LOCATION EXPANSION OF AN ELECTRICAL POWER STATION HARDWARE SUPPLIER

by

Mr. Charnwit Somprakij

A Final Report of the Three - Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in Computer and Engineering Management
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Project Title	Location Expansion of an Electrical Power Station Hardware Supplier
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The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

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ABSTRACT

For location expansion of an electrical power station hardware supplier, which should be selected for the best location in investment. It is the long-term period to run the business, so the expansion location must be analyzed by using models, especially in this situation, Thailand confronts an economic crisis for a long period to solve this problem. Before investment starts, the author concentrated on selecting the optimum place. In this project, the existing factory will get some effects of the government regulations, which do not permit ten-wheel truck to drive through Bangkok. The committees of electrical hardware manufacture consider investing to in other provinces in which the company bought land in the past.

This project will provide some knowledge to the reader such as the fundamentals of finding new locations. It has steps of decision making and methods for selecting. Before the author chooses a location, we should understand some basic of theories. From the procedure, the author tries to analyze the existing location and proposed location. They describe part two and three of this project. The author compares the developing of the proposed a location. When the author analyzes both of them, the author should find out the factors, which relate to the new locations.

The author cannot refer only one model to analyze, because it doesn't support and conclude investment. The model, which is suitable for selecting the best location, is Factor-Rating model and cost evaluation analysis, because they have many factors to effect selecting. It is closest to the real situation which happens in the present and the future. The result is selected by using two models, so it can reduce cost and low risk for investment in the long term period. It can be applied to other electrical manufacturers, who want to establish new factories in Thailand.

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I. INTRODUCTION

1.1 Background of the Project

An electrical hardware manufacturer produces Electrical hardware for Provincial Electricity Authority of Thailand. Our executive committees are considering building a new factory upcountry. It has many factors that led us to build a new factory such as law, environment, zone, investment and so on. We must select location, calculate main cost, transportation, and so on. We had three plots of land to make a selection. One is Bang Pa In district in Ayudhaya province, one is Bangkra district in Chacherng Sao province and the last one is Ratchasan district in Chacherng Sao province.

Transportation is an important part to run business, which has many factors. Each factor will effect the cost of production, so the author considers the suppliers to send the product to consumers. They must use some technique to compare to get the best location. At present, the author aims to reduce the cost, because the company must compete with other companies in bidding. And each order must use the empty space or warehouse to store the products in the company, and Thai regulations do not allow the trucks to pass through Bangkok to solve traffic jams. The company should invest and find out the optimal location.

1.2 Objectives

The author has many locations to expand the company to support in the future, so the author should make a decision on it. The first time the author should set some objectives to search and find out some information to support in making a decision.

(1) To find out the data for selecting the best location to establish the new factory in supporting electrical power station hardware.

(2) To investigate appropriate locations.

(3) To calculate the worth for investment used in site selection.

1.3 Scope

Before the author analyzes the locations, the author should have some boundary to be clear and obtain the objective. The land is considered which Electrical hardware manufacturer bought it for investment. For the project, the author considers only 3 locations for establishing. They are Bang Pa In district in Ayudhaya province, Bangkra district in Chacherng Sao province, and Ratchasan district in Chacherng Sao province.

II. LITERATURE REVIEW

2.1 Logistics System

Logistics system is a parameter to be supplied by management in the light of competitive circumstances and market objectives. The higher the standard with respect to speed and reliability of delivery to customers, the more costly the distribution phase of the system will become. Hence the advantages of improved service must be weighed against accomplishing increase of costs with a view to determine whether profit will increase as a result.

The objective in planning and managing the logistics system is to meet the standard at the lowest total cost or, to put it more positively, at maximum profit to the firm. This is not accomplished simply by minimizing the costs encountered in the logistics function, there are important interrelations among production, logistics, and marketing that affect total cost delivered to the customer. An increase of production cost may be offset by a greater reduction in logistics cost. Profit improvement may follow from an increase of bidding which exceed the added logistics costs incurred. Effective physical distribution, indeed, is a competitive tool, which can be, employed to enlarge market areas and to improve market share.

The logistics function must be managed in conjunction with the other functions of the business in a way calculated to increase profit. Unless the various tasks involved in goods handling is imagined as a system, they cannot be managed in that way. Cost minimizing standards applied to particular goods handling tasks may as readily reduce as increased profit. Many of the functions embraced within logistics systems are highly complex, including especially the transportation function which requires selection pact of government regulations, the management of distribution is better understood , accordingly, after some of these complexities have been reviewed (William 1981).

2.2 Tradeoffs between Transportation and Location

Outputs can be distributed to customers by transporting them, if there is a facilitating good, or by locating where the customers can easily obtain them. Since service outputs without a facilitating good are generally difficult, expensive, or even impossible to transport, service organizations distribute their output by locating in the vicinity of their recipients. Of course, there are exceptions to this general practice when the recipients transport themselves to the service location. These situations usually occur when a service is of exceptional quality, or famous.

Some pure service organizations, however, do attempt to transport their services, although frequently with a great deal of trouble. These instances occur when the nature of the service makes it impractical to remain in one fixed location for an extended duration or, more commonly, when the service is deemed very important to the public but may otherwise be inaccessible.

Product organizations, on the other hand, can generally trade transportation costs for location costs more easily and, therefore, can usually minimize their logistics costs. In some instance, however, even product organizations are forced into fixed locations. One of these instances concerns the nature of the firm's inputs, and the other concerns its outputs (Shafer 1998).

2.3 Multifacility Distribution

The trade-off between transportation and location. We have restricted our discussion to the single-facility situation in which, for example, one facility services a set of geographically dispersed recipients, as shown in Figure 2.1.

The next level of complexity is multiple facilities. Determining the best locations for multiple facilities is known as the multifacility location problem. Franchises are a Specialized form of branch facilities, as are warehouses, and factories.

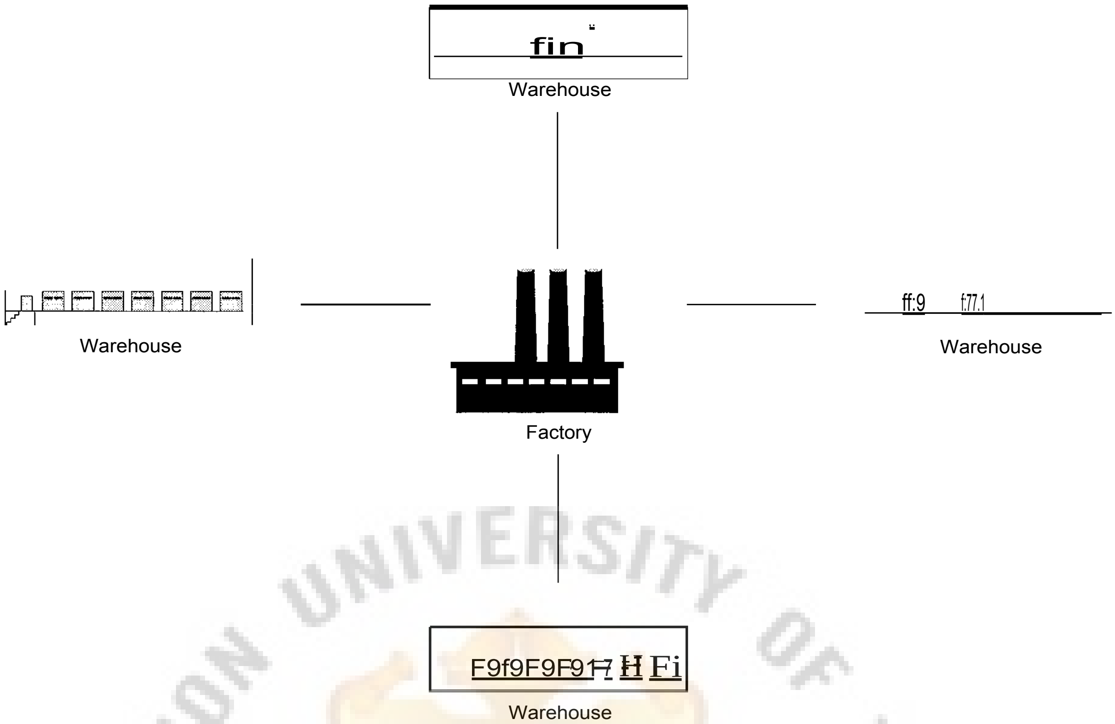


Figure 2.1. A Single Source and Multiple Recipients (Shafer 1998).

The analysis is complex because the best location-distribution pattern for each facility depends on the location distribution patterns for each of the other facilities. Some of the major complications associated with multifacility distribution are described below:

2.3.1 Multiple Facilities

First, more than one facility produces the output for multiple recipients. There may be an eastern plant, a center plant, and a western plant among which the output can be divided up to supply the customers. Three situations often arise in this case: locating one additional facility with N existing facilities already situated; locating (or relocating) all N facilities at once; and, last, once facilities are situated, determining the new allocation of outputs from them to the recipients. A special point about the location of all N facilities is that locating them one at a time cannot solve the problem. Rather, they must all be located at once, since changing the distribution pattern of any one facility will change the distribution patterns.

Multiple stages: There may also be multiple intervening staging points between the production facility and the recipients, such as factory warehouses, distribution centers, wholesalers, and retailers. This can be the case with either a single production facility or, as shown in See Figure 2.2, with multiple production facilities.

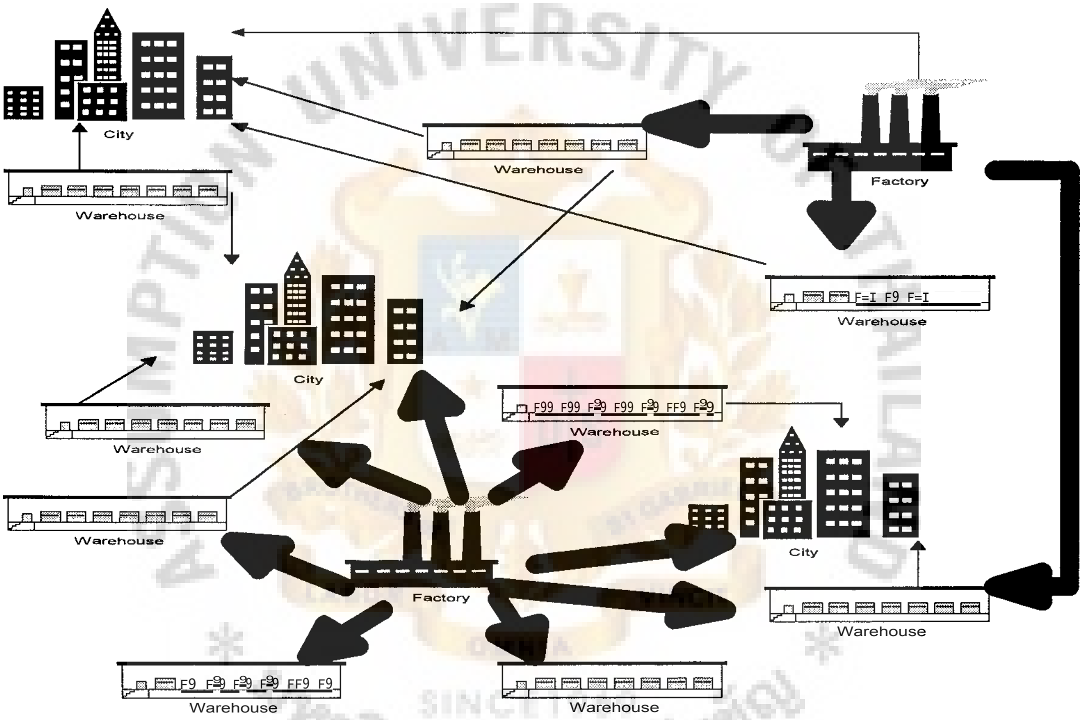


Figure 2.2. The Multi-facility Locations (Shafer 1998).

2.3.2 Unspecified Sites

Sometimes possible sites are identified beforehand, and the problem becomes one of selecting the best set of N sites from M locations. This may even be the case in the single-facility problem. If the sites are not determined in advance, the problem is clearly more complex.

2.3.3 Unknown Quantities

The number of production facilities may also be unknown, and the problem is to determine not only where they should be located and which recipients they should serve but also how many facilities there should be. Obviously, this problem is very complicated. In additional, the number of interviewing facilities at any stage (e.g., warehouses) may be unknown, as well as the number of stages, making for a significantly more complex problem.

2.3.4 Multiple Outputs

So far, we have assumed that there is only one output; in fact, though, there may be any number. The problem arises when the distribution of demand among the recipients for the different outputs varies considerably, necessitating different solutions in the situations above (Shafer 1998).

2.4 Time and Place Utility

Logistics involves the movement of products (raw materials, parts, supplies, and finished goods) from point-of-origin to point-of-consumption. A product produced at one point has very little value to the prospective customer unless it is moved to the point where it will be consumed. Transportation achieved this movement.

Movement across space or distance creates value or places utility. Time utility is mostly created or added by the warehousing and storage of product until it is needed. But transportation is also a factor in time utility; it determines how fast and how consistently a product moves from one point to another. This is known as time-in-transit and consistency of service. If a product is not available at the precise time it is needed, there may be expensive repercussions, such as lost sales, customer dissatisfaction, and production downtime. Most logistics managers are familiar with the problems created by late arrival of needed items.

2.5 Location Analysis

The site selection decision can be approached from macro and micro perspectives. The macro perspective examines the issue of where to locate warehouses geographically (in a general area) to improve the sourcing of materials and the firm's market offering (improve service and/or reduce cost). The micro perspective examines factors that pinpoint specific locations within the larger geographic areas.

In the macro approach, which identified three types of location strategies: (1) market positioned, (2) production positioned, and (3) intermediately positioned. The market positioned strategy locates warehouses nearest to the final customer. This maximizes customer service levels and enables the firm to utilize transportation economies- shipments-from plants or sources to each warehouse location. The factors that influence the placement of warehouses near the market areas served include transportation costs, order cycle time, the sensitivity of the product, order size, local transportation availability, and customer service levels offered.

Production positioned warehouses are located in close proximity to sources of supply or production facilities. These warehouses generally cannot provide the same level of customer service as that offered by market positioned warehouses: instead, they serve as collection points or mixing facilities for products manufactured at a number of different plants. For multiproduct companies, transportation economies result from consolidation of shipments into TL or CL quantities. The factors that influence the placement of warehouses close to the point of production are perishability of raw materials, number of products in the firm's product mix, assortment of products ordered by customers, and transportation consolidation rates.

The final location strategy places warehouses at a midpoint between the final customer and the producer. Customer service levels for the inten_iediately positioned warehouses are typically higher than for the production positioned facilities and lova than market positioned facilities. A firm often follows this strategy if it must offer high customer service levels and if it has a varied product offering being produced at several plant locations.

Although macro approach is to locate facilities using one of three strategies:

(1) Product warehouse strategy

(2) Market area warehouse strategy

(3) General purpose warehouse strategy

Under the product warehouse strategy, the firm places only one product or product grouping in a warehouse. Each warehouse will therefore have a lot of one type of product, but little or no inventory of other products. This can be a useful strategy when a firm has only a few products or product groupings that are high turnover items. If the company has important customers that demand a specific product in the market area being served by the warehouse, of if it manufactures products that have distinctly different transportation freight classifications and size/weight/loadability characteristics, it may also consider the product warehouse strategy. This strategy has also been used for new product introductions. Industries that employ this strategy include the farm equipment, appliance, electronics, apparel, and textile industries.

A market area warehouse strategy position is full line warehouses in specific market territories. Each facility stocks all the firm's products so that customer can receive complete orders from a single warehouse. Industries using this strategy include the beverage , food, paper products, glass, iron, chemical, and furniture industries.

The general-purpose warehouse strategy is similar to the previous approach in that facilities carry a full line of products. It differs however, in that each warehouse serves all markets within a geographical market. Manufacturers of consumer packaged goods often employ this strategy.

A final macro approach includes the combined theories of a number of economic geographers. Many of these theories are based on distance and cost considerations, for a strategy of facility location is based on cost minimization. When locating points of production, transportation costs should be minimized to result in maximum profits. The model assumed that market price and production costs would be identical (or nearly so) for any point of production. Since the profits equal market price minus production costs and transportation costs, the optimal location would have to be the one that minimized transportation expenditures.

Model developed facility location based on cost minimization. According to that, the optimal site was the location that minimized "total transportation" (Farris 1979).

2.6 Defining Site Selection

Site selection, or facility location, for either manufacturing is deciding on a location for constructing, expanding or acquiring a physical entity of a firm in order to reach new markets, increase production capacity to customers. The ultimate decision on site selection is often based on the cost of operating the new facility, or on the level of revenues expected to be generated. Site selection for a manufacturing facility is more complex than for an office facility, as there is a bigger capital investment, a higher content of labor requirements and, thus, a greater downside risk. Location decisions are a highly important part of production system design. One is that they entail a long-term commitment, which makes mistakes difficult to overcome (Waller 1999).

Location can be considered to four options in location planning.

(1) To expand an existing facility that can be attractive if there is adequate area for expansion, especially if the location has desirable features that are not readily available elsewhere. Expansion costs are often less than those of

other alternatives.

(2) To add new locations while retaining existing ones, as is done in many retail operations. It is essential to take into account what the impact **will** be on the total system. It may be a defensive strategy designed to maintain a market share or to prevent competitors from entering a market.

(3) To shut down at one location and move to another. An organization must weigh the costs of a move and the resulting benefits against the costs and benefits of remaining in an existing location.

(4) To do nothing. If a detailed analysis of potential locations fails to uncover benefits that make one of the previous three alternatives attractive, a firm may decide to maintain the status quo, at least for the time being (Stevenson 1996).

2.7 Procedure for Making Location Decisions

When the author selects the best location, we have steps to run it step by step. The step of making a decision follows the step below:

2.7.1 Decide on the criteria that will be used to evaluate location alternatives, such as increased revenues, reduce cost, and find out labor, shortest time and distance for transportation.

2.7.2 Identify important factors, such as location of land or raw materials, labor force, productivity, distance between suppliers and customers, cost controlling, sources reliable, and reliable transportation system, and so on.

(a) Land

The land is already developed-power, water, and sewer hookups have been attended to, and zoning restrictions do not require special attention. It should be an adequate allowance for possible future expansion.

(b) Raw Materials

Firm locates near or at the resource of raw materials for three primary reasons.

(c) Cost Controlling

When we want to invest in some place, we consider budget of each project. We consider Land, infrastructure around the place such as electricity and water cost, transportation cost, raw material for production, building, labor cost.

(d) Labor Costs

Labor costs enter directly into the cost of manufactured products. The higher the labor costs, the higher is the product. Labor costs include not only the basic salary, or wages, but also all socials and other charges to the government in the form of taxes, which depends on the laws. Skills of potential employees may be a factor, although some companies prefer to train new employees rather than rely solely on previous experience. Increasing specialization in many industries makes this possibility even more likely than in the past. Although most companies concentrate on the supply of blue-collar workers, some firms are more interested in scientific and technical people as potential employees, and they look for areas with high concentrations of those types of workers. Some companies offer their current employee's jobs if they move to a new location. However, in many instances, employees are reluctant to move, especially when it means leaving families and friends. Furthermore, in families with two wage earners, relocation would require that one wage earner gives up a job and then attempts to find another job in the new location.

(e) Availability of Competent Labor

In site selection, there must be a good pool of labor that can be appropriately trained for the type of work. Choosing a region where there is a high level of unemployment is an indicator of labor availability. Most countries shown have youth unemployment levels higher than the total, except countries with apprentice systems.

(f) Productivity

A reputation for the high productivity of their labor force, which, coupled to the low labor cost, gives a reason for companies to locate to these region. Measuring productivity with labor cost. When a site is selected either for productivity levels or labor cost, the two elements have to be considered together.

(g) Transportation

This covers the transportation facilities and networks for raw materials, finished goods and personnel. Transportation costs are important in industries where processing eliminates much of the bulk connected with a raw material, making it much less expensive to transport the product or material after processing. Where inputs come from different locations, some firms choose to locate near the geographic center of the sources. For example, steel producers use large quantities of both coal and iron ore, and many are located somewhere between the Appalachian coalfields and iron ore mines. Transportation costs are often the reason that vendors locate near their major customers. A good road network is important for the delivery of raw materials and then for dispatching finished goods. Transportation costs can add significantly to the cost of finished products.

(h) Environmental Regulations

Environmental regulations cover local, regional and national rules for air, water, land and noise pollution. Locating a facility in an area where the environmental laws are strict can be costly. Many communities actively try to attract new businesses because they are viewed as potential sources of future tax revenues and new job opportunities. However, communities do not, as a rule, want firms that will create pollution problems or otherwise lessen the quality of life in the community. Local groups may actively seek to exclude certain companies on such grounds, and a company may have to go to great lengths to convince local officials that it will be a " responsible citizen". Some companies discover that even through overall community attitude is favorable, there may still be considerable opposition to specific sites from nearby residents who object to possible increased levels of noise, traffic, or pollution.

2.7.3 Develop Location Alternatives. When we decide the criteria to evaluate locations alternatives, we find out the factors which have effect to decision making And we should select the region to invest for finding out information to evaluate in the next step.

(a) Identify the general region for a location.

(b) Identify a small number of community alternatives.

(c) Identify site alternatives among the community alternatives.

2.7.4 Evaluate the alternatives and make a selection. It has methods for calculation such as:

(a) Location Cost-Volume Analysis

The economic comparison of location alternatives is facilitated by the use of cost-volume profit analysis. The analysis can be done numerically or graphically. The graphical approach will be demonstrated here because it enhances understanding of the concept and indicates the ranges over which one of the alternatives is superior to the others.

The procedure for location cost-volume analysis involves these steps:

(1) Determine the fixed and variable costs associated with each location alternative.

(2) Plot the total-cost lines for all location alternatives on the same graph.

(3) Determine which location has the lowest total cost for the expected level of output.

This method assumes the following:

(a) Fixed costs are constant for the range of probable output.

(b) Variable costs are linear for the range of probable output.

(c) The required level of output can be closely estimated.

(d) Only one product is involved.

(b) Factor Rating

A typical location decision involves both qualitative and quantitative inputs, which tend to vary from situation to situation depending on the needs of each organization. Factor rating is a general approach that is useful for evaluating a given alternative and comparing alternatives. The value of factor rating is that it provides a rational basis for evaluation and facilitates comparison among alternatives by establishing a composite value for each alternative that summarizes all related factors. Factor rating enables decision-makers to incorporate their personal opinions and quantitative information into the decision process.

The following procedure is used to develop a factor rating:

(1) Determine which factor is relevant (e.g., location of market. Water supply, parking facilities, revenue potential).

(2) Assign a weight to each factor that indicates its relative importance compared with all other factors. Typically, weights sum to 1 :

(a) Decide on a common scale for all factors (e.g., 0 to 100).

(b) Score each location alternative.

(c) Multiply the factor weight by the score for each factor, and sum the results for each location alternative.

(d) Choose the alternative that has the highest composite score.

For computing which it suits for each location by using the following equation:

$$x_i = \sum_{1=1}^{n} w_i x_{ij}$$

where

i = the location factor number

j = the candidate location number

n = the number of location factors

w, = the weight assigned to factor i

x_{ij} = a rank/score assigned to factor i for location j

x- a suitability index calculated for location j

The best location is candidate j with the maximum $\left| \sum_{j=1}^{m} X_j \right.$

Where m = the number of candidate locations.

(c) The Center of Gravity Method

The center of gravity method can be used to determine the location of a distribution center that will minimize distribution costs . The method includes the use of map that shows the locations of destinations. The map must be accurate and drawn to scale. A coordinate system is overlaid on the map to determine relative locations. The location of the 0,0 point of the coordinate system, and scale, is unimportant. Once the coordinate system is in place, you can determine the coordinates of each destination. If the quantities to be shipped to very location are equal, you can obtain the coordinates of the center of gravity (i.e., the location of the distribution center) by finding the average of the x coordinates and the average of the y coordinates. The averages can be easily determined using the following formulas:

$$x = \underline{\Sigma x_i} \qquad Y = \Sigma y_i$$

where

xi = x coordinate of destination i

yi = y coordinate of destination i

n = number of destinations

When the number of units to be shipped is not the same for all destinations (usually the case), you must use a weighted average to determine the center of gravity, with the weights being the quantities to be shipped. The approximate formulas are:

$$\bar{x} = \frac{\Sigma x_i Q_i}{\Sigma Q_i} \qquad Y = \frac{\Sigma y_i Q_i}{\Sigma Q_i}$$

where

Qi = Quantity to be shipped to destination

Xi = x coordinate of destination i

Yi = y coordinate of destination i

(d) Transportation Cost Model: Rate-Volume-Distance

A number of approaches are based on a simple measure of total distribution costs, supply costs, or both. The procedure is to sum the products of the transportation rate (T), The volume (V), and the distance (D) over all the locations- hence the abbreviation for this approach: TVD. The usual method of calculating total transportation cost is as follows:

$$C = T_1V_1D_1 + T_2V_2D_2 + T_3V_3D_3 + \dots T_nV_nD_n$$

where

T = cost of transportation needed, in baht per unit volume (or weight) per unit distance (e.g., baht/ kilogram / kilometer)

V = volume (or weight) being transported

D = distance from facility to recipients demand

Step 1 is simply a matter of managerial preference. Step2 through 4 may need some elaboration.

(e) The Load Distance Technique

Transportation part uses this technique to make decisions for finding a best location. If a facility will be the sole source or destination of shipments, the transportation costs can be included in a location cost -volume analysis by incorporating the transportation cost per unit being shipped into th?

variable cost per unit. The technique used for selecting the desirable locations based on the transportation, which considers the distance between the source to destination. The single candidate site, we can compute using the following equation:

$$LDi = \overset{n}{\underset{1-1}{E}} li\ di$$

where

LDi = the load-distance value

li = the load, transportation, expressed as a weight, the number of units shipped, the number of trips between the candidate site and the location i

di = the distance from the candidate site to the location I

$$= Ni(xi-XI \quad \overline{\quad (Yi-0^{2}}$$

where

(x ,y) = coordinates of the candidate site

$(Xi_{\text{¸}} y_i)$ = coordinates of the location i

From all methods, location evaluation method or location model is a common approach to narrowing the range of location alternatives that is to first identify a country or region that seems to satisfy overall needs and then identify a number of community site alternatives for more in depth analysis. A variety of methods are used to evaluate location alternatives. We can use location cost-volume analysis, the transportation model, factor rating or the center of gravity method for making decision to selecting the best location (Stevenson 1996).

(f) The Transportation Model

The transportation model is a special class of the linear programming problem. It deals with the situation in which a commodity is shipped from sources (factories or suppliers) to destinations (warehouse or customer). The objective is to determine the amounts shipped from each source to each destination that minimize the total shipping cost while satisfying both the supply limits and the demand requirements. The model assumes that the shipping cost on a given route is directly proportional to the number of units shipped on that route. In general, the transportation model can be extended to areas other than the direct transportation of a commodity, including, among others, inventory control, employment scheduling, and personnel assignment.

The network in Figure 2.3 represents the general problem. There are m sources and n destinations; each represented by a node. The arcs linking the sources and destinations represent the routes between the sources and the destinations.

Arc (i, j) joining source i to destination j carries two pieces of information: (1) the transportation cost per unit, co, and (2) the amount shipped, x1. The amount of supply at source i is ai and the amount of demand at destination j is The objective of the model is to determine the unknowns xo that will minimize the total transportation cost while satisfying all the supply and demand restrictions.

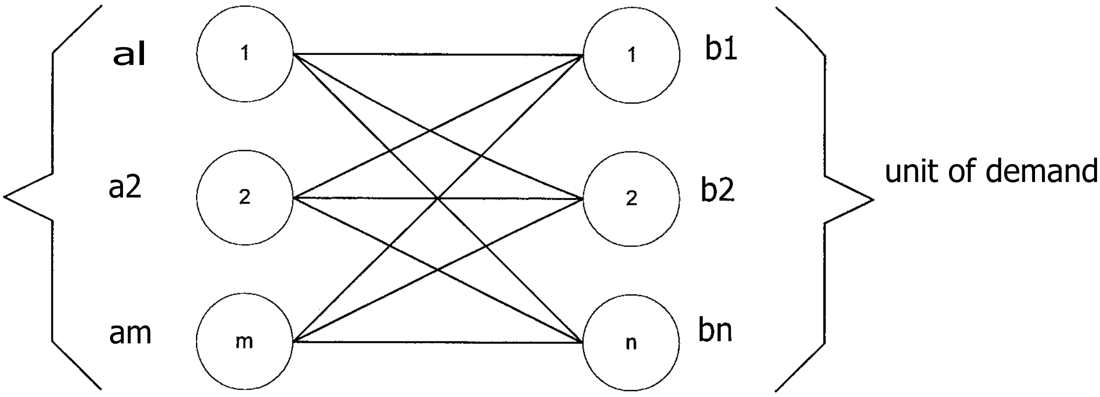


Figure 2.3. The Network of Transportation Model.

Level of supply, I = 1,2,3,....... ,m

bj : Level of demand, j = 1,2,3,.....,n

Ci: Unit transportation cost from source Ito destination j

Xij: Amount of transportation from source Ito destination j

The special structure of the transportation problem allows securing a nonartificial starting basic solution using one of three models:

(1) Northwest-corner method

(2) Least-cost method

(3) Vogel approximation method

2.8 Location Theory

Location theory is concerned with the problem of determining optimal locations for one or more new facilities to serve a set of customers. Such problems arise in many contexts. On the macro scale they involve location of airports, waste disposal sites, driver licensing facilities and manufacturing and distribution facilities. On a smaller scale they may involve location of a piece of equipment a copying machine, a tool grinder etc. with respect to other machines or equipment. Finally, such problems may also arise in the design of electronic circuit boards.

The location decision must often be made considering many criteria. These may include costs, distances, safety, etc. Often qualitative factors and political considerations affect the final choice of the location. In this section we will concentrate on some elementary location problems. The field of Location Theory covers many diverse models and topics and is a rich area for research.

Types of Location Problems:

(a) Distance Measures

(b) Objective Functions

Depending on the problem being considered location models differ greatly from one another. Fundamentally these models are affected by the way distance is measured and the objective function to be used.

Distance Measures

In thinking of distances we generally think only about the straight line distance between two points. Yet, in our day to day life, we encounter situations where it is impossible to travel along the straight line distance. Indeed, the straight line distance is often only good as an estimate for the actual distance between points. There are different kinds of distance measures that can be used for different problems. We use the rectilinear distance and the Tchebychev distance. In fact, there are a whole family of measures for the distance between two points (xi, y_i) and defined (xi, y_i) as follows:

$$L_k \quad X_1 - X_{21}{}^{k} \quad y_1 - y_2 \;{}^{k}\;{}^{1/k}$$

Notice that as k becomes larger, the larger of the x difference and the y difference influences the distance more. In the limit, k -÷ co , we find that the distance is completely dependent on the larger of the two distances. This special case is called the Tchebychev distance. The table below lists some of the more common distance measures. Note that some do not belong to the 1k family.

Common name	k	Formula	Use
Rectilinear	1	)(1. — X2 + Yi - Y2)	Plant and warehouse layout, location in large metropolitan cities, circuit board design, pipe systems.
Euclidean	2	xi. — x2 2 + Yi - Y2 | 2 1112	travel in open rural areas,travel over short areas using aircraft.
Tchebychev	3	Max)(1. — x2 1 + Y1 — Y2)	for certain kinds of equipment which allow independent motion in two orthogonal directions.
Graph -based			Road networks, city streets with different speeds etc.

The graph-based distances are commonly used when travel between two points is restricted to follow certain pre-specified paths. The length of these paths may have no relation to the co-ordinates of the end-points.

Objective Functions

The second factor which affects location models is the objective function. As we stated earlier, many facilities are located to satisfy several different objectives. Methods which deal with multiple objectives exist but are beyond the scope of our project. We will concentrate on some common single objective problems.

The easiest to understand is the minisum objective. In this case the new facility is located so that the weighted sum of distance between the existing customers and the facility is minimized. Such problems are called median location problems. This objective is appropriate when the cost of transportation or material handling is to be minimized. The weight associated with an existing customer is then the amount of interaction that the customer is expected to have with the new facility.

In locating emergency facilities, the distance of a customer from the facility can often mean the difference between saving the customer or destroying the customer in an emergency. Thus the customer who is farthest away is likely to be the one most affected in an emergency. To minimize the damage to the customer it is important that the farthest customer is as close to the emergency facility as possible. This is the minmax objective which minimizes the maximum distance from any customer. Such problems are called center problems.

If there is an absolute requirement that a customer must be within a certain distance from a new facility, we are left with the problem of determining the minimum number and location of new facilities to cover all customers. Such problems are called covering location problems.

Rectilinear Distance Problems

Rectilinear distances are commonly employed when the space being considered is overlaid with a grid. This occurs in city planning and within manufacturing and distribution plants. Travel is only permitted on the roads or aisles which form the grid.

Single Facility Minisum - 1-median

The 1-median problem involves minimizing the weighted sum of distance traveled from existing customers to the new facility. Consider a problem with m customers located at points $p_i = (a_i, b_i)$. Let the weight associated with customer at location p_i be yy . This weight may reflect the importance of the customer in some way. It may, for example, represent the expected number of trips made by the customer to the new facility or the relative worth of the time of that customer as opposed to other customers. Suppose we locate a new facility at point x = (x, y), then the sum of weighted distances for all the customers is given by:

f(x) = 1+1 / 1=1 w_i cl x, p_i) = 1+1 / 1=1 \Ai; qx — + y —

The problem is to find X that minimizes the above function. Notice first that the function is separable in x and y. Accordingly we can decompose the optimization problem into an x- problem and a y- problem.

min.f(x) = min (x) 1+1 / 1=1 E wi , — ai) + min (y) 1+1 / 1=1 E inn qV – bi

The two problems are identical in the approach required to solve them. Consider the *x*- problem as shown in figure below :

Suppose we start at some point say x = xo as shown in figure. Since all the facilities are to the right of we know that moving the facility to the right will lead to a reduction in the objective function. This will be true until we reach the point a(1). Moving any further to right will mean moving away from the customers at a(1) and closer to the rest of the customers. Suppose we move a distance A to the right of a(1)• Then the objective function will increase by w(i) *A* because of moving away from a(1) and decrease by $\sum_{i\neq 1} w(i)$? because we move closer to the other customers. The overall increase or decrease will depend on the relative values of w(1) and $\sum_{i\neq 1} w(i)$. **If** w(1) > $\sum_{i\neq 1} w(i)$ the objective function will increase, if w(1) < $\sum_{i\neq 1}$ moil will decrease and if they are equal it will remain the same. In general, if x = ao) then moving a distance A to the right will result in a change in objective function equal to $\left\| \sum - \sum w(i) \right|$

Thus to determine if it is advantageous to move the facility to the right we evaluate $\left| \sum w(i) \quad \sum MO \right.$. If ($\sum$ $\sum w(i) \Big|$ < 0 then move the facility to the right. Thus, as we move towards the right first point x = ao) at which we find $\left\| \sum w(i) - \sum w(i) \right| > 0$.

The smallest value at which this condition will be realized is $\sum w(i) \frac{1}{2} \sum$ vv6). Thus the procedure to find the optimal x-coordinate is to start from the left most point and add the customer weights to the left and at that point. If this sum of weights equals or exceeds half the total weight then the current point is optimal.

The optimal y-coordinate can be found in a similar fashion by starting at the smallest y-coordinate and moving up until the condition on the sum of weights is satisfied.

From the above discussion it is clear that the optimal solution to the this problem satisfies the following property:

The x-coordinate (y-coordinate) of the optimal solution must be equal to the x-coordinate (y-coordinate) of one of the existing customers. (This does not mean that the solution must lie at the same location as one of the exist customers.) For example:

Consider the following 5 existing customer locations and their respective weights:

i	1	2	3	4	5
ai	3	3	4	6	8
bi	5	1	6	7	2
wi	5	8	7	15	12

x-problem:

Note that there are two customers at the same co-ordinate 3 and so we combine their weights.

0)	1	2	3	4
ao)	3	4	6	8
	5+8=13	7	15	12
E w	13	20	35>47/2=23.5	47

y-problem:

(j)	1	2	3	4	5
b(j)	1	2	5	6	7
W(j)	8	12	5	7	15
E w (i) i~j	8	20	25>47/2=23.5	32	47

Hence the optimal location for this problem is at point (6,5) (www.ews.uiuc.edu 2000).

2.9 Location Analysis via Present-Worth and Capitalized Cost Evaluation

A future amount of money converted into its equivalent present value has a magnitude of the present worth amount that is always less than that of the actual cash flow, because for any interest rate greater i than zero, all P/F factors have a value less than 1. For this reason, present worth calculations are often referred to as discounted cash flow (DCF) methods. Similarly the interest rate used in making the calculations is referred to as the discount rate. Other terms frequently used in reference to present worth calculations are present worth (PW), present value (PV), and net present value (NPV). Regardless of what they are called, present worth calculations are routinely used to make economic related decisions. Up to this point present worth computations have been made from cash flows associated with only a single project or alternative. In this part, techniques for comparing alternatives by the present worth method are treated. While the illustration may be based on comparing two alternatives, the same procedures are followed in a present worth evaluation of three or more alternatives.

2.9.1 Present-Worth Comparison of Equal-Life Alternatives

The present-worth (PW) method of alternative evaluation is very popular because future expenditures or receipts are transformed into equivalent bahts now. That is, all the future cash flows associated with an alternative are converted into present bahts. In this form, it is very easy, even for a person unfamiliar with economic analysis, to see the economic advantage of one alternative over another.

The comparison of alternatives having equal lives by the present-worth method is straightforward. If both alternatives are used in identical capacities for the same time period, They are timed equal-service alternatives. Frequently, an alternative cash flows represent disbursements only; that is, no receipts are estimated. For example, we might be interested in identifying the process, which has the lowest equivalent initial cost, operating cost, and maintenance. Other times, the cash flows will include both receipts and disbursements. Receipts, for example, could come from product sales. Equipment salvage values, or realizable savings associated with a particular aspect of the alternative. Since a majority of the problems we will consider have both receipts and disbursements, represent disbursements as negative cash flows and receipts as positive.

Thus, whether alternatives involve disbursements only, or receipts and disbursements, the following guidelines are applied to select an alternative using the present worth measure of worth:

One alternative. If PW 0, the requested rate of return is met or exceeded and the alternative is finally variable.

Two or more alternatives. Select the alternative with the PW value that is numerically larger, that is fewer negatives or more positive indicating a lower PW of costs or larger PW of net cash flow of receipt and disbursement. Hereafter we use the symbol PW, rather than P, to indicate an alternative's present-worth amount.

2.9.2 Present-Worth Comparison of Different-Life Alternatives

When the present-worth method is used for comparing mutually exclusive alternatives that have different live, the procedure of the previous section is followed with one exception: The alternative must be compared over the same number of year.

This is necessary since by definition a present-worth comparison involves calculating the equivalent present value of all future cash flows for each alternative. A fair comparison can be made only when the present worth represent cost and receipts associated with equal service, as described in the preceding section. Failure to compare equal service will always favor the shorter-lived alternative (for costs), even if it were not the most economical one, because fewer periods of costs are involved. The equal-service requirement can be satisfied by either or two approaches:

(a) Compare the alternatives over a period of time equal to the least common multiple (LCM) for their lives.

(b) Compare the alternatives using a study period of length n years, which does not necessarily take into consideration the lives of the alternatives. This is also called the planning horizon approach.

For the LCM approach equal service is achieved by making the comparison over the least common multiple of lives between the alternatives, which automatically makes their cash flows extend to the same time period. That is, the cash flow for one "cycle" of an alternative is assumed to be duplicated for the least common multiple of years in terms of constant-value dollars. Then service is compared over the same total life for each alternative. It is important to remember that when an alternative has a positive (negative) terminal salvage value, this must also be included an shown as an income (a cost) on the cash flow diagram in each life cycle. Such a procedure obviously requires that some assumptions be made about the alternatives in their subsequent life cycles. Specifically, these assumptions are:

(1) The alternatives under consideration will be needed for the least common multiple of years or more.

(2) The respective costs of the alternatives will be the same in all subsequent

life cycles as they were in the first one.

This second assumption is valid when the cash flows are expected to change by exactly the inflation or deflation rate that is applicable through the LCM time period. If the cash flows are expected to change by any other rate, then a study period based PW analysis must be conducted using constant value bahts.

2.9.3 Life Cycle Cost

The term life cycle cost (LCC) is interpreted to mean the total of every cost estimate considered possible for a system with a long life from the design phase through the manufacturing and the field use phase onto the scrap phase followed by replacement with a new more advanced system. The LCC includes all estimated service retrofit, upgrade, scrap, and anticipated recycle costs. Application is usually made to project, which will require research and development time to design and test a product or system intended to perform a specific task.

The technique of LCC analysis is applied by large contractor corporations to government sponsored system especially defense-related projects. For some system the total cost over the system life is many multiplies of the initial cost. The LCC concept is just as meaningful for smaller systems.

The total anticipated costs of an alternative are usually estimated using major cost categories such as:

Research and development costs. All expenditures for design prototype fabrication testing manufacturing planning engineering service, software engineering, software development, and the like for a product or service.

Production costs. The investment necessary to produce or acquire the product including expenses to employ and train personal, transport subassemblies and the final product, build new facilities, and acquire equipment.

Operating and support costs. All costs incurred to operate, maintain, inventory, and manage the product for its entire anticipated life. This may include periodic rework costs and average costs if the system requires recall or major in service repairs, based upon cost experiences for other systems already developed.

Present worth computations using the P/F factor to discount the costs in each category to the time that the analysis is performed are applied to complete the LCC analysis. The major difference between LCC analysis and the analyses we have performed thus far is the scope of the effort to include all types of costs over the long-term future of the system. Also, LCC analysis is most useful when performed for systems with relatively long lives.

The approach of the LCC evaluation is to determine the cost of each alternative for its entire life and select the one with the minimum LCC. Actually, a PW analysis and comparison with all definable costs estimated for the life of each alternative is the same as the LCC analysis.

2.9.4 Capitalized Cost Calculations

Capitalized cost (CC) refers to the present worth of a project that is assumed to last forever. Some public works projects such as dams, irrigation system, and railroads fall into this category. In general, the procedure followed in calculating the capitalized cost of an infinite sequence of cash flows is as follows:

(1) Draw a cash flow diagram showing all nonrecurring (one time) costs (and/or incomes) and at least two cycles of all recurring (periodic) costs and receipts.

(2) Find the present worth of all nonrecurring amounts.

(3) Find the equivalent uniform annual worth (A value) through one life cycle of all recurring amounts and add this to all other uniform amounts occurring

in yerar 1 through infinity. This results in a total equivalent uniform annual worth (AW).

(4) Divide the AW obtained in step 3 by the interest rate I to get the capitalized cost.

(5) Add the value obtained in step 2 to the value obtained in step 4.

The purpose for beginning the solution by drawing a cash flow diagram should be evident. However, the cash flow diagram is probably more important in CC calculations than elsewhere, because it facilitates the differentiation between nonrecurring and recurring (periodic) amounts.

Since the capitalized cost is another term for the present worth of a perpetual cash flow sequence the present worth of all nonrecurring amounts is determined (step2). In step 3 the AW of all recurring and uniform annual amounts is calculated. Then, step 4, which is effectively A/i, determines the present worth of the perpetual annual series using the equation:

Capitalized cost = AW or PW— AW

The equation is derived from the (P/A,i,n) factor when n = Go . The equation for P using the P/A factor is:

(1—if —1

If the numerator and denominator are divided by (1.+O^n . The equation becomes

$$P = A \quad 1 \quad \frac{1}{(1+i)n}$$

;

Now, as n approaches co , the numerator term becomes 1 yielding P = A/i.

2.9.5 Capitalized Cost Comparison of Two Alternatives

When two or more alternatives are compared on the basis of their capitalized cost, the procedure of previous section is followed for each alternative. Since the capitalized cost represents the present total cost of financing and maintaining a given alternative forever, the alternatives will automatically be compared for the same number of years. The alternative with the smaller capitalized cost will represent the most economical one. As in present worth and all other alternative evaluation methods, it is only the differences in cash flow between the alternatives, which must be considered for comparative purposes. Therefore, whenever possible, the calculations should be simplified by eliminating the elements of cash flow which are common to both alternatives. On the other hand, if true capitalized cost values are needed instead of just comparative ones, the actual cash flows rather than the differences should be used. True capitalized cost values would be needed, for example, if one wanted to know the actual or true financial obligations associated with a given alternative (Blank 1998).

III. ANALYSIS OF AN EXISTING LOCATION

3.1 Overview of an Existing Location

An electrical power station hardware supplier was established in 1983 for bidding with Provincial Electricity Authority (PEA) in Thailand. Electrical hardware manufacturer produces hardware such as ground rod, machine bolt, pin insulator, thimble eyebolt, eyenut, and so on. Electrical hardware manufacturer produces amount of product by big lots every year. When the author transports the products to PEA, the author uses ten wheel trucks to transfer our product. The regulation law doesn't permit the truck passing through Bangkok for solving traffic problems, so committees have planned to move to another place.

When the author established the present factory, the location was an empty space. And the committees considered some factors that have affect at that time. The traffic is not bad and the location did not have many houses, buildings, and so on.

3.2 Factors under Consideration

In the past, committees considered only three factors, which were land cost, utilities, and distance. It was easy to make decisions to select the location, but it was not the best solution to invest. We didn't consider community, resource, pollution, productivity, transportation factors, quality of life issues, and so on. At that time, committees didn't care about effects with the factors like the present. They considered only three factors.

(a) Land Cost

It was the main factor for consideration, because they paid some money for the land. They selected the land which was cheapest in Bangkok. The road was very rough driving to the factory. And it was far away from the hospital and all the facilities.

(b) Utilities

They considered only basis for consideration that concern only the general background for establishing. It was electricity and water.

(c) Transportation

They analyzed only the distance from the factory to PEA. They didn't weigh the traffic crisis. When time passed, Bangkok tends to have more cars. When we transported the products to the destination, it took time for transportation. It lost the productivity for factory, because the labor could not come back and produce more. The way of transport should be considered, because it was the problem at the present. We did not have any choice to transmit the products to the customer. If we had other ways to transport, we would not consider this at the present. It lost the time to establish, chances to open the market, money to invest and connect to subcontract nearest to the factory.

3.3 Impact of Suboptimal Site Selection

The impact lacked analysis, which didn't have any method to apply for selection. It happened from the subjective adjustment from one or two persons to select the location. We should collect some data to analyze for get the close objective in selection. In the past, we did not collect data for analyzing during selecting, because government and many organizations did not have data or information to support us. The result would distort the real effect. If the time changes, some factors will have more weight to consider and some factors will be neglected. Committees should predict some factors that have effect to location in the long term. In the past, traffic is smooth and fast to send the products, but the present situation is opposite to that.

IV. LOCATION PLANNING FOR THE NEW SITE

4.1 Proposed Locations

The locations are considered in two provinces and three locations. The author tries to choose the best location from three choices. And the author has some limitation to select the location where the company bought them. The three locations consist of Bang Pa In district of Ayudtaya province, Bang Kra district of Chacherng Sao province, and the last one Rachasan district of Chacherng Sao province. Each location is not easy to select to get the best location.

4.2 Location Model Selection

The author considers many location models for selection. It has location cost-volume analysis, factor rating, the center of gravity method, transportation cost model, load distance technique, transportation model, and cash flow analysis. Each method has some limitations for using, so we should analyze the limitation of each method, including:

(1) Location Cost-Volume Analysis

From the name of it, cost and volume mean to analyze with cost relates per volume. The important data cost which is separated to be fixed cost and variable cost. Fixed cost include costs such as buildings, insurance, fixed overhead or indirect costs, some minimum level of labor, and capital recovery. The fixed cost component is usually constant for all value of the variable, so it doesn't vary with differing production levels or workforce size. Even if no units are produced, fixed costs are incurred, because the factory must be maintained and some employees paid. Variable cost includes costs such as direct labor, materials, indirect and supports labor, contractors, marketing, advertisement, and warranty. It changes with production level, workforce size, and other variables. It is usually possible to decrease variable costs through better product design, manufacturing efficiency, and sales volume. From the previous definition of fixed cost and variable cost, this project used for selecting the best location does not establish or produce any product. The fixed cost is constant for using with this formula, because every location is invested in the same size of building and same pattern of construction. The variable can vary with the labor force, subcontract, and so on. The author doesn't chose this method, because it does not suit to find some formula and calculate them and no data exists to support this method too.

(2) Factor Rating

The factor rating method, involves both qualitative and quantitative inputs, which tend to adjust condition and situation of each factory. Some method uses only subjective part to analyze the data, which style is suitable for the expert person and it has more errors. Some methods use objective part to analyze the data and conclude the results. It refers to data, but sometime the data is not the main factor to have effect with selection. So the author tries to use this method, because the author can find out the information to support them. The author finds out the subjective part from the brainstorm of all committees. The subjective part is weight part in the formula of factor rating. The author searches the objective parts from historical data of each departments. The objective part shows in Table 4.3.

(3) The Center of Gravity Method

The center of gravity method, requires some data such as many destinations, and maps. This method is used for finding the best location, which will minimize distribution costs, but the author sees some limitation. This method should have a map, which is the same scale for matching them. And this method finds out the optimal location that may get the land of other person or the land no that has facility support. The locations used to analyze, where the author had the land, so it is not suitable to select this method.

(4) Factor Ranking Model

In this model, the author uses many factors to consider such as transportation cost, and load distance. Transportation cost uses three factors to analyze; such as cost of transportation in terms of bahts per unit and volume per unit distance, volume, and distance from facility to recipients demand. When the author analyzes each factors, the author considers them one by one. Volume is fixed amount, because it has only one recipient or one customer. The demand is constant. These factors cannot be used for comparing in this case. When the author considers the cost of transportation, it is not the same with all of each location in terms of bahts per unit volume. It isn't proportional to the volume. It depends on the distance and time for transportation. The two factors do not concern the formula; it shows that distance and time are the effective factors. When the author selects some location for investment, the author should consider more factors close to the real situation. So the author can conclude that this method is not suitable for using in this case. The transportation used to determine the amounts shipped from each source to each destination minimizes the total transportation cost. The limitation of this model should satisfy both the supply limits and the demand requirements. In this case, the author considers only one destination, so the level of demand is constant. It cannot use the table which is used to calculate the optimal location. The author does not analyze it.

The Load distance is based on the transported load and the distance. The distance from the candidate site to the location, which plots into the map to know the coordinates of the candidate sites and coordinates of the location. The author notices that the value of d_i can measure from the real distance. The real distance shows the exact information to analyze, so this is not good for this case too.

(5) Cash Flow Analysis

Cash flow analysis is used to analyze the worth of investment. It shows the real conditions and situations from investment. This method can help the author to select the highest benefit for investment. This method will be better when the author uses the condition and old data for evaluation.

4.3 The Considered Locations

The author considers three locations where is Bang Pa In district of Ayudhaya province, Bangkra district of Chacherng Sao province, and Rachasan district of Chacherng Sao province. The first, the author gives some background and history data of each locations for selecting.

(a) Bang Pa In district of Ayudhaya has an area about 143,182 Rai. The north closes to Pranakorn district, south closes to Krong Loung district, eastern closes to Wangnoi district, and western closes to Bangsai district. The population of this district has 46,627 persons who separate to be 22,259 males and 24,368 females. It has a school about 37 places and teacher has

569 persons. Hospital of the district has 60 beds, 2 doctors, and 46 nurses. It has 6 clinics, the train stop has 5 places, and bank has 14 places. The average of temperature is about 28.2 Celsius. The average amount of raining is about 1,232.8 mm. It is close to PEA and has only one direction for transportation. It uses time to destination about 22 minutes and the distance is about 19 kilometers.

(b) Bangkra district of Chacherng Sao has the area about 142,437 Rai. The north closes to Kig Ampur Kong Kein, the south closes to Prang Yue district, the eastern closes to Rachasan district the western closes to Ampur Meang. The population of this district has 31,342 persons who separate to be 14,814 males and 16,528 females. It has school about 30 places and teacher has about 425 persons. Hospital of district has 30 beds. The average temperature is about 27.7 Celsius. The average amount of raining is about 1,913.8 mm. The direction of transportation has 5 ways. Each ways use different time, so it is in the list in Table 4.1 and See map from Appendix D.

Table 4.1. Transportation Distance and Time between Bangkra to PEA.

Route	Distance (km)	Time (Minute)
1. Bangkra to Bangna to PEA.	114.6	102
2. Bangkra to Motorway to Bangna to PEA.	116.4	85
3. Bangkra to Motorway to PEA.	162	70
4. Bangkra to Meanburi to PEA.	63	94
5. Bangkra to Prajean to Nakorn Na Yok to PEA.	110.7	115

(c) Rachasan district of Chacherng Sao has area about 84,312 Rai. The north close to Ban Sag district of Prachenburi province, the south close to Prangyoe, the eastern close to Pranom Sarakram, the western close to Bangkra. The population of this district is about 8,095 persons separated to 3,885 males, and 4,210 females. It has a school about 10 places and teacher has 103 persons. Hospital of district has 30 beds. The average temperature is about 27.7 Celsius. The average amount of rain is about 1,913.8 mm. The direction of transportation has 5 ways. Each way uses different time, so it is in the list in Table 4.2.

Table 4.2. Transportation Distance and Time between Rachasan to PEA.

Route	Distance (km)	Time (Minute)
1. Rachasan to Bangna to PEA.	161.6	137
2. Rachasan to Motorway to Bangna to PEA.	163.4	120
3. Rachasan to Motorway to PEA.	209	105
4. Rachasan to Meanburi to PEA.	110	129
5. Rachasan to Prajean to Nakorn Na Yok to PEA.	157.7	150

4.4 Sources of Data

Sources of data can be separated into two ways. The first is weight of data, which comes from brainstorming of each committee in electrical hardware manufacture. The range of weight is from 1 to 10. The author does not use range from 0 to 10, because zero value means that the factors do not relate or effect to the selection. The author does not use range from 0 to 100 or wide range, because it is difficult to analyze the results. For example the difference of the value between 62 and 66, it cannot be used for adjusting. The second is rating value, which comes from statistic value, measurement, and source of government. The rating comes from many factors, which can be seen from the table 4.3. The data of distance and time, the author measures from driving by using car. During driving, the author drives about 80kms/hour, which is the speed of running trucks. When the author measures distance, the author records the time from starting point to destination. The author drives past the real distance from road.

Table 4.3. Location Factors and Data.

Factors	Bang Pa In of Ayudhaya	Bangkra of Chacherng Sao	Rachasan of Chacerng Sao
1.Number of Male(persons)	22,259	14,814	3,885
2.Number of Female(persons)	24,368	16,528	4,210
3.Size of Location(Tarang wa)	2,000	3,600	5,600
4.Cost of Land / Square wa	45,000	5,000	2,000
5.Cost for Site Preparation	8,000	5,400	16,800
6.Amount of Rain(mm)	1,232.8	1,913.8	1,913.8
7.Temperature of Location(Celsius)	28.2	27.7	27.7
8.Number of Highways	1	5	5
9.The Number of Sources of Raw Material	25	38	38
10.Number of Schools	37	30	10
11.Number of Teachers	569	425	103
12.Number of Beds in Hospital	60	30	30
13.Product of Time and Distance	418	5,922	14,190

4.5 The Considered Factors

The factors shown in Table 4.3 have some reasons for using them. The author will describe why he considers each factor.

(a) Number of Males is important factor, because the principle of electrical hardware manufacturer produces the hardware, which is made from steel. Number of male is important when moving the products and producing the products in the production line See in Table 4.4. However, it does not mean that female cannot do it. It depends on the job such as assembly of products, arrange the products, make thread of bolt, and the small products like washer, bolt, clamp, and so on.

(b) Number of Females is one factor that uses to consider in this project See Table 4.4. The author tries to relate simple logic. If the location is more populated than other places, it should be easy to find out the employees in the organization. All companies should consider this factor, before they establish the factory or investment in other sections. The author separates weight between male and female, because it depends on the job. If our job have more assembly than moving products, amount of females will be more important than male.

Table 4.4. Amount of Population of Each Location.

Sex	Bang Pa In of Ayudhaya	Bangkra of Chacherng Sao	Rachasan of Chacherng Sao
Male	22,259 persons	14,814 persons	3,885 persons
Female	24,368 persons	16,528 persons	4,210 persons

(c) The person who has vision in the long-term period considers size of locations See in Table 4.5. Vision of investor should know the target of business, because the size is more effective to the future. If the factory wants to expand the size when the facility is already there, the land cost is more expensive than present. And the land should have space to stock some products to save the lease cost of warehouse area. It is not only the expansion view, but the shape is an important thing. Shape of land suits parking; truck loading the products, and so on. It links to layout planning of construction to arrange process line. The data of this part comes from the title deed to a piece of land.

Table 4.5. Area of Each Location.

Bang Pa In of Ayudhaya	Bangkra of Chacherng Sao	Rachasan of Chacherng Sao
2,000 Tarang Wa	3,600 Tarang Wa	5,600 Tarang Wa

(d) Cost of Land should consider the trend of developing. The author means that the land suits establishing factory or leasing or sale to other. The developing can be noticed from infrastructure such as electricity, water, the way of transportation, the market and population of that area. The cost of each location can be seen in Table 4.6.

Table 4.6. The Estimate Cost of Each Location.

Bang Pa In of Ayudhaya	Bangkra of Chacherng Sao	Rachasan of Chacherng Sao
45,000 Bahts per Tarang Wa	5,000 Bahts per Tarang Wa	2,000 Bahts per Tarang Wa

(e) Cost for Site Preparation is the factor that many people do not care about. It is one main thing for consideration. The author makes relationship between flood and dumping soil. Many factories have a problem when they run the factory, because the government will develop the basic facilities. When government drills the road and make conduits for draining water, they adjust the high level of road. The investor should care and consider preparing this effect. When this problem happened, the labor cannot work during wet area. The factory loses time and cost to rebuild the foundation and other construction. It will increase cost for bidding too. And it makes business stop, so we should consider this factor.

(f) Amount of Rain is one factor of interest, because Thailand has problems with flood. When the author knows the amount of rain, the author can prepare something to support it such as making high level of land, making a wide way for water flow which causes expense cost for investment. And some part of production, we use hot dip galvanized. If the water mix with chemical, it is difficult to control it.

(g) Temperature of Location is not an important factor for many persons. They try to neglect it, but it has some reason for using indirect effect. The labor will make high productivity when the weather is good. The author considers the winter season, the employees have more rate of production than the summer season, so we can use this factor for evaluation.

(h) Number of Highways used to select the way for transportation, because someway cannot transfer the products to customer. If one way renovates, the products can reach the customer on time. When the customer orders our organization, the author will contract limit with date of submission. If the products cannot be sent on time, the customer will fine for late submission.

(i) The Number of Sources of Raw Material is important to analyze, because it makes the company get the cheapest cost of raw material. When electrical hardware manufacture has many subcontracts or sources of raw material, electrical hardware manufacture has more opportunity to negotiate with other companies. In reality, subcontractor will meet and communicate with us for negotiating the price. When electrical hardware manufacture gets the cheap raw material, it will have more chances to win in the bidding.

(j) Number of Schools is important for employees and employer family, because they have indirect effect on son or daughter to learn in the good school. The employees will consider this point more than employers will. They think that their son and daughter should get good place for training their son. It can attract or motivate to the employees to work with our organization.

(k) Number of Teachers is the same viewpoint with number of schools. But they will indicate quality of teacher of each school. It is adjusted by each person, so the author should use it to weigh.

(1) Number of Beds in Hospital is important factor, because it shows the quality of life. The basic need of people is medicine. When someone has some accident during working, the factory can let them go to hospital that is nearest to factory. When workers suffer from the health or accident, the owner should send them as fast as we can.

(m) Product of Time and Distance is applied from transportation cost model, which has only two factors to relate to each other. The volume can be neglected to consider, because it is the same volume at each location. A shortest distance of transportation is the important cost. The way to survey has many ways, but the author chooses the shortest distance to compare with each location. When the distance is close to customer, it saves the cost of gasoline, labor, productivity, and so on. If the distance is far away from the destination, it will have more risks such as damage, and losing products during transportation. The least time of transportation is a factor, which has effect on development location. The long distance may use shorter time than the short distance when transport passing through the city or bad traffic. From this point, the author must take care of this factor which can apply some relationship in the last factors. Time and distance are important factors to consider. When the author links two factors to be one more factor in weighting, this factor will have more weight in consideration and near relation. Sometime short distance may use more time for transportation, because the traffic and the road are not comfortable to pass through. The weight from combined factor, the author finds the average weighting of it from time factor add to distance factor and divide by two. In this case, the author does not use load distance technique, because the company has the location for selection. The author can measure the distance and time for this case, because it is not too much distance for measurement. If other projects don't have the location, the author will use this technique for selecting. The transportation model does not apply with this project, because it has only one destination for sending the products. The author will apply this method, when the company has many destinations to consider the demand of each location.

4.6 Getting Information

Information comes from surveying and collecting from statistics in the past. The distance and time come from measuring during the author driving in each direction. It is shown in Tables 4.1 and 4.2. The author chooses the shortest distance and shortest time from all data for calculation. The data is weather searched from website. The author tries to make a relationship of weather with location. One part of it which is found for using is temperature, because it has indirect effect on employees. The employees will have more productivity when the climate is good. Because some department in processing, the workers must work near the oven for melting steel and iron. The number of schools, the author calls to Ministry of Education, which has statistical information to support this project. The author looks at this point, because some workers who work at the present location have families in Bangkok. In terms of employers, we should focus on this point to support their family. If it can attract working, it will save time for training the new employees. For data of beds in the hospital, the author asks from Ministry of Public Health. During working some may have accident inside the factory, so these factors are more important too. The sources of material are important part for getting the cheapest cost in bidding. When the source is close to location, the subcontract or supplier will discount some price for transportation. Source may maintenance machines, when the machine is lost or cannot work from the part of source, the author gets information from Ministry of Industry. Other information is searched from website from suggestions of authority of Ministry of Interior.

Some data to analyze the worth in the cash flow, is shown in Table 4.7. Each information is found out from different source and different ways. Electrical hardware manufacture gets loans from bank, so the author has many conditions in contract. They are:

Table 4.7. Cost for Investment in Each Location.

Title	Bang Pa In	Bangkra	Rachasan
1.Building and Construction	4,000,000	4,000,000	4,000,000
2.Machines	18,000,000	18,000,000	18,000,000
3.Electricity	532,000	6,840,000	1,292,000
4.Water	280,280	360,360	680,680
5.Dumping Soil	2,640,000	2,376,000	5,544,000
6.Profit of Each Year	15,000,000	15,000,000	15,000,000
7.Wage and Salary of Each Year	4,608,000	4,608,000	4,608,000
8.Depreciation of Machines of Each Year by Straight Line Method	9 00,000	900,000	900,000
9.Entertainment of Customer	3,000,000	3,000,000	3,000,000
10.Insurance of Factory	100,000	100,000	100,000
11.Maintenance of Machine	200,000	200,000	200,000

(1) Building and construction will make payment every year until 10 years, which has interest equal to 8 percent. Borrow 8,000,000 bahts, interest per year 8,000,000 multiple by 8 % equal to 640,000 bahts per year. Payment of principles equals to 8,000,000 bahts per year, so principles add to interest equal to 1,440,000 bahts per year.

(2) Machines have 20 life years, and used for investment to be 18,000,000 bahts. The conditions is to pay back within 5 years, so interest of it equals to 1,440,000 bahts per year, principles of machines equal to 3,600,000 bahts per year. The author must pay principle with interest equal to 5,040,000

bahts per year, which starts at year 2.

(3) Electricity Cost depends on the distance for installation the transmission line, which Provincial Electricity Authority charges 760,000 bahts per kilometer. The author multiplies distance from the main line to each location. It is shown below:

Electricity Cost	=	distance (km) x 760,000 bahts /km
Bang Pa In	=	0.7 x 760,000
		532,000 bahts
Bangkra	=	0.9 x 760,000
		684,000 bahts
Ratchasan	=	1.7 x 760,000
		1,292,000 bahts

(4) Water installation cost is calculated from the distance, which is the approximate calculation. Government charges 280 bahts per meter and multiply by 1.43 time, which is the factor for estimate cost per distance of pipe line.

Water Installation Cost	=	(distance x 280) x 1.43
Bang Pa In	=	(700 x 280) x 1.43
		280,280 bahts
Bangkra	=	(900 x 280) x 1.43
		360,360 bahts
Ratchasan	=	(1,700 x 280) x 1.43
		680,680 bahts

(5) Dumping Soil is an important cost for calculation, but the author will use land about 50 percent in using. One ten-wheel truck has 20 m^3. One truck

can carry the soil per trip equal to 3,300 bahts.

Cost of Dumping Soil $= \frac{(\text{Rai} \times 1{,}600 \times \text{height})}{20} \times 3{,}300$

Bang Pa In $\frac{(5 \times 1{,}600 \times 4)}{20} \times 3{,}300$

5,280,000 bahts

Bangkra $\frac{\times 1{,}600 \times}{20} \times 3{,}300$

4,752,000 bahts

Ratchasan $\frac{(14 \times 1{,}600 \times}{20} \times 3{,}300$

11,088,000 bahts

(6) Profit from net sale, the author sets the net sale to be 300 million bahts per year. When the author estimates the lowest margin of profit to be 5 percent of net sale, the author will get profit about 15 million bahts per year.

(7) Wage and Salary have two levels for payment. The first, managers and technicians are 10 persons in which each person has salary about 15,000 bahts per month. The second, laborers are 50 persons, and each person has wage about 180 bahts per day. The factory will open from Monday to Saturday, so one month work is about 26 days. The total cost of wage and salary is equal to 4,608,000 per year.

(8) Depreciation of Machine uses straight-line method. The lifetime of

machines is 20 years. And the author will analyze only 10 years, so it will have salvage value of the machine at year 10 equal to 9,900,000 bahts. The depreciation is calculated by cost of machines divided by number of lifetime, so the depreciation of each year equal to 900,000 bahts per year. It starts to count from year 2.

(9) Entertainment cost is one special cost for this business. The author will spend some money for customers. The author calculates this factor to be 1 percents of net sale, which equal to 3,000,000 bahts per year.

(10) Insurance of Machine and factory will start to pay at year 2, because the author will pay for them after the author buys the machines.

(11) Maintenance Cost applies with machines. The author will start to count them at year 5 to 10.

V. COMPARISON OF EACH LOCATION

5.1 The Model and Method for Evaluation

The author finds out the model to select the best location for expansion of distribution logistics of an electrical power station hardware supplier. For each location, the author chooses where the place was bought by electrical hardware manufacture. It will save some money for investment and it can be used in the long-term period. The cost of investment is an important factor for electrical hardware manufacture to bid with other competitors.

In this project, we consider to choose the Factor Rating to analyze the locations for selecting the best place in investment. The Factor Rating method can evaluate and compare all alternatives by focus on qualitative and quantitative. The author thinks that it can let us get the real and right selection.

We get the optimum solution by using Factor Rating method which is one model of decision making of getting the best location.

5.2 Factor Rating Method

It is the method that the author chooses used which is in this project for finding the best location for investment in the factory. It composes of qualitative and quantitative data in analysis. The element has many things, which something concerns directly and more effectively in establishing the factory, but some factors do not relate to this project.

For this project, the author can find out 13 factors to consider in this method. And the part of weight, the author can get information by interview from the committees in electrical hardware manufacture. The committees consist of five persons concerned with these projects. They share investment in this project, so they are direct persons which have more real weight for each factor. The factors are shown in Table 5.1.

Table 5.1. The Factors of Comparison.

Factors	Weight	Rating		
		Bang Pa In of Ayudhaya	Bangkra of Chacherng Sao	Rachasan of Chacherng Sao
1.Number of Male	5.40	22,259	14,814	3,885
2.Number of Female	5.40	24,368	16,528	4,210
3.Size of Location	7.00	2,000	3,600	5,600
4.Cost of Land	3.20	45,000	5,000	2,000
5.Cost for Site Preparation	5.60	8,000	5,400	16,800
6.Amount of Rain	7.00	1,232.8	1,913.8	1,913.8
7.Temperature of Location	3.80	28.2	27.7	27.7
8.Number of Highways	5.20	1	5	5
9.The Number of Source of Raw Material	9.00	25	38	38
10.Amount of Schools	4.00	37	30	10
11.Amount of Teachers	4.00	569	425	103
12.Number of Beds in Hospital	7.40	60	30	30
13.Product of Time and Distance	6.20	418	5,922	14,190

The weight of each committee gives for evaluation See Table 5.2 in the below table.

Table 5.2. The Weight from Each Committee.

Factors	A	B	C	D	E
1.Number of Male	2	7	1	8	9
2.Number of Female	2	7	1	8	9
3.Size of Location	5	8	5	10	7

Table 5.2. The Weight from Each Committee. (Continued)

Factors	A	B	C	D	E
4.Cost of Land	1	8	3	2	2
5. Cost for Site Preparation	5	8	3	7	5
6.Amount of Rain	5	8	9	6	7
7.Temperature of Location	2	3	3	6	5
8.Number of Highways	2	5	5	6	8
9.The Number of Sources of Raw Material	10	9	10	10	6
10.Amount of Schools	6	5	2	6	1
11.Amount of Teachers	6	5	2	6	1
12.Amount of Beds in Hospital	7	8	9	8	5
13.Product of Time and Distance	4	8	5	7	7

From the Table 5.2, we can calculate the average of each factors by add all data of each committees and divide by number of committees. The step of calculation is shown below:

The average of weight = sum of all data / no. of data

1. Number of Male = (2+7+1+8+9) / 5

5.4

2. Number of Female = (2+7+1+8+9)/5

5.4

3. Size of Location = (5+8+5+10+7)/5

7

4. Cost of Land = (1+8+3+2+2)/5

3.2

5. Cost for Site Preparation = (5+8+3+7+5)/5

		=	5.6
6.	Amount of Rain	=	(5+8+9+6+7)/5
		=	7
7.	Temperature of Location	=	(2+3+3+6+5)/5
		=	3.8
8.	Number of Highways	=	(2+5+5+6+8)/5
		=	5.2
9.	The Source of Raw Material	=	(10+9+10+10+6)/5
		=	9
10.	Number of Schools	=	(6+5+2+6+1)/5
		=	4
11.	Number of Teachers	=	(6+5+2+6+1)/5
		=	4
12.	Amount of Beds in Hospital	=	(7+8+9+8+5)/5
		=	7.43
13.	Product of Time and Distance	=	(4+8+5+7+7)/5
		=	6.2

All the raw data is in different range, so we should translate them to be the same range. It has two types of patterns, one is directly relative and other one is indirectly relative range. The direct range is the factor relative to investment. If those factors have more, it will have positive investment. Otherwise, an indirect range is not the factor relative to investment. It means if those factors have more, it will have negative way for investment. The formula expresses in below:

$$\text{Score of Direct related Factor} = \left[\frac{(\text{Value of data} - \text{Min.value of data})}{(\text{Max.value of data} - \text{Min.value of data})} \times \text{Range} \right] + 1$$

$$\text{Score of Indirect related Factor} = \left[\left[- \frac{(\text{Value of data} - \text{Min.value of data})}{(\text{Max.value of data} - \text{Min.value of data})} \right] \times \text{Rang} \right] + 1$$

So we will separate the direct range to be the factors such as amount of male, amount of female, size of location, interstate of transportation, the number of source of raw material, amount of school, amount of teacher, and amount of bed in the hospital. It is important to an indirect range is the price of land, cost for dumping soil, amount of raining, temperature of location, and relation of time and distance. The detail of calculation are shown in Tables 5.3, 5.4, and 5.5.

Table 5.3. Transfer Raw Data to Range Step 1.

Factors	Bang Pa IN (A)	Bangkra Chacheng(B)	Rachasan Chacheng(C)	Max min	A-min	B-min	C-min
Male	22,259	14,814	3,885	18,374	18,374	10,929	-
Female	46,627	31,342	8,095	38,532	38,532	23,247	-
Size of Location	2,000	3,600	5,600	3,600	-	1,600	3,600
Cost of Area	45,000	5,000	2,000	43,000	43,000	3,000	
Amount of Rain	1,232.80	1,913.80	1,913.80	681	-	681	681
Temperature	28.20	27.70	27.70	1	0.5		
Cost for Dumping	8,000	5,400	16,800	11,400	2,600	-	11,400
No. of Highways	1.00	5	5	4		4	4
No. of Schools	37	30	10	27	27	20	

Table 5.3. Transfer Raw Data to Range Step 1. (Continued)

Factors	Bang Pa TN (A)	Bangkra Chacheng(B)	Rachasan Chacheng(C)	Max-min.	A-min	B-min	C-min
No. of Teachers	569	425	103	466	466	322	
Amount of bed in hospital	60	30	30	30	30		
Source of Raw Material	25	38	38	13		13	13
Time * Distance	418	5,922	14,190	13,772		5,504	13,772

Table 5.4. Transfer Raw Data to Range Step 2.

Factors	Weigh VW)	Rev.(A-min)/(max-min)	Rev.(B-min)/(max-min)	Rev.(C-min)/(max-min)	((Rev.(A-min)/(max-min))*9)+1	((Rev.(B-min)/(max-min)).9)+1	((Rev.(C-min)/(max-min))*9)+1
Male	5.40	1.00	0.59	-	10.00	6.35	1.00
Female	5.40	1.00	0.60	-	10.00	6.43	1.00
Site of Location	7.00	-	0.44	1.00	1.00	5.00	10.00
Cost of Area	3.20		0.93	1.00	1.00	9.37	10.00
Amount of Rain	7.00	1.00			10.00	1.00	1.00
Temperature	3.80	-	1.00	1.00	1.00	10.00	10.00
Cost for Dumping	5.60	0.77	1.00		7.95	10.00	1.00
No. of Highways	5.20		1.00	1.00	1.00	10.00	10.00
No. of Schools	4.00	1.00	0.74	-	10.00	7.67	1.00
No. of Teachers	4.00	1.00	0.69	-	10.00	7.22	1.00
Bed in hospital	7.43	1.00		-	10.00	1.00	1.00
Source of Raw Material	9.00		1.00	1.00	1.00	10.00	10.00

Table 5.4. Transfer Raw Data to Range Step 2. (Continued)

Factors	Weight(W)	Rev.(A-min)/(max-min)	Rev.(B-min)/(max-min)	Rev.(C-minvo ax-min)	((Rev.(A-min)/(max-mm))-9)+1	((Rev.(B-minwmax-min))*9)+1	((Rev.(C-min)/(max-min))-9)+1
Time * Distance	6.20	1.00	0.60		10.00	6.40	1.00

Table 5.5. Transfer Raw Data to Range Step 3.

Factors	Weight(W)	((Rev.(A-min)i(max-min))*9)+1	((Rev.(B-minxmax-min))*9)+1	((Rev.(C-minmmax-min))*9)+1	(((Rev.(A-minvoax-min))*9)+1)*W	(((Rev.(B-minmax-min))*9)+1)*W	(((Rev.(C-minv(max-min))*9)+1)*W
Male	5.40	10.00	6.35	1.00	54.00	34.31	5.40
Female	5.40	10.00	6.43	1.00	54.00	34.72	5.40
Site of Location	7.00	1.00	5.00	10.00	7.00	35.00	70.00
Cost of Area	3.20	1.00	9.37	10.00	3.20	29.99	32.00
Amount of Rain	7.00	10.00	1.00	1.00	70.00	7.00	7.00
Temperature	3.80	1.00	10.00	10.00	3.80	38.00	38.00
Cost for Dumping	5.60	7.95	10.00	1.00	44.51	56.00	5.60
No of Highways	5.20	1.00	10.00	10.00	5.20	52.00	52.00
No. of Schools	4.00	10.00	7.67	1.00	40.00	30.67	4.00
No. of Teachers	4.00	10.00	7.22	1.00	40.00	28.88	4.00
Amount of bed in hospital	7.43	10.00	1.00	1.00	74.30	7.43	7.43
Source of Raw Material	9.00	1.00	10.00	10.00	9.00	90.00	90.00
Time * Distance	6.20	10.00	6.40	1.00	62.00	39.70	6.20
					467.10	483.69	327.03

When we get the value from calculation, we will sum up all of value from the Table 5.5. The author gets the maximum value for selecting in this case. The sum of each location is show in below:

Bang Pa In Ayudhaya

= 54+54+6+4.1+70+3.8+43.71+5.2+38+38+74+9+62

= 461.81

Bangkra Chacherng Sao

= 34.31+34.72+30+38.43+7+38+55+52+29.13+27.43+7.40+90+39.7

= 483.12

Rachasan Chacherng Sao

= 5.4+5.4+60+41+7+38+5.5+52+3.8+3.8+7.4+90+6.2

= 325.50

From the data the author chooses the maximum value, which is Bangkra Chacherng Sao to be the best location for this method.

5.3 Cash Flow Analysis

This is one method for selecting, which has data in Table 5.6.

Table 5.6. Data in Cash Flow Analysis.

Title	Bang Pa In	Bangkra	Ratchasan
1.Building and Construction	4,000,000	4,000,000	4,000,000
2.Machines	18,000,000	18,000,000	18,000,000
3.Electricity	532,000	6,840,000	1,292,000
4.Water	280,280	360,360	680,680
5.Dumping Soil	2,640,000	2,376,000	5,544,000
6.Profit of Each Year	15,000,000	15,000,000	15,000,000

Table 5.6. Data in Cash Flow Analysis. (Continued)

Title	Bang Pa In	Bangkra	Ratchasan
7.Wage and Salary of Each Year	4,608,000	4,608,000	4,608,000
8.Depreciation of Machines of Each Year by Straight Line Method	900,000	900,000	900,000
9.Entertainment of Customer	3,000,000	3,000,000	3,000,000
10.Insurance of Factory	100,000	100,000	100,000
11.Maintenance of Machine	200,000	200,000	200,000

From the cash flow diagram, the author has three variables for substituting.

X is value of electricity cost

Y is value of water installation

Z is value of dumping soil

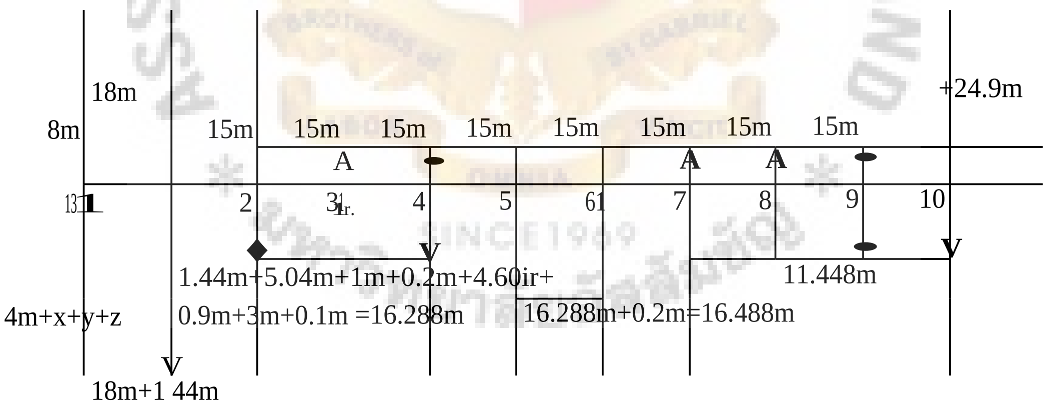


Figure 5.1. A Cash Flow Diagram.

We can calculate the diagram of above by:

$$NPV(8\%) = 8m - (4m + x + y + z) - 1.44m\left(\frac{P}{F},8\%,1\right) - 1.288m\left(\frac{P}{A},8\%,3\right)\left(\frac{P}{F},8\%,1\right)$$

$$-1.488m\left(\frac{P}{A},8\%,2\right)\left(\frac{P}{F},8\%,4\right) + 3.552m\left(\frac{P}{A},8\%,3\right)\left(\frac{P}{F},8\%,6\right) + 13.452m\left(\frac{P}{F},8\%,10\right)$$

where

$\left(\frac{P}{F},8\%,1\right) = 0.9259$

$\left(\frac{P}{A},8\%,2\right) = 1.7833$

$\left(\frac{P}{F},8\%,6\right) = 0.6302$

$\left(\frac{P}{F},8\%,10\right) = 04632$

$\left(\frac{P}{A},8\%,3\right) = 2.5771$

$\left(\frac{P}{F},8\%,4\right) = 0.735$

$\left(\frac{P}{F},8\%,6\right) = 0.6302$

$\left(\frac{P}{F},8\%,10\right) = 0.4632$

When the author knows all the value from the formula, the author substitute all value to the net present worth of each location. The result of calculation shows below:

$NPV_{Bang\ Pa\ In} = 0.55m + (1.44m \times 0.9259) - (1.288m \times 2.5771 \times 0.9259)$

=— (1.488m x 1.7833 x 0.735) + (3.552m x 2.5771 x 0.6302) + (13.45m x 0.4632)

= 0.55m+5,642,728.61

= 6,192,728.61 bahts

$NPV_{Bangkra}$ =0.58m + (1.44m x 0.9259)— (1.288m x 2.5771 x 0.9259)

=— (1.488m x1.7833 x 0.735) + (3.552m x 2.5771 x 0.6302) + (13.45m x 0.4632)

= 0.58m+5,642,728.61

= 6,222,728.61 bahts

$NPV_{Ratchasan}$ =— 3.512m + (1.44m x 0.9259)— (1.288m x 2.5771 x 0.9259)

=— (1.488m x1.7833 x 0.735) + (3.552m x 2.5771 x 0.6302) + (13.45m x 0.4632)

= -3.512m+5,642,728.61

= 2,130,728.61 bahts

From this method, the result shows NPVBan$_g$kra is highest worth, so the author selects $NPV_{Bangkra}$ to be the best solution for this method.

VI. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The location expansion of an electrical power station hardware supplier is the location which supports the demand from bidding. The electrical power station hardware is special products for some company. When the author wants to get some bidding, it depends on the cost for competing with the competitors. The opportunity of new factory should find out some place which is giving more profit in industry.

The present location suits running business in the same pattern, it cannot expand to reserve the big order from marketing. The traffic is not good in Bangkok the author loses time to deliver the products to customer. If the government and other segments set some law, which has effect on traffic, the company will get trouble with them. The perfect company should have plans to support the future that the author called vision of each organization. Many factories try to move their company from the center to urban or other provinces. It helps our country to distribute development to other provinces. The government wants Thailand to be a decentralized system, so our project indirectly supports that point.

The author decides to choose the new locations for investment. It supports the future problems about location. When the problems occur to our organization, the author does not waste time to analyze this point. The committees have some information, which has some factors to support before they make decision for investment in the new location. The author focuses on three locations. They are the locations where the company bought it. There is Bang Pa In district Ayudhaya province, Bangkra district Chacherng Sao province, and Ratchasan district Chacherng Sao province.

From many methods for selecting location, the author selects the Factor Rating and cash flow analysis to apply in this case. The author wants to relate both main types of data to consideration. There are two types of data, which are qualitative and quantitative. It will make the result nearly real to the case. The author chooses the qualitative from the target groups who are the persons to have authority to make decisions. The quantitative data have many factors, some factors are concerned and many factors are not concerned. The author can arrange the quantitative data in five groups, which are population, land, climate, facility, and transportation. Each group can be split to many factors to analyze. The factors of transportation, the author can split into three factors such as time, distance, and route of transportation. The author considers time and distance, relates to each other. The author measures time and distance from the data. The author notices that the long distance uses short periods, and the short distance uses long time period for transportation. It depends on the traffic of each route, so the author combines two factors by multiplying two results and weight for getting the closer to the real case.

The author selects the Factor Rating method to evaluate each location, because main factors are an important part for getting the best location in investment. The author has thirteen factors to analyze for finding the best location. The author uses all data and substitutes them to the formula. Then the calculation results show in the previous section. The author selects the highest scores to be the best location for investing. It is Bangkra district in Chacherng Sao province. For cash flow analysis, the author gets the Bangkra district in Chacherng Sao province to be the maximum worth of investment. The two methods get the same result of investment. The location is selected by calculation, which can support to conclude in investment. It will be the location to establish for expansion of distribution logistics of an electrical power station hardware supplier. If the author can find out the effect, which others do not care about it, the result will be close to the real situation.

6.2 Recommendations

If they are not the same result, the author suggests weighing the factor rating again from the committees. They can change the result because it is the part of intangible evaluation. The author should consider some factors during the result which changes too much. If the author focuses on one factor, the result will be distorted from the real condition. The distortion will cause more error during calculation. The author thinks to the effect, which may occur in the future. When the author gets all the factors, the author tries to scan the factors against each other. The main point for this project concerns the factor for weighting and data to support which combines qualitative and quantitative together. The author suggests that the factors of consideration should have more effect on area of job, because every business does not have the same pattern. Some business deals with marketing and some business deals with specific customers. This method is worldwide for using in the general, but cannot work very well from amount of factor to consideration. The other method may work very well with other case. It depends on the case of selecting. In this project, the author has three locations, which are some limitation to selecting. Other case can choose some method in the literature review part, the author suggests trying all the methods. From evaluation part, the author recommends about weighting, because it has more effect with the results. The author should explain briefly views of questions when the author records the data from other persons. If the person missunderstand the concept of each factor, the result will have error data for calculation. In this project, the author has only five persons to weigh the factors, but all persons are investors of this project. If the author weigh from other persons, who are not concerned with the project, it will change the result of selection. If another project has many destinations, the author will use transportation model to apply, because that method will make us get the optimum solution. If the company did not have the locations, the author will suggest using load distance technique. It will be good when the project have no boundary for establishing. The author hopes that the reader will get the optimum solution, and follow the steps in the procedure of this project.

APPENDIX A

WEIGHTS FROM EACH COMMITTEE

Table A.1. Questionnaire for Finding the Weight of Each Person in the Committees.

Factors	A	B	C	D	E
1.Number of Male	7	1	2	8	9
2.Number of Female	7	1	2	8	9
3.S ize of Location	8	5	5	10	7
4.Cost of Land	1	8	3	2	2
5. Cost for Site Preparation	5	8	3	7	5
6.Amount of Rain	5	8	9	6	7
7.Temperature of Location	2	3	3	6	5
8.Number of Highways	2	5	5	6	8
9.The Number of Sources of Raw Material	10	9	10	10	6
10.Amount of Schools	6	5	2	6	1
11.Amount of Teachers	6	5	2	6	1
12.Amount of Beds in Hospital	7	8	9	8	5
13.Product of Time and Distance	4	8	5	7	7

APPENDIX B

DATA OF EACH LOCATION

Table B.1. List of Data in Each Location.

Factors	Bang Pa In of Ayudhaya	Bangkra of Chacherng Sao	Rachasan of Chacerng Sao
1.Number of Male(persons)	22,259	14,814	3,885
2.Number of Female(persons)	24,368	16,528	4,210
3.Size of Location(Tarang wa)	2,000	3,600	5,600
4.Cost of Land / Square wa	45,000	5,000	2,000
5.Cost for Site Preparation	8,000	5,400	16,800
6.Amount of Rain(mm)	1,232.8	1,913.8	1,913.8
7.Temperature of Location(Celsius)	28.2	27.7	27.7
8.Number of Highways	1	5	5
9.The Number of Sources of Raw Material	25	38	38
10.Number of Schools	37	30	10
11.Number of Teachers	569	425	103
12.Number of Beds in Hospital	60	30	30
13.Product of Time and Distance	418	5,922	14,190

APPENDIX C

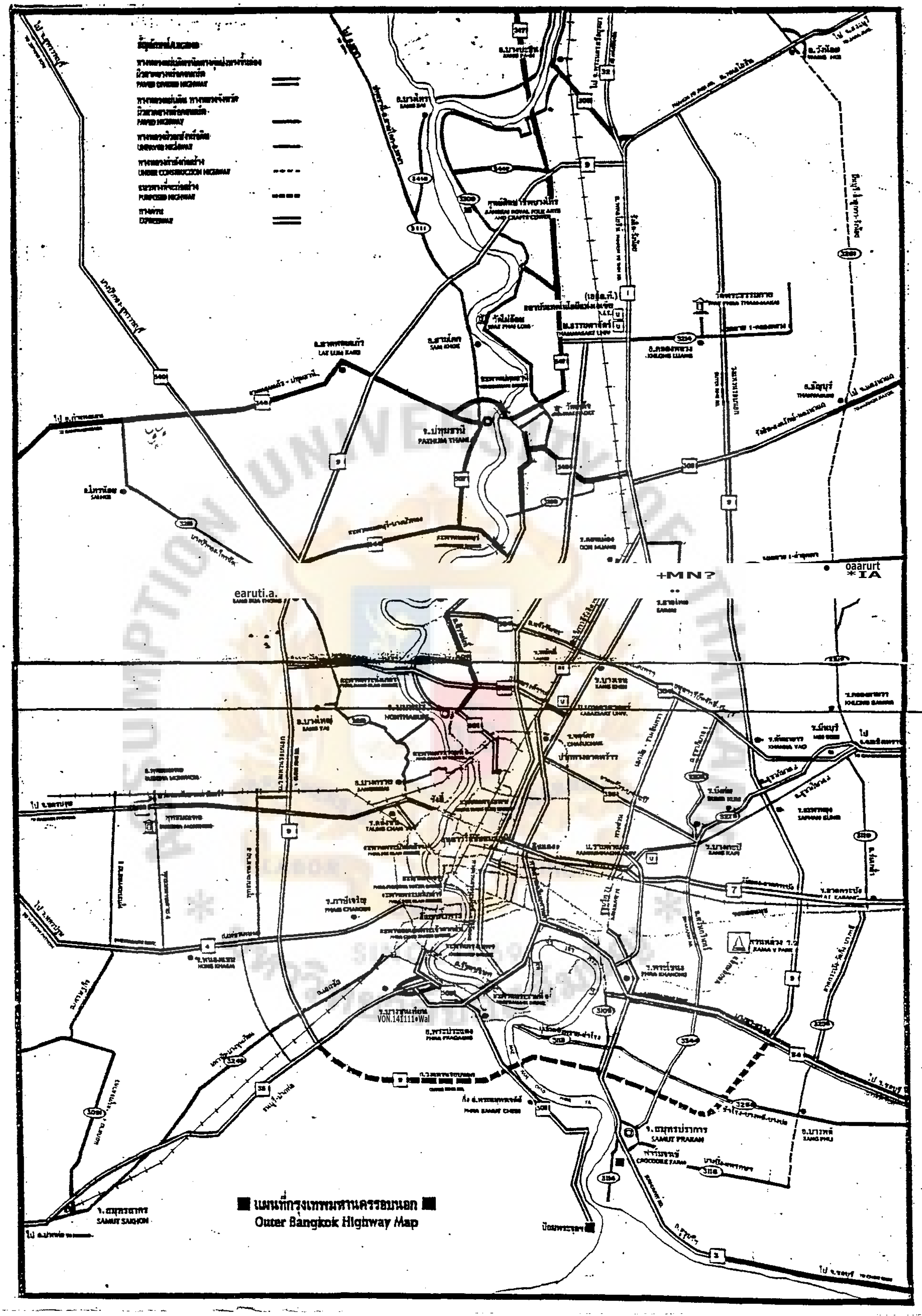
A TABLE OF DISTANCE AND TIME FROM MEASUREMENT

Table C.1. Table of Distance and Time from Measurement.

No.	Route	Distance(km)	Time (Minute)
1	Ratchasan to Bangna to PEA	161.6	137
2	Ratchasan to Motorway to Bangna to PEA	163.4	120
3	Ratchasan to Motorway to PEA	209	105
4	Ratchasan to Meanburi to PEA	110	129
5	Ratchasan to Prajeanburi to Nakornayok to Rangsit to PEA	157.7	150
6	Bangkra to Bangkok to PEA	114.6	102
7	Bangkra to Motorway to Bangna to PEA	116.4	85
8	Bangkra to Motorway to PEA	162	70
9	Bangkra to Meanburi to PEA	63	94
10	Bangkra to Prajeanburi to Nakornayok to Rangsit to PEA	110.70	115
11	Bang Pa In to PEA	19	22

APPENDIX D

OUTER BANGKOK HIGHWAY MAP



•Figure D.1. Outer Bangkok Highway Map.

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