The Design Case

Last semester you were involved with analyzing an existing chemical plant. This case is called the **rating case.** For the rating case, your team completed mass and energy balances, identified the function of each piece of equipment, determined if the equipment was operating properly, and also suggested improvements and optimizations to improve the performance of the process.

This semester we will be involved with the **design case.** The design case involves designing a process to produce a new product. The idea for the product usually comes from upper management within a chemical company, although it may come from other sources. Your team is usually assigned the project and must perform an analysis to determine if this is a good product for the company. "Good" might mean a variety of things to different companies. For most companies it usually means that the product will make money, but it may also mean that the product:

- Is consistent with the company mission and vision.
- Fits within the existing product lines.
- Uses existing raw materials that the company already produces or uses.
- Has adequate technical support and experience.
- Has adequate marketing and sales support.

Your team's assignment at this stage is to perform a **preliminary design** of the process. The preliminary design analysis is not a complete, detailed design - adequate information is not provided to actually construct the plant. The purpose of the preliminary design analysis is to

provide adequate information to upper management so that they can make a decision on spending additional money to complete the detailed design specifications. A **full design** includes complete and detailed information to construct the plant. This includes a complete PFD, P&ID, plant layout, detailed equipment specifications, vendor quotes, and so forth. Your preliminary design may also recommend additional pilot plant and laboratory studies to obtain information required to complete the full design work.

Only a few new product ideas actually result in construction of a new plant. Most of the new product ideas fail for a variety of reasons. This may include,

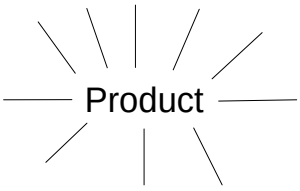
- The product is not profitable (see below).
- The technology to produce the product is inadequate.
- The market demand for the product is inadequate,
- The project is too risky, based on uncertainty in the market or technology.
- Legal restrictions, including patent protection owned by others.
- Political climate within the company.

A product may be unprofitable due to a number of reasons, including,

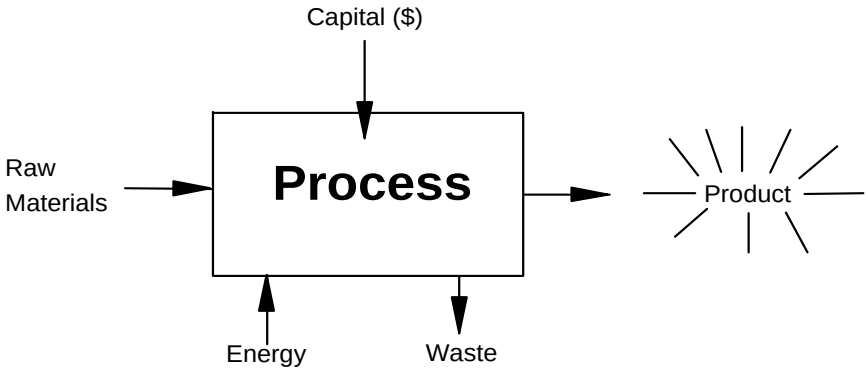
- The market price of the product is too low.
- The equipment (capital) costs are too high.
- The operating expenses for the process are too high, including costs for raw materials and energy.

Since most new product ideas fail, your company will only want to spend a minimal amount of money to make this determination - that is why a preliminary design analysis is completed rather than a full design specification. The bottom line is that your company wants to spend the minimum amount of money to obtain adequate information to make a decision on what to do next.

When your team receives a new product design project, you are usually only provided with the product name, and perhaps a few additional supporting or restricting statements.



Your team's assignment is to provide the following additional detail:



Management is usually interested in two questions related to this new product:

1. How much profit can we make?
2. How much will it cost us to make that profit?

However, in order to answer these two questions you need to provide answers to the following secondary questions:

a. How much product should we produce, i.e. production capacity? What are the product specifications?

b. What method or process should we use to produce the product? If more than one method is available, which method is the best?

c. How much raw materials are required to produce this product?

d. How much energy is required to produce this product?

e. How much waste does this process produce?

f. How safe is this process and what are the hazardous properties of the raw materials, intermediate materials, and product

g. What is the market demand and price, both current and historical, for this

product?

h. Where should we locate the plant?

i. Who are our competitors for this product, where are their plants located and how much do they produce? Who purchases their product?

j. How much money will we spend on operating expenses, including the cost of raw materials, energy, and waste disposal? How much will we spend on overhead and indirect costs?

k. How much risk is associated with this process?

In order to answer these questions, and more, your team will need to complete the following tasks:

1. Business objectives: Includes plant capacity, purity and quality of product, plant location, service factor, expansion capability, turn-down ratio, etc.
2. Detailed chemistry - Include chemical reactions, heats of reactions, kinetics (if known), physical properties, phase equilibria, and any other chemical information required to complete the project.
3. Technical feasibility - What are all the ways to make this product? What were the criteria you used to select a process and why?
4. Safety / environment issues - Describe the safety and environmental issues (including waste disposal) and how they are addressed.
5. Market survey - This includes a historical summary of total production, product price, and raw material prices. Identify and discuss sudden changes in any of these values and project into the future.
6. Base case selection - Select a process configuration that just meets your business objectives that requires the least capital investment.
7. Mass and energy balances - These should close exactly for a paper study.
8. Process flow sheet - Including both overall and detailed.
9. Equipment sizing and technical specifications - This should include equipment size, materials of construction, operating temperature and pressure, duty, etc.
10. Equipment costing
11. Operating expenses - This includes raw material, energy, and waste disposal

costs.

12. Capital expenses - This includes the total cost of the plant and any indirect and overhead expenses.
13. Cash flow for base case - Includes both capital and operating expenses, income, taxes, and any indirect and overhead expenses. This must include the time value of money.
14. Incremental options study - Describe possible capital expenditures that may increase the profitability of the process. Determine the change in capital and operating expenses, and apply a true incremental cash flow. Define a new optimized base case which includes all of the profitable incremental options.
15. Sensitivity - What happens if the raw material or energy prices increase? What happens if the product price decreases? Include Strauss plots showing these effects.
16. Risk - Monte Carlo, other methods.

At the completion of the project your team will assemble a detailed report describing what you did and the results obtained. If the product is not favorable, your report should state clearly why it is unfavorable and what must change for the product to become favorable. This report should be archival and free standing, that is, someone in the future should be able to determine exactly what you did, without question, from the report itself.

During the work, your supervisor might ask for written and/or oral reports on your work. The oral reports might be scheduled or impromptu.

Your employer is looking primarily for one thing in your results: confidence that your team obtained the correct result. Ideally, they would prefer that you achieved this in a minimum amount of time using the least amount of resources. Realistically, this never happens.

From your team's standpoint, there is inadequate time to complete the objectives of your project work. Thus, your team needs to work efficiently. This requires that everyone in your team works hard, the work is equitably distributed, and everyone participate in producing a polished

final result and report. There is a certain amount if intellectual risk in this work, that is, decisions must be made to move the project forward without complete information.