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Nigerian Gas Transmission Tariff Framework Study*

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Abstract

The Federal Government of Nigeria plans to develop the domestic gas market by opening investment opportunities for infrastructural development, and by including gas pipeline construction among key projects in the national budget. The domestic gas market is estimated to have an annual growth potential of about 15% to 18%, which attests to its potential profitability. In this study, we investigated the gas transmission tariff and profitability potential for investment in the gas transmission investment opportunity proposed in the Nigerian Gas Master Plan. The gas transmission systems are the South-North System, the Western System, and the Interconnector System. Deterministic and stochastic methods were used for cashflow modelling and sensitivity analysis. Using 17% internal rate of returns, the resulting tariffs for the gas transmission systems were the following: $0.47/Mscf for the Western Pipeline System, $0.97/MScf for South-North pipeline system, and $0.34/MScf for Interconnector pipeline system. The most sensitive cost items to internal rate of returns for investment in the pipeline systems were determined as the peak flow of gas, gas pipeline costs, and installation costs. The calculated tariffs could be coupled with the casing head gas price and processing fee to yield the likely price of the lean gas.

Introduction

The gas sector holds a significant economic potential for Nigeria with a robust proven reserve base of about 187 trillion cubic feet out of which 86% are in the Niger Delta while 14% are in the Deep Water. This represents about a third of gas reserves in Africa. Nigerian gas reserves is also the seventh largest in the world.

The Nigerian gas market is in its embryonic stage and is characterized by small market, few competitors, limited infrastructure, and high risk. Gas demand for domestic and industrial use is expected to grow from less than 2Bcfd in 2007 to more than 12Bcfd by 2013. But the Nigerian gas sector is not supplying gas as rapidly as the market opportunity dictates due to inadequate gas infrastructure, reserve growth vis-à-vis operator portfolio conflict, and inadequate commercial framework. The domestic gas utilization is underdeveloped due to lack of adequate pipelines facilities to transport the gas[1].

The critical infrastructure in Seven Point Agenda of the government includes the national gas transmission system. It is assumed that development of the gas transmission system will ensure gas availability to energy dependent industries and for electricity generation. Such development, it is generally believed would help Nigeria achieve sustainable economic growth and emerge as a modern economy and industrialized nation by 2020. Besides, as shown in figure 1.0, the domestic supply for gas is already falling short of demand and the trend would protract if nothing is done to avert the situation.

To deal with this challenge, the government initiated the Nigerian Gas Master Plan to provide a structured and holistic framework for the enhancement of gas availability and sustainable supply in the country. The gas infrastructural blueprint provides for the development of the Nigerian gas grid.

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[1] Onyekonwu M. "Best Practices and Policies - the Nigerian Oil and Gas industry: Policy Problems", Port Harcourt Petroleum Review, Vol. 1 No. 1, pp 14 - 21.

In that regard, government has opened investment opportunities for the construction of the central processing facilities and transmission facilities within the country.

In the 2009 budget proposal for the Nigerian gas transmission system, the sum of N17 billion (about $140 million) was voted for the South-North Pipeline System[2]. But such provision is low considering investment in the whole transmission systems which we estimated to cost about $7 billion. Thus, the need for investors to participate in this initial investment stage - as advocated during the Nigerian Gas Master Plan Investors Road Show in 2008 - cannot be over-emphasised.

Essentially, the decision to invest is based on the evaluation of the project profitability. Therefore, there is need to carry out economic studies to investigate the profitability of investing in the domestic gas transmission systems proposed by government. The investigation should consider the fiscal incentives for the gas transmission systems and investment regulation using the internal rate of return. Sometimes, economic evaluations are carried out using deterministic cashflow models and most likely inputs resulting in best estimate profit indices. But how certain are the calculated profitability indicators? In order to examine the profitability of the proposed investment opportunity, there is need to incorporate uncertainties into the results of the cashflow model. Using simulations and statistical distributions, the economic evaluations would give better insight into the risks that could be associated with the investment opportunities.

Consequently, there is need to use the stochastic approach for this study. Using this approach, the uncertain parameters would be defined as stochastic variables. Using simulations, the statistical distributions of the profitability indicator results would throw more light on the risks and uncertainties which could be associated with investing in the gas transmission system.

Aim and Objectives

The aim of this study is to estimate the transmission tariff for the proposed gas transmission systems in Nigeria. To achieve this aim, this study is set to achieve the following objectives:

- Estimate the cost of investment in the proposed gas transmission network
- Develop cash flow models for investment in the Nigerian gas transmission systems
- Determine the gas transmission tariffs
- Conduct sensitivity analyses on the project profitability indicators
- Identify the conditions which would make investments in the transmission systems attractive

Methodology

The approach to this study would take the following steps:

- Development of the discounted cashflow models using a cost model and calculation of the profitability indicators
- Definition of the stochastic variables and their distributions
- Simulation runs, determination of the cost items which the rate of returns is most sensitive to; and sensitivity analyses
- Discussions of the results, conclusion and recommendations

[2] Omoh, G.: "Yar'Adua Presents N2.87 Trillion Budget", Vanguard Online Edition posted on December 3, 2008. www.vangardngr.com/content/view/232434

In order to achieve these objectives, the three gas transmission systems proposed by the government were used as case study. Microsoft Excel spreadsheet was used to develop the deterministic cashflow models. Then, Crystal Ball software (a Microsoft Excel-add in) was used to model the distribution of the uncertain parameters. We used five thousand runs of Monte Carlo simulation to obtain the stochastic distribution for the profitability indicators. From the stochastic distribution, the risks associated with the profitability indicators were quantified.

The Gas Transmission Systems

This study covered the gas transmission investment opportunity proposed by the Federal Government of Nigeria. The details of these pipelines systems are shown in Figure 2.0. The three gas transmission systems include:

- South-North System: This pipeline system include: 55 kilometres of 56-inch pipeline, and 1080 kilometres of 48-inch pipeline. The gas throughput at peak flow is 3,800MMScfd.
- Western System: This pipeline system include: 200 kilometres of 42-inch offshore pipeline, and 265 kilometres of 24-inch pipeline from Sagamu to Jebba. The gas throughput at peak flow is estimated to be 3,250MMScfd.
- Interconnector System: This pipeline system include: 110 kilometres of 42-inch pipeline, and 96 kilometres of 36-inch pipeline

Estimation of Cost of The Pipelines

The purchase and installation cost of the pipelines were estimated using Questor (cost estimation software). We estimated the cost of the pipelines as offshore projects and used statistical data to arrive at the likely equivalent land pipeline cost. The statistical data and cost estimations are presented in Table 1 and Table 2.

Definition of Statistical Distributions

Certain cost items were assumed to be uncertain. Statistical distributions were assigned to such cost items in order to reflect such uncertainties in the result of the profitability indicators. By so doing, the minimum, most likely, and maximum possible values of the profitability indicators were obtained.

Considering the uncertainties and the typical outlook of the cost items, the statistical distributions for the perceived variable cost items were assigned as follows:

- Normal statistical distribution for pipeline and installation cost, fixed cost, variable cost, and discount value
- Log-normal distribution for tariff rate
- Triangular distribution for the transit fee and inflation rate
- Uniform distribution for the OPEX escalation rate and peak gas flowrate.

Economic Assumptions and Cash Flow Modeling

The assumptions applied in generating the discounted cashflow model for the gas transmission systems are as follows:

- Depreciation: straight line method for five years after the first three-year tax free period
- Tax rate: 40% same as Company Income Tax (CITA)
- The pipeline system was assumed to have a project life of thirty years
- Discount rate - 10%
- Inflation rate – 2%

The cash flow model was developed based on the following cost models:

$$\text{Revenue} = \text{Tariff Rate} * \text{Gas flowrate per year} \quad \text{.....(1)}$$

$$\text{Profit Tax} = \text{Tax Rate} * (\text{Revenue} - \text{OPEX} - \text{Depreciation}) \quad \text{..(2)}$$

$$\text{Cashflow} = \text{Revenue} - \text{CAPEX} - \text{OPEX} - \text{Profit Tax} - \text{Transit Fees} + \text{Depreciation} \quad \text{.....(3)}$$

The deterministic model for this study was developed in Microsoft Excel spreadsheet. Likely values were used as inputs in the cashflow model of the transmission systems. The input parameters and the cashflow model for the three transmission systems are presented in the Appendix A.

Profitability Indicator Results

The profitability indicators used were the net present value, the internal rate of return, and the discounted payback period. We calculated the transmission tariffs which would yield 17% internal rate of returns for the three transmission systems. The results are presented in Table 3.0 below.

Simulation Approach

We used Crystal Ball software to carry out the simulation. Five thousand runs of Monte Carlo simulation was carried out to generate the risk profile of the profitability indicators. The parameters used to define the probability distribution of the variables are presented in Table 4, Table 5, and Table 6. The summaries of results of the stochastic modelling are shown in Table 7, Table 8, and Table 9. The probability distribution of the internal rate of returns for the transmission systems are shown in Figure 3, Figure 4, and Figure 5.

There were cost items which the profitability indicators are most sensitive to. Such cost items were spotted from the simulation results. For the internal rate of returns of the three transmission systems, the result from the simulation showing their most sensitive parameters were presented in Figure 6, Figure 7, and Figure 8.

Sensitivity Analysis

Sensitivity analysis was carried out on the developed cashflow models to investigate the effect of some changes on the base case transmission tariff and profitability indicator results. Since the investment opportunity would be regulated using the internal rate of returns, the first sensitivity analysis was carried out to ascertain the changes on the transmission tariff rate due to changes in the internal rate of return. The results are presented in Figure 9. Compilations of the result of the other profitability indicators at different internal rate of returns are presented in Appendix B.

A case was studied by combining all transmission systems as a single project with maximum throughput of 7050MMScfd. Using 17% internal rate of returns, the cashflow and profitability indicator results were generated as presented in Appendix C1. Another case study was a situation whereby at 17% rate of returns, the investors would fund sixty percent (60%) of the capital expenditure for transmission systems, and borrow forty percent (40%) of capital expenditure at an interest rate of thirteen percent (13%) which would be repaid over ten years. The tables for this case study were presented in Appendix C2. The result of this analysis show that at 17% rate of returns, the transmission tariff, net present value, and return on investment became lower. When the interest rate was reduced from thirteen percent (13%) to eight percent (8%) as shown in Appendix C3, the transmission tariff and net present value further reduced.

Discussion of the Results

The economic study was carried out on the three transmission systems proposed by the government. The cash flow model for each transmission system was developed. Assuming an internal rate of returns of seventeen percent (17%), the transmission tariff and profitability indicator results for the transmission systems were determined.

From the cash flow models, the following parameters were assumed to be variables: pipeline and installation cost, fixed cost, variable costs, discount rate, cost escalation rate, transit fee, inflation rate, peak flowrate of gas, and tariff rate. Their distributions were defined and Monte Carlo simulation was run for the profitability indicators to determine their minimum, most likely and maximum possible values. From the probability distribution of the simulation results, the risks inherent in the profitability indicators were envisaged.

The project acceptability could be based to a large extent on low transmission tariff. On that basis, the investment opportunities for the main transmission lines were ranked based on perceived acceptability to the regulatory authorities as follows:

- Western System – 1st
- South-North System – 2nd

We carried out some sensitivity analyses to determine the effects of changes in the internal rate of returns on the profitability indicators. The results showed that the proposed investments begin to turn unattractive below 15% internal rate of returns.

Investment in the transmission system would be subject to rate of return by the Gas Regulator. Thus, we carried out sensitivity analyses to determine the input variables which the rates of returns were most sensitive; and also to identify the variables whose influence could be ignored. The results are presented in Table 5, Table 6 and Table 7.

For the South-North System, the most critical parameters to internal rate of returns were the pipeline and installation costs, and the peak flow of gas. This implies the gas market for the South-North System should be properly secured, and cheaper contractors should be engaged during the pipeline purchase and installation.

For the Western pipeline system, the internal rate of returns was most sensitive to the pipeline purchases and installation costs. This implies that effort should be concentrated on minimizing the pipeline and installation cost to make the project profitable.

As for the Interconnector system, the pipeline purchases and installation cost, the tariff rate and peak flow of lean gas are the most sensitive parameters. Thus, the pipeline cost should be minimized, while the tariff rate and peak flow estimates should be upheld so as to achieve good returns.

On another note, the result of sensitivity on the combination of all the transmission lines show that when part of investment fund was assumed to be borrowed the net present value and the transmission tariff reduced. Also, as the loan interest rate reduces while keeping the internal rate of returns constant, the net present value and transmission tariff reduces. These results imply that borrowing at low interest rate to fund the investment could be an approach to reduce the transmission tariff even though the net present value of the investment also reduces.

Summarily, the best conditions to make the investment in the transmission systems profitable returns are the following: by keeping the most sensitive cost items under control, by investing in the

pipeline systems which would charge lower tariff and still yield high returns, and by borrowing the investment fund at low interest rate.

Conclusion

In this study, the analyses carried out show that:

1. At an internal rate of returns of 17%, the transmission systems had good profitability indicators.
2. At 17%, the transmission tariff for the different pipeline systems were:
   South-North: $0.97/MScf
   Western System: $0.47/MScf
   Interconnector System: $0.34/MScf
3. Since cheaper transmission tariff would be more affordable and acceptable, the most preferable transmission system to invest in is the Western System.
4. The most sensitive parameters to the internal rate of returns of the transmission systems are the following:
   - South North System: Peak flow of gas, pipeline and installation cost
   - Western System: Pipeline and installation cost
   - Interconnector System: Transmission tariff, Pipeline and installation cost
5. The South-North System has the highest most likely net present value and return on investment. This shows that although the South-North pipeline system require the highest capital outlay, its investment opportunity could be very profitable.
6. Interconnector System is the least risky by virtue of payout period.
7. From sensitivity analysis, the investments in the pipeline transmission systems begin to turn unattractive below 15% internal rate of returns.
8. The transmission tariff of the pipeline systems can be reduced by borrowing the investment capital at low interest rates.
9. The most likely estimates of net present value for the projects were positive indicating that the projects would be profitable. It is left for the investors to use their minimum acceptable criteria for net present value, internal rate of returns, return in investment, and payout period to ascertain which project to embark upon.

Recommendations

1. Since most of the transmission line investment are most sensitive to pipeline and installation cost, effort should be concentrated on reducing such costs so as to make the investment opportunity remain profitable.
2. Since the South-North transmission system is most sensitive to peak flow of gas, there is need to secure their gas markets so as to operate profitably at flowrate of 3800MMScfd.
3. Since below 15% internal rate of returns, the profitability indicators start turn unattractive, the gas regulator should be prepared to allow investment to be at higher internal rate of returns so as to make the investment attractive.
4. Investors in the transmission systems could borrow investment capital fund to offset high transmission tariff.
5. There is need to use domain expert's estimate of capital and operating expenses for more accurate results.
6. The developed models can be useful for deterministic and probabilistic analysis of the profitability of the gas transmission systems.

7. Probability analysis should be carried out alongside deterministic economic analysis to give insight into the economic risks associated with proposed projects.

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Nomenclature

Bcfd	Billion cubic feet per day
IRR	Internal Rate of Returns
MMMScf/yr	Trillion cubic feet per year
MMScf	Million cubic feet
MMScfd	Million cubic feet per day
MScf	Thousand cubic feet
NPV	Net present value
OPEX	Operating expenses
PI	Profitability Index
ROI	Return on Investment

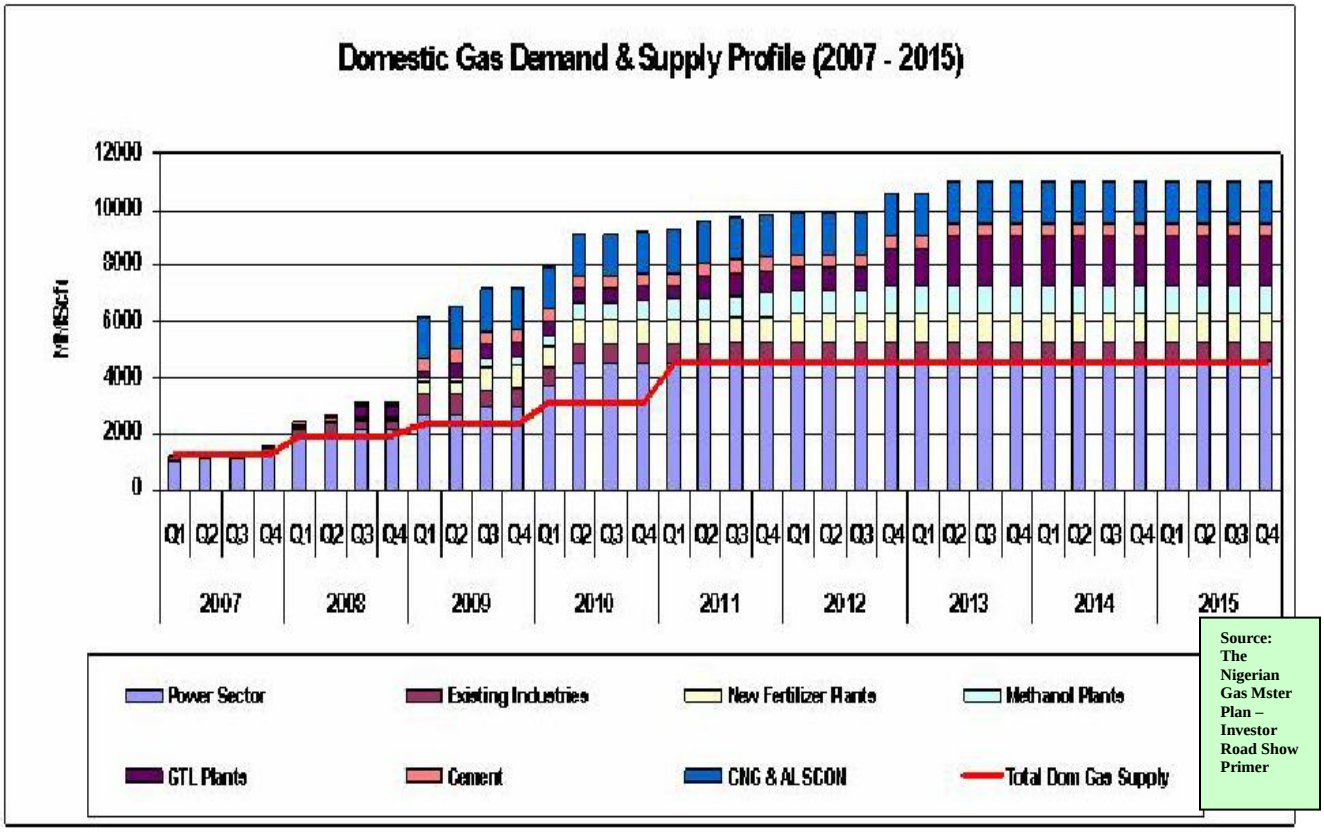

Figure 1.0: The plot of domestic gas supply falling short of demand

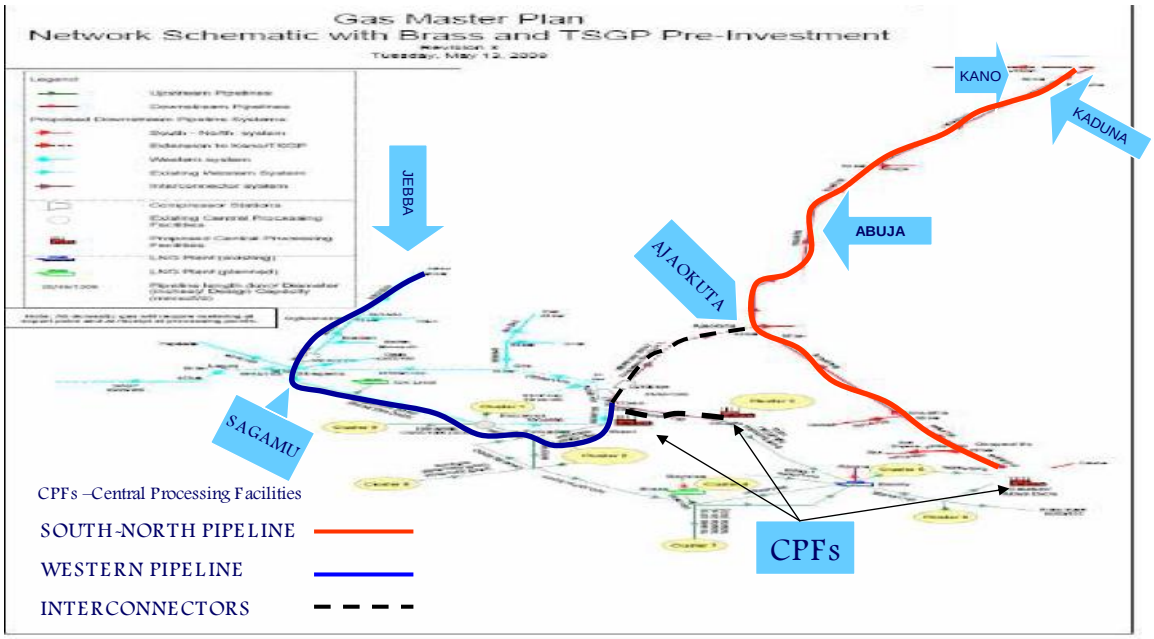

Figure 2.0: The gas transmission systems

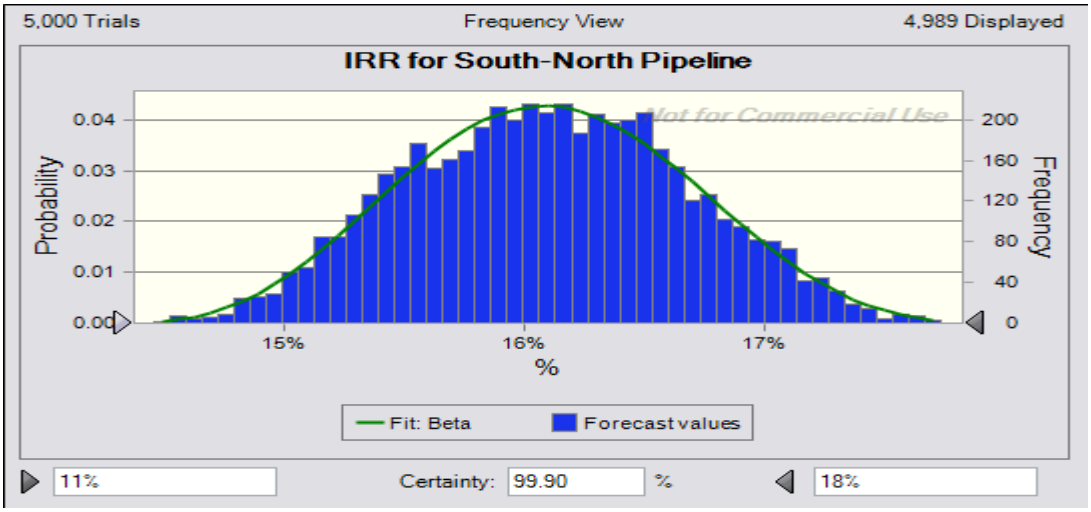

Figure 3.0: The probability distribution of IRR for South-North Pipeline System

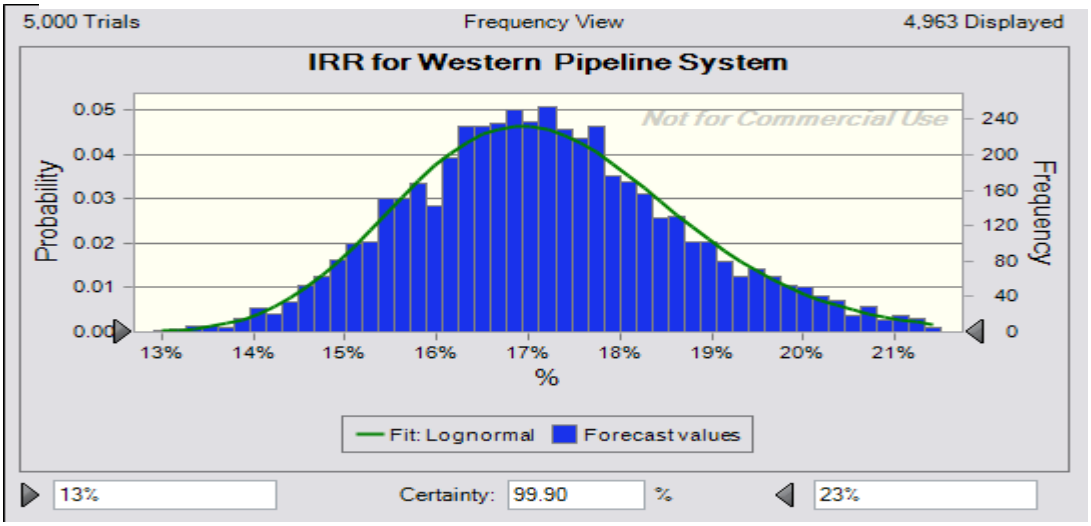

Figure 4.0: The probability distribution of IRR for Western Pipeline System

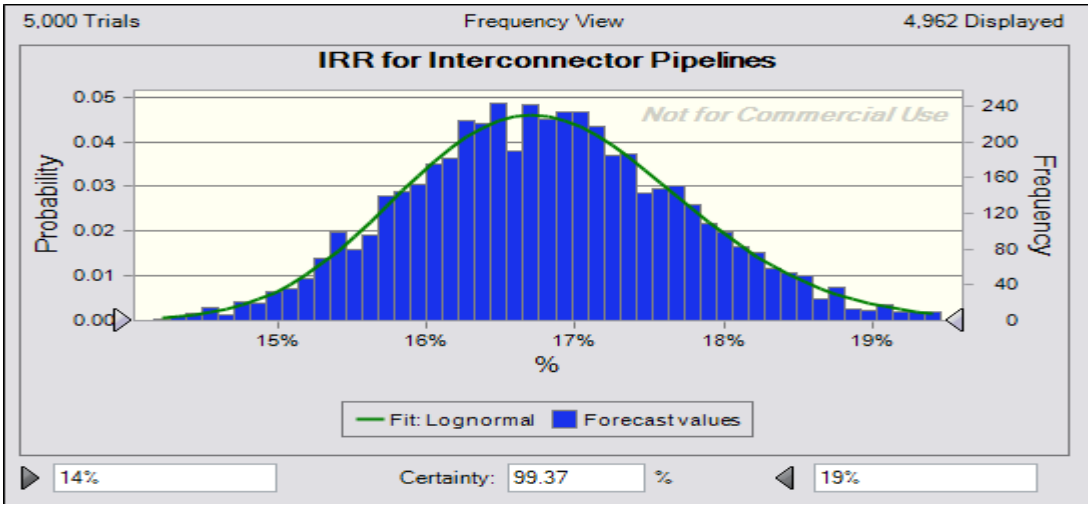

Figure 5.0: The probability distribution of IRR for Interconnector Pipeline System

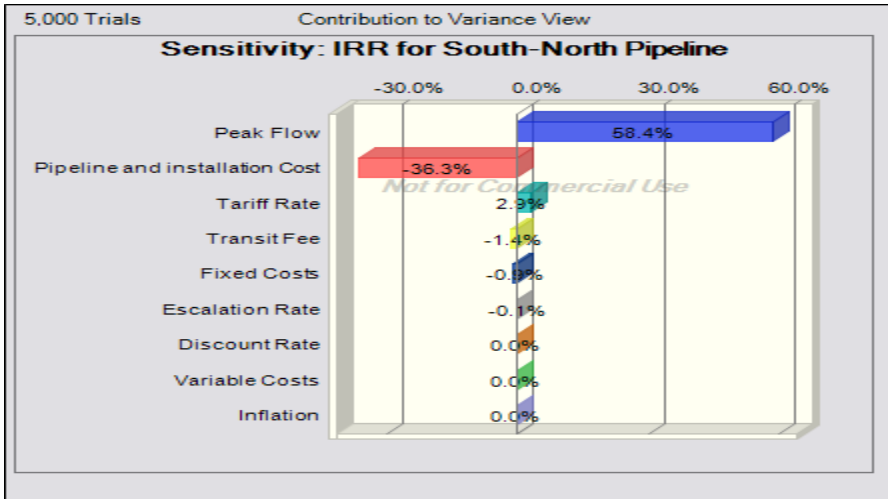

Figure 6.0: The IRR sensitivity result for South-North Pipeline System

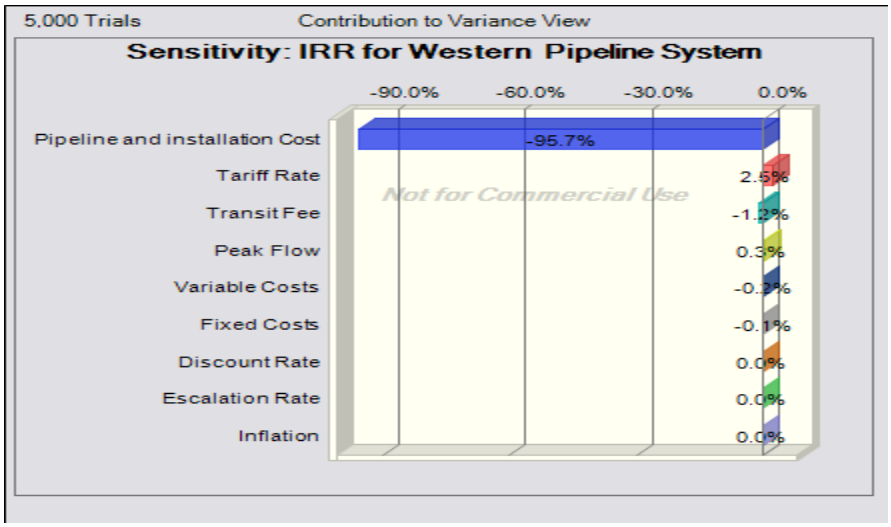

Figure 7.0: The IRR sensitivity result for Western Pipeline System

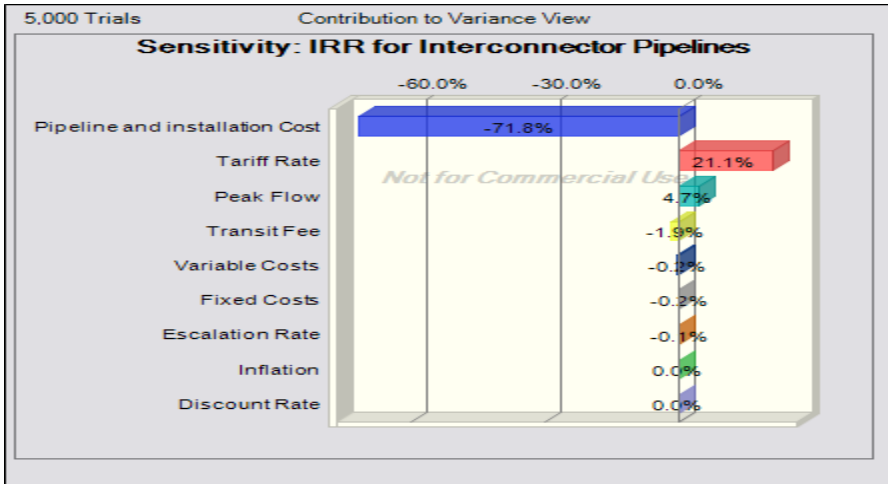

Figure 8.0: The IRR sensitivity result for Interconnector Pipeline System

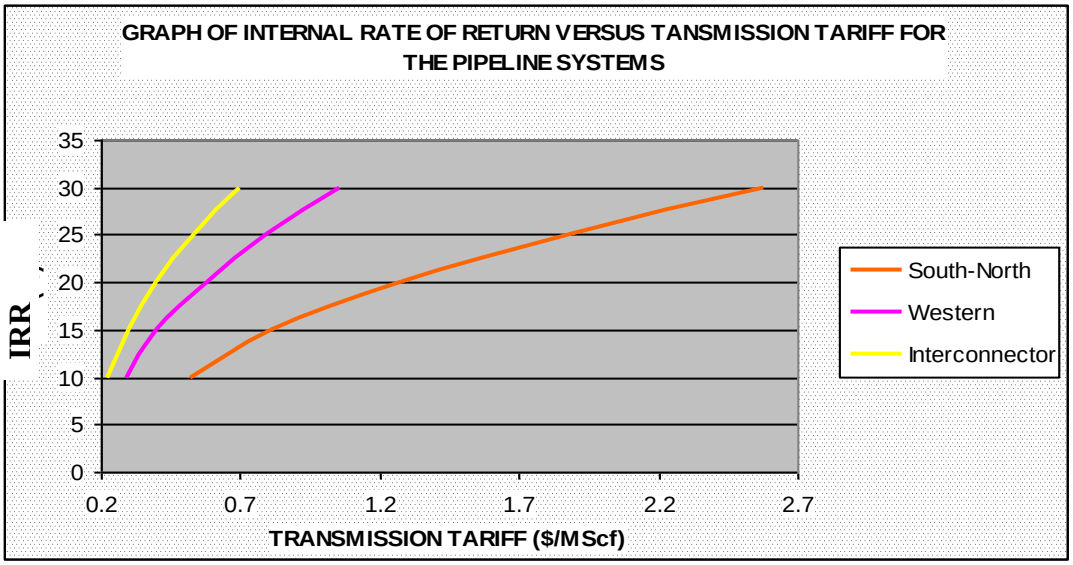

Figure 9.0: The graph of IRR versus transmission tariff for the Pipeline Systems

Table 1: Statistical data used for cost conversion

S/NO	YEAR	ONSHORE	OFFSHORE	ONSHORE/OFFSHORE
1	1995-1996	$898,907	$1,316,164	0.683
2	2000-2001	$1,611,818	$2,578,413	0.625
			Average ratio (onshore/offshore)	**0.654**

Table 2: The Estimated Cost of Pipelines

S/no	Pipeline System	Length Km	ID	Material cost $'000	Installation Cost $'000	Project Mgt $'000	Insurance $'000	Contingency & ROW $'000	Multiplication Factor	Total $'000
1	Offshore - Sagamu	200	42"	644,424	146,579	10,139	32,046	208,297	1.000	1,041,485
2	Sagamu-Jebba	265	24"	479,091	134,637	14,420	25,126	163,319	0.654	534,052
3	South-North	1080	48"	4,624,948	808,978	43,272	219,088	1,424,072	0.654	4,656,714
4	South-North	55	56"	285,115	63,694	6,248	14,202	92,315	0.654	301,869
5	Intrconnector A	196	36"	536,339	133,734	11,730	27,272	177,269	0.654	579,669
6	Interconnector B	110	48"	356,681	92,461	8,446	18,304	118,973	0.654	389,042

Table 3.0: The result of profitability indicators for the transmission systems

PIPELINE SYSTEM	TRANSMISSION TARIFF ($/MScf)	NET PRESENT VALUE ($'million)	INTERNAL RATE OF RETURNS (%)	DISCOUNTED PAYBACK PERIOD (years)
SOUTH-NORTH	0.97	1567	17	10.52
WESTERN	0.47	501	17	10.42
INTERCONNECTOR	0.34	303	17	10.41

Table 4.0: The input data for defining the variables for the South-North Systems

VARIABLE	DISTRIBUTION	MEAN			STANDARD DEVIATION
Pipeline and Installation Cost ($'million)	Normal	4959			120
Fixed Cost ($'million)	Normal	73			5
Variable Cost ($'million)	Normal	0.06			0.01
Discount Rate (%)	Normal	10			1
		MINIMUM		MAXIMUM	
Cost Escalation Rate (%)	Uniform	1		2	
Peak Flow of Gas (MMScfd)	Uniform	3200		3800	
		MINIMUM	MOST LIKELY	MAXIMUM	
transit Fee ($/MScf)	Triangular	0.05	0.06	0.07	
Inflation Rate (%)	Triangular	1	2	5	
		MINIMUM	MEAN		STANDARD DEVIATION
Tariff Rate ($/MScf)	Log Normal	0.95	0.97		0.01

Table 5.0: The input data for defining the variables for the Western Systems

VARIABLE	DISTRIBUTION	MEAN			STANDARD DEVIATION
Pipeline and Installation Cost ($'million)	Normal	1576			150
Fixed Cost ($'million)	Normal	27			1
Variable Cost ($'million)	Normal	0.06			0.01
Discount Rate (%)	Normal	10			1
		MINIMUM		MAXIMUM	
Cost Escalation Rate (%)	Uniform	1		2	
Peak Flow of Gas (MMScfd)	Uniform	3000		3250	
		MINIMUM	MOST LIKELY	MAXIMUM	
Transit Fee ($/MScf)	Triangular	0.05	0.06	0.07	
Inflation Rate (%)	Triangular	1	2	5	
		MINIMUM	MEAN		STANDARD DEVIATION
Tariff Rate ($/MScf)	Log Normal	0.45	0.47		0.01

Table 6.0: The input data for defining the variables for the Interconnector Systems

VARIABLE	DISTRIBUTION	MEAN			STANDARD DEVIATION
Pipeline and Installation Cost ($'million)	Normal	969			50
Fixed Cost ($'million)	Normal	17			1
Variable Cost ($'million)	Normal	0.06			0.01
Discount Rate (%)	Normal	10			1
		MINIMUM		MAXIMUM	
Cost Escalation Rate (%)	Uniform	1		2	
Peak Flow of Gas (MMScfd)	Uniform	3000		3250	
		MINIMUM	MOST LIKELY	MAXIMUM	
Transit Fee ($/MScf)	Triangular	0.05	0.06	0.07	
Inflation Rate (%)	Triangular	1	2	5	
		MINIMUM	MEAN		STANDARD DEVIATION
Tariff Rate ($/MScf)	Log Normal	0.3	0.34		0.01

Table 7.0: The result of stochastic analysis for South-North Pipeline System

S/no	PROFITABILITY INDICATORS	MINIMUM	MOST LIKELY	MAXIMUM	MOST SENSITIVE VARIABLES
1	Net Present Value, $'million	-408	1000	2500	Discount & Inflation rate
2	Internal Rate of Returns, %	11	16	18	Peak Flow & Pipeline-Installation Cost
4	Discounted payback Period, Years	9	11	21	Discount Rate & Inflation rate

Table 8.0: The result of stochastic analysis for Western Pipeline System

S/no	PROFITABILITY INDICATORS	MINIMUM	MOST LIKELY	MAXIMUM	MOST SENSITIVE VARIABLE
1	Net Present Value, $'million	-102	450	1000	Discount Rate, Inflation Rate & Pipeline-Installation Cost
2	Internal Rate of Returns, %	13	17	23	Pipeline-Installation Cost & Transmission Tariff
4	Discounted payback Period, Years	8	11	17	Pipeline-Installation Cost & Discount rate

Table 9.0: The result of stochastic analysis for Interconnector Pipeline System

S/no	PROFITABILITY INDICATORS	MINIMUM	MOST LIKELY	MAXIMUM	MOST SENSITIVE VARIABLE
1	Net Present Value, $'million	-95	200	724	Discount & Inflation Rates, Pipeline-Installation Cost
2	Internal Rate of Returns, %	14	16.5	19	Pipeline-Installation Cost, Transmission Tariff
4	Discounted payback Period, Years	9	11	18	Discount & Inflation Rates, Pipeline-Installation Cost

APPENDIX A: CASHFLOW MODELS FOR THE TRANSMISSION SYSTEMS

TABLE A1: THE INPUT PARAMETERS FOR SOUTH-NORTH PIPELINE SYSTEM

Input Parameters	Values	Units
Length of Pipeline	1080	Kilometers
Nominal diameter	48	Inches
Pipeline and installation Cost	$4,959	Million
OPEX		
Fixed Costs	$73	Million
Variable Costs	$0.06	Mllion/unit of gas sold
Tax rate first 3 years	0%	
Tax Rate	40%	
Escalation Rate	1%	per annum
Tariff Rate	$0.97	/MScf
Transit Fee	$0.06	/MScf
Discount Rate	10%	
Inflation	2%	
Nominal Discount	12.2%	
Peak Flow of Gas	3800	MMScfd
Capital Investment Pattern	25%	in year 1
	50%	in year 2
	25%	in year 3

TABLE A2: THE CASHFLOW MODEL FOR SOUTH-NORTH PIPELINE SYSTEM

CASHFLOW FOR THE SOUTH-NORTH 48" & 56" PIPELINE (ALL COSTS IN MILLION DOLLARS)

YEAR	CAPEX $	OPEX $	TRANSIT FEE $	DEPRECIATION $	GAS SALES (MMMScf/YR)	REVENUE $	PROFIT TAX $	CASHFLOW $	DISCOUNTED CASHFLOW $	CUMM DIS CASHFLOW $	PAYBACK COMPUTATION
1	1240	0	0	0	0	0	0	-1240	-1105	-1105	0
2	2479	0	0	0	0	0	0	-2479	-1969	-3074	0
3	1240	0	0	0	0	0	0	-1240	-878	-3952	0
4	0	89	16	0	277	270	0	165	104	-3848	0
5	0	104	31	0	555	540	0	404	227	-3620	0
6	0	120	47	0	832	809	0	642	322	-3299	0
7	0	136	63	992	1110	1079	0	1872	836	-2462	0
8	0	153	79	992	1387	1349	82	2028	807	-1655	0
9	0	155	79	992	1387	1349	81	2027	719	-936	0
10	0	156	79	992	1387	1349	80	2026	641	-295	0
11	0	158	79	992	1387	1349	80	2025	571	276	10.51654054
12	0	159	79	0	1387	1349	476	635	160	436	0
13	0	161	79	0	1387	1349	475	634	142	578	0
14	0	162	79	0	1387	1349	475	633	126	704	0
15	0	164	79	0	1387	1349	474	632	113	817	0
16	0	166	79	0	1387	1349	473	632	100	917	0
17	0	167	79	0	1387	1349	473	631	89	1006	0
18	0	169	79	0	1387	1349	472	630	79	1085	0
19	0	171	79	0	1387	1349	471	628	71	1156	0
20	0	172	79	0	1387	1349	471	627	63	1218	0
21	0	174	79	0	1387	1349	470	626	56	1274	0
22	0	176	79	0	1387	1349	469	625	50	1324	0
23	0	178	79	0	1387	1349	469	624	44	1368	0
24	0	179	79	0	1387	1349	468	623	39	1407	0
25	0	181	79	0	1387	1349	467	622	35	1442	0
26	0	183	79	0	1387	1349	466	621	31	1474	0
27	0	185	79	0	1387	1349	466	620	28	1501	0
28	0	187	79	0	1387	1349	465	619	25	1526	0
29	0	189	79	0	1387	1349	464	618	22	1548	0
30	0	190	79	0	1387	1349	463	617	20	1567	0
	$4,959	$4,384									

Economic Indicators	
NPV	$1,567
IRR	17%
ROI	12%
PAYBACK YRS	10.52

TABLE A3: THE INPUT PARAMETERS FOR WESTERN PIPELINE SYSTEM

Input Parameters	Values	Units
Length	200	Kilometers
Nominal diameter	42	Inches
Pipeline and installation Cost	$1,576	$'Million

OPEX		
Fixed Costs	$27	$'Million
Variable Costs	$0.06	$'Million/unit of gas sold
Tax rate first 3 years	0	%
Tax Rate	40%	
Escalation Rate	1%	per annum
Tariff Rate	$0.47	/MScf
Transit Fee	$0.06	/MScf
Discount Rate	10%	
Inflation	2%	
Nominal Discount	12.2%	
Peak Flow of Gas	3250	MMScfd
Capital Investment Pattern	25%	in year 1
	50%	in year 2
	25%	in year 3

TABLE A4: THE CASHFLOW MODEL FOR WESTERN PIPELINE SYSTEM

CASHFLOW FOR THE WESTERN PIPELINE SYSTEM (ALL COSTS IN MILLION DOLLARS)

YEAR	CAPEX $	OPEX $	TRANSIT FEE $	DEPRECIATION $	GAS SALES (MMMScf//YR)	REVENUE $	PROFIT TAX $	CASHFLOW $	DISCOUNTED CASHFLOW $	CUMM DIS CASHFLOW $	PAYBACK COMPUTATION
1	394	0	0	0	0.00	0	0	(394)	(351)	(351)	0
2	788	0	0	0	0.00	0	0	(788)	(626)	(977)	0
3	394	0	0	0	0.00	0	0	(394)	(279)	(1256)	0
4	0	41	14	0	237.25	111	0	55	35	(1221)	0
5	0	55	28	0	474.50	221	0	137	77	(1144)	0
6	0	70	43	0	711.75	332	0	219	110	(1034)	0
7	0	84	57	315	949.00	442	17	599	268	(766)	0
8	0	99	71	315	1186.25	553	55	642	256	(510)	0
9	0	100	71	315	1186.25	553	55	642	228	(283)	0
10	0	101	71	315	1186.25	553	55	641	203	(80)	0
11	0	102	71	315	1186.25	553	54	641	181	101	10.44211121
12	0	103	71	0	1186.25	553	180	199	50	151	0
13	0	104	71	0	1186.25	553	180	198	44	195	0
14	0	105	71	0	1186.25	553	179	198	39	234	0
15	0	106	71	0	1186.25	553	179	197	35	270	0
16	0	107	71	0	1186.25	553	178	196	31	301	0
17	0	108	71	0	1186.25	553	178	196	28	328	0
18	0	110	71	0	1186.25	553	177	195	25	353	0
19	0	111	71	0	1186.25	553	177	194	22	375	0
20	0	112	71	0	1186.25	553	177	194	19	394	0
21	0	113	71	0	1186.25	553	176	193	17	411	0
22	0	114	71	0	1186.25	553	176	192	15	426	0
23	0	115	71	0	1186.25	553	175	192	14	440	0
24	0	116	71	0	1186.25	553	175	191	12	452	0
25	0	117	71	0	1186.25	553	174	190	11	463	0
26	0	119	71	0	1186.25	553	174	190	10	472	0
27	0	120	71	0	1186.25	553	173	189	8	481	0
28	0	121	71	0	1186.25	553	173	188	7	488	0
29	0	122	71	0	1186.25	553	172	187	7	495	0
30	0	123	71	0	1186.25	553	172	187	6	501	0
	$1,576	$2,800									

Economic Indicators	
NPV	$501
IRR	17%
ROI	12%
PAYBACK, YRS	10.44

TABLE A5: THE INPUT PARAMETERS FOR INTERCONNECTOR PIPELINE SYSTEM

Input Parameters	Values	Units
Length of Pipeline A	306	Kilometers
Nominal diameter	36 & 42	Inches
Pipeline and installation Cost	$969	Million
OPEX		
Fixed Costs	$17	Million
Variable Costs	$0.06	Million/unit of gas sold
Tax rate first 3 years	0%	
Tax Rate	40%	
Escalation Rate	1%	per annum
Tariff Rate	$0.34	/MScf
Transit Fee	$0.06	/MScf
Discount Rate	10%	
Inflation	2%	
Nominal Discount	12.2%	
Peak Flow of Gas	3250	MMScfd
Capital Investment Pattern	25%	in year 1
	50%	in year 2
	25%	in year 3

TABLE A6: THE CASHFLOW MODEL FOR INTERCONNECTOR PIPELINE

CASHFLOW PREDICTION FOR INTERCONNECTOR PIPELINE SYSTEM (ALL COSTS IN MILLION DOLLARS)

YEAR	CAPEX $	OPEX $	TRANSIT FEE $	DEPRECIATION $	GAS SALES (MMMScf/YR)	REVENUE $	PROFIT TAX $	CASHFLOW $	DISCOUNTED CASHFLOW $	CUMM DIS CASHFLOW $	PAYBACK COMPUTATION
1	242	0	0	0	0	0	0	(242)	(216)	(216)	0.00
2	485	0	0	0	0	0	0	(485)	(385)	(601)	0.00
3	242	0	0	0	0	0	0	(242)	(172)	(772)	0.00
4	0	30	13	0	237	80	0	36	23	(750)	0.00
5	0	44	27	0	475	160	0	89	50	(700)	0.00
6	0	57	40	0	712	239	0	142	71	(629)	0.00
7	0	71	54	194	949	319	22	367	164	(465)	0.00
8	0	84	67	194	1186	399	48	393	156	(308)	0.00
9	0	86	67	194	1186	399	48	392	139	(169)	0.00
10	0	87	67	194	1186	399	47	391	124	(45)	0.00
11	0	88	67	194	1186	399	47	391	110	65	10.41
12	0	88	67	0	1186	399	124	119	30	95	0.00
13	0	89	67	0	1186	399	124	119	27	121	0.00
14	0	90	67	0	1186	399	123	118	24	145	0.00
15	0	91	67	0	1186	399	123	118	21	166	0.00
16	0	92	67	0	1186	399	123	117	19	184	0.00
17	0	93	67	0	1186	399	122	116	16	201	0.00
18	0	94	67	0	1186	399	122	116	15	215	0.00
19	0	95	67	0	1186	399	122	115	13	228	0.00
20	0	96	67	0	1186	399	121	115	11	240	0.00
21	0	97	67	0	1186	399	121	114	10	250	0.00
22	0	98	67	0	1186	399	120	114	9	259	0.00
23	0	99	67	0	1186	399	120	113	8	267	0.00
24	0	100	67	0	1186	399	120	112	7	274	0.00
25	0	101	67	0	1186	399	119	112	6	280	0.00
26	0	102	67	0	1186	399	119	111	6	286	0.00
27	0	103	67	0	1186	399	118	111	5	291	0.00
28	0	104	67	0	1186	399	118	110	4	295	0.00
29	0	105	67	0	1186	399	118	109	4	299	0.00
30	0	106	67	0	1186	399	117	109	3	303	0.00
	$969	$2,387									

Economic Indicators	
NPV	$303
IRR	17%
ROI	12%
DIS. PAYBACK	10.41

APPENDIX B: THE RESULT OF SENSITIVITY ON THE INTERNAL RATE OF RETURNS AND THE OTHER PROFITABILIT INDICATORS

TRANSMISSION SYSTEMS SOUTH-NORTH			BASE CASE			
Internal Rate of Returns, %	10	15	17	20	25	30
Net Present Value, $'millions	-570	851	1567	2828	5257	8061
Discounted PayBack Period, Years	never	12.29	10.52	9.5	8.25	7.39
Transmission Tariff, $/MScf	0.52	0.81	0.97	1.28	1.89	2.58

WESTERN SYSTEM			BASE CASE			
Internal Rate of Returns, %	10	15	17	20	25	30
Net Present Value, $'millions	-177	269	501	890	1651	2552
Discounted PayBack Period, Years	never	11.9	10.42	9.47	8.24	7.37
Transmission Tariff, $/MScf	0.29	0.40	0.47	0.58	0.80	1.06

INTERCONNECTOR			BASE CASE			
Internal Rate of Returns, %	10	15	17	20	25	30
Net Present Value, $'millions	-108	166	303	534	1007	1560
Discounted PayBack Period, Years	never	11.62	10.41	9.46	8.21	7.35
Transmission Tariff, $/MScf	0.22	0.30	0.34	0.40	0.54	0.70

APPENDIX C1:

Input Parameters for the Combined Transmission Project

Input Parameters	Values	Units
Length of Pipeline	1906	Kilometers
Nominal diameter	24,36,42,48,56	Inches
Pipeline and installation Cost	$7,503	Million
OPEX		
Fixed Costs	$128	Million
Variable Costs	$0.06	Mllion/unit of gas sold
Tax rate first 3 years	0%	
Tax Rate	40%	
Escalation Rate	1%	per annum
Tariff Rate	$0.83	/MScf
Transit Fee	$0.06	/MScf
Discount Rate	10%	
Inflation	2%	
Nominal Discount	12.2%	
Peak Flow of Gas	7050	MMScfd
Capital Investment Pattern	25%	in year 1
	50%	in year 2
	25%	in year 3

The Cashflow Model for the Combined Transmission System Project

CASHFLOW PREDICTION FOR THE COMBINED TANSMISSION SYSTEMS (ALL COSTS IN MILLION DOLLARS)

YEAR	CAPEX $	OPEX $	TRANSIT FEE $	DEPRECIATION $	GAS SALES (MMMScf/YR)	REVENUE $	PROFIT TAX $	CASHFLOW $	DISCOUNTED CASHFLOW $	CUMM DIS CASHFLOW $	PAYBACK COMPUTATION
1	1876	0	0	0	0	0	0	(1876)	(1672)	(1672)	0
2	3751	0	0	0	0	0	0	(3751)	(2980)	(4652)	0
3	1876	0	0	0	0	0	0	(1876)	(1328)	(5980)	0
4	0	157	29	0	515	427	0	241	152	(5828)	0
5	0	186	58	0	1029	855	0	610	343	(5484)	0
6	0	215	87	0	1544	1282	0	979	491	(4994)	0
7	0	245	117	1500	2059	1709	0	2848	1272	(3721)	0
8	0	276	146	1500	2573	2137	144	3070	1223	(2499)	0
9	0	279	146	1500	2573	2137	143	3069	1089	(1410)	0
10	0	282	146	1500	2573	2137	142	3067	970	(440)	0
11	0	285	146	1500	2573	2137	141	3065	864	424	10.50884259
12	0	288	146	0	2573	2137	740	964	242	667	0
13	0	290	146	0	2573	2137	738	962	215	882	0
14	0	293	146	0	2573	2137	737	960	192	1074	0
15	0	296	146	0	2573	2137	736	958	170	1244	0
16	0	299	146	0	2573	2137	735	957	152	1396	0
17	0	302	146	0	2573	2137	734	955	135	1531	0
18	0	305	146	0	2573	2137	732	953	120	1651	0
19	0	308	146	0	2573	2137	731	951	107	1757	0
20	0	311	146	0	2573	2137	730	949	95	1852	0
21	0	315	146	0	2573	2137	729	948	84	1937	0
22	0	318	146	0	2573	2137	728	946	75	2012	0
23	0	321	146	0	2573	2137	726	944	67	2079	0
24	0	324	146	0	2573	2137	725	942	59	2138	0
25	0	327	146	0	2573	2137	724	940	53	2191	0
26	0	331	146	0	2573	2137	722	938	47	2238	0
27	0	334	146	0	2573	2137	721	936	42	2280	0
28	0	337	146	0	2573	2137	720	934	37	2317	0
29	0	341	146	0	2573	2137	718	932	33	2350	0
30	0	344	146	0	2573	2137	717	930	29	2380	0
	$7,503	$7,911									

Economic Indicators	
NPV	$2,379.75
IRR	17%
ROI	12%
DIS. PAYBACK	10.51

APPENDIX C2

Input Parameters for the Combined Transmission Project

Input Parameters	Values	Units
Length of Pipeline	1906	Kilometers
Nominal diameter	24,36,42,48,56	Inches
Pipeline and installation Cost	$7,503	Million
OPEX		
Fixed Costs	$128	Million
Variable Costs	$0.06	Mllion/unit of gas sold
Tax rate first 3 years	0%	
Tax Rate	40%	
Escalation Rate	1%	per annum
Tariff Rate	$0.49	/MScf
Transit Fee	$0.06	/MScf
Discount Rate	10%	
Inflation	2%	
Nominal Discount	12.2%	
Equity	60%	
Loan rapayment	10	years
Loan amount	$3,001	Million
Loan rate	13%	
Peak Flow of Gas	7050	MMScfd
Capital Investment Pattern	25%	in year 1
	50%	in year 2
	25%	in year 3

The Cashflow Model for the Combined Transmission System Project

CASHFLOW PREDICTION FOR THE COMBINED TANSMISSION SYSTEMS (ALL COSTS IN MILLION DOLLARS)

YEAR	INVESTOR'S SHARE	CAPEX $	PRINCIPAL	INTEREST	OPEX $	TRANSIT FEE $	DEPRECIATION $	GAS SALES (MMMScf/YR)	REVENUE $	PROFIT TAX $	CASHFLOW $	DISCOUNTED CASHFLOW $	CUMM DIS CASHFLOW $	PAYBACK COMPUTATION
1	675.25479	1125	0	0	0	0	0	0	0	0	(675)	(602)	(602)	0
2	1350.50958	2251	0	0	0	0	0	0	0	0	(1351)	(1073)	(1675)	0
3	675.25479	1125	0	0	0	0	0	0	0	0	(675)	(478)	(2153)	0
4		0	(163)	(390)	157	29	0	515	252	0	(488)	(308)	(2460)	0
5		0	(184)	(369)	186	58	0	1029	503	0	(294)	(165)	(2626)	0
6		0	(208)	(345)	215	87	0	1544	755	0	(101)	(51)	(2676)	0
7		0	(235)	(318)	245	117	1500	2059	1007	0	1593	711	(1965)	0
8		0	(266)	(287)	276	146	1500	2573	1258	0	1783	710	(1255)	0
9		0	(300)	(253)	279	146	1500	2573	1258	0	1780	632	(623)	0
10		0	(339)	(214)	282	146	1500	2573	1258	0	1778	562	(61)	0
11		0	(383)	(170)	285	146	1500	2573	1258	0	1775	500	439	10.1219259
12		0	(433)	(120)	288	146	0	2573	1258	388	(116)	(29)	410	0
13		0	(489)	(64)	290	146	0	2573	1258	387	(118)	(26)	384	0
14		0			293	146	0	2573	1258	386	433	86	470	0
15		0			296	146	0	2573	1258	385	432	77	547	0
16		0			299	146	0	2573	1258	384	430	68	615	0
17		0			302	146	0	2573	1258	382	428	60	675	0
18		0			305	146	0	2573	1258	381	426	54	729	0
19		0			308	146	0	2573	1258	380	424	48	777	0
20		0			311	146	0	2573	1258	379	422	42	819	0
21		0			315	146	0	2573	1258	377	421	37	857	0
22		0			318	146	0	2573	1258	376	419	33	890	0
23		0			321	146	0	2573	1258	375	417	30	919	0
24		0			324	146	0	2573	1258	374	415	26	946	0
25		0			327	146	0	2573	1258	372	413	23	969	0
26		0			331	146	0	2573	1258	371	411	21	989	0
27		0			334	146	0	2573	1258	370	409	18	1008	0
28		0			337	146	0	2573	1258	368	407	16	1024	0
29		0			341	146	0	2573	1258	367	405	14	1038	0
30		0			344	146	0	2573	1258	366	403	13	1051	0
		$4,502			$7,911									

Economic Indicators	
NPV	$1,050.95
IRR	17%
ROI	5%
DIS. PAYBACK	10.12

APPENDIX C3

Input Parameters for the Combined Transmission Project

Input Parameters	Values	Units
Length of Pipeline	1906	Kilometers
Nominal diameter	24,36,42,48,56	Inches
Pipeline and installation Cost	$7,503	Million
OPEX		
Fixed Costs	$128	Million
Variable Costs	$0.06	Mllion/unit of gas sold
Tax rate first 3 years	0%	
Tax Rate	40%	
Escalation Rate	1%	per annum
Tariff Rate	$0.44	/MScf
Transit Fee	$0.06	/MScf
Discount Rate	10%	
Inflation	2%	
Nominal Discount	12.2%	
Equity	60%	
Loan rapayment	10	years
Loan amount	$3,001	Million
Loan rate	8%	
Peak Flow of Gas	7050	MMScfd
Capital Investment Pattern	25%	in year 1
	50%	in year 2
	25%	in year 3

The Cashflow Model for the Combined Transmission System Project

CASHFLOW PREDICTION FOR THE COMBINED TANSMISSION SYSTEMS (ALL COSTS IN MILLION DOLLARS)

YEAR	INVESTOR'S SHARE	CAPEX $	PRINCIPAL	INTEREST	OPEX $	TRANSIT FEE $	DEPRECIATION $	GAS SALES (MMMScf/YR)	REVENUE $	PROFIT TAX $	CASHFLOW $	DISCOUNTED CASHFLOW $	CUMM DIS CASHFLOW $	PAYBACK COMPUTATION
1	675.25479	1125	0	0	0	0	0	0	0	0	(675)	(602)	(602)	0
2	1350.50958	2251	0	0	0	0	0	0	0	0	(1351)	(1073)	(1675)	0
3	675.25479	1125	0	0	0	0	0	0	0	0	(675)	(478)	(2153)	0
4		0	(207)	(240)	157	29	0	515	224	0	(410)	(258)	(2411)	0
5		0	(224)	(224)	186	58	0	1029	448	0	(244)	(137)	(2548)	0
6		0	(242)	(206)	215	87	0	1544	672	0	(78)	(39)	(2587)	0
7		0	(261)	(186)	245	117	1500	2059	896	0	1588	709	(1878)	0
8		0	(282)	(165)	276	146	1500	2573	1120	0	1751	697	(1181)	0
9		0	(304)	(143)	279	146	1500	2573	1120	0	1748	620	(561)	0
10		0	(329)	(119)	282	146	1500	2573	1120	0	1745	552	(9)	0
11		0	(355)	(92)	285	146	1500	2573	1120	0	1742	491	482	10.01822129
12		0	(383)	(64)	288	146	0	2573	1120	307	(68)	(17)	465	0
13		0	(414)	(33)	290	146	0	2573	1120	319	(82)	(18)	447	0
14		0			293	146	0	2573	1120	331	350	70	517	0
15		0			296	146	0	2573	1120	329	348	62	579	0
16		0			299	146	0	2573	1120	328	347	55	634	0
17		0			302	146	0	2573	1120	327	345	49	682	0
18		0			305	146	0	2573	1120	326	343	43	726	0
19		0			308	146	0	2573	1120	325	341	38	764	0
20		0			311	146	0	2573	1120	323	339	34	798	0
21		0			315	146	0	2573	1120	322	338	30	828	0
22		0			318	146	0	2573	1120	321	336	27	855	0
23		0			321	146	0	2573	1120	320	334	24	878	0
24		0			324	146	0	2573	1120	318	332	21	899	0
25		0			327	146	0	2573	1120	317	330	19	918	0
26		0			331	146	0	2573	1120	316	328	16	934	0
27		0			334	146	0	2573	1120	314	326	15	949	0
28		0			337	146	0	2573	1120	313	324	13	962	0
29		0			341	146	0	2573	1120	312	322	11	973	0
30		0			344	146	0	2573	1120	310	320	10	983	0
		$4,502			$7,911									

Economic Indicators	
NPV	$983.13
IRR	17%
ROI	5%
DIS. PAYBACK	10.02