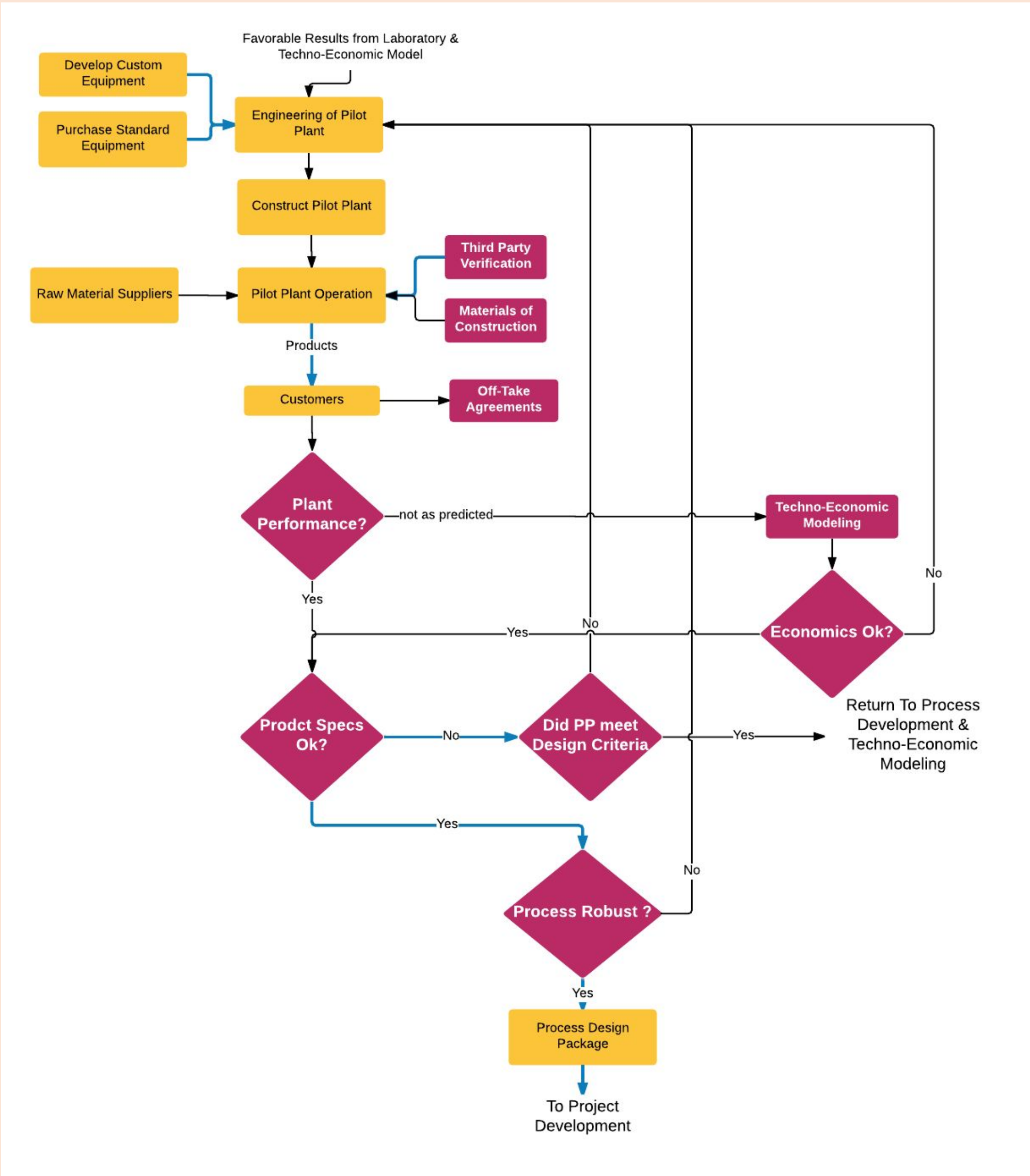

Figure 2. The Role of Techno-Economic Modeling During Piloting of New

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Of course, by definition there will be setbacks in a pilot plant. When a unit operation does not perform as expected, the impact on economics can be evaluated with the techno-economic model and depending on the results the decision can be made to spend time engineering a solution to the problem if the impact is severe or postponing improvement until the engineering stage of the project if the potential impact is not severe and proven commercial solutions exist. Of course, the latter viewpoint is only possible if the performance of the balance of the plant is not severely hampered by the underperforming unit operation.

Marketing during the Pilot Plant

It is during the pilot plant that relationships with potential customers of your products should be built. The best showcase for this is the pilot plant itself, the best evidence the project is viable is to produce on-spec product samples for the customer. In some cases, the size of these samples can be quite large when their ultimate measure is how they perform in a process owned by the customer.   If the customer is a potential investor, then showing them the results of the techno-economic model may be appropriate.

The Engineering Phase of Metallurgical Process Development

Once a process has been developed in the lab, proven in the pilot plant, and shown to be economical with a reasonable expectation of a good return, a Project can be developed to commercialize this technology, Figure 3. Some details from the Pilot Plant are repeated in this schematic to show how the Pilot Plant fits into the larger picture.

As shown in the schematic below, the major functions during this phase are:

- Engineering
- Procurement
- Construction
- Financing, and
- Startup

Upgrading the Techno-Economic Model

During engineering, the first good estimate of capital costs are made. Previous to this the sixth tenth law is used with the capital costs of similar projects to estimate various financial factors like IRR (Internal Rate of Return) and NPV (Net Present Value). In both the Pre-Feasibility and Feasibility Study, it is often useful to estimate the capital cost of two or more plant sizes and then fed that into the techno-economic model to help select the optimum size plant to build and to understand how the size of the plant impacts the financial yardsticks being used.

Some typical uses of the model in this Commercialization Phase include:

- To evaluate various funding options/sources on project profitability.
- To evaluate various engineering strategies to minimize risks - for example, what is the impact of redundancy in the plant on viability/profitability.
- What if the plant is built larger? How will that impact ROI? Cost? Raw Material Requirements?
- How do project delays or accelerations impact return on investment?
- Can a more expensive piece of equipment be justified by its improved performance?
- How does the taxes/tariffs/labor rates/energy rates, etc. in two different sites impact viability?

A good model just becomes another tool in one's arsenal to achieve a viable project.

Conclusion

Of course, there is a lot more to having a successful project besides a techno-economic model -- but that is beyond the scope of this paper. Hopefully, this paper has given you a new perspective on how such models can improve the odds of your project being viable and allow you to use your limited resources more effectively.

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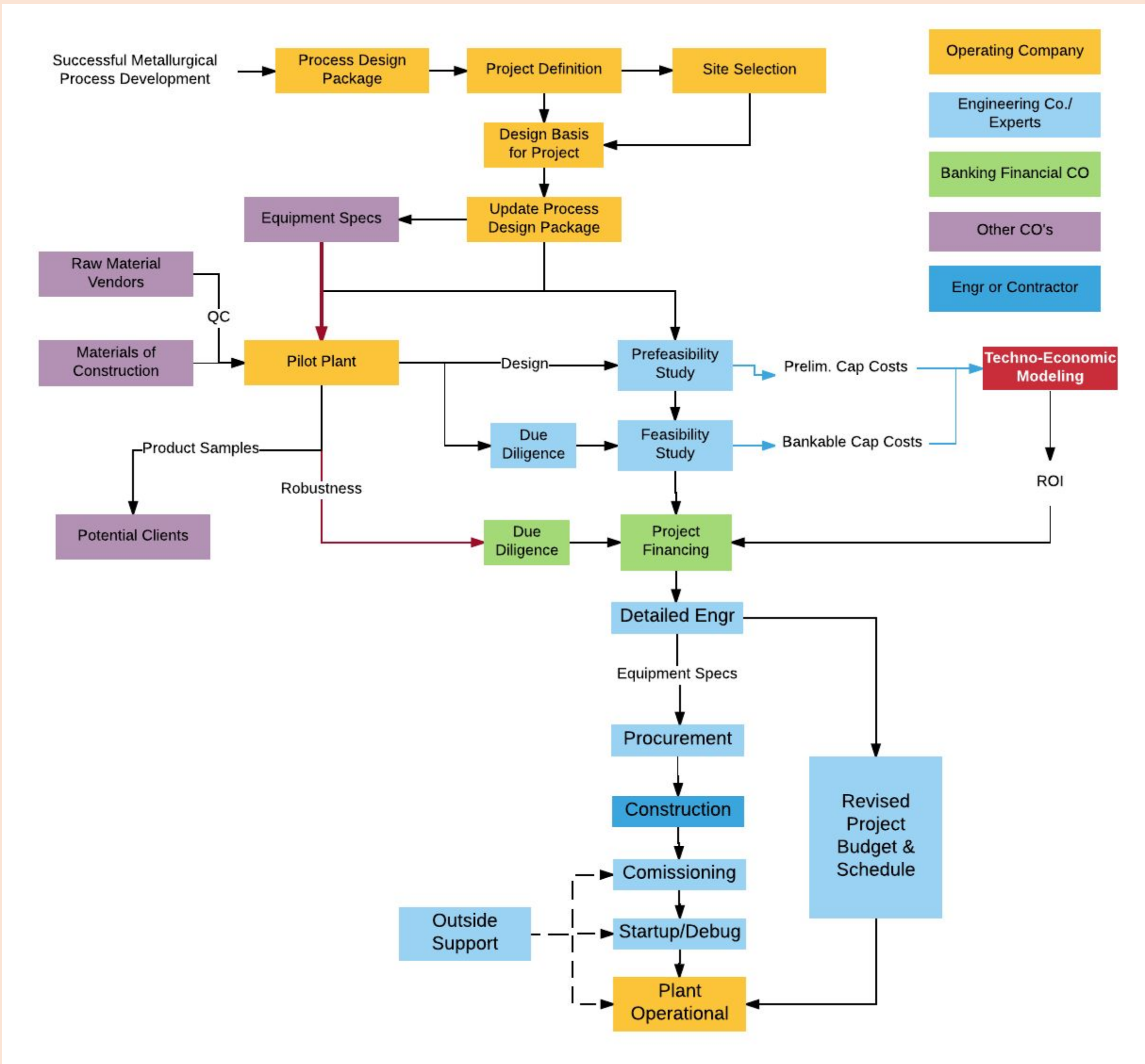

Figure 3. The Engineering Phase of Project Development