

# Economic Profitability Studies of Liquefied Natural Gas Project under Joint Ventures and Production Sharing Contracts.

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## ABSTRACT

Based on the huge financial commitments of the Federal Government of Nigeria on many oil and gas projects and the statutory duty of the government to render diverse socio-economical responsibilities to the people, it is worthy and justified to evaluate the economic profitability of a typical liquefied natural gas (LNG) project under different fiscal regimes. The LNG project considered here is Brass LNG and the fiscal regimes are joint ventures (JVs) and production sharing contracts (PSCs).

Since 2000, prices of natural gas in the North American region have risen to an averaging value of US\$4.50/MMBtu, the heating value for natural gas is 1.0 MBtu/scf, therefore, for the purpose of this study, natural gas feedstock price of US\$4.50/Mscf is considered. Also, the least LNG price projected by the Energy Information Administration is about US\$5.40/MMBtu. In this work, the natural gas price and ranges of LNG prices are used in evaluating economic indices such as net present value, minimum cost-effective LNG price, internal return rate (IRR), profitability index, return on investment (ROI), and R-factor.

For the Brass LNG plant, under JVs, the minimum cost-effective LNG price is estimated as US\$2.54/MMBtu. The IRR values for the company, contractors and government at an LNG price of US\$5.40/MMBtu are found to be 191.68%, 191.68%, and 498.68%, respectively; while the corresponding profitability index, annualized ROI and R-factor for the company are 11.999, 191.70%, and 2.286, respectively. However, under PSCs, the minimum cost-effective LNG price is evaluated as US\$2.76/MMBtu. The IRR values for the

company and contractors at an LNG price of US\$5.40/MMBtu are found to be 282.51 and 75.62%, respectively; while the IRR value for the government has no limit. Also, the corresponding profitability index, annualized ROI and R-factor for the company are 17.683, 282.51%, and 2.352, respectively. Hence, JVs is found to accommodate relatively lower product sales price compared to PSCs and it is also more favorable to contractors than PSCs; however, PSCs are a more favorable fiscal regime to the company compared to JVs. Under PSCs, the project is found to be highly beneficial to the government irrespective of the discount rate.

(Keywords: economic profitability, liquefied natural gas, joint ventures, production sharing contracts)

## INTRODUCTION

The discovery of gas in Nigeria is as old as that of oil, but not much attention has been directed at this source of energy. As of 2001, Nigeria's gas reserves were estimated at 182 trillion cubic feet (or 25 billion barrels of oil equivalent) which is almost as high as the country's estimated oil reserves of 27 billion barrels. Appropriate utilization of the abundant natural gas in Nigeria would offer many benefits for the nation. The benefits include (to mention a few) production of dry gas for local consumption; production of liquefied petroleum gas for export; production of liquid hydrocarbons from natural gas; increased availability of gas as a cheaper alternative source of energy to boost commercial activities, employment levels, and national income; advancement of knowledge through research; gas technology transfer and the development of indigenous expertise in the Nigeria gas industry; the use of natural gas in electricity generation;

and promotion of environmental protection and safety through the elimination of gas flaring (OPEC Bulletin, 1997).

The plan to utilize these vast gas reserves motivated the Federal Government through NNPC to put in place some gas projects in Nigeria. At the forefront of the gas industry is the Nigeria Liquefied Natural Gas (NLNG) corporation which was established in December 1989. Some other gas companies are Nigeria Gas Company (NGC) Limited, Shell Nigeria Gas (SNG) Limited, West African Gas Pipeline (WAGP), Natural Gas Liquid, Independent Power Products (IPPs), and Compressed Natural Gas (CNG) projects. NNPC also put in place to be executed within five years from 2000 multiple plans for gas utilization projects such as Esravos Gas-to-Liquids (EGTL), and Brass Liquefied Natural Gas (Brass LNG) which is aimed at producing 10 million tons/year of LNG (and 2.5 million tons/year of associated LPG with condensates).

Joint operating agreements leading to joint ventures (JVs) are still dominant in the oil and gas industry in Nigeria, presently accounting for over 90% of total oil and gas production in the country. The joint venture arrangements has created an enormous drain on government resources urgently needed to address other competing economic and social issues and also has caused delays in the implementation of major projects in the oil sector when government funds have not been available. In reaction, the government has opted to award new petroleum exploration and production licenses under Production Sharing Contracts (PSCs).

Also, the emergence of offshore oil and gas operations and the granting of deep water acreages to the oil producing companies have witnessed a shift from JVs regimes to PSCs, with implications for the operation and regulation of the oil industry in Nigeria. A number of oil and gas projects using the PSCs model are due to come on stream soon and the successes recorded so far in this area have encouraged the government to consider extending PSCs arrangements to other areas of the industry which had hitherto operated under JVs.

It is, therefore, pertinent at this time to carry out an assessment of the economic implications of joint ventures and production sharing contracts applications particularly on LNG technology in Nigeria. This is with a view to evaluating the

profitability of establishing and operating LNG project (Brass LNG in particular) under JVs and PSCs, on the sides of both the multinational oil companies and the Nigerian National Petroleum Corporation representing the interest of the Federal Government of Nigeria.

## LITERATURE REVIEW

### Description of LNG Technology

LNG is made up mainly of methane and less than 0.1mol% of pentane and heavier hydrocarbon (Shukri, 2004). Gas coming from reservoirs is, therefore, treated as follows:

- (i) Acid gas removal, where acid gases are removed to avoid CO<sub>2</sub> and H<sub>2</sub>S freezing in the early stages of the liquefaction process.
- (ii) Dehydration to remove the water out of the gas to avoid hydrates formation in pipelines and vessels.
- (iii) Mercury removal, since the presence of mercury causes corrosion problems in the aluminum heat exchangers used in the liquefaction process.

The LNG technologies involve liquefaction, shipping, and regasification and delivery into the pipeline grid. When natural gas, mainly methane, is cooled and liquefied through cryogenic processes at a temperature of approximately -260°F (-162°C), liquefied natural gas (LNG) is formed. As a result of this, natural gas volume is reduced to one six-hundredth (1/600), allowing its transportation by specialized LNG tanker ships over long distances. A typical LNG receiving terminal includes storage tanks and regasification processes. Rosetta (2005) has identified three basic vaporizers: Submerged Combustion Vaporizers (SCV), Open Rack Vaporizers (ORV) and Ambient Air Vaporizers (AVV).

### Brass LNG (BLNG) Project

In 2006, the four shareholders of Brass LNG Limited signed the Shareholders' Agreement for the Brass LNG Project. The shareholders are Nigerian National Petroleum Corporation (NNPC) 49% Equity, ENI International 17% Equity, Phillips (Brass) Limited (an affiliate of ConocoPhillips) 17% Equity, and Brass Holdings Company

Limited (an affiliate of Total) 17% Equity (Alexander's Oil and Gas Connections, 2007; [www.downstreamtoday.com](http://www.downstreamtoday.com); SPD Media Limited, 2008; [www.hydrocarbon-technology.com](http://www.hydrocarbon-technology.com)). The Shareholders' agreement regulates the manner in which Brass LNG Limited will undertake the project for the construction and operation of two liquefied natural gas (LNG) trains at Brass in Bayelsa state and the delivery of LNG to the Atlantic Basin gas market.

The contract for the Front End Engineering Design (FEED) for the project was awarded to Bechtel Corporation; a San Francisco, CA, USA based engineering company, in November 2004. The award of the FEED contract has put the project on track towards completion by the second half of 2009 ([www.gulfoilandgas.com](http://www.gulfoilandgas.com)), through optimizing FEED designs, preparing the scopes of work for the award of Engineering Procurement and Construction (EPC) contracts and pre-qualifying contractors for the EPC activities.

The Brass LNG facility, being built on Brass Island in Nigeria's Bayelsa state, will initially consist of two trains with a combined capacity of 10m t/y to be on stream in 2011. The plant will also produce 2.5m t/y of LPG and some condensates with facilities for liquefied butane and propane extraction, segregation, and treatment; two 185,000 m<sup>3</sup> LNG storage tanks; two 110,000 m<sup>3</sup> LPG storage tanks; one 500,000-barrel capacity NGL tank; marine facilities for the products export; and accommodation for plant operators.

Brass LNG products will be loaded onto vessels by cryogenic pipelines and then transported to terminal facilities in the Atlantic Basin. The natural gas will then be transported to the United States and Mexico. The project is expected to produce 10 million tons of liquefied natural gas per year during its 20-year lifetime. Bechtel Corp. is the project manager of the plant site. The project costs an estimated US\$8.5 billion.

### **Revenue Flow for JOAs and PSCs**

The revenue flow for Joint Operating Agreements (JOAs) is shown in Figure 1, while Figure 2 shows the revenue flow for the production sharing contracts.

## **METHODOLOGY**

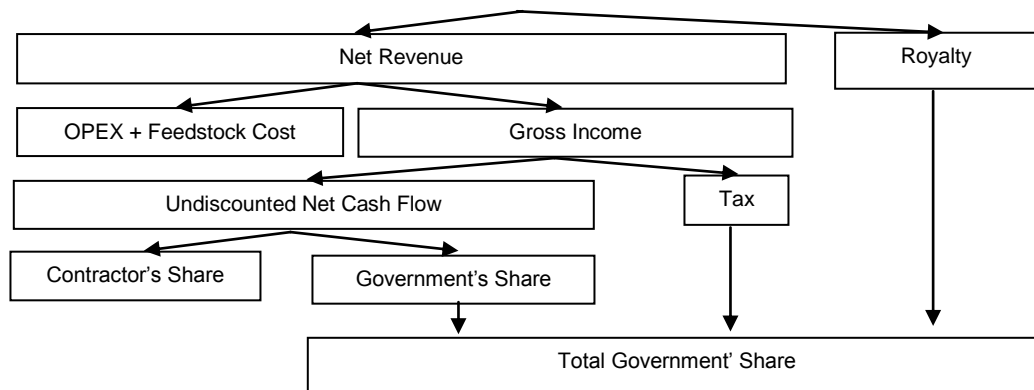
### **Production Parameters Used for the Research**

The production parameters used for the research are stated as follows:

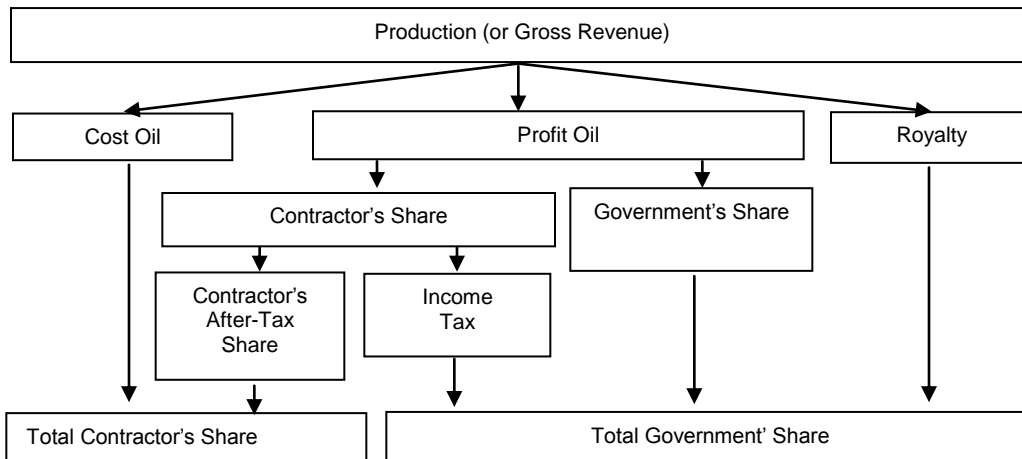
- (i) Twenty (20) years of plant life,
- (ii) Fifteen percent (15%) interest/discount rate on project,
- (iii) Plant operation at 330 days per year for both Brass LNG project,
- (iv) OPEX, feedstock cost and annual revenue are assumed to be distributed equally over the entire life of the plants,
- (v) All cash flows occur at the end of year,
- (vi) Bonuses paid by the oil companies upon successful bids are not considered in computing net cash flow to the government,
- (vii) Under Joint Ventures, 12.5% royalty on gross revenue and 30% tax on gross income (i.e., profit) are considered,
- (viii) Under PSCs, 10% royalty on cost oil, 50% government's share and 50% contractor's share of profit oil, and 50% income tax on contractors' share,
- (ix) A CAPEX of US\$8.5 billion for Brass LNG project is distributed equally over the four year construction period.

### **Economic Modeling of Fiscal Regimes**

To evaluate the economic indices for the projects, annual gross revenues are generated as a function of product sale price. Also, royalties, cost functions and income tax are considered before obtaining the undiscounted cash flows for the companies, contractors and government. Net present value (NPV) analysis is then carried out to determine the minimum cost-effective product sale price and the corresponding economic indices. Also, economic indices at a particular product sale price are evaluated.



**Figure 1: Joint Operating Agreements (JOAs) Revenue Flow.**



**Figure 2: Production Sharing Contracts (PSCs) Revenue Flow.**

**Joint Ventures Economic Model Objective Functions for JVs:** The assumption here is that the investor maximizes the net present value of cash flows from the plant during its operating life, where the net cash flow for the plant is defined as:

$$ncf(pc) = \sum_{yr} \begin{bmatrix} revenue(pc, yr) - royalty(pc, yr) - opex(pc, yr) \\ - fdstockcost(pc, yr) - incometax(pc, yr) \end{bmatrix}$$

where  $revenue(pc, yr)$  is the gross revenue for a given plant size  $pc$  during year  $yr$ , here, it is assumed to be uniformly distributed throughout

the life of the plant,  $royalty(pc, yr)$  is the 12.5% royalty paid to the government by the company for a given plant size  $pc$  during year  $yr$ ,  $opex(pc, yr)$  is the annual operating expenditure for a given plant size  $pc$  during year  $yr$ ,  $fdstockcost(pc, yr)$  is the cost of the natural gas feedstock needed by the plant for a given plant size  $pc$  during year  $yr$ , and  $incometax(pc, yr)$  is 30% tax on gross income for a given plant size  $pc$  during year  $yr$ .

The contractors' share of the plant net cash flow is defined as:

$$contractshare(pc) = \sum_{yr} \left[ \frac{revenue(pc, yr) - royalty(pc, yr) - opex(pc, yr)}{-fdstockcost(pc, yr) - incometax(pc, yr)} \right] * \frac{contractinv(pc)}{capex(pc)}$$

where  $contractinv(pc)$  is the contractor's investment/equity in the plant and  $capex(pc)$  is the capital expenditure (i.e., initial investment).

The government's share of the plant net cash flow is defined as:

$$govtshare(pc) = \sum_{yr} \left[ \frac{revenue(pc, yr) - royalty(pc, yr) - opex(pc, yr)}{-fdstockcost(pc, yr) - incometax(pc, yr)} \right] * \frac{govtinv(pc)}{capex(pc)}$$

where  $govtinv(pc)$  is the government's investment (i.e., state's equity) in the plant.

The net cash flow to the state during the life of the plant  $ncfgovt(pc)$  includes passive revenue from royalty and taxes, and revenue from the state's equity in the plant and is given as:

$$ncfgovt(pc) = \sum_{yr} [royalty(pc, yr) + incometax(pc, yr) + govtshare(pc)]$$

The net present value of cash flow for the plant is defined as:

$$npv(pc) = \sum_{yr} \left[ \left( \frac{revenue(pc, yr) - royalty(pc, yr) - opex(pc, yr)}{-fdstockcost(pc, yr) - incometax(pc, yr)} \right) * discfactor \right] - capex(pc)$$

where  $discfactor = \frac{1}{(1+discrate)^t}$  is the discount factor and  $discrate$  is the discount rate at which

the present value of future cash flow is determined. The net present value of cash flow for the contractors is defined as:

$$contractnpv(pc) = \sum_{yr} \left[ \left( \left( \frac{revenue(pc, yr) - royalty(pc, yr) - opex(pc, yr)}{-fdstockcost(pc, yr) - incometax(pc, yr)} \right) * \frac{contractinv(pc)}{capex(pc)} \right) * discfactor \right] - contractinv(pc)$$

The net present value of cash flow for the state is defined as:

$$govtnpv(pc) = \sum_{yr} \left[ \left( \frac{\left( \text{revenue}(pc, yr) - \text{royalty}(pc, yr) - \text{opex}(pc, yr) \right) * \text{govtin}(pc)}{\text{capex}(pc)} \right) - \text{fdstockcost}(pc, yr) - \text{incometax}(pc, yr) \right] * \text{discfactor} - \text{govtin}(pc)$$

**JVs Economic Indices Estimation:** The minimum cost-effective product sale price for the plant is obtained by solving  $npv(pc)$  for a range of product sale price, and considering the price at which  $npv(pc) \approx 0$ . However, the internal return rate for the plant at a particular product sale price is obtained by solving  $npv(pc)$  for a range of discount rate, and considering the discount rate at which  $npv(pc) \approx 0$ .

The other economic indices for the plant during the life of the plant are estimated as:

$$\text{profindex}(pc) = \left( \frac{\text{pvfuturecf}(pc)}{\text{pvinitialinv}(pc)} \right) = \left( \frac{\text{pvfuturecf}(pc)}{\text{capex}(pc)} \right)$$

where  $\text{profindex}(pc)$  is the profitability index,  $\text{pvfuturecf}(pc)$  is the present value of future

cash flow and  $\text{pvinitialinv}(pc)$  is the present value of initial investment.

$$\text{annualized-roi}(pc, yr) = \left( \frac{\text{invprof}(pc, yr)}{\text{invcost}(pc)} \right) = \left( \frac{\text{invprof}(pc, yr)}{\text{capex}(pc)} \right)$$

where  $\text{annualized-roi}(pc, yr)$  is the return on investment for a given plant size  $pc$  during year  $yr$ , also called annualized rate of return,  $\text{invprof}(pc, yr)$  is the profit on investment for a given plant size  $pc$  during year  $yr$ .

Care must be taken not to confuse annual and annualized returns. An annual return on investment is a single-period return, while an annualized return on investment is a multi-period, geometric average return; it is uniformly distributed throughout the life of the plant.

$$r - \text{fact}(pc) = \left( \frac{\text{cumrecept}(pc, yr)}{\text{cumexpd}(pc, yr)} \right) = \left( \frac{\text{accrneteam}(pc, yr)}{\text{accrtotalexpd}(pc, yr)} \right)$$

$$r - \text{fact}(pc) = \left( \frac{\text{revenue}(pc, yr) - \text{royalty}(pc, yr)}{\left( \text{capex}(pc, yr) + \text{opex}(pc, yr) \right) + \text{fdstockcost}(pc, yr)} \right)$$

where  $r - \text{fact}(pc)$  is r-factor, it is initially zero during exploration when there is no product sale and gradually grows with time. An r-factor less than 1 means costs have not been fully recovered yet; total expenditures exceed total receipts. Here, earnings and expenditures are assumed to

be uniformly distributed throughout the life of the plant.  $\text{cumrecept}(pc, yr)$  and  $\text{cumexp}(pc, yr)$  are the cumulative receipts and cumulative expenditure respectively for a given plant size  $pc$  during year  $yr$ .

Also,  $accrneteam(pc, yr)$  and  $accrtotalexpd(pc, yr)$  are the accrued net earnings and the accrued total expenditures respectively for a given plant size  $pc$  during year  $yr$ .

### Production Sharing Contracts Economic Model Objective Functions for PSCs

Also, the assumption here is that the investor maximizes the net present value of cash flows from the plant during its operating life, where the net cash flow for the plant is defined as:

$$ncf(pc) = \sum_{yr} [revenue(pc, yr) - royalty(pc, yr) - costoil(pc, yr)]$$

where  $revenue(pc, yr)$  and  $royalty(pc, yr)$  retain their usual meanings and  $costoil(pc, yr)$  is the allocation of oil (in this case, gas) to

reimburse the contractor(s) for capital investment, operating expenditure and feedstock cost.

Income tax on contractors' share of the plant net cash flow is defined as:

$$\begin{aligned} taxoncontractshare(pc) &= \sum_{yr} [(revenue(pc, yr) - royalty(pc, yr) - costoil(pc, yr)) * 0.5] * 0.5 \\ &= \sum_{yr} [(revenue(pc, yr) - royalty(pc, yr) - costoil(pc, yr)) * 0.25] \end{aligned}$$

The contractors' after-tax share of the plant net cash flow is defined as:

$$\begin{aligned} contractafertaxshare(pc) &= \sum_{yr} [(revenue(pc, yr) - royalty(pc, yr) - costoil(pc, yr)) * 0.5] * 0.5 \\ &= \sum_{yr} [(revenue(pc, yr) - royalty(pc, yr) - costoil(pc, yr)) * 0.25] \end{aligned}$$

The total cash flow to the contractors during the life of the plant  $tcfcontract(pc)$  includes cost oil and

contractors' after-tax share of the plant net cash flow and is given as:

$$tcfcontract(pc) = \sum_{yr} [costoil(pc, yr) + contractafertaxshare(pc, yr)]$$

However, the actual cash flow for contractors during the life of the plant  $acfcontract(pc)$  is the summation of capital expenditure recovered per

annum and contractors' after-tax share of the plant net cash flow and is given as:

$$acfcontract(pc) = \sum_{yr} [capexperannum(pc, yr) + contractafertaxshare(pc, yr)]$$

where  $capexperannum(pc, yr)$  is capital expenditure recovered per annum and is assumed to

be distributed equally over the twenty-year production period.

The government's share of the plant net cash flow is defined as:

$$govtshare(pc) = \sum_{yr} [revenue(pc, yr) - royalty(pc, yr) - costoil(pc, yr)] * 0.5$$

The net cash flow to the government during the life of the plant  $ncfgovt(pc)$  includes passive revenue from royalty and taxes, and government's share of the plant NCF and is given as:

$$ncfgovt(pc) = \sum_{yr} [royalty(pc, yr) + taxoncontractshare(pc, yr) + govtshare(pc, yr)]$$

The net present value of cash flows for the plant is defined as:

$$npv(pc) = \sum_{yr} [(revenue(pc, yr) - royalty(pc, yr) - costoil(pc, yr)) * discfactor] - capex(pc)$$

where  $discfactor$  retains its usual meaning.

The net present value of actual cash flows for the contractors is defined as:

$$contactnpv(pc) = \sum_{yr} [(capexperannum(pc, yr) + contractaftertaxshare(pc, yr)) * discfactor] - capex(pc)$$

The net present value of cash flows for the government is defined as:

$$govtnpv(pc) = \sum_{yr} [(royalty(pc, yr) + taxoncontractshare(pc, yr) + govtshare(pc, yr)) * discfactor]$$

### PSCs Economic Indices Estimation

The minimum cost-effective product sale price for the plant, the internal return rate for the plant at a particular product sale price, the profitability index, return on investment and r-factor for PSCs are estimated as earlier indicated for JVs.

estimated at US\$0.50 /MMBtu and regasification cost is estimated at US\$0.30/MMBtu; i.e., a total of US\$1.80/MMBtu (Rahman, 2008). Hence, for Brass LNG, an OPEX of US\$1.80/MMBtu is considered. The thermal efficiency is such that the heating value of natural gas is 1MBtu/scf and the heating value of LNG is 5.7 MMBtu/bbl which is approximately 1,015Btu/scf (Patel, 2005). Density of LNG = 2.65 lb/cuft; hence, volume of 10 million tons/yr of the Brass LNG

## RESULTS AND DISCUSSION

### Economic Indices Evaluation For Brass LNG Project

**Brass LNG Capital Expenditure:** CAPEX per annum for Brass LNG is US\$425,000,000/yr.

**Brass LNG Annual Operating Expenditure:** Operating cost (excluding depreciation and feedstock cost) of the liquefaction plant counts for nearly US\$1.00/Mscf, while shipping cost is

$$= 10 \times 10^6 \times 10^3 \text{ kg} \left( \frac{\text{lb}}{0.45 \text{ kg}} \right) \left( \frac{\text{cuft}}{2.65 \text{ lb}} \right) \left( \frac{\text{bbl}}{5.616 \text{ cuft}} \right) / \text{yr}$$

$$= 1,493,454,004 \text{ bbl} / \text{yr}$$

$$= 1,493,454,004 \text{ bbl} / \text{yr} \times 5.7 \text{ MMBtu} / \text{bbl}$$

$$= 8,512,687,823 \text{ MMBtu} / \text{yr} \text{ and the OPEX}$$

$$= 8,512,687,823 \text{MMBtu} / \text{yr} \times \text{US}\$1.80 / \text{MMBtu}$$

$$= \text{US}\$15,322,838,080 / \text{yr}.$$

**Brass LNG Feedstock Cost Analysis Natural Gas Feedstock Price:**

Since the year 2000, prices of natural gas in the North American region have risen to an averaging value of US\$4.50/MMBtu (Patel, 2005); the average price for the previous five years was \$2.25/MMBtu. The heating value for natural gas is 1.0 MBtu/scf (Patel, 2005); hence, natural gas price is US\$4.50/Mscf. Therefore, for the purpose of this study, natural gas feedstock price of US\$4.50/Mscf is considered.

**Brass LNG Feedstock Cost:** Approximately 19 billion scf/d of natural gas monetization will be required to produce 140 MM tons/year of LNG (Patel, 2005). Hence, the Brass LNG will require about 1,357,142,857 scf/d of natural gas feedstock to produce 10 MM tons/year of LNG and about 2.5 MM tons/year of associated LPG and condensates. The quantity of feedstock to be used over the period of 330 days/year is 447,857,472.8 M scf/yr. Hence, the cost of feedstock to be used over the production period will be,

$$447,857,472.8 \text{Mscf} / \text{yr} \times \text{US}\$4.5 / \text{Mscf} = \text{US}\$2,015,358,628 / \text{yr}.$$

**Brass LNG Products Cost Analysis LNG Products Sales Prices:**

From the historical and projected LNG prices in the United States, by the Energy Information Administration – EIA (Artunduaga, 2007 and Alleyne, 2008), the least LNG price projected is about US\$5.40/MMBtu.

Nevertheless, in this project work, different prices of LNG within the range of US\$1.00/MMBtu to US\$6.00/MMBtu are analyzed to know the minimum cost-effective LNG price i.e., at NPV = 0. As at 2005, the average product price for LPG and condensates was US\$12.00/bbl (Adegoke et al., 2005). However, of recent, the LPG price is US\$180/ton (Rahman, 2008).

**Brass LNG Annual Gross Revenue:** The annual gross revenue is generated based on LNG per MMBtu and the average product price for LPG. The annual gross revenue is assumed to be

uniformly distributed throughout the life of the plant. The product breakdown for the Brass LNG project is as follows: 10 million tons/yr of LNG and 2.5 million tons/yr of LPG/condensates. Hence, annual gross revenue = *LNGrevenue* + *LPGrevenue*.

(i) Density of LNG = 2.65 lb/cu ft, hence, volume of 10 million tons/yr of LNG is estimated as

$$10 \times 10^6 \times 10^3 \text{kg} \left( \frac{\text{lb}}{0.45 \text{kg}} \right) \left( \frac{\text{cuft}}{2.65 \text{lb}} \right) / \text{yr} =$$

$$8,385,744,235 \text{cuft} / \text{yr} = 1,493,454,004 \text{bbl} / \text{yr}.$$

The heating value is then evaluated as:  $1,493,454,004 \text{bbl} / \text{yr} \times 5.7 \text{MMBtu} / \text{bbl}$

$= 8,512,687,823 \text{MMBtu} / \text{yr}$  and the annual gross revenue

$$= 8,512,687,823 \text{MMBtu} / \text{yr} \times \text{LNGprice} / \text{MMBtu}.$$

(ii) LPG consists mainly of liquid propane of density 500 - 510 kg/m<sup>3</sup> and liquid butane of density 570 - 580 kg/m<sup>3</sup>. However, in this research project work, densities of liquid propane and liquid butane are considered as 500 kg/m<sup>3</sup> and 570 kg/m<sup>3</sup> respectively. Assuming 50% by weight (or mass) of both liquid propane and liquid butane, the average density of LPG is evaluated as 535 kg/m<sup>3</sup>. Then the annual LPG volume is

$$\text{estimated as } \frac{2.50 \times 10^6 \times 10^3 \text{kg} / \text{yr}}{535 \text{kg} / \text{m}^3} =$$

$$4,672,897.20 \text{m}^3 / \text{yr} \times \frac{\text{bbl}}{0.159 \text{m}^3}$$

$$= 29,389,290.57 \text{bbl} / \text{yr}.$$

Using the current LPG price of US\$180/ton (Rahman, 2008), the revenue from LPG could be estimated as  $2.5 \times 10^6 \text{tons} / \text{yr} \times \text{US}\$180 / \text{ton} = \text{US}\$450,000,000 / \text{yr}$ . Hence, annual gross revenue =  $[8,512,687,823 \text{MMBtu} / \text{yr} \times \text{LNGpriceperMMBtu}] + \text{US}\$450,000,000 / \text{yr}$ .

For example, at LNG price of US\$1.0/MMBtu, annual gross revenue from Brass LNG =

$$[8,512,687,823 \text{MMBtu} / \text{yr} \times \text{US}\$1.0 / \text{MMBtu}] + \text{US}\$450,000,000 / \text{yr} =$$

US\$8,512,687,823/ yr +  
 US\$450,000,000/ yr =  
 US\$8,962,687,823/ yr.

Annual gross revenues generated at other LNG prices of US\$2.00/MMBtu to US\$6.00/MMBtu are estimated accordingly to know the minimum cost-effective LNG price i.e., at NPV ≈ 0.

**Brass LNG Cost Oil under PSCs:** The cost oil per annum of Brass LNG project under PSCs is estimated as:

$$\text{Cost Oil per Annum} = \text{CAPEX per Annum} + \text{Annual OPEX} + \text{Annual Feedstock Cost}$$

Cost Oil per Annum

$$= \text{US\$} \left( \frac{425,000,000 + 15,322,838,080}{+ 2,015,358,628} \right) / \text{yr}$$

$$= \text{US\$} 17,763,196,710 / \text{yr}.$$

## ECONOMIC PROFITABILITY ANALYSIS OF BRASS LNG PROJECT

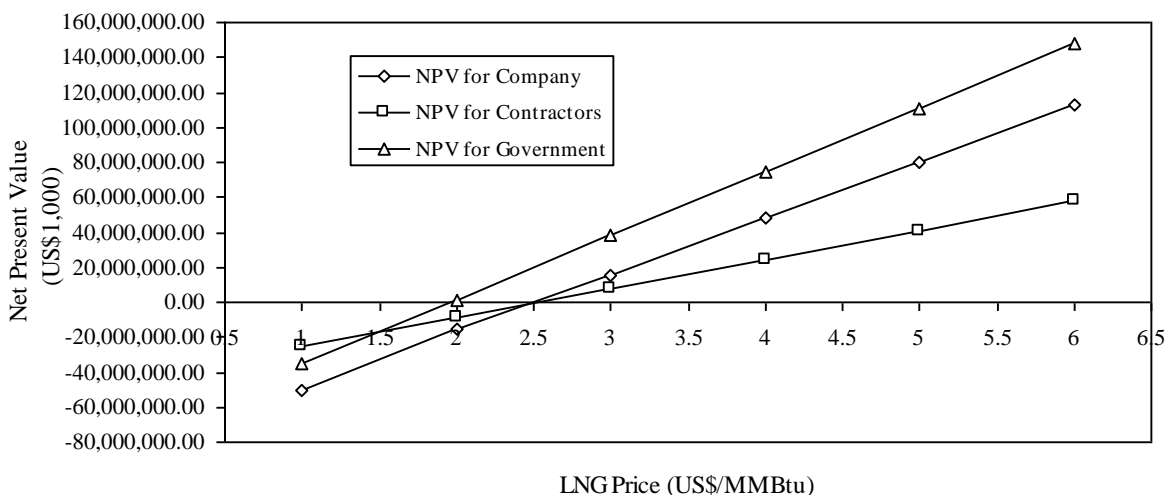
### Brass LNG Profitability Under Joint Ventures

**NPV Profit Analysis for Determining Minimum Cost-Effective LNG Price for Brass LNG Project under JVs at 15% Discount Rate:** Excel spreadsheet is used to calculate Net Present Value profits for the Brass LNG project under JVs at 15% interest rate on loan for investment and at different prices of LNG within the range of US\$1.00/MMBtu to US\$6.00/MMBtu to determine the minimum cost-effective LNG price (i.e., at NPV ≈ 0); this is shown in tabular and graphical forms in Table 1 and Figure 3.

Here, the minimum cost-effective LNG price (at NPV ≈ 0) for the company and contractors is chosen as the minimum cost-effective LNG price for the Brass LNG project under joint ventures. The iterated value of the minimum cost-effective LNG price at 15% discount rate is evaluated as US\$2.54/MMBtu.

**Table 1:** Variation of NPV with LNG Price for Brass LNG Project under JVs at Natural Gas Price of US\$4.5/Mscf and 15% Discount Rate.

LNG Price (US\$/MMBtu)	1.0	2.0	3.0	4.0	5.0	6.0
Annual Gross Revenue (US\$1,000)	8,962,687.82	17,475,375.65	25,988,063.47	34,500,751.29	43,013,439.12	51,526,126.94
NPV for Company (US\$1,000)	-50,106,348.48	-15,302,847.05	15,166,226.71	47,802,514.28	80,438,801.84	112,975,089.40
NPV for Contractors (US\$1,000)	-25,554,237.71	-8,909,731.05	7,734,775.59	24,379,282.23	41,023,788.96	57,668,295.64
NPV for Government (US\$1,000)	-35,370,723.49	1,268,379.48	37,907,607.64	74,546,835.74	111,186,063.96	147,825,292.08



**Figure 3:** Brass LNG NPV versus LNG Price (at US\$4.50/Mscf Natural Gas Feedstock Price under JVs).

**NPV Profit Analysis for Determining Internal Return Rates for Brass LNG Project under JVs at 15% Discount Rate and LNG Price of US\$5.40/MMBtu:** To determine the IRR values for the company, contractors and government under JVs at LNG price of S\$5.40/MMBtu, NPV profits analysis at different discount rates within the range of 100% to 600% is carried out. This is shown in tabular and graphical forms in Table 2 and Figure 4, from which the IRR values (i.e., at  $NPV \approx 0$ ) are determined. The iterated IRR values for the company, contractors and government are 191.68%, 191.68%, and 498.68%, respectively.

**Evaluation of Brass LNG Net Present Value, Profitability Index, Return on Investment and R-Factor at LNG Price of US\$5.40/MMBtu and Discount Rate of 15% under JVs:** The net present value of future cash flow at LNG price of

US\$5.40/MMBtu is estimated, at the discount rate of 15%, as US\$93,493,316,910 (Table 3).

$$\text{Profitability Index} = \frac{PV\text{ofFutureCashFlow}}{PV\text{ofInitialInvestment}} = \frac{US\$101,993,316,910}{US\$8,500,000,000} = 11.999$$

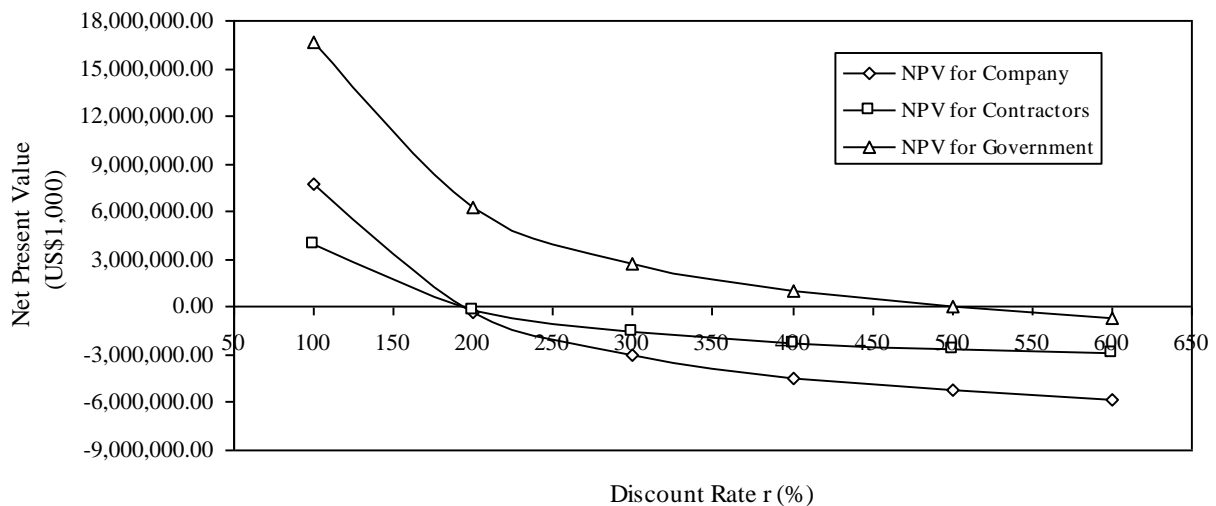
The return on investment is estimated as:

$$ROI = \frac{\text{Profit on Investment}}{\text{Cost of Investment}}$$

$$\text{Annualized ROI} = \frac{US\$16,294,602,280}{US\$8,500,000,000} = 1.917 \text{ or } 191.70\%$$

**Table 2:** Variation of NPV with Discount Rate for Brass LNG Project under JVs at Natural Gas Price of US\$4.5/Mscf and LNG price of US\$5.4/MMBtu.

Discount Rate (%)	100	200	300	400	500	600
Annual Gross Revenue (US\$1,000)	46,418,514.24	46,418,514.24	46,418,514.24	46,418,514.24	46,418,514.24	46,418,514.24
NPV for Company (US\$1,000)	7,794,586.73	-352,698.84	-3,068,465.92	-4,426,349.44	-5,241,079.54	-5,784,232.95
NPV for Contractors (US\$1,000)	3,975,239.23	-180,298.62	-1,564,917.61	-2,257,438.21	-2,672,950.56	-2,949,958.80
NPV for Government (US\$1,000)	16,605,050.57	6,220,035.19	2,758,356.79	1,027,517.57	-10,985.93	-703,321.61



**Figure 4:** NPV versus Discount Rate for Brass LNG Plant, Contractors and Government under JVs at LNG Price of US\$5.40/MMBtu.

Hence, the 20-year ROI = 38.340 or 3,834.00% and, R-factor is evaluated as:

$$R - \text{factor} = \frac{\text{AccruedNetEarning}}{\text{AccruedTotalExpenditure}}$$

$$= \frac{\text{AccruedNet Revenue}}{(\text{CAPEX} + \text{OPEX} + \text{FeedstockCost})}$$

$$= \frac{\text{AnnualGross Revenue} - \text{Royalty}}{(\text{CAPEX} + \text{OPEX} + \text{FeedstockCost})}$$

$$R - \text{factor} = \frac{\text{US\$40,616,199,960}}{\text{US\$17,763,196,710}} = 2.286$$

### BRASS LNG PROFITABILITY UNDER PRODUCTION SHARING CONTRACTS

**NPV Profit Analysis for Determining Minimum Cost-Effective LNG Price for Brass LNG under PSCs at 15% Discount Rate:** Also, NPV profit analysis is done for the Brass LNG project under PSCs at 15% discount and at different prices of LNG within the range of US\$1.00/MMBtu to US\$6.00/MMBtu to determine the minimum cost-effective LNG price i.e., at NPV  $\approx$  0. This is shown in tabular and graphical forms in Table 4 and Figure 5. Here, the minimum cost-effective LNG price for the contractors is chosen as the minimum cost-effective LNG price for the Brass LNG project under production sharing contracts. The iterated value of the minimum cost-effective LNG price at 15% discount rate is US\$2.76/MMBtu.

**NPV Profit Analysis for Determining Internal Return Rates for Brass LNG Project under PSCs at 15% Discount Rate and LNG Price of US\$5.40/MMBtu:** To determine the corresponding IRR values for the Brass LNG project under PSCs at LNG price of S\$5.40/MMBtu, another NPV profit analysis is carried out at different discount rates within the range of 50% to 600%. This is shown in tabular and graphical forms in Table 5 and figure 6, from which the IRR values (i.e., at NPV  $\approx$  0) are determined.

The iterated values of IRR for the company and contractors are 282.51% and 75.62% respectively; also, the project is highly beneficial to the government irrespective of the discount rate, (i.e., the IRR for government has no limit).

**Evaluation of Brass LNG Net Present Value, Profitability Index, Return on Investment and R- Factor at LNG Price of US\$5.40/MMBtu under PSCs:** The net present value of future cash flow at LNG price of S\$5.40/MMBtu is estimated, at the discount rate of 15%, as US\$141,808,244,220 (see Table 6).

$$\text{Profitability Index} = \frac{\text{PVofFutureCashFlow}}{\text{PVofInitialInvestment}} = \frac{\text{US\$150,308,244,220}}{\text{US\$8,500,000,000}} = 17.683$$

The return on investment is estimated as:

$$\text{ROI} = \frac{\text{Pr ofitonInvestment}}{\text{CostofInvestment}}$$

$$\text{AnnualizedROI} = \frac{\text{US\$24,013,466,110}}{\text{US\$8,500,000,000}} = 2.8251 \text{ or } 282.51\%$$

Hence, the 20-year ROI = 56.502 or 5,650.20% and, R-factor is evaluated as:

$$R - \text{factor} = \frac{\text{AccruedNetEarning}}{\text{AccruedTotalExpenditure}}$$

$$= \frac{\text{AccruedNet Revenue}}{(\text{CAPEX} + \text{OPEX} + \text{FeedstockCost})}$$

$$= \frac{\text{AnnualGross Revenue} - \text{Royalty}}{(\text{CAPEX} + \text{OPEX} + \text{FeedstockCost})}$$

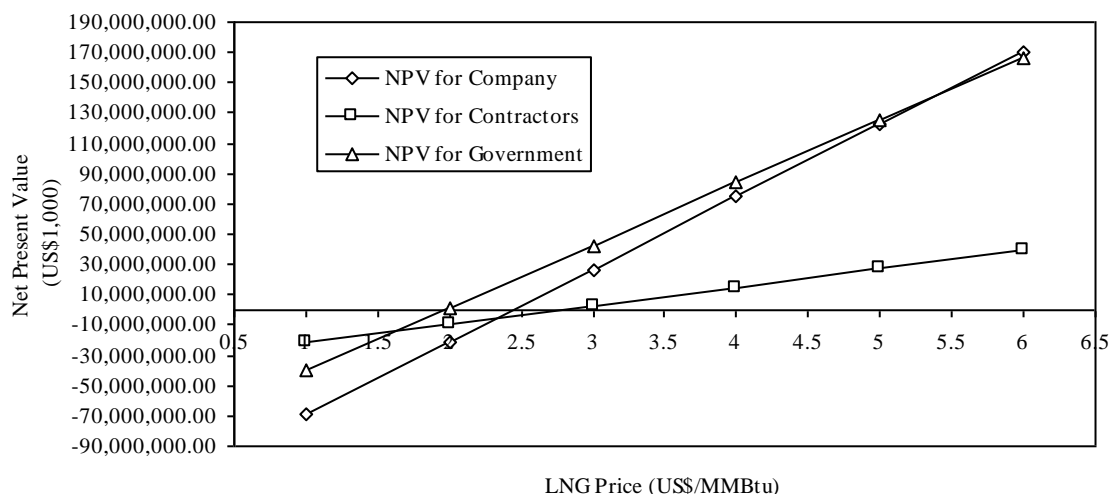
$$R - \text{factor} = \frac{\text{US\$41,776,662,820}}{\text{US\$17,763,196,710}} = 2.352$$

Table 3: NPV Profit Analysis for Evaluating Brass LNG Project NPV under JVs @ Natural Gas Price of US\$4.5/MMBtu and Discount Rate of 15%.

Year	CAPEX (US\$1,000)	Annual Gross Revenue (US\$1,000)	12.5% Royalty (US\$1,000)	New Revenue (US\$1,000)	OPEX (US\$1,000)	Feedstock Cost (US\$1,000)	Gross Income (Profit) (US\$1,000)	30% Tax (US\$1,000)	Undiscounted Net Cash Flow for Company (US\$1,000)	Undiscounted Cash Flow for Contractors (51%) (US\$1,000)	Undiscounted Net Cash Flow for Government (US\$1,000)	Discount Factor	Discounted Net Cash Flow for Company (US\$1,000)	Discounted Cash Flow for Contractors (US\$1,000)	Discounted Net Cash Flow for Government (US\$1,000)
0	8,500,000.00	0	0	0	0	0	0	0	-8,500,000.00	-8,535,000.00	-4,165,000.00	1.0000	-8,500,000.00	-4,335,000.00	-4,165,000.00
1	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.8696	14,189,219.37	7,226,301.88	18,060,930.76
2	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.7561	12,321,060.33	6,283,740.76	15,705,157.18
3	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.6575	10,713,965.50	5,464,122.40	13,656,638.42
4	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.5718	9,316,491.74	4,751,410.78	11,872,355.15
5	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.4972	8,101,297.16	4,131,661.55	10,226,395.78
6	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.4323	7,044,800.23	3,592,749.18	8,979,474.59
7	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.3759	6,125,744.55	3,124,129.72	7,808,238.77
8	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.3269	5,326,734.39	2,716,634.54	6,789,772.85
9	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.2845	4,631,943.95	2,362,390.90	5,904,150.30
10	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.2472	4,027,776.48	2,054,166.00	5,134,043.74
11	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.2149	3,502,414.33	1,786,231.31	4,464,385.86
12	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.1869	3,045,577.68	1,553,241.61	3,882,074.66
13	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.1625	2,648,238.41	1,350,647.49	3,375,717.10
14	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.1413	2,302,894.27	1,174,476.08	2,935,406.17
15	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.1229	2,002,516.76	1,021,383.55	2,552,577.11
16	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.1069	1,741,319.92	888,072.65	2,219,588.79
17	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.0929	1,514,190.37	772,237.09	1,930,077.21
18	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.0808	1,316,887.27	671,510.51	1,678,238.01
19	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.0703	1,144,945.46	589,922.18	1,459,415.66
20	0	46,418,514.24	5,802,314.28	40,616,199.96	15,322,338.08	2,015,358.65	23,278,003.25	6,983,400.97	16,294,602.38	8,310,247.16	20,770,070.37	0.0611	995,604.74	507,738.42	1,269,057.09
															NPV = 83,493,316.91 47,681,588.80 125,841,752.20

**Table 4:** Variation of NPV with LNG Price for Brass LNG Project under PSCs at Natural Gas Price of US\$4.5/Mscf and 15% Discount Rate.

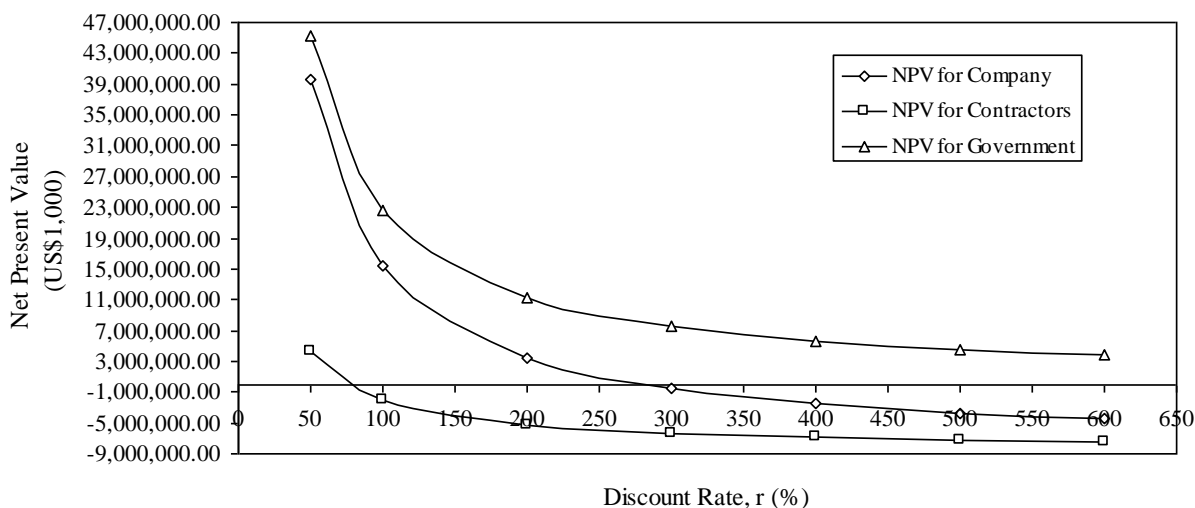
LNG Price (US\$/MMBtu)	1.0	2.0	3.0	4.0	5.0	6.0
Annual Gross Revenue (US\$1,000)	8,962,687.82	17,475,375.65	25,988,063.47	34,500,751.29	43,013,439.12	51,526,126.94
NPV for Company (US\$1,000)	-69,195,345.63	-21,239,984.25	26,715,377.00	74,670,738.33	122,626,099.73	170,581,461.05
NPV for Contractors (US\$1,000)	21,013,620.53	-9,024,780.13	2,964,060.09	14,952,900.39	26,941,740.77	38,930,581.09
NPV for Government (US\$1,000)	-39,911,465.89	1,383,428.68	42,678,323.10	83,973,217.57	125,268,112.07	166,563,006.54



**Figure 5:** Brass LNG NPV versus LNG Price (at US\$4.5/Mscf natural gas feedstock price) under PSCs.

**Table 5:** Variation of NPV with Discount Rate for Brass LNG Project under PSCs at Natural Gas Price of US\$4.5/Mscf and LNG Price of US\$5.4/MMBtu.

Discount Rate (%)	50	100	200	300	400	500	600
Annual Gross Revenue (US\$1,000)	46,418,514.24	46,418,514.24	46,418,514.24	46,418,514.24	46,418,514.24	46,418,514.24	46,418,514.24
NPV for Company (US\$1,000)	39,512,489.14	15,513,443.19	3,506,733.04	-495,511.30	-2,496,633.50	-3,697,306.79	-4,497,755.65
NPV for Contractors (US\$1,000)	4,352,866.66	-2,071,639.62	-5,285,816.75	-6,357,211.16	-6,892,908.37	-7,214,326.70	-7,428,605.58
NPV for Government (US\$1,000)	45,290,277.84	22,651,929.39	11,325,975.49	7,550,650.32	5,662,987.74	4,530,390.21	3,775,325.15



**Figure 6:** NPV versus Discount Rate for Brass LNG Plant, Contractors, and Government under PCSs at LNG Price of US\$5.40/MMBtu.

**COMPARISON OF BRASS LNG ECONOMIC PROFITABILITY INDICES UNDER JOINT VENTURES AND PRODUCTION SHARING CONTRACTS**

As shown in Table 7, the minimum cost-effective LNG prices for Brass LNG project under JVs and PSCs are US\$2.54/MMBtu and US\$2.76/MMBtu respectively. This shows that JVs can still accommodate relatively lower product sales price compared to PSCs. Also, at LNG price of US\$5.40/MMBtu, the IRR values for the company, contractors and government under JVs are 191.68%, 191.68% and 498.68% respectively. However, at the same price, the IRRs for the company and contractors under PSCs are 282.51% and 75.62% respectively while IRR for government has no limit. This shows that JVs is more favorable to the contractors than PSCs, but under PSCs, the project is highly beneficial to the government irrespective of the discount rate.

At LNG sales price of US\$5.40/MMBtu, the profitability index, annualized return on investment and R-factor under PSCs are 17.683, 282.51% and 2.352, respectively; these are observed to be higher than the corresponding values of 11.999, 191.70% and 2.286 under JVs.

This shows that, for Brass LNG project, PSCs is a more favorable fiscal regime compared to JVs.

**CONCLUSION**

Under joint ventures, for Brass LNG plant, the minimum cost-effective LNG price is estimated as US\$2.54/MMBtu. The IRR values for the company, contractors and government at an LNG price of US\$5.40/MMBtu are found to be 191.68%, 191.68% and 498.68% respectively; while the corresponding profitability index, annualized ROI and R-factor for the company are 11.999, 191.70% and 2.286 respectively. However, under PSCs, the minimum cost-effective LNG price is evaluated as US\$2.76/MMBtu.

The IRR values for the company and contractors at an LNG price of US\$5.40/MMBtu are found to be 282.51 and 75.62% respectively; while the IRR value for the government has no limit. The corresponding profitability index, annualized ROI and R-factor for the company are 17.683, 282.51% and 2.352 respectively. Hence, JVs is found to accommodate relatively lower product sales price compared to PSCs and it is also more favorable to contractors than PSCs (though PSCs is more beneficial to the company than JVs); but

under govern

Table 6: NPV Profit Analysis for Evaluating Brass LNG Project ENPV under PSCs @ Natural Gas Price of US\$4.50/MMscf, LNG Price of US\$5.40/MMBtu and Discount Rate of 15%

Year	CAPEX (US\$1,000)	Annual Gross Revenue (US\$1,000)	10.0% Royalty (US\$1,000)	Cost Oil per Annum (US\$1,000)	Profit Oils, Undiscounted Net Cash Flow for Company (US\$1,000)	50% Income Tax on Contractors' Share (US\$1,000)	Contractors' After-Tax Share (US\$1,000)	Government's Share (US\$1,000)	Actual Undiscounted Cash Flow for Contractors (US\$1,000)	Undiscounted Net Cash Flow for Government (US\$1,000)	Discount Factor	Discounted Net Cash Flow for Company (US\$1,000)	Actual Discounted Cash Flow for Contractors (US\$1,000)	Discounted Net Cash Flow for Government (US\$1,000)	
0	3,500,000.00	0	0	0	-3,500,000.00	0	0	0	-3,500,000.00	0	1.0000	-3,500,000.00	-3,500,000.00	0	
1	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.8696	20,881,274.88	5,589,883.94	19,692,348.70	
2	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.7561	18,157,650.33	4,860,768.64	17,133,129.31	
3	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.6575	15,789,443.76	4,226,753.34	14,394,024.49	
4	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.5718	13,729,177.19	3,675,459.43	12,951,324.51	
5	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.4972	11,958,936.68	3,196,034.38	11,262,023.05	
6	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.4323	10,381,684.07	2,779,160.25	9,793,063.52	
7	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.3759	9,027,531.37	2,416,661.08	8,511,107.41	
8	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.3269	7,850,044.67	2,101,444.42	7,404,982.97	
9	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.2845	6,826,125.80	1,827,342.97	6,459,098.23	
10	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.2472	5,915,761.56	1,588,992.89	5,599,217.85	
11	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.2149	5,161,531.79	1,381,733.82	4,868,833.35	
12	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.1869	4,488,288.52	1,201,507.67	4,233,311.61	
13	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.1625	3,902,849.58	1,044,789.38	3,681,733.31	
14	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.1413	3,393,790.94	908,513.41	3,201,369.84	
15	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.1229	2,951,222.56	790,010.79	2,783,399.86	
16	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.1069	2,566,193.33	686,865.91	2,420,892.33	
17	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.0929	2,231,472.63	597,361.66	2,104,922.63	
18	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.0808	1,940,410.98	519,444.92	1,830,193.59	
19	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.0703	1,687,313.90	451,691.24	1,591,646.60	
20	0	46,418,314.24	4,641,831.42	17,653,196.71	24,013,466.11	6,003,366.53	6,003,366.53	12,006,733.06	6,423,366.53	22,651,951.01	0.0611	1,467,229.48	392,744.99	1,384,040.52	
															NPV = 141,808,244.22 31,737,176.93 141,786,067.88

**Table 7:** Comparison of Brass LNG Economic Profitability Indices under JVs and PSCs.

Brass LNG Project							
Joint Ventures				Production Sharing Contracts			
At Minimum Cost-Effective LNG Price of US\$2.54/MMBtu		At LNG Price of US\$5.40/MMBtu		At Minimum Cost-Effective LNG Price of US\$2.76/MMBtu		At LNG Price of US\$5.40/MMBtu	
Internal Return Rate (IRR)		Internal Return Rate (IRR)		Internal Return Rate (IRR)		Internal Return Rate (IRR)	
Internal Return Rate	Company: 15.32% Contractors: 15.32% Government: 96.73%	Internal Return Rate	Company: 191.68% Contractors: 191.68% Government: 498.68%	Internal Return Rate	Company: 44.52% Contractors: 15.18% Government: No Limit	Internal Return Rate	Company: 282.51% Contractors: 75.62% Government: No Limit
Profitability Index = 1.018		Profitability Index = 11.999		Profitability Index = 2.789		Profitability Index = 17.683	
Annualized ROI = 0.1626 or 16.26%, 20-Year ROI = 3.2529 or 325.29%		Annualized ROI = 1.917 or 191.70% 20-Year ROI = 38.34 or 3,834.00%		Annualized ROI = 0.4456 or 44.56% 20-Year ROI = 8.912 or 891.20%		Annualized ROI = 2.8251 or 282.51% 20-Year ROI = 56.502 or 5,650.20%	
R-factor = 1.087		R-factor = 2.286		R-factor = 1.213		R-factor = 2.352	

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