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2008
The Impact of Government Requirements and Fiscal Terms on the State’s Revenue from a Liquefied Natural Gas Plant

by

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Thesis
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The Impact of Government Requirements and Fiscal Terms on the State’s Revenue from a Liquefied Natural Gas Plant

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Dedication

To my wife, Coral, and our children, Zahra and Zenon.
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Abstract

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Supervisor: Christopher J. Jabolonowski

World natural gas consumption is expected to increase from 270 BCFD to 450 BCFD between 2004 and 2030. In response to this, the LNG business in the Atlantic basin is projected to have a sustained annual growth rate of 7% over the next two decades. LNG projects require the investment of large sums of money and government sanction and support for these projects is often necessary for their success. In exchange for their sanction, governments impose requirements and fiscal terms on LNG projects so that their countries can gain benefits from the projects and share in the economic value generated by the projects. This thesis investigates how the requirements which a government might impose on an LNG project impact the state revenue from the project.
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Chapter 1: Introduction

The worldwide annual consumption of natural gas is projected to increase from 100 trillion cubic feet (TCF) to 163 TCF from 2004 to 2030 (EIA, 2007). About 30% of this increase will be in the OECD\textsuperscript{1} countries which will be expected to rely more heavily on imports of natural gas. Close to 75% of the world’s natural gas reserves are in the Middle East and Eurasia with Russia, Iran and Qatar together accounting for 58% of the world’s natural gas reserves as of January 1, 2007 (EIA, 2007). The growth in natural gas consumption in the next two decades should therefore lead to an increase in the quantities of natural gas which are transported via long distance pipeline or LNG as the international trade in natural gas increases to meet the increase in consumption, much of it being in countries which are remote from the reserves. For example, over the period 2004 to 2030 the USA is expected to increase its annual imports of LNG from 652 billion cubic feet to 4.5 trillion cubic feet (EIA, 2007). The global LNG trade can therefore be expected to grow significantly in the next two decades. Anecdotal evidence of this can be found in the fact that in 2005 ExxonMobil added 1.7 billion barrels of oil equivalent (BOE) to its reserves. About 95% of this total was attributable to gas reserves associated with the company’s LNG projects in Qatar (Tusiani, and Shearer, 2007).

As depicted in Figure 1, LNG is the most cost effective means of transporting natural gas over distances greater than 4000 – 5000 kilometers. This chart illustrates a general rule for comparing the different methods of transportation; specific cases should be evaluated using data specific to the situations. In addition to its cost advantage, LNG might also be selected instead of a pipeline development if there is a need for the pipeline

\textsuperscript{1} The OECD countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.
to cross many international boundaries and thus add to the complexity of the project because the project developers would need to deal with one or more governments in addition to those of the buyer and seller. LNG is typically transported across international waters, thus avoiding the need to deal with many countries to arrange its transit.

Figure 1: Gas and Oil Transportation Costs

(Source: Flower, 1998)

The LNG business consists of a number of segments, as illustrated in Figure 2, which link the natural gas in the reservoir to the end user. This sequence of segments is referred to as the LNG Value Chain. The segments are:

1. Production of natural gas
2. Transportation of the natural gas to the LNG Plant by pipeline
3. Liquefaction of the gas to LNG in the LNG Plant

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2 BOE – Barrel of Oil Equivalent - A term used to summarize the amount of energy that is equivalent to the amount of energy found in a barrel of crude oil. One barrel of oil will contain approximately 5.8 MMBtus. 5450 cubic feet of natural gas = 1 boe (This assumes that the heating value of the gas is 1065 Btu / cubic foot. MMBtus – A measurement of the energy content of natural gas, commonly used for pricing LNG and natural gas, equal to 10^6 Btu. A Btu is the amount of heat energy needed to raise the temperature of one pound of water by 1°F (Tusiani and Shearer, 2007).
4. Shipping of the LNG in special LNG tankers
5. Regasification of the LNG at the Regasification Terminal in the importing location
6. Marketing / Distribution of the natural gas to storage or directly to the end user for consumption.

![LNG Value Chain Diagram]

**Figure 2: LNG Value Chain**

It is very important that each link in the chain be operational and economically viable particularly in cases where the ownership of the parts of the chain is different and has different financing. The LNG business only works when all part of the chain work and there is a ‘Chain of LNG Project Contracts’ (Miller, 1998) in support of this. The hallmarks of the LNG business are:

1. The integrated and dedicated nature of the value chain
2. The size of the undertaking – a greenfield project can involve the simultaneous development of a natural gas field, the laying of a pipeline to transport gas to the LNG plant, the construction of the LNG plant and port facilities and the construction of LNG tankers and re-gasification facilities.
3. The cost – a natural corollary to the size of the undertaking is the cost. A greenfield project can require 3 - 4 $US billion.

4. Security of supply – because of the larger investments involved and because much of the financing can be based on the project revenues it is important to all parties that there are adequate natural gas reserves to support the venture.

5. Long project life – An LNG project typically has an operating life of at least 20 years

6. Involvement of Governments – Governments have a natural interest in LNG projects because they involve the monetization of natural resources for which the government wants to earn economic rent. They are also involved because they control the regulatory and fiscal regimes which can impact the viability of the projects.

7. Spirit of Mutual Understanding and Trust (Miller, 1998) – LNG projects bring parties together through large investments which are recouped over many years. The success of the venture is therefore predicated on a determination by the parties to make things work.

The LNG business utilizes economies of scale to transport natural gas efficiently. This exploitation of economies of scale requires large investments by the parties involved in the project who usually investigate a variety of mechanisms for sharing the risks and rewards of the venture. This thesis is a study of some of the methods that a state might use to capture its rewards from an LNG project within its borders.
Chapter 2:

OBJECTIVE

The sanction of an LNG project by the government of the country in which the project is located is necessary to provide license to operate for the project and the government in granting sanction usually seeks to influence the project through regulations and fiscal terms which optimize the benefits to the state from the project. The government’s actions can be partly responsible for the success of the project. The Trinidad and Tobago government’s role in the first Atlantic LNG Train I is cited (Shepherd and Ball, 2004) as one of the contributing factors leading to a successful LNG business in Trinidad and Tobago after three false starts. The government’s actions are thought (Shepherd and Ball, 2004) to have given a competitive advantage to the Trinidad and Tobago project allowing it to capture an opportunity in the US market ahead of competing projects from other countries. The fiscal package which was given to the Atlantic Train I project consisted of (Shepherd and Ball, 2004):

- A tax holiday of 10 years
- Relief from taxes on dividends and other distributions
- Valued Added Tax exemptions on imports, including capital imports
- Concessions on import duties
- Relief on withholding tax.

The purpose of this thesis is to investigate how the requirements and fiscal terms imposed by the government impact the state’s revenue from an LNG plant while accounting in detail for the typical attributes of LNG projects and agreements. The thesis

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3 The subsequent LNG trains did not receive tax holidays.
is based on the hypothetical expansion\(^4\) of an existing LNG plant in Trinidad and Tobago and examines scenarios representing different government requirements and fiscal terms based on:

- Different commercial structures in the LNG Plant;
- Variations in the state’s equity in the LNG plant;
- The sale of portions of the plant’s LNG output at a discount to special markets;
- Variations in the Valued Added Tax applied to the investment cost of the plant.

Each scenario is examined for a range of plant capacities and under uncertainties in the market price for LNG and the construction cost of the LNG plant.

**METHOD OF ANALYSIS**

The analysis of the problem is organized as follows:

1. Definition of the scenarios representing government requirements and fiscal terms.
2. Selection of LNG plant capacities.
3. Estimation of LNG prices.
4. Estimation of LNG plant construction costs.
5. Determination of the expected returns to investor/operator of the LNG plant under each scenario for each plant capacity and selection of scenarios that yield acceptable returns.
6. Determination of the state’s revenues for the scenarios which yield acceptable returns to the investor.

---

\(^4\) Trinidad and Tobago has been considering adding to its existing 4 trains of LNG for some time. Interest in the expansion through a 5\(^{th}\) train, ‘Train X’ has ebbed and flowed and feasibility studies for this project are being undertaken (WGI, 2008)
Scenarios Investigated

LNG Plant Commercial Structures

An LNG plant can be operated under different commercial structures. The plant can purchase natural gas, liquefy it and sell the LNG and accept all marketing risks. This arrangement exists for the Atlantic LNG (ALNG) Train 1 at the LNG facility in Trinidad and Tobago (Shepherd and Ball, 2004). Alternatively, the gas producer can retain ownership of the natural gas through the liquefaction plant, pay a processing fee to the LNG plant, and sell the LNG. Under this arrangement the plant is called a tolling plant and the processing fee guarantees the plant owner an agreed annual rate of return of between 8% and 12% on his investment in the plant. The ALNG Train 4 operates as a tolling plant. The third commercial structure created for the purpose of this analysis is a hybrid commercial structure in which the plant accepts the marketing risk for 50% of the gas processed and operates as a tolling plant for the remaining 50% of the gas processed. One of these three commercial arrangements is used in the definition of each scenario in the analysis.

State Equity in LNG Plant

The state can take equity in the LNG plant either directly or through a state company. The Trinidad and Tobago government for example has a 10% stake (Tusiani, and Shearer, 2007) in ALNG Train 1 and an 11.1% stake (Tusiani, and Shearer, 2007) in ALNG Train 4 through the state-owned National Gas Company of Trinidad and Tobago. The state equity in the scenarios is selected as 10, 15 or 20% of the investment in the LNG plant or $400 Million, whichever is less. The scenarios in the thesis therefore cover the current levels of state participation in the Trinidad and Tobago LNG project as well
as higher levels of participation which represent a potential consideration of the government in a future LNG project.

**Special Markets**

Trinidad and Tobago is a member of the Caribbean Community (CARICOM) trading group which includes 20 Caribbean states. All CARICOM member states, except Trinidad and Tobago, are net importers of energy. Trinidad and Tobago has had initiatives aimed at assisting CARICOM sister-states with preferential petroleum pricing. A potential consideration in the operation of a future LNG project in Trinidad and Tobago may be allocation of some of the plant’s output to the CARICOM market at a preferential price\(^5\). As a result each scenario considers that 0, 40 or 75 MMSCFD of the LNG plant’s throughput is marketed at a discount. The volume sold in the special market is applied to the plant’s total throughput and is not directly connected to the state’s equity in the plant. The economic impact of selling some of the plant’s output at a discount is felt by all investors in the plant in proportion to their equity.

**Valued Added Tax on LNG Plant Cost**

The Valued Added Tax (VAT) regulations in Trinidad and Tobago provide for the facility cost in qualifying industries to be exempt from VAT. The four existing LNG trains in Trinidad and Tobago have received this exemption but a future train may not receive it. As a result each scenario reflects either 0 or 15% VAT on the LNG plant cost.

The three commercial arrangements, three levels of state participation, three special marketing volumes and two VAT rates on the LNG plant cost result in 54 possible combinations or scenarios.

\(^5\) In November 2004 Jamaica signed an agreement with Trinidad and Tobago to purchase 1.1 million metric tons of LNG per year beginning in 2008 from a new LNG train in Trinidad and Tobago. This is equivalent to 160 MMSCFD. The pricing arrangement was not disclosed but Jamaica had been making a case for a preferential price because it was a member of CARICOM. This sale will not come to fruition on schedule but discussions are continuing (WGI, 2007).
LNG Plant Capacities

There are four LNG trains at the existing LNG facility in Trinidad and Tobago. The capacity of three of the trains is 3.3 million tonnes per annum (mtpa) and that of the fourth is 5.2 mtpa, which represent natural gas throughputs of 480 MMSCFD and 750 MMSCFD. The trains all utilize the Phillips Optimized Cascade liquefaction process which is one of several proprietary processes used in natural gas liquefaction plants. Maintaining a high plant availability and limiting costs are very important to the success of an LNG project. Therefore, in order to make maximum use of the existing infrastructure and the experience of operating the existing trains any expansion of the LNG facility in Trinidad and Tobago would likely utilize the same liquefaction process and select a train capacity which is within the range covered by the existing trains. Plant capacities of 500, 600, 700 or 800 MMSCFD are selected for analyzing each scenario. These four plant capacities and the fifty-four scenarios described earlier are combined to yield the 216 possible cases which form the basis of the study in this thesis.

LNG Prices

Each case specified by a commercial LNG plant structure, a level of state participation, a size of special market, a VAT on plant cost and a plant capacity is used to define an LNG plant expansion project. The Net Present Value (NPV) of each project is the basis of determining the attractiveness of a case. The project life is set at 20 years and the annual LNG price during the project life is treated as a random variable\(^6\). The wellhead price of natural gas is set as a percentage of the LNG price.

---

\(^6\) For simplicity LNG prices are assumed to be random variables. This disregards any correlation between inter-period LNG prices. It should be noted that for LNG from Trinidad and Tobago the realized LNG price is a combination of prices from the US, Europe and Asia because cargoes are often sold in the market with the best price at the time of the sale.
**LNG Plant Costs**

The cost of the LNG plant in each project is treated as a random variable\(^7\). One thousand realizations of each project are performed and from these realizations the expected NPV for the project is determined.

**Methodology of Analysis**

The determination of the cases which yield the best returns to the state can be determined by two different approaches. One approach, which is used by Furlonge, 2007 in a similar investigation, is to determine the case(s) which maximize the returns to the operator and the case(s) which maximize the returns to the state given some limiting rate of return to the operator and to use these cases to define a negotiating space which the operator and state use to negotiate a final position which satisfies both parties’ needs. An alternative approach, which is used here, is to determine the cases which an operator would use to maximize returns and determine the returns to the state which would result from those cases. The state is then in a position to modify the case if it seeks to change its returns. The premise is that given a set of regulatory requirements and fiscal terms the operator can always determine the conditions that yield the maximum return.

\(^7\) The LNG plant cost is treated as a random variable even though there may be some correlation with LNG prices because ultimately there may be some correlation between project capital costs and commodity prices
Chapter 3: Modeling

A simplified economic model of the LNG Value chain shown in Figure 2 is used to determine the returns to the operator and the state for each case. The model is focused on the LNG plant and includes realistic assumptions for the other segments of the value chain to ensure that realistic results are obtained for the returns in the LNG plant. The software used to implement the model is the General Algebraic Modeling System (GAMS). See www.gams.com for further information. While GAMS is most commonly used to formulate and solve optimization problems, this model involves no formal optimization-i.e. it does not use an optimization algorithm to choose values for a set of decision variables to optimize some objective subject to constraints. The plant operator does maximize his expected npv of future profits, by choosing a combination of a plant size and a commercial structure. Each of these is defined over a small discrete set, and the best combination is determined by complete enumeration. GAMS is useful in this context because of its abilities to define and manipulate variables and equations indexed over multiple index sets. It is used like a spreadsheet, to evaluate and report on the economic outcomes of many cases. The flowchart of the General Algebraic Modeling System (GAMS) model is shown in Figures 3a and 3b.
Figure 3a: Flow Chart of GAMS Model for Optimizing LNG Plant
The following simplifications are made in modeling the LNG Value chain:

- The price of natural gas at the wellhead is assumed to be a fixed percentage of the market price of natural gas.
- A fixed pipeline tariff is assumed for transporting gas from the wellhead to the LNG plant.
A fixed tariff is assumed for shipping LNG from the plant to the Regasification terminal.

A fixed fee is assumed for the regasification of LNG to natural gas.

A fixed margin is assumed for the marketing of LNG.

These assumptions are aimed at ensuring that allocations to these segments of the Value chain are adequate to yield the rates of return normally achieved in these segments. As shown in Figure 3, the process in the model is to first define a case based on a combination of government requirements and VAT terms and then determine returns for 1000 realizations for each of four plant sizes. In each realization LNG prices and plant construction costs are selected as random variables. A detailed description of these steps follows.

**CASE DEFINITION**

The combination of the three possible levels of state participation, the three volumes committed to special markets and two rates of VAT on the plant investment yield 18 possible policy combinations. The model is designed to probe the impact of these policies on state returns from the LNG plant. The first step in model formulation is the selection of one of the 18 policies. The policy is evaluated for 4 plant sizes under 3 commercial structures to determine which plant size / commercial structure combination would be selected by a risk neutral operator based on the acceptability of the returns. Each of the 18 policies leads to the definition of 12 cases (4 plant sizes and 3 commercial structures) for modeling. The returns to the state for cases which meet the operator’s selection criteria are then determined.
COST FUNCTIONS

Costs include the capital cost for the plant, the cost of natural gas for the plant, the expense for transporting natural gas to the plant and the operating expense of the plant.

LNG Plant Costs

The cost of the LNG plant is one of the larger investments in the LNG Value chain and can represent 30 – 45% of the investment in the value chain (EIA, 2003). The cost of the plant is heavily dependent on its location (WGI, 2007), however, there are trends in the average unit cost for plants and as Figure 4 shows these costs were declining in the 1998 – 2003 period but have been increasing since then. The reductions in cost are attributable to technology improvements in the plants, and benefits from economies of scale and more efficient project execution.

Figure 4: LNG Plant Unit Costs Adapted from (Tusiani, Shearer, 2007)
The recent increases in cost are attributable to increases in the prices of raw materials and increases in the cost of the skilled labor required to implement projects (Tusiani, Shearer, 2007). Because the expansion being studied will be at the Trinidad & Tobago site the global trends are useful, but historical costs at that location are more important in estimating the plant cost. Expansion projects were conducted at the Trinidad & Tobago site to add ALNG Trains 2 & 3 in 2002 and 2003 and to add ALNG Train 4 in 2006. Trains 2&3 were completed at a unit cost of $225 / ton per annum (tpa); Train 4 was installed for $250 /tpa (WGI, 2007). Based on this data and discussions with persons in the industry who are knowledgeable of plant costs at the Trinidad & Tobago site a most likely cost of $400/tpa is assumed for the hypothetical expansion which is assumed to start operation in 2011 based on a three year construction period and a project start in 2008. In the model the uncertainty LNG plant costs is represented by a triangular distribution with low, most likely and high costs of $280, $400 and $500/tpa. A triangular distribution is used for simplicity because the minimum, most likely and maximum future costs are known and there is little other data to guide us in determining future costs.

For each realization in the model a cost is selected at random from the triangular distribution and the unit cost so determined and the plant size are used to compute the LNG plant cost.

**Natural Gas Prices**

Under some commercial structures the LNG plant purchases natural gas at the wellhead. In the model the wellhead price of natural gas is a fixed percentage of the LNG market price. LNG from Trinidad and Tobago can access the North America, Europe or Asia markets. These markets (Tusiani, Shearer, 2007) have different mechanisms for pricing LNG. In North America, the LNG price is indexed to the Henry Hub natural gas price. For LNG terminals in the Gulf of Mexico there could be small, if any, differential;
at the East Coast terminals there has historically been a premium relative to Henry Hub while West Coast terminals there has been a discount. In the Asia-Pacific region LNG prices are set with reference to crude oil prices. In Europe the LNG price is computed with reference to several fuel alternatives. The net effect is that there can be vastly different prices between North America, Europe and Asia-Pacific such that selling LNG from Trinidad and Tobago into a distant market can be more profitable than selling it in the closer North America market. The attractiveness of the European market is illustrated by netback prices\(^8\) of $9.17 and $5.32 for Trinidad and Tobago cargoes sold to Spain and the UK in September 2006 compared with netback prices of $3.71 for the US (Gaul, Platt, 2007). In response to these circumstances, in the model LNG prices are defined as a triangular distribution with the most likely price being the Henry Hub price, the minimum price being Henry Hub *0.8 and the maximum price being Henry Hub * 1.33. The Henry Hub price of $7.45/MMBtu in the model is the average of the monthly Henry Hub prices for the period January 2005 – September 2007 taken from the EIA database (EIA, 2007). Figure 5 shows the historical LNG prices in the US and examples of the realized LNG prices in the model. The realized prices reflect the fact that LNG sales are made up of sales in different markets as defined by the triangular distribution for LNG prices. “Future Prices_1”, “Future Prices_2” and “Future Prices_3” in Figure 5 represent three randomly selected LNG price vectors in the model.

\(^8\) The netback price is the LNG selling price less the marketing margin, regasification cost and shipping cost.
Wellhead gas prices are set at 45% of the LNG price. This is a conservative figure and it is used here because the model is focused on the LNG plant and the upstream segment of the value chain is not modeled. The net back factor of 45% covers the possibility that the gas for the hypothetical expansion project is more costly than the gas presently produced in Trinidad and Tobago.

**Sampling from Triangular Distributions**

For values $a$, $b$ and $c$ representing the low, high and most likely values, the probability density function for a triangular distribution is given by:

$$
\frac{2(x-a)}{(b-a)(c-a)} \quad \text{for} \quad a \leq x \leq c
$$

(1)

$$
\frac{2(b-x)}{(b-a)(b-c)} \quad \text{for} \quad c \leq x \leq b.
$$

(2)
The cumulative distribution function (F) is given by:

\[ F = \frac{(x-a)^2}{(b-a)(c-a)} \quad \text{for} \quad a \leq x \leq c \]  

(3)

\[ F = 1 - \frac{(b-x)^2}{(b-a)(b-c)} \quad \text{for} \quad c \leq x \leq b. \]  

(4)

F is distributed between 0 and 1.

To sample from the distribution a random number between 0 and 1 is substituted for F in (3) and (4) above and solving for x yields the value of the sample as shown:

\[ x = a + \sqrt{F(b-a)(c-a)} \quad \text{for} \quad 0 \leq F \leq \frac{(b-c)}{(b-a)} \]  

(5)

\[ x = b - \sqrt{(1-F)(b-a)(b-c)} \quad \text{for} \quad \frac{(b-c)}{(b-a)} \leq F \leq 1 \]  

(6)

In the model I assume that there is perfect foresight with respect to future prices so twenty years of prices for all 1000 realizations are revealed at the start of a model run.

The same set of LNG prices and plant costs are used for evaluating all cases.

Sets

The variables and equations of the GAMS model are indexed over the following sets, where the values of the set elements given are the model default values

pc plant sizes \{1,2,...,4\}

yr years \{1,2,...,20\}

Operating Expense

OPEX represents the annual cost for operating and maintaining the plant. It is defined as:

\[
opex(pc, yr) = (((ome \ast avail) + gae) \ast plantcap(pc) + ome \ast avail \ast plantcap(pc) \ast (omevat \ast vat + omeedutycduty \ast cduty)) \ast inf lfactor(yr) \ast 365/1000
\]  

(7)
where: \( \text{opex}(pc, yr) = \text{opex} \) for a given plant size \( pc \) during year \( yr \), $mm; \text{ome} = \text{operating and maintenance cost, } $/\text{mscf}; \text{avail} = \text{plant availability, } \%; \text{gae} = \text{general and administrative cost, } $/\text{mscf}; \text{plantcap}(pc) = \text{plant size, mmscfd}; \text{omevat} = \text{portion of ‘ome’ which attracts VAT}; \text{vat} = \text{general VAT rate}; \text{omecduty} = \text{portion of ‘ome’ which attracts customs duty}; \text{cduty} = \text{rate of customs duty}; \text{inflfactor}(yr) = \text{inflation factor for year ‘yr’}. \text{ome} \text{ and } \text{gae} \text{ are held constant at } $0.175/\text{mscf} \text{ and } $0.0625/\text{mscf} \text{ respectively and } \text{omevat}, \text{omecduty}, \text{vat} \text{ and } \text{cduty} \text{ are held constant at } 0.32, 0.48, 0.15 \text{ and } 0.20 \text{ respectively.}

**Gas Transportation Expense**

The annual cost of transporting gas from the producing field to the LNG plant is defined as:

\[
\text{transport}(pc, yr) = (\text{plantcap}(pc) \times \text{heat} \times \text{plt} \times \text{avail})
\times \text{inflfactor}(yr) \times 365/1000000
\]

Where: \( \text{heat} = \text{heating value of natural gas, Btu/scf}; \text{plt} = \text{pipeline tariff, } $/\text{MMBtu}; \text{ and } \text{plantcap}(pc), \text{avail} \text{ and } \text{inflfactor}(pc) \text{ are as previously defined. A heating value of } 1065\text{ Btu }/\text{SCF}^{10} \text{ and a pipeline tariff of } $0.10 / \text{MMBtu} \text{ are used.}

**OBJECTIVE FUNCTIONS**

The model assumes that the investor is a risk neutral decision maker who maximizes the expected net present value of cash flows from the plant during its operating life, where the npv of cash flows is defined as:

\[
\text{ncf}(pc) = \sum_{yr} \left[ (\text{revenue}(pc, yr) - \text{opex}(pc, yr) - \text{transport}(pc, yr)) \times \text{corptax}(pc, yr) \times \text{discfactor}(yr) \right]
\times -\text{capex}(pc) \left[ 0.2 + \frac{0.4}{(1+r)} + \frac{0.4}{(1+r)^2} \right]
\]

\(^9\text{Mscf – thousand standard cubic feet.}\)

\(^{10}\text{SCF – standard cubic foot.}\)
The annual revenue is defined differently for the three commercial structures as:

**Market Risk (MR) commercial structure**

\[
\text{revenue}(pc, yr) = (((\text{plantcap}(pc) - \text{specmkt}) \times \text{shrink} \times \text{fobp}(yr) \\
+ \text{specmkt} \times \text{shrink} \times \text{fobp}(yr)(1 - \text{mktdisc}) \\
- \text{plantcap}(pc) \times \text{lngp}(yr) \times \text{nbf}) \\
\times \text{heat} \times \text{inflfactor} \times 365 \times 10^{-6} \times \text{avail})
\]  (10)

where: \( \text{discfactor}(yr) \) = discount factor for year, \( yr \); \( \text{specmkt} \) = volume of gas which is marketed as LNG in special markets, MMSCFD; \( \text{shrink} \) = shrinkage in gas volume a across the LNG plant, MMBtu of LNG / MMBtu of gas; \( \text{fobp}(yr) \) = annual FOB price for LNG at the LNG plant, $/MMBtu; \( \text{mktdisc} \) = discount on LNG price in the special markets; \( \text{nbf} \) = net back factor, LNG price / wellhead gas price; \( r \) = discount rate. The discount rate\(^{11}\) is held constant at 10% and the rate of inflation is held constant at 2.5%. The gas shrinkage and plant availability are held constant at 0.85 and 96% respectively. The net back factor is fixed at 0.45.

\[ \text{fobp}(yr) = \text{lngp}(yr) - \text{shp} - \text{rg} - \text{mkt} \]  (11)

where: \( \text{lngp}(yr) \) = annual LNG price, $/MMBtu; \( \text{shp} \) = shipping tariff, $/MMBtu; \( \text{rg} \) = regasification fee, $/MMBtu; \( \text{mkt} \) = marketing margin for LNG, $/MMBtu.

**Tolling Plant commercial structure**

\(^{11}\) State revenues are discounted at the same rate as cash flows to the operator. Another approach would be to apply a sovereign discount rate to the state revenues. A suitable estimate of the sovereign discount rate is the cost of capital to the state which can be determined from the rates on long term government bonds such as the 9-year bond with a 8.25% interest rate which was issued in July 2008 by the Trinidad and Tobago Central Bank.
\(\text{revenue}(pc, yr) = ((\text{plantcap}(pc) - \text{specmkt}) \times \text{heat} \times \text{shrink} \times \text{pf}) \times \text{inflfactor}(yr)\)  
\[\times 365\times 10^{-6} \times \text{avail}\]
\[+((\text{plantcap}(pc) - \text{specmkt}) / \text{plantcap}(pc)) \times \text{transport}(pc, yr)\]  
\[+\text{opex}(pc, yr) + (\text{specmkt} \times \text{shrink} \times \text{fobp}(yr) \times (1 - \text{mktdisc}) -
\text{specmkt} \times \text{lngp}(yr) \times \text{nbf}) \times \text{heat} \times \text{inflfactor}(yr) \times 365\times 10^{-6} \times \text{avail}\]  

where: \(\text{pf}\) = processing fee that yields a rate of return of 10%, $/MMBtu.

**MR-Tolling plant commercial structure**

\(\text{revenue}(pc, yr) = \text{Eqn}[10] \times 0.5 + \text{Eqn}[12] \times 0.5\) \hspace{1cm} (13)

\(\text{corptax}(pc, yr) = (\text{revenue}(pc, yr) - \text{expenses}(pc, yr) \times \text{tax}\) \hspace{1cm} (14)

\(\text{expenses}(pc, yr) = \text{opex}(pc, yr) + \text{deprc}(pc, yr) + \text{transport}(pc, yr)\) \hspace{1cm} (15)

where: \(\text{tax}\) = corporation tax rate; \(\text{deprc}(pc, yr)\) = annual depreciation for a plant size, \(pc\).

The plant investment is depreciated over 15 years using the straight line method. The corporation tax rate is 35%.

The net present value of the annual cash flows to the state during the life of the plant, \(\text{ncfgovt}\), includes passive revenue, from taxes and duties, and revenue from the state’s equity in the plant and is given by:

\[\text{ncfgovt}(pc) = \sum_{yr} \left[ (\text{corptax}(pc, yr) + \text{vatincome}(pc, yr) + \text{customduty}(pc, yr)) \right.\]
\[\left. + \text{vatcapex}(pc, yr) + \text{gvtshare}(pc, yr) \times \text{discfactor}(yr) \right] \]
\[\text{govtshare}(pc, yr) = \left( \text{revenue}(pc, yr) - \text{opex}(pc, yr) - \text{transport}(pc, yr) \right) \]
\[\text{govtshare}(pc, yr) = \frac{\text{govtshare}(pc, yr)}{\text{capex}(pc)}\]  

\(\text{vatincome}(pc, yr) = \text{ome} \times \text{plantcap}(pc) \times \text{omevat} \times \text{vat} \times \text{inflfactor}(yr) \times 365 \times 10^{-3}\)  
\(\text{customduty}(pc, yr) = \text{ome} \times \text{plantcap}(pc) \times \text{omecduty} \times \text{cduty} \times \text{inflfactor}(yr) \times 0.365\)  
\(\text{vatcapex}(pc) = \text{capex}(pc) \times \text{vatcap}\)  
\(\text{govtshare}(pc, yr) = \left( \text{revenue}(pc, yr) - \text{opex}(pc, yr) - \text{transport}(pc, yr) \right)\)
where in equations 16 – 20: quantities are as previously defined; \( vatcap \) = rate of VAT on plant investment cost; \( govinv \) = government investment in the plant, $MM.

**CONSTRAINTS**

There is a constraint placed on the government’s investment in the LNG plant. This is limited to the budget available for this investment as defined by:

\[
\begin{align*}
govinv(pc) &= capex(pc) \times ttequity \\
govinv(pc) &\leq budgetcap
\end{align*}
\]  
(21, 22)

where: \( ttequity \) = the government’s planned level of investment in the LNG plant; 
\( budgetcap \) = money available to government for investment in the LNG plant, $MM. 
Budgetcap is set at $400 MM.

**MODELING ASSUMPTIONS**

A number of assumptions are made in the model and these are listed and briefly discussed here.

- All cash flows occur at the end of the year.
- Revenue from any natural gas liquids which are recovered at the LNG Plant are not considered.
- Project life is 20 years from the start of plant operation.
- The construction period for the plant is 3 years and the drawdown schedule is 20%:40%:40%.
- A fixed shipping tariff of $0.50 / MMBtu
- A fixed regasification fee of $0.45 / MMBtu
- A marketing margin of $0.85 / MMBtu.
- The operator/investor accepts all cases where the return on investment is \( \geq 10\% \).
In addition to computing the expected NPV earned by the operator the model also computes the variance of the expected NPV. The returns to the state are divided into passive revenue and equity revenue. Passive revenue comprises revenue from corporation tax, value added tax and customs duty. Equity revenue is revenue obtained from the state’s investment in the LNG plant.
Chapter 4: Results

The model computes the Expected Net Present Value (ENPV) and the Return On Investment (ROI) earned by the operator / investor in the LNG plant and the returns to the state from the LNG Plant for projects developed in accordance with the 216 cases formed by combining the 3 commercial structures, 3 levels of state equity in the plant, 3 volumes of LNG committed to special markets and 2 levels of VAT on the investment in the plant. Each case represents a combination of requirements which the government can impose as a condition for approving the LNG expansion project.

For the purpose of discussing the results the term ‘operator’ will be used to refer to investor or investors in the LNG plant one or a group of who would typically be responsible for building and operating the LNG plant. All cases are analyzed under identical forecasts of LNG market prices and LNG plant costs and with the same assumptions for: the wellhead cost of natural gas to the LNG plant; the transportation cost for piping the gas to the LNG plant; the cost of shipping LNG; the cost of LNG regasification; and the cost of marketing.

The study is focused on the LNG plant segment of the LNG Value chain and as a result the model is focused on sharing the value created in the LNG plant between the operator and the government. This approach is in contrast to what often occurs in the study of an LNG project (Furlonge, 2007) where the focus in on the sharing of value between segments of the LNG value chain. The approach which is taken in this thesis is appropriate where the government of the country where the LNG plant is located has no sovereign right over the gas which is processed in the plant and therefore cannot gain value from the upstream segment of the LNG value chain which is where (Furlonge, 2007) significant economic value lies.
A typical subset of the model results is given in Tables 1 and 2 where the results have been conveniently separated to show the results for the operator and the government respectively. The results from each model run are divided to produce a row in each table. The plant capacity and special market quantity refer to volumes of natural gas not LNG; the plant capacity refers to the quantity of natural gas which the plant can process and the special market quantity refers to the quantity of gas which is converted to LNG for sale to special markets.

Table 1: Typical Model Results showing Returns to the Operator - (Each row represents one model run and is the average 1000 realizations)

<table>
<thead>
<tr>
<th>Plant Capacity MMSCFD</th>
<th>State’s Equity in Plant %</th>
<th>Special Market Quantity MMSCFD %</th>
<th>VAT on Plant Investment</th>
<th>Expected Plant Cost $MM</th>
<th>Operator Expected NPV $MM</th>
<th>Variance of Expected NPV</th>
<th>Standard Deviation $MM</th>
<th>Return on Investment %</th>
</tr>
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<tbody>
<tr>
<td>500</td>
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<td>1364</td>
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26
In a typical Tolling Plant the operator has no rights to the LNG produced in the plant. However, in this model, to ensure that all cases are evaluated on the same basis, under the Tolling commercial structure it is assumed that the plant purchases the special market volume of gas at the wellhead price and sells the LNG at the specified discounted price. The processing fee for the plant is adjusted to cover any losses incurred in the special marketing arrangement to provide the plant with the agreed guaranteed Return on Investment.

Table 2: Typical Model Results showing Returns to the State - (Each row represents one model run and is the average 1000 realizations)

<table>
<thead>
<tr>
<th>Plant Capacity MMSCFD</th>
<th>State’s Equity in Plant %</th>
<th>Special Market Quantity MMSCFD</th>
<th>VAT on Plant Investment %</th>
<th>Expected Plant Cost $MM</th>
<th>Expected Govt Total Take $MM</th>
<th>Variance of Expected Govt Take $MM</th>
<th>Standard Deviation $MM</th>
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</table>

In a typical Tolling Plant the operator has no rights to the LNG produced in the plant. However, in this model, to ensure that all cases are evaluated on the same basis, under the Tolling commercial structure it is assumed that the plant purchases the special market volume of gas at the wellhead price and sells the LNG at the specified discounted price. The processing fee for the plant is adjusted to cover any losses incurred in the special marketing arrangement to provide the plant with the agreed guaranteed Return on Investment.
IDENTIFICATION OF ACCEPTABLE CASES

The study of the impact of policy requirements and fiscal measures on the state’s returns is undertaken on cases which the operator identifies as acceptable. These cases contain conditions which the operator believes are satisfactory for investing in the LNG plant expansion project. The operator is assumed to be a risk neutral decision maker who maximizes ENPV. The study assumes that the Tolling commercial structure guarantees a return on investment (ROI) of 10%.

Where, \[ \text{ROI} = \frac{\text{Expected Net Present Value}}{\text{Investment}}. \]

A threshold ROI of 10% is used as a means of identifying cases which are acceptable to the operator. Table 3 contains a representative subset of the results from the model and shows the ENPV earned by the operator for an 800 MMSCFD plant. The state’s equity in the plant is 10%. As indicated in Table 3 all cases which feature a zero VAT on the investment are acceptable and cases with 15% VAT on the investment are only acceptable under the Market Risk (MR) and Market Risk-Tolling 50:50 (MR-Tolling 50:50) commercial structures when the volume committed to special markets is zero. The MR-Tolling-50:50 cases with special market volumes of 40 MMSCFD and 15% VAT on the plant investment are rejected because under these conditions only the plant capacity of 800 MMSCFD achieves the threshold 10% ROI, for plant capacities of 500 – 700 MMSCFD the ROIs are less than 10%. Given the guaranteed ROI for the Tolling commercial structure all cases are acceptable under this commercial structure.

Table 4 shows the ENPVs for an 800 MMSCFD plant with varied levels of state equity and ENPVs for plants of various sizes with a fixed level of state equity. These results illustrate that, all other things being equal, the operator’s ENPV increases with plant size and decreases as the state’s equity and the volume committed to special markets increase.
### Table 3: Model Results - Summary of Operator Returns

<table>
<thead>
<tr>
<th>Commercial Structure</th>
<th>Plant Capacity (MMSCF/D)</th>
<th>State's Equity in Plant (%)</th>
<th>Special Market Quantity (MMSCF/D)</th>
<th>VAT on Plant Investment (%)</th>
<th>Expected NPV ($MM)</th>
<th>Return on Investment (%)</th>
<th>Remarks</th>
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</thead>
<tbody>
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<td>MR (Market Risk)</td>
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<td>0</td>
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<td>480</td>
<td>24.7</td>
<td>Accept</td>
</tr>
<tr>
<td>MR (Market Risk)</td>
<td>800</td>
<td>10</td>
<td>75</td>
<td>0</td>
<td>368</td>
<td>18.9</td>
<td>Accept</td>
</tr>
<tr>
<td>MR (Market Risk)</td>
<td>800</td>
<td>10</td>
<td>40</td>
<td>15</td>
<td>262</td>
<td>11.7</td>
<td>Accept</td>
</tr>
<tr>
<td>MR (Market Risk)</td>
<td>800</td>
<td>10</td>
<td>75</td>
<td>15</td>
<td>202</td>
<td>9.0</td>
<td>Reject</td>
</tr>
<tr>
<td>MR (Market Risk)</td>
<td>800</td>
<td>10</td>
<td>40</td>
<td>15</td>
<td>150</td>
<td>2.9</td>
<td>Reject</td>
</tr>
<tr>
<td>Tolling Plant</td>
<td>800</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>198</td>
<td>10.2</td>
<td>Accept</td>
</tr>
<tr>
<td>Tolling Plant</td>
<td>800</td>
<td>10</td>
<td>40</td>
<td>0</td>
<td>198</td>
<td>10.2</td>
<td>Accept</td>
</tr>
<tr>
<td>Tolling Plant</td>
<td>800</td>
<td>10</td>
<td>75</td>
<td>0</td>
<td>198</td>
<td>10.2</td>
<td>Accept</td>
</tr>
<tr>
<td>Tolling Plant</td>
<td>800</td>
<td>10</td>
<td>0</td>
<td>15</td>
<td>229</td>
<td>10.2</td>
<td>Accept</td>
</tr>
<tr>
<td>Tolling Plant</td>
<td>800</td>
<td>10</td>
<td>40</td>
<td>15</td>
<td>230</td>
<td>10.3</td>
<td>Accept</td>
</tr>
<tr>
<td>Tolling Plant</td>
<td>800</td>
<td>10</td>
<td>75</td>
<td>15</td>
<td>229</td>
<td>10.2</td>
<td>Accept</td>
</tr>
<tr>
<td>MR-Tolling-50:50</td>
<td>800</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>330</td>
<td>18.0</td>
<td>Accept</td>
</tr>
<tr>
<td>MR-Tolling-50:50</td>
<td>800</td>
<td>10</td>
<td>40</td>
<td>0</td>
<td>321</td>
<td>16.5</td>
<td>Accept</td>
</tr>
<tr>
<td>MR-Tolling-50:50</td>
<td>800</td>
<td>10</td>
<td>75</td>
<td>0</td>
<td>295</td>
<td>15.2</td>
<td>Accept</td>
</tr>
<tr>
<td>MR-Tolling-50:50</td>
<td>800</td>
<td>10</td>
<td>0</td>
<td>15</td>
<td>258</td>
<td>11.5</td>
<td>Accept</td>
</tr>
<tr>
<td>MR-Tolling-50:50</td>
<td>800</td>
<td>10</td>
<td>40</td>
<td>15</td>
<td>228</td>
<td>10.2</td>
<td>Reject*</td>
</tr>
<tr>
<td>MR-Tolling-50:50</td>
<td>800</td>
<td>10</td>
<td>75</td>
<td>15</td>
<td>202</td>
<td>9.0</td>
<td>Reject</td>
</tr>
</tbody>
</table>

* This case is rejected since the ROI for plant capacities < 800 MMSCF/D is < 10.0

### Table 4: Variation of Operator ENPV and ROI with Plant Size and State Equity

| Commercial Structure | Plant Capacity (MMSCF/D) | State's Equity in Plant (%) | Special Market Quantity (MMSCF/D) | VAT on Plant Investment (%) | Operator Expected NPV ($MM) | Return on Investment (%) |
|----------------------|--------------------------|-----------------------------|-----------------------------------|----------------------------|-----------------------------|-------------------------|---------|
| MR (Market Risk)     | 800                      | 10                          | 0                                 | 0                          | 480                         | 24.7                    | Accept  |
| MR (Market Risk)     | 800                      | 15                          | 0                                 | 0                          | 453                         | 24.7                    | Accept  |
| MR (Market Risk)     | 800                      | 20                          | 0                                 | 0                          | 433                         | 24.5                    | Accept  |
| MR (Market Risk)     | 500                      | 10                          | 0                                 | 0                          | 290                         | 23.7                    | Accept  |
| MR (Market Risk)     | 600                      | 10                          | 0                                 | 0                          | 354                         | 24.1                    | Accept  |
| MR (Market Risk)     | 700                      | 10                          | 0                                 | 0                          | 419                         | 24.6                    | Accept  |
| MR (Market Risk)     | 800                      | 10                          | 0                                 | 0                          | 480                         | 24.7                    | Accept  |
The risk neutral operator who wishes to maximize ENPV would prefer the MR commercial structure for cases representing combinations of any level of state equity and special market volume with zero VAT on the LNG plant investment. The MR commercial structure would also be preferred for cases representing any level of state equity, with zero special market volume and a 15% VAT on the plant investment. The Tolling commercial structure would be preferred for cases which provide for 15% VAT on the plant investment and special market volumes of 40 or 75 MMSCFD.

Figure 6 contains data representing 12 cases under the MR commercial structure, 12 cases under the MR-Tolling-50:50 commercial structure and 4 cases under the Tolling commercial structure. As shown in the legend, there are 7 bars for each plant size and each represents a given commercial structure and special market volume. Only 4 cases are shown for the Tolling commercial structure because the results for a given plant size are the same for all special market volumes. All data points on the figure represent a state equity of 10 percent in the LNG plant and zero VAT on the plant investment. The MR commercial structure yields the highest ENPV for a given plant size in all instances.

Figure 7 contains data representing cases in which the VAT on the plant investment is 15%. Four cases are presented under the MR commercial structure and 4 cases are presented under the MR-Tolling-50:50 commercial structure. In all these cases the special market volume is zero. The cases with special market volumes of 40 and 75 MMSCFD yield unacceptable ENPVs under these commercial structures. The ENPVs under the Tolling commercial structure are acceptable. The ENPV is the same for all special market volumes for a given plant size.

---

12 The convention used in naming cases is [commercial structure – special market volume (in MMSCFD) – rate of VAT on plant cost (%)]. Where, MR, MR-Toll and Toll represent the three commercial structures. e.g. MR-40-0 represents the MR commercial structure, 40 MMSCFD special market volume and 0% VAT on plant cost.
Figure 6: Operator ENPV (State Equity - 10%; VAT on Inv, - 0)

13 “Toll-VAT=0” in the legend represents cases which include the Tolling commercial structure, any special market volume and 0% VAT on the plant cost.
In order to maximize ENPV the operator would select the largest possible plant, the smallest volumes committed to special markets, the lowest level of state equity, the MR commercial structure and zero VAT on investment in the plant. Even though when VAT is applied to the investment in the plant the ENPV decreases significantly, the operator would still prefer the MR commercial structure because it yields the higher ENPV in most instances.

Figure 8 is a mean-standard deviation diagram (Luenberger, 1998) for the ENPV data for the cases in Figures 6 and 7. The standard deviation is used here as a measure of uncertainty or risk (Lasdon, 2007, Bell and Savage, 1999). As indicated in the legend each of the 7 symbols in the figure represents data for a given special market volume and commercial structure for 4 plant sizes. Only one data set is shown for the Tolling cases.
because results are the same for all special market volumes for a given plant size. For each set of data the plant size increases from 500 to 800 MMSCFD from the lower left of the graph to the upper right.

Figure 8: Operator ENPV vs Std. Dev. (State Equity - 10%; VAT on Inv. - 0)

Most operators have some risk aversion and may choose to balance risk as indicated by the standard deviation and reward as indicated by the ENPV (Faya, 2007; Lasdon, 2007). The Tolling cases, blue symbols, show lower standard deviations than the MR-Tolling-50:50 cases, red symbols, which in turn show lower standard deviations than the MR cases, green symbols. However, the reduction in risk, as indicated by the reduction in the standard deviation comes with a significant reduction in reward and the
operator may not opt for this trade-off for these cases. Figure 9 shows data for the cases with VAT of 15% on the LNG plant investment.

![Operator Expected NPV vs Std Dev](image)

**Figure 9: Operator ENPV vs Std. Dev. (State Equity - 10%; VAT on Inv. - 15%)**

As in Figure 8 there are lower standard deviations and hence risk for the Tolling cases, blue symbols, than for the MR-Tolling-50:50 cases, red symbols, and in turn for the MR cases, green symbols. However, unlike for the cases for which the VAT on the plant investment was zero, for the cases where the VAT on the plant investment is 15% there is a significant difference in risk for a marginal difference in reward. For a 800 MSCFD plant the green triangle representing the MR commercial structure shows an ENPV and standard deviation of $262 MM and $228 MM and the same plant under the MR-Tolling -50:50 commercial structure shown by a red triangle has ENPV and standard
deviation values of $258$ MM and $202$ MM. Because the ENPV of the MR case is only $4$ $\text{MM}$ greater than that of the MR-Tolling-50:50 case while the standard deviation of the MR-Tolling-50:50 case is $26$ $\text{MM}$ lower, the operator may show a preference for the MR-Tolling -50:50 structure under a policy where there is $15\%$ VAT on the plant investment because there is a relatively large reduction in risk for a marginal reduction in reward.

Table 5: Ranking of Cases by Operator ENPV and ROI

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MR 800 10 0 0</td>
<td>2160 430 24.68</td>
<td>1 1</td>
<td>MR 800 15 0 0</td>
<td>2160 453 24.68</td>
<td>2 2</td>
<td>MR 700 10 0 0</td>
<td>1892 419 24.61</td>
<td>5 3</td>
<td>MR 700 15 0 0</td>
</tr>
</tbody>
</table>

In place of ENPV, the operator may consider ranking the cases in terms of ROI which is a good measure of “bang for the buck” because it shows the return earned for each dollar invested. The measure is deficient in being independent of the size of the investment and is thus more useful in judging cases of similar magnitude like the three
800 MMSCFD cases which are highlighted in Table 5. The table lists a subset of 24 of the 168 acceptable cases. Each row represents a case and the columns on the right give the ranks of the cases based on ENPV and ROI. The ROI ranking highlights the operator’s preference for minimizing the volume committed to special markets because the ROI decreases as the special market volume increases. The highlighted 500 MMSCFD case has a higher ROI rank than two of the highlighted 800 MMSCFD cases but the operator might consider the increased ROI too small in comparison to the materially higher ENPV of the 800 MMSCFD cases.

In summary, in assessing the cases the operator will accept:

- All cases which include zero VAT on the plant investment.
- Only accept cases with 15% VAT on the plant investment under the MR and MR-Tolling-50:50 commercial structures with zero special market volumes
- The Tolling commercial structure for all cases.
- Consider the MR-Tolling-50:50 commercial structure instead of the MR commercial structure in cases where there is 15% VAT on the plant investment.

**STATE RETURNS**

For the purposes of this study the returns to the state are classified as either passive or active. The passive state returns include revenue from corporation taxes, Value Added Tax (VAT) and customs duty. The active state returns represent income from the state’s equity investment in the LNG plant. The notion of passive and active state returns is akin to the passive and active investing (Sharpe, 2002) whereby just as the passive investor does not have to buy and sell stocks to manage his investment so too the returns to the state from taxes and duties are not driven by deliberate investment actions on the part of the state as are the state’s returns from its investment in the LNG plant.
Based on the assessment of the operator, 168 cases comprised of combinations of commercial structures, levels of state equity in the plant, special market volumes, VAT rates on the plant cost and plant sizes, as listed in Table 6, are acceptable for investment. Each row of Table 6 contains one group of combinations. Thus the 3rd row of the table shows that, any of the 3 commercial structures, can be combined with any of the 3 levels of state equity, and any of the 3 special market volumes, and only 1 rate of VAT on the plant cost (0%), and any of the 4 plant sizes, to yield 108 acceptable cases. In a similar way the 4th and 5th rows of the table detail the composition of the other acceptable cases. These cases form the basis of the investigation of the impact of the government requirements and fiscal terms on the state’s returns from the LNG plant.

Table 6: Cases Acceptable to the Operator Based on Combinations of Policy Elements

<table>
<thead>
<tr>
<th>Commercial Structure</th>
<th>State Equity In Plant %</th>
<th>Special Market Volume MMSCFD</th>
<th>VAT on Plant Cost %</th>
<th>Plant Size MMSCFD</th>
<th># of Cases (based on Combining elements)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>3<em>3</em>3<em>1</em>4 = 108</td>
</tr>
<tr>
<td>MR, MR-Tolling</td>
<td>10, 15, 20</td>
<td>0, 40, 75</td>
<td>0</td>
<td>500, 600 700, 800</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2<em>3</em>1<em>1</em>4 = 24</td>
</tr>
<tr>
<td>MR, MR-Tolling</td>
<td>10, 15, 20</td>
<td>0</td>
<td>15</td>
<td>500, 600 700, 800</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>1<em>3</em>3<em>1</em>4 = 36</td>
</tr>
<tr>
<td>Tolling</td>
<td>10, 15, 20</td>
<td>0, 40, 75</td>
<td>15</td>
<td>500, 600 700, 800</td>
<td></td>
</tr>
<tr>
<td>Total Cases (based on adding possible combinations)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>168</td>
</tr>
</tbody>
</table>
The state’s revenue for all cases in which the VAT on the plant cost is zero is shown in Figure 10. As the legend indicates there are seven bars for each plant size. Each bar represents a given commercial structure and a given special market volume. The data for state revenue is comparable with the data for operator ENPV in Figure 6 because they come from the same cases. There is only one bar representing Tolling for each plant size because the state revenue is the same for all special market volumes for a given plant size under the Tolling commercial structure. The state’s equity in the LNG plant is 10% for all cases. In all instances the MR commercial structure yields the highest state revenues. This is a similar finding as for the operator ENPV.

Figure 10: State Revenue vs Plant Size (State Equity - 10%; VAT on Inv. - 0)

14The convention used in naming cases is [commercial structure – special market volume (in MMSCFD) – rate of VAT on plant cost (%)]. Where, MR, MR-Toll and Toll represent the three commercial structures. “Toll-VAT = 0” represents cases under the Tolling commercial structure for all values of special market volume with zero VAT on the plant cost.
Figure 11 shows state revenue for the cases in which there is a 15% VAT on the LNG plant cost. The state’s equity in the LNG plant is 10% and the volume committed to special markets is zero for all cases. The MR commercial structure yields the highest state revenue for these cases and the cases which include a 15% VAT on the plant cost yield the highest state revenues overall.

![Expected State Revenue vs LNG Plant Size](image)

**Figure 11: State Revenue vs Plant Size (State Equity - 10%; VAT on Inv. - 15%)**

**Composition of State Returns**

The State’s revenue from the LNG plant consists of: equity revenue from the state’s investment in the plant, corporation tax from the operation of the plant, VAT income and customs duty through the purchase of goods and services for operating the plant and VAT income charged on the plant cost. As shown in Figures 12 and 13,
Corporation tax is responsible for 87% of state revenues when there is no VAT applied to the plant cost and comprises 67% of state revenues when 15% VAT is applied to the plant cost. The data in the figures is taken from cases for an 800 MMSCFD plant under the MR commercial structure where the special market volumes are zero and the state equity is 10%. Under different commercial structures and larger special market volumes there are only small (<5%) changes in the relative proportions of the components of state revenue.

Figure 12: Components of State Revenue (State Equity - 10%; VAT on Inv. - 0)
Corporation Tax

Corporation tax is a function of plant size, the special market volume and the VAT charged on the plant cost. The bars on the left in Figure 14 show corporation tax for a 500 MMSCFD plant and the other bars are for an 800 MMSCFD plant. In each set of bars the first bar represents zero special market volume and zero VAT on the plant cost, the second bar represents a 40 MMSCFD special market volume and zero VAT on the plant cost and the third bar represents zero special market volume and 15% VAT on the plant cost.
Comparing the values from the first two sets of bars shows the effect of plant size on corporation tax, comparing the 1st and 2nd bars in any set of bars shows the effect of special market volume and comparing the 1st and 3rd bars of any set shows the effect of VAT on the plant cost on corporation tax.

The data shows that the larger the plant size, the larger the corporation tax, all other things being equal. Under the MR and MR-Tolling -50:50 commercial structures, increases in the special market volume reduce corporation tax because they reduce the income from the plant, all other things being equal. However, under the Tolling commercial structure changes in the special market volume have no impact on corporation tax because the processing fee is adjusted to provide the guaranteed return. Under the MR and MR-Tolling-50:50 commercial structures the VAT applied to the plant
cost causes a reduction in corporation tax, all other things being equal, as can be seen by comparing the first and second bars in the first three sets of bars. This occurs because the VAT on the plant cost increases the plant cost which leads to a higher depreciation and lower corporation tax. Under the Tolling commercial structure the VAT on the plant cost leads to an increase in the processing fee in order to provide the guaranteed return and this leads to an increase in corporation tax. The MR commercial structure yields the highest corporation tax, all other things being equal, followed by the MR-Tolling-50:50 and Tolling commercial structures.

Valued Added Tax and Customs Duty

Income from Valued Added Tax (VAT) and Customs Duty are a component of the state’s passive revenue. VAT is collected by the state from the purchase of goods and services used in operating the plant and from VAT which is applied to the plant cost. Customs duty is collected from the importation of materials used in the operation and maintenance of the plant. The income from VAT and customs duty is thus a function of plant size and is significantly affected by VAT applied to the plant cost as is clearly shown in Figure 15. As indicated in the legend, the four groups of bars represent the four plant sizes: 500, 600, 700 and 800 MMSCFD. For each plant size the three leftmost bars represent cases in which zero VAT is applied to the plant cost and the other three bars represent cases in which 15% VAT is applied to the plant cost. The bars represent the three commercial structures with the bar furthest to the left in each group representing the MR commercial structure followed by the MR-Tolling-50:50 and then by the Tolling commercial structure for the first three bars. The order is repeated for the second three bars. Income from VAT and Customs duty is independent of the commercial structure.
Figure 15: Value Added Tax (VAT) and Customs Duty Analysis

The income from VAT and Customs duty is dependent on the plant size and is unaffected by the volumes which are committed to special markets. Though it is a smaller percentage of state revenue than corporation tax unlike corporation tax the income from VAT and Customs duty is based on the plant being in operation and not on its ability to make a profit.

**Equity Income**

Equity income is the final component of the state revenue and is directly related to the level of state investment in the plant. It is the state’s share of the Net Present Value (NPV) generated by the plant and, as is shown in Figures 12 and 13, is typically one of the smallest components of state revenue. Under the MR and MR-Tolling-50:50 commercial
structures equity income increases with the state’s equity in the plant and decreases with an increase in the volume committed to special markets and the level of VAT applied to the plant cost as shown in Figure 16.

Figure 16: Equity Income under varying levels of: State Equity in the Plant, Special Market Volume, and VAT on the Plant Cost

Figure 16 shows equity income for an 800 MMSCFD plant under three commercial structures. As indicated in the legend each bar is identified by three numbers (State Equity-Special Market Volume-VAT on Investment). In each group of bars, the bar furthest to the left represents 10% state equity, zero special market volume and zero VAT on the plant cost and the bar next to it represents 20% state equity, zero special market volume and zero VAT on the plant cost. The other pairs of bars to the right
represent 40 and 75 MMSCFD special market volumes respectively and the last pair represents zero special market volume and 15% VAT on the plant cost.

Comparing the bars within any pair shows the change in equity income due a change in the level of state equity with constant special market volume and VAT on the plant cost. Comparing the corresponding bars between the first three pairs of bars shows the change in equity income due to a change in special market volume with a constant level of state equity and VAT on the plant cost. Finally, comparing the corresponding bars in the 1\textsuperscript{st} and 4\textsuperscript{th} pairs shows the change in equity income with changes in the VAT on the plant cost with constant levels of state equity in the plant and special market volume.

Under the Tolling commercial structure equity income is constant for variations in the special market volume because the processing fee is adjusted to achieve the guaranteed ROI. The processing fee is also adjusted (increased) in response to the increase in VAT on the plant cost. This results in a slightly higher equity income under the Tolling commercial structure when VAT is applied to the plant cost.

The relationships between the components of state revenue and the elements which the state will use to formulate the policy for the LNG plant expansion project are summarized in Table 7.
Table 7: Changes to the Components of State Revenue due to Increases in the Policy Elements

<table>
<thead>
<tr>
<th>Component of State Revenue</th>
<th>Special Market Volume</th>
<th>VAT on the Plant Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MR</td>
<td>Tolling</td>
</tr>
<tr>
<td>Plant Size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Equity in Plant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corporation Tax</td>
<td>Increase</td>
<td>None</td>
</tr>
<tr>
<td>VAT Income and Customs Duty</td>
<td>Increase</td>
<td>None</td>
</tr>
<tr>
<td>Equity Income</td>
<td>Increase</td>
<td>Increase</td>
</tr>
</tbody>
</table>

In Table 7 the three components of state revenue are listed in the first column and the policy elements are listed in the other columns. The columns for special market volume and VAT on the plant cost are sub-divided by commercial structure. Each row contains information for one component of state revenue. Each cell in the table indicates the change in the component of state revenue in the row with an increase in the policy element in the column. Thus, in the first row, corporation tax increases if the plant size increases and has no change if the level of state equity increases. It decreases if the special market volume increases under the MR and MR-Tolling-50:50 commercial structures but has no change if special market volume increases under the Tolling commercial structure. Finally, corporation tax decreases if the VAT on the plant cost is increased under the MR and MR-Tolling-50:50 commercial structures but it increases for
an increase in VAT on the plant cost under the Tolling commercial structure. The information for the other cells in the table is interpreted in a similar manner.

**THE IMPACT OF STATE POLICIES ON THE STATE REVENUE FROM THE LNG PLANT**

The discussion of the preferences of the operator and the characteristics of the components of state revenue create a useful basis for probing the impacts which the policies which the state applies to the LNG plant have on the state revenue from the plant. State revenue from the plant will depend on the choices which the operator makes in developing the LNG project in response to the state’s policies, notably the choice of commercial structure and plant capacity. The operator’s options are analyzed by defining cases based on possible policy formulations and determining the ENPV of the cases under the base LNG price and the base LNG plant cost conditions and then examining the sensitivity of the ENPV to high and low LNG price and high LNG plant cost scenarios. A base case is used as a common reference with which to compare cases. The base case for this investigation is defined by:

- An 800 MMSCFD plant,
- 10% State Equity,
- Zero special market volume,
- Zero VAT on the LNG plant cost.

The selection of an 800 MMSCFD plant is arbitrary. ENPV increases with plant size so it is maximized by the selection of the largest plant possible. A 10% state equity is selected because this is the level of state equity in Atlantic LNG’s Trains I and IV in Trinidad and Tobago. The zero special market volume and zero VAT on the LNG plant cost are also the same as prevail in all the Atlantic LNG trains in the Trinidad and Tobago. The range of LNG prices and LNG plant costs is shown in Table 8. The choice
of the base LNG price and the base LNG plant cost have been discussed earlier in the
discussion of the parameters in the model.

Table 8: Range of LNG Prices and LNG Plant Costs

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Most Likely</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Price - $/ MMBtu</td>
<td>5.98</td>
<td>7.45</td>
<td>9.91</td>
</tr>
<tr>
<td>Base Cost - $/ Million Tons per Year</td>
<td>280</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>High Price - $/MMBtu</td>
<td>10.00</td>
<td>12.00</td>
<td>14.00</td>
</tr>
<tr>
<td>Low Price - $/MMBtu</td>
<td>4.80</td>
<td>6.00</td>
<td>8.00</td>
</tr>
<tr>
<td>High Cost - $/Million Tons per Year</td>
<td>280</td>
<td>500</td>
<td>700</td>
</tr>
</tbody>
</table>

The high and low LNG price and high LNG plant cost scenarios used in the
sensitivity analysis are based on discussions with persons who are active in the petroleum
industry in Trinidad and Tobago. The ‘most likely’ price in the low price scenario is
approximately equal to the average price paid for LNG from Trinidad and Tobago in the
US in 2004 (EIA, 2008). The ‘low’ and ‘high’ prices are set at 80% and 133%
respectively of the ‘most likely’ price. The ‘most likely’ price in the high price scenario
reflects the judgment of persons in the gas industry in Trinidad and Tobago. The ‘low’
and ‘high’ prices are set using the same methodology as for the low price scenario. The
high cost scenario for LNG plant cost is based on the view of a knowledgeable
professional involved in the LNG projects for a major energy company involved in the
Atlantic LNG trade. In computing the results under the price and cost sensitivities the
same assumptions are used as in the main cases with one exception. In the low LNG price
scenario the marketing margin is reduced from $0.85 per MMBtu of LNG to $0.50 per
MMBtu.
The three elements, level of state equity, special market volume and level of VAT on the LNG plant cost, form the basis of state policy on the LNG plant and are examined separately and then in combination.

**Valued Added Tax (VAT) on Plant Cost**

As illustrated earlier in Figure 11, the state can earn the highest revenue when VAT is applied to the plant cost. To illustrate the effect of applying VAT to the plant cost, Figure 17 shows the ENPV for the base case and the ENPV for a test case (800 MMSCFD plant; state equity – 10%; special market volume – 0; VAT on plant cost – 15%) under the three commercial structures and at base LNG price and base LNG plant cost conditions. The test case is examined under the high and low price and high cost scenarios. In these sensitivities only one parameter, either the price of LNG or the cost of the LNG plant is varied at a time.

Under the MR commercial structure the ENPV for the test case is below the base case value for the base price and cost conditions, increases significantly above the base case in the high price scenario but turns negative in the low price and high cost scenarios. The results under the MR-Tolling-50:50 commercial structure show a similar pattern in terms of the increases and decreases relative to the base case. However, the range of the values is smaller and the ENPV does not become negative in the low price and high cost scenarios. Under the Tolling commercial structure the ENPV is directly proportional to the plant cost because of the guaranteed ROI, which is essentially a return on the plant cost. Therefore the ENPV for the test case at the base price and cost conditions and the high and low price sensitivities are equal and higher than for the base case because the 15% VAT on the plant cost is essentially an increase in the plant cost. The high cost scenario reflects a second increase in plant cost and a further increase in ENPV under the Tolling commercial structure.
Figure 17: Sensitivity of ENPV to LNG Prices and LNG Plant Cost

A negative ENPV means that the project is not generating enough earnings to cover the cost of the investment. Therefore the operator would deem the MR commercial structure unacceptable if VAT is applied to the plant cost because of the potential to lose money in low LNG price or high LNG plant cost situations. Figure 18 shows the mean-standard deviation diagram for the ENPV for the MR-Tolling-50:50 and Tolling commercial structures from Figure 17.
Figure 18: ENPV vs Standard Deviation with Variations in LNG Prices and LNG Plant Cost (State Equity – 10%; VAT on Inv. – 15%)

The operator can use the data in Figure 18 to compare the MR-Tolling-50:50 cases (square symbol) with the Tolling cases (triangle symbol) and balance the risk as indicated by the standard deviation with the reward of the ENPV. The names of the commercial structures are abbreviated to MR-Toll and Toll in the legend. The black square and the black triangle represent the base cases for the MR-Tolling-50:50 and Tolling commercial structures respectively. The MR-Tolling-50:50 case would be preferred over the Tolling case because it reflects a large (~$170 MM) increase in ENPV for a small increase in risk. When VAT is applied to the plant cost as in the test case, the black triangle is replaced by the plum-colored triangle for all the price scenarios under the Tolling structure and the black square is replaced by the yellow, green and red
squares for base, high and low prices respectively for the MR-Tolling-50:50 structure. The operator may show a preference for the MR-Tolling-50:50 commercial structure because at the base price the ENPV is ~ 10% greater than under the Tolling structure with minimal increase in risk and under the high price scenario there is a six fold increase ($1352 MM) in ENPV with no increase in risk and this may be seen as adequately balancing the decrease of $215 MM in ENPV which occurs between the Tolling and MR-Tolling 50:50 commercial structures under the low price scenario.

Based on the identification of the MR-Tolling-50:50 and Tolling commercial structures as viable options, the state revenues for the base and test cases are shown in Figure 19 using the same approach with respect to price and cost as for Figure 17.

![Figure 19: Price and Cost Sensitivity of Expected State Revenue](image)
In Figure 19, as in Figure 17, in each group of bars, starting at the left, the bars represent: the base case (no VAT on plant cost) at the base price and cost, the test case (800 MMSCFD, 10% state equity, 0 special market volume, 15% VAT on the plant cost) at the base price and cost, the test case at the high price, the test case at the low price and the test case at the high cost.

The impact on state revenue of applying VAT to the plant cost is illustrated by comparing the results for the base case and test case. Under the base LNG price and base plant cost conditions the state revenue for the test case is higher than for the base case under both the MR-Tolling-50:50 and Tolling commercial structures with the revenue under the MR-Tolling-50:50 structure being marginally (~1%) greater. This is seen by comparing the 2nd bars in each group. In the high LNG price scenario state revenue for the test case under the MR-Tolling-50:50 commercial structure (the 3rd bar in the first group) is substantially higher than for the base price and cost conditions but there is no increase under the Tolling structure (the 3rd bar in the second group). There is a decrease in state revenue for the test case under the MR-Tolling-50:50 structure in the low price scenario which is unmatched under the Tolling structure. This is shown by comparing the 2nd and 4th bars within each group. Both commercial structures show state revenues under the high plant cost scenario (the 5th bars in each group) which are higher than under the base price and cost conditions with the increase for the Tolling commercial structure being greater. Applying VAT to the plant cost increases state revenue with the effect under the MR-Tolling-50:50 commercial structure being greater than under the Tolling commercial structure.

The expected state revenues are also examined in a mean – standard deviation diagram, Figure 20.
Figure 20: Expected State Revenue vs Standard Deviation with Variations in LNG Prices and LNG Plant Cost.

The values of expected state revenue in Figure 20 are the same as those in Figure 19 with the MR-Tolling-50:50 cases represented by the square symbol and the Tolling cases represented by the triangle symbol. The orange triangle is used to represent the base conditions, high price and low price scenarios for the test case under the Tolling commercial structure because the values are the same.

The impact of applying VAT to the plant cost is illustrated by the shift from the black square (base case) to the yellow square for the MR-Tolling-50:50 commercial structure, and the shift from the black triangle (base case) to the orange triangle for the Tolling commercial structure. In each instance the shift represents an increase in expected revenue with a decrease in risk. The green and red squares represent the state revenues
for the test case under the MR-Tolling-50:50 commercial structure for the high price and low price scenarios respectively. When they are compared with the orange triangle (Tolling commercial structure) they show that there is a large increase in expected revenue of ~ $900MM and a small increase in risk between the Tolling structure and the MR-Tolling-50:50 structure in the high price scenario and a small decrease in expected revenue with a small increase in risk in the low price scenario.

This analysis indicates that applying VAT to the LNG plant cost leads to the likely selection of the MR-Tolling-50:50 commercial structure over the Tolling structure for the LNG plant by the operator. Applying VAT to the plant cost increases state revenue under both commercial structures with the MR-Tolling-50:50 commercial structure presents opportunities for high state revenues in high LNG price environments.

**Special Market Volumes**

The special market volumes are quantities of natural gas which are converted into LNG to be sold at a discount in special markets. As a result, special market volumes decrease ENPV and, under the MR and MR-Tolling-50:50 commercial structures with VAT on the plant cost, the impact of special market volumes is to lower the ROI to below the 10% threshold. Thus there are no acceptable cases which include VAT on the plant cost and special market volumes under the MR and MR-Tolling-50:50 commercial structures.

Figure 21 shows ENPV under the three commercial structures for the base case and two test cases; one which includes 40 MMSCFD special market volume and the other includes 75 MMSCFD special market volume. The test cases are identical to the base case except for special market volume. In each group of bars the leftmost bar represents the base case. The second and third bars to the right represent the test cases at the base price and cost conditions. The fourth and fifth bars represent the test cases at low price
and base cost conditions and the sixth and seventh bars represent the test cases under the base price and high cost scenario. Under the MR commercial structure the ENPVs of the test cases, which are shown as Low Price_SM40 and Low Price_SM75 in Figure 21, are negative in the low price scenario. This could influence the operator’s acceptance of the MR commercial structure for the plant if special market volumes are a government requirement for the project and the operator could opt for the MR-Tolling-50:50 or Tolling commercial structure.

![ENPV vs Special Market Volumes](image)

**Figure 21: Impact of Special Market Volumes on ENPV under various Price and Cost Scenarios with 0% VAT on the Plant Cost.**

The impact of special market volumes on state revenue is a function of the commercial structure. Figure 22 shows the state revenue under two commercial
structures; MR-Tolling-50:50 and Tolling. These are represented in Figure 22 by the abbreviated names MR-Toll and Toll. Only these commercial structures are used because of the operator’s likely elimination of the MR commercial structure from consideration. Each group of bars on Figure 22 begins with state revenue for the base case followed, to the right, by state revenue for the test cases under the base price and cost followed by pairs of bars for the test cases under high price, low price and high cost scenarios. Under the MR-Tolling-50:50 commercial structure, all other things being equal, the level of state revenue decreases with an increase in special market volume. This is shown in Figure 22 by comparing the first three bars in the MR-Toll group which represent identical conditions except for 0, 40 and 75 MMSCFD special market volumes.

![Figure 22: State Revenue under different Commercial Structures with various Special Market Volumes and 0% VAT on the Plant Cost](image-url)
The 4th and 5th, 6th and 7th and, 8th and 9th bars present additional examples of the reduction in state revenue due to increases in special market volume under different price and cost conditions.

The pattern of state revenues under the Tolling commercial structure is different from the pattern under the MR-Tolling-50:50 commercial structure. Under the Tolling structure state revenue is independent of the special market volume. This is shown by the first seven bars in the Tolling group. Similarly, state revenue is constant for the test cases under the high cost scenario shown by the 8th and 9th bars in the Tolling group. This occurs because the processing fee is adjusted to ensure that the ROI of the project is 10%. The special market volumes are accommodated under the Tolling structure by providing for the purchase of the special market volumes at wellhead prices and the sale of the LNG resulting from this volume of gas at the discounted LNG price. The processing fee is set so as to keep the operator’s income whole on the special market arrangement. As a result, the ENPVs and state revenues are not impacted by the special market volumes under the Tolling commercial structure.

Special market volumes reduce state revenue under the MR-Tolling-50:50 commercial structure and they have no impact on state revenue under the Tolling commercial structure, all other things being equal. As can be seen by comparing the corresponding bars in each group in Figure 22, the MR-Tolling-50:50 commercial structure yields state revenues which are slightly (~10%) higher at the base price and significantly higher in a high price environment than the Tolling commercial structure. The Tolling commercial structure yields higher state revenues than the MR-Tolling-50:50 structure in the low price and high cost environments but overall the MR-Tolling-50:50 commercial structure yields the higher state revenues.
**State Equity**

The level of state equity does not impact the operator’s ROI but it reduces the operator’s share in the project. As shown in Figure 23 all commercial structures are impacted similarly by changes in the level of state equity so these changes do not create a preference by the operator for one commercial structure over another but the operator will maximize ENPV by selecting the MR commercial structure.

![Figure 23: ENPV versus State Equity](image)

**Figure 23: ENPV versus State Equity**

The state shares in the profit and loss generated by the plant through the level of state equity in the plant. Figure 24 shows the state revenue for different levels of state equity for the three commercial structures in an 800 MMSCFD plant with zero special market volume and zero VAT on the plant cost.
In Figure 24 there are 4 pairs of bars in each group. The leftmost pair represents the base case and 20% state equity and the successive pairs to the right represent the high price, low price and high cost environments respectively. Comparing the values in any pair of bars shows the impact of a 10% change in state equity. The increase in the level of state equity from 10% to 20% gives an increase in state revenue of $290 MM in the high LNG price scenario under the MR commercial structure and an increase of $157 MM under the MR-Tolling-50:50 structure. Under the Tolling structure this increase is an order of magnitude smaller. In the low LNG price scenario there is no change in state revenue under the MR commercial structure with the increase in the level of state equity, as shown by the 3rd pair of bars, indicating that there is no profit from the plant and state
revenue is made up of only passive revenue. There is a small increase under the MR-Tolling-50:50 structure.

In summary, the impact of the level of state equity on state revenue is greatest under the MR commercial structure and least under the Tolling structure.

**VAT on Plant Cost and Special Market Volumes**

As discussed earlier and shown in Table 6, when VAT on the plant cost is combined with Special Market Volumes only cases under the Tolling commercial structure are acceptable to the operator. The impact of this combination of elements on state revenue is therefore defined by the variation of state revenue under Tolling and is shown in Figure 25.

![Figure 25: State Revenue under the Tolling Commercial Structure](image-url)
In Figure 25, as shown in the legend, each group of bars represents the following six cases for a plant of 800 MMSCFD with a 10% state equity:

- Zero special market volume and zero VAT on the plant cost;
- 40 MMSCFD special market volume and zero VAT on the plant cost;
- 75 MMSCFD special market volume and zero VAT on the plant cost;
- Zero special market volume and 15% VAT on the plant cost;
- 40 MMSCFD special market volume and 15% VAT on the plant cost;
- 75 MMSCFD special market volume and 15% VAT on the plant cost;

The state revenue is a function of the plant cost and under the base conditions is $757MM when no VAT is applied to the plant cost and $1142 MM when 15% VAT is applied to the plant cost. In the high plant cost scenario, shown in the set of bars on the extreme right, the state revenue shows a similar pattern but is higher as a result of the higher plant cost. Because the plant is under the Tolling commercial structure there is no change in state revenue with changes in the special market volume or LNG price. Therefore the revenues are the same for the groups representing base conditions, high LNG price and low LNG price and within any group there are only two levels of revenue; one for cases in which no VAT is applied to the plant cost and the other for cases when VAT is applied to the plant cost.

When VAT on the plant cost is combined with special market volume in formulating a policy for the LNG plant the Tolling commercial structure is used in the plant and state revenue is fairly constant because it is only affected by the plant cost.

**VAT on Plant Cost and State Equity**

Figure 26 shows the state revenue for cases which are acceptable to the operator and represent combinations of the level of state equity in the plant and the level of VAT on the plant cost. The MR-Tolling-50:50 and Tolling commercial structures are the only
ones possible, because, as discussed earlier, the operator would not select the MR commercial structure if VAT is applied to the plant cost as the ENPV is negative in the low price scenario. The two groups of bars in the figure represent the acceptable commercial structures and each group of bars represents the following cases for an 800 MMSCFD plant with zero special market volumes:

- 10% state equity in the plant and zero VAT on the plant cost under base price and cost conditions;
- 10% state equity in the plant and 15% VAT on the plant cost under base price and cost conditions;
- 20% state equity in the plant and 15% VAT on the plant cost under base price and cost conditions;
- 20% state equity in the plant and 15% VAT on the plant cost under high price and base cost conditions;
- 20% state equity in the plant and 15% VAT on the plant cost under low price and base cost conditions;
- 20% state equity in the plant and 15% VAT on the plant cost under base price and high cost conditions.

As shown in the legend the cases listed are shown from left to right. The cases representing 15% state equity in the plant are not shown but this data is midway between the 10% and 20% data points in all instances.
The difference between the 1\textsuperscript{st} and 2\textsuperscript{nd} bars in each group shows the effect on state revenue of applying 15\% VAT to the plant cost and the difference between the 2\textsuperscript{nd} and 3\textsuperscript{rd} bars shows the effect of increasing the level of state equity by 10\%. The highest state revenue under the base LNG price and base LNG plant cost conditions is earned by the plant under the MR-Tolling-50:50 commercial structure with a 20\% state equity in the plant and 15\% VAT on the plant cost. The state revenue of $1184 MM is marginally higher than the $1161 MM under the Tolling structure. The sensitivity of the state revenue under the two acceptable commercial structures to LNG price and LNG plant cost is presented in Table 9.
Table 9: Sensitivity of State Revenue to LNG Prices and LNG Plant Cost - with zero Special Market Volume

<table>
<thead>
<tr>
<th>Commercial Structure</th>
<th>Base Price Base Cost</th>
<th>High Price Base Cost</th>
<th>Low Price Base Cost</th>
<th>Base Price High Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR-Tolling-50:50</td>
<td>1184</td>
<td>2215</td>
<td>994</td>
<td>1278</td>
</tr>
<tr>
<td>Tolling</td>
<td>1161</td>
<td>1161</td>
<td>1161</td>
<td>1436</td>
</tr>
</tbody>
</table>

The state revenue shows greater sensitivity to LNG price under the MR-Tolling-50:50 commercial structure and greater sensitivity to LNG plant cost under the Tolling commercial structure.

State Equity and Special Market Volume

Figure 27 presents the state revenues for an 800 MMSCFD plant with zero VAT applied to the plant cost, under the MR-Tolling-50:50 and Tolling commercial structures and with various combinations of state equity in the plant and special market volume. The earlier discussion of the price sensitivity analysis on the impact of special market volumes on operator ENPV indicates that with 40 or 75 MMSCFD special market volume the ENPV is negative under the low LNG price scenario. Because of this operator would see the MR commercial structure as unacceptable for cases which include a special market volume.
Figure 27: State Revenue vs State Equity and Special Market Volume

Each group of bars in Figure 27 represents the following cases, from left to right:

- 10% state equity in the plant and zero special market volume under base price and cost conditions;
- 10% state equity in the plant and 40 MMSCFD special market volume under base price and cost conditions;
- 15% state equity in the plant and 40 MMSCFD special market volume under base price and cost conditions;
- 20% state equity in the plant and 40 MMSCFD special market volume under base price and cost conditions;
- 20% state equity in the plant and 75 MMSCFD special market volume under base price and cost conditions;
• 20% state equity in the plant and 40 MMSCFD special market volume under high price and base cost conditions;
• 20% state equity in the plant and 40 MMSCFD special market volume under low price and base cost conditions;
• 20% state equity in the plant and 40 MMSCFD special market volume under base price and high cost conditions.

The effects on state revenue of varying the level of state equity in the plant and the special market volume can be seen by comparing the values represented by adjacent bars for the first 5 bars in each commercial structure. Under the MR-Tolling-50:50 commercial structure increases in the state equity in the plant increase the state revenue while increases in the special market volume decrease state revenue. For the Tolling commercial structure state revenue increases for increases in state equity but is unaffected by increases in special market volume.

The sensitivity of state revenue to LNG prices and LNG plant costs is illustrated by the last three bars in each group. The sensitivity is done for the case representing 20% state equity and 40 MMSCFD special market volume. This case was selected because it yielded the highest revenue for base price and cost conditions for each commercial structure. The data from the sensitivity analysis is presented in Table 10.
Table 10: Sensitivity of State Revenue to LNG Prices and LNG Plant Cost – with zero VAT on the Plant Cost

<table>
<thead>
<tr>
<th>Commercial Structure</th>
<th>Base Price and Cost</th>
<th>High LNG Price</th>
<th>Low LNG Price</th>
<th>High LNG Plant Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR-Tolling-50:50</td>
<td>877</td>
<td>1919</td>
<td>687</td>
<td>892</td>
</tr>
<tr>
<td>Tolling</td>
<td>776</td>
<td>776</td>
<td>776</td>
<td>959</td>
</tr>
</tbody>
</table>

For the MR-Tolling-50:50 commercial structure state revenue for the high price scenario results is above the revenue for base conditions and for the low price scenario it is below the revenue for base conditions while under the Tolling commercial structure there is no variation in state revenue with changes in LNG price.

Figure 28 is a mean-standard deviation diagram for expected state revenue. This provides a useful means of assessing the balance between risk as shown by the standard deviation and reward in the form of increased expected state revenue in establishing a preference for one commercial structure over another. The square symbols represent the MR-Tolling-50:50 commercial structure and the triangle symbols represent the Tolling commercial structure. The red triangle represents all price conditions under Tolling whereas the green, yellow and red squares represent base, high and low price conditions respectively under the MR-Tolling-50:50 structure. The differences in standard deviation along the x-axis are an order of magnitude smaller than the differences in expected revenue along the y-axis. Therefore the shift from the Tolling structure, the red triangle,
to the MR-Tolling-50:50 structure, the yellow square, yields a $100 MM increase in revenue for a $16 MM increase in standard deviation under base price conditions.

![Figure 28: Mean-Standard Deviation diagram for Expected State Revenue under different Commercial Structures](image)

In the high price scenario, the shift from the red triangle to the green square illustrates that there is a $1140 MM increase in expected revenue with a $35 MM increase in standard deviation in moving from the Tolling to the MR-Tolling-50:50 structure. The large increase in reward is obtained with a small increase in risk. Additionally, only a small decrease in expected revenue occurs with the shift from the Tolling to the MR-Tolling-50:50 structure in the low price environment shown by the shift from the red triangle to the red square.
It is possible to establish a confidence interval around the expected revenue values. A 95.4% confidence interval around each expected value is defined by 2 standard deviations on either side of the mean. The expected revenues for the base price, high price and low price scenarios are $877 MM, $1919 MM and $687 MM for the MR-Tolling-50:50 structure and $776 MM for the Tolling structure. The standard deviations in Figure 28 are $90 MM, $109MM, $82 MM and $74 MM respectively. The confidence intervals are given in Table 11.

**Table 11: Confidence Intervals for Expected State Revenue under Different Commercial Structures**

<table>
<thead>
<tr>
<th>Price Conditions</th>
<th>Confidence Interval - $MM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MR-Tolling-50:50</td>
</tr>
<tr>
<td>Base Prices</td>
<td>697 - 1057</td>
</tr>
<tr>
<td>High Prices</td>
<td>1701 – 2137</td>
</tr>
<tr>
<td>Low Prices</td>
<td>523 – 851</td>
</tr>
</tbody>
</table>

There is a 95.4% chance that the expected values will be within these confidence intervals. This can form the basis by which the state identifies a preferred commercial structure.

**VAT on Plant Cost, State Equity and Special Market Volume**

The combined impact of VAT on the plant cost, state equity and special market volume on state revenue is assessed by examining cases under the Tolling commercial structure because the combination of VAT on the plant cost and special market volume eliminates all cases under the MR and MR-Tolling-50:50 commercial structures from consideration. Figure 29 shows the state revenue for an 800 MMSCFD plant under the Tolling commercial structure.
Figure 29: State Revenue vs the level of State Equity, Special Market Volume and VAT on Plant Costs

Each group of bars represents the following cases:

- 10% state equity, zero special market volume and zero VAT on plant cost;
- 10% state equity, 40 MMSCFD special market volume and 15% VAT on plant costs;
- 15% state equity, 40 MMSCFD special market volume and 15% VAT on plant costs;
- 20% state equity, 40 MMSCFD special market volume and 15% VAT on plant costs;
- 10% state equity, 75 MMSCFD special market volume and 15% VAT on plant costs;
• 15% state equity, 75 MMSCFD special market volume and 15% VAT on plant costs;
• 20% state equity, 75 MMSCFD special market volume and 15% VAT on plant costs.

The difference between adjacent bars is a means of isolating the impacts of VAT on the plant cost, state equity and special market volume on state revenue.

For the group of bars representing ‘base conditions’, the impact on state revenue of increasing state equity is seen by comparing the 2\textsuperscript{nd}, 3\textsuperscript{rd} and 4\textsuperscript{th} bars which represent 10%, 15% and 20% state equity respectively for the same 40 MMSCFD special market volume and 15% VAT on the plant cost. The impact is small; there is about 1% change in state revenue for a 5% change in state equity. The fact that the 2\textsuperscript{nd} (10% state equity, 40 MMSCFD special market volume and 15% VAT on plant cost) and 5\textsuperscript{th} (10% state equity, 75 MMSCFD special market volume and 15% VAT on plant cost) bars have the same value indicates that an increase in special market volume, from 40 to 75 MMSCDF in this case, has no impact on state revenue. This is expected because the processing fee is adjusted to keep the operator whole with respect to any possible loss from the marketing of the special volume of LNG. Finally, the difference between the 1\textsuperscript{st} and 2\textsuperscript{nd} bars indicates the impact on state revenue of increasing the VAT on plant cost by 15% from zero VAT in the base case to 15% VAT in the case represented by the 2\textsuperscript{nd} bar. The 40 MMSCFD increase in special market volume between the cases has no impact on state revenue. The increase in state revenue attributable to the 15% VAT on the plant cost is large; there is a 50% change in state revenue for a 15% change in VAT on the plant cost. The group of bars representing the high cost scenario illustrates the large increase in state revenue from the 15% VAT applied to the higher plant cost.
The impact of the combined elements of VAT on the plant cost, state equity and special market volume on state revenue is defined by the fact that this combination of elements results in the Tolling commercial structure being applied to the plant. Under this structure the state revenue is very dependent on the plant cost and it thus heavily influenced by VAT on the plant cost.

Summary

The LNG price and LNG plant cost sensitivity analysis is effective in reducing the number of acceptable cases from 168 in Table 6 to 132 as detailed in Table 12.

Table 12: Cases Acceptable to the Operator Based on LNG Price and LNG Plant Cost Sensitivity Analysis

<table>
<thead>
<tr>
<th>Commercial Structure</th>
<th>Elements which can be combined to form Cases</th>
<th>State Equity in Plant °</th>
<th>Special Market Volume MMSCFD</th>
<th>VAT on Plant Cost %</th>
<th>Plant Size MMSCFD</th>
<th># of Cases (based on Combining elements)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MR</td>
<td>10, 15, 20</td>
<td>0</td>
<td>0</td>
<td>500, 600 700, 800</td>
<td>1<em>3</em>1<em>1</em>4 = 12</td>
</tr>
<tr>
<td>MR-Tolling</td>
<td>3</td>
<td>10, 15, 20</td>
<td>0</td>
<td>15</td>
<td>500, 600 700, 800</td>
<td>1<em>3</em>1<em>1</em>4 = 12</td>
</tr>
<tr>
<td>2</td>
<td>MR-Tolling Tolling</td>
<td>10, 15, 20</td>
<td>0, 40, 75</td>
<td>0</td>
<td>500, 600 700, 800</td>
<td>2<em>3</em>3<em>1</em>4 = 72</td>
</tr>
<tr>
<td>1</td>
<td>Tolling</td>
<td>10, 15, 20</td>
<td>0, 40, 75</td>
<td>15</td>
<td>500, 600 700, 800</td>
<td>1<em>3</em>3<em>1</em>4 = 36</td>
</tr>
<tr>
<td>Total Cases (based on adding possible combinations)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>132</td>
<td></td>
</tr>
</tbody>
</table>
The sensitivity analysis has reduced the acceptable cases under the MR commercial structure by excluding cases which have special market volumes or VAT on the plant cost because these yield negative ENPVs in the low LNG price scenario. This highlights the point that VAT on the plant cost and special market volume impact state revenue in two ways. There is the direct impact which is seen by the increases and decreases in state revenue which occur with changes in the levels of VAT on the plant cost and special market volumes, and there is the indirect, and potentially larger impact, which results from a change in the commercial structure. Therefore adding special market volume can cause a decrease in state revenue within a given commercial structure and an even greater decrease if the addition of special market volume causes a change in the commercial structure.
Chapter 5: Conclusion

CONCLUSIONS

The LNG business in the Atlantic basin is projected to have a sustained annual growth rate of 7% over the next two decades to meet the global demand for natural gas. The governments of countries with LNG industries and those seeking to start LNG industries will be in search of ways of increasing their revenue from LNG projects and sharing in the value which these projects generate especially in an environment of high LNG prices. Governments can utilize their role in approving projects as a mechanism for attaching policy conditions to their approval of the projects to achieve their ends of increasing state revenue from these projects. Thus, being able to predict the impact which their policies would have on state revenues from the LNG projects is important if the strategy of the countries to increase state revenue from the projects is to be successful.

The Nature of State Revenue

State revenue is made up of three components: corporation tax, Valued Added Tax (VAT) and Customs duty, and equity income. The components have different characteristics and have different levels of importance in the state revenue total.

Corporation tax is the dominant component of state revenue and can account for 67 to 87% of state revenue. It is a tax on annual profit and thus is directly related to the fortunes of the LNG plant. It is therefore a useful mechanism for capturing value which results from high prices. States need to be mindful of this when they seek ways of sharing in the benefits of high prices. Corporation tax can also suffer the effects of low prices, though it can never become negative. It constitutes a major part of state revenue and transmits to state revenue variations tied to the fortunes of the plant.
VAT income and Customs duty are much smaller components of state revenue than corporation tax and can comprise 7 to 30% of the state revenue from an LNG plant. Unlike corporation tax they are associated with the existence and operation of the plant not with its profitability. The VAT income and Customs duty which are associated with the operation of the plant can constitute 7% of state revenue and provide a fairly constant and predictable payment to the state. The VAT income from the plant cost can constitute 23% of state revenue and it provides the state with significant revenue at the start of the LNG project. However, VAT on the plant cost has the effect of increasing the cost of the LNG plant and therefore it can impact the viability of the project. This is an important consideration because a project can be in competition with projects in other countries to capture markets, and government policies while being important in capturing value for the state can also be a source of competitive advantage (Shepherd and Ball, 2004) for a project.

Equity income is typically a small part of state revenue comprising 3 to 6%. It is the state’s share of the net cash flow generated by the LNG plant based on the state’s investment in the plant. Unlike the other components of state revenue it comes at a cost to the state but provides the state with the opportunity to earn a decent return on its investment. Equity income is intimately tied to the fortunes of the LNG plant but unlike corporation tax it can be negative.

The Needs of the State

The state can have various needs which it wants to meet when it establishes a policy for the LNG plant and its final decision should be based on selecting the policy which delivers results that best fits its needs. The state’s needs with respect to state revenue can be described by one or a combination of the following:
• Steady Income – In this situation the state revenue is required to be of a predetermined level and has to be earned with the regularity of a bond payment.

• Minimum Income – In this situation the state revenue can fluctuate but it must never fall below an established minimum or ‘floor’ amount

• Investment Income – In this situation the state revenue is expected to meet return targets as part of a diversified investment portfolio.

In addition to its revenue needs the state could have a need to access LNG at preferential prices.

**Commercial Structures**

The three commercial structures provide different risk / reward profiles in terms of state revenue. This is best illustrated by the mean – standard deviation diagram for the base case (800 MMSCFD; 10% state equity; 0 special market volume; 0 VAT on plant cost) in Figure 30.
Figure 30: Mean - Standard Deviation Diagram Expected State Revenue

Figure 30 shows the expected value and standard deviation of state revenue for base, high and low prices for the three commercial structures. The MR commercial structure, diamond symbol, offers the largest rewards in terms of the highest expected state revenues but also the highest risk as shown by the largest standard deviation. The MR-Tolling-50:50 commercial structure, square symbol, offers intermediate rewards and risks and the Tolling commercial structure, circle symbol, offers the lowest risk and in many cases the lowest reward. The commercial structures can be viewed as a risk/reward continuum with the MR and Tolling commercial structures occupying the end points.

The commercial structures are also differentiated in terms of the ROI which they deliver. Everything else being equal the MR structure delivers the highest ROI and the Tolling structure the lowest. For this reason the choice of commercial structure can have
greater impact on state revenue than an individual policy element. Table 13 compares the effects on state revenue of changing both the commercial structure and the level of VAT on the plant cost.

**Table 13: Comparing the Impacts on State Revenue of Switching a Commercial Structure and a Policy Element**

<table>
<thead>
<tr>
<th>Commercial Structure</th>
<th>VAT on Plant Cost</th>
<th>Base Price &amp; Cost</th>
<th>High Price Base Cost</th>
<th>Low Price Base Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tolling</td>
<td>Zero</td>
<td>756</td>
<td>756</td>
<td>756</td>
</tr>
<tr>
<td>Tolling</td>
<td>15%</td>
<td>1140</td>
<td>1140</td>
<td>1140</td>
</tr>
<tr>
<td>MR-Tolling-50:50</td>
<td>Zero</td>
<td>865</td>
<td>1803</td>
<td>694</td>
</tr>
<tr>
<td>MR</td>
<td>Zero</td>
<td>957</td>
<td>2834</td>
<td>615</td>
</tr>
</tbody>
</table>

The first row of Table 13 shows the state revenue from an 800 MMSCFD plant using a tolling commercial structure with 10% state equity in the plant, zero VAT on the plant cost and zero special market volume. The second row of the table shows the impact on state revenue shown in the first row if ‘VAT on the plant cost’ is changed from zero to 15% and everything else remained fixed. The third and fourth rows of the table show the impact of changing the commercial structure only of the case in row 1. The change in VAT on the plant cost results in higher state revenue under base conditions with no fluctuations due to price changes while the change to the commercial structure results in state revenues which are lower under base conditions but which are dramatically higher when LNG prices are high and somewhat lower under low prices.
The Operator’s Choices

In response to a policy requirement for approval of the LNG expansion project established by the state the operator selects a plant size and commercial structure which will create an economically viable project. Plant size and commercial structure define the main variables at the operator’s disposal in defining the project. It is important to the operator to maximize ENPV in making his selection but he may also take risk into account and test the sensitivity of ENPV to price and cost variations. Because the operator’s criteria for determining project viability are known, at least in general terms, by the state, these can be used in the state’s evaluation of policy proposals in advance of their issuance because it is the operator’s choices which will ultimately determine state revenue.

The State’s Policy Options

The 132 acceptable cases remaining after the LNG price and LNG plant cost sensitivity analyses create an operating space within which the state can target its policy requirements to achieve its outcomes. Because there will be trade-offs made, the state will need to be clear on the relative importance of its desired outcomes. The more critical of these are:

Capture of Value from High LNG Prices

The largest impact on state revenue from high LNG prices occurs under the MR commercial structure. However to achieve an MR commercial structure in the plant there would have to be zero VAT on the plant cost and zero special market volume.
Access to LNG at preferential Prices

The special market volume provides the state with access to LNG at preferential prices but this is only possible under the MR-Tolling-50:50 or Tolling commercial structures and the special market volume decreases state revenue.

Higher Revenue with Low Risk

Applying VAT to the plant cost creates higher state revenue in a low risk environment but this is only possible under the MR-Tolling-50:50 or Tolling commercial environments and is effectively an increase in the cost of the plant. Though this option may work, by changing the plant cost it can affect the investment decision because it requires the shareholders to raise additional capital.

Steady State Revenue

The state may require the revenue from the LNG plant to be steady with no chance of decreasing. In this case a Tolling commercial structure would be preferred and the state could make it a requirement.

Level of State Equity

The higher the level of state equity the higher the state revenue and this has greatest impact under the MR commercial structure but with this comes the possibility of loss. The state must be clear on its risk tolerance and the risk profile of the commercial structure of the plant when deciding on a level of participation.

Plant Capacity

The larger the plant, the larger the state revenue, so the state needs to be aware of infrastructure constraints which may limit the size of the plant.
RECOMMENDATIONS

The MR-Tolling-50:50 commercial structure reflects a mixture of the risk / reward profiles of the MR and Tolling commercial structures. The blending of the commercial structures is a mechanism which might be worth pursuing to arrive at a commercial structure whose profile matches the risk tolerance of the state.

SUGGESTIONS FOR FURTHER WORK

The evaluation of the cases depends heavily on the ENPV with some consideration of risk using the variance of the ENPV. The use of additional risk measures of semi variance, expected loss and numbers of scenarios with negative NPV (Lasdon, Faya, Lake, Dyer and Chen, 2007) should be considered because these will provide additional dimensions for viewing the operator’s choices and provide a means of better addressing the state’s concerns for not losing money in its investments.

Feedback from private companies and state entities involved in the LNG trade will provide opportunities to refine the methodology and identify areas for further study.
Appendix – GAMS Code

The GAMS code for the model is presented below.

*Title A Model For Analysing the State's Returns from an LNG Plant*
$onmessage onmessageref onelinkref onelinkref onelinkref
$ONTEXT

This model investigates the options for expanding the Trinidad & Tobago
LNG Plant. It considers the effect which various requirements, which the
government might impose as conditions for approving the expansion of the plant,
can have on the passive and active returns to the state.

The model assumes that the plant is operated by a firm which seeks to maximise
its returns by maximising its Net Cash Flow. The returns to the state are
determined under these conditions.

Developed by
Neal Alleyne

This model was prepared as part of an M.S.E thesis

$OFFTEXT

SETS
  F "Commercial Structures for the LNG plant"
  /MR, TOLL, HGSG-50/
  FC "The name plate LNG Plant capacity"
  /Vlarge, Large, Med, Low/
  YR "Years for which the plant operates"
  /Year1*Year20/
  SUBYR(YR) "Years over which costs are depreciated"
  /Year1*Year15/
  REAL2 "The iterations of the model which will yield an expected NCP"
  /real1*real1000/;
SCALARS

ttequity "the level of state equity in the LNG Plant" /0.10/
speckt "the quantity of LNG in MMBMF sent to special markets" /75/
vatecp "the rate of VAT on the LNG plant investment cost" /.15/;

PARAMETERS

Plantcap {PC} "Name plate capacity of LNG Plant in MMCFU"
/Large 800
/Large 700
/Mod 600
/Low 500/;

x "terminal discount rate" /0.10/
budgetcap "State Investment Budget, $MM" /400/
tax "corporate tax rate" /0.35/
vet "General VAT rate" /0.15/
cduty "the rate for customs duty" /0.20/
cme "operation and maintenance cost, $/MCF" /0.375/
gge "general and administrative cost, $/MCF" /0.0425/
cmevat "VATable portion of "cme"" /0.32/
cmeeduty "portion of "cme" attracting Custom duty" /0.48/
infl "annual inflation rate" /0.025/
netz "net back factor" /0.48/
plkt "Pipeline tariff, $/MMBTU" /0.10/
shrink "Shrinkage factor for gas across LNG Plant" /0.95/

smea "Plant availability, percent" /95/
least "Heating value of gas, BTU/MMBTU" /1085/
locatc "Local Content of LNG Plant Cost" /0.10/
reg "Regasification fee, $/MMBTU" /0.45/
chp "Shipping cost, $/MMBTU" /0.50/
mktdisc "LNG Price discount to special mkt" /0.15/
mkt "LNG marketing margin, $/MMBTU" /0.05/
lcp "Lowest gas price, $/MMBTU" /5.98/
lprice "most likely price, $/MMBTU" /9.48/
hhighp "high price, $/MMBTU" /9.91/

transfpc "This helps in sampling the price distribution"
lcfrac "lowest lng plant cost, $/TPA" /280/
lclcost "most likely lng plant cost, $/TPA" /400/
hhighc "high lng plant cost, $/TPA" /500/
transfrc "This helps in sampling the cost distribution"

transfpc = (mlprice-lcfrac)/(highc-lcfrac);
transfrc = (mlcost-lcfrac)/(highc-lcfrac);
Gas price data is from the EIA database. The most likely price is the average price in the US for Trinidad LNG for Jan 2005 – Sept 2007. The loop is 50% of the mlprice. The high price represents a 33.3% premium above the average price and represents a premium price in Europe or Asia.

MODEL SOURCES FOR PARAMETERS AND SCALARS

The data on OPE, gas and plt were obtained from the MGC.

The plant construction last for 3 years hence the shift in the discount and inflation factors. Plant operation commences 3 years after plant construction begins.

PARAMETER

DISCFACTOR(YR) "Annual discount factor"
INFLFACTOR(YR) "Annual inflation factor"

DISCFACTOR(YR) = 1/(1+r)^{ord(YR)+2}:
INFLFACTOR(YR) = (1+r)^{ord(YR)+2}:

The items 'Opex', 'Capex', 'transport' and 'Deprec' are functions of the plant capacity.
As such they can be modeled as parameters if plant capacities are determined exogenously or as variables when plant capacities are determined endogenously. They are modeled here as parameters.
The plant cost is a parameter obtained from sampling a triangular distribution of LNG plant costs. The price data reflect 2003 estimates for expanding a plant in the Atlantic basin.
A Capex for the LNG Plant is assigned for each realization.
The loop that follows generates a vector of plant costs.
These costs are used for computing all the scenarios in the model.
The plant cost is computed from the throughput and the cost per metric Tons of LNG per year. A factor of 0.0069 converts the daily throughput to the plant in MMSCF to Millions of Tons per year of LNG. This is a convenient factor for determining plant cost in $MM.

PARAMETER

CAPEX(PC,REAL2) "Capital Expenditure on the LNG Plant in $MM"

cost(PC,REAL1) "A number for sampling the cost distribution"

loop((PC,REAL2),
cost(PC,REAL1) = uniform(0,1);
if (cost(PC,REAL1)<transc,

capex(PC,REAL2)=(high + sqrt(cost(PC,REAL1)*(high - low)*(mcoast - low)))*plantcap[pc]*0.0069*(1+vatcap);
else
capex(PC,REAL2) = (high-low*(1-cost(PC,REAL1)))*(high - low)*(mcoast - low)*plantcap[pc]*0.0069*(1+vatcap);
);

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The natural gas price is determined by sampling from a triangular distribution defined by lowp, mup and highp. A price is determined for each year of operation for each realization.

The loop statement which follows reveals the matrix of LNG Prices, these are used in the computation of all the realizations.

```
PARAMETER
 LNGP(REALZ, YR) "LNG Selling price in $/MMBTU"
   pnumber(REALZ, YR) a number for sampling the price distribution:

   loop((REALZ, YR),
       pnumber(REALZ, YR) = uniform(0,1);
   if(pnumber(REALZ, YR) <= tran2p,
      LNGP(REALZ, YR) = loop + sqrt(pnumber(REALZ, YR) *(highp - lowp) *(miprice - lowp));
   else
      LNGP(REALZ, YR) = highp + sqrt((1-pnumber(REALZ, YR) |
        * (highp-lowp) *(highp - miprice));
   );

Annual depreciation is a function of the plant cost. It is assumed that the cost for the plant is expensed over a 3 year period 20%, 40%, 40% and that the plant cost is depreciated over the first 15 years of plant operation. Plant cost is determined by sampling from a triangular distribution for plant cost. Annual Depreciation is a parameter in the model.

PARAMETERS
 DEPCO(PC, REALZ, YR) "Annual Depreciation expense in $MM";
 DEPCO(PC, REALZ, subyr) = cpeop(PC, REALZ) * 0.067;
 PARAMETERS
 FOSP(PC, REALZ, YR) "FCB price for LNG in $/MMBTU";
 FOSP(PC, REALZ, YR) = lngp(REALZ, yr) - rge - csp - wtt;
```

The annual Operating expense for the plant is a function of the plant capacity. The operating and maintenance portion of the Opex reflects the availability of the plant.

```
PARAMETERS
 OPEX(PC, YR) "Annual Operating expense in $MM";
 OPEX(PC, YR) = | ( (cme*ease1/100) + gme) * plantcap(PC) * 1000 * cme |
  * ((Vwall/100) * plantcap(PC) * 1000) * cmevat * vat |
  + cmeduty * duty | * infifactor(YR) * 365 * 0.000001;
```

It is possible to determine the annual transportation cost for each plant throughput. This remains fixed for each plant throughput since plant uptime is assumed fixed. The cost of transporting gas to the LNG plant is a cost to the plant whenever the LNG plant shares in the market risk and buys gas for the plant. The cost is inflated by the inflation factor each year and reflects the availability of the plant. The cost is a straight pass through cost under the Tolling commercial structure.

```
PARAMETERS
 TRANSPORT(PC, YR) "Annual Cost to pipe gas from well to plant in $MM";
 TRANSPORT(PC, YR) = (plantcap(PC) * heatplt*ease1/100) * infifactor(YR) * 365 * 0.000001;
```
Establishing a parameter to capture the unrealized losses for the proper computation of Corporation Tax. This allows losses to be carried forward to be offset against income from subsequent years.

**PARAMETER**

<table>
<thead>
<tr>
<th>PARAMETER</th>
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<tbody>
<tr>
<td>UNRLHPCREALZYR</td>
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**VARIABLES**

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**EQUATIONS**

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**POSITIVE VARIABLES**

<table>
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<th>POSITIVE VARIABLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORPTAX</td>
</tr>
</tbody>
</table>
EQUATIONS

OBJ

"Objective function"

Establishing the budget constraint on the Government's equity in the Plant

\[\text{GOINV.1|PC,REALZ}^{\text{capex}(PC,REALZ) \times \text{ttEquity} = \text{budgetcap}} = \]
\[\text{CAPEX}(PC,REALZ) \times \text{ttEquity} = \text{budgetcap}} = \]

These cases reflect a commercial structure in which the LNG Plant
accepts market risk by purchasing natural gas at the well head
and marketing LNG

\[\text{REVENUE.1|PC,REALZ,YP} = \{(\text{plantcap} |\text{pc} \times \text{specmkt} \times \text{shrink} \times \text{heat} \times \text{fcbp} | \text{REALZ, yr})
\times \text{specmkt} \times \text{shrink} \times \text{heat} \times \text{fcbp} \times (\text{REALZ, yr}) \times (1 \times \text{metdic})\}
\times \{\text{plantcap} |\text{pc} \times \text{heat} \times \text{inp} | \text{REALZ, yr} \times \text{nhbf})\}
\times \text{infactor} |\text{yr} \times 355/1000000 \times \text{avail}/100;\]

\[\text{EXPENSES.1|PC,REALZ,YP} = \text{opex} |\text{pc, yr} + \text{deprec} |\text{PC,REALZ, yr} + \text{transport} |\text{pc, yr};\]

This section of the code accounts for the unrealized losses
used in computing Corporation Tax

\[\text{Unreal(\text{PC,REALZ,YP}) |\text{ord} |\text{yr} (=\{\text{revenue.1|PC,REALZ, yr} < \text{expenses.1|PC,REALZ, YP}\})
= \text{Expense.1|PC,REALZ, YP} - \text{income.1|PC,REALZ, TR};\]
\[\text{Unreal(\text{PC,REALZ,YP}) |\text{ord} |\text{yr} (=\{\text{revenue.1|PC,REALZ, yr} < \text{expenses.1|PC,REALZ, YP}\)
+ \text{Unreal(\text{PC,REALZ, 'Year1'})})
= \text{expenses.1|PC,REALZ, YP} - \text{Unreal(\text{PC,REALZ, 'Year1'})} - \text{revenue.1|PC,REALZ, TR};\]
\[\text{Unreal(\text{PC,REALZ,YP}) |\text{ord} |\text{yr} (=\{\text{revenue.1|PC,REALZ, yr} < \text{expenses.1|PC,REALZ, YP}\)
+ \text{Unreal(\text{PC,REALZ, 'Year2'})})
= \text{expenses.1|PC,REALZ, YP} - \text{Unreal(\text{PC,REALZ, 'Year2'})} - \text{revenue.1|PC,REALZ, TR};\]
Uncal(PC, Realz, TR) | ord | yr |= 4 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year3'))]

Uncal(PC, Realz, TR) | ord | yr |= 5 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year4'))]

Uncal(PC, Realz, TR) | ord | yr |= 6 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year5'))]

Uncal(PC, Realz, TR) | ord | yr |= 7 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year6'))]

Uncal(PC, Realz, TR) | ord | yr |= 8 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year7'))]

Uncal(PC, Realz, TR) | ord | yr |= 9 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year8'))]

Uncal(PC, Realz, TR) | ord | yr |= 10 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year9'))]

Uncal(PC, Realz, TR) | ord | yr |= 11 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year10'))]

Uncal(PC, Realz, TR) | ord | yr |= 12 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year11'))]

Uncal(PC, Realz, TR) | ord | yr |= 13 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year12'))]

Uncal(PC, Realz, TR) | ord | yr |= 14 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year13'))]

Uncal(PC, Realz, TR) | ord | yr |= 15 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year14'))]

Uncal(PC, Realz, TR) | ord | yr |= 16 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year15'))]

Uncal(PC, Realz, TR) | ord | yr |= 17 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year16'))]

Uncal(PC, Realz, TR) | ord | yr |= 18 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year17'))]

Uncal(PC, Realz, TR) | ord | yr |= 19 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year18'))]

Uncal(PC, Realz, TR) | ord | yr |= 20 $ [revenue.1(pc, realz, yr) < (expenses.1(PC, REALZ, TR) + Uncal(PC, Realz, 'Year19'))]
Computing Cash Flow

CASHFLOw.1(PC, REALZ, YR) = REVENUE.1(PC, REALZ, YR) - OPEX(PC, YR) - TRANSPORT(PC, YR) - CORPAX.1(PC, REALZ, YR);
GOVSHARE.1(PC, REALZ, YR) = CASHFLOW.L(PC, REALZ, YR) * GOINV.1(PC, REALZ) / CAPEX(PC, REALZ);
OPSHARE.1(PC, REALZ, YR) = CASHFLOW.L(PC, REALZ, YR) * (1 - GOINV.1(PC, REALZ) / CAPEX(PC, REALZ) + DISCFACOR(YR));
OPNCF.1(PC, REALZ) = SUM(YR, OPMF.1(PC, REALZ, YR) - CAPEX(PC, REALZ) * (0.2 + 0.4/1.1 + 0.4/1.1 ** 2)) + DISCFACOR(YR);
DCP.1(PC, REALZ, YR) = CASHFLOW.L(PC, REALZ, YR) * DISCFACOR(YR);
NCF.1(PC, REALZ) = SUM(YR, DCF.1(PC, REALZ, YR) - CAPEX(PC, REALZ) * (0.2 + 0.4/1.1 + 0.4/1.1 ** 2));
VATINCOME.1(PC, REALZ, YR) = (snpolntc(order) * 1000 * cmevist * vatinfactor(YR) * 165/1000000);
VATCAP.1(PC, REALZ) = CAPEX(PC, REALZ) * VATCAP;
CUSTOMDUTY.1(PC, REALZ, YR) = snpolntc(order) * 1000 * customduty *lduty * vatinfactor(YR) * 165/1000000;

The code below computes results at the level of the plant.

It averages the results for the realizations.

PROFIT.1(PC) = SUM(REALZ, ncf.1(PC, REALZ)) / (CARD(REALZ));
OPROFIT.1(PC) = SUM(REALZ, OPMCF.L(PC, REALZ)) / (CARD(REALZ));
VOPROFIT.1(PC) = SUM(REALZ, (cbes(profit.1(PC) - ncf.1(PC, REALZ)) ** 2)) / (CARD(REALZ));
PLANTCOST.1(PC) = SUM(REALZ, cmevist(order) / CARD(REALZ));
OPFINV.1(PC) = SUM(REALZ, (cmevist(order) - GOINV.1(PC, REALZ)) / CARD(REALZ));
ROI.1(PC) = PROFIT.1(PC) / PLANTCOST.1(PC) * 100;
OPROI.1(PC) = OPROFIT.1(PC) / OPFINV.1(PC) * 100;
The code below computes results for State Revenue

\[
\text{GOVREV.1(PC, REALZ, YR) if } \{ \text{card(YR)}=1 \} = \text{CORPTAX.1(PC, REALZ, YR)} + \text{VATINCOME.1(PC, REALZ, YR)} + \text{CUSTOMDUTY.1(PC, REALZ, YR)} + \text{VATCAPS.L(PC, REALZ)}; \\
\text{GOVREV.1(PC, REALZ, YR) if } \{ \text{card(YR)}>1 \} = \text{CORPTAX.1(PC, REALZ, YR)} + \text{VATINCOME.1(PC, REALZ, YR)} + \text{CUSTOMDUTY.1(PC, REALZ, YR)}; \\
\text{GOVTAXREV.1(PC, REALZ, YR)} = \text{GOVREV.1(PC, REALZ, YR) + GOVTSHARE.1(PC, REALZ, YR)}; \\
\text{DISCPTREV.1(PC, REALZ, YR)} = \text{GOVREV.1(PC, REALZ, YR) * DISCPTFACTOR(YR)}; \\
\text{DISCTAX.1(PC, REALZ, YR)} = \text{CORPTAX.1(PC, REALZ, YR) * DISCPTFACTOR(YR)}; \\
\text{DCPGOV.1(PC, REALZ, YR)} = \text{GOVTAXREV.1(PC, REALZ, YR) * DISCPTFACTOR(YR)}; \\
\text{NCPREV.1(PC, REALZ)} = \text{sum(yc, discprev.1(pc, realz, yr))}; \\
\text{NCPTAX.1(PC, REALZ)} = \text{sum(yc, discptax.1(pc, realz, yr))}; \\
\text{NCPTAX1.1(PC, REALZ)} = \text{sum(yc, discptax.1(pc, realz, yr))}; \\
\text{NCPTAX1.1(PC, REALZ)} = \text{sum(yc, discptax.1(pc, realz, yr))}; \\
\text{GOVTAXLE.1(PC)} = \text{sum(realz, ncprev.1(pc, realz)) / \{ \text{card(realz)} \}}; \\
\text{TOTALTAXLE.1(PC)} = \text{sum(realz, NCPTAX1.1(pc, realz)) / \{ \text{card(realz)} \}}; \\
\text{GOVTAXLE.1(PC)} = \text{sum(realz, ncpgovt.1(pc, realz)) / \{ \text{card(realz)} \}}; \\
\text{VARGOVTAKE.1(PC)} = \text{sum(realz, abs(govttake.1(PC) - ncpgovt.1(PC, REALZ)) * 2)} / \{ \text{card(realz)} \}; \\
\]

*display plantcost.1, profit.1, varprofit.1, rol.1, opcprofit.1, 
   opcrol.1, govttake.1, vargovt.1, govttake.1, totaltax.1;

*OBJECTIVE FUNCTION

OBJ.. TARGET =E= profit.1('vlarge');

MODEL LGPLANT SELECTING THE BEST CASE / ALL /;
SOLVE LGPLANT USING NLP MAXIMIZING TARGET;

***** END OF PROGRAM *****


8. “‘Train X’ still under study” in World Gas Intelligence, May 7, 2008 v19 i19 p5(1).


