Sirte University Scientific Journal(Applied Sciences) *Vol.8 (1),65–76 June 2018*

Interpretations of Sensitivity & Probability Risk Analysis of Oil and Gas Project in Developing Country

Jamal Saad Ellafi
e-mail: prof.jamalellafi@su.edu.ly

Petroleum Department, Engineering Faculty, Sirte University

Abstract

Risk management is an essential part of project assessment. Identifying possible risks involved during the construction and development of petroleum projects, is a vital to its financial and economic viability. It is also necessary to measure the effect of those risks on project economic parameters. These methodologies also known as quantitative risk analysis and qualitative risk analysis. Analysing those risk by calculating their impact on the project cash flow and economic indicators would give project sponsors, promoters and decision makers an important tool to assess these risks and subsequently follow them closely during to offset and mitigate them. This paper explains the effect of risks on petroleum project's cash flow and economic parameters using the western Libyan gas project which transport natural gas to Italy as case study. It aims to explain how to relate these risks to project's parameter which is subsequently will be effected the most during project life time. Probability and sensitivity risk analysis will be discussed to explain the methodology behind them when executing petroleum projects in developing countries. The paper also introduces base, best worst case scenario for risks to highlight their significant.

Keywords: Risk management, quantitative and qualitative risk analysis, oil and gas projects

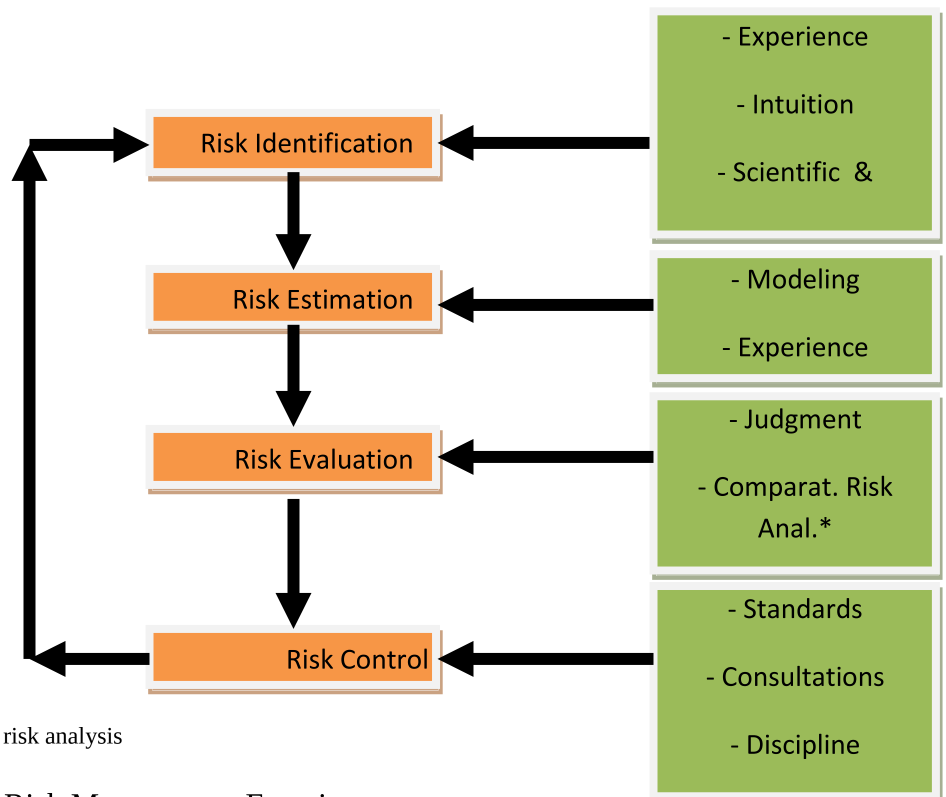
1. Risk identification

The beginning of any bright idea or initiating any business venture or a project will generate thoughts, usually about the chances of failure due to the risks incurred or success. In general, the types of risk encountered in the petroleum industry vary from one country to another. Many of the risks encountered in a developed country may have less impact on a projects commercial viability than those encountered in a developing country. Irrespective of a projects location, it is paramount that a risk assessment is carried out before a project is sanctioned. The requirements of managers and decision makers to obtain all the information needed for a project may reduce or prevent any obstacles during the desired lifetime of the project[1].

Figure below illustrate the strategy used on how these risks are identified, estimated and controlled, other strategies can also be used as long as is proved suitable to pinpoint risks involved to petroleum projects[2].

2. Risk Analysis

In order to assess the impact of any risky situations, it must be analysed to establish their effect on the project out come if / when they happened. It is aimed to assess the impact of those risks on a project and to determine their outcomes, which include estimating the probability of the risk occurring and the likely impact of the risk on the project's economics. There are two methods used in the risk analysis process; qualitative risk analysis and quantitative risk analysis.



*Comparative risk analysis

Exhibit 1. Risk Management Functions

2.1 Qualitative risk analysis

It consists of compiling a list of risks and a description of their likely consequences. Qualitative risk analysis involves evaluations that do not result in numerical values.[4]

2.2 Quantitative risk analysis

It often involves the use of computer models and employs statistical data to conduct risk analysis. The two most widely used techniques for quantitative risk analyses are the following:

i. **Sensitivity risk analysis:** is a deterministic modelling technique that is used to test the change in the value of a dependent variable (risk) on a project. Economic parameters such as Net Present Value (NPV), Internal Rate of Return (IRR) and Cash Pay Back (CPB) are typical dependent variables in economic analysis.**[5]**

ii. **Probability Analysis:** is used to overcome the limitation of sensitivity analysis by specifying a probability distribution for each risk and then considering the effects of each risk on the economic parameters of the project in combination. The most commonly used form of quantitative risk analysis is the Monte Carlo Technique[3].

3. The Western Libyan Gas Pipeline Project Risk Analysis

In order for risks to be identified, evaluated, assessed and controlled a petroleum project has to be introduced based on real case. The Western Libyan Gas Project (WLGP) or Gas Pipeline Project (GPP) is used to illustrate risk identification, assessment and control concept. The project is transporting 11bcm/yr. The bulk of gas and oil/condensate production from Libya's offshore Bahr Essalam and desert Wafa fields and transport it under the Mediterranean sea to Sicily. A joint venture company between the Libyan National Oil Company (LNOC) and Eni Gas has been signed and the project total cost is approximately US $ 5 billion. Eni and LNOC investigated harnessing the gas to generate electrical power in southern Europe via a long-distance submarine cable, however, the cost and technical risk appeared too great, the appointment of Saipem S.P.A (Subsidiary of Italian company Eni) for the construction and the procurement of the project prove to be successful in controlling many of the risks involved.

3.1 Financial Estimate

Below is a summary of the project's financial estimates.
Cost of construction is the same as for the previous cases.
Project Debt / Equity ratio is 80/20.
Cost of the loan (4 billion US dollar) based on 8% interest payable in 4 years
Interest on Loan = $[4 * (1+ 0.08)^{4} – 4] / 12*4$
= US $ 30.04 million / month for 4 years.

Cost of Equity based on 9.2% interest payable after 2 years from paying the debt to the end of the project lifetime.

Interest on Equity = $[1*(1+0.092)^{18} - 1] / 12*18$ = 17.94 mm US $ a month.

3.2 General

- Purpose of concession: the construction of gas export network.
- Project period: 31 years.
- Commencement of contract: January 2006
- Right of ownership: the promoter will own the facility for entire lifetime after which ownership becomes vested in the principal.
- Project revenue: will be allocated according to lenders and operator agreement

3.3 Specifics

- Adjustment to the concession: an increase in the concession period for a maximum of two years.
- Commercial freedom: the promoter will have freedom to operate and manage the facilities and selling of products; product prices will be linked to the oil and gas markets. If any of project outlets are sold locally, further arrangements regarding gas tariffs will be settled with the local authorities.
- Taxation: 15% which may be waived for the first 4 years.
- Transfer of revenue: permitted after servicing of the debt.

3.4 Obligations

- The principal will be responsible for carrying out Public Enquires and any Compulsory Purchase Orders in respect of pipeline routes and providing appropriate assistance.
- The promoter will pay for any land purchases, equipment, construction, financing, the operation and maintenance of the project facilities; the route, locations and services will be determined by statutory authorities.

3.5 Common Terms

- Legislation: Developing country own legislation usually translated from French or England.
- Termination: Default on behalf of principal or promoter
- Disputes: to be solved by a predetermined international arbitration agency

3.6 Schedule of Activities:

Exhibit 2. shows the schedule of activities for the Gas Pipeline Project (GPP).

Gas Pipeline Project (GPP) Planning Program & Activity						
ID	Activity Description	Sample	Start up	Finish	Duration*	Precedence
1	**1- Appraisal Program**	**- AA**	- Jan 2017	May 2018	16	0
2	**Development Program**	**10- DD**	May 2018	Jun 2018	1	1
3	**Inshore Development**	**ID**	Jun 2018	Jan 2020	19	2
4	**Inshore Construction**	**11- IC**	- Jan 2020	- Feb 2020	1	3
5	Construction 1	**2- IC1**	- Feb 2020	- Jan 2024	47	4
6	Construction 2	**IC2**	Feb 2020	Jan 2024	47	5
7	**Offshore Development**	**OD**	Jun 2018	Jan 2020	19	2
8	**Offshore Construction**	**OC**	Jan 2020	Feb 2020	1	7
9	Offshore Construction 1	**3- OC1**	- Feb 2020	- Jan 2024	47	8
10	Offshore Construction 2	**OC2**	Feb 2020	Jan 2024	47	9
11	**Gas Plant Construction**	**14- PC**	Jan 2020	Feb 2020	1	2
12	Construction 1	**PC1**	Feb 2020	Jan 2024	47	11
13	Construction 2	**PC2**	Feb 2020	Jan 2024	47	13
14	**2- Start-up production**	**15- PP**	- Jan 2024	- Feb 2024	1	6,10,13
15	**3- Financing**	**FCE**	- Feb 2024	- Feb 2028	48	14
16	**4- Equity Financing**	**EQI**	- Feb 2030	- Feb 2048	216	15
17	**5- Taxation**	**TAX**	- Feb 2024	- Feb 2048	288	14
18	**Operation &Maintenance**	**O&M**	Feb 2024	Feb 2048	288	14
19	**7- Revenue**	**RR**	Feb 2024	Feb 2048	288	14
20	**8- Project End**	**END**	Feb 2048	Feb 2048	1	14,15,16,17,18,19

* Months

Exhibit (2): Schedule of activity for GPP.

The bar chart for the GPP under project financing is shown in Exhibit (3).

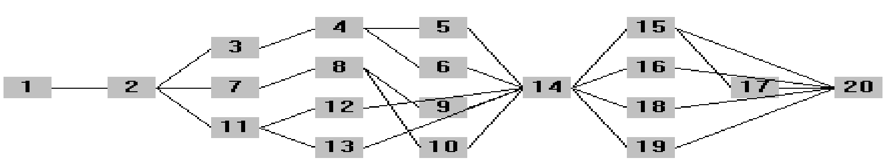


Exhibit 3. The bar chart for the activities of the GPP.

4. Risks

The following risks are identified when financing the GPP.

- **The Appraisal Phase**

Exploration
Reserve Durability

- **Development Phase**

Design
Technical Feasibility
Approval
Site condition
Construction delay
Weather
Supply

- **Operation and Maintenance Phase**

Operation and maintenance risk
Price
Political
Environmental
Taxation
Interest Rate

Exhibit (4) shows distribution of risks for GPP before implementing risk mitigation. The effect of individual risks on the IRR is also provided using sensitivity analysis.

4.1 Sensitivity Analysis of GPP

Sensitivity analysis for base case appears in Exhibit 5. The graph shows that the GPP is not sensitive to the following risks:

- Exploration (EXP)
- Weather (WTH)
- Approval (APP)
- Operation and Maintenance (O&M)
- Environmental (ENV)
- Taxation (TAX)
- Interest Rate (INT)

These risks, should they occur, can reduce the IRR by 5 % or less. In contrast the project was found to be sensitive to the following risks:

- Technical Feasibility (TFB)
- Design (DES)
- Site Condition (SCO)
- Construction Delay (COD)
- Supply (SUP)
- Price (PRI)

- Political (POL)
- Reserve Durability (RSD)

Exhibit 4. shows distribution of risks for GPP.

ID	Type of Risks	- Affected Activity	Sample	Distribution Range		5- Changes in 6- The IRR %
				Lower	Upper	
1	Exploration	AA	EXP	0	20	-1 %
2	Technical Feasibilities	IC, OC, PC	TFB	0	20	-12.5 %
3	Approval	ID, OD, IC, OC, PC	APP	0	20	-15.9 %
4	Design	IC, OC, PC	DES	0	20	-12.3 %
5	Site conditions	IC, OC, PC	SCO	0	20	-10.5 %
6	Construction delay	IC, OC, PC	COD	-10	20	+6 %, -10.5 %
7	Weather	IC, OC, PC	WTH	0	10	-6.7 %
8	Supply	IC, OC, PC	SUP	-10	20	+6 %, -10.5 %
9	Operation maintenance	O&M	O&M	0	20	-1.6 %
10	Environmental risks	O&M	ENV	0	20	-1.6 %
11	Price	RR	PRI	-20	20	+18.5%, -22 %
12	Reserve durability	RR	RSD	0	15	- 16 %
13	Political	RR	POL	0	30	- 34.9 %
14	Taxation	RR	TAX	0	20	- 0.4 %
15	Interest	FEC	INT	-20	20	+2 %, -2 %

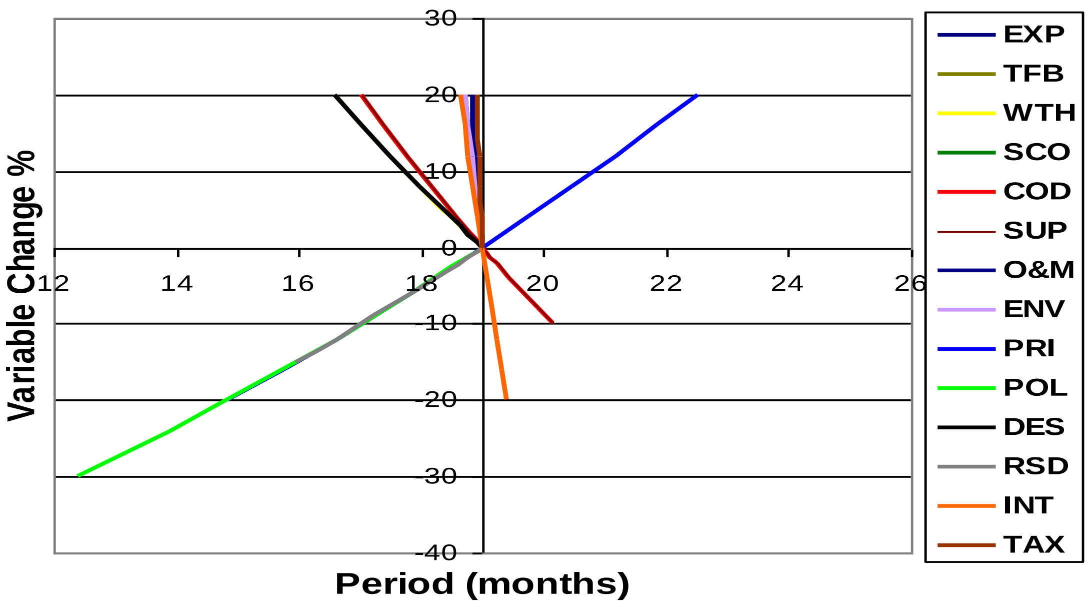


Exhibit 5. Sensitivity Analysis of GPP, before risk mitigation (BRM).

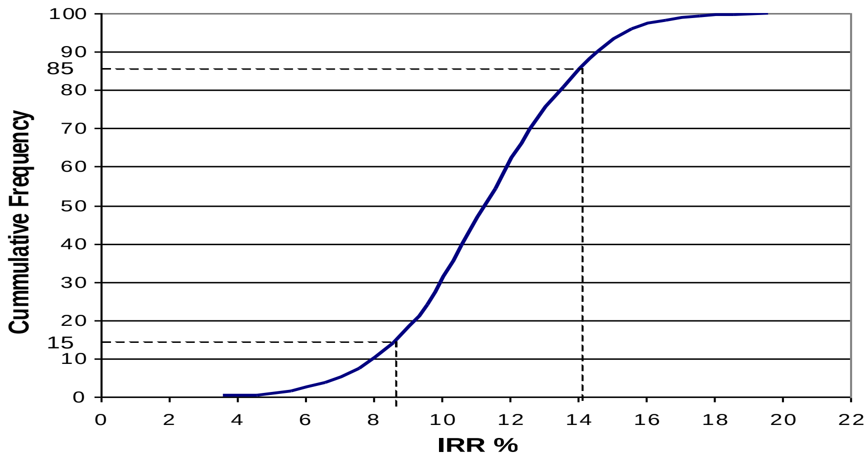


Exhibit 6. Probability Analysis for GPP, BRM.

The economic parameters for the GPP are listed in Exhibit (7) below:

Exhibit 7. Economic Parameters for Case IV, BRM

Before Risk Mitigation	Base Case	Worst Case	Best Case
NPV (mm $ US)	26,935	3,166	30,365
IRR %	19.01	3.6	20
Cash Lock up (mm $ US)	4,958	8,725	4,760
Payback Time (Years)	10.7	19.5	10.4

In exhibit (7) the IRR (before risk mitigation) for the base and the best case are 19.01 % and 20 % respectively; the IRR for the worst case is a low 3.6 %. Also net present value (NPV) for the base and the best cases are US $ 26,935 and 30,365 million respectively; the worst case will approximately generate US $ 3,166 million. For the cash lock up (CLP) the cost of construction for the base case is US $ 4,958 million. This figure drops to US $ 4,760 million for the best case and dramatically increases to US $ 8,725 for the worst case scenario.

Exhibit 7 also shows that the payback time (PBT) for the base and best are very close: 10.7 and 10.4 years respectively. The result of the simulation indicated that the PBT for the worst case is very long about 19.5 years.

5. Risk Management

The promoter of the GPP must adopt Risk Mitigation Methods to minimise or allocate the risks involved in the project to convince project lenders that the project can be funded as well as repayment of the loan provisioned. Project lenders' main requirement is that the project would generate enough cash flow to repay the loan. Most of the mitigation methods, recommended to reduce and allocate the risks, are explained previously. Exhibit (8) shows the distribution of risk in the GPP scheme.

The effect of these risks on project activities and the IRR after introducing RMM (risk mitigation methods), to manage, reduce or mitigate them are either by:

- offset the risk identified by employing experienced managers and qualified labour.
- allocate the risk identified to other parties who experience enough to deal with them by providing service guarantee.
- insurance cover for most of risky project's activities to reduce their costs if they occur.
- the use of financial instruments and techniques reduces and offset many of price and financial risk that faces many construction and oil and gas projects. Ellafi, 2008

Exhibit 8. Risk Distributions for GPP and the Effect on the IRR after RMM

ID	Type of Risks	- Affected Activity	Sample	Distribution Range		9- Changes in 0- the IRR %
				Lower	Upper	
1	Exploration	AA	EXP	0	5	-1 %
2	Technical Feasibilities	WC, OC, MC	TFB	0	5	-3.5 %
3	Approval	WD, OD, WC, OC, MC	APP	0	5	-5.8 %
4	Design	WC, OC, MC	DES	0	5	-3.5 %
5	Site conditions	WC, OC, MC	SCO	0	5	-2.8 %
6	Construction delay	WC, OC, MC	COD	-10	10	+6 %, -5.5 %
7	Weather	WC, OC, MC	WTH	0	5	-3.5 %
8	Supply	WC, OC, MC	SUP	-10	5	+2.9 %, -2.8 %
9	Operation maintenance	O&M	O&M	0	5	-0.4 %
10	Environmental risks	O&M	ENV	0	5	-0.4 %
11	Price	RR	PRI	-10	10	+9.6%, -10.4 %
12	Reserve durability	RR	RSD	0	5	- 5.1 %
13	Political	RR	POL	0	10	- 10.4 %
14	Taxation	RR	TAX	0	5	- 0.11 %
15	Interest	FEC	INT	-5	5	+0.5 %, -0.5 %

The new sensitivity analysis after successful implementation of RMM is shown in exhibit (9). To study the effect of RMM on the economic parameters (in this case IRR), a comparison between the Probability Analysis for GPP before and after implementing the RMM is illustrated in exhibit (10). The figures show substantial improvements for the IRR after introducing RMMs.

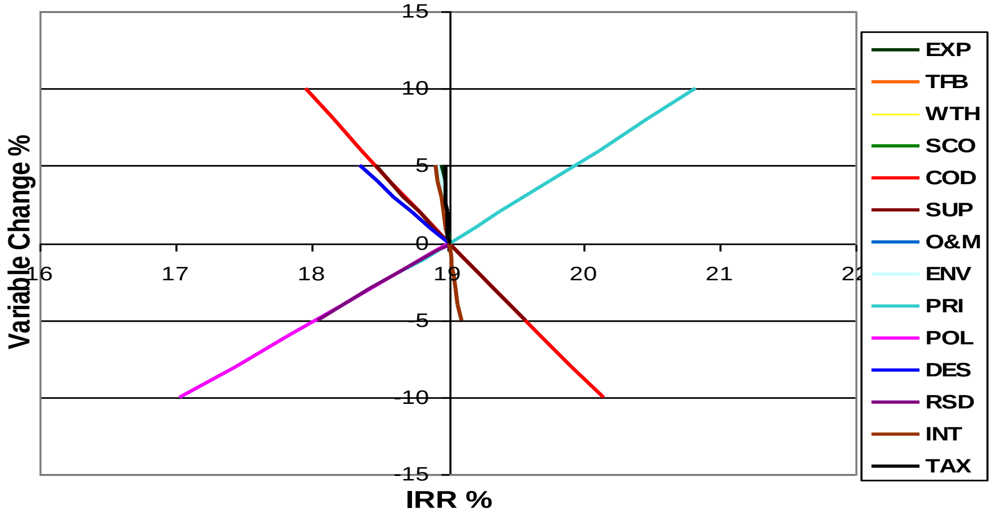


Exhibit 9. Sensitivity Analysis for GPP after RMM

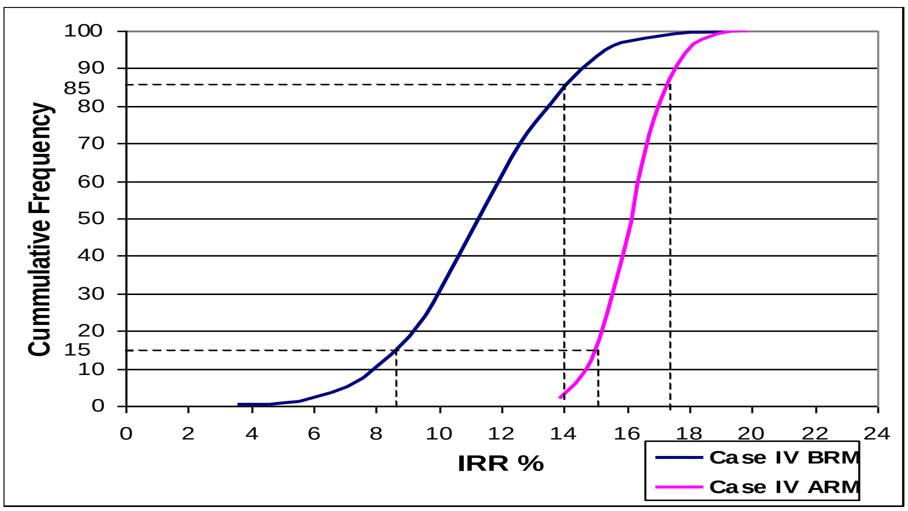


Exhibit 10**.** Comparison of Probability Analysis before and after Introducing Risk Mitigation Methods for GPP.

There is a 15 % probability that the IRR will be 15 % after RMM, while before implementing RMM the IRR was less than 9 %; which indicates a great chance of success for the projectes after using RMM. Exhibit (10) also indicates that there is 85 % chance that the IRR will be 17.5 %. The overall result highlights a large reduction in the uncertainty surrounding the GPP when risk management tools are used.

Exhibit (11) shows all economic parameters for GPP after using RMM for the three case scenarios.

Exhibit 11. Economic Parameters after RMM.

After Risk Mitigation	Base Case	Worst Case	Best Case
NPV (mm $ US)	26,935	17,506	29,760
IRR %	19.01	13.9	20.4
Cash Lock up (mm $ US)	4,958	6,041	4,590
Payback Time (Years)	10.7	12	10.3

The cumulative cash flow diagram for the three case scenarios is very promising from the lenders' and promoter's point of view after introducing RMM, Figure (12). The NPV for the base and best case are US $26,935 and 29,760 million respectively, but for the worst case it is US $ 17,506 million; this result for the worst case might appear low compared to the base and best cases but the financial performance of the project is commercially viable.

There is little difference in the IRR case for the base and best case which are 19.01% and 20.4 % respectively, but it is slightly lower for the worst case at about 14 %. Again the PBTs for the base and best case are close, 10.7 and 10.3 years respectively, while it is 12 years for the worst case. The overall financial evaluation for the GPP after using risk management measures indicate that the GPP can be financed privately and will satisfy all lenders' financial requirements.

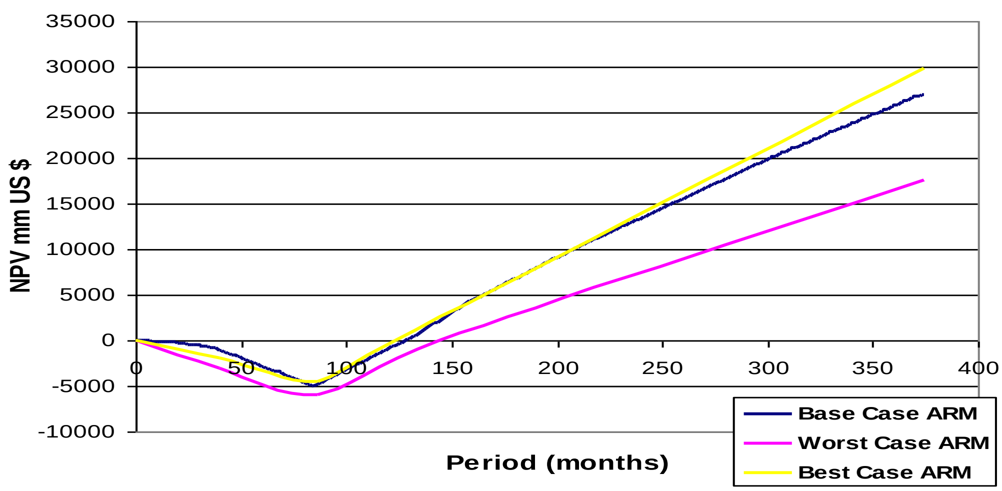


Exhibit 12. Cumulative Cash Flow for GPP after RMM.

6. Conclusions

Risk management can be applied effectively to oil and gas project like any other investment project. Once a base case model of an oil and gas project has been developed the effect of risks on any activity can be stimulated using computer software (in this case the CASPAR program or

Excel). The ranges used in this stimulation will be based on experience and past data, which can vary from country to country, and from one oil and gas project to another. The results of risks analysis, both sensitivity and probability can identify the quantitative effect on a project economics should such risk occur.

Some of the risks identified in these analyses can be avoided or reduced by mitigating risks through securing guarantees, insurance cover, transfer and hedging strategies. The risk analysis and subsequent risk mitigation provides financial information to potential lenders, promoters or equity providers for each scenario. This assessment can be used by the Promoter to attract both lenders and investors.

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