11

Feasibility Analysis

A feasibility analysis is prepared for the purpose of determining that a proposed investment meets the minimum requirements established by management. This analysis is in sufficient detail and quality to provide management with the facts necessary to make an investment decision. In this chapter, a detailed solution for a proposed investment will be presented to demonstrate the necessary steps in the preparation of a feasibility analysis. Personnel responsible for the development of this analysis should have an appreciation of the factors that affect the reliability and the expected accuracy of the information.

11.1 INFORMATION REQUIRED

The amount of information necessary to prepare a feasibility analysis will depend upon the intended use and management's desire. If the analysis is prepared to determine whether further research and/or pilot plant studies are necessary, then preliminary capital cost and operating expense estimates may be satisfactory with their inherent accuracies. However, if the objective is to request appropriation of funds, then more firm information is necessary to prepare definitive or detailed estimates.

The minimum information required to prepare a feasibility analysis is:

- Fixed capital investment estimate
- Total capital investment
- Total operating expense estimate

- Marketing information
- Cash flow analysis
- Estimate of profitability

In addition, management may also require break-even information, sensitivity and uncertainty analyses [1].

11.1.1 Fixed Capital Investment

In order to prepare an estimate of fixed capital, it is recommended that a form be developed and used as a checklist to be sure that no items have been omitted. A list including the purchased or delivered equipment costs be prepared as a first step. From this basic information, it is then a simple matter to calculate the fixed capital investment using the Lang, Hand, Wroth, or Brown methods as described in Chapter 4. These methods are used for study or preliminary estimates. If the Chilton method is to be used for a preliminary estimate, it is recommended that a form similar to Table 4.14 is recommended. The use of the Chilton form is illustrated in Example 11.1. For a definitive or detailed estimate, a code of accounts format similar to that in Chapter 4 is suggested (Table 4.21).

The forms used in a feasibility analysis should state clearly the dollar amounts and the date of each estimate. All forms are designed so that data for other cases of scenarios may be reported by extending the tables to the right of the page.

11.1.2 Total Capital Investment

The major items constituting the total capital investment are found in Table 11.1. Blank spaces have been included to allow the user the flexibility to include other capital items not listed in Table 11.1.

Table 11.2 may be used for estimating the working capital requirements using the inventory method described in Chapter 4. If the percentage method is used, the result may be inserted directly into Table 11.1.

11.1.3 Total Operating Expenses

The total operating expenses may be estimated using two forms, Tables 11.3 and 11.4. The first table is for the Total Product Expenses discussed in Chapter 5 and includes raw material expenses, by-product credits, direct and indirect expenses, as well as packaging, and shipping expenses. The bottom line in Table 11.3 is the expense involved in the manufacturing, packaging, and loading a product on a

TABLE 11.1 Total Capital Investment

Project Name:
Project Number:
By:
Date:

	$MM
Land	
Fixed capital	
Working Capital	
Off-site capital	
Allocated capital	
Start-up expenses	
Catalysts & chemicals	
Licenses, patents, and royalties	
Interest on borrowed funds	
Total capital investment	

TABLE 11.2 Working Capital (Inventory Method)

Project Name:
Project Number:
By:
Date:

	$MM
Raw material inventory	
Goods-in-process inventory	
Finished goods inventory	
Stores & supplies inventory	
Cash	
Accounts receivable	
Accounts payable	
Total working capital	

TABLE 11.3 Total Product Expense

Product:			Total annual sales:	
Rated capacity:			Location:	
Fixed capital investment:			Operating hours per year:	
Date:			By:	
Raw materials:				
Material	Unit	Annual amount	$/unit	$/year
Gross material expense:				
By-products:				
Material	Unit	Annual amount	$/unit	$/year
By-product credit:				
Net material expense:				
Direct expenses:	Unit	Annual	$/unit	$/year
Utilities:				
Steam, low pressure				
Steam, medium pressure				
Steam, high pressure				
Gross steam expenses:				
Steam credit:				
Net steam expenses				
Electricity				
Cooling water				
Fuel gas				
City water				
Total utilities:				
Labor:				
Person/shift				
Annual labor rate per person				
Labor expense:				

TABLE 11.3 (*Continued*)

Supervision:
% of labor expense

Payroll charges, fringe benefits, etc.:
% of labor plus supervision

Maintenance:
% of fixed capital investment
Maintenance expense:

Supplies:
% of labor
Supplies expense:

Laboratory charges:
Hours per year
Expense per hour
Laboratory expense:

Clothing and laundry:
% of labor
Clothing expense:

Environmental and waste disposal expense:
Tons/year
Charge/ton
Total environmental expense:

Royalties (running):

Other:

Total direct expense:

Total direct and net material expense:

Indirect expenses

Depreciation:
% fixed capital investment
Depreciation expense:

(*Continued*)

TABLE 11.3 (*Continued*)

Plant-indirect expense:
% of fixed capital investment
Plant indirect expense:
Total indirect expenses:
Total manufacturing expense:
Packaging and shipping expense:
Annual production
Expense per ton
Packaging and shipping expense:
TOTAL PRODUCT EXPENSE

conveyance for delivery to the customer. To these expenses in Table 11.3, the general overhead expenses must be added. Table 11.4 may be used for this purpose but if the overhead expenses are calculated as a percentage of annual sales, Table 11.4 may not be needed and the result inserted in the summation of the total operating expenses at the appropriate place.

TABLE 11.4 General Overhead Expense

Project Name:
Project Number:
By:
Date:

	$MM
Sales expense	
Administration expense	
Research & engineering expense	
Finance	
Total general overhead expense	

TABLE 11.5 Marketing Data

Profit center:	Project title:	Appropriation No.:

Basis: Sales and market projections are not inflated (20__dollars)

	20__ Amount	20__ % Total	20__[b] Amount	20__[b] % Total
Total market:				
Units				
Average realistic price, $/unit				
Value, $M				
Estimated product sales (with AR[a]):				
Units				
Average realistic price, $/unit				
Value, $M				
Current product sales (without AR):				
Units				
Average realistic price, $/unit				
Value, $M				
Incremental product sales: (with AR):				
Units				
Average realistic value, $/unit				
Value, $M				
Current product sales displaced by improved product sales:				
Units				
Value, $M				
Total improved product sales:				
Units				
Value, $M				

[a] AR = appropriation request.
[b] Table extends to the right for the number of project years.

11.1.4 Marketing Information

A major part of all feasibility studies is the marketing data so that income projections may be made. It is essential to have the latest estimate of the company's market position for management's consideration. A tabulation of projected sales volume, sales price, and share of the market not only domestically but also globally is considered minimal information. Table 11.5 is a sample of such marketing information.

TABLE 11.6 Cash Flow Analysis

	Cash flow summary		
	200X	200Y	200Z, etc.[a]
Investment			
Land			
Fixed capital investment			
Offsite capital			
Allocated capital			
Working capital			
Start-up expenses			
Interest			
Catalysts and chemicals			
Licenses, patents, etc.			
Total capital investment			
Income statement			
Income			
Expenses			
Cash operating expenses			
Depreciation			
Total operating expenses			
Operating Income			
Net income before taxes			
Federal income taxes			
Net income after taxes			
Cash flow			
Capital recovery			
Cumulative cash flow			

[a] Table extended to the right for the number of project years.

11.1.5 Cash Flow Analysis

A cash flow analysis similar to Table 11.6 is useful in presenting the cash flow items in a clear, concise format. This table may be modified to include a choice of time zero and to allow management to add or delete certain items.

11.1.6 Measures of Profitability

The profitability of a project may be included as part of the cash flow analysis or it may be given in a special form like Table 11.7. The classical methods

TABLE 11.7 Profitability Analysis

Project Name:
Project Number:
By:
Date:
Net present worth (%)
Discounted cash flow rate of return
Payout period
Internal rate of return
Economic value added
Market value added

have been included, but some of the contemporary measures such as economic value added (EVA) and market value added (MVA) may also be presented. A company may only compute certain values, so Table 11.7 may be modified for specific uses. In this table, the interest rate used in the calculation of the net present worth is noted.

11.1.7 Break-even Analysis

Frequently management requests a break-even chart as part of the feasibility analysis. Such charts are predicated on numerous assumptions but will give some indication of the sensitivity of production rates on profitability. The assumptions should be clearly stated in the analysis. This type plot may be constructed like Figure 11.1 not only to indicate the break-even and shutdown points but also to be of use in marketing and production planning.

11.1.8 Sensitivity Analysis

The effect of errors and inaccurate information upon the profitability of a proposed venture is determined by means of a sensitivity analysis. The author prefers a graphical format similar to that shown in Figure 11.2, which was developed by Strauss [2]. At a glance, busy executives can quickly note those variables that

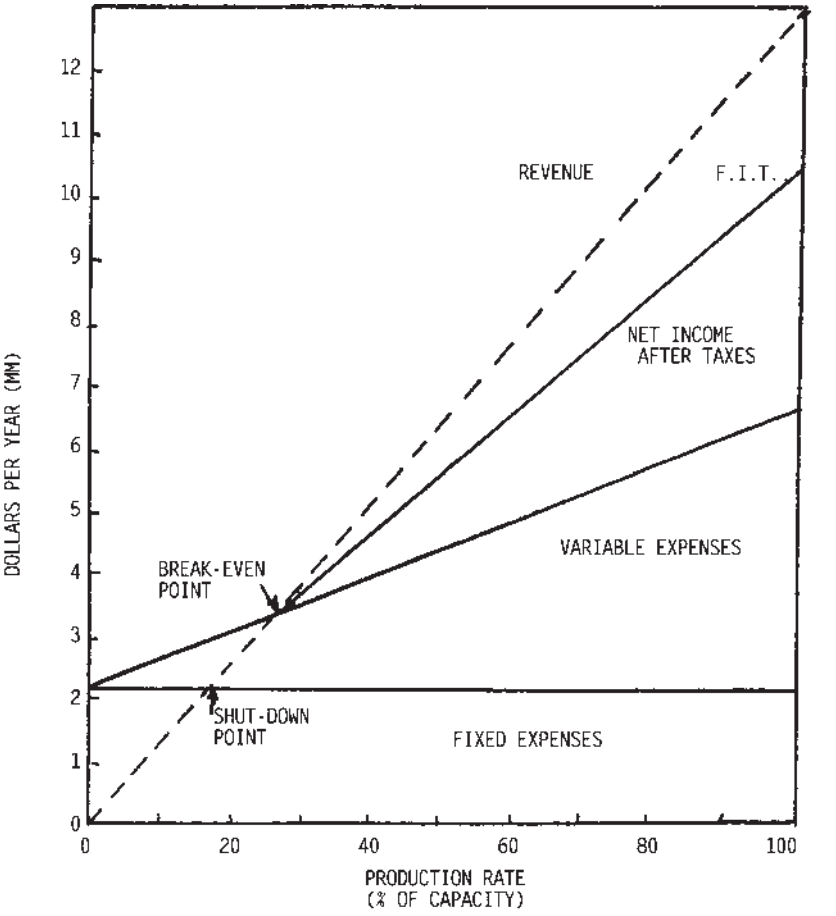

FIGURE 11.1 Typical break-even plot.

affect profitability the most. If the data are presented in tabular format, searching through such tables can be time consuming and tedious, whereas a sensitivity plot clearly indicates the variables that need further attention.

11.1.9 Uncertainty Analysis

Some companies include uncertainty analysis as part of the feasibility analysis package. The objective is to determine the probability of the risk of receiving a

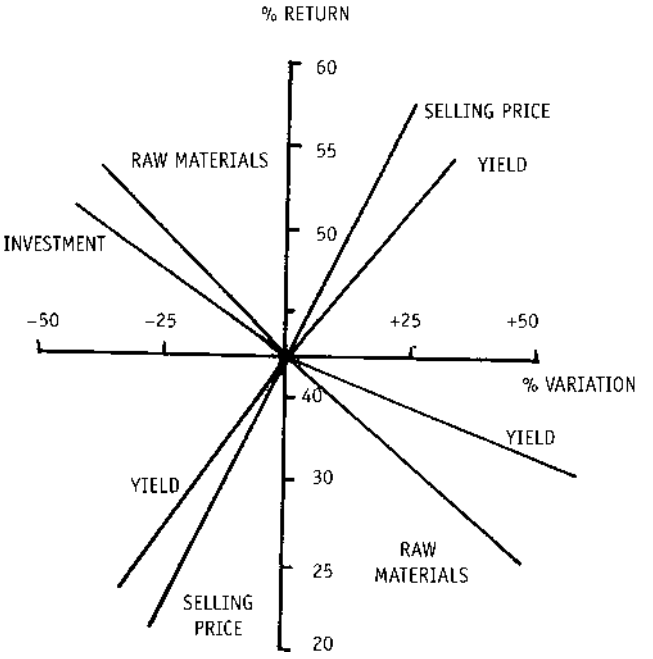

FIGURE 11.2 Typical sensitivity analysis plot.

greater (or lesser) return on the investment predicted by the measures of profitability used. Probabilities are assigned to each variable in the analysis based upon past experience. For example, what is the probability that the proposed sales pattern will develop? Some executives believe that such studies are exercises in futility since little information regarding accurate probability distribution models for a given variable are known or can be proposed. The results of an uncertainty analysis may be presented in a plot like Figure 11.3. There are computer programs that are available that do the calculations, but the person preparing this analysis still must tell the program what probability distribution fits a certain variable.

11.2 PROCEDURE

It is essential that management establish a procedure for the preparation of a feasibility analysis to ensure uniformity in reporting. The following outline of steps that might serve as a guide in gathering information for the analysis:

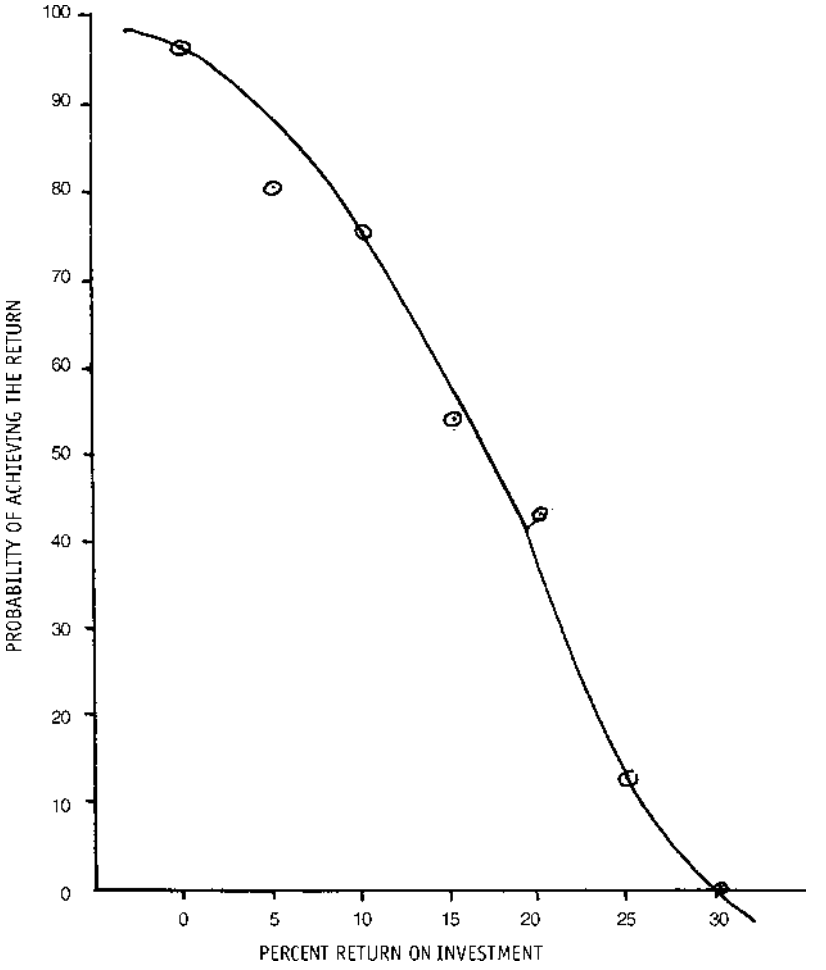

FIGURE 11.3 Typical uncertainty analysis plot.

1. Assemble all the necessary forms that company policy requires for a feasibility analysis.
2. Determine the quality of the fixed capital investment estimate that is appropriate considering the time frame and funds available for the preparation of the analysis.
3. Develop or gather the data necessary for substitution in the appropriate places in the various forms.

4. From step 3 above, determine the economic feasibility of the venture as required.

The use of standardized forms cannot be emphasized strongly enough since they serve as a check to ensure that all requisite items have been included and that stepwise results are presented in a logical, orderly, and organized manner.

11.3 FACTORS THAT AFFECT THE ACCURACY OF A FEASIBILITY ANALYSIS

11.3.1 Capital Cost Estimates

The various types of cost estimates and their purported accuracies are found in Chapter 4. For example, an order-of-magnitude estimate accuracy is -30 to $+50\%$, a preliminary estimate is -20 to $+30\%$, and a detailed estimate is -5 to $+10\%$. The basis for any estimate is equipment costs, so it is essential to use the latest cost information available and to know the data accuracy. The fixed capital investment estimate is critical since is used in the estimate of working capital, in certain items of the operating expenses, and in start-up expenses. In the preparation of this estimate, a well-defined scope must be developed consistent with the estimate data. A poorly defined scope potentially contributes to serious errors and considerable uncertainty regarding the project's feasibility.

11.3.2 Operating Expense Estimates

In the preparation of this estimate, it is wise to seek the advise of manufacturing personnel. Their input will help temper the estimates, minimizing guesses. These people are valuable sources with respect to labor requirements for a process. Raw material requirements can be obtained with reasonable accuracy from material balances, research reports, or pilot plant data. Utilities may be estimated from material and energy balances and the guidance of utilities supervisors with respect to prices and projected costs at a plant site.

11.3.3 Marketing Data

One of the largest potential sources of error is the quality of marketing information used in a feasibility estimate. Market volume is sometimes difficult to predict accurately because customers may change their requirements, use substitute products, or perhaps purchase a competitor's product. Any one of these

items can deal a devastating blow to the estimate of sales volume. Sales price is a volatile variable since it is affected by sales volume as well as competition in the marketplace from similar or substitute products. Market volume and market price affect the return on investment to a great extent. Sensitivity analyses will show the effect of these variables on the economics of a project. Therefore, a substantial amount of effort and time should be expended to obtain the best market data possible.

11.3.4 Inflation

In the mid-to late 1970s, inflation was rampant in part due to the Middle-East oil crises. If inflation is not handled properly, it can cause considerable errors in feasibility analyses. Smith [3], Jones [4], and Griest [5] are classical texts published in the late 1970s and early 1980s that deal broadly with the subject. In that time period, inflation was double digit as high as 13.5%. In the current period (2002–2003) it is 1–2% and therefore is not a source of serious error.

One school of thought suggests that a specific time be selected and all economic data for a proposed project be corrected and reported on a constant-dollar basis as of that date. An alternative would be to project the inflation rate based upon past experience and near-recent trends, and then to apply to the economics of the project. Inflation rates are reported by the federal government and may be found frequently in the *Wall Street Journal.* One company the author knows projects inflation rates on a 6-month basis and then corrects the rate as current data become available using a moving-average forecasting technique. Whatever approach is used, company policy will dictate a method, but inflation should not be glossed over as serious consideration must be given to its affect on capital cost and operating expense estimates.

Griest [5] summarized the effects of inflation upon evaluations as follows:

- Inflation does affect the profitability of a project, reflecting unfavorably upon the net present worth.
- Inflation can change the order of preference of project selection in a capital budgeting decision.
- Inflation may be built into the discount rate used in calculating the net present worth.
- If inflation is a variable in an analysis, then it can be handled statistically in an uncertainty analysis.
- High rates of inflation tend to improve the attractiveness of a lease alternative relative to capital investment in a lease-purchase study.
- Higher rates of inflation, in general, tend to favor lower capital projects.

11.3.5 Depreciation

Through the years depreciation methods have been revised by Congress and the Internal Revenue Service. These revisions occurred whenever the economy was depressed, and the intent of the revisions was to stimulate the economy by hopefully encouraging capital spending. Write-off periods were shortened, which increased the cash flow in the early years of a project. The depreciation model used can drastically alter the cash flow patterns affecting the feasibility analysis. As of 2003, straight-line or the Modified Accelerated Cost Recovery System (MACRS) are the methods presently used [6].

11.3.6 Production Rate

The amount of material produced by a company is highly dependent on the marketing data. From these data, production schedules are prepared. Should the market volume decrease, the company will quickly build inventories that may result in an economically unhealthy situation unless the production is decreased. Such a move may be below an economically attractive operating rate. Many processes require operation at 50–60% of rated capacity to break even, and operation at 100% of capacity may not always be possible. A break-even chart is often included in a feasibility analysis so that at a glance management may observe the effect of changing production rates upon the profitability of a project.

11.3.7 Tax Credits

Investment tax credits have been allowed by the Internal Revenue Service under specified conditions at various times. Although tax credits based upon investment in manufacturing equipment did alter the cash flow of a project, in many cases it did not have the strong influence that revisions to depreciation had upon a project's feasibility. The reader should be aware of the latest tax credits since they have been allowed and discontinued frequently over the past several decades.

11.3.8 Concluding Comments

In this chapter, the information needed to prepare a feasibility analysis has been presented. This information includes a capital cost estimate, operating expense estimate, cash flow analysis, project profitability, sensitivity and uncertainty analysis. It should be mentioned that the information may be modified depending upon management's requirements, so not every feasibility study will contain the information in this chapter. One should recognize that

all the calculations are based upon estimates that are subject to error. It is therefore essential to determine what affect potential errors have upon the results of the study. Such information is obtained from sensitivity and an uncertainty analysis.

As mentioned previously in Chapter 9, besides the quantitative results, qualitative factors must be considered in the decision-making process.

11.4 EXAMPLE OF A FEASIBILITY ANALYSIS

Example 11.1

Problem Statement:

Nue Chemical, Inc. is a small company that produces a wide variety of specialty chemicals for various customers. In 1999, it was considering the manufacture of an additive for use in the plastics industry. At that time, a market survey indicated that the project did not meet Nue's profitability requirements so the project was shelved.

In late 2002, Nue Chemical was acquired by Fusible Plastics, a large plastics manufacturer. Fusible wanted to integrate backward to raw materials so that the company could gain a better market and profitability position. Since the acquisition, Fusible has been reviewing the profit picture for all products in the acquisition. The marketing department of Fusible has prepared the following 10-year market information for the additive.

Year	Potential sales, MM lb/yr	Estimated sales price, $/lb
2004	40.0	0.50
2005	42.0	0.50
2006	45.0	0.52
2007	48.0	0.52
2008	50.0	0.55
2009	50.0	0.56
2010	47.0	0.50
2011	45.0	0.48
2012	40.0	0.47
2013	35.0	0.45

The process to manufacture the additive involves fluids only. The delivered equipment cost of the process equipment as of January 1, 2003 is as follows:

Item	Delivered equipment cost
Tanks	$230,000
Pumps	75,000
Heat exchangers	525,000
Filters	120,000
Reactors	1,200,000
Miscellaneous equipment	350,000
Total	$2,500,000

(*Note*: The delivered equipment cost includes cost differentials for materials of construction).

The company uses the *Chemical Engineering* cost index to update costs. For the future, management suggests a 5% per year inflation rate. Land for this project may be considered negligible but working capital may be taken as 15% of the total capital investment. Apex Contractors, Inc. has prepared a definitive estimate of the fixed capital investment of $12 million for a 50MM lb/yr plant. The equipment is to be purchased and installed over a 2 year period prior to start-up which is expected to be in early 2004.

Chlorine is used in the manufacture of the additive and is supplied by Fusible's old small 200 ton/day plant located adjacent to the proposed new additive. Ten tons of chlorine per day is used in the manufacture of the additive. The total capital investment of the chlorine facility is carried on the books at $10 million.

Operating expenses for the proposed new additive unit are:

Raw materials	$0.12/lb product
Utilities	$0.03/lb product through 2007 and $0.045 thereafter
Labor and supervision	$0.05/lb product through 2008 and $0.06 thereafter
Maintenance	6%/yr of the fixed capital investment
Other direct expenses	$0.01/lb product
Depreciation	7-year straight line for operating expenses and 7-year MACRS for cash flow analysis with half-year convention
Other indirect expenses	$0.01/lb product
General overhead	$0.02/lb product

You may assume all product made is sold.

At this stage of consideration, unless a project has a positive 25% NPW after taxes, the venture will not be considered further. The federal income Tax rate is 35%.

To conform to Fusible's company standard evaluation procedure, the following components of a feasibility study are required:

a. An estimate of the total capital investment for the venture as of January 1, 2004
b. Annual operating expenses for all production rates
c. An estimate of the profitability by the DCF rate of return method using the 7-year MACRS depreciation and continuous interest
d. The NPW at 25% for the venture
e. Cash position chart for the proposed project
f. Payout period at 25% interest
g. A sensitivity analysis based upon a 50 MM lb/yr plant capacity to determine the effect of the following variables upon the rate of return:
    1. Sales price with a $\pm 15\%$ variation
    2. Sales volume with a $\pm 15\%$ variation
    3. Raw material costs with a $\pm 15\%$ variation
    4. Fixed capital investment with a $\pm 15\%$ variation

Based upon your analysis, what recommendation would you make to management concerning the proposed venture? Substantiate your answer(s) with numerical results.

Solution:

a. *Estimate of the total capital investment as of January 1, 2004.* Apex Contractors, Inc. have submitted a detailed estimate of the fixed capital investment in the amount of $12 million that may have an inherent error of -5 to $+15\%$. As a matter of policy, it would be wise to also estimate the fixed capital investment using the Lang, Hand, Brown, and Chilton methods and compare the result with the Apex figure. (These shortcut methods can be used to obtain a preliminary figure before the outside contractor submits his estimate.)

LANG METHOD: Because the date of the delivered equipment price was January 1, 2003, an inflation factor of 1.05 must be included in the following methods. The Lang factor for a fluid processing plant is 4.74 (Table 4.9) times the delivered equipment costs. Therefore the fixed capital investment by this method is

$$(\$2.5\text{MM})(4.74)(1.05) = \$12.5\,\text{MM}$$

HAND METHOD: This method involves the use of different factors for each type of equipment. The factors are found in Table 4.10.

Item	Delivered price	factor	Component cost
Tanks	$230,000	4.0	$ 920,000
Pumps	75,000	4.0	300,000
Heat exchangers	525,000	3.5	1,838,000
Filters	120,000	4.0	480,000
Reactors	1,200,000	4.0	4,800,000
Miscellaneous	350,000	4.0	1,400,000
Total	$2,500,000		$9,738,000

The total component cost is multiplied by the inflation factor to bring costs to January 1, 2003:

$$(\$9,738,000)(1.05) = \$10,225,000$$

The fixed capital investment will be rounded off to $10,200,000.

BROWN METHOD: The Brown method has factors for materials of construction, but in this problem statement mention was made that the costs of the materials of construction were included in the delivered equipment cost. This method is described in Section 4.3.2.4, and the factors are presented in Table 4.12.

Item	Delivered equipment cost	Factor	Component cost
Tanks	$230,000	3.5	$805,000
Pumps	75,000	5.0	375,000
Heat Exchangers	525,000	3.5	1,838,000
Filters	120,000	2.4	288,000
Rectors	1,200,000	4.2	5,040,000
Miscellaneous	350,000	4.0[a]	1,400,000
Total	$2,500,000		$9,746,000

[a] Estimated factor.

The fixed capital investment by this method is

$$(\$9,746,000)(1.05) = \$10,233,000$$

CHILTON METHOD:

Item no.	Item	% of item	Factor	Component cost
1.	Delivered equipment	1	1.0	$2,500,000
2.	Installed equipment	1	1.43	3,575,000
3.	Process piping (fluid)	2	0.60	2,145,000
4.	Instrumentation (extensive)	2	0.20	715,000
5.	Buildings and site development	2	0.20	715,000
6.	Auxiliaries (minor)	2	0.03	107,000
7.	Outside lines (minor)	2	0.03	107,000
8.	Total physical plant cost			$7,364,000
9.	Engineering (simple)	8	0.25	1,841,000
10.	Contingencies (firm)	8	0.15	1,105,000
11.	Size $>$ $2.5 MM	8	0.03	221,000
12.	*Total fixed capital investment*			$10,531,000

The fixed capital investment may be rounded to $10,500,000.

The estimates of the fixed capital investment by the various methods are:

Lang	$12,500,000
Hand	10,200,000
Brown	10,233,000
Chilton	10,500,000
Apex Contractors	12,000,000

The costs obtained by the Hand, Brown, and Chilton methods produce similar results and this might be expected as the methods are somewhat similar in nature. If the errors in each method are considered, the estimates of the fixed capital investment are close. The Lang method gives a result very similar to the one from Apex Contractor, but the errors in the Lang method are greater than the method used by Apex. Because Apex's is a more detailed estimate, its figure will be used in the rest of the feasibility study. These results may be a coincidence.

Therefore, the total capital investment is

Item	Investment
Land	$0
Fixed capital investment	12,000,000
Allocated capital (10/200)($10,000,000)	500,000
Working capital	2,200,000
All other items	0
Total capital investment	$14,700,000

b. *Operating expenses*. The most efficient way to present the results of these calculations is in an electronic spreadsheet. In this form, it permits the user to develop many different scenarios. The results may be found in Table 11.8.

c and d. *Cash flow analysis and NPW and IRR calculations*.

The next step in a feasibility study is to develop a cash flow analysis. Again, like the operating expenses, it is advisable and more efficient to present this analysis as an electronic spreadsheet. The cash flow analysis is found in Table 11.9.

Fusible requires a NPW method at a 25% interest rate to consider a project for funding at this stage. From Table 11.10, the NPW at 25% is a positive $9,858,000; therefore, the projects meets the company's profitability requirements. Also, from Table 11.10, the IRR is 36.40% and this is very good. Detailed calculations are summarized in Table 11.10.

e. *Cash position chart*. A cumulative cash position chart can be constructed for this project from the cash flow analysis, Table 11.9. The plot is presented in Figure 11.4.

f. *Payout period at 25% interest.* The payout period with interest can be obtained by interpolating in the cumulative cash flow in Table 11.9 or from the plot, Figure 11.4. The payout period with 25% interest found by interpolation is 2.2 years. A 2 to 3 year payout period is reasonable for this project at this time.

g. *Sensitivity analysis*. With the aid of electronic spreadsheets for the operating expenses and the cash flow analysis, a sensitivity analysis can be prepared. Some companies prefer the results as a plot, similar to the Strauss chart or as a "tornado" plot [see Chap. 10 for the details of these charts.] Some companies prefer the results in both tabular and graphical format but Fusible prefers the result in the form of a sensitivity plot, like the Strauss chart, Figure 11.5.

h. *Uncertainty analysis.* Fusible does not require a Monte Carlo uncertainty analysis for this problem.

i. *Concluding comments*. The project meets Fusible's criteria for investment with respect to NPW and POP. The recommendation to management is to confirm the marketing, capital investment, and operating expense estimates and if

TABLE 11.8 Operating Expenses for Example 11.1 (All Monetary Amounts are in $M)

Production (MM lb/yr):	40.0	42.0	45.0	48.0	50.0	50.0	47.0	45.0	40.0	35.0
Fixed capital, $M	12,000									
Date:	07/12									
By	JRC									
Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Raw materials	4,800	5,040	5,400	5,760	6,000	6,000	5,640	5,400	4,800	4,200
Utilities	1,200	1,260	1,350	1,440	2,250	2,250	2,115	2,025	1,800	1,575
Labor and supervision	2,000	2,100	2,250	2,400	2,500	3,000	2,820	2,700	2,400	2,100
Maintenance	720	720	720	720	720	720	720	720	720	720
Other directs	400	420	450	480	500	500	470	450	400	350
Total directs	9,120	9,540	10,170	10,800	11,970	12,470	11,765	11,295	10,120	8,945
Depreciation	857	1,715	1,715	1,714	1,715	1,714	1,715	856	0	0
Other indirects	400	420	450	480	500	500	470	450	400	350
Total indirects	1,257	2,135	2,165	2,194	2,215	2,214	2,185	1,306	400	350
Total manufacturing expense	10,377	11675	12,335	12,994	14,185	14,684	13,950	12,601	10,520	9,295
General overhead	800	840	900	960	1000	1000	940	900	800	700
Total operating expense	11177	12515	13235	13,954	15185	15,684	14890	13501	11320	9995
Depreciation	857	1,715	1,715	1,714	1,715	1,714	1,715	856	0	0
Cash operating expense	10,320	10,800	11,520	12,240	13,470	13,970	13,175	12,645	11320	9995

TABLE 11.9 Cash Flow Analysis for Example 11.1 (All Cash Flow Items are in $M)

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Production, MM lb/yr	40.0	42.0	45.0	48.0	50.0	50.0	47.0	45.0	40.0	35.0
Fixed capital investment, $M	$12,000									
Sales	20,000	21,000	23,400	24,960	27,500	28,000	23,500	21,600	18,800	15,750
Cash operating expenses	10,320	10,800	11,520	12,240	13,470	13,970	13,175	12,645	11,320	9,995
Operating income	9,680	10,200	11,880	12,720	14,030	14,030	10,325	8,955	7,480	5,755
Depreciation	1,715	2,939	2,099	1,499	1,072	1,070	1,072	535	0	0
Net profit before taxes	7,965	7,261	9,781	11,221	12,958	12,960	9,253	8,420	7,480	5,755
Federal income tax, 35%	2,788	2,541	3,423	3,927	4,535	4,536	3,239	2,947	2,618	2,014
Net profit after taxes	5,177	4,720	6,358	7,294	8,423	8,424	6,015	5,473	4,862	3,741
Depreciation	1,715	2939	2,099	1,499	1,072	1,070	1,072	535	0	0
Cash flow	6,892	7,659	8,457	8,793	9,495	9,494	7,086	6,008	4,862	3,741
Capital recovery										2,200
End of project value										5,941

TABLE 11.10 Profitability Analysis for Example 11.1

Time, yr	Item	Cash flow	Factor at 25% interest	Cash flow 25%	Factor at 35% interest	Cash flow 35%	Factor at 40% interest	Cash flow 40%
− 2	Fixed capital investment	− 12,000	1.297	− 15,564	1.448	− 17,376	1.532	− 18,384
0	Work + allocation capital	− 2,700	1.000	− 2,700	1.000	− 2,700	1.000	− 2,700
1	Cash flow	6,592	0.885	5,834	0.844	5,564	0.824	5,432
2	Cash flow	7,230	0.689	4,981	0.595	4,320	0.552	3,991
3	Cash flow	8,322	0.537	4,469	0.419	3,487	0.370	3,079
4	Cash flow	8,868	0.418	3,707	0.295	2,616	0.248	2,199
5	Cash flow	9,720	0.326	3,169	0.208	2,022	0.166	1,614
6	Cash flow	9,719	0.254	2,469	0.147	1,429	0.112	1,089
7	Cash flow	7,312	0.197	1,440	0.103	753	0.075	548
8	Cash flow	6,120	0.154	942	0.073	447	0.050	306
9	Cash flow	4,862	0.120	583	0.051	248	0.034	165
10	Cash flow	3,741	0.093	348	0.036	135	0.022	82
End 10 yr	Capital recovery	2,200	0.082	180	0.030	66	0.018	40
	Net present worth:			9,858		1,011		− 2,539
	Internal rate of return:		IRR = 35	5[(1,011)/(1,011 + 2,539)] = 35.0 + 1.40 = 36.40%				

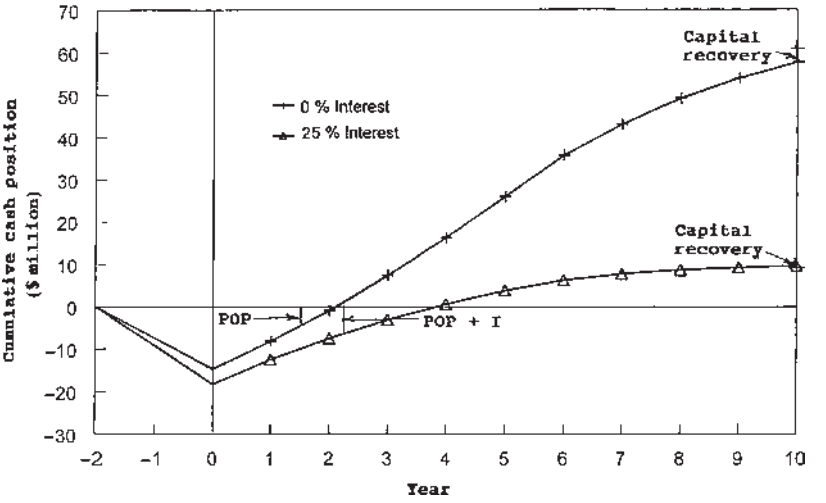

FIGURE 11.4 Cumulative cash position plot for Example 11.1.

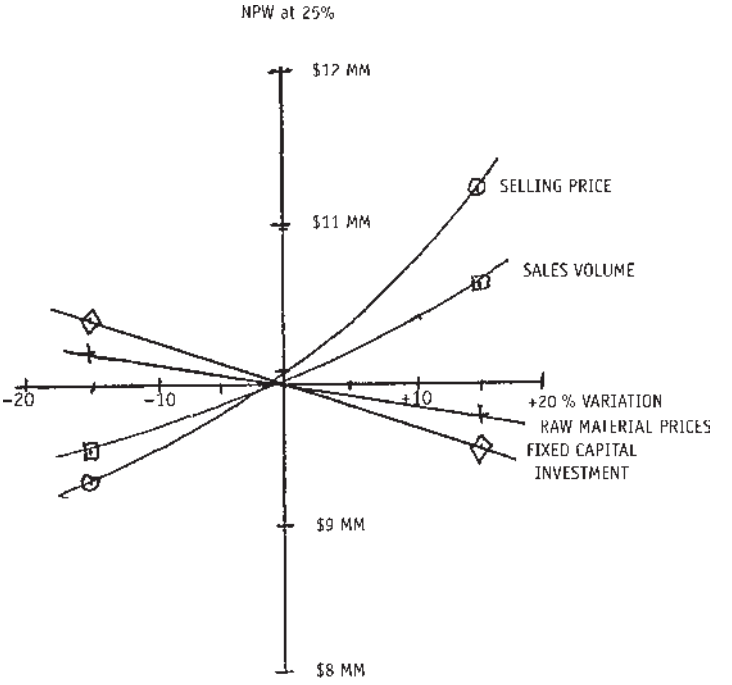

FIGURE 11.5 Sensitivity analysis plot for Example 11.1.

the project is still profitable, a detailed capital investment should be prepared. If at any time, the estimates fall below Fusible's criteria for investment, the project should be terminated.

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PROBLEMS

11.1 You are employed in the planning and economics section of ROCK Chemicals, a company that produces large-volume inorganic chemicals. The marketing department has a customer who will purchase 100 tons per calendar day of 50% caustic at a price of $200/ton. Since the current caustic production facilities are operating at 100% capacity, you have been asked to do a feasibility study for a new unit to produce the 50% caustic. You have gathered the following information:

1. The process is the electrolytic decomposition of a brine solution according to the following reaction:

$$2NaCl + 2H_2O = 2NaOH + Cl_2 + H_2$$

2. Design capacity shall be 120 tons per calendar day to accommodate the future needs of customers.
3. The process flow diagram is found in Figure 11.6.
4. The unit will operate 330 days/yr.
5. Fixed capital investment for the complete process is based on total feed to the dissolver and is given by

$$FCI = (5,000,000)\frac{\text{feed to dissolver, tons/stream day}}{200 \text{ tons/stream day}^{0.7}}$$

6. Construction period is 1 year.
7. There is no charge for land, but working capital is $400,000.
8. The electrolytic cells require 2500 kWh/ton Cl_2 produced at a cost of $0.07/kWh.

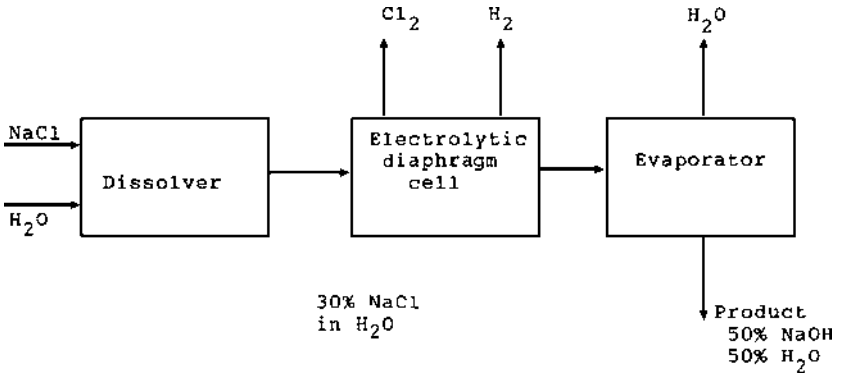

FIGURE 11.6 Flow diagram for Problem 11.1.

9. The evaporator economy is 0.8 lb water per lb steam. Steam cost is $4.50/1000 lb.
10. Depreciation is 7 years straight-line. Project life is 7 years.
11. The total of all other operating expenses including raw materials is $40/ton of product.
12. The chlorine has a value of $60/ton in another process.
13. The hydrogen may be sold to an adjacent refinery for $5/100 SCF.
14. The tax rate is 35%.
15. Your company requires a 25% IRR for projects.

You have been asked to submit the following information for management's consideration:

a. A process material balance based on 100 tons per calendar day production.
b. An economic analysis in tabular format giving the fixed capital investment, Revenue in $/yr; operating expenses, in $/yr; cash flow, $/yr.
c. Determine the present worth at 25%.
d. What is your recommendation to management? Discuss a plan of action.

11.2 You are an engineer in the economics section of AG Products, Inc., and you are asked to prepare a feasibility study on a new product, FASTGRO, that is produced as a water slurry. It will then be concentrated in an evaporator as a 50% thick liquor and sold. A flow sketch of the process is found in Figure 11.7.

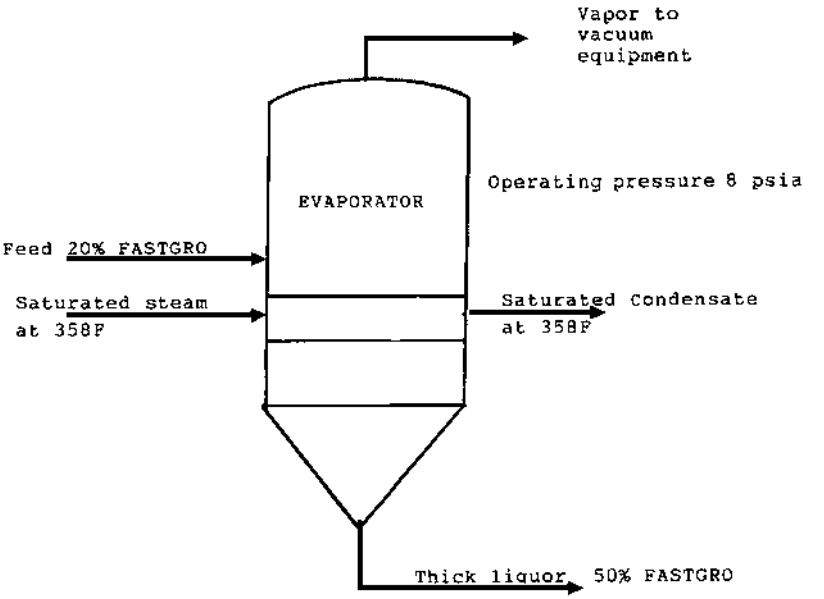

FIGURE 11.7 Flow diagram for Problem 11.2.

The following data apply:

1. The feed is 240 tons/day (330 days/yr) of 20% FASTGRO in water. The transfer price for this stream is $10/ton (treat as a raw material cost).
2. The feed is at 80 F and has a heat capacity of 0.9 Btu/lb F.
3. The 50% thick liquor is the product.
4. All storage tanks and pumps are available for this project at no cost.
5. The only significant capital cost is the evaporator.
6. The evaporator will operate at 8 psia. At this pressure the boiling temperature is 227 F, the heat of vaporization is 1000 Btu/lb and the cost of operating the vacuum equipment is $2.50/ton of condensed vapor. The evaporator may be assumed as 100% efficient for this study.
7. The overall heat transfer coefficient is 300.
8. The only significant operating expenses are raw materials, steam expenses, operating expenses for the vacuum equipment, and the expenses associated with storage, transportation, and sale of the product. This later expense is estimated to be $12/ton of product.
9. Saturated steam is available at 358 F at a cost of $5.00/1000 lb and has a latent heat of 863 Btu/lb.

10. Depreciation is 7 years straight line and project life is 7 years. The combined state and federal tax rate is 40%.
11. The construction period is 6 months with an on-stream date late this year.

Determine the sales price ($/ton) that will be required to achieve a 25% IRR for this project.

11.3 You are employed as a project manager in the planning section of West Plaines Refinery. This refinery process sour crude and produces 530 tons/day of H_2S on a continuous round-the-clock basis. Currently, the H_2S is sent to SURCO, a sulfur recovery company located adjacent to our refinery. SURCO charges West Plaines $80/ton to process H_2S under the present contract which expires 2 years from now. Your assignment is to prepare a feasibility study of doing our own H_2S processing. You have gathered the following information:

1. West Plaines recently completed a 400 ton/day H_2S recovery plant at one of its other locations. The fixed capital investment for this plant was estimated to be $21.6MM and the construction period was 1 year. A new plant could be constructed to go on-stream by the end on the current contract with SURCO.
2. Operating expenses for a 530 ton/day plant have been estimated to be $20/ton H_2S processed. This figure does not include depreciation.
3. The process chemistry is

$$H_2S + \tfrac{3}{2}O_2 = H_2O + SO_2 \quad \text{(a)}$$

$$2H_2S + SO = 2H_2S + 3S \quad \text{(b)}$$

   Preliminary negotiation have indicated that we will be able to obtain a 3-year contract to sell by-produce sulfur at $12/ton.
4. Equation (a) above is an exothermic reaction with a heat of reaction of 211,000 Btu/lb mole. Equation (b) is exothermic with a heat of reaction of 101,000 Btu/2 lb mole H_2S. The energy may be used to generate steam at an efficiency of 70%. (Assume that 70% of the energy from the reaction goes to produce steam with a value of $4.50/MM Btu).
5. We will need 100% backup in H_2S recovery facilities. This would require a duplicate plant to be built. However, SURCO has offered to provide the backup service for a maximum of 10 days/yr for a fee of $500,000/yr. This would negate our having to build a second unit to provide the 100% backup required.
6. Our company requires a 20% IRR for projects of this type. Permission has been grated from the IRS to use a 3-year straight-line depreciation and a 35% tax rate.

Please prepare answers to the following questions:

a. Will the proposed H_2S recovery plant realize a 20% IRR?
b. Should we build the plant or contract with SURCO?
c. What should be the course of action for West Plaines?

11.4 The Spurious Company is a medium-sized relatively young chemical producer of high-quality organic intermediates. The management of this company is aggressive in their investment policy. When Spurious enters a new marketing venture, they evaluate their profitability by cash flow generated, payout period with interest, and the internal rate of return measures of merit. The engineering economics staff has prepared a preliminary fixed capital cost estimate by the Chilton method of $5MM. Land allocated for this project is worth $200,000. Working Capital is $900,000 and start-up expenses are $400,000.

As a member of staff you have been asked to prepare an economic evaluation to be acted upon by the executive committee and ultimately by the board of directors. The following operational guidelines for feasibility studies are:

1. The project must yield a 20% IRR.
2. A payout period must be less than 3 years.
3. MACRS 7-year depreciation is used.
4. Federal income tax rate is 35%.

It is expected that the construction will take $1\frac{1}{2}$ years and that start-up, if the project is approved, is to be January 200Y. If the board approves the project at next month's meeting, construction could not begin before July 200Y.

After consulting with representatives of manufacturing, marketing, and engineering, you estimate that the net profit before taxes over a 10-year project life is

Year	NPBT, $M
0	0
1	2,100
2	2,500
3	3,000
4	4,000
5	4,200
6	4,200
7	4,200
8	3,800
9	3,600
10	3,000

You must assume that all dollar figures have been corrected for inflation to January 1, 200Y.

In order for the executive committee to review this project for possible funding, please prepare the following information:

a. An estimate of the total capital requirements
b. The payout period with interest
c. The NPW of the project
d. A sensitivity analysis of the effect on the NPW for the following variables:

    1. Fixed capital investment with a $\pm 20\%$ variation
    2. Net profit before taxes with a $\pm 20\%$ variation

e. Be sure to substantiate your recommendations to management with numerical values.

11.5 Tumbleweed, Inc., located in Texas, is considering the manufacture of a new specialty chemical. The market for this product is in the eastern part of the United States, but the plant is to be located in the southwestern part of the United States because of the proximity of raw materials and the availability of a reliable source of labor. The marketing department has just completed a preliminary survey which revealed the following sales potential and sales prices:

Sales volume, lb/yr	Sales price, $/lb
1,000,000	0.32
2,000,000	0.30
3,000,000 or more	0.26

For intermediate sales volume, a straight-line interpolation of sales price may be assumed.

On November 1, a preliminary report was issued by the development department based upon a promising developed by the research department. As a result of this study, the following expenses were estimated for a plant producing 1,000,000 lb/yr of product based upon 300 days of operation.

Item	Operating expense, $/day
Raw materials	200
Labor	170
Sales overhead	40
Depreciation	75
Maintenance	50
Utilities and fixed expenses	40
Total	675

The total fixed capital costs exclusive of land is 3,000,000. The plant is assumed to have a 10-year technical life. For intermediate plant capacities, the total fixed capital investment will very directly as the 0.7 power of the capacity. For this study, you may ignore the cost of land that the company owns. Working capital is estimated at 15% of the total capital investment.

Raw material expenses will be directly proportional to the amount of product manufactured. The labor expense will be constant between 1,000,000 and 2,000,000 lb/yr but for mare than 2,000,000 lb/yr the labor expense will be 1.4 times that of the 1 million rate.

Sales and overhead expenses are 1 cent/lb plus $40/day. Maintenance is 6.7% of the fixed capital investment. Depreciation is on a 7-year straight-line basis. Utilities and fixed operating expenses will be 5.34% of the total fixed capital costs. Income tax is 35%.

The following information for a feasibility analysis is required to present to the planning board:

a. Summaries of the total capital requirements, operating expenses, and profit loss statement for 1.0,1.5,2.0, and 3.00MM lb/yr rates
b. The optimum plant size calculated by the IRR method
c. The break-even point
d. A sensitivity analysis showing the effect on the optimum case of the following variables:

    1. Sales price with ± 10 and $\pm 25\%$ variation.
    2. Fixed and working capital investment with ± 10 and $\pm 25\%$ variation.

(*Note*: Several variations might be explored on these last two problems. For example, rather than straight-line depreciation, the MACRS method might be used to observe the effect on cash flow. Cumulative cash positions charts might be required. These problems could also be modified to include uncertainty analysis.)