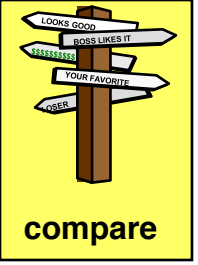


Comparison of alternatives

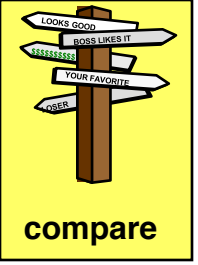
When making a recommendation: “Are we sure?”

We want to answer, “what if?”

- The product (sales) rate or price changes
- The energy costs change
- The project life changes (new technology)
- Feed material costs change

Dealing with uncertainty

We perform a sensitivity analysis

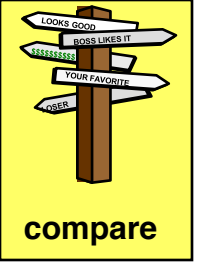


Comparison of alternatives

Sensitivity analysis

Some parameters in the analysis involve considerable uncertainty

- Concentrate on parameters with greatest uncertainty and impact on key decisions
- Determine likely range of variation
- Evaluate profitability over the range
- Determine if key conclusions change: profitability, payback
- If conclusions change, select decisions that give the highest profit considering probabilities.

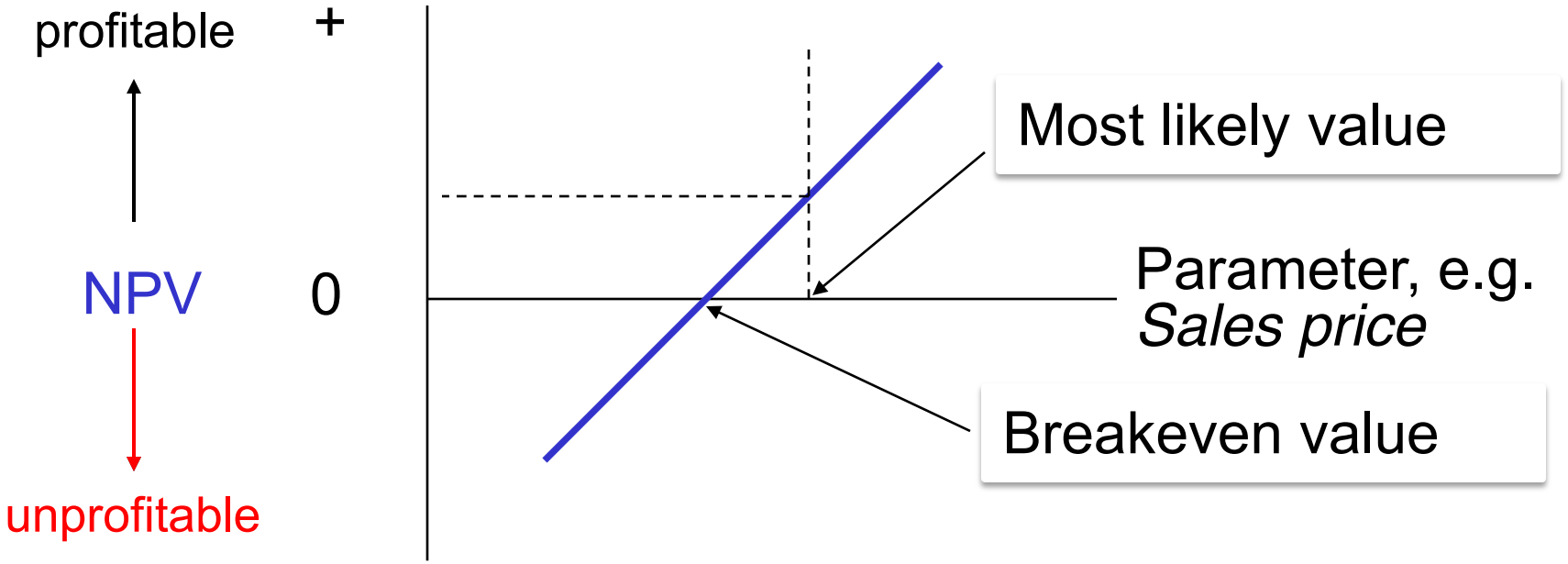


Comparison of alternatives

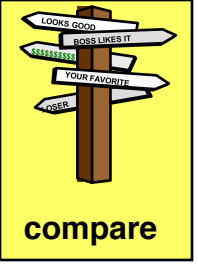
Sensitivity analysis

Results are often presented graphically

For one parameter (*with other parameters constant*)



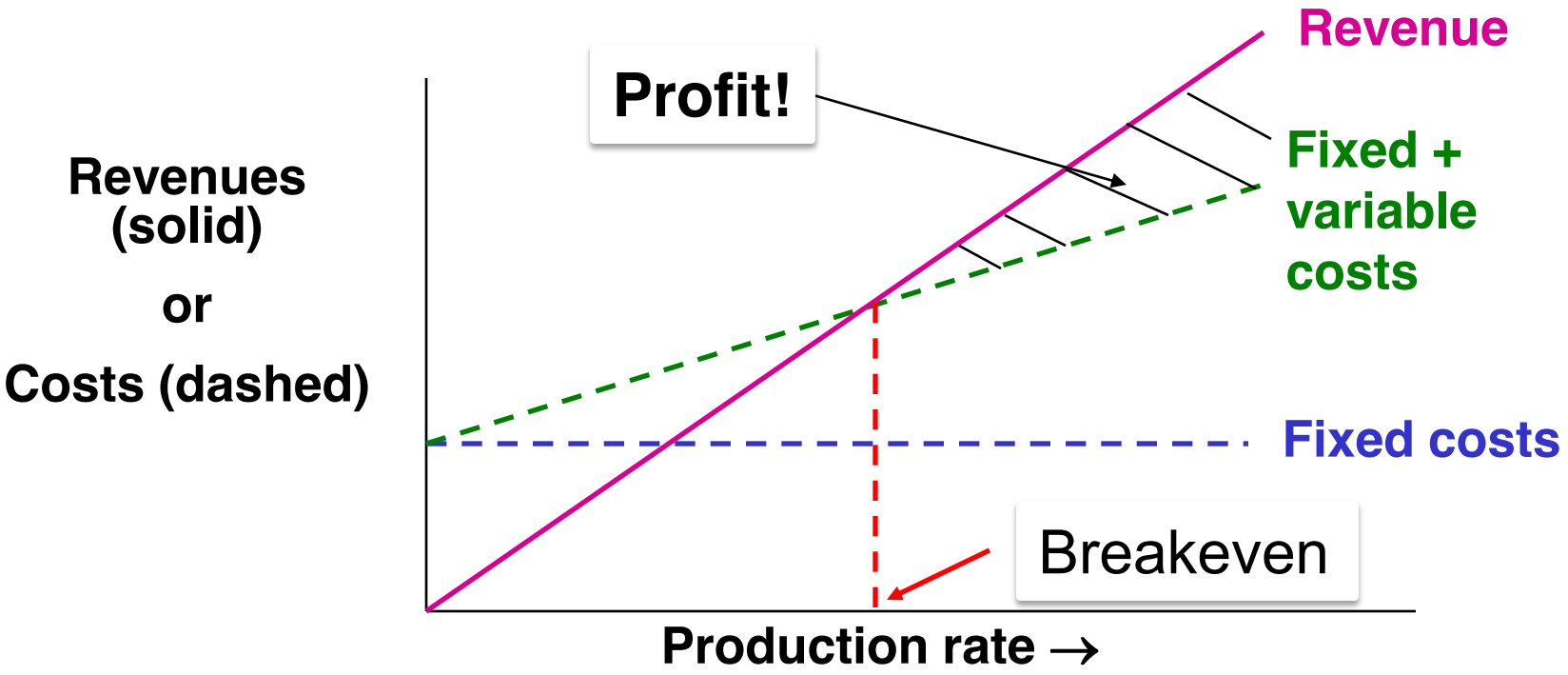
Very important for management to know when evaluating risk!



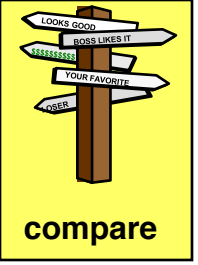
Comparison of alternatives

Sensitivity analysis: break-even analysis

Key parameter: production (sales) rate



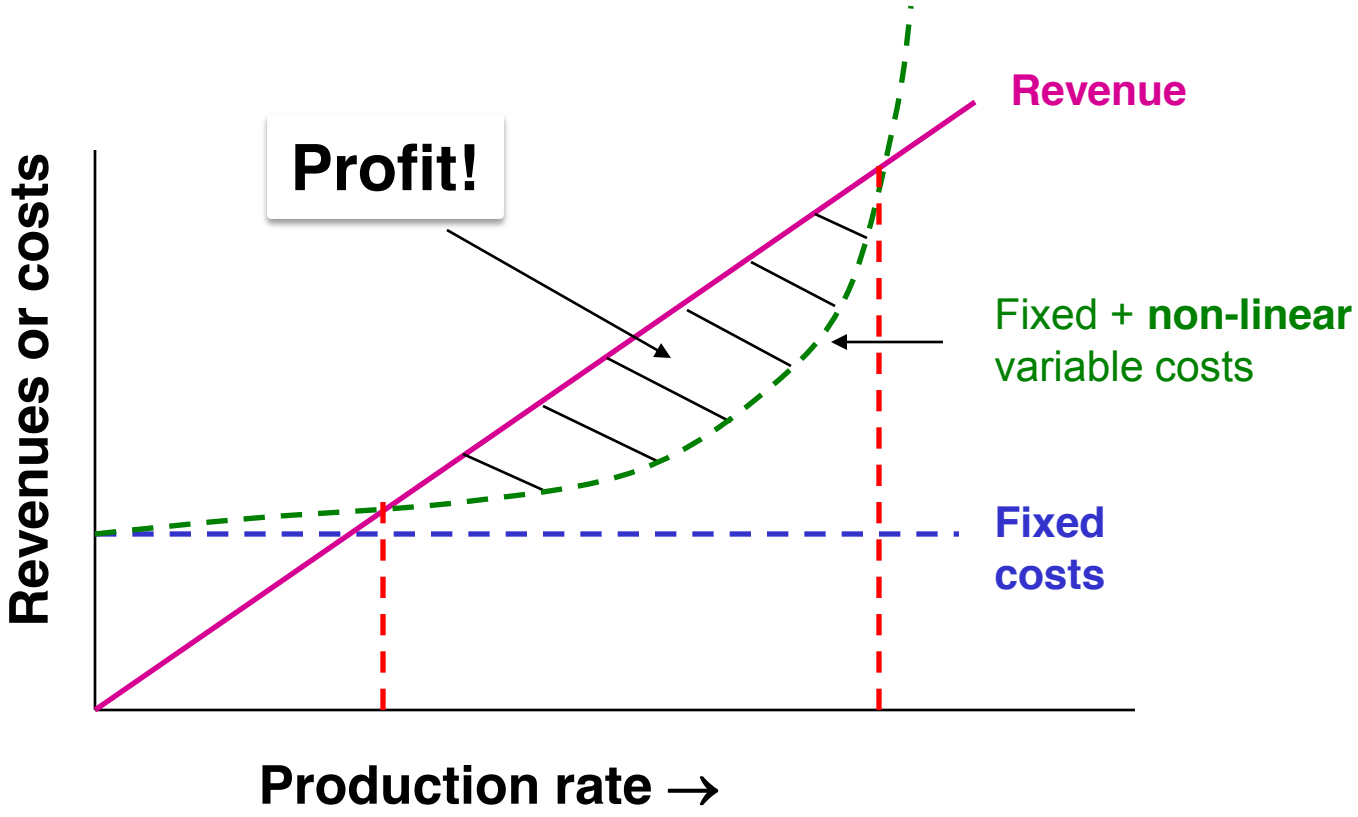
What are each of these costs?



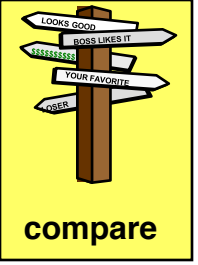
Comparison of alternatives

Sensitivity analysis: break-even analysis

Key parameter: production (sales) rate

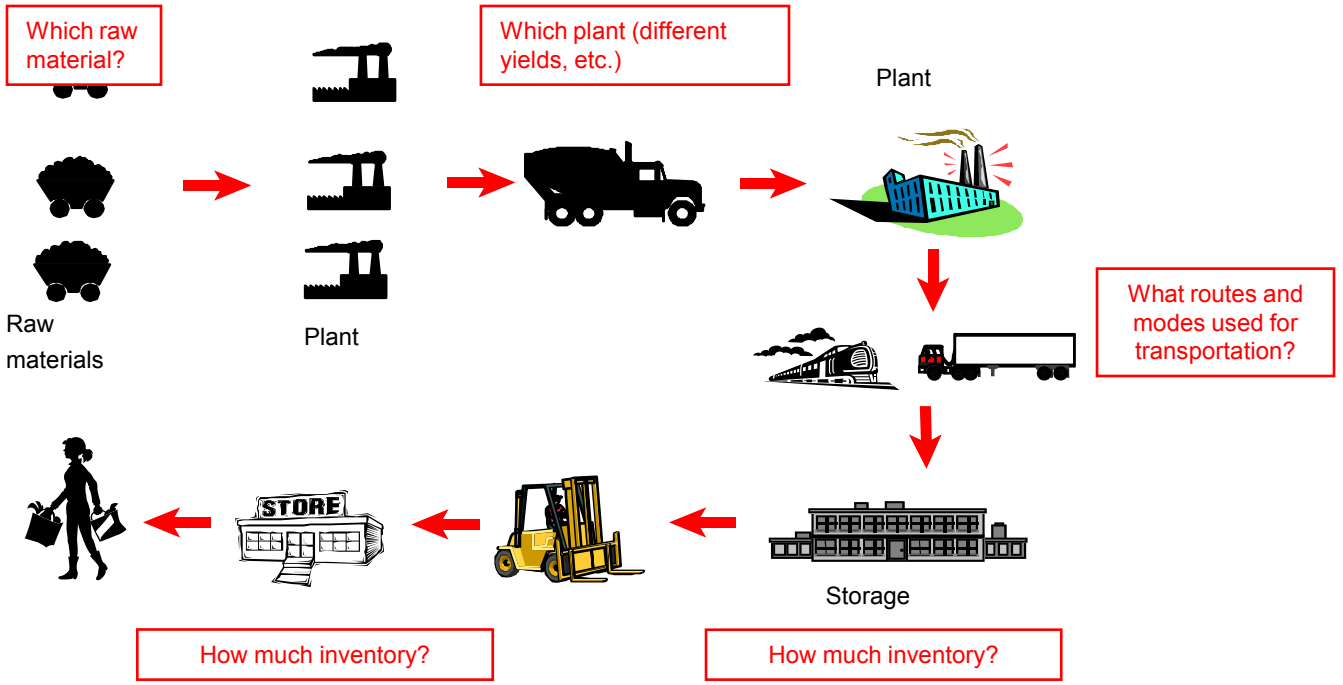


Why might this type of non-linearity occur?

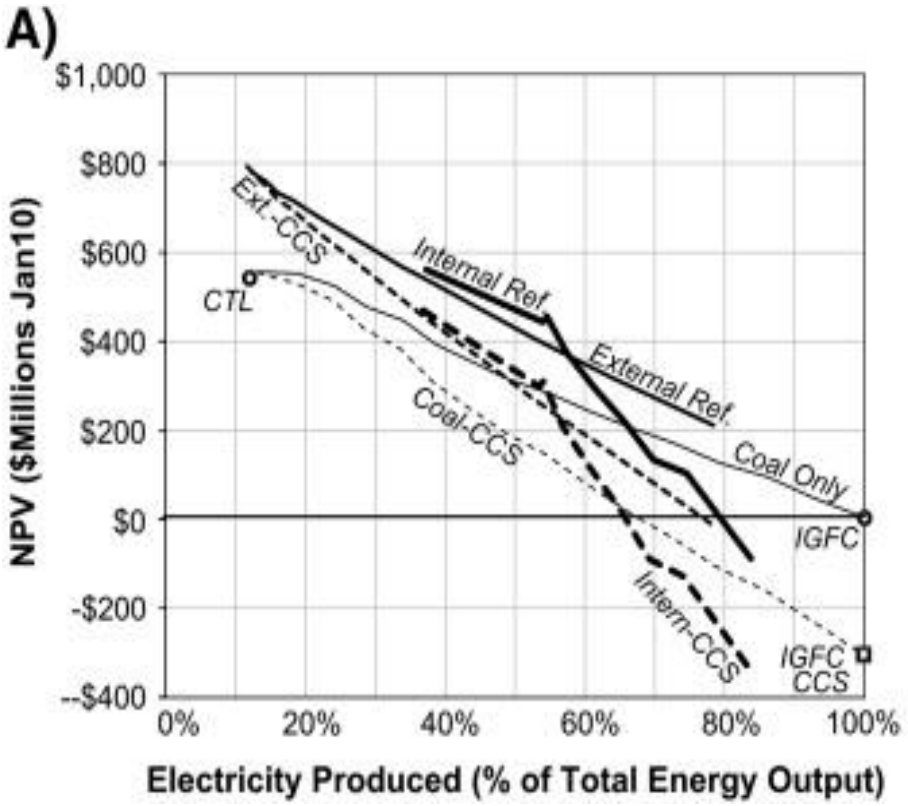


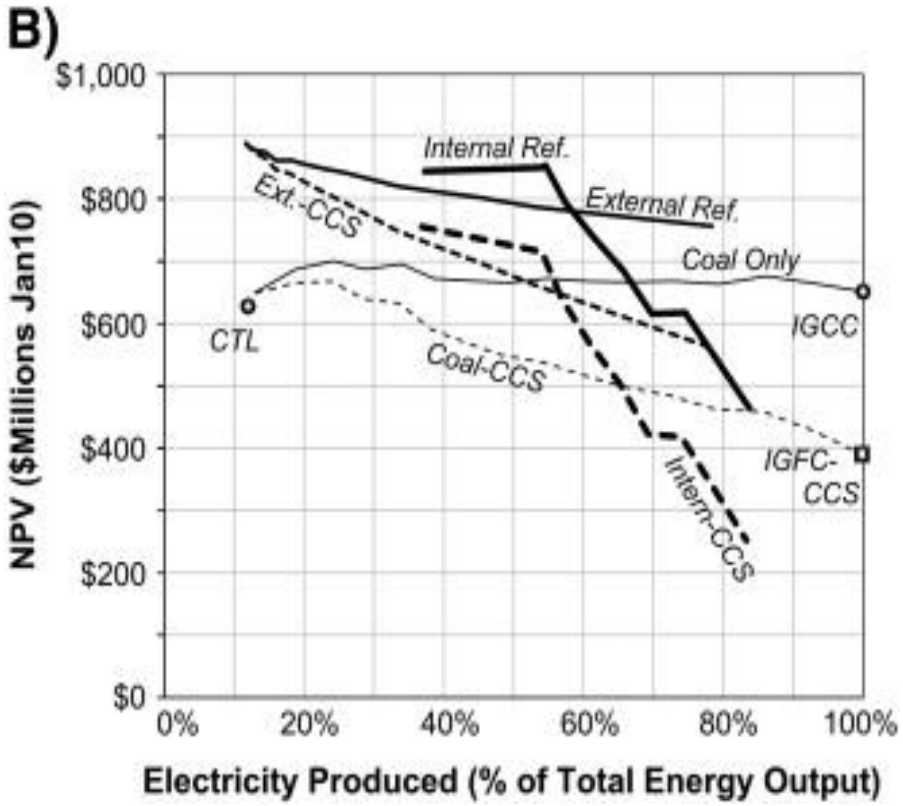
Comparison of alternatives

Sensitivity analysis



As we increase production, we may use more expensive raw materials, less efficient process units, exceed contracts and pay more for energy, etc. The costs might increase rapidly!





Electricity sold at 7c/kWh

Electricity sold at 10c/kWh

Fig.7 (A) The net present value of the six design strategies as a function of the electricity production at the base case market prices (B) The same when the price of electricity is raised to 10c/kWH

Thomas A. Adams II , Paul I. Barton

Combining coal gasification, natural gas reforming, and solid oxide fuel cells for efficient polygeneration with CO2 capture and sequestration

Fuel Processing Technology Volume 92, Issue 10 2011 2105 - 2115

http://dx.doi.org/10.1016/j.fuproc.2011.06.019

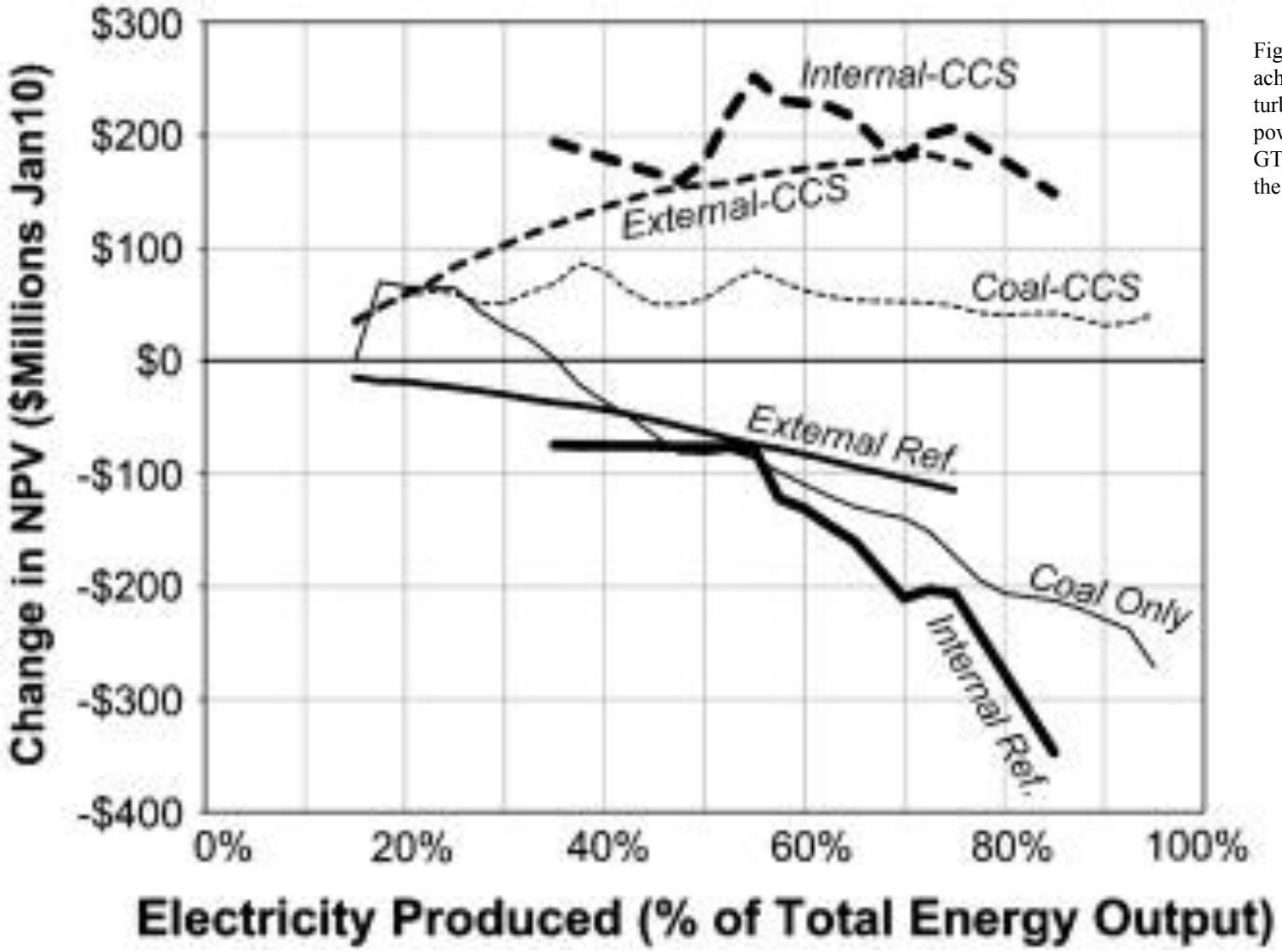


Fig.8 The change in the NPV achieved by switching from a gas turbine to SOFCs as the primary power generator (compared to GT-based cases as a function of the electricity production at t...

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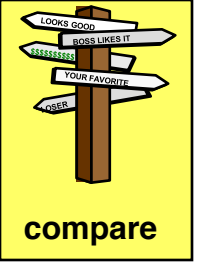
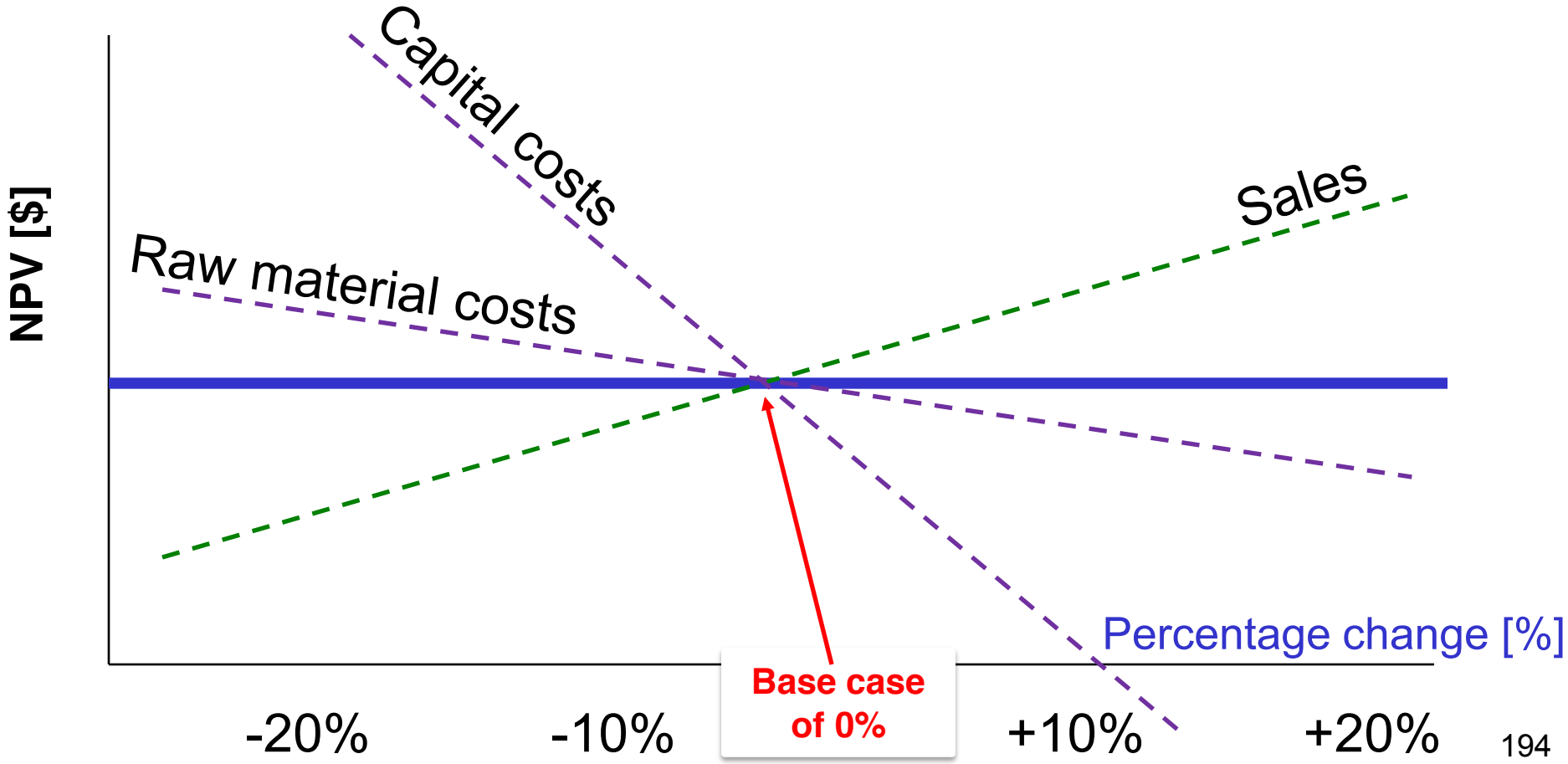
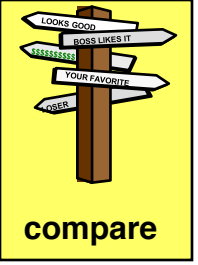


Comparison of alternatives

Sensitivity analysis

Alternative visualization

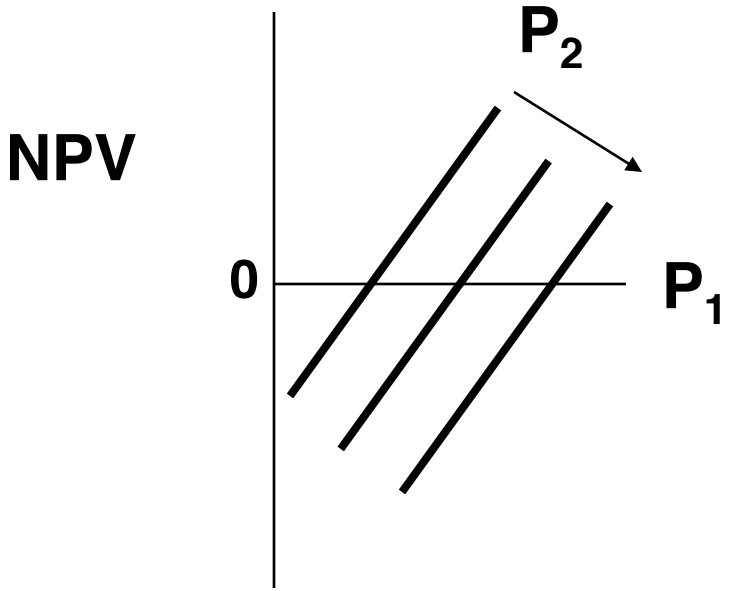


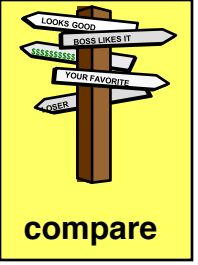


Comparison of alternatives

Sensitivity analysis

Results can be presented graphically for two parameters, P_1 and P_2





Comparison of alternatives

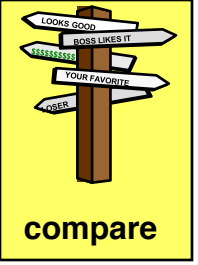
Sensitivity analysis

Apply scenario analysis to bound answer for more than two parameters

Calculate three cases to "bracket" range of profitability

1. Using the "most likely" parameter values
2. Using the combination of likely "Worst Cases"
3. Using the combination of likely "Best Cases"

Careful: Don't get too extreme (too unlikely) with the ranges, especially many concurrent (best) worst cases



Comparison of alternatives

Sensitivity analysis

Apply scenario analysis to determine the expected (most likely) value

Calculate many cases (via computer)

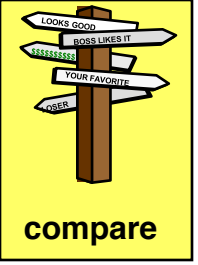
1. Estimate the distribution of parameter values
2. Define many cases, each with sampled values for each parameter. Solve each case for the profit measure.
3. Calculate the "Expected value of profitability"

$$E(P) = \sum_{k=1}^{n} f_k P_k$$

n = number of samples

P_k = profitability for scenario *k* using sampled parameters

f_k = probability of scenario *k*

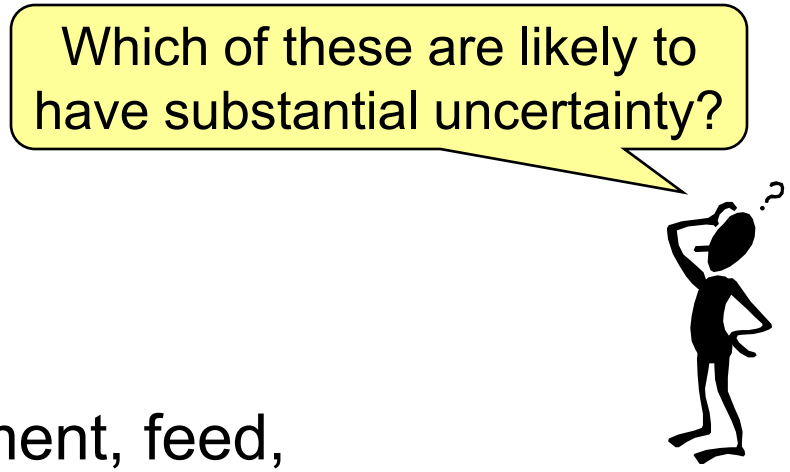


Comparison of alternatives

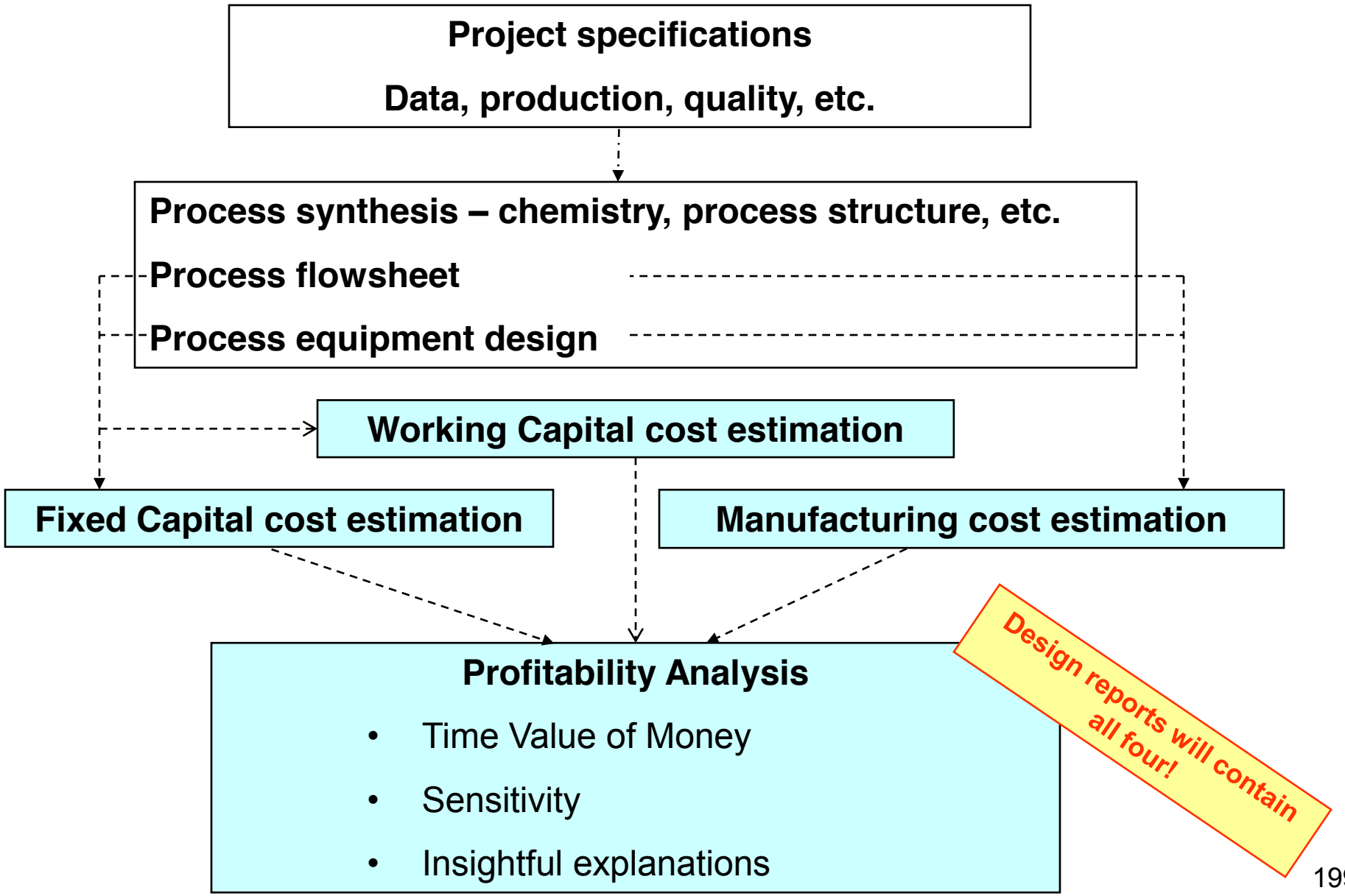
Sensitivity analysis

When defining scenarios, consider what is likely to change in a manner to influence the project decision.

- Market demand
- Tax rate
- Time to construct plant
- Values for cost of equipment, feed, energy



Schematic of Economic Analysis



ENGINEERING ECONOMICS
Reporting Results

- Cover letter provides summary of key findings
- The basis of the study is clearly explained, highlighting key elements included/not included
- All estimates reported with error ranges
- Recommendation based on profitability using time-value-of-money method
- Distribution of costs shown clearly (cash flow diagrams and pie charts are helpful).
- Sensitivity analysis is essential

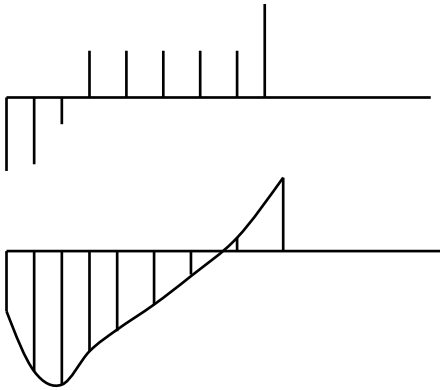
Engineering economics

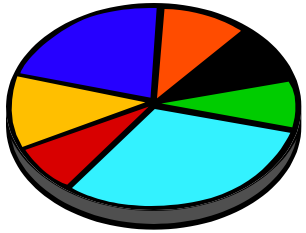
Reporting results: Numbers do not speak for themselves

Cash Flow Diagram

(at each period)

Cumulative Cash Flow Diagram

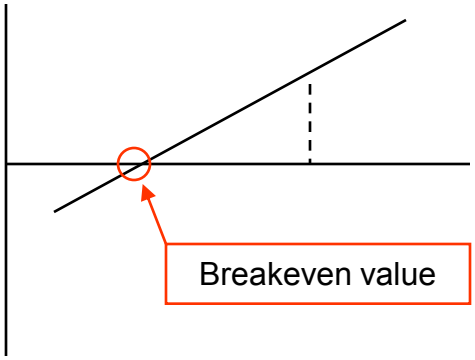




Capital: What equipment accounts for large shares of investment?

Manufacturing: What contributes large share (raw material, energy, personnel?

Sensitivity



How will you explain the results of your design project?

ENGINEERING ECONOMICS
Lessons learned the hard way

- Do not “fall in love” with a project. You must not continue to invest because you have already invested.

  Engineering economics always “looks forward”.

- Do involve all stakeholders and people with knowledge early in the project
- Do not be too conservative in an environment of rapidly changing technology

  Tendency is to accept only “proven technology”. But, large benefits come from large competitive advantage from new technology.

ENGINEERING ECONOMICS
Lessons learned the hard way

- Do prototype key technical approaches before making final decisions
- Do not allow the boss to direct your decision.
- Do use checklists to consider all important factors when project planning and estimating costs
- Do perform a thorough sensitivity analysis and consider the likelihood that key assumptions might not be fulfilled.
- Do report all estimates with error bounds, not necessarily symmetrical (e.g., -30% to +70%)

COST ESTIMATION

Learning Project 6: Covering the topic, extending beyond these visual aids

- Search for computer programs available to supply data and perform estimation calculations? Summarize strengths and weaknesses of each.
- Search for cost data bases for other equipment, food processes, environmental processes, pharmaceuticals, etc. Summarize strengths and weaknesses of each.
- Provide a cost estimate for the distillation process on page 2-65 in Dr. Wood's Process Design and Engineering Practice.
- Develop a checklist for estimating the project cost for a new plant.

Conclusion of Engineering Economics

1. Time value of money
2. Quantitative measures of profitability
3. Estimation of costs
4. Systematic comparison of alternatives

You know the basics and are able to learn additional methods to perform well as a professional engineer.