Economic Evaluation of Multiphase Meters

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Abstract

When operators must decide between a traditional approach to the production facilities and one including multiphase flow meters (MPFM), they must compare the capital and operating expenditures (CAPEX and OPEX) of each solution. In order to achieve this, CAPEX and OPEX for the same brand of test separator and multiphase flow meter were obtained.

A deterministic economic model was developed for evaluating the economics of MPFM and Test Separators. Two cases were considered. Case A considered whether it will be more economical to replace a test separator with a multiphase flow meter when the test separator is already in place while Case B considered which is more economically viable to install between the multiphase flow meter and test separator.

Net Present Value (NPV) for both cases was calculated. Case A gave an NPV of $72,630.65 while Case B gave an NPV of $91,064.83. This shows that MPFM is a more cost-effective means of obtaining well-test data. Sensitivity studies of the economic parameters were also considered and spider diagrams presented.

Keywords

Multiphase Flow Meters (MPFM); Test Separators; OPEX; CAPEX; Net Present Value (NPV)

Introduction

Until recently, large expensive test separators have been used to separate oil, water and gas which are then measured using conventional technology. Multiphase metering delivers real-time simultaneous measurement of oil, water and gas eliminating the need for test separators. It provides instant information on reservoir production [1].

Measurement of multiphase flow is complex, made difficult by the diversity of well outputs, crude oil types and operating variables. Successful multiphase flow measurement relies on understanding not only the difficulties of measuring multiphase flow but also the operating environment. The operating principle of all multiphase meters is to first measure the flow velocity (the velocity of the combined phases) and phase fractions [2]. The two measurements are then used to determine the flow rates of each individual phase. Other areas of application of multiphase metering include: well testing, production metering, comparison and measurement for process control.

This study gives a detailed comparative economic evaluation of both the multiphase flow meter and the test separator. This is imperative in order to decide which meter to accept or reject. Selecting the best meter for production operations will bring about maximum benefit and good return on investment.

Assumptions

The following are the assumptions made in this study:

1. Multiphase meters have a fifteen-year service life;
2. There is no tax implication to the investment;
3. There is no salvage value;
4. Base case of 15% discount is considered.

Development of Economic Evaluation Model

A general economic model is proposed to enable management compare the costs of investment on the multiphase flow meter and test separator and take decision. This model considers all costs involved in the evaluation life of the meters.

The total cost for the MPFM and test separator were obtained separately as shown in Tables 1 and 3 respectively using the equation:

$$\text{Total Cost, TC} = -\text{CAPEX} - \text{OPEX} \quad (1)$$

That is, for MPFM:

$$TC_{MPFM} = -(CAPEX + OPEX)_{MPFM} \quad (2)$$

and for test separator, TS:

$$TC_{TS} = -(CAPEX + OPEX)_{TS} \quad (3)$$

The total cost, TC is then discounted at 15% to obtain the present value, PV (Tables 2 and 4) given by:

$$PV = \frac{TC}{(1+d)^n} \quad (4)$$

That is, for MPFM:

$$PV_{MPFM} = \left[\frac{TC}{(1+d)^n}\right]_{MPFM} \quad (5)$$

and that for test separator is given by:

$$PV_{TS} = \left[\frac{TC}{(1+d)^n}\right]_{TS} \quad (6)$$

where the inflation compensated opportunity, d = i + f + if; i = interest rate. But, f = 0, hence, d = i.

The Net incremental Present Value (NPV*) is then calculated. This is done by using the model:

$$NPV^* = PV_{MPFM} - PV_{TS} \quad (7)$$

Hence, substituting for PV_{MPFM} and PV_{TS} gives:

$$NPV^* = \left[\frac{TC}{(1+d)^n}\right]_{MPFM} - \left[\frac{TC}{(1+d)^n}\right]_{TS} \quad (8)$$

Since both denominators are expected to be the same, it is generally concluded that:

$$NPV^{*} = \sum_{n=1} \left[\frac{TC_{MPFM} - TC_{TS}}{(1+d)^{n}} \right] \quad (9)$$

When the NPV* is calculated, decision is made as follows [3]:

- If NPV* is positive, select multiphase flow meter (MPFM);
- If NPV* is negative, select Test Separator (TS);
- If NPV* is zero, select either of them.

Two cases were considered as discussed below.

CASE A

This section considers whether is it will be more economical to replace a test separator with a multiphase flow meter when the test separator is already in place. Table 1 below shows the undiscounted cost of both the multiphase phase flow meter and test separator. OPEX and CAPEX were obtained through an e-mail message from one of the manufacturers of MPFM [4].

Table 1. Undiscounted total cost for multiphase meter and test separator

Years from start	Multiphase Flow Meter			Test separator		
	CAPES ($)	OPEX ($)	Total cost ($)	CAPEX ($)	OPEX ($)	Total cost ($)
0	165,000	0	165,000	0	0	0
1	0	27,600	27,600	0	78,000	78,000
2	0	27,600	27,600	0	78,000	78,000
3	0	27,600	27,600	0	78,000	78,000
4	0	27,600	27,600	0	78,000	78,000
5	0	27,600	27,600	0	78,000	78,000
6	0	27,600	27,600	0	78,000	78,000
7	0	27,600	27,600	0	78,000	78,000
8	0	27,600	27,600	0	78,000	78,000
9	0	27,600	27,600	0	78,000	78,000
10	0	27,600	27,600	0	78,000	78,000
11	0	27,600	27,600	0	78,000	78,000
12	0	27,600	27,600	0	78,000	78,000
13	0	27,600	27,600	0	78,000	78,000
14	0	27,600	27,600	0	78,000	78,000
15	0	27,600	27,600	0	78,000	78,000
	165,000	**414,000**	**579,000**	**0**	**1,170,000**	**1,170,000**

Table 2. Discounted total cost for the multiphase flow meter and test separator

Years from start	Multiphase Flow Meter			Test separator		
	Total cost ($)	Discount Factor (%)	15% PV ($)	Total cost ($)	Discount Factor	15% PV ($)
0	165,000	1	165,000.00	0	1	0
1	27,000	0.86957	24,000.13	78,000	0.86957	67,826.46
2	27,000	0.75614	20,869.46	78,000	0.75614	58,978.92
3	27,000	0.65752	18,147.55	78,000	0.65752	51,286.56
4	27,000	0.57175	15,780.30	78,000	0.57175	44,596.50
5	27,000	0.49718	13,722.17	78,000	0.49718	38,780.04
6	27,000	0.43233	11.932.31	78,000	0.43233	33,721.74
7	27,000	0.37596	10,375.94	78,000	0.37596	29,323.32
8	27,000	0.32690	8,022.44	78,000	0.32690	25,498.20
9	27,000	0.28426	7,845.58	78,000	0.28426	22,172.28
10	27,000	0.24718	6,822.17	78,000	0.24718	19,280.04
11	27,000	0.21494	5,932.34	78,000	0.21494	16,765.32
12	27,000	0.18691	5,158.72	78,000	0.18691	14,578.98
13	27,000	0.16253	4,485.83	78,000	0.16253	12,677.34
14	27,000	0.14133	3,900.71	78,000	0.14133	11,023.74
15	27,000	0.12289	3,391.76	78,000	0.12289	9,585.42
	579,000		**325,387.41**	**1,170,000**		**456,094.86**

The NPV* was then calculated using equation (9). Here, NPV* was found to be $72,630.65 (a positive figure). Hence, MPFM was selected.

To obtain the breakeven point, the total cost of both MPFM and test separator were then discounted at various discount rate and the present value (PV) obtained were used to generate Figure 1 below.

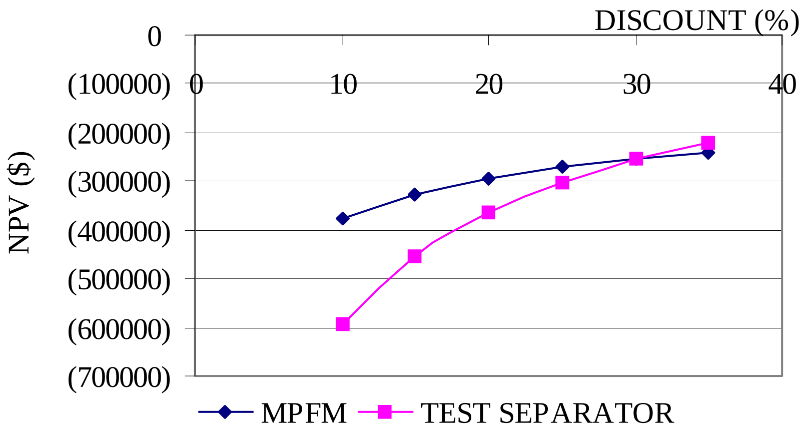

Figure 1. Plot of Present Value against Discount Factor

Figure 1 shows that the MPFM and Test Separator have a breakeven point of 30%. MPFM gives a better investment proposal in less than 30% while Test Separator gives a better investment proposal in greater that 30%.

Figure 2 shows the relationship between the CAPEX and OPEX for both MPFM and Test Separator.

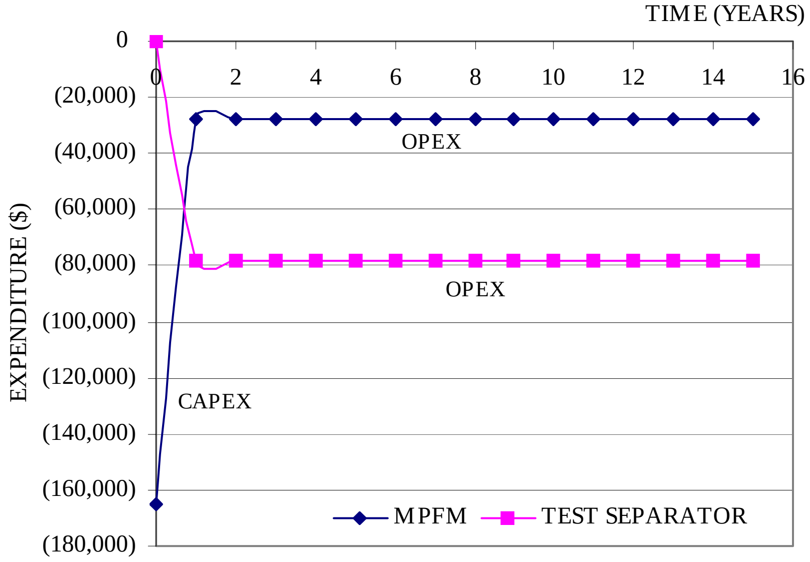

Figure 2. Expenditure curves for MPFM and Test Separator

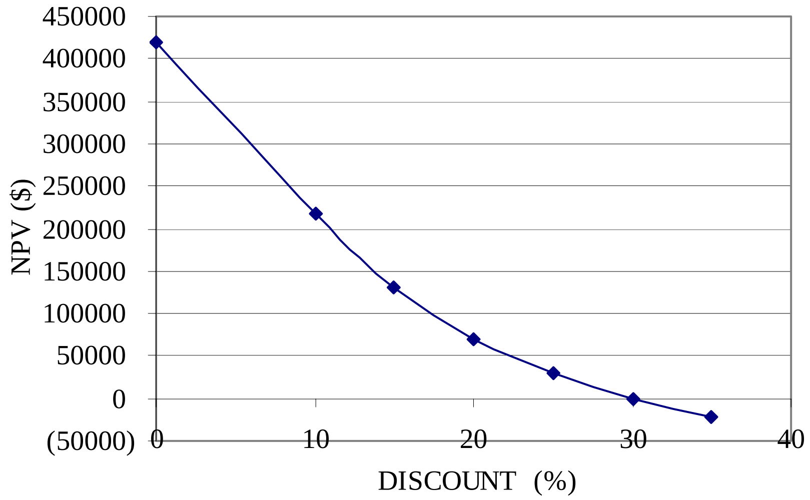

Figure 3. Incremental PV Profile

Also, the incremental present value was obtained from the difference in the present values of the MPFM and Test Separator and this was used in generating Figure 3 below.

The figure above shows that a net cost of $420,000 occurs at the zero discount axes. The intersection of the profile with the discount axis gives a discount of 30%. This indicates that investment should be accepted if the cost capital is less than 30% and should be rejected if greater than 30%.

Sensitivity Analysis

Sensitivity analysis is a way of analyzing risk in order to answer the question: what if a certain input changes [5]? Thus enabling us to compare changing variables in the base case, identify the most critical variable and establish a confidence level in the estimation of input data. Below is the sensitivity plot for case A.

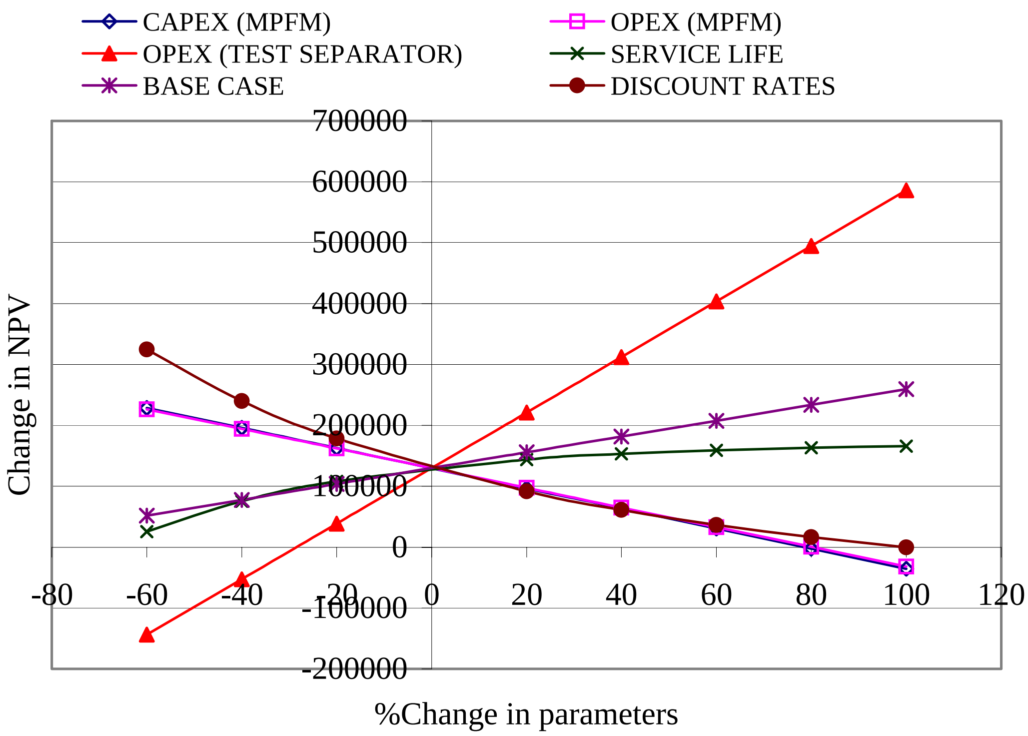

Figure 4. Sensitivity plot for case A

Case B

This section considers which is more economically viable to install between the multiphase flow meter and test separator.

Table 3 below shows the undiscounted cost of both the multiphase phase flow meter and test separator.

The NPV* was then calculated using equation (9). Here, NPV* was found to be $91,064.83 (a positive figure). Hence, MPFM was selected.

Table 3. Undiscounted total cost for multiphase meter and test separator

Years from start	Multiphase Flow Meter			Test separator		
	CAPES ($)	OPEX ($)	Total cost ($)	CAPEX ($)	OPEX ($)	Total cost ($)
0	165,000	0	165,000	150,000	0	150,000
1	0	27,600	27,600	0	78,000	78,000
2	0	27,600	27,600	0	78,000	78,000
3	0	27,600	27,600	0	78,000	78,000
4	0	27,600	27,600	0	78,000	78,000
5	0	27,600	27,600	0	78,000	78,000
6	0	27,600	27,600	0	78,000	78,000
7	0	27,600	27,600	0	78,000	78,000
8	0	27,600	27,600	0	78,000	78,000
9	0	27,600	27,600	0	78,000	78,000
10	0	27,600	27,600	0	78,000	78,000
11	0	27,600	27,600	0	78,000	78,000
12	0	27,600	27,600	0	78,000	78,000
13	0	27,600	27,600	0	78,000	78,000
14	0	27,600	27,600	0	78,000	78,000
15	0	27,600	27,600	0	78,000	78,000
			579,000			**1,320,000**

Table 4. Discounted total cost for the multiphase flow meter and test separator

Years from start	Multiphase Flow Meter			Test separator		
	Total cost ($)	Discount Factor	15% PV ($)	Total cost ($)	Discount Factor	15% PV ($)
0	165,000	1	165,000	150,000	1	150,000
1	27,000	0.86957	24,000.13	78,000	0.86957	67,826.46
2	27,000	0.75614	20,869.46	78,000	0.75614	58,978.92
3	27,000	0.65752	18,147.55	78,000	0.65752	51,286.56
4	27,000	0.57175	15,780.30	78,000	0.57175	44,596.50
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14	27,000	0.14133	3,900.71	78,000	0.14133	11,023.74
15	27,000	0.12289	3,391.76	78,000	0.12289	9,585.42
	579,000		**325,387.41**	**1,320,000**		**606,094.86**

To obtain the breakeven point, the total cost of both MPFM and test separator were then discounted at various discount rate and the present value (PV) obtained were used to generate Figure 5 below. Figure 5 show that the MPFM and Test Separator have a breakeven point of 69%. MPFM gives a better investment proposal in less than 69% while Test Separator gives a better investment proposal in greater that 69%. Figure 6 shows the relationship between the CAPEX and OPEX for both MPFM and Test Separator.

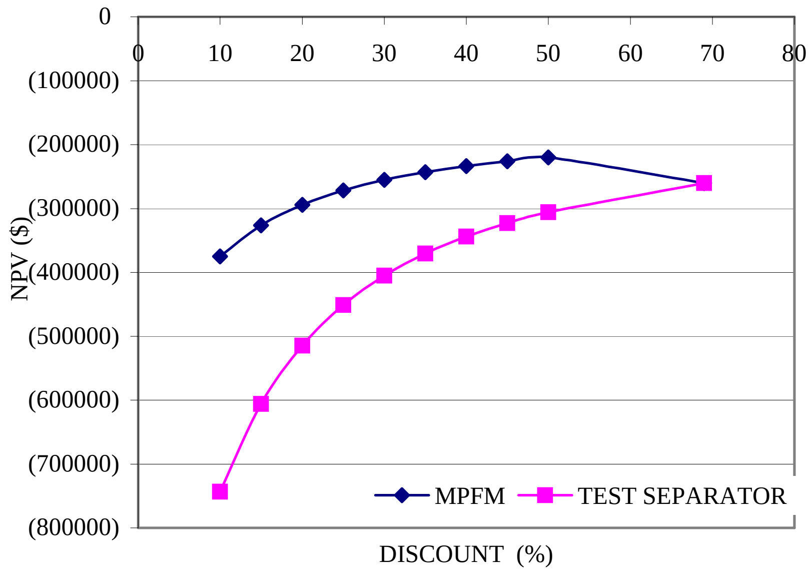

Figure 5.Plot of Present Value against Discount Factor

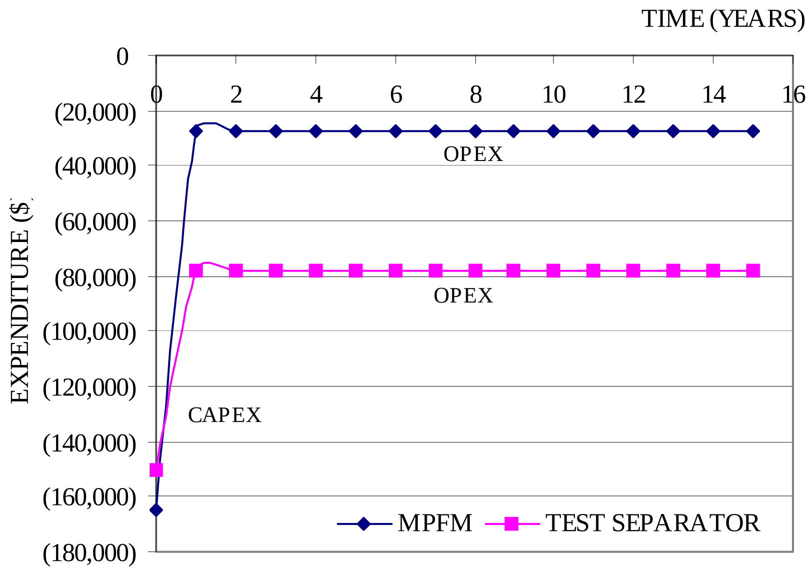

Figure 6. Expenditure curves for MPFM and Test Separator

In addition, the incremental present value was obtained from the difference in the present values of the MPFM and Test Separator and this was used in generating Figure 7 below.

The figure above shows that a net cost of $550,000 occurs at the zero discount axis. The intersection of the profile with the discount axis gives a discount of 90%. This indicates that investment should be accepted if the cost capital is less than 90% and should be rejected if greater than 90%.

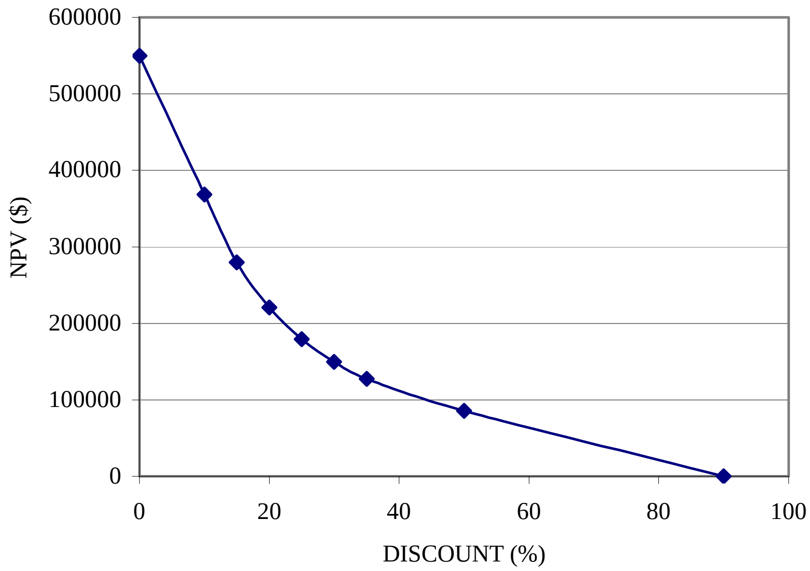

Figure 7. Incremental PV Profile

Sensitivity Analysis

Below is the sensitivity plot for case B.

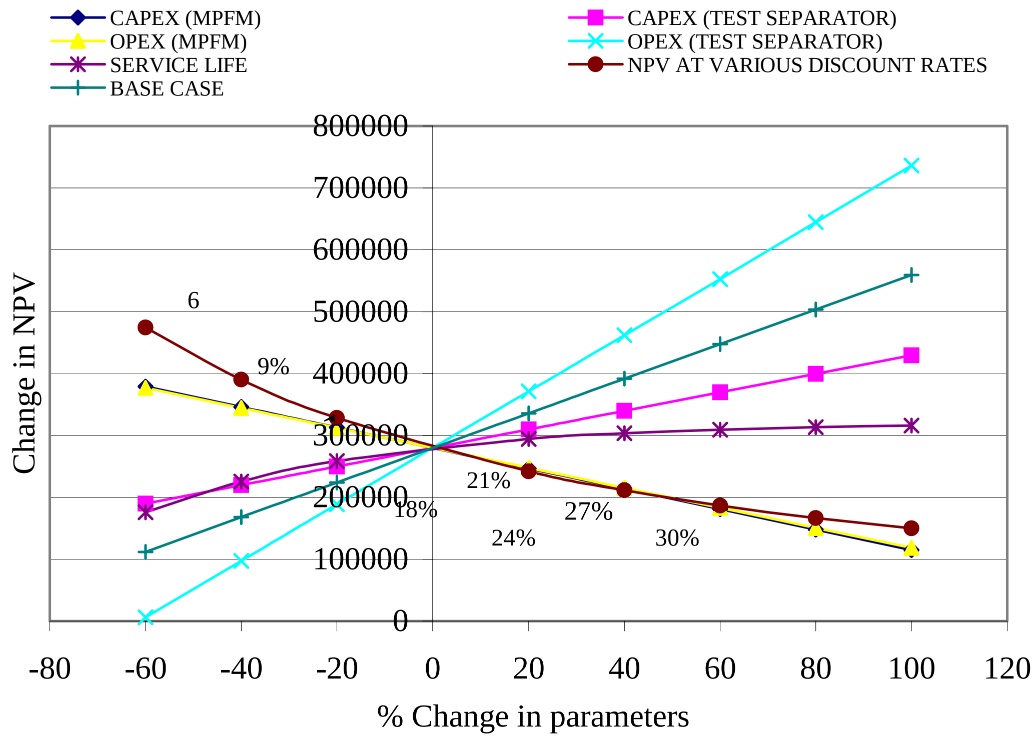

Figure 8. Sensitivity plot for case B

MPFM Market

According to the North Sea Flow Measurement Workshop (1998), the total number of wells worldwide is 904, 420. If MPFM is installed on 1% of wells within 2000 and 2010, it means that 9044.2 meters would have been installed in ten years. That is, an average of 904 meters a year. If a meter cost $165,000 then a market of $0.149 billion exists. Meaning that there is enormous market for MPFM.

Conclusion

In order to gain the large benefits of multiphase metering, companies will have to provide the financial backing to support the development of higher performance meters.

Multiphase metering systems are most certainty not “fit and forget” equipment in their present state of development. They should be developed where there are clear financial benefits and where there is real commitment to making them work.

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