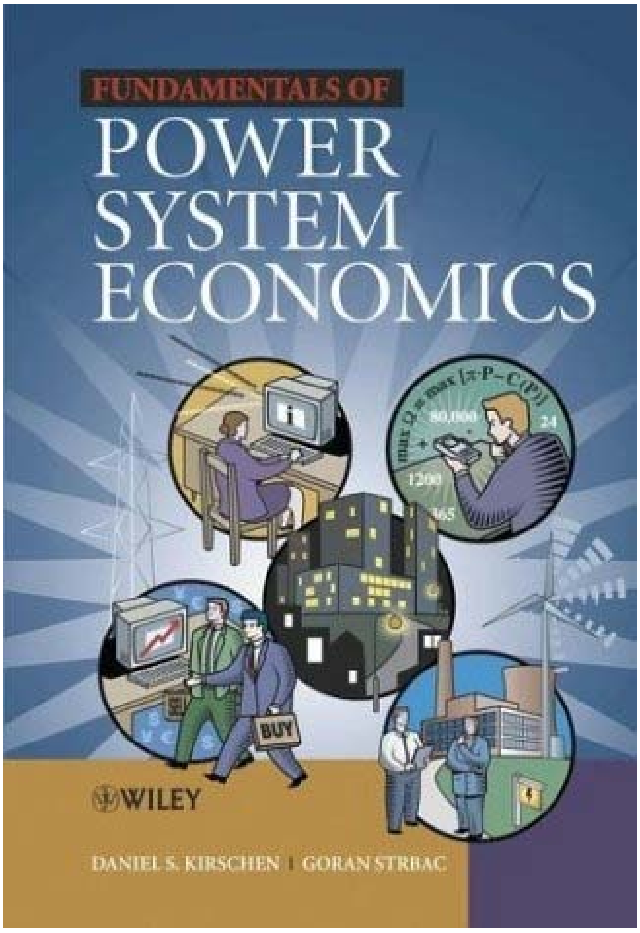
SOLUTIONS MANUAL



CHAPTER 7

INVESTING IN GENERATION

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Chapter 7

7.1 *Calculate the Internal Rate of Return (IRR) for an investment in a* 400 MW *power plant with an expected life of* 30 *years. This plant costs* 1200 \$/kW *to build and has a heat rate of* 9,800 Btu/kWh. *It burns a fuel that costs* 1.10 \$/MBtu. *On average it is expected to operate at maximum capacity for* 7,446 *hours per year and sell its output at an average price of* 31 \$/MWh. *What should be the average price of electrical energy if this investment is to achieve a Minimum Acceptable Rate of Return of* 13%?

The investment cost is:

$$400 \text{ MW} \times 1200000 \text{ \$/MW} = \$\ 480{,}000{,}000$$

The utilization factor is $\frac{7446}{8760} = 0.85$.

The estimated annual production of this plant is:

$$400 \text{ MW} \times 8760 \text{ h} \times 0.85 = 2{,}978{,}400 \text{ MWh}$$

The annual production cost is then given by:

$$2978400 \text{ MWh} \times 1.10 \text{ \$/MBtu} \times 9{,}800 \text{ Btu/kWh} = \$\ 32{,}107{,}152$$

The annual revenue is then given by:

$$2978400 \text{ MWh} \times 31 \text{ \$/MWh} = \$\ 92{,}330{,}400$$

And the annual net cash flow is:

$$\$\ 92{,}330{,}400 - \$\ 32{,}107{,}152 = \$\ 60{,}223{,}248$$

Using spreadsheet P7_1.xls, the following table can be generated:

Period	Investment ($)	Production (MWh)	Production cost ($)	Revenue ($)	Net Cash Flow ($)
0	480,000,000	0	-	-	-480,000,000
1	-	2,978,400	32,107,152	92,330,400	60,223,248
2	-	2,978,400	32,107,152	92,330,400	60,223,248
3	-	2,978,400	32,107,152	92,330,400	60,223,248
4	-	2,978,400	32,107,152	92,330,400	60,223,248
5	-	2,978,400	32,107,152	92,330,400	60,223,248
6	-	2,978,400	32,107,152	92,330,400	60,223,248
7	-	2,978,400	32,107,152	92,330,400	60,223,248

8	-	2,978,400	32,107,152	92,330,400	60,223,248
9	-	2,978,400	32,107,152	92,330,400	60,223,248
10	-	2,978,400	32,107,152	92,330,400	60,223,248
11	-	2,978,400	32,107,152	92,330,400	60,223,248
12	-	2,978,400	32,107,152	92,330,400	60,223,248
13	-	2,978,400	32,107,152	92,330,400	60,223,248
14	-	2,978,400	32,107,152	92,330,400	60,223,248
15	-	2,978,400	32,107,152	92,330,400	60,223,248
16	-	2,978,400	32,107,152	92,330,400	60,223,248
17	-	2,978,400	32,107,152	92,330,400	60,223,248
18	-	2,978,400	32,107,152	92,330,400	60,223,248
19	-	2,978,400	32,107,152	92,330,400	60,223,248
20	-	2,978,400	32,107,152	92,330,400	60,223,248
21	-	2,978,400	32,107,152	92,330,400	60,223,248
22	-	2,978,400	32,107,152	92,330,400	60,223,248
23	-	2,978,400	32,107,152	92,330,400	60,223,248
24	-	2,978,400	32,107,152	92,330,400	60,223,248
25	-	2,978,400	32,107,152	92,330,400	60,223,248
26	-	2,978,400	32,107,152	92,330,400	60,223,248
27	-	2,978,400	32,107,152	92,330,400	60,223,248
28	-	2,978,400	32,107,152	92,330,400	60,223,248
29	-	2,978,400	32,107,152	92,330,400	60,223,248
30	-	2,978,400	32,107,152	92,330,400	60,223,248

Using the same spreadsheet, the internal rate of return of the net cash flow, which is the discount rate that makes the net present value the cash flows equal to zero, is found to be 12.14 %.

By adjusting the price in this spread sheet program, we find that the minimum price at which the energy must be sold in order to achieve a minimum IRR of 13 % is 32.28 \$/MWh.

7.2 *What would be the Internal Rate of Return of the unit of Problem* 7.1 *if the utilization rate drops by* 15% *after* 10 *years and by another* 15% *after* 20 *years*?

The investment cost is as in the previous problem. The production, production cost, revenue and therefore the cash flow for the first ten years of the plant life are as in problem 7.1.

The estimated annual production for years 11 to 20 is:

$$400 \text{ MW} \times 8760 \text{ h} \times 0.70 = 2{,}452{,}800 \text{ MWh}$$

The annual production cost for years 11 to 20 is:

$$2452800 \text{ MWh} \times 1.10 \text{ \$/MBtu} \times 9{,}800 \text{ Btu/kWh} = \$\ 26{,}441{,}184$$

The annual revenue is:

$2452800 \text{ MWh} \times 31 \text{ \$/MWh} = \$ 76{,}036{,}800$

Therefore the annual net cash flow for these years is given by:

$\$ 76{,}036{,}800 - \$ 26{,}441{,}184 = \$ 49{,}595{,}616$

The estimated annual production for year 21 to 30 is given by:

$400 \text{ MW} \times 8760 \text{ h} \times 0.55 = 1927200 \text{ MWh}$

The annual production cost for years 21 to 30 is:

$1927200 \text{ MWh} \times 1.10 \text{ \$/MBtu} \times 9{,}800 \text{ Btu/kWh} = \$ 20{,}775{,}216$

The annual revenue is:

$1927200 \text{ MWh} \times 31 \text{ \$/MWh} = \$ 59{,}743{,}200$

Therefore the annual net cash flow for these years is:

$\$ 59{,}743{,}200 - \$ 20{,}775{,}216 = \$ 38{,}967{,}984$

Using the spreadsheet P7_2.xls, the following table can be built:

Period	Investment	Utilization	Production (MWh)	Production cost ($)	Revenue ($)	Net Cash Flow ($)
0	480,000,000		0	-	-	-480,000,000
1		0.85	2,978,400	32,107,152	92,330,400	60,223,248
2		0.85	2,978,400	32,107,152	92,330,400	60,223,248
3		0.85	2,978,400	32,107,152	92,330,400	60,223,248
4		0.85	2,978,400	32,107,152	92,330,400	60,223,248
5		0.85	2,978,400	32,107,152	92,330,400	60,223,248
6		0.85	2,978,400	32,107,152	92,330,400	60,223,248
7		0.85	2,978,400	32,107,152	92,330,400	60,223,248
8		0.85	2,978,400	32,107,152	92,330,400	60,223,248
9		0.85	2,978,400	32,107,152	92,330,400	60,223,248
10		0.85	2,978,400	32,107,152	92,330,400	60,223,248
11		0.7	2,452,800	26,441,184	76,036,800	49,595,616
12		0.7	2,452,800	26,441,184	76,036,800	49,595,616
13		0.7	2,452,800	26,441,184	76,036,800	49,595,616
14		0.7	2,452,800	26,441,184	76,036,800	49,595,616
15		0.7	2,452,800	26,441,184	76,036,800	49,595,616
16		0.7	2,452,800	26,441,184	76,036,800	49,595,616
17		0.7	2,452,800	26,441,184	76,036,800	49,595,616
18		0.7	2,452,800	26,441,184	76,036,800	49,595,616
19		0.7	2,452,800	26,441,184	76,036,800	49,595,616
20		0.7	2,452,800	26,441,184	76,036,800	49,595,616

21	0.55	1,927,200	20,775,216	59,743,200	38,967,984
22	0.55	1,927,200	20,775,216	59,743,200	38,967,984
23	0.55	1,927,200	20,775,216	59,743,200	38,967,984
24	0.55	1,927,200	20,775,216	59,743,200	38,967,984
25	0.55	1,927,200	20,775,216	59,743,200	38,967,984
26	0.55	1,927,200	20,775,216	59,743,200	38,967,984
27	0.55	1,927,200	20,775,216	59,743,200	38,967,984
28	0.55	1,927,200	20,775,216	59,743,200	38,967,984
29	0.55	1,927,200	20,775,216	59,743,200	38,967,984
30	0.55	1,927,200	20,775,216	59,743,200	38,967,984

Using this spreadsheet we can determine that the internal rate of return is 11.17 %

7.3 *What would be the Internal Rate of Return of the unit of Problem* 7.1 *if the price of electrical energy was* 35 $/MWh *during the first* 10 *years of the expected life of the plant before dropping to* 31 $/MWh*? What would be the value to the Internal Rate of Return if this price was* 31 $/MWh *during the first* 20 *years and* $35 $/MWh *during the last ten years. Compare these results with the Internal Rate of Return calculated in Problem* 7.1 *and explain the differences*.

The estimated annual production for this plant and the annual production cost are as in problem 7.1 For the first 10 years, the annual revenue is thus:

$$2978400 \text{ MWh} \times 35 \text{ \$/MWh} = \$ \ 104{,}244{,}000$$

Therefore for each of these 10 years the annual net cash flow is:

$$\$ \ 104{,}244{,}000 - \$ \ 32{,}107{,}152 = \$ \ 72{,}136{,}848$$

When the price drops to 31 $/MWh the results for each of the years are as in problem 7.1. Using the spreadsheet P7_3.xls the following table can be generated:

Period	Investment ($)	Production (MWh)	Production cost ($)	Revenue ($)	Net Cash Flow ($)
0	480,000,000	0	-	-	-480,000,000
1	-	2,978,400	32,107,152	104,244,000	72,136,848
2	-	2,978,400	32,107,152	104,244,000	72,136,848
3	-	2,978,400	32,107,152	104,244,000	72,136,848
4	-	2,978,400	32,107,152	104,244,000	72,136,848
5	-	2,978,400	32,107,152	104,244,000	72,136,848
6	-	2,978,400	32,107,152	104,244,000	72,136,848
7	-	2,978,400	32,107,152	104,244,000	72,136,848
8	-	2,978,400	32,107,152	104,244,000	72,136,848
9	-	2,978,400	32,107,152	104,244,000	72,136,848
10	-	2,978,400	32,107,152	104,244,000	72,136,848
11	-	2,978,400	32,107,152	92,330,400	60,223,248
12	-	2,978,400	32,107,152	92,330,400	60,223,248
13	-	2,978,400	32,107,152	92,330,400	60,223,248

14	-	2,978,400	32,107,152	92,330,400	60,223,248
15	-	2,978,400	32,107,152	92,330,400	60,223,248
16	-	2,978,400	32,107,152	92,330,400	60,223,248
17	-	2,978,400	32,107,152	92,330,400	60,223,248
18	-	2,978,400	32,107,152	92,330,400	60,223,248
19	-	2,978,400	32,107,152	92,330,400	60,223,248
20	-	2,978,400	32,107,152	92,330,400	60,223,248
21	-	2,978,400	32,107,152	92,330,400	60,223,248
22	-	2,978,400	32,107,152	92,330,400	60,223,248
23	-	2,978,400	32,107,152	92,330,400	60,223,248
24	-	2,978,400	32,107,152	92,330,400	60,223,248
25	-	2,978,400	32,107,152	92,330,400	60,223,248
26	-	2,978,400	32,107,152	92,330,400	60,223,248
27	-	2,978,400	32,107,152	92,330,400	60,223,248
28	-	2,978,400	32,107,152	92,330,400	60,223,248
29	-	2,978,400	32,107,152	92,330,400	60,223,248
30	-	2,978,400	32,107,152	92,330,400	60,223,248

Using the same spreadsheet we find that the IRR for these condition is 14.13 %.

If the price is 31 $/MWh for the first 20 years and 35 $/MWh for the remaining 10 years, the table is as follows:

Period	Investment ($)	Production (MWh)	Production cost ($)	Revenue ($)	Net Cash Flow ($)
0	480,000,000	0	-	-	-480,000,000
1	-	2,978,400	32,107,152	92,330,400	60,223,248
2	-	2,978,400	32,107,152	92,330,400	60,223,248
3	-	2,978,400	32,107,152	92,330,400	60,223,248
4	-	2,978,400	32,107,152	92,330,400	60,223,248
5	-	2,978,400	32,107,152	92,330,400	60,223,248
6	-	2,978,400	32,107,152	92,330,400	60,223,248
7	-	2,978,400	32,107,152	92,330,400	60,223,248
8	-	2,978,400	32,107,152	92,330,400	60,223,248
9	-	2,978,400	32,107,152	92,330,400	60,223,248
10	-	2,978,400	32,107,152	92,330,400	60,223,248
11	-	2,978,400	32,107,152	92,330,400	60,223,248
12	-	2,978,400	32,107,152	92,330,400	60,223,248
13	-	2,978,400	32,107,152	92,330,400	60,223,248
14	-	2,978,400	32,107,152	92,330,400	60,223,248
15	-	2,978,400	32,107,152	92,330,400	60,223,248
16	-	2,978,400	32,107,152	92,330,400	60,223,248
17	-	2,978,400	32,107,152	92,330,400	60,223,248
18	-	2,978,400	32,107,152	92,330,400	60,223,248
19	-	2,978,400	32,107,152	92,330,400	60,223,248
20	-	2,978,400	32,107,152	92,330,400	60,223,248
21	-	2,978,400	32,107,152	104,244,000	72,136,848
22	-	2,978,400	32,107,152	104,244,000	72,136,848
23	-	2,978,400	32,107,152	104,244,000	72,136,848
24	-	2,978,400	32,107,152	104,244,000	72,136,848
25	-	2,978,400	32,107,152	104,244,000	72,136,848

26	-	2,978,400	32,107,152	104,244,000	72,136,848
27	-	2,978,400	32,107,152	104,244,000	72,136,848
28	-	2,978,400	32,107,152	104,244,000	72,136,848
29	-	2,978,400	32,107,152	104,244,000	72,136,848
30	-	2,978,400	32,107,152	104,244,000	72,136,848

In this case the IRR is 12.33 %.

Because for some of the years the prices and hence the revenues are higher, the Internal Rate of Return is higher than in Problem 7.1. Note that getting a higher price in later years as in the second part of this problem has a considerably smaller effect on the IRR than getting this higher early in the life of the plant.

7.4 *In an effort to meet its obligation under the Kyoto agreement, the government of Syldavia has decided to encourage the construction of renewable generation by guaranteeing to buy their output at a fixed price of* 35 $/MWh. *Greener Syldavia Power Company is considering taking advantage of this program by building a* 200 MW *wind farm. This wind farm has an expected life of* 30 *years and its building cost amounts to* 850 $/kW. *Based on an analysis of the wind regime at the proposed location, the engineers of Greener Syldavia Power Company estimate that the output of the plant will be as shown in the table below*:

Output as a fraction of capacity	Hours per year
100%	1700
75%	1200
50%	850
25%	400
0%	4610

Given that the Greener Syldavia Power Company has set itself a Minimum Acceptable Rate of Return of 12%*, should it take the government's offer and build this wind farm*?

The investment cost for the wind farm is:

$$200\text{ MW} \times 850000\text{ \$/MW} = \$170{,}000{,}000$$

The estimated annual production for this plant is:

$$200\text{ MW} \times 1700\text{ h} + 150\text{ MW} \times 1200\text{ h} + 100\text{ MW} \times 850\text{ h} + 50\text{ MW} \times 400\text{ h} = 625000\text{ MWh}.$$

Since the wind is free, there is no annual production cost. (In practice there would be a small operation and maintenance cost, but we are neglecting it in this problem).
The annual revenue is :

625000 MWh × 35 $/MWh = $ 21,875,000

Since there no annual production cost, the annual net cash flow is equal to the annual revenue.

Period	Investment	Production (MWh)	Production cost	Revenue	Net Cash Flow
0	170,000,000	0			-170,000,000
1		625,000		21,875,000	21,875,000
2		625,000		21,875,000	21,875,000
3		625,000		21,875,000	21,875,000
4		625,000		21,875,000	21,875,000
5		625,000		21,875,000	21,875,000
6		625,000		21,875,000	21,875,000
7		625,000		21,875,000	21,875,000
8		625,000		21,875,000	21,875,000
9		625,000		21,875,000	21,875,000
10		625,000		21,875,000	21,875,000
11		625,000		21,875,000	21,875,000
12		625,000		21,875,000	21,875,000
13		625,000		21,875,000	21,875,000
14		625,000		21,875,000	21,875,000
15		625,000		21,875,000	21,875,000
16		625,000		21,875,000	21,875,000
17		625,000		21,875,000	21,875,000
18		625,000		21,875,000	21,875,000
19		625,000		21,875,000	21,875,000
20		625,000		21,875,000	21,875,000
21		625,000		21,875,000	21,875,000
22		625,000		21,875,000	21,875,000
23		625,000		21,875,000	21,875,000
24		625,000		21,875,000	21,875,000
25		625,000		21,875,000	21,875,000
26		625,000		21,875,000	21,875,000
27		625,000		21,875,000	21,875,000
28		625,000		21,875,000	21,875,000
29		625,000		21,875,000	21,875,000
30		625,000		21,875,000	21,875,000

Using the spreadsheet P7_4.xls, we find that the IRR is 12.49 %. Since the minimum acceptable IRR is 12 %, the company should build the wind farm.

7.5 *Syldavia Energy is exploring the possibility of building a new* 600 MW *power plant. Given the parameters shown in the table below, which technology should it adopt for this plant, assuming that the plant would have a utilization factor of* 0.80 *and would be able to sell its output at an average price of* 30 $/MW*h? Syldavia Energy uses a Minimum Acceptable Rate of Return of* 12%.

	Technology A	Technology B
Investment cost	1100 $/kW	650 $/kW
Expected plant life	30 years	30 years
Heat rate at rated output	7,500 Btu/kWh	6,500 Btu/kWh
Expected fuel cost	1.15 $/MBtu	2.75 $/MBtu

Technology A

The investment cost is:

$$600 \text{ MW} \times 1100000 \text{ \$/MW} = \$ \ 660{,}000{,}000$$

The estimated annual production for this technology is:

$$600 \text{ MW} \times 8760 \text{ h} \times 0.80 = 4204800 \text{ MWh}$$

The annual production cost is then:

$$4204800 \text{ MWh} \times 1.15 \text{ \$/MBtu} \times 7.5 \text{ Btu/Wh} = \$ \ 36{,}266{,}400$$

The annual revenue is:

$$4204800 \text{ MWh} \times 30 \text{ \$/MWh} = \$ \ 126{,}144{,}000$$

And the annual net cash flow is:

$$\$ \ 126{,}144{,}000 - \$ \ 36{,}266{,}400 = \$ \ 89{,}877{,}600$$

Building a table using spreadsheet P7_5.xls as in the previous examples to compute the IRR, we find a value of 13.30 %

Technology B

The investment cost is:

$$600 \text{ MW} \times 650000 \text{ \$/MW} = \$ \ 390{,}000{,}000$$

The estimated annual production for this technology is:

$$600 \text{ MW} \times 8760 \text{ h} \times 0.80 = 4204800 \text{ MWh}$$

The annual production cost is thus:

$$4204800 \text{ MWh} \times 2.75 \text{ \$/MBtu} \times 6{,}500 \text{ Btu/kWh} = \$ \ 75{,}160{,}800$$

The annual revenue is:

$4204800 \text{ MWh} \times 30 \text{ \$/MWh} = \$ 126{,}144{,}000$

And the annual net cash flow is:

$\$ 126{,}144{,}000 - \$ 75{,}160{,}800 = \$ 50{,}983{,}200$

From the second sheet of the spreadsheet P7-5.xls, we find that the IRR is 12.71 %

Since both technologies give an IRR higher than 12.00%, they are both acceptable. If technology A is selected, then the investment is higher. However if we calculate the Internal Rate of Return on the difference between the cash flows of technologies A and B, we get an Incremental Internal Rate of Return of 14.13 %. Since this is higher than the Minimum Acceptable Rate of Return, Technology A should be chosen.

7.6 Borduria Power has built a plant with the following characteristics:

Investment cost	1000 $/kW
Capacity	400 MW
Expected plant life	30 years
Heat rate at rated output	9,800 Btu/kWh
Expected fuel cost	1.10 $/MBtu
Expected utilization factor	0.85
Expected average selling price	31 $/MWh

After 5 *years of operation, market conditions change dramatically. The fuel price increases to* 1.50 $/MBtu*, the utilization factor drops to* 0.45 *and the average price at which Borduria Power can sell the energy produced by this plant drops to* 25 $/MWh.
What should Borduria Power do with this plant? What should Borduria Power have done if it had known about this change in market conditions? Assume that Borduria Power uses a MARR *of* 12% *and ignore the recoverable cost of the plant.*

The investment cost is:

$400 \text{ MW} \times 1000000 \text{ \$/MW} = \$ 400{,}000{,}000$

The estimated annual production for this plant at the first 5 years is given by:

$400 \text{ MW} \times 8760 \text{ h} \times 0.85 = 2978400 \text{ MWh}$

The annual production cost is:

$$2978400 \text{ MWh} \times 1.10 \text{ \$/MBtu} \times 9{,}800 \text{ Btu/kWh} = \$\ 32{,}107{,}152$$

The annual revenue is:

$$2978400 \text{ MWh} \times 31 \text{ \$/MWh} = \$\ 92{,}330{,}400$$

And the annual net cash flow is:

$$\$\ 92{,}330{,}400 - \$\ 32{,}107{,}152 = \$\ 60{,}223{,}248$$

For the remaining 25 years, the estimated annual production is:

$$400 \text{ MW} \times 8760 \text{ h} \times 0.45 = 1576800 \text{ MWh}$$

The annual production cost is:

$$1576800 \text{ MWh} \times 1.50 \text{ \$/MBtu} \times 9{,}800 \text{ Btu/kWh} = \$\ 23{,}178{,}960$$

The annual revenue is:

$$1576800 \text{ MWh} \times 25 \text{ \$/MWh} = \$\ 39{,}420{,}000$$

And the annual net cash flow is:

$$\$\ 39{,}420{,}000 - \$\ 23{,}178{,}960 = \$\ 16{,}241{,}040$$

Since the plant continues to produce a positive cash flow during the remaining 25 years, it should be kept open. Using the spreadsheet P7-5&6.xls, we get the following table:

Period	Investment	Production (MWh)	Production cost	Revenue	Net Cash Flow
0	400,000,000	0	-	-	-400,000,000
1		2978400	32,107,152	92,330,400	60,223,248
2		2978400	32,107,152	92,330,400	60,223,248
3		2978400	32,107,152	92,330,400	60,223,248
4		2978400	32,107,152	92,330,400	60,223,248
5		2978400	32,107,152	92,330,400	60,223,248
6		1,576,800	23,178,960	39,420,000	16,241,040
7		1,576,800	23,178,960	39,420,000	16,241,040
8		1,576,800	23,178,960	39,420,000	16,241,040
9		1,576,800	23,178,960	39,420,000	16,241,040
10		1,576,800	23,178,960	39,420,000	16,241,040
11		1,576,800	23,178,960	39,420,000	16,241,040
12		1,576,800	23,178,960	39,420,000	16,241,040
13		1,576,800	23,178,960	39,420,000	16,241,040

14	1,576,800	23,178,960	39,420,000	16,241,040
15	1,576,800	23,178,960	39,420,000	16,241,040
16	1,576,800	23,178,960	39,420,000	16,241,040
17	1,576,800	23,178,960	39,420,000	16,241,040
18	1,576,800	23,178,960	39,420,000	16,241,040
19	1,576,800	23,178,960	39,420,000	16,241,040
20	1,576,800	23,178,960	39,420,000	16,241,040
21	1,576,800	23,178,960	39,420,000	16,241,040
22	1,576,800	23,178,960	39,420,000	16,241,040
23	1,576,800	23,178,960	39,420,000	16,241,040
24	1,576,800	23,178,960	39,420,000	16,241,040
25	1,576,800	23,178,960	39,420,000	16,241,040
26	1,576,800	23,178,960	39,420,000	16,241,040
27	1,576,800	23,178,960	39,420,000	16,241,040
28	1,576,800	23,178,960	39,420,000	16,241,040
29	1,576,800	23,178,960	39,420,000	16,241,040
30	1,576,800	23,178,960	39,420,000	16,241,040

Using this spreadsheet we find that the IRR is only 6.31%. If the company had known that the conditions would change, it would not have built the plant because this IRR is below its MARR.

7.7 *Assume that Borduria Power decides to continue operating the plant of Problem 7.6 and that the market conditions do not improve. Five years later, the plant suffers a major breakdown that would cost* \$120,000,000 *to repair. It is expected that this repair would allow the plant to continue operating for the rest of its design life. What should Borduria Power do? What should it do if this breakdown occurs fifteen years after the plant was built*?

The repair needs to be amortized over the remaining 20 years of life of the plant. Assuming that it continues operating under the conditions described in problem 7.6, the following table can be generated using the second sheet of the spreadsheet P76_77.xls:

Period	Investment	Production (MWh)	Production cost ($)	Revenue	Net Cash Flow
0	120,000,000	0	-	-	-120,000,000
1		1,576,800	23,178,960	39,420,000	16,241,040
2		1,576,800	23,178,960	39,420,000	16,241,040
3		1,576,800	23,178,960	39,420,000	16,241,040
4		1,576,800	23,178,960	39,420,000	16,241,040
5		1,576,800	23,178,960	39,420,000	16,241,040
6		1,576,800	23,178,960	39,420,000	16,241,040
7		1,576,800	23,178,960	39,420,000	16,241,040
8		1,576,800	23,178,960	39,420,000	16,241,040
9		1,576,800	23,178,960	39,420,000	16,241,040
10		1,576,800	23,178,960	39,420,000	16,241,040
11		1,576,800	23,178,960	39,420,000	16,241,040
12		1,576,800	23,178,960	39,420,000	16,241,040

13	1,576,800	23,178,960	39,420,000	16,241,040
14	1,576,800	23,178,960	39,420,000	16,241,040
15	1,576,800	23,178,960	39,420,000	16,241,040
16	1,576,800	23,178,960	39,420,000	16,241,040
17	1,576,800	23,178,960	39,420,000	16,241,040
18	1,576,800	23,178,960	39,420,000	16,241,040
19	1,576,800	23,178,960	39,420,000	16,241,040
20	1,576,800	23,178,960	39,420,000	16,241,040

The IRR for these conditions is 12.17%, which is higher than the MARR; therefore Borduria should repair the plant.

On the other hand, if the repair has to be done when the plant has only 15 years of life left, the third sheet of the spreadsheet P-6&7.xls shows that the IRR is only 10.51%. Performing the repair is therefore not justifiable given the target MARR.

7.8 *An old* 100 MW *power plant has a heat rate of* 13,000 Btu/kWh *and burns a fuel that costs* 2.90 $/MBtu*. The owner of the plant estimates the fixed cost of keeping the plant available at* $ 360,000 *per year. What is the minimum price that would justify keeping this plant available if it has a* 1% *utilization rate? Compare this price with the average production cost of the plant.*

The estimated annual production for this plant is:

$$100 \text{ MW} \times 8760 \text{ h} \times 0.01 = 8760 \text{ MWh}$$

The annual production cost is:

$$8760 \text{ MWh} \times 2.90 \text{ \$/MBtu} \times 13{,}000 \text{ Btu/kWh} = \$\ 330{,}252$$

The annual revenue is:

$$8760 \text{ MWh} \times \pi \text{ \$/MWh} = \$\ 8760\pi$$

And the annual net cash flow is:

$$\$\ 8760\pi - \$\ 330{,}252 - \$\ 360{,}000$$

In order to not make losses, the cash flow should be at least equal to zero, therefore:

$$\pi = \frac{690252}{8760} = 78.796 \text{ \$/MWh}$$

The price π should therefore be greater than 78.796 $/MWh. The average production cost of this plant is $330250 / 8760 MWh = 37.70 $/MWh