EVALUATION OF ALTERNATIVES FOR PETROLEUM PRODUCTION CONCESSION EXTENSION IN THAILAND

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การประเมินทางเลือกของการต่อสัญญาสัมปทานการผลิตปิโตรเลียมในประเทศไทย

นายเอกสิทธิ์ ตั้งกาญจนานนท์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
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คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
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เอกสิทธิ์ ตั้งกาญจนานนท์ : การประเมินทางเลือกของการต่อสัญญาสัมปทานการผลิตปิโตรเลียมในประเทศไทย . (EVALUATION OF ALTERNATIVES FOR PETROLEUM PRODUCTION CONCESSION EXTENSION IN THAILAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: อ.ดร. ฐิติศักดิ์ บุญปราโมทย์, 69 หน้า.

ในการประเมินทางเลือกของการต่อสัญญาสัมปทานการผลิตปิโตรเลียมในประเทศไทย ผลตอบแทนระหว่างรัฐบาลและผู้ประกอบการเป็นตัวแปรสำคัญในการตัดสินใจต่อสัญญาการผลิตปิโตรเลียม ปัจจัยที่ใช้ในการประเมินทางเลือกของการต่อสัญญาสัมปทาน การผลิตปิโตรเลียมคือช่วงเวลาในการตัดสินใจในการต่อสัญญาสัมปทานปิโตรเลียม และความผันผวนของราคาก๊าซ การประเมินทางเลือกของการต่อสัญญาสัมปทานโดยไม่คำนึงถึงปัจจัยเหล่านี้ทำให้การตัดสินใจในการต่อสัญญาสัมปทานไม่อยู่ในทางเลือกที่ดีที่สุด จุดประสงค์ของวิทยานิพนธ์นี้คือการศึกษาผลกระทบจากปัจจัยทั้ง 2 ต่อการประเมินทางเลือกในการต่อสัญญาสัมปทานการผลิตปิโตรเลียม โดยวิธีการ Real Options ภายใต้แนวทางการจัดเก็บผลประโยชน์ของรัฐหรือระบบภาษีปิโตรเลียม 2 ระบบที่ใช้ในประเทศไทยที่เรียกว่า Thai I และ Thai III

การศึกษาแบ่งออกเป็น 3 ส่วน ได้แก่ (1) การประเมินทางเลือกของการต่อสัญญาสัมปทานปิโตรเลียมภายใต้แนวทางการจัดเก็บผลประโยชน์ของรัฐระบบ Thai I และ Thai III (2) การประเมินทางเลือกของการเลื่อนการตัดสินใจในต่อสัญญาสัมปทานปิโตรเลียมด้วยวิธีการ Real Options ภายใต้แนวทางการจัดเก็บผลประโยชน์ของรัฐระบบ Thai I และ Thai III (3) การประเมินทางเลือกของการต่อสัญญาสัมปทานปิโตรเลียมโดยคำนึงถึงผลกระทบของความผันผวนของราคาก๊าซ

การศึกษาส่วนแรกพบว่า การประเมินการตัดสินใจในการต่อสัญญาสัมปทานภายใต้ระบบภาษีปิโตรเลียมแบบแรกหรือ Thai I ผู้ประกอบการและรัฐได้รับผลตอบแทนที่คุ้มค่าในการลงทุนเช่นเดียวกับระบบภาษีปิโตรเลียมแบบที่สอง หรือ Thai III ในส่วนที่ 2 การเลื่อนการตัดสินใจในการต่อสัญญาสัมปทานปิโตรเลียมภายใต้แนวทางการจัดเก็บผลประโยชน์ของรัฐ Thai I และ Thai III ทำให้ผู้ประกอบการและรัฐบาลได้รับผลตอบแทนที่คุ้มค่าน้อยลง ในส่วนสุดท้าย การต่อสัญญาสัมปทานโดยคำนึงถึงความผันผวนของราคาก๊าซ ผลตอบแทนภายใต้ระบบภาษีปิโตรเลียม Thai III มีความผันผวนน้อยกว่าผลตอบแทนระบบภาษีปิโตรเลียม Thai I

ภาควิชา วิศวกรรมเหมืองแร่และปิโตรเลียม ลายมือชื่อนิสิต..

สาขาวิชา วิศวกรรมปิโตรเลียม ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก......................

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EKASIT TANGKANJANANON. EVALUATION OF ALTERNATIVES FOR PETROLEUM PRODUCTION CONCESSION EXTENSION IN THAILAND. ADVISOR: THITISAK BOONPRAMOTE, Ph.D., 69 pp.

In assessing of alternatives for petroleum production concession extension in Thailand; the most important key factors in decision on petroleum production concession extension is the benefit-sharing between concessionaire and the government. The main factors used in evaluation of alternatives for petroleum production concession extension are the timing of extension of concession, and the volatility of petroleum prices. Evaluation of alternatives for concession extension, regardless of these factors, cannot bring about the best alternative results. The objective of this thesis is to study the effects of the timing of extension of concession, and the fluctuation of petroleum prices, in evaluation of alternatives for petroleum production concession extension under fiscal regime Thai I and Thai III.

The study is divided into three parts: (1) to evaluate the alternatives for petroleum production concession under fiscal regime Thai I and Thai III, (2) to evaluate the alternatives for petroleum production concession by deferring the decision of concession extension using Real Options Valuation under the two fiscal regimes, and (3) evaluation of alternatives for petroleum production concession with regard to the impact of the volatility of petroleum prices.

In the first study, it was found that in the decision of concession extension under fiscal regime Thai I, both concessionaire and the government's returns were feasible similar to the decision of concession extension under fiscal regime Thai III. In the second part of the study, deferring the decision of concession extension under fiscal regime Thai I and Thai III resulted in lower returns for both the oil companies and the government. And, finally, in the last section, the gas price fluctuations enhance the volatility of profits. The volatility of profits under fiscal regime Thai III are less than the volatility of profits under fiscal regime Thai I for both the government and the concessionaire.

Department: Mining and Petroleum Engineering Student's Signature:……........…..........
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List of Abbreviations

DCF	Discount Cash Flow Analysis
EMV	Expected Monetary Value
MMCF	Million Cubic Foot
MMBTU	Million British thermal unit
NPV	Net Present Value
ROA	Real Option Approach

Nomenclature

C	cash flow at that point in time
$E\{X\}$	expectation operator
$E(x)$	mean value of variable x
i	discounted rate
K	strike price
N	total time of the project
$N(d)$	cumulative distribution function of the standard normal distribution
$P(x_i)$	the unconditional probability associated with variable x
r	risk free rate
S	spot price of the underlying asset
S_v	volatility of returns of the underlying asset
$S(x^2)$	summation of squared deviations of x from its mean.
t	time to maturity

GREEK LETTER

σ	standard deviation

SUBSCRIPTS

1, 2, 3	component number

CHAPTER I

INTRODUCTION

In 1967, the government introduced a concession system, entitled as the Consideration Bases in Applying for Petroleum Exploration and/or Production. In 1971, Thailand promulgated the Petroleum Act[1](PA) and the Petroleum Income Tax act[2](PITA). Many concessions in Gulf of Thailand produced petroleum for more than 20 years and were going to expire under Petroleum Act B.E. 2514, of section 26[3]. The concessionaire proposed to extend the concession in advance in order to prepare for development plan and increase the production rate under agreement with their customers. As the Petroleum concessions were going to expire, this is what made concessionaire and government to come to the table and try to reach a negotiation in order to decide to grant the concession extension.

As the concession, in this study, would get terminated in year X, the assumption was to evaluate these concessions in year X-6, which was to analyze, by research the concessions (these concessions are for the Gulf of Thailand), named here in as filed Y, composing of block A, B, D, and E respectively. The concessionaire wanted to get the concessions extended in advance in order to prepare for the development plan in accordance with the increment production rate agreement with their customer in the year X. In this agreement, the concessionaire was to increase production rate per day (DCQ[4]) from 910 MMCF to 1,240 MMCF in X. The concessionaire provided the complete development plan under fiscal regime Thai I to

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[1]The PA established a concession system based on the Consideration Bases issue in 1971, and nine Ministerial Regulations were dealing with major subjects under that act.

[2]The PITA established an income tax system applicable only to concessionaires, tax rate of 50% was prescribed by Royal Decree.

[3]The petroleum production period under any concession shall not exceed thirty years from the day following the date of termination of the petroleum exploration period, notwithstanding any petroleum production undertaken during the petroleum exploration period. If the concessionaire has been complying with all provisions of his concession and submitted an application for a renewal of his petroleum production period not less than six months prior to the termination of the petroleum production period, he shall be entitled to one renewal of his petroleum production period of not exceeding ten years on terms, obligations and conditions generally prevalent at that time**[1]**.

[4]DCQ stands for Daily Contract Quantity.

the government for decision to grant the extension of concessions in year X-5. Figure 1.1 provides the time line and production profile.

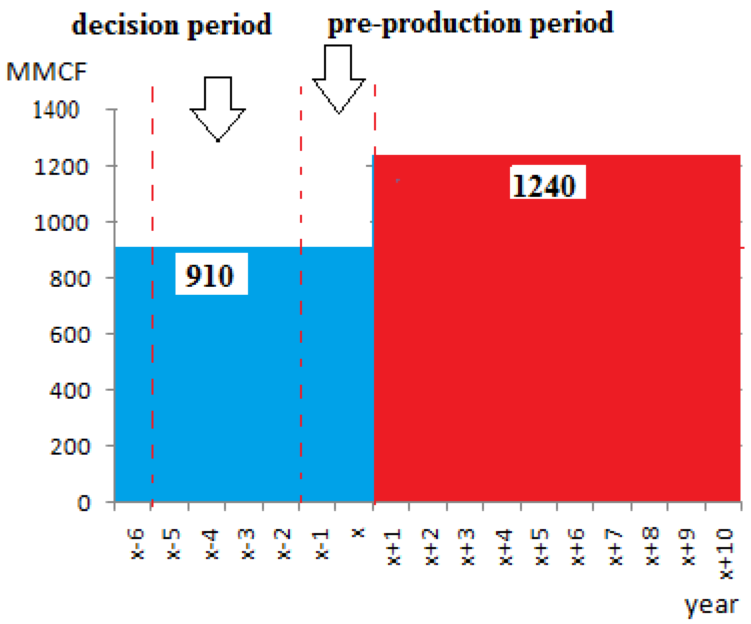

Figure 1.1 Time line and production profile

According to Figure 1.1, the government had to decide to grant the concession extension before year X-1 because the concessionaire needed minimum 2 years as pre-production period. It meant that the government could decide to grant the concession extension in year X-5 (first year), X-4, X-3 and X-2 respectively.

There were many challenges such as, fluctuating petroleum prices, unforeseeable market forces, abandonment in case of changing of the operational concessionaire, flexible approach in which minimum-risk and maximum returns could not be achievable. In the case of decision to grant the concession extension, the government could defer the decision under fiscal regime Thai I, and compare it with that of Thai III along with the effect of fluctuating petroleum price.

1.1 Research Questions

This study attempts to evaluate the petroleum 'concession extension' on several research queries:

1. Should the government extend the concessions under fiscal regime Thai I or Thai III?
2. When should the government extend these concessions?
3. Does volatility of petroleum prices affect the extension of concessions or not?

1.2 Purpose, Scope and Methodology of Thesis

The focus of this thesis is on the petroleum concessions which would expire in course of 6 years' time. The concessionaire and the government could not reach any negotiation, regarding the new concessions in detail, for which the concessionaire had provided the government with all the required background information (as provided in Appendix A-1) under fiscal regime Thai I, so that the government could decide to grant the concession extension in the year X-5, as the first year, and X-4, X-3 and X-2 as the last year.

Thus the primary objectives in this case study is to apply the Real Options Valuation[5] to the evaluation of extension concession which is identified as above, and to be explained in more detail in the following Chapter 3. The conventional Discount Cash Flow model[6] (DCF), which is the traditional evaluation; cannot capture the value of management flexibility on petroleum price movement, and rejects all good decision. When applied to analyze the decision to grant extension of concession, the DCF assumes that no volatility and flexibility are concerned, and thus the decision to grant the concession extension is now or never.

Whereas the real options valuation is a flexible technique for valuing decision and making strategic decisions. The real option valuation provides an alternative for

[5]Real Options Approach is discussed in detail in Chapter 3.
[6]Discount Cash Flow model concept is presented in detail in Chapter 3.

Optimal Timing Decision Analysis, as a deferral option[7], and combines ten thousand times more iteration than that of the Monte Carlo simulation.

The specific methodology used in this thesis is as following:

1. Deterministic model by applying the DCF to evaluate the decision, to grant petroleum concession extension, using gas price from background information with no volatility. To determine Net Present Value (NPV) for concessionaire and government.
2. Stochastic model using the estimation of volatility and escalation of the petroleum price which are taken from historical fuel oil price[8]. Determine Expected Monetary Value (EMV) for both concessionaire and government by using Monte Carlo Simulation as a tool.
3. Real Option Variation by applying the real option approach to the evaluation for alternatives of concession extension, as a deferral option. The government can defer the decision to grant the extension of concession from year X-5 to X-4, or X-3 or X-2. To estimate the effects of the deferral decision under fiscal regime Thai I and Thai III.
4. Scenario setting by applying the effect of escalation of investment cost, and variation of volatility of petroleum price, to estimate the effects from escalation of investment cost and volatility of petroleum price on the decision to grant the concession extension under fiscal regime Thai I and Thai III.

1.3 Thesis Outline

Chapter 2 reviews the literature on evaluation of concession extension using conventional approach, Real Options studies and the application of Real Option. In evaluation of concession extension the fiscal regime is the main factor. The fiscal regime research studies in Thailand are also provided in this chapter.

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[7] Deferral Option is presented in Real Options topic in chapter 3.
[8] Relationship between gas price in Thailand and fuel oil price is presented in Chapter 3.

Chapter 3 reviews the methodology in detail including the theory and concept that are used in this thesis. Deterministic Model, Stochastic Model, Real Option valuation and Scenario setting are described as well.

Chapter 4 reviews the results and discussions of evaluation of case studies' extension of concession under fiscal regime Thai I and Thai III, with the Deterministic Model, Stochastic Model, Real Option valuation and Scenario setting.

Chapter 5, the final chapter, reviews the case studies conclusions, resulting from applying Deterministic Model, Stochastic Model, Real Option valuation and Scenario setting to evaluate the extension of petroleum concessions under fiscal regime Thai I and Thai III.

CHAPTER II

LITERATURE REVIEW

This Chapter reviews the previous studies on Real Options Approach (ROA) and provides some background on standard methodologies generally used for evaluation in oil and gas businesses. The justification for choice of methodology used in this thesis is also explained. The brief introduction of the 'Real Options approach[9]' and the Discount Cash Flow model presented in Chapter 1 are discussed in detail as well.

Chapter 2 serves as a theoretical base on previous studies of evaluation projects by using Real Options Valuation. The chapter starts off with the previous studies of Evaluation of concession extension and then Real Options emphasizing the concessionaire's profit studies which are evaluation of concession extension is provided, methodology review and applications of real options respectively. The detailed discussion of the motives in applying Real Options Valuation is then presented.

2.1 Evaluation of Concession Extension

This section discusses some works relate to evaluation of concession extension which consist of two parts. In the first part, development of a model for extendible options embedded in the petroleum offshore E&P contracts that happen in some countries is reviewed. In the second part, Evaluation for electricity concession extension is provided.

The holder of a petroleum exploration concession has an investment option until the expiration date fixed by the government, in some countries these rights can be extended by additional cost. Dias and Rocha [10][2] evaluated these rights and optimal investment timing by solving a stochastic optimal control problem of an option with extendible maturities. They used the uncertainty in oil prices to model as

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[9]Deferral Option and volatility are also in this topic.

[10]Dias, M.A.G. and Rocha, K.M.C presented this topic as Petroleum Concession with Extendible options using Mean reversion with Jumps to model oil prices in [3th] Annual International Conference on Real Options which is also provided in www.realoptions.org.

mix jump-diffusion process. Several sensitivity analyses were performed for each parameter of this process including volatility. Dias, M.A.G. and Rocha, K.M.C. developed a model for extendible options embedded in the petroleum offshore E&P contracts and indicated that the higher time to expiration without a significant additional delay of investment, the higher option value is.

Rocha and Silva [3] presented comparative studies between the possibility of extending or not extending concession and found the most advantageous option to Chesf[11]. They used Discount Cash Flow model and compared against the alternatives as the scenarios which gives the highest Net Present Value is assumed to be the most advantageous. The value of net present value is calculated for the period between the 2013 and 2042 by using WACC reported by Electrobras. The first scenario is to extend the concession in 2013 and the second scenario is not to extend the concession. Rocha and Silva shown that extension of concession in 2013 is the most advantageous to the company, compared with the non-extension option.

2.2 Methodology Review

There are a number of issues and studies in evaluation project. M.A. Mian[12][4], in *Deterministic Model*[13]topic, notes that there are several basic principles of cash flow analysis vital to the correct analysis of investment including basics definition, the treatment of depreciation and depletion, capital costs, concepts of nominal and real cash flow-in, before-tax cash flow, tax liability calculations and after-tax cash flow models.

In *Probabilistic Model (Stochastic Model)*[14] topic, M.A. Main notes that on a project being evaluated, the decision maker may be faced with decision made under certainty, risk, and uncertainty. He also presented some concepts of descriptive

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[11] Chesf is an electrical utility concession operator controlled by Electrobras, is publicly traded mixed economy company.

[12]M.A. Main published these topics in *Project Economics and Decision Analysis Volume I and Volume II*.

[13]Deterministic Model is the model that every set of variable states is uniquely determined by parameters in the model and by previous states of variables.

[14]Probabilistic Model or Stochastic Model performed the randomness and variable states are described by probability distributions.

statistics and probability, including Expectation Value concepts, Standard Deviation of Random Variable, and Expected Monetary Value (EMV).

Copeland and Antikarov[15] [5] introduced some concepts of Real Options. A Real Option is the proper approach, but not the obligation to take an action as is the 'deferral option[16]', expanding option, contracting option, or abandoning option. Copeland and Antikarov also note that the value of real options depends on five basic variables[17] which are the values of the underlying risky assets, the exercise price, the time of expiration of the option, the standard deviation of the value of the underlying asset, and the risk-free rate of interest over the life of the option. A deferral option is an American call option found in most projects where one has the right to delay the start project. Copeland and Antikorov also presented the four-step process for valuing real options[18] by using *Monte Carlo Simulation*[19]. They described how to perform a Monte Carlo Simulation, estimate the project's volatility, build an even tree, and use historical data following the $\sigma\sqrt{T}$ *rule*[20].

Mun[21] [6] introduced evaluating capital investment by using 'Real Options Analysis'. He described qualitative and quantitative description of real options, methods used in solving real options, the real-life scenarios. Mun also described in detail about probability distributions, selection of a distribution and sampling method.

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[15]Tom Copeland and Vladimir Anitikarov published these topics in *Real Options: A Practitioner's Guide*

[16] Deferral Option is detailed presented in Chapter 3.

[17] The five basics variables are presented in Chapter 3.

[18]The four-step process for valuing real options is discussed in detail in Chapter 3.

[19]Monte Carlo Simulation is mathematical technique that allows people to account for risk in quantitative analysis and decision making. For detailed presented on Chapter 3.

[20]If the independent variable in a regression is time, then the 95 percent confidence band follows a $\sigma\sqrt{T}$ rule, that increasing with the rate square root of time outside of the sample period used to fit the regression equation. In other words, the out-of-sample confidence interval will increase with the rate $\sigma\sqrt{T}$approximately.

[21]Johnathan Mun introduced these topics in *Real Options Analysis: Tool and Techniques for valuing Strategic Investments and Decisions.*

2.3 Applications of Real Options

There are many numbers of applications in Real Options. Neufville [7] used a Real Options Analysis on systems planning and design under uncertainty. He explained how Real Options affect the outcome, and presented cases documenting the changes in attitude. Neufville illustrates the wide range of applications for the analysis of real options, using documented cases in many fields of engineering and major organizations using real options in planning and development of major systems indicates that the processes involve at least three distinct phases[22].The Flexibility in Timing was described in his paper; the timing of an investment may be considered as an option. He indicated that the value of the flexibility has not been recognized by the traditional methods[23] of project evaluation.

Hooper III [8] described how five existing spreadsheet algorithms which were reserve calculations, capital requirements, After Federal Income Tax (AFIT) economic spreadsheets, and tax and fiscal regime were integrated to develop for evaluations. He also discussed on flexibility and limitations, as Custom exit strategies *(which are abandonment criteria and have been used before)* Production Forecast, Timing Uncertainties, and Creative Financing.

Real Options are also the applications in stochastic models. Brandao et al [9] introduced using Binomial Decision trees[24] to solve real-option valuation problems. *Brandao et al* used binomial decision tree with risk-neutral probabilities to approximate the uncertainty associated with the changes in the value of binomial decision tree compared with binomial lattice[25]. He indicated that, for the stochastic model as in the reality, commercial success does not guarantee positive Net Present

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[22]Three distinct phases are Discovery during the group attempts to identify the most interesting areas of uncertainty, Selection which evaluates the possible means of providing flexibility to the system, and determines options, and Monitoring the process of the evaluation under uncertainties.

[23]Traditional methods are detailed described in chapter 3.

[24]Binomial Decision Tree is a graphical representation of possible intrinsic values that an option may take at different nodes or time periods. Binomial Decision Trees are useful tools when pricing options and embedded options.

[25]Binomial Lattice is the one type of Binomial Decision Tree which is the probability of upside and downside as the same value.

Value (NPV) and decision can be analyzed as easily using stochastic models, as can be done using decision tree models. The advantage of stochastic models is that the impact of engineering and development uncertainty is an integral part of the decision analysis.

In 2009, Park et al [11] presented a stochastic analysis for petroleum development under uncertain market and technical environments. Park et al used Mean-reversion with jumps[26] for uncertain price forecasting of various scenarios for reservoir properties, Monte Carlo simulation for obtaining the feasible range of NPV and confirmed the necessity of qualifying uncertainties for realistic decision-making at the developmental stage initially.

Cortaza et al [12] developed a real options model for natural resource exploration investments when there was joint price and geological-technical uncertainty. Cortaza et al maintained a relative valuation structure by collapsing price and geological-technical uncertainty into one-factor model. He applied the model to a copper exploration and found that a fraction of total project value is dependent on the operation, development, and exploration options available for the project evaluation. In 2010, Purwar et al [13] applied real options in optimization integrating response surfaces model in case of gas flooding. Purwar et al developed a workflow and tool which integrated reservoir response surfaces, including reservoir-economic optimization tool and investigated the selection of initial well configurations, and injection capacities, while simultaneously accounting for the option to update the decisions after information was available in the initial periods of production.

There are many types of real options which used in evaluated the project including deferral option, expand option and switch option. Dias et al [12] applied real option approach to oil field development as deferral option and expand option. *Dias et al* determined the effect of volatility parameters on the value of deferral option, by using the oil price threshold curves for exercising options, including

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[26]Mean-reversion with jumps is a stochastic model which mixed Poisson-Gaussian (jump-diffusion) process.

stochastic processes, Geometric Brownian motion[27] and mean reversion. Dias *et al* indicated that the option to wait for better conditions *(deferral option)* to commit to the investment is higher in such cases. In 2009, Rungcharoen [14] applied Real Option Approach to oil field development as option to switch, option to contract, and option to abandon. In option to switch case, Rungcharoen allowed the project to be switched into another option that drills more production wells. The result of this switch option was in Binomial lattice and she indicated that the option to Switch can increase the project value by 10.18% of the base option. In option to contract case, she decreased the scale of operation, and assumed that 50 percent of some assets would be sold and Rungcharoen has shown that the oil field value had increased by 1.87%. Finally, in option to abandon case, she allowed the project to be abandoned in order to receive its salvage value. She assumed that 14,500,000 USD is the savage value, when the oil prices are low enough in year 5, 6 and 7, and she indicated that the oil field value had increased by a very small value of 0.02%, and this type of option did not much influence on the overall project value, because of the number of surface facilities to be sold.

From the above discussions the real option analysis used risk and uncertainty to build flexibility in the evaluation, resulting in systematically increasing project's value. The value of real options has been increased directly from the project's risks and uncertainty. In the following chapter, the methodology is described in detail.

[27]Geometric Brownian motion (GBM) also known as exponential Brownian motion is a continuous-time stochastic process in which the logarithm of randomly varying quantity follows a Brownian motion.

CHAPTER III

METHODOLOGY

The preceding chapters reviewed, the studies conducted previously, in evaluating the concession extension in the other fields, evaluating a project using Real Option Approach and the studies done in that fiscal regime. This chapter reviews and discusses the methodology conducted in afore mentioned researches, and includes the concepts of *Deterministic Model*, *Stochastic Model*, *Real Option Valuation* plus the *Scenario Setting*.

3.1 Deterministic Model

Most of the concessionaires evaluate the project by using the Quantitative Analysis Method. The traditional method is the *Deterministic Model,* but these methods have the assumptions based on, that the management is now or never decision analysis, i.e. start the project immediately or to operate it continuously at a set scale till the end of the project's life. And *Deterministic Model* also has the important weakness which are no flexibility and volatility concerning. This method is ignorant of the effects of risk and uncertainty, but in reality, the petroleum extension of concession does have some uncertainties in the fluctuation of petroleum price. The petroleum prices are not constant until at the end of the project.

3.2 Stochastic Model

The Stochastic Model is the model that concerns in volatility of petroleum price by using Monte Carlo simulation and sampling the value of petroleum prices in the range of fluctuation by using the historical fuel oil price as a proxy. And this model also concerned with the escalation of petroleum prices which can estimate the regression by using least square method. But in the real world investment, there are many opportunities to alter its investment, e.g. the alternative that the decision-maker can wait until further information or good market conditions or an increase in production costs. If the future condition is good, the decision to grant the extension of concession will be committed, to take advantage from this flexibility.

3.3 Real Option Valuation

The *Real Option valuation* is the approach that concerns with both the volatility and the flexibility. The above three mentioned approaches have two majors factor that impact the decision in extension of concession, which are: - escalation of investment cost and percentage volatility of petroleum prices.

3.4 Scenario Setting

In this study, *Scenario Setting* provides the effect of escalation of petroleum cost in the deferring to grant the concession extension, and the effect of volatility of petroleum prices in the volatility of the project, under fiscal regime Thai I and Thai III.

3.1 Deterministic Model (Base Case)

Deterministic Model is a mathematical model in which outcomes are precisely determined through known relationships among states and events, without random variation. In this model, a given input will always produce the same output. This study uses deterministic model as a cash flow model, which is the model that evaluates cash inflow and cash outflow, by discounting the cash flow to the present value by using net present value, as an investment criteria.

3.1.1 Cash Flow Model

Cash flow Model is a model of the movement of money in a business, project, or financial product. It is usually measured during a specified, finite period of time. It is the cycle of cash inflows and cash outflows that determine the profit or benefit-sharing of the project. This study used cash flow model as an annual cash flow model.

3.1.1.1 Cash Inflow

Cash inflows include the transfer of funds to a company from another party as a result of investments. Such cash inflows include payments to the company by customers and banks and the contribution of equity by investors who purchase the company's stock, or partial ownership in a company. For evaluation of concession extension, cash inflow results from the value of petroleum production which consists of Gas production and Condensate production. In deterministic model, petroleum prices assume to be constant until at the end of project.

3.1.1.2 Cash Outflow

Cash outflows include the transfer of funds by a company to another party. Such cash outflows include payments to business partners including employees, suppliers or creditors. Cash outflows occur when long-term assets are acquired, investments are purchased, or settlements and expenses are paid. Cash outflow consist of Capital Expenditure (CAPEX), Operating Expenditure (OPEX) and Tax which is based on 2 fiscal regimes, Thai I and Thai III respectively. CAPEX and OPEX in the deterministic model are assumed not to be effected by the escalation of investment cost[28].

3.1.1.2.1 Capital Expenditures and Operating Expenditures

CAPEX in evaluation of concession extension consists of wells cost[29], Platform cost[30], abandonment cost and decommissioning cost, and OPEX is associated with the operation and maintenance of an income producing property[31].

Cost escalation is defined as changes in the cost or price of specific goods or services in a given economy over a certain period. Escalation includes general inflation related to the money supply. It is also driven by changes in technology and practices that are specific to a good or service in an economy. In an evaluation of the project management usage, escalation is considered as an uncertainty. In this study, there are two main escalation cost which are petroleum prices i.e. Gas price and

[28] The effect of escalation of investment cost is concerned in stochastic model, real option valuation and scenario setting.

[29] Wells cost also include development wells, delineation wells.

[30] Platform cost also include Wellhead Platform cost, Central Processing Platform, and other platforms.

[31] The details of CAPEX and OPEX are illustrated in Background information as shown in Appendix A

condensate price, and investment cost (CAPEX and OPEX). The detail of escalation of investment cost is provided in chapter 4.

3.1.1.2.2 Fiscal Components

Thailand Petroleum fiscal regime is under a concession system[32] which composed of Income tax, and Royalties. Every company that engaged in petroleum exploration and production in Thailand was subject to petroleum income tax at the rate of 50% of annual profit which is regulated under the petroleum tax law. Each petroleum regime of Thailand has different tax structures and benefit sharing. In this part of the study Thailand fiscal regimes Thai I and Thai III will be presented in detail.

Fiscal Regime Thai I

Thailand I was applied to every petroleum project that had been awarded petroleum licenses before 1982. Wherein, 12.5% of petroleum revenue is calculated as royalty rate. As it has been said before that petroleum income tax for every projects need to be paid at the rate of 50% of annual profit, Thailand I regime has the rate of petroleum income tax at 50% of annual profit and the royalty can be used as tax credit[33]. It has been limited to 30 years production period with 10 years extension allowance. The area should not exceed 10,000 square meters per exploration block, and this regime allows petroleum companies to explore up to 5 exploration blocks. In this fiscal regime, the concessionaire's take is net income after tax and government's take consists of royalty and tax as shown in Figure 3.1. Figure 3.1 provides the concept of fiscal regime Thai I.

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[32] According to Johnston, D. (1994), petroleum fiscal regime can be classified into 2 systems; Concessionary system and Contractual system.

[33]Fiscal regime Thai I use royalty as a tax credit but in fiscal regime Thai III use royalty as a tax deduction.

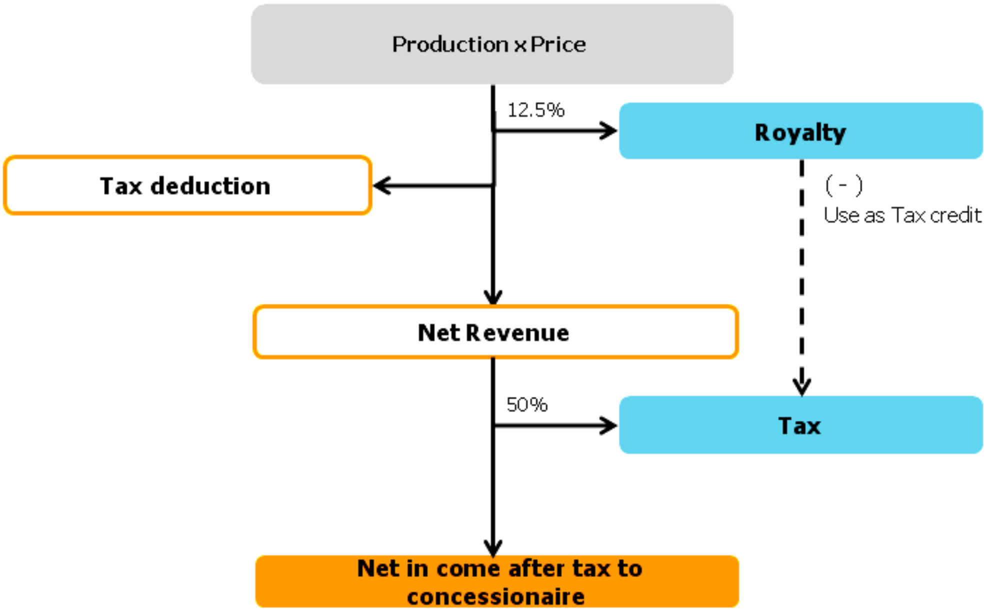

Figure 3.1 Concept of fiscal regime Thai I[34]

Fiscal Regime Thai III

Thailand III petroleum regime is applied to the projects whose license was issued by the ministry of Energy from B.E. 2532 (1989). The royalty rate is in the sliding scale of 5%-15% of petroleum sold. Petroleum income tax is 50% of annual petroleum profit. Royalty is used as a tax deduction and Special Remuneration Benefit (SRB) is progressive at a rate of 0-75% on Windfall Profit, which is different from Thailand I, 1971. In addition, if the period of exploration and production is 6 years, it allows for 3 years extension allowance for exploration, and in case of 20 years it allows for 10 years extension allowance for the said production period. The project area is limited at a maximum of 4000 square kilometers per exploration block. Furthermore, the government allows petroleum companies to operate up to 5 exploration blocks at a time. In this fiscal regime, concessionaire's take is net income after tax deduction, and the government's take consist of royalty, SRB and Tax as shown in Figure 3.2.

[34] This figure bases on Fiscal Regime presentation by Petroleum Institute of Thailand.

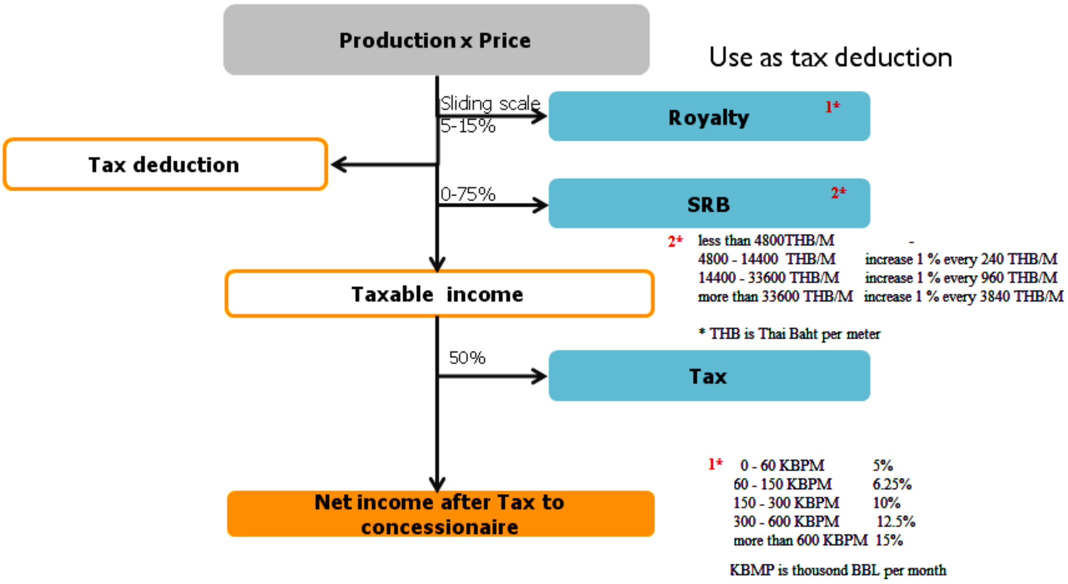

Figure 3.2 Concept of fiscal regime Thai III[35]

From the Figure 3.2, SRB is calculated in the year after recovered all investment cost or concessionaire has petroleum profit[36]. SRB formula and the example of sliding scale calculation are provided as follows:

$$A = \frac{Rev}{K + M} \qquad (3.1)$$

Where: A = Annual Petroleum Profit per one meter drilled.

Rev = petroleum profit.

M = cumulative meters drilled.

K = Geological risk compensatory, initial provider of tax (SRB) free allowance.

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[35] This figure bases on Fiscal Regime presentation by Petroleum Institute of Thailand.

[36]In calculating such petroleum profit for the year, there may be deducted capital expenditure, operating costs, a special reduction (expense “uplift”) for the year, and petroleum loss carried forward from prior years.

<u>*Example:*</u> Net Revenue of concessionaire is 552 MMUSD

Step 1: convert 552 MMUSD to THB (1 USD is assumed to be 30 THB)

522 MMUD = 16,571,701,344 THB

Step 2: calculate Annual Petroleum Profit per one meter drilled (*A*)

(*M* is assumed to be 3,046,903 meter)

A = 16,571,701,344/(150,000+3046903) = 5,184 THB/m

<u>*Example*</u>*:* Petroleum profit of concessionaire is 20,191 THB/m

Step 1: rearrange 20,191 into each sliding scale

20,190 = 4,800 + 9,600 + 5,791

Step 2: calculate each sliding scale

less than 4,800	0%
4,800 – 14,400 increase 1 % every 240 THB/m = $\frac{9{,}600}{240}$ = 40	40%
14,400 – 33,600 increase 1 % every 960 THB/m = $\frac{5{,}791}{960}$ = 6	6%

Total SRB is 0 + 40 + 6 = 46%[37]

3.1.2 <u>Discounting the Annual Cash Flow</u>

The discounting of the annual cash flow is the estimation of future cash flow discounts to give its present value and the sum of all future cash flow, both cash inflow and cash outflow, is the Net Present Value (NPV) with the discount rate.

[37] In chapter 4, SRB calculation is followed this calculation.

3.1.2.1 Discount Rate

Discount rate is the interest rate used in discounted cash flow analysis to determine the present value of future cash flows. The discount rate takes into account the time value of money, and the risk or uncertainty of the anticipated future cash flows. Figure 3.3 provides the relationship between discount rate and NPV of the concessionaire under fiscal regime Thai I. From the curve in the figure below, the suitable discount rate for this evaluation is 12%. This study also uses 12% discount rate.

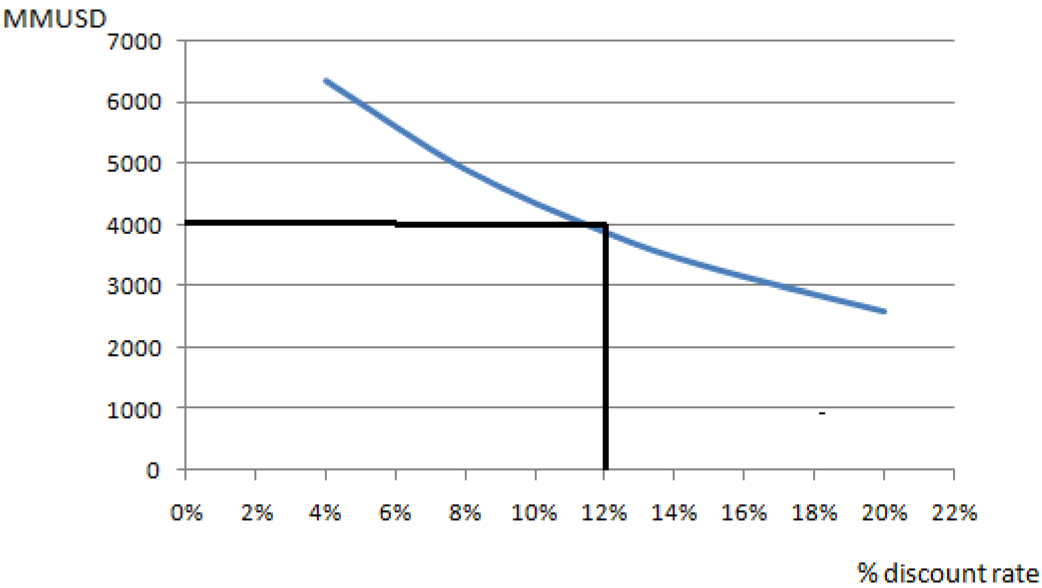

Figure 3.3 Relationship between Percentage of discount rate and NPV

3.1.3 Investment Criteria

NPV, the net present value, is defined as the present value of the receipts less the present value of the disbursements. The formula for NPV is as follows:

$$NPV=\sum_{t=0}^{N}\frac{C_t}{(1+i)^t} \quad (3.2)$$

Where: t = the time of the cash flow,

N = the total time of the project,

i = the discounted rate

C = the cash flow at that point in time.

If the NPV of the project's cost of capital is positive, then the project is economical and viable, and the higher the NPV number, the more desirable the project becomes, but if the NPV is negative, then the project is not feasible for investment at all.

Hence, results of this model provides us with the estimation as to under which fiscal regime the government decided to grant the concession extension under constant petroleum prices, and that decision was taken in the year X-5. This model has a very big drawback, because in ground reality the things are different and the prices of petroleum are not always constant in regards to volatility and escalation, and hence, it is advisable that the government should defer the decision to grant concession extension to the year X-4, X-3 and X-2. The use of stochastic model and real option valuation are deemed as extremely necessary.

3.2. Stochastic Model

Stochastic model is a financial model in which one or more variables within the model are random. Stochastic modeling is for the purpose of estimating the probability of outcomes within a forecast to predict what conditions might be like under different situations. The uncertainties are usually constrained by historical data. From previous model (Deterministic model), the volatility and the escalation of petroleum price are important factors in evaluation of concession extension which deterministic model does not consider in both volatility and escalation, while stochastic model does. In this section, the volatility and the escalation of petroleum prices are discussed in detail.

3.2.1. Volatility

Volatility is a statistical measure of the dispersion of returns for a given security or market index. Volatility can either be measured by using the standard deviation or variance between returns from that same security or market index. A higher volatility means that a security's value can potentially be spread out over a larger range of values. This means that the price of the security can change dramatically over a short time period in either direction. A lower volatility means that a security's value does not fluctuate dramatically, but changes in value at a steady pace over a period of time. The volatility of petroleum prices and the volatility of project are also clarified.

3.2.1.1. <u>Volatility of Petroleum Prices</u>

Petroleum productions in this study are gas and condensate. The gas price structure in Thailand is depends on many variables such as Producer Price Index and Oil and Gas Machinery Price Index according to following formula:

$$By = IBP \, [\, b1\% \, PPI + FX \, (b2\% \, OM + b3\% \, FO + Constant) \,] \tag{3.3}$$

Where : By is Normal Price

IBP is Initial base Price adjusted by Economic Index

PPI is Producer Price Index

FX is exchange rate

OM is Oil and Gas Machinery Price Index

FO is Fuel Oil Price

From the gas price structure, there are many variables in the formula and some variables are confidential for the concessionaire. This study simplifies the formula of gas price and assumes to be 20% of fuel oil price. It means that in this assumption, the gas price is in direct change of fuel oil price and the volatility of fuel oil price was used as a volatility of gas price proxy. The volatility of fuel oil price is also used as volatility of condensate price because condensate prices are assumed to be in the same trend as that of gas price. In this study, the volatility of petroleum prices (gas price and condensate price) are estimated by using a historical 3 years fuel oil prices as shown in APPENDIX B.

3.2.1.2. Volatility of the Project

Volatility of the project in this study stands for the volatility of NPV for concessionaire and government which are the result from Monte Carlo simulation[38]. It means that using the volatility of petroleum prices as inputs to find the volatility of project as shown in Figure 3.4. The volatility of petroleum prices affects the volatility of the project.

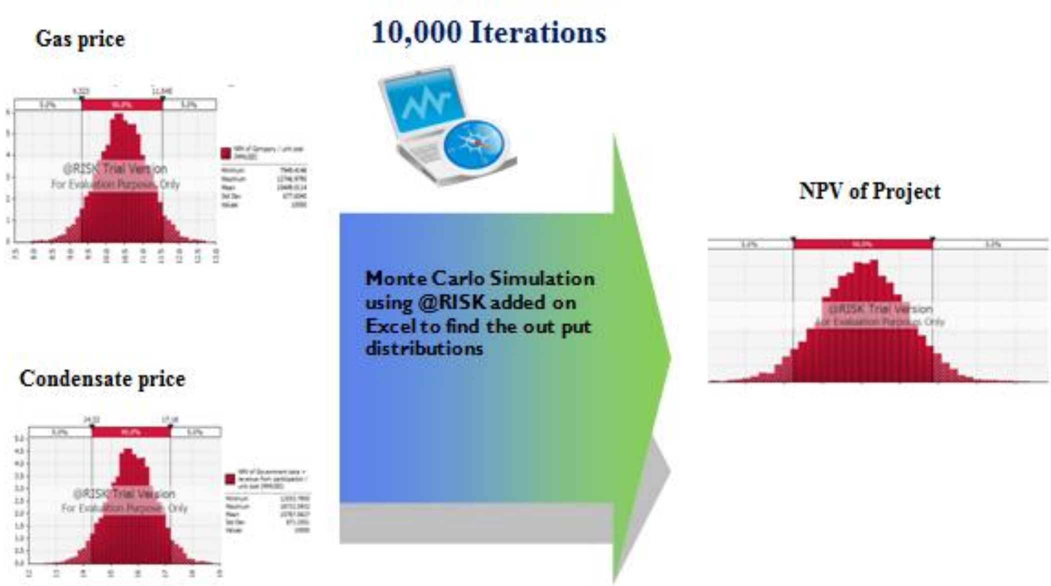

Figure 3.4 Monte Carlo Simulations

3.2.2. Escalation

In deterministic model, escalation is assumed but not considered (constant petroleum prices and fixed investment costs) but the stochastic model is concerned in escalation of investment cost. This section provides the escalation of petroleum prices and clarifies the difference between escalation of petroleum prices and escalation of investment cost.

[38]Monte Carlo simulation is a numerical technique that allows people to account for risk in quantitative analysis and decision making. This technique is widely used in finance, project management, energy, manufacturing, engineering, research and development, insurance, transportation, and the oil and gas business. Monte Carlo simulation help the decision-maker evaluate the project with a range of possible outcomes and the probabilities. This research used @RISK which is the leading Monte Carlo simulation add-in for Excel. Monte Carlo simulation also combine many uncertainties into one by running them through an excel add-in, @RISK. Each sampling of set of variables generates an estimate of present value of project.

3.2.2.1.Escalation of Petroleum Prices

In the real world situation the petroleum prices are not constant and the historical data[39] shown that the prices were in the increasing linear trend. It means that the petroleum prices are not only volatile, but also escalate. The escalation of petroleum prices is estimated by regression using least squares method[40].

3.2.2.2. Escalation of Investment Cost

Escalation of investment means a provision that allows the increase of costs to be passed on in one way or another. This study used escalation of investment cost as escalation rate (*percentage of escalation*) which concessionaire provided in background information at which an annual change in the price levels of the goods and services occurs or is expected to occur. Figure 3.5 illustrates the difference of incremental characteristic between escalation of petroleum prices and escalation of investment cost. In the figure below shows that escalation of investment cost is exponential escalation while escalation of petroleum is linear escalation.

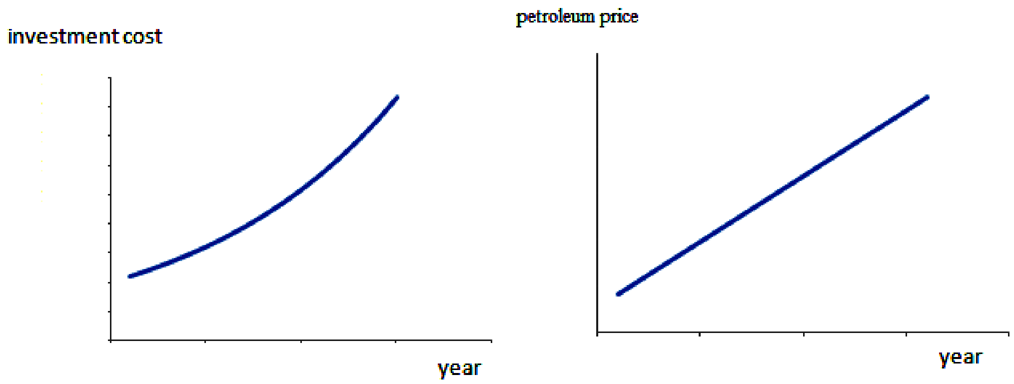

Figure 3.5 Difference of incremental characteristic of escalation

The result from this model may provide us with the results of the fiscal regime under which the government decided to grant the concession extension had been more realistic than deterministic model, but this model also is not flexible to consider, as

[39]This study used fuel oil prices as petroleum prices proxy and historical 3 years 20% of fuel oil prices are illustrated in APPENDIX B).

[40]Least squares method is a standard approach to the approximation of set of equations in which there are more equations than unknowns. "Least squares" means that the overall solution minimizes the sum of the squares of the errors made in the results of every single equation.

the government cannot defer the decision to grant the concession extension. The next section provides the real option valuation which concerns the effect of flexibility.

3.2.3. Investment Criteria

From previous model, NPV is criteria in the investment but NPV is no volatility consideration criteria. In Stochastic model, the main criterion in the investment is Expected Monetary Value (EMV) which is considered in uncertainty by weighting average with probability. In this study, EMV is the result from Monte Carlo simulations as the mean in the output distribution.

3.2.3.1. Expected Monetary Value (EMV)

EMV is a weighted average of the possible monetary values (usually net present value, NPV), weighted by their respective probabilities. Alternatively, it is defined as the mean of probability distribution of all possible monetary outcomes. The formula of EMV is:

$$EMV = E\{NPV\} \tag{3.4}$$

$$EMV = \sum_{i=1}^{n} NPV_i \times P(NPV_i) \tag{3.5}$$

The higher the EMV number, the more desirable the project is and the largest EMV is selected and all investments with EMV greater than zero are acceptable.

The value of EMV is the range of NPV. The distribution of output returns the mean and standard deviation. The EMV (range of NPV) is a variation of NPV from mean value to one standard deviation with 68% of all NPV values as shown in Figure 3.6.

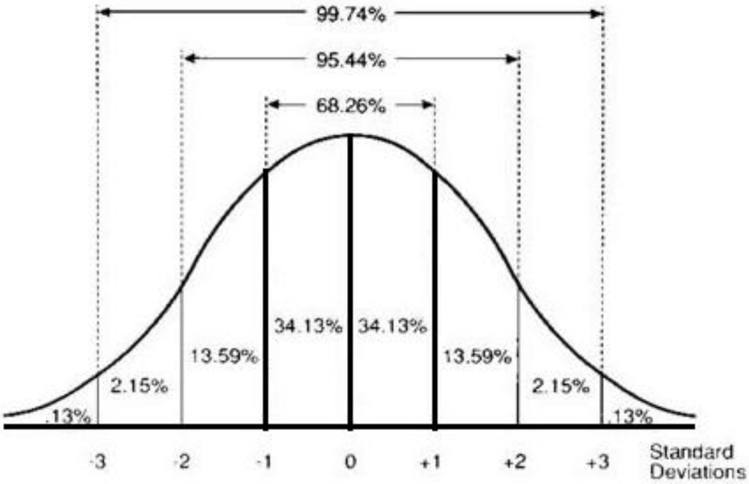

Figure 3.6 Normal Distribution

3.3 Real Option Valuation

Real Options is referred to as an analogy of financial investment options, and is faced in many activities which are related to a choice of technology, such as a production decision, a decision on investment timings and the option to temporarily or permanently shut down, as well as to many other decisions dealing with real physical tangible assets. Moreover, the Real Options Approach is to address the problem of irreversibility of investments that cannot be recovered. In other words, this approach is the irreversible flexible decision in time, when the potential reduction of uncertainty is lost. The high uncertainty related to critical variables such as, the consumption of energy, the oil price and the construction costs. In other words, an analogy can be made between the variables that determine the value of a stock option and real options. This section provides the idea of *Black-Scholes Model* which is valuation of option, characteristic of real option and flexibility of real option.

Black-Scholes Model

The *Black-Scholes Model* is used to calculate the theoretical price of European put and call options, ignoring any dividends paid during the option's lifetime. While the original Black-Scholes model did not take into consideration the effects of dividends paid during the life of the option, the model can still be adapted to account for dividends by determining the ex-dividend date value of the underlying stock. The formula of Black-Scholes equation is:

$$C = SN(d_1) - N(d_2)Ke^{-rt} \tag{3.4}$$

$$d_1 = \frac{\ln\left(\frac{S}{k}\right) + (r + \frac{s^2}{2})t}{s\ \sqrt{t}} \tag{3.5}$$

$$d_2 = \ d_1 - s\sqrt{t} \tag{3.6}$$

Where: *N*(*d*) is the cumulative distribution function of the standard normal distribution

t is the time to maturity

S is the spot price of the underlying asset

K is the strike price

r is the risk free rate

S is the volatility of returns of the underlying asset

The real options are the rights, and not the obligations, to take actions on the business decision, for example, deferring, expanding, contracting, or abandoning at the predetermined cost (*called the exercise price*) or for a predetermined period of time (*called the expiration*).Real options analysis uses risk and uncertainty to build flexibility in the evaluation, thus resulting in systematical increase in project's value. The value of real options has been increased directly from the project's risk and uncertainty. Real Options permits for choices to be made later. Those choices allow the project to maximize its upside and to minimize the downside expenditures. The value of real options depends on the following:

1. *The value of the underlying asset*, the underlying asset's value is direct variation of the real options value. One of the differences between financial and real options is that the owner of financial options cannot affect the value of underlying asset, whereas on the other hand, the

management that operates a real asset can raise its value and thereby raise the value of all real options that depend on it.

2. *The exercise price is the amount of money that is invested to exercise the options*. If the exercise price is increased, the value of call increases, but for ‘put and call’ options, it is decreased as an inverse variation.
3. *The time to expiration of the options*. The time to expiration is in direct variation to the value of the option. If the time to expiration is increased, the option value increases.

4. *The standard deviation of the value of the underlying risky asset*. The value of option increases with risky underlying asset because the payoff of a call option depends on the value of the underlying exceeding its exercise price.

5. *The risk-free rate of interest over the life of the option*. As the risk-free rate is raised, the value of the option will increase simultaneously.

3.1.1 Flexibility

Flexibility is allowing each decision to improve its upside potential during the limited time of its downside losses. There are two types of flexibility, the first type is internal flexibility which is allowed in a project by adjusting the project as the future conditions having changed, including expansion, deferring the decision, alteration and even abandonment of the projects. The second type is external flexibility in the project which is to perform another project that may not have been possible initially. In addition, flexibility is a valuable commodity and usually the more flexibility the better it is for the project’s value. A project’s flexibility may provide great benefits, which are given less consideration when comparing a project’s tangible costs and benefits. This study used a real option approach, as a flexible evaluation of the project under risk, and uncertainty combining with Monte Carlo simulation as an accounting, for risk in quantitative analysis and decision making. This part illustrated the flexibility of real options which are the alternatives for decision. The deferral option which is used in this study is also discussed.

Value of flexibility

The Real Options can be separated into six categories based on the type of flexibility provided. The six categories are: the option to defer *(deferral option)*, option for staged investments, option to change scale, option to abandon, option to switch, and option to grow.

1. The *deferral option* is to defer a decision until some date in the future is available by allowing management to determine the resources that will be spent on a project at that future date. For example, we do the deferring of the project, instead of investing at the period of higher cost to extract the oil. If we keep those reserves, we need to pay a small tax that allows you to defer the project every year, but then the oil price might suddenly hike making the cost of extracting the oil high, so that paying the tax allows the project to postpone decision to extract the oil, as and when the conditions change.
2. The *option for staged investments* is available when a project investment happens in an array of outlays that allow the project to be abandoned when the conditions become unfavorable. Each stage in development of a project can be considered as a category of options on the value of future stages.
3. The *option to change scale* can result in the project being expanded, contracted, or shut down and restarted. Depending on the conditions that prevail at a particular time, the rate of resource expenditure can be adjusted to meet the new conditions.
4. The *option to abandon* allows the project to be abandoned, providing that the conditions drop dramatically. The company can then sell off any assets available to offset the loss or switch those assets to other projects.
5. The *option to switch* allows an organization to change the input mix or output mix of a facility. If the conditions change, this option provides the flexibility to alter either the process or product.

6. The *option to grow* is used when an initial investment is required for further development. The project can be considered as a related project. Each related project is required for the future growth. The company may invest in research and development even though it has a negative value when it is considered as the isolated project. Investment is made because the results of that research and development impact the future growth value.

In evaluation of concession extension, the government can defer the decision to grant the concession extension from year X-5 to X-4 or to X-3 or to X-2. The *Real Option Valuation* in this study is used as deferral options which allow for the decision to be deferred while waiting the new information or more favorable conditions (*petroleum prices to increase*). In deferring the decision to grant the concession extension of government, the concessionaire has to change a development plan because the concessionaire will start to invest for increasing the production rate under agreement with their customer in the year that the government decides to extend the concession. The concessionaire drill at least 100 wells to hold the constant production rate and the additional development wells which concessionaire drill for increasing the production rate are drilled in the year that the government decides to grant the concession extension. The detail in calculation of deferral development plan is illustrated in chapter 4.

3.4 Scenario Setting

This section provides the two scenarios which are Investment cost escalation and Variation of petroleum volatility. The first scenario illustrates the effect of Investment cost escalation on deferring the decision to grant concession extension. The variation of petroleum volatility scenario provides the effect of petroleum volatility to the project volatility under fiscal regime Thai I as compared with that of fiscal regime Thai III.

3.4.1 Investment Cost Escalation

From the result of real option valuation, the alternative that government can defer the decision to grant the concession extension to year X-4, X-3 and X-2 is available. The effect of deferral option is to wait for the petroleum prices to increase, but deferring the investment is also to increase the investment cost due to investment cost escalation. This scenario provides the result of investment cost escalation when deferring the decision in concession extension. The details of this scenario are provided in chapter 4.

3.4.2 Variation of Petroleum Price Volatility

In evaluation of alternatives for petroleum concession extension, the volatility of petroleum price *(input*) affect the volatility of NPV for concessionaire and government (*output*). This scenario provides the effect of petroleum volatility to project volatility under fiscal regime Thai I compare with fiscal regime Thai III. The result of this scenario may provide the result of which fiscal regime that government decides to grant the concession extension under variation of petroleum volatility.

CHAPTER IV

RESULTS AND DISCUSSIONS

This chapter illustrates the results and discussions from the previous chapter providing step by step[41], including the detail in calculation. And discussion of each case study is also provided. First, the *Deterministic Model* (Base case) illustrated the results that the government decides to grant the concession extension under fiscal regime Thai I as compared to Thai III. Second, the *Stochastic Model* is more realistic than deterministic because it uses volatility of historical fuel oil prices, such as petroleum volatility proxy and the escalation of petroleum price. The result of the case study provides us with the alternatives of government decision under fiscal regime Thai I and Thai III. Third, the *Real Option Valuation* illustrates the flexible model in which the government can defer the decision to grant the concession extension from year X-5 to year X-4 or to X-3 or X-2 respectively. This model is also evaluated under fiscal regime Thai I and Thai III. And finally, *Scenario Setting* provides two scenarios which are investment escalation and variation of petroleum volatility. Investment escalation scenario provides the effect of escalation of investment cost by deferring the decision to extend the concession, and variation of petroleum volatility and it illustrates the effect of petroleum volatility on project volatility under fiscal regime Thai I and Thai III.

4.1 Deterministic Model

There were 4 blocks in field Y, namely block A, block B, block C and block D. The productions of this field are gas and condensate. The background information for each block is provided in APPENDIX A-1). Before constructing deterministic model, we must first make some assumptions that are relevant to this deterministic model of the project and then identify the information of the Cash Inflow and Cash Outflow of this field development.

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[41] The procedure of this chapter is shown in chapter 3.

Assumption of Deterministic Model

- Constant petroleum prices (gas price and condensate price)
- 12% Discount rate
- No escalation of investment cost
- No escalation of petroleum price
- K factor in calculation of SRB under fiscal regime Thai III is 150,000 m.

Background Information

- Development well cost	1.0 MMUSD[42]/Well
- Delineation well cost	1.2 MMUSD/Well
- Gas price	4.18 USD/MMBTU
- Condensate price	40 USD/BBL
- Heat Factor	1050 MMBTU/MMCF

Cash Inflow

- Gross Revenue
  - Gas production x Gas price
  - Condensate production x condensate price

Cash Outflow

- CAPEX
  - Development wells cost
  - Delineation wells cost
  - Abandonment and decommissioning cost
- OPEX
- Royalty
  - Fix 12.5% on gross revenue under fiscal regime Thai I
  - Sliding scale on gross revenue under fiscal regime Thai III
- SRB
  - Sliding scale on petroleum profit per meter drilled under fiscal regime Thai III

[42] MMUSD stands for Million USD

- Tax
    - 50% on taxable income
    - Royalty is used as Tax credit under fiscal regime Thai I
    - Royalty is used as Tax deduction under fiscal regime Thai III

Next step is construct cash flow spreadsheet using information above. The algorithms of calculation are provided as example followed. The example shows the calculation of cash flow under fiscal regime Thai I in year X-5. The background information for year X-5 is provided in APPENDIX A-1).

Example: Calculation of cash flow in year X-5 under fiscal regime Thai I.

First step: Heat conversion of gas production.

Equivalent Heat = (366,946 MMCF) x (1,050 MMBTU/MMCF)

= 385,293,300 MMBTU

Second step: calculation the gross revenue.

Gross Revenue = (Gas production x Price production) +
(Condensate production x Condensate price)
= (385,293,300 MMBTU x 4.18 USD/MMBTU) +
(22,305 MBO x 40 USD/BBL)
= 2,503 MMUSD

Third step: Find Net Revenue.

Net Revenue = Gross Revenue – Royalty
= 2,503 – (0.125 x 2,503)
= 2,503 – 313
= 2,190 MMUSD

Forth step: Find DD&A.

DD&A	=	(682 + 4 + 190)/5
	=	175 MMUSD

Fifth step: Calculation Taxable Income.

Taxable income	=	2,190 – 175 – 262
	=	2,066 MMUSD

Sixth step: Find Tax.

Tax	=	(0.5 x 2,066) – 313
	=	720 MMUSD

Seventh step: Calculate Net income after Tax

Net income after Tax	=	2,190 – 720
	=	1,470 MMUSD

Last step: Find Concessionaire take and Government take.

Concessionaire Take	=	Net income after Tax – CAPEX – OPEX
	=	1,470 – (682+4+190) – 262
	=	332 MMUSD
Government Take	=	Royalty + Tax
	=	313 + 720
	=	1,033 MMUSD

NPV for concessionaire and government are estimated by constructing the spreadsheet using the above algorithm in every year and discounted to present value with 12% discount rate. The spreadsheet for concession extension under fiscal regime Thai is provided in APPENDIX A). The NPV for concessionaire and government are summarized in Table 4.1 including NPV of CAPEX, OPEX, Royalty and Tax.

Table 4.1 NPV under fiscal regime Thai I

	Million USD	Percentage
Net Revenue	9,312	100.00
Royalty	2,348	25.23
Net Tax	3,075	33.04
NPV of Government take	5,424	58.27
NPV of Concessionaire take	3,884	41.73

Before calculating the NPV under fiscal regime Thai III, clarifying the time period of concession extension is necessary, because the concession was under fiscal regime Thai I, and it will expire in the year X. It means that in case of extension of concession under fiscal regime Thai I, the concession will be under fiscal regime from year X+1 to X+10. The algorithms of calculations are also provided in the following example. In the calculation, SRB has to be calculated block by block.

This example shows the calculation of cash flow of block A under fiscal regime Thai III in year X+1 and NPV under fiscal regime Thai III are summarized in Table 4.2.

<u>*Example*</u>: Calculation of cash flow in year X+1 under fiscal regime Thai III.

First step: Gross Revenue = (156,931,222 x 4.18) + (10,412 x 40)

= 1,072 MMUSD

Second step: Net Revenue = Gross Revenue – Royalty[43] - SRB[44]

= 1,072 – 123 – 15

= 950 MMUSD

Third step: Taxable income = Net Revenue – Tax Deduction

= 950 – 361

[43] Under fiscal regime Thai III, Royalty is used as Tax deduction while under fiscal regime Thai I, Royalty used as Tax credit.

[44] The SRB calculation in detail is provided in Chapter3.

= 556 MMUSD

Forth step: Tax = 0.5 x 556

= 288 MMUSD

Fifth step: Net income after Tax = 950 – 288

= 657 MMUSD

Sixth step: Net Revenue = 657 – (136+196+3+61)

= 259 MMUSD

Seventh step: Concessionaire's take = 259 MMUSD

Government's take = 123 + 278 + 15

= 416 MMUSD

Table 4.2 NPV under fiscal regime Thai III

	Million USD	Percentage
Net Revenue	9,312	100.00
Royalty	2,158	23.18
Net Tax	3,527	37.88
SRB	11	0.12
NPV of Government take	5,695	61.16
NPV of Concessionaire	3,617	38.84

According to Table 4.1 and Table 4.2, NPV for concessionaire is 3884 MMUSD and NPV for government is 5,424 MMUSD under fiscal regime Thai I while NPV for concessionaire is 3,617 MMUSD and NPV for government is 5,695 MMUSD under fiscal regime Thai I. As a result, NPV for concessionaire and government are positive under fiscal regime Thai I and Thai III. The government can decide to grant the concession extension under fiscal regime Thai I and Thai III, because in this case concession extension using deterministic model is feasible for concessionaire investment. From the Table 4.1 and Table 4.2 provided that NPV for government under fiscal regime Thai I is more than NPV for government under fiscal regime Thai III, because under fiscal regime Thai I the royalty is used as tax deduction while under fiscal regime Thai III, royalty is used as Tax credit.

4.2 Stochastic Model

The major uncertainties of this case study are gas price and condensate price. The natural gas price in Thailand is the direct change of the fuel oil price which approximates to 20 percent of the fuel oil price. According to the previous chapter, the standard deviation (σ) was estimatedby the 3 years historical fuel oil price. The standard deviation of 20% of fuel oil price is 50%. The escalation of petroleum prices (gas prices and condensate price), are estimated by least squared regression using historical fuel oil price as a proxy. The linear escalation of petroleum prices is 30% per year. The historical fuel oil price [16] was illustrated in APPENDIX B. Before estimating using stochastic model, we must first make some assumption for this model.

Assumption of Stochastic Model

- 50% Volatility of petroleum prices (gas price and condensate price)
- 12% Discount rate
- No escalation of investment cost
- 30%linear escalation of petroleum price
- K factor in calculation of SRB under fiscal regime Thai III is 150,000 m.

The algorithm of cash flow calculations in stochastic model is same as the deterministic model including *royalty, tax and SRB calculations*, under fiscal regime Thai I and Thai III. The results of this model are the distributions, which is the range of NPV value. The Expected Monetary Value (EMV) is provided as a mean value of the distribution and volatility of the project is provided as a standard deviation of the distribution. The Figure 4.1-4.4 illustrates the distribution of NPV for concessionaire and government under fiscal regime Thai I and Thai III and Table 4.3 provides EMV and volatility for stochastic model.

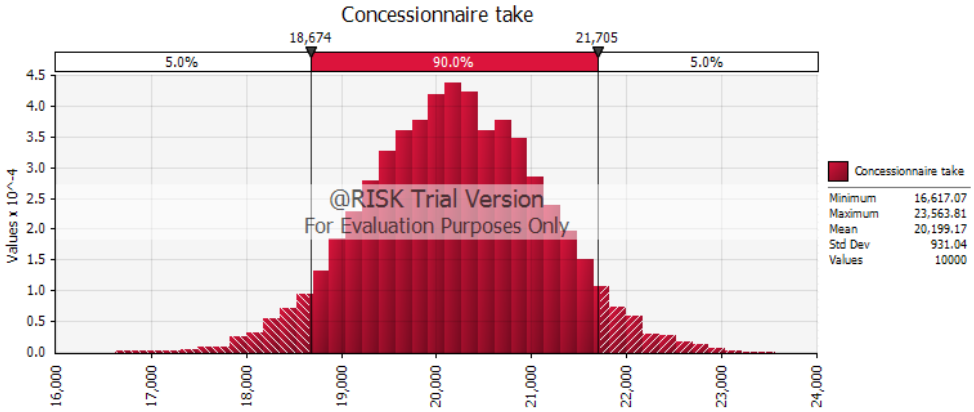

Figure 4.1 Distribution for concessionaire take under fiscal regime Thai I

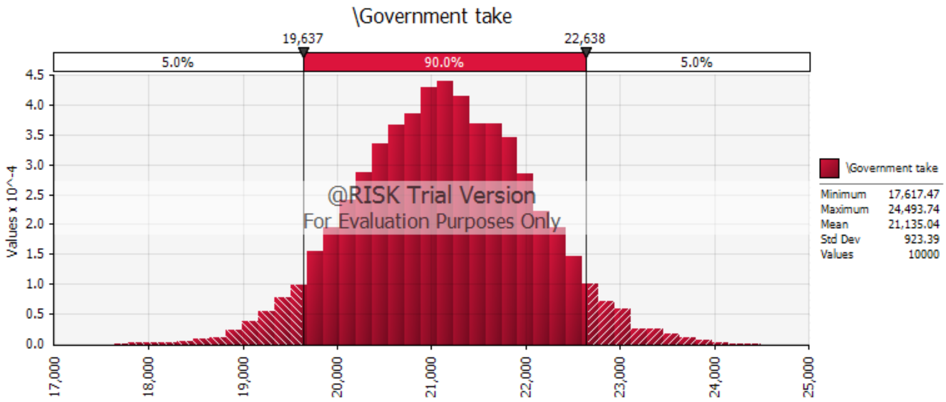

Figure 4.2 Distribution for government take under fiscal regime Thai I

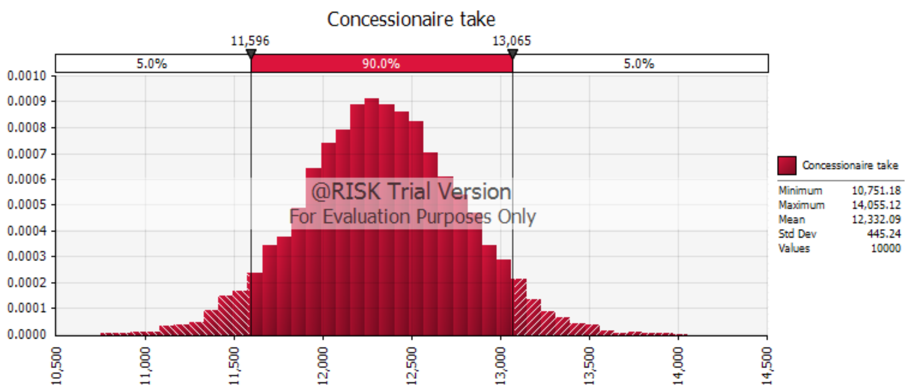

Figure 4.3 Distribution for concessionaire take under fiscal regime Thai III

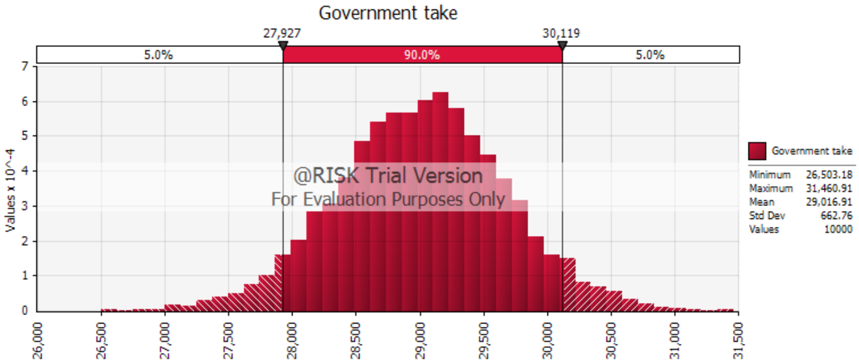

Figure 4.4 Distribution for government take under fiscal regime Thai III

Table 4.3 EMV and volatility of project for stochastic model (MMUSD)

Fiscal regime	Concessionaire		Government	
	EMV	Volatility of project	EMV	Volatility of project
Thai I	20,199	931	21,135	923
Thai III	12,322	445	29,016	662

According to Table 4.3, EMV (mean value of NPV) for concessionaire and government in *stochastic model* is more than NPV for concessionaire and government under both fiscal regime Thai I and Thai III. The results show that the concessionaire's and government's take more benefit-sharing in stochastic model with escalation of petroleum price consideration. In *deterministic model*, petroleum prices are constant whereas petroleum price escalations are available in stochastic model because the stochastic model is concerned with volatility and escalation of petroleum prices, and thus the effect of volatility and escalation of petroleum prices increases the benefit-sharing between concessionaire and the government.

4.3 Real Option Valuation

The uncertainty and the decision topics in the Real Option Valuation are summarized in Table 4.4 as follows. The option that was available in this evaluation was deferral option that allowed the decision to start the extension of concession to be able to defer for 1 to 2 or else 3 years. And the assumption for real option valuation is also provided as follows.

Table 4.4 Overviews of Decision parameters

	Parameter
Uncertainty	Future Gas price
Alternatives	Should the company and government defer the decision?
Alternatives	When should company and government decide to extend the concession?

Assumption for Real Option Valuation

- 50% Volatility of petroleum prices (gas price and condensate price)
- 12% Discount rate
- No escalation of investment cost
- 30% linear escalation of petroleum price
- K factor in calculation of SRB under fiscal regime Thai III is 150,000 m.
- Government can defer the decision to grant the concession extension from year X-5 to X-4 or X-3 or X-2 respectively.

According to the concessionaire's background information, the next step is to design the deferral development plan. The company had to drill at least 100 wells to hold the constant production rate and drill additional development wells in the year when there was a successful negotiation between the concessionaire and the government and in order to increase its production rate in year X (*The number of* *development wells can be calculated by production rate ratio).* The numbers of original development wells are provided in Table 4.5.

Table 4.5 Proposed development plan for extension approval in year X-5

Block	Development wells			
	X-5	X-4	X-3	X-2
A	45	29	55	57
B	54	39	7	106
C	52	45	47	57
D	32	27	37	13
total	183	140	146	233

The algorithm for deferral development plan for deferring the decision to extend the concession for 1 year is provided as follows.

First step: block production ratio calculation

Gas production for block A = 69,309 MMCF

Gas production for block B = 51,817 MMCF

Gas production for block C = 160,307 MMCF

Gas production for block D = 85,514 MMCF

Total gas production = 366,946 MMCF

% gas production for block A = $\frac{69,309}{366,946}$ x 100 = 19%

% gas production for block B = $\frac{51,817}{366,946}$ x 100 = 14%

% gas production for block C = $\frac{160,307}{366,946}$ x 100 = 44%

% gas production for block D = $\frac{85,514}{366,946}$ x 100 = 23%

Second step: Number of development wells for year X-5 calculation. From the background information, concessionaire has to drills at least 100 wells to hold the constant production rate.

Number of development wells for block A	=	19% x 100 = 19 wells
Number of development wells for block B	=	14% x 100 = 14 wells
Number of development wells for block C	=	44% x 100 = 44 wells
Number of development wells for block D	=	23% x 100 = 23 wells

Third step: Number of development wells for year X-4, X-3 and X-2 calculation. The additional development from year X-5 are added in the remaining 3 year, year X-4, X-3 and X-2 by averaging.

<u>Block A</u>

Additional development wells for block A	=	(45-19)/3 = 8.66 wells
Number of development wells in year X-4	=	29 + 8 = 37 wells
Number of development wells in year X-3	=	55 + 9 = 64 wells
Number of development wells in year X-2	=	57 + 9 = 66 wells

<u>Block B</u>

Additional development wells for block B	=	(54-14)/3 = 13.33 wells
Number of development wells in year X-4	=	39 + 13 = 52 wells
Number of development wells in year X-3	=	7 + 13 = 20 wells
Number of development wells in year X-2	=	106 + 14 = 120 wells

<u>Block C</u>

Additional development wells for block C	=	(52-44)/3 = 2.66 wells

Number of development wells in year X-4	=	45 + 3 = 48 wells
Number of development wells in year X-3	=	47 + 3 = 50 wells
Number of development wells in year X-2	=	57 + 2 = 59 wells

Block D

Additional development wells for block D	=	(32-23)/3 = 3 wells
Number of development wells in year X-4	=	27 + 3 = 30 wells
Number of development wells in year X-3	=	37 + 3= 40 wells
Number of development wells in year X-2	=	13 + 3 = 16 wells

According to the algorithm above, deferral development plan for year X-3 and X-2 are as same as deferral plan for year X-4. The deferral development plans are summarized in Table 4.6-4.8.

Table 4.6 Proposed development plan for extension approval in year X-4

Block	Development well			
	2007	2008	2009	2010
10	19	37	64	66
11	14	52	20	120
12	44	48	50	59
13	23	30	40	16
total	100[45]	167	174	261

[45] 100 wells are the minimum number of development well to maintain the production to meet the DCQ

Table 4.7 Proposed development plan for extension approval in year X-3

Block	Development well			
	2007	2008	2009	2010
10	19	23	71	73
11	14	10	41	141
12	44	45	52	60
13	23	22	44	20
total	100	100	208	294

Table 4.8 Proposed development plan for extension approval in year X-2

Block	Development well			
	2007	2008	2009	2010
10	19	23	28	116
11	14	10	11	171
12	44	45	36	76
13	23	22	25	39
total	100	100	100	402

According to Table 4.6 – 4.8, CAPEX in cash flow calculations are changed by changing number of development wells. After 10,000 times simulation, the EMV for concessionaire and government are summarized in Table 4.9 and 4.10.

Table 4.9 EMV and volatility of project under fiscal regime Thai I (MMUSD)

Extension year[46]	Concessionaire		Government	
	EMV	Volatility of project[47]	EMV	Volatility of project
X-4	20,199	931	21,135	923
X-3	20,201	948	21,139	944
X-2	20,201	952	21,139	942

[46] Extension year in the table stands for the year which the government decides to grant the concession extension.

[47] Volatility of project stands for standard deviation of the NPV distribution which is the result from Monte Carlo Simulation.

Table 4.10 EMV and volatility of project under fiscal regime Thai III (MMUSD)

Extension year	Concessionaire		Government	
	EMV	Volatility of project	EMV	Volatility of project
X-4	12,339	442	29,017	648
X-3	12,340	437	29,024	660
X-2	12,354	440	29,041	655

According to the deferral development plans in Table 4.6-4.8, the EMV for concessionaire and government in case of deferring the decision in concession extension, using Real Option Valuation, and from the simulation 10,000 iterations can be estimated. With the assumption of Real Option valuation under fiscal regime Thai I, the highest EMV of both concessionaire and government is the decision to start the extension of concession in the year X-2, which is same asunder fiscal regime Thai III. The results showed that the longer the government defers to grant the concession extension, the benefit-sharing increases between concessionaire and government because of effect of deferral option. Deferral option allows the government to defer the decision and to wait for the petroleum prices to increase.

4.4 Scenario Setting

According to previous models, this section provides two scenarios which consider the effect of investment cost escalation and petroleum volatility. The first scenario is Investment cost Escalation. This scenario compares the EMV for concessionaire and government in deferring the decision to extend the concession in case of no investment cost escalation with the case of investment cost escalation. The last scenario is Variation of petroleum prices volatility which analyzes the effect of petroleum prices volatility on project volatility including comparing the results of fiscal regime Thai I with that of Thai III.

4.4.1 Investment Cost Escalation

According to Real Option Valuation in which the decision can be deferred for 1 or 2 or 3 years, this scenario adds the effect of investment cost escalation to Real Option Valuation. The escalation rate of investment cost is assumed to be 2.5% per year from the concessionaire assumption. The investment cost (CAPEX) in the calculation increase 2.5% per year. From the previous model, deferral development plans are also used in this scenario. The EMV for concessionaire and government with escalation of investment cost are summarized in Table 4.11 and Table 4.12.

Table 4.11 EMV and volatility of project under fiscal regime Thai I with investment escalation

Extension year	Concessionaire			Government		
	Million USD		Percentage	Million USD		Percentage
	EMV	Volatility of project	% Volatility of project	EMV	Volatility of project	% Volatility of project
X-5	20,199	931	4.61	21,135	923	4.37
x-4	20,201	948	4.69	21,139	944	4.47
X-3	20,201	952	4.71	21,139	942	4.46
X-2	20,207	940	4.65	21,150	931	4.40

Table 4.12 EMV and volatility of project under fiscal regime Thai III with investment cost escalation

Extension year	Concessionaire			Government		
	MMUSD		Percentage	MMUSD		Percentage
	EMV	Volatility of project	% Volatility of project	EMV	Volatility of project	% Volatility of project
X-5	12,322	445	3.61	29,016	662	2.28
X-4	12,339	442	3.58	29,017	648	2.23
X-3	12,340	437	3.54	29,024	660	2.27
X-2	12,354	440	3.56	29,041	655	2.26

According to the Table 4.11 and Table 4.12, the EMV for concessionaire and government in case of deferring the decision in concession extension in Real Option Valuation and that from the simulation 10,000 iterations, can be estimated as same as the Real Option Valuation. With the assumption of investment cost Escalation scenario under fiscal regime Thai I, the highest EMV of both concessionaire and government is in the decision to start the extension of concession in the year X-5 or the first year, which is same asunder fiscal regime Thai III but from the previous model (*Real Option Valuation*) the highest EMV for both concessionaire and government is in year X-2. The results show that with no investment cost consideration, the longer the government defers the decision, the higher the benefit-sharing between concessionaire and government, whereas with investment cost escalation, the longer the government defers the decision, the benefit-sharing is less between concessionaire and government, because deferring the decision to extend the concession, the effects of deferral option drive the EMV for both concessionaire and government higher, but when deferring the decision with investment cost escalation, the effect of investment cost escalation is more than that of deferral option.

4.4.2 Variation of Petroleum Volatility

According to stochastic model, the volatility of petroleum prices is important factor in evaluation for alternatives of petroleum concession extension. Variation of petroleum volatility scenario provides the relationship between petroleum volatility and project volatility including compare the results under fiscal regime Thai I with Thai III.

Assumption for Variation of Petroleum Volatility

- 12% Discount rate
- 30% linear escalation of petroleum price
- K factor in calculation of SRB under fiscal regime Thai III is 150,000 m.
- 10%, 20%, 30% and 40% Volatility variation

After 10,000 iterations simulation, the volatility of the project is a result as of standard deviation of distribution. The volatility of project in each petroleum volatility under fiscal regime Thai I and Thai III is provide in Table 4.13 and Table 4.14.

Table 4.13 Variation of volatility under fiscal regime Thai I

%Petroleum volatility	Concessionaire			Government		
	EMV (MMUSD)	Volatility of project	% Volatility of project	EMV (MMUSD)	Volatility of project	% Volatility of project
10%	19,437	186	0.96	20,440	186	0.91
20%	19,439	372	1.91	20,441	372	1.82
30%	19,431	558	2.87	20,434	558	2.73
40%	19,434	758	3.90	20,438	757	3.70
50%	19,427	946	4.87	20,436	938	4.59

Table 4.14 Variation of volatility under fiscal regime Thai III

%Petroleum volatility	Concessionaire			Government		
	EMV (MMUSD)	Volatility of project	% Volatility of project	EMV (MMUSD)	Volatility of project	% Volatility of project
10%	11,811	87	0.74	28,068	131	0.47
20%	11,811	173	1.46	28,069	261	0.93
30%	11,807	266	2.25	28,080	399	1.42
40%	11,804	352	2.98	28,078	531	1.89
50%	11,802	429	3.63	28,073	651	2.32

According to Table 4.14 and Table 4.15, the petroleum prices volatility (input) affects the volatility of project (output) for both concessionaire and government. The more petroleum price volatility, the higher gets the project volatility, because in cash flow calculation, petroleum prices is cash inflow and the petroleum prices fluctuation drive the NPV of the project to fluctuate. The results also show that the volatility of project for both concessionaire and government under fiscal regime Thai III are more than volatility of project under fiscal regime Thai I because in cash flow calculation under fiscal regime Thai I, the royalty is fixed at 12.5% on gross revenue while under fiscal regime Thai III, the royalty slides on the scale from 0% to 15% and the SRB slides on the scale on petroleum profit. The results indicate that fiscal regime Thai III is more flexible than Thai I or fiscal regime Thai III is more robust than Thai I.

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the evaluation of alternatives for petroleum production concession extension in Thailand in by *Deterministic Model*, *Stochastic Models, Real Option Valuation and Scenario Setting*. The major factor in evaluation is fiscal regime. The government can decide to grant the concession extension under fiscal regime Thai I or Thai III. The available option in the assessment is the deferral option, which allows the evaluator to defer the extension of the concessions over a period of time. The effect of volatility on the evaluation under fiscal regime Thai I and Thai III are discussed as well. In addition, recommendations for further study have also been included.

5.1 Conclusions

5.1.1 Deterministic Model

As a result, NPV for concessionaire and government are positive under fiscal regime Thai I and Thai III. The government can decide to grant the concession extension under either fiscal regime Thai I or Thai III because concession extension using deterministic model is feasible for concessionaire investment. And NPV for government under fiscal regime Thai I is more than NPV for government under fiscal regime Thai III because under fiscal regime Thai I the royalty is used as tax deduction while under fiscal regime Thai III, royalty is used as Tax credit as shown in Table 5.1

Table 5.1 NPV for deterministic model under fiscal regime Thai I and Thai III

	Thai I	Thai III
	Million USD	Million USD
Net Revenue	9,312	9,312
Royalty	2,348	2,158
Net Tax	3,075	3,527
SRB	-	11
NPV of Government take	5,424	5,695
NPV of Concessionaire take	3,884	3,617

5.1.2 Stochastic Model

In deterministic model, petroleum prices are constant while petroleum prices escalation are available in stochastic model. The results shown that the concessionaire and government take more benefit-sharing in stochastic model with escalation of petroleum price consideration because the stochastic model concern volatility and escalation of petroleum prices and the effect of volatility and escalation of petroleum prices increase the benefit-sharing between concessionaire and the government. Table 5.2 provides EMV of concessionaire take and government take under fiscal regime Thai I and Thai III.

Table 5.2 EMV for Stochastic Model (MMUSD)

Fiscal regime	Concessionaire	Government
Thai I	20,199	21,135
Thai III	12,322	29,016

5.1.3 Real Option Valuation

As the results of Real Option Valuation under fiscal regime Thai I, the highest EMV of both concessionaire and government is the decision to start the extension of concession in the year X-2 – the same as was done under fiscal regime Thai III. It is indicated that that the longer the government defers to grant the concession extension, the more benefit-sharing is between concessionaire and the government's take as shown in Table 5.3.

Table 5.3 EMV for Real Option Valuation (MMUSD)

Extension year	Concessionaire		Government	
	Thai I	Thai III	Thai I	Thai III
X-4	20,199	12,339	21,135	29,017
X-3	20,201	12,340	21,139	29,024
X-2	20,201	12,354	21,139	29,041

5.1.4 Scenario Setting

As the results of Investment cost escalation scenario show that with no investment cost consideration, the longer government defers the decision, the higher is the benefit-sharing between concessionaire and government, whereas with investment cost escalation, the longer government defers the decision, benefit-sharing between concessionaire and government gets less and less. Table 5.4 provides the EMV of both concessionaire take and government take under fiscal regime Thai I and Thai III.

Table 5.4 EMV for Investment Cost Escalation (MMUSD)

Extension year	Concessionaire		Government	
	Thai I	Thai III	Thai I	Thai III
X-5	20,199	12,322	21,135	29,016
x-4	20,201	12,339	21,139	29,017
X-3	20,201	12,340	21,139	29,024
X-2	20,207	12,354	21,150	29,041

According to Variation of Petroleum Volatility scenario, the more petroleum price volatility, the highest project volatility and the volatility of project for both concessionaire and government under fiscal regime Thai III are more than volatility of projects under fiscal regime Thai I. It indicates that fiscal regime Thai III is more flexible than Thai I as shown in Table 5.5.

Table 5.5 Volatility of Project for Volatility Variation (Percentage)

Volatility of petroleum price	Concessionaire		Government	
	Thai I	Thai III	Thai I	Thai III
10%	0.96	0.74	0.91	0.47
20%	1.91	1.46	1.82	0.93
30%	2.87	2.25	2.73	1.42
40%	3.90	2.98	3.7	1.89
50%	4.87	3.63	4.59	2.32

5.2 Recommendations

As the results of *Deterministic Model*, *Stochastic Model*, *Real Option Valuation and Scenario Setting*, the three research questions are answered as follows:

Question 1: Should the government extend the concessions under fiscal regime Thai I or Thai III?

In the *Deterministic Model* (under constant petroleum price), the NPV for concessionaire and government are positive under fiscal regime Thai I and Thai III. The investment of concessionaire is feasible for both fiscal regimes same as was the case in the Stochastic model (with petroleum prices volatility and escalation), the EMV of both concessionaire and government is also positive. According to these results, the government can decide to grant the concession extension under fiscal regime Thai I and Thai III.

Question 2: When should the government extend these concessions?

According to the results of *Real Option Valuation* and *Investment Cost Escalation* scenario (with no investment cost escalation), the government may delay the decision to year X-2, because the longer the government defers the decision, the higher the benefit-sharing between concessionaire and government become, by effect of deferral option.

As the results of *Investment Cost Escalation*, thus the government may decide to grant concession extension at the first year (year X-5), because again, deferring the decision drives the benefit-sharing between concessionaire and government towards a decreasing phase. It indicates that the effect of investment cost escalation is more than the effect of deferral option.

From the conclusion above, the government may decide to grant the concession extension in the first year, because in the ground reality situation, the effect of investment cost escalation is definitely considered.

Question 3: Does volatility of petroleum prices affect the extension of concessions or not?

From the *Variation of Petroleum Prices Volatility* scenario, the volatility of petroleum prices affects the project's volatility. The more petroleum prices fluctuate, the higher volatility of the project goes. It is indicated that fiscal regime Thai III is more flexible than Thai I. Considering the petroleum price fluctuation, the government may decide to grant the concession extension under fiscal regime Thai III.

5.3 Limitations and Recommendations for further study

The evaluation in this study is based on the assumption that the production rate of all development wells are the same with the development plan provided in information background, and the 'K' value of SRB calculations in all blocks are constant at 150000 m. The volatility of gas prices is 50% in this study because of the direct effect of the world economic crisis on the pricing. The gas price was in the increasing trend with high volatility; although not same now anymore according to the current trend. All the assumptions used in this analysis are reasonable but are not the actual value in the ground reality situations. Finally, the conclusion is that, the fiscal regime Thai III is more flexible system than Thai I. Thus, further study of the flexibility of fiscal regime Thai III is highly recommended.

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APPENDICES

APPENDIX

A-1) Background Information

Table A-1.1 Background Information for block A

Block A	Year															
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Gas Sales (MMCF)	69,309	73,989	94,322	94,755	113,532	125,659	149,458	113,903	133,845	132,321	142,148	111,407	79,349	30,964	27,132	35,068
Liquids (mbo)	13,385	11,084	10,684	11,504	9,748	9,959	10,412	9,314	8,517	5,851	5,910	5,433	4,179	2,214	1,550	1,892
Opex ($mm)	80	71	82	87	94	108	136	109	124	118	138	119	96	56	50	48
Capex ($mm)	172	193	206	179	142	190	198	220	78	55	92	109	75	37	94	145
Abandonment ($mm)	1	1	3	2	2	2	3	3	0	1	2	2	3	-	1	303
Abandoned Wells	7	10	23	16	15	14	23	28	4	9	16	15	22	-	9	771
Development Wells	45	29	55	57	45	61	57	85	18	9	16	35	22	-	24	69
Delineation Wells	1	2	2	-	3	3	3	2	-	-	1	-	-	1	2	-
Meters Drilled	169,648	114,328	210,216	208,372	177,024	236,032	221,280	320,856	66,384	33,192	62,696	129,080	81,136	3,688	95,888	254,472
Meters Abandoned	25,816	36,880	84,824	57,164	55,320	51,632	84,824	103,264	14,752	33,192	59,008	55,320	81,136	-	33,192	2,841,604

Table A-1.2 Background Information for block B

Block B	Year															
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Gas Sales (mmcf)	51,817	34,016	35,934	44,192	99,609	107,022	77,066	120,060	107,029	89,531	64,117	130,695	175,476	259,374	239,296	200,417
Liquids (mbo)	1,635	3,726	4,099	3,649	5,525	5,938	5,153	5,149	4,583	4,378	3,546	5,436	6,405	8,513	7,232	6,212
Opex ($mm)	43	34	37	40	74	85	78	98	92	85	75	132	178	265	253	214
Capex ($mm)	183	187	93	302	176	167	161	213	146	178	184	151	479	442	305	201
Abandonment ($mm)	-	1	-	3	-	1	1	-	2	5	1	-	3	0	0	448
Abandoned Wells	-	6	-	26	-	5	5	-	14	41	6	-	25	3	4	1,149
Development Wells	54	39	7	106	49	55	48	66	48	61	73	6	160	139	71	60
Delineation Wells	1	1	1	4	4	2	3	4	1	3	1	7	8	5	5	-
Meters Drilled	191,455	139,240	27,848	381,170	184,493	198,417	177,531	243,670	170,569	222,784	257,594	45,253	584,808	501,264	264,556	208,860
Meters Abandoned	-	20,886	-	88,766	-	17,405	17,405	-	48,734	142,721	20,886	-	87,025	10,443	13,924	3,997,929

Table A-1.3 Background Information for block C

Block	Year															
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Gas Sales (mmcf)	160,307	151,010	118,239	110,588	154,865	141,386	134,017	118,907	107,326	125,268	142,291	115,600	100,950	56,065	87,041	135,114
Liquids (mbo)	4,637	4,238	3,143	3,171	4,542	3,696	3,714	3,476	3,257	4,124	4,689	3,502	2,693	1,635	2,758	4,395
Opex ($mm)	87	82	68	67	95	91	96	87	83	102	124	105	97	62	95	144
Capex ($mm)	202	191	176	174	52	175	218	219	263	331	214	198	148	224	326	211
Abandonment ($mm)	3	1	2	1	-	4	3	1	0	6	5	2	2	2	0	377
Abandoned Wells	26	11	18	7	-	32	28	8	3	47	41	13	15	17	4	1,244
Development Wells	52	45	47	57	1	64	69	61	92	129	68	70	44	58	104	77
Delineation Wells	3	1	3	1	1	2	4	5	4	4	3	2	2	7	6	-
Meters Drilled	201,190	168,268	182,900	212,164	7,316	241,428	267,034	241,428	349,339	486,514	257,889	261,547	168,268	237,770	402,380	281,666
Meters Abandoned	95,108	40,238	65,844	25,606	-	117,056	102,424	29,264	9,145	171,926	149,978	47,554	54,870	62,186	14,632	4,548,723

Table A-1.4 Background Information for block D

Block D	Year															
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Gas Sales (mmcf)	85,514	74,437	83,764	82,667	84,713	78,456	91,905	99,526	104,642	105,576	104,271	95,256	96,946	106,244	99,082	81,911
Liquids (mbo)	2,648	2,647	3,227	3,006	3,189	2,781	3,113	3,446	3,886	3,970	3,805	3,424	3,305	3,582	2,921	2,563
Opex ($mm)	51	44	52	53	56	55	71	75	84	89	95	90	96	111	106	88
Capex ($mm)	125	130	114	90	100	138	160	141	176	110	180	257	184	172	164	137
Abandonment ($mm)	-	1	2	-	-	-	2	-	0	2	7	7	0	2	0	282
Abandoned Wells	-	11	17	-	-	-	13	-	3	16	57	63	4	18	1	925
Development Wells	32	27	37	13	20	53	44	48	60	31	69	102	55	52	44	53
Delineation Wells	1	1	-	2	3	1	4	1	3	1	2	3	3	2	3	-
Meters Drilled	116,490	98,840	130,610	52,950	81,190	190,620	169,440	172,970	220,625	112,960	248,865	368,885	204,740	190,620	165,910	187,090
Meters Abandoned	-	38,830	60,010	-	-	-	45,890	-	8,825	56,480	201,210	222,390	14,120	63,540	3,530	3,263,485

A-2) Cash Flow Spreadsheet

Table A-2.1 Cash Flow Spreadsheet under fiscal regime Thai I

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Production Rate per year (mmcf)			366946	333452	332260	332202	452719	452523	452446	452397	452842	452696	452827	452958	452721	452647	452551	452510
Production Rate per year (mmbtu) (1050)			385293300	350124600	348873000	348812100	475354950	475149150	475068300	475016850	475484100	475330800	475468350	475605900	475357050	475279350	475178550	475135500
Gas Price (USD/BTU)			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Liquid (mbo)			22,305	21,696	21,154	21,330	23,003	22,374	22,391	21,385	20,244	18,324	17,949	17,795	16,582	15,944	14,461	15,062
Condensate price (USD/bbl)			40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
liquid revenue (mmUSD)			892	868	846	853	920	895	896	855	810	733	718	712	663	638	578	602
Opex (mmUSD)			262	231	239	246	319	339	381	369	383	393	432	447	467	494	505	495
Capex (mmUSD)			682	701	589	746	470	670	736	792	663	674	670	714	886	875	889	694
Abandonment (mmUSD)			4	5	7	6	2	6	8	4	3	13	14	11	8	5	2	1411
Number of Abandoned well			33	38	58	48	15	51	69	36	23	113	120	91	66	38	18	4087
Number of Development well			183	140	146	232	115	233	218	260	217	230	226	212	281	249	243	259
Number of Delineation well			6	5	6	7	11	8	14	12	8	8	6	12	13	15	16	17
Production Rate per day																		
Wells cost			190	146	153	240	128	243	235	274	227	240	233	226	297	267	262	279
Gross Revenue (MMUSD)			2503	2331	2304	2311	2907	2881	2881	2841	2797	2720	2705	2700	2650	2624	2565	2589
Royalty 12.5%			313	231	239	246	319	339	381	369	383	393	432	447	467	494	505	495
Net Revenue			2190	2100	2066	2065	2588	2542	2501	2472	2414	2327	2274	2253	2183	2130	2060	2094
DD&A (20%)			175	170	150	198	120	184	196	214	179	185	183	190	238	229	231	477
Tax deductions			437	577	734	940	1133	1161	1229	1281	1275	1350	1389	2574	2380	2228	2054	1860
Taxable Income			2066	1755	1570	1371	1774	1720	1653	1560	1522	1369	1316	126	271	396	511	728
Tax payment (50%)			1033	877	785	686	887	860	826	780	761	685	658	63	135	198	255	364
Net Tax			720	646	546	440	568	521	445	411	378	292	226	0	0	0	0	0
well cost+capex			876	852	749	992	600	919	979	1070	893	927	917	951	1191	1147	1153	2384
Net Income after Tax			1470	1454	1519	1626	2020	2021	2055	2061	2036	2035	2047	2253	2183	2130	2060	2094
Net cash flow after tax(-Capex-Opex)			332	371	531	387	1101	764	695	622	761	716	698	854	526	489	402	786
Investment			2484	2191	2012	2170	2125	2456	2567	2588	2420	2397	2439	1908	2260	2333	2419	3738
Company take			332	371	531	387	1101	764	695	622	761	716	698	854	526	489	402	786
Government take			1033	877	785	686	887	860	826	780	761	685	658	447	467	494	505	495
Government take			1033	877	785	686	887	860	826	780	761	685	658	447	467	494	505	495
check			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Discount rate	12.00%	sum	1365	1248	1316	1073	1988	1623	1522	1402	1522	1400	1356	1301	993	983	906	291
Revenue	18153																	
CAPEX	6542																	
OPEX	2303																	
Net Revenue	9307	#####																
Royalty	2348	25.23%																
Net Tax	3075	33.04%																
NPV of Government take	5424	58.27%																
NPV of Concessionnaire take	3884	41.73%																

Table A-2.2 Cash Flow Spreadsheet under fiscal regime Thai III for block A

block A	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Production Rate per year (MMCF)	69309	73,989	94,322	94,755	113,532	125,659	149,458	113,903	133,845	132,321	142,148	111,407	79,349	30,964	27,132	35,068
Production Rate per year (MMBTU) (1050MMBTU/M	72774450	77688847	99038411	99492730	119208116	131942124	156931222	119598600	140537128	138937203	149255132	116977314	83315987	32512607	28488506	36821630
Gas Price (USD/BTU) (20%Fuel Oil)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Liquid (MBO)	13,185	11,084	10,684	11,504	9,748	8,859	10,412	9,314	8,517	5,851	5,919	5,433	4,179	2,214	1,550	1,892
Liquid price (USD/bbl)	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
liquid revenue	535	443	427	460	390	398	416	373	341	234	236	217	167	89	62	76
Opex (MMUSD)	80	71	82	87	94	108	136	109	124	118	138	119	96	56	50	48
Capex (MMUSD)	172	193	206	179	142	190	198	220	78	55	92	109	75	37	94	145
Abandonment (MMUSD)	1	1	3	2	2	2	3	3	0	1	2	2	3	0	1	303
Total Production wells before this year	1460	1498	1517	1549	1590	1620	1667	1701	1758	1772	1772	1772	1792	1792	1792	1807
Number of Abandoned well	7	10	23	16	15	14	23	28	4	9	16	15	22	0	9	771
Number of Development well	45	29	55	57	45	61	57	85	18	9	16	35	22	-	24	69
Number of Delineation well	1	2	2	-	3	3	3	2	-	-	1	-	-	1	2	-
Total Production well	1498	1517	1549	1590	1620	1667	1701	1758	1772	1772	1772	1792	1792	1792	1807	1106
Meters drilled 3,688	169,648	114,328	210,216	208,372	177,024	236,032	221,280	320,856	66,384	33,192	62,696	129,080	81,136	3,688	95,888	254,472
Meters abandoned	25,816	36,880	84,824	57,164	55,320	51,632	84,824	103,264	14,752	33,192	59,008	55,320	81,136	-	33,192	2,841,604
Development Well and Delineation Well cost	46	31	57	57	49	65	61	87	18	9	17	35	22	1	26	69
Gross Revenue (MMUSD)	840	768	841	876	888	950	1072	872	928	815	860	706	515	224	181	230
Total Capex (MMUSD)	219	225	266	238	193	256	261	311	97	65	111	146	100	38	122	516
Equivalent bbl (10MMBTU/bbl)	7277445	7768885	9903841	9949273	11920812	13194212	15693122	11959860	14053713	13893720	14925513	11697731	8331599	3251261	2848851	3682163
Equivalent bbl per month	606454	647407	825320	829106	993401	1099518	1307760	996655	1171143	1157810	1243793	974811	694300	270938	237404	306847
0 - 60000 bbl 5.00%	4	4	3	3	3	3	2	3	2	2	2	2	2	2	2	2
60000 - 150000 bbl 6.25%	8	7	6	6	5	5	5	5	4	4	4	4	4	5	4	4
150000 - 300000 bbl 10.00%	21	18	15	16	13	13	12	13	12	11	10	11	11	12	11	11
300000 - 600000 bbl 12.50%	53	52	67	70	77	86	103	76	86	75	82	61	37	-3	-6	1
more than 600000 bbl 15.00%																
Royalty (Sliding Scale)							123	97	105	92	98	78	54	17	12	18
Royalty 12.5%	105	96	105	110	111	119										
Net Revenue (MMUSD)	840	768	841	876	888	950	950	776	823	723	762	628	461	208	169	211
DD&A (20%) (MMUSD)	44	45	53	48	39	51	52	62	19	13	22	29	20	8	24	103
Tax deductions (Opex+DD&A)	124	160	224	277	322	343	379	361	347	316	307	420	335	275	257	233
Taxable Income	716	608	617	600	567	607	556	415	468	407	456	208	126	67	88	21
Tax payment (50%)	358	304	309	300	283	303	278	207	234	203	228	104	63	0	0	0
net tax	253	208	203	190	172	185										
Net Income after Tax (MMUSD)	482	464	533	576	605	646	657	568	581	519	535	524	398	208	169	211
Net cash flow after tax(-Capex-Opex)	183	168	185	252	319	283	259	148	360	336	286	260	203	114	3	354
total meter drilled	1,879,651	1,993,979	2,204,195	2,412,567	2,589,591	2,825,623	3,046,903	3,367,759	3,434,143	3,467,335	3,530,031	3,659,111	3,740,247	3,743,935	3,839,823	4,094,295
net income before srb							552	356	603	539	514	364	266	114	3	354
Rate change from USD to THB (1USD=30THB)	5488064878.38	5035778831.44	5535526675.36	7549725086.71	9562851210.85	8490831328.80	16,571,701,344	10,673,475,567	18,080,739,448	16,177,916,443	15,411,152,445	10,914,367,749	7,973,725,587	3,416,914,092	85,977,761	10,606,591,503
total Project Profit (THB)	5488064878.38	10523843709.82	16059370385.18	23609095471.89	33171946682.74	41662778011.53	58,234,479,356	68,907,954,923	86,988,694,371	103,166,610,813	118,577,763,258	129,492,131,007	137,465,856,594	140,882,770,686	140,796,792,924	130,190,201,421
Project Profit/m (THB)	2703.95	2348.80	2351.35	2946.16	3490.61	2853.46	5183.67	3034.17	5044.65	4472.33	4187.78	2865.33	2049.67	877.50	-21.55	-2499.02
SBR check	2703.95	2348.80	2351.35	2946.16	3490.61	2853.46	5,184	3,034	5,045	4,472	4,188	2,865	2,050	877	0	
less than 4800 THB																
4800 - 14400 THB (increase percentage every 240	0.00	0.00	0.00	0.00	0.00	0.00	2	0	1	0	0	0	0	0	0	0
14400 - 33600 THB (increase percentage every 96	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0
more than 33,600 THB (increase percentage every	0.00	0.00	0.00	TRUE	0.00	0.00	0	0	0	0	0	0	0	0	0	0
%SRB	0.00	0.00	0.00	0.00	0.00	0.00	2	0	1	0	0	0	0	0	0	0
SRB (MMUSD)	0.00	0.00	0.00	0.00	0.00	0.00	15	0	8	0	0	0	0	0	0	0
Free Cash Flow FCF (MMUSD)	183	168	185	252	319	283	935	776	815	723	762	628	461	208	169	211
Company take	183	168	185	252	319	283	259	148	360	336	286	260	203	114	3	354
Government take	358	304	309	300	283	303	416	304	347	295	326	182	117	17	12	18
Government take	358	304	309	300	283	303	416	304	347	295	326	182	117	17	12	18

Discount rate	12.00%	
Revenue	5601	
CAPEX	1460	
OPEX	658	
Net Revenue	3482	100%
Royalty	669	19.22%
Net Tax	1315	37.76%
SRB	10	0.28%
NPV of Government take +	1994	57.26%
NPV of Concessionare block	1488	42.74%

Table A-2.3 Cash Flow Spreadsheet under fiscal regime Thai III for block B

block B		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Production Rate per year (MMCF)		51,817	34,016	35,934	44,192	99,609	107,022	77,066	120,060	107,029	89,531	64,117	130,695	175,476	259,374	239,296	200,417
Production Rate per year (MMBTU) (1050MMBTU/M		54407416	35716505	37731202	46401563	104589883	112373403	80919213	126063381	112380254	94007584	67322653	137229848	184249833	272342241	251261095	210437784
Gas Price (USD/BTU) (20%Fuel Oil)		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Liquid (MBO)		1,635	3,726	4,099	3,649	5,525	5,938	5,153	5,149	4,583	4,378	3,546	5,436	6,405	8,513	7,232	6,212
Liquid price (USD/bbl)		40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
liquid revenue		65	149	164	146	221	238	206	206	183	175	142	217	256	341	289	248
Opex (MMUSD)		43	34	37	40	74	65	78	98	92	85	75	132	178	265	253	214
Capex (MMUSD)		183	187	93	302	176	167	161	213	146	178	184	151	479	442	305	201
Abandonment (MMUSD)		0	1	0	3	0	1	1	0	2	5	1	0	3	0	0	448
Total Production wells before this year		1460	1514	1547	1554	1634	1683	1733	1776	1842	1876	1896	1963	1969	2104	2240	2307
Number of Abandoned well		0	6	0	26	0	5	5	0	14	41	6	0	25	3	4	1149
Number of Development well		54	39	7	106	49	55	48	66	48	61	73	6	160	139	71	60
Number of Delineation well		1	1	1	4	4	2	3	4	1	1	1	7	8	5	5	-
Total Production well		1514	1547	1554	1634	1683	1733	1776	1842	1876	1896	1963	1969	2104	2240	2307	1219
Meters drilled		191,455	139,240	27,848	381,170	184,493	198,417	177,531	243,670	170,569	222,784	257,594	45,253	584,808	501,264	264,556	208,860
Meters abandoned		-	20,886	-	88,566	-	17,405	17,405	-	48,734	142,721	20,886	-	87,025	10,443	13,924	3,997,929
Development Well and Delineation Well cost		55	40	8	110	54	57	52	71	49	65	74	14	170	145	77	60
Gross Revenue (MMUSD)		293	298	322	340	658	707	544	733	653	568	423	791	1026	1479	1340	1128
Total Capex (MMUSD)		238	228	101	415	230	225	213	284	197	247	259	165	652	587	382	709
Equivalent bbl (10MMBTU/bbl)		5440742	3571650	3773120	4640156	10458988	11237340	8091921	12606338	11238025	9400758	6732265	13722985	18424983	27234224	25126110	21043778
Equivalent bbl per month		453395	297638	314427	386680	871582	936445	674327	1050528	936502	783397	561022	1143582	1535415	2269519	2093842	1753648
0 - 60000 bbl	5.00%	2	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2
60000 - 150000 bbl	6.25%	4	6	6	5	4	4	5	4	4	4	4	4	4	4	4	4
150000 - 300000 bbl	10.00%	10	15	15	13	11	11	12	10	10	11	11	10	10	10	10	10
300000 - 600000 bbl	12.50%	12	0	2	10	54	60	38	65	55	44	25	73	103	160	143	117
more than 600000 bbl	15.00%																
Royalty (Sliding Scale)		28	23	26	30	72	78	57	82	72	61	42	89	119	176	159	132
Royalty 12.5%		37	37	40	42	82	88	68	92	82	71	53	99	128	185	167	141
Net Revenue (MMUSD)		265	275	296	310	586	629	488	651	581	507	381	702	907	1303	1181	996
DD&A (20%) (MMUSD)		48	46	20	83	46	45	43	57	39	49	52	33	130	117	76	142
Tax deductions (Opex+DD&A)		91	127	151	236	316	325	315	371	322	318	315	829	817	865	804	711
Taxable Income		202	171	171	104	342	383	173	280	259	189	66	127	90	438	377	283
Tax payment (50%)		101	86	86	52	171	191	86	140	130	95	33	0	45	219	189	141
net tax		64	48	45	9	89	103										
Net Income after Tax (MMUSD)		192	213	236	288	487	516	401	511	452	412	348	702	862	1084	992	855
Net cash flow after tax(-Capex-Opex)		89	49	98	167	184	206	110	129	162	81	14	404	33	232	357	69
total meter drilled		1,901,458	2,040,698	2,068,546	2,449,715	2,634,208	2,832,625	3,010,156	3,253,826	3,424,395	3,647,179	3,904,773	3,950,026	4,534,834	5,036,098	5,300,654	5,509,514
net income before srb								196	269	292	175	47	404	78	451	546	71
Rate change from USD to THB (1USD=30THB)		-2681315160.96	-1480718778.50	2930945877.48	-5002716983.46	5508109255.77	6193295585.18	5,887,214,700	8,078,365,446	8,759,061,482	5,256,744,904	1,411,463,878	12,126,656,176	2,333,178,788	13,533,443,998	16,368,747,981	2,184,776,582
total Project Profit (THB)		-2681315160.96	-4162033939.46	-1231088061.98	-6233805045.44	-725695789.68	5467599795.51	11,354,814,495	19,433,179,942	28,192,241,423	33,448,986,328	34,860,450,205	46,987,106,381	49,320,285,169	62,853,729,167	79,222,477,148	81,407,253,730
Project Profit/m (THB)		-1307.03	-675.91	1321.11	-1924.33	1978.34	2076.46	1862.95	2373.32	2450.50	1384.38	348.10	2957.70	498.03	2609.56	3003.08	386.04
SBR check		0.00	0.00	1321.11	0.00	1978.34	2076.46	1,863	2,373	2,451	1,384	348	2,958	498	2,610	3,003	386
less than 4800 THB																	
4800 - 14400 THB (increase percentage every 240		0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0
14400 - 33600 THB (increase percentage every 96		0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0
more than 33,600 THB (increase percentage every		0.00	0.00	0.00	TRUE	0.00	0.00	0	0	0	0	0	0	0	0	0	0
%SRB		0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0
SRB (MMUSD)		0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0
Free Cash Flow FCF (MMUSD)		89	49	98	167	184	206	488	651	581	507	381	702	907	1303	1181	996
Company take		89	49	98	167	184	206	110	129	162	81	14	404	33	232	357	69
Government take		101	86	86	52	171	191	143	222	201	156	75	89	164	395	347	274
Government take		101	86	86	52	171	191	143	222	201	156	75	89	164	395	347	274

Investment		
Discount rate	12.00%	
Revenue	3928	
CAPEX	1908	
OPEX	570	
Net Revenue	1451	100%
Royalty	463	31.90%
Net Tax	531	36.63%
SRB	0	0.00%
NPV of Government take +	994	68.53%
NPV of Concessionaire block	457	31.47%

Table A-2.4 Cash Flow Spreadsheet under fiscal regime Thai III for block C

block C		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Production Rate per year (MMCF)		160,307	151,010	118,239	110,588	154,865	141,386	134,017	118,907	107,328	125,268	142,291	115,600	100,950	56,065	87,041	135,114
Production Rate per year (MMBTU) (1050MMBTU/N		168322202	158560106	124151442	116117564	162608184	148455480	140717423	124852071	112692267	131531400	149405222	121380066	105997369	58868398	91393148	141869569
Gas Price (USD/BTU) (20%Fuel Oil)		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Liquid (MBO)		4,637	4,238	3,143	3,171	4,542	3,696	3,734	3,478	3,257	4,124	4,689	3,502	2,693	1,635	2,758	4,395
Liquid price (USD/bbl)		40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
liquid revenue		185	170	126	127	182	148	149	139	130	165	188	140	108	65	110	176
Opex (MMUSD)		87	82	68	67	95	91	96	87	83	102	124	105	97	62	95	144
Capex (MMUSD)		202	191	176	174	52	175	218	219	263	331	214	198	148	224	326	211
Abandonment (MMUSD)		3	1	2	1	0	4	3	1	0	6	5	2	2	2	0	377
Total Production wells before this year		1460	1486	1520	1549	1599	1600	1632	1673	1726	1815	1897	1924	1981	2010	2051	2151
Number of Abandoned well		26	11	18	7	0	32	28	8	3	47	41	13	15	17	4	1244
Number of Development well		52	45	47	37	1	64	89	61	92	129	88	70	44	78	104	77
Number of Delineation well		3	1	1	1	1	2	4	5	4	4	3	2	2	7	6	-
Total Production well		1486	1520	1549	1599	1600	1632	1673	1726	1815	1897	1924	1981	2010	2051	2151	984
Meters drilled		201,190	168,268	182,900	212,164	7,316	241,428	267,034	241,428	349,339	486,514	257,889	261,547	168,268	237,770	402,380	281,666
Meters abandoned		95,108	40,238	45,844	27,606	-	117,056	102,424	28,264	9,145	171,926	149,978	47,554	54,870	62,186	14,632	4,348,723
Development Well and Delineation Well cost		56	46	51	58	2	66	74	67	96	134	71	72	46	66	111	77
Gross Revenue (MMUSD)		889	832	645	612	861	768	737	661	601	715	812	647	551	311	492	769
Total Capex (MMUSD)		261	239	229	233	54	246	295	286	359	470	290	271	197	293	437	666
Equivalent bbl (10MMBTU/bbl)		16832220	15856011	12415144	11611756	16260818	14845548	14071742	12485207	11269227	13153140	14940522	12138007	10599737	5886840	9139315	14186957
Equivalent bbl per month		1402685	1321334	1034595	967646	1355068	1237129	1172645	1040434	939102	1096095	1245044	1011501	883311	490570	761610	1182246
0 - 60000 bbl	5.00%	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
60000 - 150000 bbl	6.25%	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4
150000 - 300000 bbl	10.00%	10	9	9	9	10	9	9	10	10	10	10	10	9	10	10	10
300000 - 600000 bbl	12.50%	87	80	57	53	84	73	69	59	51	65	77	57	45	15	37	72
more than 600000 bbl	15.00%																
Royalty (Sliding Scale)		102	95	72	68	99	87	83	74	66	80	92	72	60	30	53	87
Royalty 12.5%		111	104	81	77	108	96	92	83	75	89	102	81	69	39	62	96
Net Revenue (MMUSD)		787	737	573	544	763	681	653	587	535	634	720	575	491	281	440	682
DD&A (20%) (MMUSD)		52	48	46	47	11	49	59	57	72	94	58	54	39	59	87	133
Tax deductions (Opex+DD&A)		139	182	213	259	299	292	307	310	331	433	465	759	693	587	526	517
Taxable Income		750	650	431	353	563	477	346	278	204	201	255	184	203	306	86	165
Tax payment (50%)		375	325	216	177	281	238	173	139	102	101	128	0	0	0	0	83
net tax		264	221	135	100	174	142										
Net Income after Tax (MMUSD)		514	507	429	436	580	530	480	448	433	534	592	575	491	281	440	599
Net cash flow after tax(-Capex-Opex)		166	187	133	136	431	193	89	75	9	38	178	199	197	74	93	210
total meter drilled		1,911,193	2,079,461	2,262,361	2,474,525	2,481,841	2,723,269	2,990,303	3,231,731	3,581,070	4,067,584	4,325,473	4,587,020	4,755,288	4,993,058	5,395,438	5,677,104
net income before srb								262	214	93	62	305	199	197	74	93	128
Rate change from USD to THB (1USD=30THB)		4975955851.36	5595384748.44	3978704330.09	4072604005.65	12921181250.52	5784399638.47	7,869,185,243	6,417,843,699	2,782,856,438	1,864,097,959	9,155,131,871	5,966,429,643	5,922,451,419	2,208,101,512	2,789,110,124	3,836,425,284
total Project Profit (THB)		4975955851.36	10571340599.80	14550044929.89	18622648935.54	31543830186.06	37328229824.54	45,197,415,068	51,615,258,767	54,398,115,205	56,262,213,165	65,417,345,036	71,383,774,679	77,306,226,098	75,098,124,586	72,309,014,462	68,472,589,178
Project Profit/m (THB)		2414.11	2509.75	1649.30	1551.75	4909.56	2013.18	2505.87	1897.80	745.86	441.98	2045.62	1259.53	1207.36	-429.34	-502.96	-658.38
SBR check		2414.11	2509.75	1649.30	1551.75	4909.56	2013.18	2,506	1,898	746	442	2,046	1,260	1,207	0	0	0
less than 4800 THB																	
4800 - 14400 THB (increase percentage every 240		0.00	0.00	0.00	0.00	0.46	0.00	0	0	0	0	0	0	0	0	0	0
14400 - 33600 THB (increase percentage every 96		0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0
more than 33,600 THB (increase percentage every		0.00	0.00	0.00	TRUE	0.00	0.00	0	0	0	0	0	0	0	0	0	0
%SRB		0.00	0.00	0.00	0.00	0.46	0.00	0	0	0	0	0	0	0	0	0	0
SRB (MMUSD)		0.00	0.00	0.00	0.00	-1.97	0.00	0	0	0	0	0	0	0	0	0	0
Free Cash Flow FCF (MMUSD)		166	187	133	136	431	193	653	587	535	634	720	575	491	281	440	682
Company take		166	187	133	136	431	193	89	75	9	38	178	199	197	74	93	210
Government take		375	325	216	177	281	238	256	213	168	181	220	72	60	30	53	170
Government take		375	325	216	177	281	238	256	213	168	181	220	72	60	30	53	170

Investment		
Discount rate	12.00%	
Revenue	5035	
CAPEX	1866	
OPEX	614	
Net Revenue	2555	100%
Royalty	604	23.64%
Net Tax	996	38.97%
SRB	1	0.04%
NPV of Government take +	1600	62.61%
NPV of Concessionare block	956	37.39%

Table A-2.5 Cash Flow Spreadsheet under fiscal regime Thai III for block D

block D		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Production Rate per year (MMCF)		83,314	74,437	83,784	82,667	84,713	78,436	91,905	99,528	104,642	105,576	104,271	95,256	96,946	106,244	99,082	81,911
Production Rate per year (MMBTU) (1050MMBTU/M		89789487	78159047	87952282	86800137	88948732	82378390	96499955	104502694	109874182	110855063	109484944	100018669	101793595	111555691	104035608	86006091
Gas Price (USD/BTU) (20%Fuel Oil)		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Liquid (MBO)		2,648	2,647	3,227	3,006	3,189	2,781	3,113	3,446	3,886	3,970	3,805	3,424	3,305	3,582	2,921	2,563
Liquid price (USD/bbl)		40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
liquid revenue		106	106	129	120	128	111	125	138	155	159	152	137	132	143	117	103
Opex (MMUSD)		51	44	52	53	56	55	71	75	84	89	95	90	96	111	106	88
Capex (MMUSD)		125	130	114	90	100	138	160	141	176	110	180	257	184	172	164	137
Abandonment (MMUSD)		0	1	2	0	0	0	2	0	0	2	7	7	0	2	0	282
Total Production wells before this year		1460	1492	1508	1528	1541	1561	1614	1645	1693	1750	1765	1777	1816	1867	1901	1944
Number of Abandoned well		0	11	17	0	0	0	13	0	3	16	57	63	4	18	1	925
Number of Development well		32	27	37	13	20	53	44	48	60	31	69	102	55	32	44	53
Number of Delineation well		1	1	-	2	1	1	4	1	3	1	2	3	3	2	3	-
Total Production well		1492	1508	1528	1541	1561	1614	1645	1693	1750	1765	1777	1816	1867	1901	1944	1072
Meters drilled		116,490	98,840	130,610	52,950	81,190	190,620	169,440	172,970	220,625	112,980	248,865	368,885	204,740	190,620	165,910	187,090
Meters abandoned		-	18,830	60,010	-	-	-	45,890	-	8,825	56,480	201,210	222,390	14,120	63,540	3,530	3,263,485
Development Well and Delineation Well cost		33	28	37	15	24	54	49	49	63	32	71	105	59	54	48	53
Gross Revenue (MMUSD)		481	433	497	483	499	456	528	575	615	622	610	555	558	610	552	462
Total Capex (MMUSD)		159	160	153	106	123	192	210	190	239	145	258	369	243	228	212	472
Equivalent bbl (10MMBTU/bbl)		8978949	7815905	8795228	8680014	8894873	8237839	9649995	10450269	10987418	11085506	10948494	10001867	10179360	11155569	10403561	8600609
Equivalent bbl per month		748246	651325	732936	723334	741239	686487	804166	870856	915618	923792	912375	833489	848280	929631	866963	716717
0 - 60000 bbl	5.00%	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
60000 - 150000 bbl	6.25%	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
150000 - 300000 bbl	10.00%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
300000 - 600000 bbl	12.50%	36	29	37	35	37	32	41	47	52	53	51	44	45	52	45	34
more than 600000 bbl	15.00%																
Royalty (Sliding Scale)		51	45	53	51	53	48	57	63	68	68	67	60	61	67	60	49
Royalty 12.5%		60	54	62	60	62	57	66	72	77	78	76	69	70	76	69	58
Net Revenue (MMUSD)		430	388	444	432	446	408	471	512	547	554	543	495	497	542	492	413
DD&A (20%) (MMUSD)		32	32	31	21	25	38	42	38	48	29	52	74	49	46	42	94
Tax deductions (Opex+DD&A)		83	108	146	168	196	202	228	240	275	284	303	562	529	496	463	393
Taxable Income		398	325	350	315	303	253	243	272	273	270	240	67	32	46	29	20
Tax payment (50%)		199	162	175	157	152	127	122	136	136	135	120	0	0	23	14	10
net tax		139	108	113	97	89	70										
Net Income after Tax (MMUSD)		282	270	322	326	348	329	349	376	411	419	423	495	497	519	477	403
Net cash flow after tax(-Capex-Opex)		72	66	116	167	168	81	69	111	88	186	71	35	158	180	159	157
total meter drilled		1,826,493	1,925,333	2,055,943	2,108,893	2,190,083	2,380,703	2,550,143	2,723,113	2,943,738	3,056,698	3,305,563	3,674,448	3,879,188	4,069,808	4,235,718	4,422,808
net income before srb								191	247	224	321	190	35	158	203	173	147
Rate change from USD to THB (1USD=30THB)		2171619437.24	1982159739.99	3487872978.99	5016105677.70	5051744455.84	2438962366.90	5,715,769,583	7,402,116,059	6,734,080,321	9,617,813,185	5,713,049,307	1,055,387,234	4,747,277,284	6,101,367,352	5,195,906,033	4,423,426,582
total Project Profit (THB)		2171619437.24	4153779177.23	7641652156.22	12657757833.92	17709502289.76	20148464656.67	25,864,234,239	33,266,350,299	40,000,430,620	49,618,243,805	55,331,293,112	56,386,680,346	61,133,957,630	67,235,324,982	72,431,231,015	68,007,804,433
Project Profit/m (THB)		1098.72	955.10	1581.13	2220.60	2158.79	963.75	2116.84	2576.34	2176.68	2999.29	1653.29	275.96	1178.22	1445.89	1184.73	-967.33
SRB check		1098.72	955.10	1581.13	2220.60	2158.79	963.75	2,117	2,576	2,177	2,999	1,653	276	1,178	1,446	1,185	0
less than 4800 THB																	
4800 - 14400 THB (increase percentage every 240		0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0
14400 - 33600 THB (increase percentage every 96		0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0
more than 33,600 THB (increase percentage every		0.00	0.00	0.00	TRUE	0.00	0.00	0	0	0	0	0	0	0	0	0	0
%SRB		0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0
SRB (MMUSD)		0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0
Free Cash Flow FCF (MMUSD)		72	66	116	167	168	81	471	512	547	554	543	495	497	542	492	413
Company take		72	66	116	167	168	81	69	111	88	186	71	35	158	180	159	157
Government take		199	162	175	157	152	127	179	199	204	203	187	60	61	90	75	59
Government take		199	162	175	157	152	127	179	199	204	203	187	60	61	90	75	59

Investment		
Discount rate	12.00%	
Revenue	3589	
CAPEX	1304	
OPEX	461	
Net Revenue	1823	100%
Royalty	422	23.16%
Net Tax	685	37.56%
SRB	0	0.00%
NPV of Government take +	1107	60.72%
NPV of Concessionaire blocl	716	39.28%

A-3) Summarized Distribution

Table A-3.1 EMV of concessionaire take under fiscal regime Thai I for Real Option Valuation

Extension year*	Concessionaire		
	EMV*	volatility of project*	% volatility of project
X-4	20199	931	4.61%
X-3	20201	948	4.69%
X-2	20201	952	4.71%

Table A-3.2 EMV of government take under fiscal regime Thai I for Real Option Valuation

Extension year*	Government		
	EMV*	volatility of project*	% volatility of project
X-4	21135	923	4.37%
X-3	21139	944	4.47%
X-2	21139	942	4.46%

*MMUSD

Table A-3.3 EMV of concessionaire take under fiscal regime Thai III for Real Option Valuation

Extension year*	Concessionaire		
	EMV*	volatility of project*	% volatility of project
X-4	12339	442	3.58%
X-3	12340	437	3.54%
X-2	12354	440	3.56%

*MMUSD

Table A-3.4 EMV of government take under fiscal regime Thai I for Real Option Valuation

Extension year*	Government		
	EMV*	volatility of project*	% volatility of project
X-4	29017	648	2.23%
X-3	29024	660	2.27%
X-2	29041	655	2.26%

*MMUSD

Table A-3.5 EMV of concessionaire take under fiscal regime Thai I for Investment Escalation

Extension year*	Concessionaire		
	EMV*	volatility of project*	% volatility of project
X-5	20199	931	4.61%
x-4	20201	948	4.69%
X-3	20201	952	4.71%
X-2	20207	940	4.65%

*MMUSD

Table A-3.6 EMV of government take under fiscal regime Thai I for Investment Escalation

Extension year*	Government		
	EMV*	volatility of project*	% volatility of project
X-5	21135	923	4.37%
x-4	21139	944	4.47%
X-3	21139	942	4.46%
X-2	21150	931	4.40%

*MMUSD

Table A-3.7 EMV of concessionaire take under fiscal regime Thai III for Investment Escalation

Extension year*	Concessionaire		
	EMV*	volatility of project*	% volatility of project
X-5	12322	445	3.61%
X-4	12339	442	3.58%
X-3	12340	437	3.54%
X-2	12354	440	3.56%

*MMUSD

Table A-3.8 EMV of government take under fiscal regime Thai III for Investment Escalation

Extension year*	Government		
	EMV*	volatility of project*	% volatility of project
X-5	29016	662	2.28%
x-4	29017	648	2.23%
X-3	29024	660	2.27%
X-2	29041	655	2.26%

*MMUSD

Table A-3.9 EMV of concessionaire take under fiscal regime Thai I for Volatility Variation

%Petroleum volatility	Concessionaire		
	EMV*	volatility of project*	% volatility of project
10%	19437	186	0.96%
20%	19439	372	1.91%
30%	19431	558	2.87%
40%	19434	758	3.90%

*MMUSD

Table A-3.10 EMV of government take under fiscal regime Thai I for Volatility Variation

%Petroleum volatility	Government		
	EMV*	volatility of project*	% volatility of project
10%	20440	186	0.91%
20%	20441	372	1.82%
30%	20434	558	2.73%
40%	20438	757	3.70%

*MMUSD

Table A-3.11 EMV of concessionaire take under fiscal regime Thai III for Volatility Variation

%Petroleum volatility	Concessionaire		
	EMV*	volatility of project*	% volatility of project
10%	11811	87	0.74%
20%	11811	173	1.46%
30%	11807	266	2.25%
40%	11804	352	2.98%

*MMUSD

Table A-3.12 EMV of government take under fiscal regime Thai III for Volatility Variation

%Petroleum volatility	Government		
	EMV*	volatility of project*	% volatility of project
10%	28068	131	0.47%
20%	28069	261	0.93%
30%	28080	399	1.42%
40%	28078	531	1.89%

*MMUSD

APPENDIX B

B) Historical data

Table B-1 Historical 20% of Fuel oil Price

week	price	week	price	week	price	week	price	week	price	week	price	year	mean		
1	7.84	27	8.42	53	8.78	79	9.74	105	12.52	131	13.15	2004	8.72	SD 3 year	2.408859
2	7.84	28	8.44	54	7.24	80	9.74	106	14.72	132	13.74	2005	10.16		
3	7.84	29	8.43	55	8.21	81	9.77	107	14.39	133	13.09	2006	13.42		
4	7.84	30	8.60	56	8.21	82	9.77	108	13.76	134	12.74				
5	7.50	31	9.06	57	8.21	83	9.77	109	13.01	135	13.82				
6	7.55	32	9.36	58	8.21	84	9.77	110	13.98	136	13.74				
7	7.57	33	9.36	59	8.97	85	9.77	111	14.40	137	13.74				
8	7.50	34	9.36	60	8.97	86	9.77	112	13.96	138	13.09				
9	7.54	35	9.35	61	8.75	87	9.77	113	13.12	139	12.74				
10	7.59	36	9.35	62	8.88	88	9.77	114	13.09	140	12.74				
11	7.54	37	9.34	63	8.88	89	9.73	115	13.14	141	13.74				
12	7.72	38	9.34	64	8.88	90	9.73	116	13.15	142	13.74				
13	7.72	39	9.09	65	9.62	91	9.72	117	12.28	143	13.09				
14	7.61	40	9.54	66	9.91	92	9.77	118	13.19	144	12.74				
15	7.84	41	9.54	67	9.91	93	9.73	119	13.58	145	13.82				
16	7.84	42	9.59	68	9.91	94	9.73	120	13.17	146	13.74				
17	8.93	43	9.59	69	9.94	95	9.72	121	14.72	147	13.74				
18	8.91	44	9.58	70	9.87	96	13.82	122	14.39	148	13.09				
19	8.91	45	10.05	71	9.87	97	13.74	123	13.76	149	12.74				
20	8.91	46	9.67	72	9.85	98	13.74	124	13.01	150	12.74				
21	9.00	47	9.60	73	9.82	99	13.09	125	13.98	151	12.74				
22	8.93	48	9.60	74	9.79	100	12.74	126	14.40	152	12.74				
23	8.91	49	9.60	75	9.79	101	14.72	127	13.96	153	13.27				
24	8.91	50	9.14	76	9.79	102	14.39	128	13.12	154	12.74				
25	8.91	51	9.14	77	9.76	103	13.76	129	13.09	155	13.82				
26	8.56	52	9.39	78	9.75	104	13.01	130	13.14	156	13.74				

VITAE

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