Chapter 2.

Theoretical Considerations

This chapter will explain the theoretical considerations that relevant to this thesis. Theories that are applied for this study, consist of Feasibility study, Transportation problem and Sensitivity analysis.

2.1 Theoretical Considerations

2.1.1 Feasibility Study

The objective of feasibility study is to provide the basic information for deciding whether to begin and continue project or not. It also helps decision-makers to select the most desirable alternatives among the others.

The objective of feasibility study is not to find out whether the project is good enough to be financed but to determine the best alternative under specified conditioned.

Feasibility study must contain commercial, marketing, technical, financial, and economic analysis of critical elements that concern production or operation of products or services. Each elements is evaluated not only separately but also in relation to all the others. It means that selection of the right technical aspect will depend on the scope of the market or demand and supply of products or services, capacity of agency, and attitude and behaviour of consumers and producers.

Feasibility should define production capacity at selected location, technologies, materials and inputs to be used, investment and production costs, sales revenue, and return on investment.

Most feasibility studies have the same or similar areas of study even though each project has different magnitude, complexity and nature. Regardless these factors, feasibility study have to answer the following basic questions. (Baum, Warren C., Tolbert, and Stoke M., 1985)

- Does the project act accordance with development objectives and priorities of country?
- Is the relevant policy framework compatible with achievement of project's objectives?

- Is the project technically sound and is it the best available technical options?
- Can the project administrative be done?
- Is there enough demand for the output of project?
- Is the project economically justified and financially successful operation?
- Is the project environmentally sound?
- Is the project compatible with the traditions and customs of the beneficiaries?

It should bear in mind that the large project will be required more information than the small project. Iterative process with feedback loops and interlinkages should be launched in order to achieve all above objectives.

When technical aspect in feasibility study is evaluated, it should be done only in preliminary engineering considerations. Since detailed engineering is time consuming and cost a lot of money, it should be done after project is selected to proceed.

Economic analysis of benefits and costs should be conducted to the point that economic rate of retum can be calculated with a reasonable recommended degree of accuracy. The analysis should discover whether the demand of project will make the output to be sold at prices that are pay. The project selection criteria that normally use for financial and economic analysis will explain in Chapter 5.

Financial analysis should discover the financial attractiveness to investors, intended participants, and beneficiaries. It should give general outline of a financial plan to make sure that there are available funds to operate the project. Feasibility study may define further actions that should be done otherwise objectives of project and successful in operation may not be achieved.

Other aspects such as institutional, environment, and managerial should be conducted in feasibility analysis since they have an important effect on successful of project.

Feasibility study can be base on market oriented or material inputs. That means initiatives of feasibility study come from an assumed or existing demand or form available material inputs.

Feasibility study is not the end process but it arrives at a decision on investment that is not necessary to have the same conclusion as in this study. It is rarely find that decision of investors is fully conformed the results of feasibility study.

In addition, Feasibility study of this project will concentrate on three elements that are marketing, technical and economic analysis.

2.1.2 Transportation Problem

Transportation Problem is a specific case of linear programming. The transportation problem is one in which the purpose for minimization is the cost of transporting a certain product or service from number of sources or origins to number of destinations. This problem deals with the product's transporting that the distance and distribution cost are difference. Primarily, the distribution cost depends on the distance between source *i* and destination *j*. The task is then to minimize the overall transportation cost subject to the demand and supply restrictions for the products or services.

In general, a product is available in known quantities at each of *m* sources (eg. warehouse or oil depot) and it is required in known quantities at each of *n* destinations (eg. factories or end users). Let a_i be the amount of a product available at source *i* ($i = 1,2,\ldots,m$), and b_j be the amount required at destination *j* ($j = 1,2,\ldots,n$). Let c_{ij} be the cost per unit of transporting the product from sources *i* to destination *j*. The objective is to determine the amount of product (x_{ij}) transported from sources *i* to destination *j* such that the total transportation costs are minimized.

Mathematically, the transportation problem with *m* sources and *n* destinations can be expressed as follows:

$$\text{Minimize} \quad C = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}\,x_{ij}$$

$$\text{Subject to} \quad \sum_{j}^{n} x_{ij} = a_i \qquad i = 1,2,\ldots,m \quad \text{(limited supplies)}$$

$$\sum_{j}^{m} x_{ij} = b_j \qquad j = 1,2,\ldots,n \quad \text{(known demands)}$$

$$\text{and} \quad x_{ij} \geq 0, \qquad i = 1,2,\ldots,m;\ j = 1,2,\ldots,n$$

In addition, it is important to note that the total demand equals to total supply. Furthermore, the assumption ;

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$$

The transportation method uses a transportation tableau. In this tableau, the sources are shown as rows, and the destinations are shown as columns.

Several methods are available for finding an initial feasible solution to a transportation problem. Four commonly used methods are presented in this section.

From	To	Destination "j" 1	2	3	...	n	Amount available a_i
Source "i"	1	x_{11} c_{11}	x_{12} c_{12}	x_{13} c_{13}	...	x_{1n} c_{1n}	a_1
	2	x_{21} c_{21}	x_{22} c_{22}	x_{23} c_{23}	...	x_{2n} c_{2n}	a_2
	3	x_{31} c_{31}	x_{32} c_{32}	x_{33} c_{33}	...	x_{3n} c_{3n}	a_3
	...	...	...	...	...	...	...
	m	x_{m1} c_{m1}	x_{m2} c_{m2}	x_{m3} c_{m3}	...	x_{mn} c_{mn}	a_m
Amount Required b_j		b_j	b_j	b_j	...	b_j	

Table 2.1 Transportation tableau. (S.S. Rao, 1979)

(1) *North-West Corner Rule*

The first method is the simplest one because it does not consider transportation costs.

According to this rule, allocate the maximum amount possible to the variable x_{11} (the variable in the northwest corner of the transportation array) such that the constraints of the first source (row) and the first destination (column) are not violated. The satisfied row (column) is then deleted indicating that the remaining variables in the deleted row (column) are zero. If both the row and the column are satisfied simultaneously, either one may be deleted. The first uncrossed element (again the one in the northwest corner) in the next row (column) is then selected and the maximum permissible amount is allocated to it. Again the satisfied row (column) is deleted. This procedure is continued until all the rows and columns are deleted. It

is to be noted that in the last stage, one row and one column remain and both these must be deleted after the last variable is assigned a value.

The method just presented is simple and easy to apply. However, it does not give a good solution because the procedure does not consider the C_{ij}. Also, when assigning values x_{ij}, you might want to know why we did not start from the northeast or southwest corners. As a matter of fact, any corner is an acceptable starting point and there is no way to tell in advance which one would provide the best starting point.

(2) *Least Cost Method*

In the previous method (the northwest corner), although very fast, the feasible solution is determined without any consideration of the transportation costs. Thus, the solution found by the northwest corner may be very far from the optimum solution and as such it may require large number of iterations to reach the optimum point.

The least cost method includes the transportation costs in determining a solution and therefore commonly generates a cheaper solution. So, this rule gives a better (less costly) solution than the one give by the northwest corner rule.

In the least cost method, the unit cost array, is scanned for the smallest C_{ij} and the first basic variable is chosen to be X_{pq} such that

$$X_{pq} = \min_{(i,j)} C_{ij}$$

The value of x_{pq} is set equal to the minimum of its row or column total, i.e. minimum of (a_p and b_q) and the row or column where the minimum is attained is then deleted. If both the row and column totals are minimum simultaneously, then either the row or the column is deleted arbitrarily. To choose the next basic variable, the remaining unit cost array is scanned for the smallest C_{ij} and the corresponding value of x_{ij} is set as large as is consistent with corresponding row and column totals. If some other basic variables are already chosen in the same row or column, their values also have to be considered in the row or column totals.

(3) *Minimal Column Value*

The minimal column value is one of Transportation problem method for finding an optimum initial feasible solution that in this project is the suitable site for

construction of Oil depot. This method requires a few more computations than the northwest corner method, but it provides a better solution. This method includes the costs in determining an initial basic feasible solution and therefore usually generates a cheaper solution. This method requires the search of each column for the lowest cost.

It is clear that this solution is better than the northwest corner method solution. However, the solution depends on the demand in which the columns are chosen. A different demand might yield a different feasible initial solution.

An obvious variation of this method would be the search for the smallest cost value along each row rather than each column. Even though the procedure is basically the same, it is often more advantageous to use minimal column value if there are more columns than rows, and to use minimal rows value if there are more rows than columns.

(4) *Vogel Approximation Method (VAM)*

This method, although more complicated than the previous methods, is usually far superior to them (especially for large problems). Vogel's method analyses the differences between the cheapest and next cheapest cell in each column and each row and attempts to avoid expensive assignments in this manner.

The Transportation methods that will apply in this thesis are The Least Cost method and The Minimal Column Value.

2.1.3 Sensitivity Analysis

Sensitivity analysis is an approach to examining the effects of uncertainties in the forecasts on the viability of a project. According to, the economic analysis of a project can only be based on the best estimates that can be made of the investment required and the cash flow. The actual cash flows achieved in any year will be affected by any changes in such as raw material costs, and other operation & maintenance costs; and will be very dependent on the price and sales volume. To carry out the analysis the investment and cash flows are first calculated using what are considered the most probable values for the various factors; this establishes the base case for analysis. Whatever, the cash flows and criteria of performance are to be used, are then calculated assuming a range of error for each of the parameters in turn; for instance, an error of $\pm$ 10 percent on the investment or O & M costs might be assumed.

A sensitivity analysis is a technique, aiming to monitor how sensitive the cash flows and economic criteria are to errors in the forecast figures. It gives some idea of risk concerned in making judgements on the forecast performance of the project.

2.2 Literature Survey

Chantana Chantaro and Sirichan Thongprasert (1989) explained about project feasibility study for business and industry project. It concerns about marketing, engineering, financial management, economic and business environment effect.

The National Energy Policy Office (1990), This study has the goal of analysing the structure of the oil trade, together with the character of trading, the total number of traders, investment and transportation costs and the state of competition in the oil trade, both in Bangkok and in the provinces. Moreover, the study clearly pointed out that the transport system of the highest level of efficiency, to all parts of the country expect the South at the present is by tanker trucks of 30,000 litre capacity, because they have the lowest financial and economic costs. For transport to the South the most efficient form of transport is by tanker ship to local depot.

Gale, Tony B. (1999) has summarised that pipeline route selection is a strategic component of pipeline company expansion activities, which can significantly affect the success or failure of s project. It involved the consideration of physical, environmental, political, social, economic and regulatory concerns. The ability to understand and model the variables affecting the route selection process provided a basis for controlling cost, environmental impact and risk to public safety.

The Research and Development Department, Petroleum Authority of Thailand (1996) studied and mentioned about the pipeline Right-of-Way (ROW). In which ROW will be selected to combine maximum safety for the pipeline, minimum disturbance of the affected landowners, and will, in some sections, seek to share the energy corridors with the power transmission lines and within the highway and railroad rights-of-way.

Mohitpour M., Von G. Bassenheim, and Braun Arden (1998) studied about selecting a route for a pipeline Right-Of-Way (ROW) that generally consists of engineering (technical and economic), socioeconomic and biophysical components. To effectively select a rout, simultaneous consideration must be given to all the components from the initiation of a project to the integration of all aspects of each throughout the route selection process. It is the consideration of all these issues that will lead to a ROW, which will provide a technically acceptable solution, which is at the same tine the least expensive, economically viable and acceptable to the community it traverses.

This paper provided an overview of route selection techniques (including new technologies) used and the process generally practiced by pipeline designers, highlighting controlling issues and optimisation methods that need to be utilised in order to achieve a cost effective route selection. It provided details on significant feeling/perception issues that can either thwart or, by careful consideration of these issues, lead to a successful pipeline project.

Virapon Suwannut (1981), This book showed about project feasibility study by analysis in each item of plan and project, benefits-expenditure and cost effectiveness. In each item, it was explained by examples and calculation methods.

Don T. Phillips, James J. Solberg and A. Ravindran (1987) explained transportation problems that are generally concerned with the distribution of a certain product from several sources to numerous localities at minimum cost. It is the finding an optimal shipping schedule that minimizes the total cost of transportation from all the warehouses to all the markets. Moreover, the least cost rule is presented that is the criterion used for selecting the successive basic variables. In the least cost method, the variable with the lowest shipping cost will be chosen as the basic variable.

Sureeporn Surat (1995) studied about benefit-cost analysis for investment decision in the exported seafood industry. His thesis educated on three sizes of production for choosing the best one. The criterions for decision are Net Present Value, Internal Rate of Return and Benefit-Cost Ratio.

Canadian Standards Association (1996) presented about the financial projection. The financial projection defined that pipeline will operate for at

least 30 years upon completion. This period is broken into the construction and operating periods.

Donnelly, Gerald and Struss, Mark W (1996) presented a discussion on the planning, design and construction of a petroleum pipeline project in New Jersey, Pennsylvania. This project connected two refineries, enabling the transfer of feedstocks bi-directionally and the efficient production of fuels that met the demands of the 1990 Clean Air Act amendments. Key elements of the project included : Feasibility Study Preliminary Planning Environmental Permitting Final Engineering Design Right-of-Way Acquistion Construction Extensive environmental studied critical for permitting, the complexity of design and construction due to constricted workspace, waterways and wetlands, urban development, and extensive utilities are discussed with examples. The paper was written to help other owners and engineers to properly plan, permit and design pipeline crossings and increase their awareness of current environmental issues which needed to be addressed along any proposed pipeline corridor.