



CHAPTER 4

ENGINEERING ANALYSIS

In this chapter will explain engineering analysis in order to know the feasibility of technical product/service specification, process of infectious wastes incinerating, production program, machine and equipment, plant location, transportation routing plant layout, raw material, and utilities. Finally, the environmental effect and economic and social study will be explained as following items.

4.1 Service specification

Incinerating service business for infectious wastes of ABC Company is to receive infectious waste from customers and to incinerate them with high efficiency using the Controlled Air Incinerating process.

4.2 Incinerating Process

ABC Incinerating process is shown in the following figure.

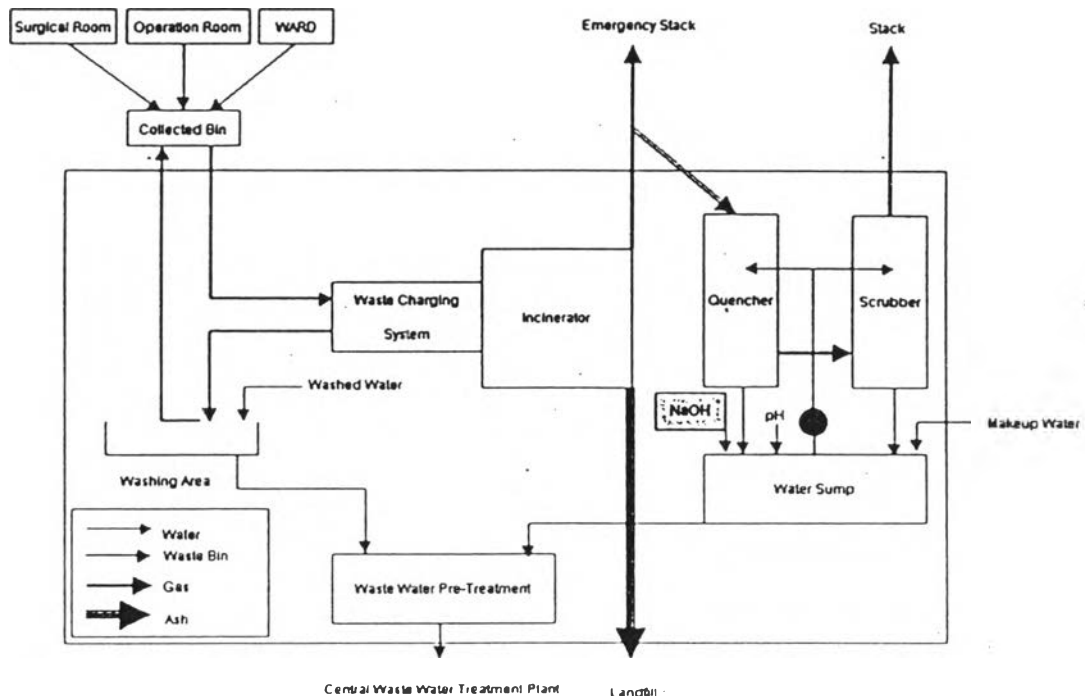


Figure 4.1: Infectious waste dispose process
Source: Adapted from Somrat Kerdsuwan (2001)

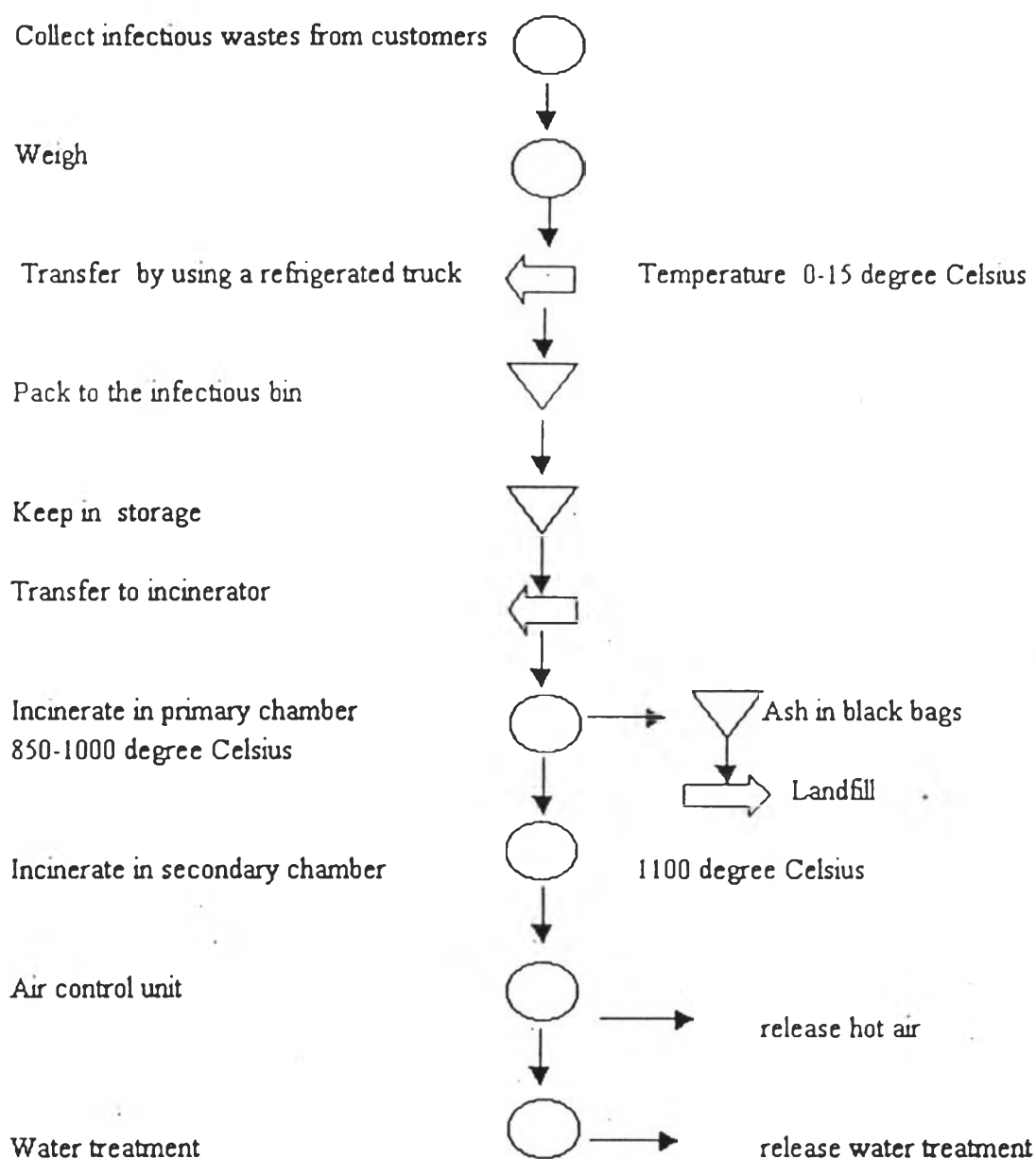


Figure 4.2: Incinerating process

According to figure 4.2, detail of each procedure is shown in the following items.

- 1) Collect infectious wastes from each customer such as hospital, clinic, industry and so on. . In general, the customers have infectious waste areas from which the waste is collected. In this step, the operator will use the suitable suit and protecting equipment for protects contacting with the infectious wasted (Environment Institute of Thailand :1996). as shown in the following figure.

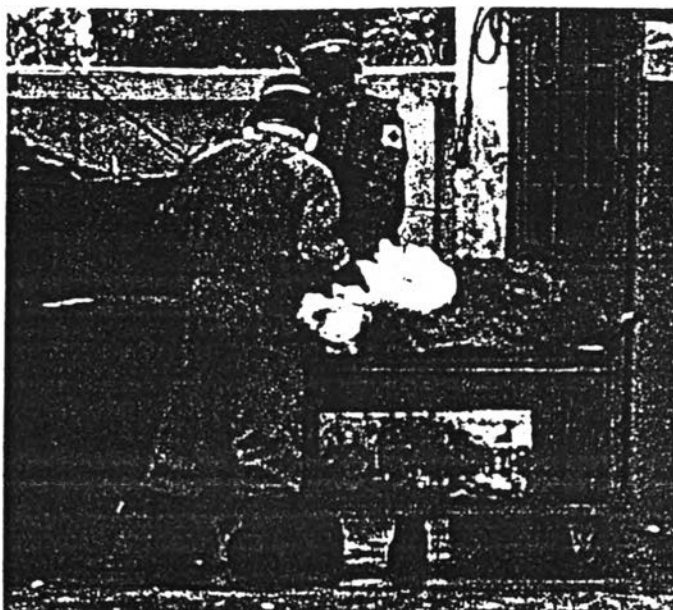


Figure 4.3: ABC's operators

- 2) Weigh the infectious wastes in order to record the amount.
- 3) Transfer the infectious waste from infectious area by using a refrigerated 1 ton truck with temperature 0 degree Celsius in order to stop growth of any bacteria, virus, etc.
- 4) Pack infectious wastes from the car into the infectious bin.
- 5) Transfer the infectious to the infectious waste storage.
- 6) Transfer the infectious waste bin into the incinerating plant.
- 7) The automatic feeder will tip the infectious waste into the primary chamber. The infectious waste can be fed from the waste bin into the incinerator mechanically without exposing the operator to direct contact with the infectious waste. The hydraulic drive unit is used to operate the charging door and the pushing ram.

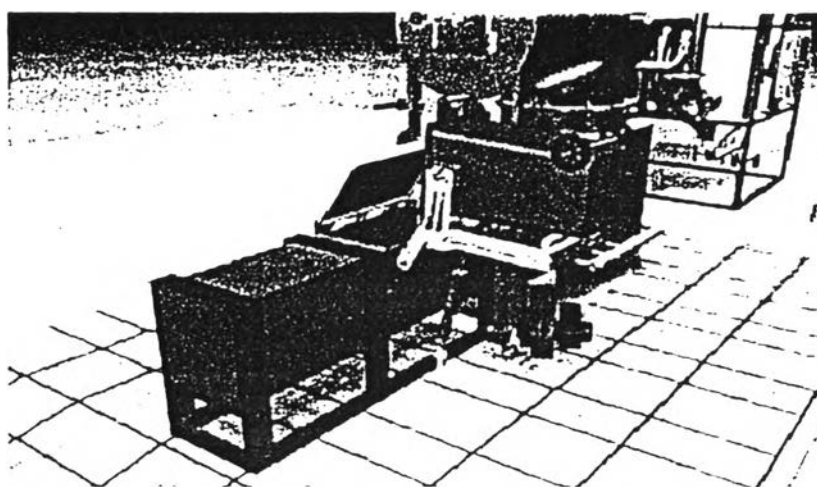
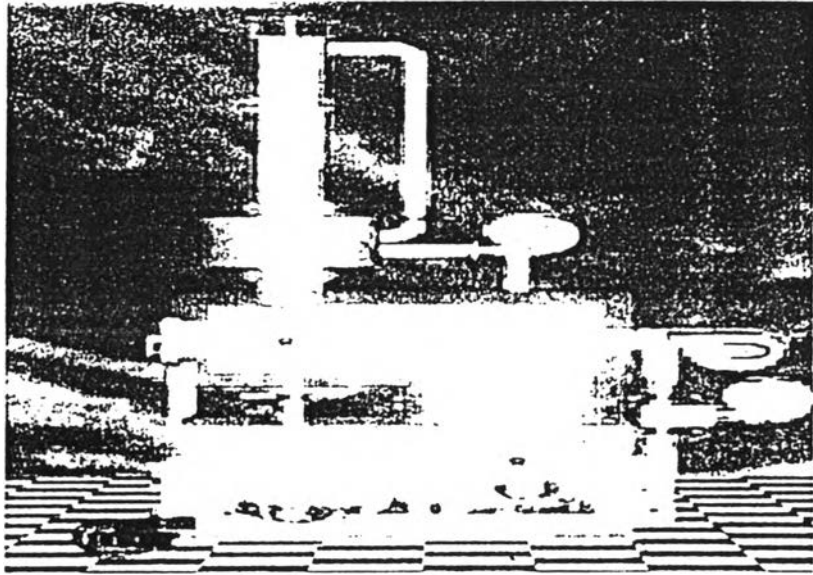


Figure 4.4: Feeder process

- 8) Infectious wastes is incinerated in primary chamber at 850 degree Celsius which uses excess air to ensure complete combustion.



4.5: Incinerator

Ash is released from the primary chamber by the ash removing. In addition, it removes the ash once a day after burn-down and cool-down periods are attained (usually in the morning before start-up). Ash removal is done by raking the ash through the de-ashing door which is located on the back of the incinerator for ease of operation. The door can turn freely. When the ash cools down it is shoveled into black bags for transfer to landfill.

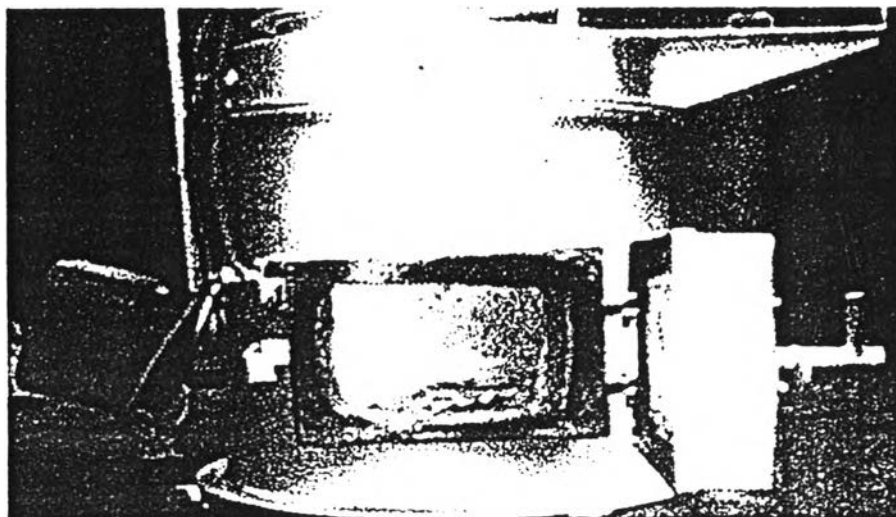


Figure 4.6: Primary Chamber

Flue gas from primary chamber is combusted in the secondary chamber at 1,100-degree Celsius in order to completely incinerate the wastes. The secondary chamber can combust Toxins and Carcinogens completely.

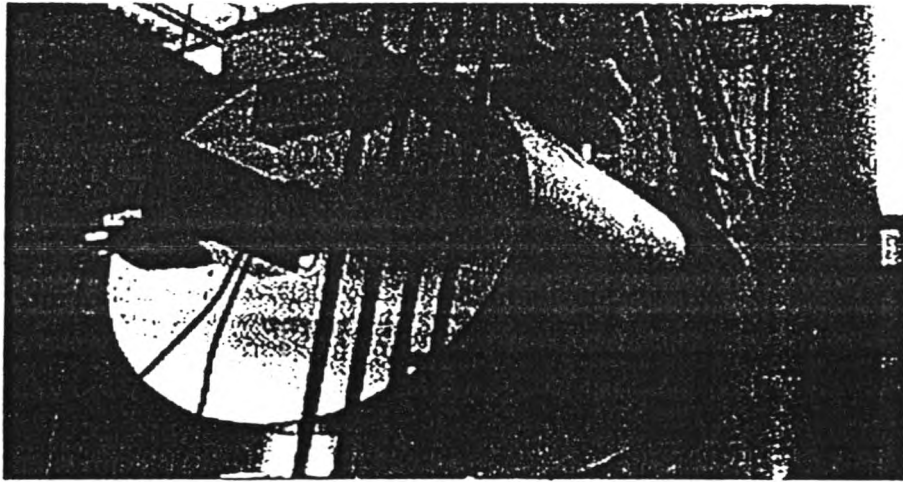


Figure 4.7: Secondary Chamber

- 9) After incinerating the gas in secondary chamber, it will be sent to an air pollution control unit for removal of Carbon particulate and absorb Hydrochloric acid and hot air. This scrubber will decrease gas temperature, destroy toxic gas and remove smoke.

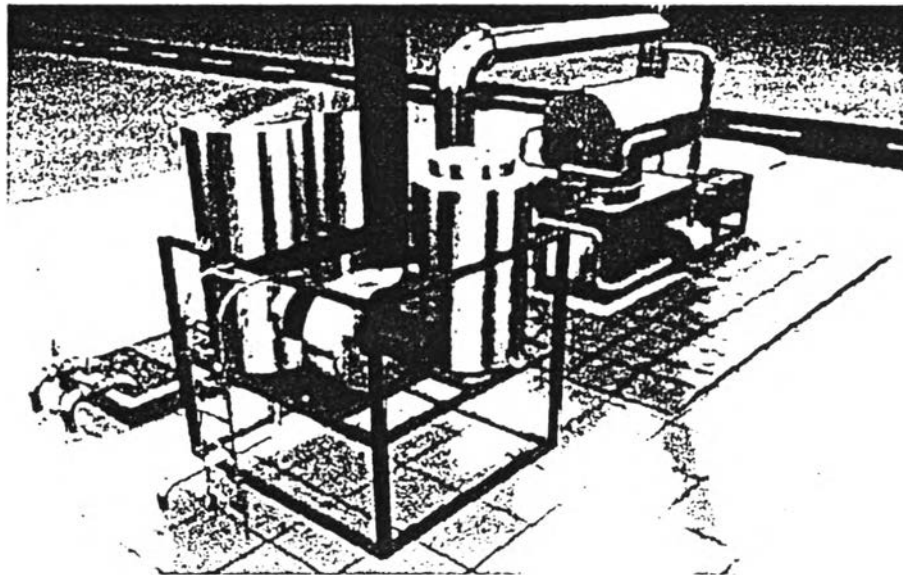


Figure 4.8: Air Pollution Control unit

- 10) Wastewater from Air Pollution Controlled unit will be sent for treatment and recheck by ABC's laboratory before discharging to the river.

4.3 Production Program

Production program dictates the level of production activities with respect to time scale. In consistency with sale projection and technical factors, production program will subsequently settled.

In case of ABC Company, it wants market share 50% so it will use Controlled Air Incinerator, which has capacity 2.5 tons/day. The production program is shown in the following table.

Table 4.1: Production program

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Production Program(%)	71.2	74.6	78.2	81.6	85.0	88.4	91.8	95.4	98.8	100

4.4 Machinery and Equipment

Machinery and equipment which are necessities for ABC Company are, for example; the controlled-air incinerator, Automatic Feeder, Scrubber Air Pollution Control, Ash Removal, pH meter, and Refrigeration truck.

4.4.1 Controlled Air Incinerator

The controlled-air incinerator is usually based on the temperature of the primary and secondary chambers. Systems operating under controlled-air principle have varied degrees of combustion air control. The primary and secondary combustion air systems are automatically and continuously regulated or "modulated" to maintain the desired combustion chamber temperature despite varying waste composition and characteristics. The following figure shows ABC's incinerator.

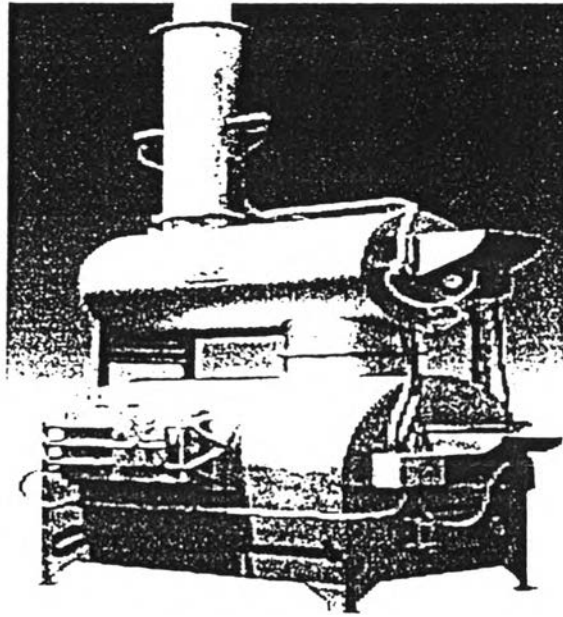


Figure 4.9: Incinerator

Controlled Air Incinerator, which ABC Company will use, it should have the following specification;

- 1) Incinerator capacity 2.5 tons/day.
- 2) Suitable for solid/semi solid wastes.
- 3) Built in ash chamber provided for the wastes, which have high ash content.
- 4) Option of diesel fuel.
- 5) Castable refractory used to withstand high temperatures.
- 6) The working principle of the incinerator is of an intermittent controlled-air type.
- 7) The incinerator is designed to work with a waste-charging device.
- 8) The incinerator has a de-ashing door allowing convenient ash removal from the chamber.
- 9) The burner installed at the primary combustion chamber is for igniting the waste and maintaining the chamber temperature at 850 C.
- 10) The burner installed at the secondary chamber is for reburning the gas coming from the primary chamber and maintaining the temperature at 1100 C.

- 11) The combustion air is supplied by a blower installed at the back of incinerator, and flows through the runner pipe to each chamber, the flow rate of which can be adjusted by a butterfly valve to match the controlled-air principle.
- 12) The primary chamber has a size big enough to be filled by a waste charging rate.
- 13) The secondary chamber should be designed to have a resident time of at least 1 seconds for complete incineration of the gas.
- 14) The primary burner will stop immediately when the charging door or the de-ashing door opens.
- 15) The operator cannot charge any waste into the primary chamber if the setting time is not yet attained. This is to prevent over-charging of the incinerator which may result in incomplete combustion.

For supplier selection, there are 4 potential suppliers for incinerators as shown in the following list.

- Maxxfire Company Ltd.

1213/68 Soi Srivara(Ladprao 94) Ladprao Rd., Wongtonglang, Bangkok 10310

- Hovai Company Ltd.

33-36 Soi Senloi 3 Chan Rd, Satorn Bangkok 10120

- Hirakawa Kdum Company Ltd

177/1 Bangkoksahapakanpai2 Surawong Rd, Bangruk Bangkok 10500

- Techern Co Ltd

7 Moo1 Ramintra Rd Tarang Bangkan Bangkok 10220

Detail of each incinerator's specification is shown in the following table.

Table 4.2: Incinerator's specification

Supplier	Maxxfire Company	Hovai Company	Hirakawa Kdum Company	Teethern Company
Capacity	2.5 ton/day	2.5 ton/day	2.5 ton/day	2.75 ton/day
High of stack	10 m	8m	12m	8m
Equipment area	6.38 m ³	7.28m ³	10m ³	6.5m ³
Temperature at primary chamber	850C	900C	800C	850C
Temperature at secondary chamber	1100C	1200C	1000C	1200C
Maximum Heat Resistance	1750C	1800C	1500C	1800C
Number of Burner	2	3	2	2
Price(baht)	2,500,000	3,500,000	3,200,000	3,750,000
Warrantee(year)	2	2	1	2
Technology	Thailand	Switzerland	Japan	German

According to ABC Company incinerator requirement, the company will select the appropriate suppliers for this significant machinery by applied weight Point Method (Linear Average) as shown in the following table.

Table 4.3: Incinerator's supplier selection

Supplier	Weight	Maxxfire Company	Hovai Company	Hirakawa Kdum Company	Teethern Company
Quality	40	33	35	30	38
Price	30	29	22	25	20
Delivery	10	9	8	8	8
Service	20	18	17	15	15
Total	100	89	82	78	81

According to the weight point method found that the most appropriate suppliers for Incinerator is Maxxfire Company.

4.4.2 Automatic Feeder

ABC company will use the automatic feeder because it provide added safety to the operating personnel by preventing heat, flames, and combustion products from escaping the incinerator during charging. In addition, it limits ambient air infiltration into the incinerator.

This assists in controlling the combustion rate by strictly controlling the amount of available combustion air. Furthermore, it facilitates charging the incinerator with smaller batches of waste at regulated time intervals.

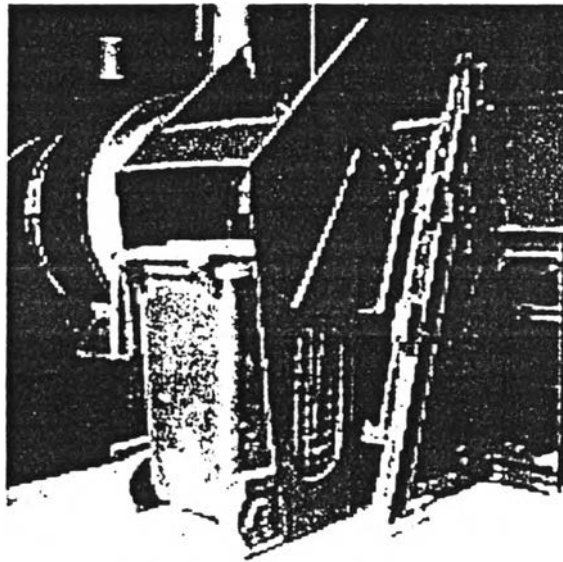


Figure 4.10: Tipping Mechanism

Source: www.thermeng.com

The function of the automatic feeder system is to sustain the waste charge coming from the sources or from the storage room. When the operator of the incinerator pushes the waste bin to the feeder, a mechanism would tip the waste inside the bin into the hopper. Then, the fire door opens automatically through the action of a hydraulic cylinder. The feed ram then pushes the waste in the hopper forward into the primary chamber. After that, the feed ram retracts to the original position and the fire door lowers to the closed position.

The system is used for handling infectious wastes; therefore, the following design concepts will be adopted.

- 1) Hydraulic drive is to be chosen because of its suitability for handling heavy loads, which includes the fire door and the feed ram. Thus, two sets of hydraulic cylinders will be needed.
- 2) Waste tipping is done manually with the aid of a tipping mechanism because the waste feed and the bin are of low weight, offering a cost-saving opportunity.

The following figure shows the schematic of the operation of automatic feeder

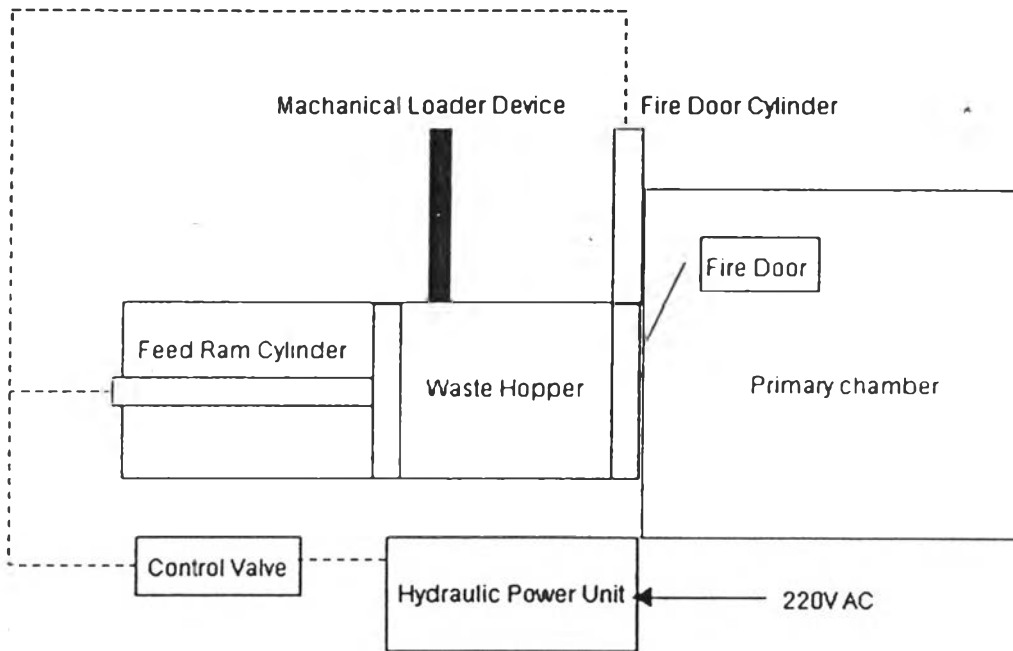


Figure 4.11 : the schematic of the operation of automatic feeder
Source : Somrat Kerdsuwan(2001)

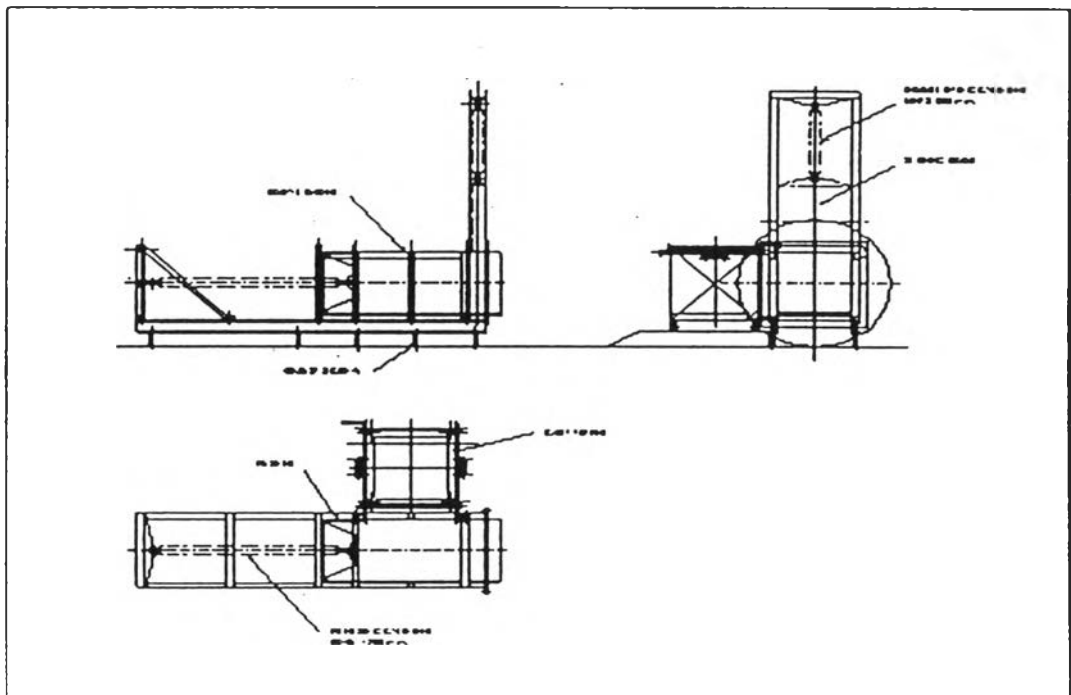


Figure 4.12: the Assembly view of automatic feeder

Source : Somrat Kerdsuwan(2001)

In case of supplier selection for the automatic feeder, ABC Company will consider of the following companies.

- Hovai Company Ltd.

33-36 Soi Senloi 3 Chan Rd, Satorn Bangkok

- Inter Machinery Company Ltd.

100 Ratanatibet Rd, Tumbol Trima nonthaburi

- Hirakawa Kdum Company Ltd

177/1 Bangkoksahapakanpai2 Surawong Rd, Bangruk Bangkok

- TMN Engineering

11 Moo 4 Chang-A-Kad Utid Sikan Donmuang Bangkok

The specification and price of this machine are shown in the following table.

Table 4.4 : Supplier specification of Automatic Feeder

Supplier	Hovai Company	InterMachinery Company	Hirakawa Kdum Company	TMN Engineering Company
Charging chamber volume	0.9 m ³	0.7 m ³	0.9 m ³	0.9 m ³
Width of charging aperture	760 mm	500 mm	500 mm	450 mm
Length of charge aperture	1830 mm	1200 mm	1500 mm	1000 mm
Depth of charging chamber	610 mm	500mm	610 mm	500 mm
Hydraulic pump				
Feed flow	15 lit/min	10 lit/min	8 lit/min	5 lit/min
Operating Pressure (bar)	60	50	60	40
Maximum pressure (bar)	120	120	120	120
Capacity of hydraulic tank (lit)	60	50	60	50
Pump motor				
Speed of rotation	1450/min	1250/min	1000/min	800/min
Power output(kW)	2.2	2.2	2.2	2.2
Voltage	220/380	220/380	220/380	220
Operation	9A	9A	27A	27A
Starting	27A	27A	27A	36A
Price(baht)	750,000	500,000	650,000	475,000
Warrantee(year)	2	2	1	6 months

ABC Company will select the appropriate suppliers for this significant machinery by applied weight Point Method as shown in the following table.

Table 4.5: Automatic Feeder's supplier selection

Supplier	Weight	Hoval Company	InterMachinery Company	Hirakawa Kdum Company	TMN Engineering Company
Quality	40	36	34	30	28
price	30	20	28	25	30
Delivery	10	9	9	8	7
Service	20	18	18	15	12
Total	100	83	89	78	77

According to the weight point method found that the most appropriate suppliers for Automatic Feeder is InterMachinery Company.

4.4.3 Scrubber Air Pollution Control

ABC Company uses the Air Pollution Control System (Scrubber) which is system used to prevent acid gases and heavy metals from being discharged to the atmosphere. The Scrubber is attached to the Oxidizer system through a T-section in the exhaust stack from the Afterburner.

The Scrubber incorporated the use of water, a neutralizing chemical and fine, Teflon plastic fibres to clean the exhaust gas from burning garbage. The industry typically refers to this type of system as a Wet Scrubber. Due to the very low emission levels of the Oxidizer system, a baghouse is not required to filter solid material in the exhaust gas stream. The following figure presents the Air Pollution Control System (Scrubber).

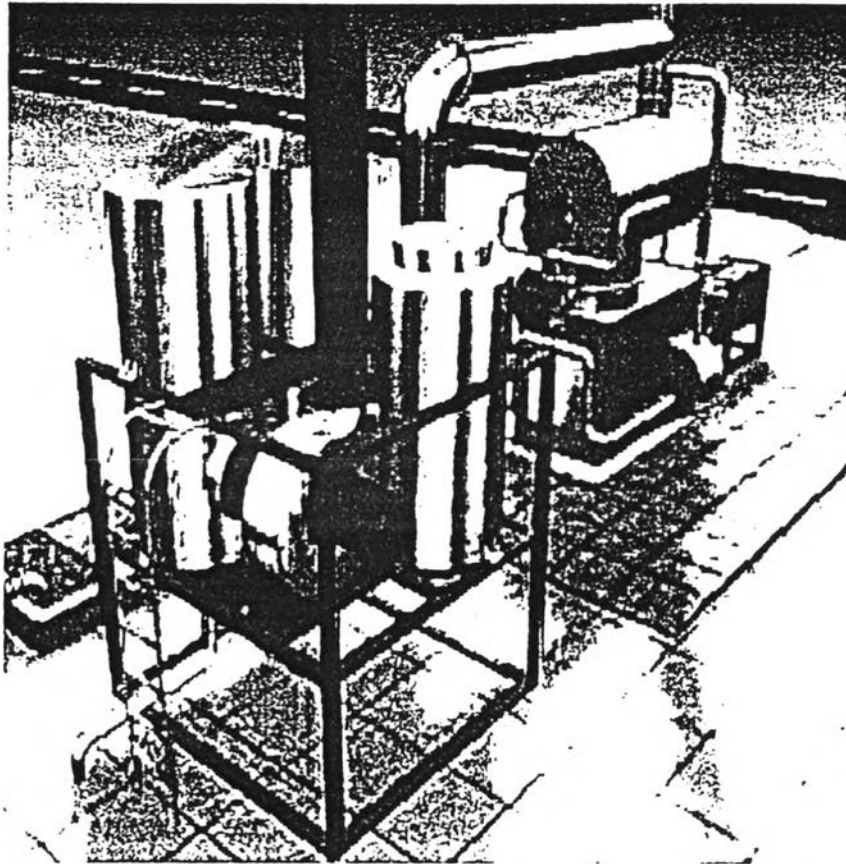


Figure 4.13: Scrubber Air Pollution Control

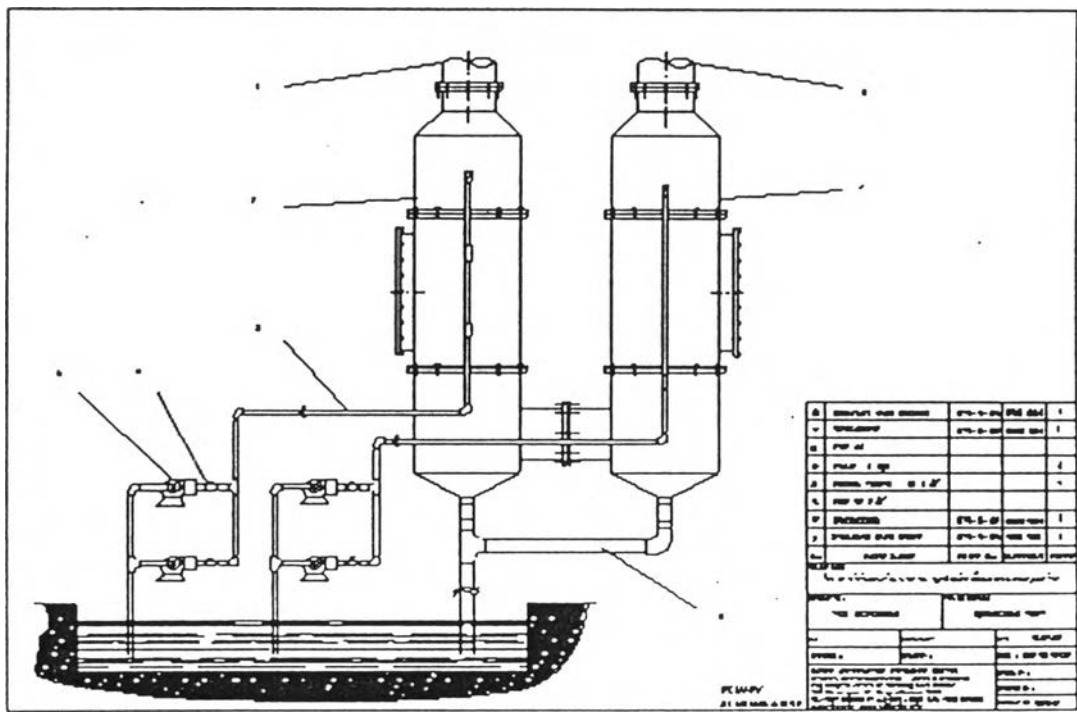


Figure 4.14: detailed design

Source : Somrat Kerdsuwan(2001)

- 1) Water is used to cool hot gases from the Oxidizer very rapidly. Gases enter the Scrubber at approx. 1000C, and are cooled by use of water sprays. At this stage, heavy metals in the form of a vapor will solidify and be collected in a water discharge tank.
- 2) After cooling, the gases enter into a packed tower where they are sprayed with a solution of sodium hydroxide and water. This solution causes a reaction to change the acid gas into salt and water.
- 3) The neutralized gases are drawn out to the atmosphere. Due to the high moisture content a white plume of steam will be visible from the Scrubber exhaust stack.
- 4) The water that contains the pollutant materials is held in a discharge tank for release to the sanitary sewer system or for further treatment if a sanitary sewer is not available.

In addition, typical usage is approximately 8 gallons of sodium hydroxide per ton of medical waste (used as a neutralizer for acid gases) depending on plastic content in waste.

For supplier selection, there are 4 potential suppliers for Air Pollution Control System as shown in the following items

- Maxxfire Company Ltd.

1213/68 Soi Srivara(Ladprao 94) Ladprao Rd., Wongtonglang, Bangkok

- Hovai Company Ltd.

33-36 Soi Senloi 3 Chan Rd, Satom Bangkok

- Hirakawa Kdum Company Ltd

177/1 Bangkoksahapakanpai2 Surawong Rd, Bangruk Bangkok

- TDD Company

25/3 Pracharat Rd, Talardkul Nonthaburi

Table 4.6: Air Pollution Control's supplier information

Supplier	Maxxfire Company	Hovai Company	Hirakawa Kdum Company	TDD Company
Capacity for reduce particle content	below 500 MG/Nm ³	below 400 MG/Nm ³	below 400 MG/Nm ³	below 400 MG/Nm ³
Temperature at Quencia Tower	1100C	1100C	1200C	800C
Temperature at Exhaust gas	80C	80C	75C	100C
Maximum Heat Resistance	1200C	1100C	1200C	800C
Gas Reduction	HCL, HFI,SO ₂	HCL, HFI,SO ₂	HCL, HFI,SO ₂	HCL, HFI
Price(baht)	5,500,000	4,500,000	6,500,000	4,250,000
Warrantee(year)	2	2	2	1

ABC Company will select the appropriate suppliers for this significant machinery by applied weight Point Method as shown in the following table.

Table 4.7: Supplier evaluation for Air pollution Controlled System

Supplier	Weight	Maxxfire Company	Hovai Company	Hirakawa Kdum Company	TDD Company
Quality	40	33	35	38	28
Price	30	18	27	20	28
Delivery	10	9	9	10	7
Service	20	17	18	19	15
Total	100	77	89	87	78

After considering of each information, ABC Company will select Hovai Company for Air Pollution Controlled System.

4.4.4 Material Handling Equipment for Residual Removal

ABC Company uses material handling equipment for ash removal as shown in the following figure.

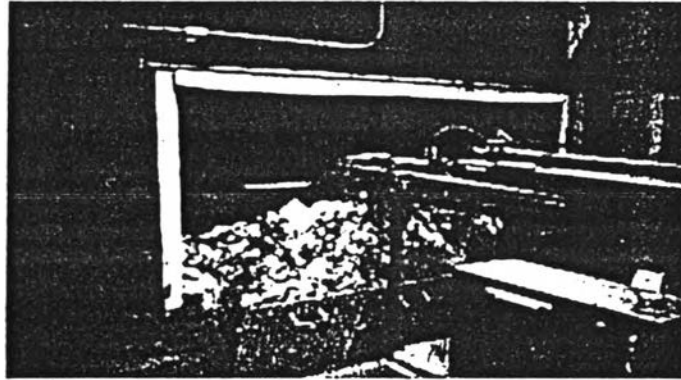


Figure 4.15: Ash Removal

This system is a semi-automatic unit used to drag the ash out of the Primary Chamber.

- 1) It requires few operator and the typical time for ash removal is short time period per Primary Chamber.
- 2) The unit is designed as a hydraulically operated boom that is outfitted with a very large metal removal blade.
- 3) The operator has the use of hand controls to move the blade up and down and forward and backwards. The operating principles are similar to a backhoe machine.
- 4) Each blade on the Ash unit extends to the full length and width of the Primary Chamber and is retracted to pull the material out. It typically will require 3 – 4 passes by the unit to remove all of the left over the ashes after a burn cycle is completed.

The potential suppliers for Ash Removal equipment are as follow;

- Hui-Yang Company Ltd.

72 Sukumwit Rd., Soi 60 Banggank, Prakanong Bangkok

- Sahapong Company Ltd.

1/34/35 Moo 3, Liabklongsorn, Amphur Klong Klung, Phatumthani

- TNC Kan Chang Company Ltd

543 Moo 4, Preaksa, Amphur Muang, Samut Prakarn

- TDD Company

25/3 Pracharat Rd, Talardkul Nonthaburi

Table 4.8: Ash Removal's supplier information

Supplier	Hui-Yang Company	Sahapong Company	TNC Kan Chang Company	TDD Company
Capacity(kg/min)	100	50	50	200
Heat Resistance	1100C	850C	750C	1200C
Automation	Semi-automation	Semi-automation	Manual	Full automation
Operator	1	1	2	-
Price(baht)	125,000	75,000	55,000	550,000
Warrantee(year)	1	1	6 months	2

According to ABC Company Ash removing specification, it will select the appropriate suppliers for this machinery by Series Method as shown in the following table.

Table 4.9: Ash removing supplier selection

Supplier	Total Score	Hui-Yang Company	Sahapong Company	TNC Kan Chang Company	TDD Company
Quality	40	36	32	30	38
price	30	24	27	28	20
Delivery	10	8	8	8	9
Service	20	18	16	15	18
Total	100	86	83	81	85

After considering of each information, ABC Company will select Hoi-Yang Company for Air Pollution Controlled System.

4.4.5 pH Meter

The pH meter is necessary equipment for ABC laboratory, quality control or field application. The specifications of pH meter are as follow;

- 1) Fast-response pH probe.
- 2) It should have silicon chip sensor stores dry and requires no maintenance.
- 3) The probe should use for general pH testing.
- 4) Diameter of probe should have 3.5mm-5mm for micro pH probe.
- 5) Auto buffer recognition at lease 9 buffers, .1/.01/.001 pH resolution, one-, two- or three- point calibration.
- 6) Memory/ Recall at least 20 data sets, and it should set up for uploading time, date, pH, temperature, and mV readings to the PC.
- 7) Both an AC adapter for desktop operation and a 9v battery for portability are included.

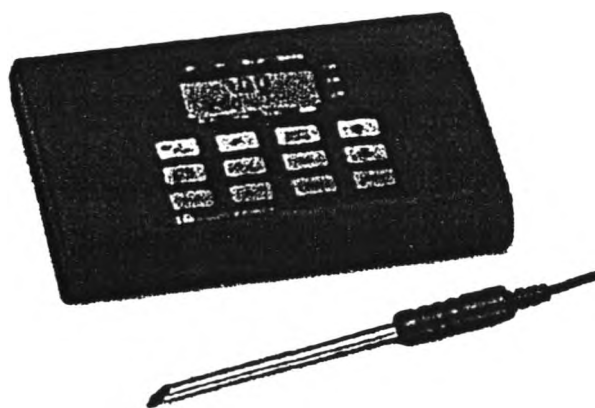


Figure 4.16: pH Meter

There are many suppliers for pH meter as follows.

- Gen Chem Interlab

25/8 Moo 12 Klongsam Phathumtani

- Wahikowa Company

36 Prachanurumit Bangsoi Bangkok

- Siam Chemical Company

620 Moo4 Patana 1Rd, Praksa Samut Prakarn

- Hua Yang Company

543 Moo 4, Preaksa, Amphur Muang, Samut Prakarn

Details of pH meter information are shown in the following table.

Table 4.10: pH meter's supplier information

Supplier	GenChem Interlab	Wahikowa Company	Siam Chemical Company	Hua Yang Company
Material of Probe	Stainless steel	Aluminum	Stainless steel	Glass
Diameter of probe	3.5mm	5mm	3.5mm	7mm
Immersion dimension	2mm	3mm	3mm	5mm
Length	12 cm	15cm	20cm	30cm
Sensor	Silicon chip sensor	Silicon chip sensor	Silicon chip sensor	-
Buffer	9	9	10	5
Memory	20 dataset	15 dataset	25 dataset	10 dataset
Temperature Setting	0-100C	0.1-100.0C	0.1-200C	0-100C
pH Range	0.00-14.00	0.00-14.00	0.000-14.000	0.00-14.00
Continuous using	200hr	200hr	300hr	100hr
Price(baht)	35,000	25,000	42,000	15,000
Warrantee(year)	1	1	1	6 months

ABC Company will select the appropriate suppliers for this significant pH meter as shown in the following table.

Table 4.11: Supplier selection

Supplier	Weight	GenChem Interlab	Wahikowa Company	Siam Chemical Company	Hua Yang Company
Quality	40	36	33	38	30
Price	30	23	25	20	28
Delivery	10	9	8	9	7
Service	20	18	17	18	16
Total	100	86	83	85	81

After considering of each information, ABC Company will select GenChem Interlab Company for pH meter of ABC Company.

4.4.6 Refrigerated Truck

ABC Company use at least a 1.2 ton truck and use refrigerating system by control temperature 0 degree Celsius in order to stop growth of any bacteria, virus, etc.

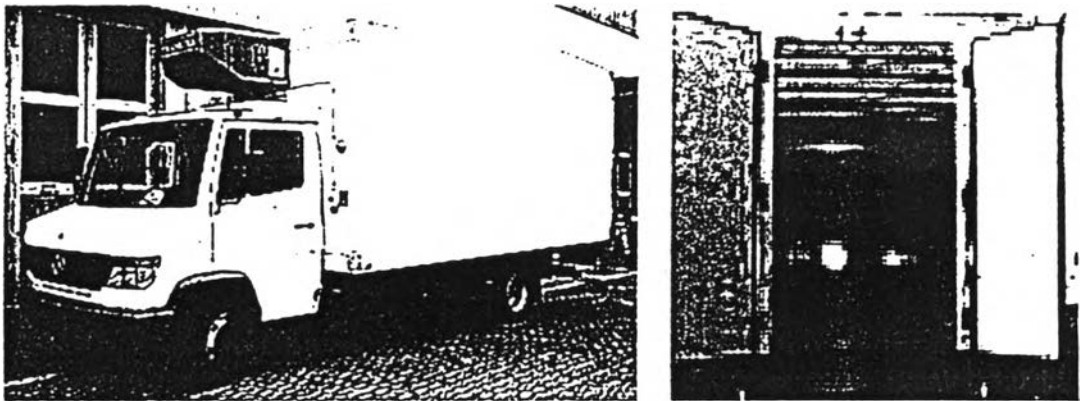


Figure 4.17: Refrigerating Truck

Source: www.boss-truck.com(2003)

The requirements for this Refrigerated truck are shown in the following items.

1. It must control temperature 0-15 C
2. It will hold the temperature for over 12 hours
3. The insulation is over 8" thick.
4. It should have a single rear door of the trailer for easy unloading and safety.

5. Volume is at least 1.2 tons
6. The width is 2.0-2.5m
7. Length is 2.5- 5.4 m
8. Height is 2.5-3.5 m
9. Power requirements are 240 volt, 20 amp,
10. It should have storage area in the front for bins, tools, cords, etc.
11. Diesel Engine

The suppliers for this truck are as follow;

- www.concessiontrailer.com

Fort Eric, Canada

- Maxxfire Company Ltd.

1213/68 Soi Srivara(Ladprao 94) Ladprao Rd., Wongtonglang, Bangkok

- Boss Truck Commercial vehicle Company

Via Palazzo, 6 Albereto di Montescudo Italy(www.boss-truck.com(2003))

Details of each supplier's information are shown in the following table.

Table 4.12: Supplier specification

Supplier	Concessiontrailer.	Maxxfire Company	Boss Truck Commercial vehicle Company
Width (m)	2.4	2.4	2.4
Length	5.4	2.5	5.4
High	3.9	3.0	3.0
Hold temperature	12 hr	10hr	15hr
Km	100,000	500,000	730,000
Insulation thick	Over 8"	Over 8"	Over 8"
Operator	2	2	3(2 driver)
Price(baht)	500,000	1,250,000	2,700,000
Warrantee(year)	1	1	2
Other	Second hand		

ABC Company will select the appropriate suppliers for this significant Refrigerated truck by Weight Point Method as shown in the following table.

Table 4.13: Supplier Selection

Supplier	Weight	Concession trailer.	Maxxfire Company	Boss Truck Commercial vehicle Company
Quality	40	28	32	35
Price	30	29	26	20
Delivery	10	7	9	7
Service	20	12	15	17
Total	100	76	82	79

According to the weight point method found that the most appropriate suppliers for the Refrigerated truck is Maxxfire Company.

4.4.7 Total machinery and equipment cost

Total machinery and equipment costs of ABC Company are shown in the following table.

Table 4.14: machinery and equipment

Item	Price	Number	Total Price
Controlled-air incinerator	2,500,000	1	2,500,000
Automatic feeder	500,000	1	500,000
Scrubber Air Pollution Control	4,500,000	1	4,500,000
Residual Removal	125,000	1	125,000
pH meter	35,000	10	350,000
Refrigerating Truck	1,250,000	4	5,000,000
Total			12,975,000

4.5 Location Decision Making

In order to select the most appropriate location, the ABC Company should consider many important factors, then they should compare several locations together before make decision. In general, location decision-making procedure usually consists of 4 steps. (William J. Stevenson, 1990:232). These are determine the criteria of the company, identify the important factor that effect location decision. Then develop location alternative and evaluate the alternative that suitable for ABC's plant. Accordingly, the ABC Company location decision making is shown as below.

4.5.1 Determine Criteria

This section determines the criteria that will be used to evaluate location alternatives for ABC Company which should be determined before relocate all manufacturing activities are as followings:

4.5.1.1 Far from Resident

Because ABC Incineration plants equipped with a modern standard flue gas cleaning system creates little air pollution or odor. Therefore, siting seldom poses a problem with regard to air quality. The plants should be located with due respect to meteorological conditions that is in open areas where emissions will not normally be trapped. For example, plants should not be sited in narrow valleys or areas prone to smog. Besides, most noise will come from flue fans and the ventilators used in cooling, which operate at least 12hr a day. Ventilators are usually on the roof of the plant, which make them particularly noisy. Handling the infectious wastes and residuals inside the plant may also emit noise. Transportation to and from the plant will create noise, particularly during the day, therefore, the ABC's plant should be at least 300-500 meter away from residential areas to minimize the noise impact and to protect against odor nuisances.

In addition, the ABC incinerating plant must not be located near community for example;

- The infectious waste must locate far from the water table at least 100 m.
- It must be located far from school at least 65m.
- It must be located far from an airport at least 3km.
- It must not locate nearby rivers, lakes, sea, and so on.
- It must not locate in the historic area

4.5.1.2 Community

The nearby community must accept ABC Company for them to set the plant there. The company should develop a good relationship with the surrounding communities to give advice and to reassure them of how safe the incineration plant is.

4.5.1.3 Area

The infectious waste incinerating plant of ABC Company should have

- 400 square metres for incinerating area
- 200 square metres for waste water treatment area
- 400 square metres for office
- 200 square metres for car park
- 200 square metres of sidewalk
- 100 square metres of storage space.
- 400 square metres of laboratory
- 500 square metres of space area.

Thus, total space area required is at least 2400 square metres. Furthermore it should have adequate area for future expansion.

4.5.1.4 Transportation Facility

Transportation facility is very important because this business needs to receive the infectious wastes from many province and sent to incinerate in its plant so the infectious plant should be set not far away from main road.

4.5.1.5 Facilitate Service

In the incinerating process, basic services such as water, and electricity are needed.

4.5.1.6 Proximity

Local suppliers, vendors and local waste market and landfill sites should not be located far from plant.

4.5.1.7 Labor

ABC Company should employ local labor since it is cheaper, the labor force does not have to commute and it benefits the local community. The company should also take measures to keep employee turnover ratio low.

4.5.1.8 Government Policy

Taxes, law and government support should be considered in determining a suitable location.

4.5.2 Identify Factors

After determining the criteria, the company needs to identify effect the criteria and the factors, which will be used to evaluate the location alternatives.

4.5.2.1 Community Attitudes

ABC Company should consider of community attitudes because the community (both local authorities and the people) under consideration should be pleased to have the plant located in its area. The community should be able to provide essential services such as police and fire protection, street maintenance, and trash and garbage disposal. According to Sule, D. R. " Good community living conditions will be needed to attract and maintain motivated workers. Cultural facility's character and its growth potential. If something essential is lacking, the company should determine the cost of providing for need."

4.5.2.2 Traffic and Transport

Incineration plant attracts heavy traffic, with infectious waste and consumables coming in and treatment residue going out. The plant should therefore be near major roads or railway line that allow heavy traffic. A traffic study may be traffic congestion, the truck will be send vibration, emit dust, and generate noise. The infectious waste transportation vehicles should therefore not pass through residential street or other sensitive areas.

4.5.2.3 Proximity Factors

Location of ABC Company infectious plant should be located near their customer, raw material, and labor as explained below;

□ **Infectious Waste Generation Center**

According to James M. Moore(1962: 39) “ The market-that is, the location of the buyers- is a factor to be considered in plant location.” Being closes to the Infectious Waste Generation Center lets ABC Company better serve customers and save costs. In addition, proximity to the waste center of gravity is important for using the collection vehicles and crews as efficiently as possible that is to minimize idle time on the road. Extended transport time due to long distances or traffic jams requires more vehicles transfer stations. Both solution increase cost.

□ **Raw materials**

One of the important factors for location decision making is nearness to raw materials such as diesel. Being near raw materials allows ABC Company get better service and to save transportation cost. Furthermore, the supplier should have ability to keep the stock for supporting the company in case of uncertainty demand. For infectious wastes incinerating service, the raw materials for all manufacturing activities are compose of diesel oils and other indirect raw material such as paper and etc. However, I suggest that, if ABC Company locates new factory in eastern of Thailand, it should use local suitable raw material in order to reduce cost. The

following table is presented potential local vendors which can supply diesel oil for ABC company in Thailand.

Table 4.15: Potential Local Venders

Company	Capacity(KBD)
Thai Oil Refinery	188
Bangchak Refinery	91
Esso Refinery	121
Star Petroleum Refinery	131
TPI Refinery	56

□ Labor supply

One of the important factors for location decision making is labor supply. The primary labor considerations relate to the cost and availability of labor, wage rates in area, labor productivity and attitudes toward work, and whether there is a serious potential for problems with unions. (William J. Stevenson: 1990, 234). In addition, some employees from Bangkok will come to set up this factory. On the other hand, some employees will recruit in eastern of Thailand such as secretarial, operators, and so on. Labor cost is very significant for the ABC Company. The following table presents entry-level salaries in Thailand.

Table 4.16: Entry Level Salaries for Select Job

Position	Baht(per month)	USS
• Engineer	16,307	417
• Technician	10,379	265
• Designer	10,000	265
• Electrical engineer	20,000	512
• Industrial engineer	17,000	435
• Junior secretary	10,487	268
• Computer staff	11,116	284
• Account	10,500	269
• System analyst	21,500	550

Source: Ministry of Labor

Anyway, for labourer and unskilled operator positions, their wage rates is very cheap. The Minimum Daily Wage Rates are as in the following table;

Table 4.17: Minimum Daily Wage Rates

Minimum Daily Wage Rates	Baht	US\$
Bangkok, Samut Prakan, Nonthaburi, Pathum Thani, Phuket, Nakhon Pathom, and Samut Sakon	165	3.70
Phangga, Ranong, Chon Buri, Nakhon Ratchasima, Saraburi, and Chiangmai	143	3.20
Other Provinces	133	2.98

Source: Ministry of Labor

If ABC Company wants to hire employees in eastern of Thailand, they can set employees salary a little higher than the average salary that is shown in this table. In addition, ABC's minimum daily wage should set higher than the Minimum Daily Wage Rates in order to attract local employees.

In summary, the ABC Company should select the right types and number of employees in a new infectious plant by considered influencing factors of employment. These are composed of prevailing wages, workweek restrictions, productivity level, existence of competing companies that can cause high turnover or labor unrest, the education and experience of available potential employees, and labor problems. Furthermore, the labor cost should be reasonable and inexpensive cost.

□ **Landfill**

Although infectious incineration significantly minimizes the volume of wastes for disposal, residues that have to be disposed of in landfills will remain. These residues consist of bottom ash from burned infectious wastes and fly ash and other residues from flue gas cleaning. For this reason, the ABC Incineration plant should be relatively close to a landfill, the distance is not crucial, as the weight of the residues to be disposed of will equal about 25% of the amount of the waste incinerated at the plant, and the volume will reduce to about 10% of the original infectious wastes.

4.5.2.4 Financial Factors

For financial factors, ABC Company should consider of Government grants/ subsidies /loan, taxes, and tariffs/duties as explain below;

□ **Government grants/subsidies/loans**

Thai government has policy to encourage investment in manufacturing. Furthermore, there are two government agencies, which support the manufacture. Firstly is the Board of Investment (BOI) and second is the Industrial Estates Authority of Thailand (IEAT).

□ **The Board of Investment (BOI)**

BOI provides incentives for business-related investment only. BOI privilege requires minimum investment one million baht, excluding the cost of land and working capital. According to BOI information, under the Investment Promotion Act the BOI provides benefits in many aspect as follows:

- Against tax exempt import by government agencies or state enterprises
- Grant tariff protection
- Competition from new state enterprises
- Price control
- State monopolization of the sale of products similar to those produced by promoted projects

□ **The Industrial Estates Authority of Thailand (IEAT)**

The Industrial Estates Authority of Thailand (IEAT) has the objective to develop and ensure orderly planned industrialization of the industries. Some industrial estates are composed of two sections; General Industrial Estate, and Export Process Zone. However, the industries permitted to set up factories in the Export Process Zone will be able to import raw materials and equipment and export their products duty-free. Facilities provided in these estates include telephone, post and telegraph systems, roads, electricity, water supply and drainage systems, central sewage and garbage treatment and disposal system, fire protection system, trade center, banks, medical centers, and residential quarters for workers. (http://boiweb.boi.go.th/thai/business/ind_estates.html)

In case of ABC Company, I suggest that the infectious plant should have government support in order to gain government grants. Moreover, a plant should apply for promotional privilege of BOI in order to gain privilege promotions. For non-BOI promoted manufactories, other ministries establish regulation such as The Alien Occupation Law: Working of Alien Act BE 2522, and there are restrictions.

□ **Taxation**

In general, Thailand divides income tax into three categories as Corporate Income Tax, Value Added Taxes (or Specific Business Taxes), and Personal Income Tax. However, for business, all companies registered under Thai law are subject to taxation as stipulated in the Revenue Code are subject to income earned from sources within and outside of Thailand. Foreign companies not registered or not residing in Thailand are subject to tax only on income derived from sources within Thailand. (<http://www.boi.go.th>)

In any case, taxes will be an operating cost so many areas offer tax incentives such as exemptions to encourage companies to locate factories in their communities. According to BOI privileges, a package of incentives and tax concession are permitted as investment incentives. If a infectious wastes

incinerating plant can apply for promotional privilege of BOI, it will gain tax exemption.

□ **Tariffs/duties**

One of necessary location decision-making factors is the “Tariff/duties” that are taxes collected by the government from goods coming into a country. In Thailand, BOI offer special tariff protection as follows: (BOI, Protection Measures: 1999)

“ Imposition of surcharge on competitive foreign product at a rate not exceeding 50 percent of the CIF value for a period not longer than one year at a time; import ban on competitive products; authority by the Chairman to order any assisting action or tax relief measures for the benefit of Promoted Persons. ” In case of new factory of ABC Company, they should apply for BOI promoted to gain tariff protection.

4.5.2.5 Availability of Land

Availability of land is necessary to location decision making. Although, cost of land is important, the company should consider of several factors as below

□ **Land shape**

For ABC Company, land shape should be considered for location decision because it should be fit to the layout especially flow of materials and products.

□ **The soil and characteristics and topography**

The soil and characteristics and topography affect building cost. If ABC factory located in acid soil, it will destroy their building.

□ **Space for future expansion**

The infectious wastes incinerating business enables ABC Company to achieve more competitive advantage. Therefore, the company will expand factory in the

future. For this reason, land space should be readily available to support the growth the market in the future.

4.5.2.6 Geographical and Weather Considerations

The geographical characteristics of the site can greatly affect the cost of the buildings to be constructed there as well as plant operating costs. In addition, the geographical and weather factors to be considered are altitude, temperature, humidity, average wind speed, annual rainfall and terrain. (Sule, D.R. : 1998,553)

4.5.3 Develop Alternative Location

ABC Company will have many potential locations for an infectious waste incinerating plant. The following figure presents BOI Location:



Figure 4.17 : Map of BOI zone

Source : www.boi.go.th

Zone 1: includes Bangkok, Sumutprakan, Samutsakhon, Nakhon Pathom, Nonhtaburi and Pathum Thani (Bangkok and 5 provinces)

Zone 2: includes Ang Thong, Ayutthaya, Chachoengsao, Chon Buri, Kanchanaburi, Nakhon Nayok, Phuket, Ratchaburi, Rayong, Samut Songkhram, Saraburi, and Suphanburi (12 provinces)

Zone 3: encompasses the remaining 58 provinces

Projects approved by the BOI attract investment incentive such as favorable land deals, import tariff relief and tax breaks on corporate earnings, which are available to both domestic and foreign-owned enterprises. The following information present BOI Privilege location. (Bea Tower, Robert Mc Gragor : 1998,127-134)

4.5.3.1 Zone 1

The following investment incentives are available for approved projects establishing in Zone 1 :

Incentive : Import duty reduction on machinery subject to tariff reduction by the Ministry of Finance

Concession : 50% on duty greater than 10% of the landed value of the equipment

Conditions : 80% of sales must be exported or the factory must be located in an approved industrial estate

Incentive : Reduction of corporate income tax

Concession : Three year exemption from tax

Conditions : 80% of sales must be exported and the factory must be located in approved industrial estates or approved free trade zones

Incentive : Import duty reduction on raw materials

Concession : Full duty for one year

Conditions : 30% of sales must be exported

4.5.3.2 Zone 2

Incentives for zone 2 are the same as zone 1 except that additional incentives are available for the import of machinery. (For zone 1, this important concession is limited to machinery subject to tariff reduction by the Ministry of Finance.)

Incentives for Zone 2

Incentive : Import duty reduction on all machinery

Concession : 50% on duty greater than 10%

Conditions : 80% of sales must be exported or the factory must be located in approved industrial estates

Incentive : Reduction of corporate income tax

Concession : Three-year exemption from tax

Conditions : 80% of sales must be exported and the factory must be located in approved industrial estates or approved free trade zones

Incentive : Import duty reduction

Concession : Full duty for one year

Conditions : 30% of sales must be exported

4.5.3.3 Zone 3

It includes the rest of Thailand. Additional incentives apply across the board for projects in Zone 3 areas.

Incentives for Zone 3

Incentive : Import duty reduction on all machinery

Concession : Total exemption

Conditions : 80% of sales must be exported or the factory must be located in Approved industrial estates

Incentive : Reduction of corporate income tax
 Concession : Eight year exemption from tax plus 50% reduction of tax for the ensuing five years after the eight year period
 Conditions : 80% of sales must be exported and the factory must be located in approved industrial estates or approved free trade zones

Incentive : Import duty reduction on raw materials for exported products
 Concession: : Full duty for one year
 Conditions : 30% of sales must be exported

Incentive : Import duty reduction on raw materials for domestic products
 Concession : 75% of duty for five years
 Conditions : Provided materials of comparable quality are not being produced in Thailand

Incentive : Double reduction of cost of utilities
 Concession : Double reduction of utility from taxable income for 10 years
 Conditions : None.(Bea Tower, Robert Mc Gragor : 1998, 134)

4.5.3.4 Other

ABC Company is not only restricted to the previous BOI Zoned., but other areas are also considered for decision making. According to BOI, all areas for infectious wastes incinerating business have a 8 years “no tax” period, which is licensed by BOI.

4.5.4 Evaluate the Alternative Location

After proposing alternative locations, most potential locations do not meet the critical requirements such as location from the water table, schools, rivers, lakes, sea, historical area, residential zones, and so on. As result, the remaining 5 potential locations are considered. The alternative locations, which fulfill basic requirements, are as;

- 1) **Sumutprakan**
1/29 Moo 2 Bangmung , **Sumutprakan**
- 2) **Bangpakong**
Ban Kong Hrajak Moo 13 Bangpakong **Chachoengsao**
- 3) **Chonburi**
Bangbung-Bankai Rd. Soi Samakom Sawongchitkuson Bangbung
Chonburi
- 4) **Wong Chan**
49/19 Moo1, Tambon Chumsang, Amphur Wong Chan, **Rayong**
- 5) **Kang**
193 Moo 1 Tambon Kasaebon, Amphur Kang **Rayoung**
- 6) **Na Yai Arm**
118 Moo3 Na Yai Arm, **Chanthaburi**

There is no single model or techniques that will select the best location. However, there are techniques available that help to ABC's plant location information are location factor rating system and financial evaluation.

4.5.4.1 Location Factor Rating System

One of the more popular methods for evaluating and comparing different locations is the location factor rating system.(Roberta S. Russell, Bernard W. Taylor III:1995,387) For this method, each of major factors is rated from 0-200 with regard

to its importance such as proximity to raw material, vendors, customer, ability of land, transportation facility, suitable utility, taxation, community and etc. Each individual location is rate from 0 to the maximum for each factor. The scores for the location determine the final ranking is as following tables

Table 4.18 : Location Rating

Considerations	Maximum Weight	Sumutprakan 1	Chachoengsao 2	Chonburi 3	Rayong WangChao 4	Rayong Kang 5	Chanthaburi 6
Demand for waste incineration	100	85	70	90	80	80	75
Proximity to vendors	100	85	80	90	85	80	80
Proximity to labour	100	70	85	80	85	80	80
Proximity to landfill	100	70	80	95	90	85	80
Ability of Land	100	75	75	80	90	85	90
Transportation Facilities	100	85	80	85	85	80	80
Suitable Utility	100	90	80	85	85	85	80
Government grants	50	45	40	45	40	40	40
Geographical and weather	50	47	47	45	40	40	40
Far away from resident area	50	35	40	37	45	40	45
National security	50	48	45	35	45	45	45
Community	100	85	85	49	85	70	85
Total	1000	820	807	816	855	810	820

1) Demand for Waste Incineration

The volume of waste produced in a day are as shown in the following table.

Table 4.19: volume of waste

Province	Volume of Infectious (Kg/day)
Sumutprakan	1446.14
Chachoengsao	437.66
Chonburi	1561.97
Rayong	751.54
Chanthaburi	521.125

Source: Adapted from Sukon Cheersakul (2002)

According to the information, the ranking is shown in the following figure.

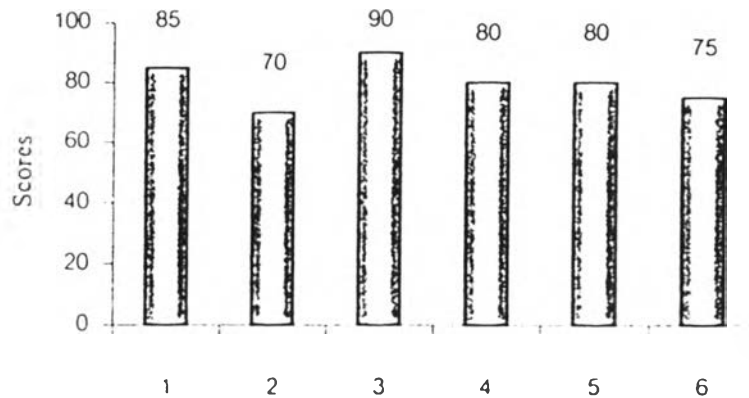


Figure 4.18: Demand for Waste Incineration Ranking

Therefore, the most demand for infectious waste incineration is Chonburi, its score is 90. The second is Sumutprakan with a score of 85. For Chachoengsao has a score of 70, Rayong for both sites have scores of 80. And Chanthaburi has the lowest demand so its score is 75.

2) Proximity to vendor

One of the necessary factors, which ABC Company needs to consider, is raw material. For the infectious waste incineration business an important raw material is “Diesel”. Consequently, the ABC plant should locate close to a “Petro-Station”. The following figure presents the ranking from the proximity to raw materials.

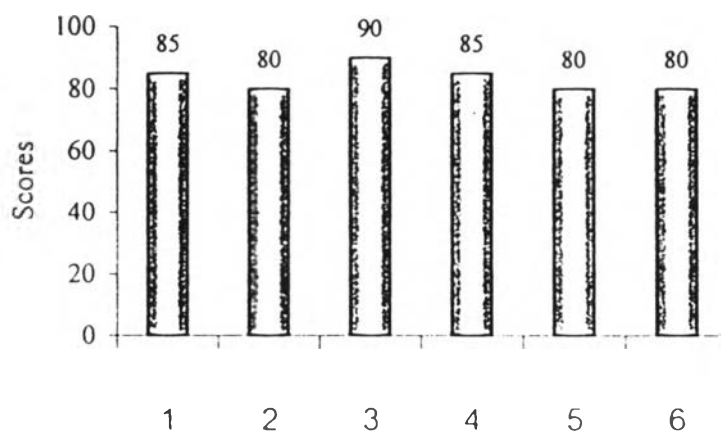


Figure 4.19: Proximity to vendor Ranking

According to figure 4.19, Chonburi site has the closet proximity to the Petro - station so the score is 90. The second location is Sumutprakan and Rayong, which both have a score of 85. In case of Rayong at Kang site, Chanthaburi and Chachoengsao have an equal score of 80.

3) Proximity to Labor

Labor supply is a fundamental factor for ABC's plant location decision making. The proximity to labor ranking is shown in the following figure.

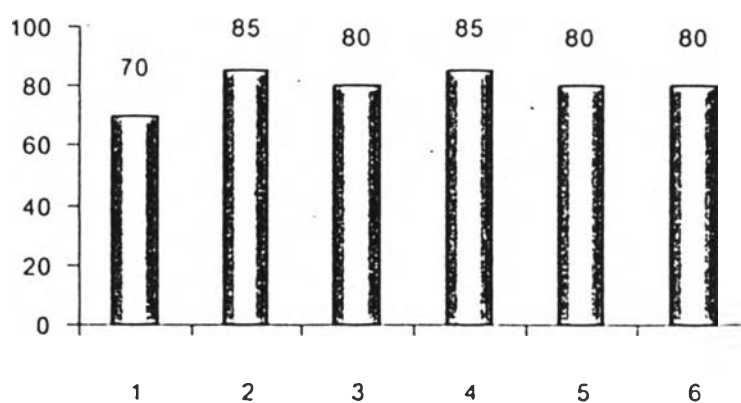


Figure 4.20: Proximity to Labor Ranking

In Sumutprakan, there is a long supply of factory labor however, few labor is interested in infectious waste plant so its score as only 70. In Chachoengsao and Wong Chan, there is much labor at these locations thus score are 85. In case of Kang and Chanthaburi, and Chonburi, there is also much factory labor is interest and a lot of the labors are interested in working in an infectious plant so their score is 80.

4) Proximity to Landfill

Because volume of ash removal is 10% of infectious waste so the location of ABC's plant should be close to a landfill site. In eastern zones the authority landfill is located in Chonburi so the score ranking for this topic is shown in the following figure.

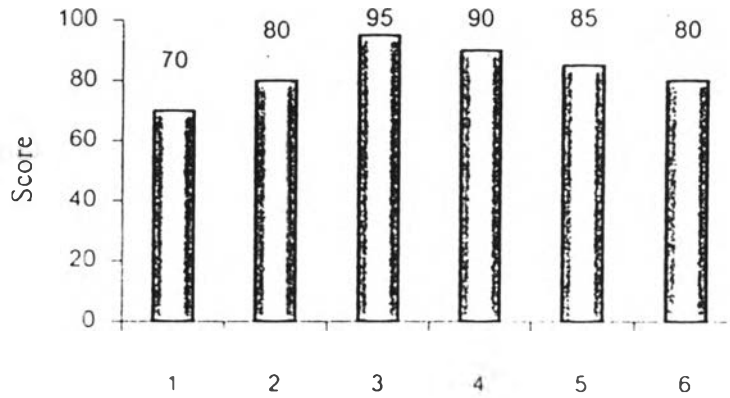


Figure 4.21: Proximity to Landfill Ranking

Due to the landfill placed in the Chonburi, the ranking for site 3 (Chonburi) has the highest score of 95. Next, the Wong Chan site has a score of 90. Kang is located not far from this landfill so its score is 85. Both Chachoengsao and Chanthaburi have 80 scores. The site furthest away from a landfill site is Sumutprakan so its score is 70.

5) Availability of Land

For this factor, ABC Company will consider of shape of land, the soil, characteristic, topography, and space for future expansion. The following table presents the Weight Point Method for Availability of land decision making.

Table 4.20: Availability of Land

Considerations	Maximum Weight	1	2	3	4	5	6
Land Shape	30	20	20	24	28	23	24
Soil characteristic and topography	40	35	35	31	37	33	38
Space for expanding	30	20	20	25	25	29	28
Total	100	75	75	80	90	85	90

Details of each site are shown in the following items.

□ **Site 1: Sumutprakan**



Figure 4.22: Sumutprakan site

Sumutprakan site has quadrilateral shape so it scores is 20. The soil of this site is suitable for plant set up so its score is 35. However, this site is only 2,000 square metres so there is a lack of space for future expansion so its score is 20. The total score is 75.

□ **Site 2 : Chachoengsao**



Figure 4.23: Chachoengsao site

Chachoengsao site is 2000 square metres , it has trapezium shape which is not suitable for ABC's plant so its score is 20. The soil is also suitable for plant location thus its score is 35. The space for future expansion like the Sumutprakan site, there is little space for expansion.

□ Site 3 : Chonburi



Figure 4.24: Chonburi at Band Bung site

Chonburi (Band Bung) site is a 2,500 square metres quadrilateral shape so it is suitable for ABC's plant, so its score is 24. However, the soil is sand, which is not suitable for the location of wastewater treatment pond of the ABC Company so its score is 31. Space area of this size is enough for plant location thus its score is 25. The total score is 80.

□ **Site 4: Rayong (Wong Chan)**

Wong Chan site is 2,500 square metres quadrilateral, which is acceptable for plant layout. Its score is 28. Soil characteristic is suitable for plant location thus its score is 37. In addition, it has suitable space for expansion, so its score is 25. The total score is 90.



Figure 4.25: Rayong at Wong Chan site

□ **Site 5 : Rayong (Kang)**

Kang is 5,000 square metres shape. It has 33 score for land shape because plant layout of ABC Company is suitable for quadrilateral. Soil characteristic of this site is quite sandy so it will have some problems with wastewater treatment of ABC's incinerating plant, so its score is 33.



Figure 4.26: Rayong at Kang site

For space expansion, this site has large space area with 5,000 square metres, so its score is 20. The total score is 85.

□ **Site 6 : Chanthaburi (Na Yay Arm)**



Figure 4.27: Chanthaburi (Na Yay Arm) site

Na Yay Arm site is 3,000 square metres with parallelogram shape, it is suitable for plan layout so its score is 24. Soil characteristic is suitable for located plant then its score is 38. Space for expansion is 28 because it has large space area. The total score is 90.

After evaluating each site, the following figure shows the total ranking.

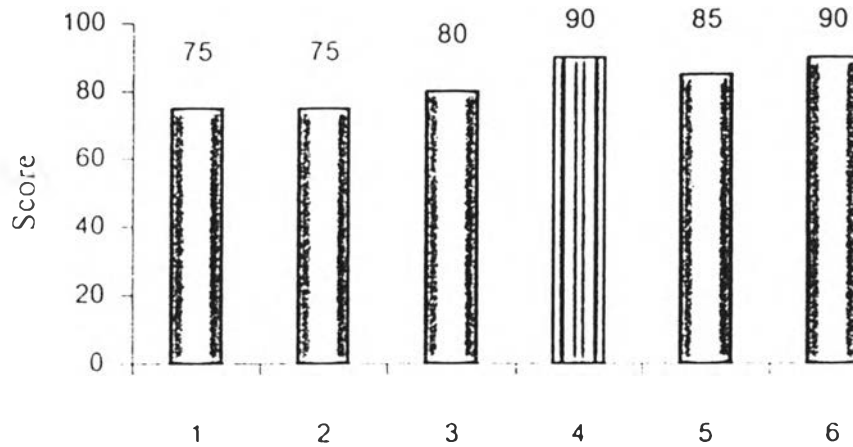


Figure 4.28: Total Ranking

According to figure 4.28, the most suitable land is at Wong Chan site at Rayong.

6) Transportation Facilities

The following figure presents the ranking of each site's transportation facilities.

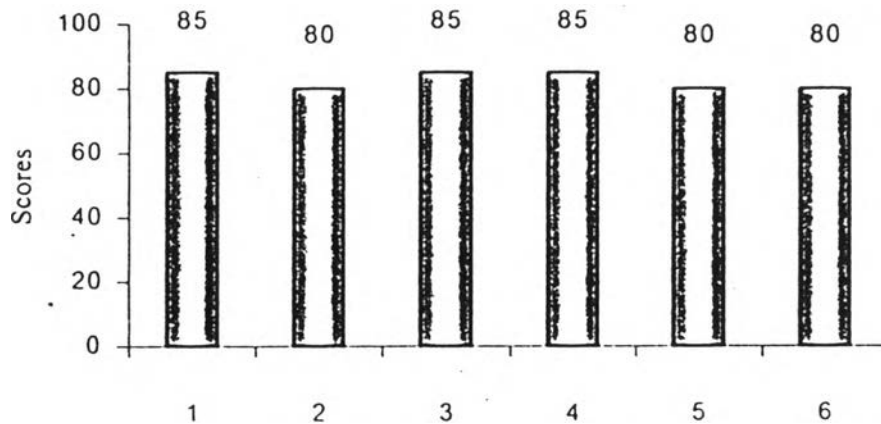


Figure 4.29: Transportation Facility Ranking

According to the ranking, Sumutprakan, Chonburi and Rayong (Wong Chan site) have suitable facilities. For Chachoengsao, Kang and Chanthaburi, they all have a score of 80 because they have fewer main roads there.

7) Suitable Utility

The following figure shows the utility ranking.

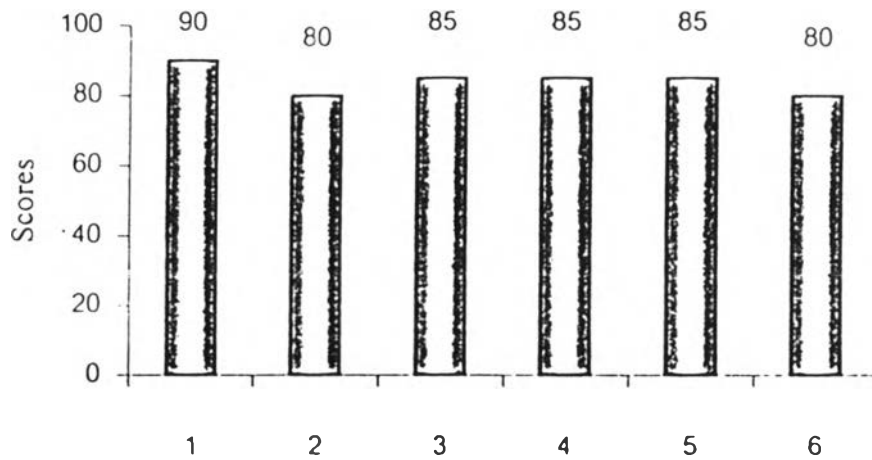


Figure 4.30: Utilities Ranking

According to figure 4.30, Sumutprakan is the highest score is 90 because it is located near Bangkok and all utilities are available for plant location. Second ranked are Chonburi and Rayong, their scores are 85 each. The lowest score are Chachoengsao and Chonburi, their utility is not complete so their score is 80.

8) Government Grant

Sumutprakan and Chonburi have been selected for government grants for environmental control, so their rank is 45. The other areas have a rank of 40.

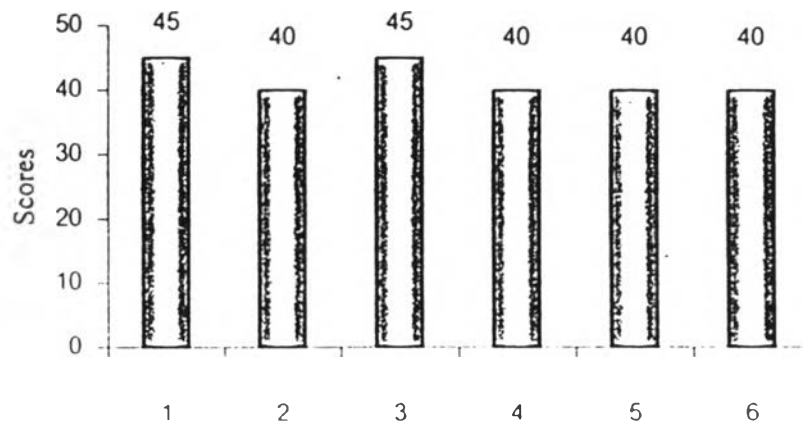


Figure 4.31: Government Grants Ranking

9) Geographic and weather

Geographical and weather condition can greatly effect the cost of building. The ranking of this factor is shown in the following figure.

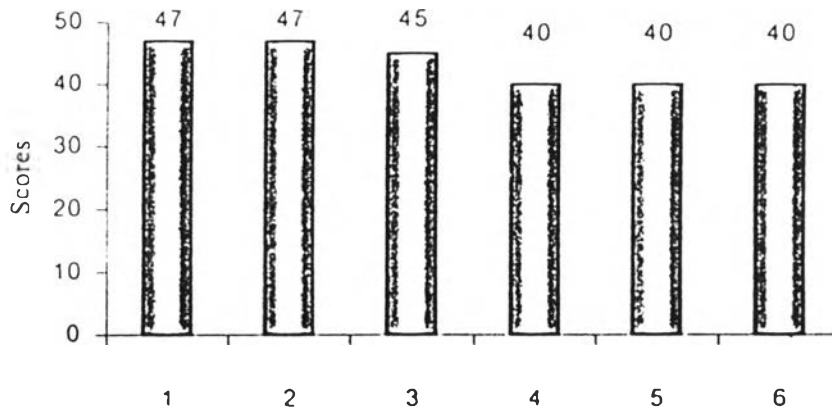


Figure 4.32: Geographical and weather Ranking

According to figure 4.32, Sumutprakan and Chachoengsao have the lowest humidity and rainfall so their score are 47. For Chonburi, it has rainfall and some humidity, therefore their score are 45. In addition, for Rayong and Chonburi, they always have high rainfall and humidity and sometimes have high wind speeds so their score is 40.

10) Far away from resident

An infectious waste plant should be far away from residential areas, at least 500 m. However, it should have connection to utilities. The following figure shows the ranking for each location.

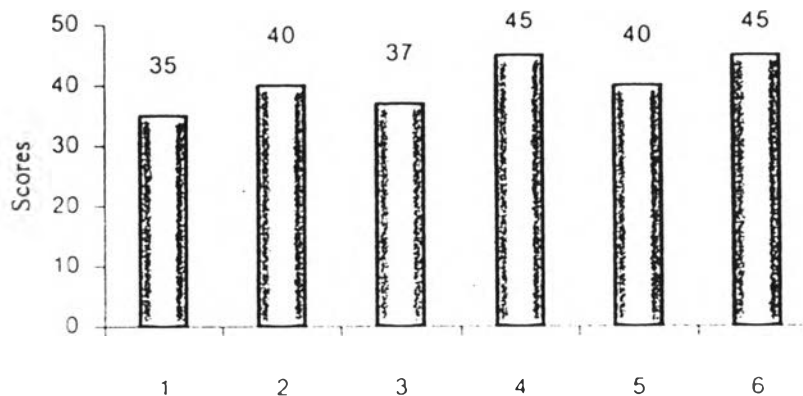


Figure 4.33: Far away from resident Ranking

Both Wong Chan and Na Yay Arm (Chanthaburi) are furthest from residential areas so their scores are 45. Next, Chachoengsao and Kang are second and their score are 40. Next Chonburi and Sumutprakan site, which is quite close to resident areas so their scores are 35, 40, respectively.

11) National Security

One of the significant factors is national security, because it will make ABC Company assured that its plant is safe. The following figure shows the ranking of National Security for each location.

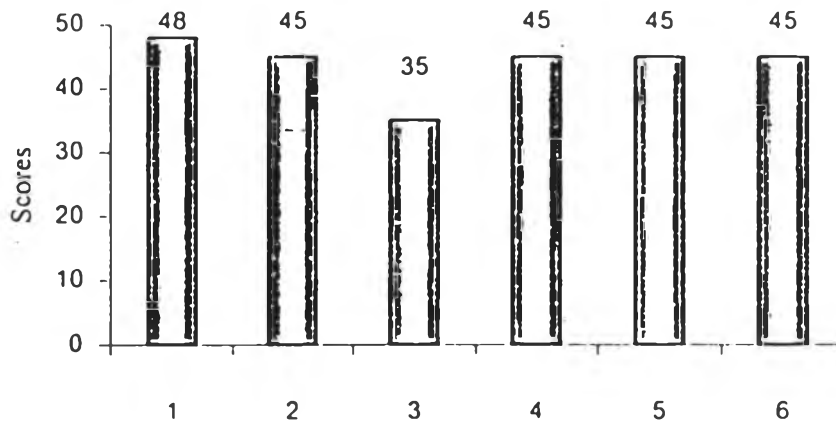


Figure 4.34: National Security Ranking

According to figure 4.34, the most national security ranking score is Sumutprakan which has 48 score. Next, Chachoengsao, Rayong, and Chanthaburi has 45 score. However, at Chonburi, many people do not please for waste disposal plant so it has not safety for the plant.

12) Community

Community consideration is the most necessary factor for an infectious waste in incineration plant. The following figure shows the location ranking for each alternative location.

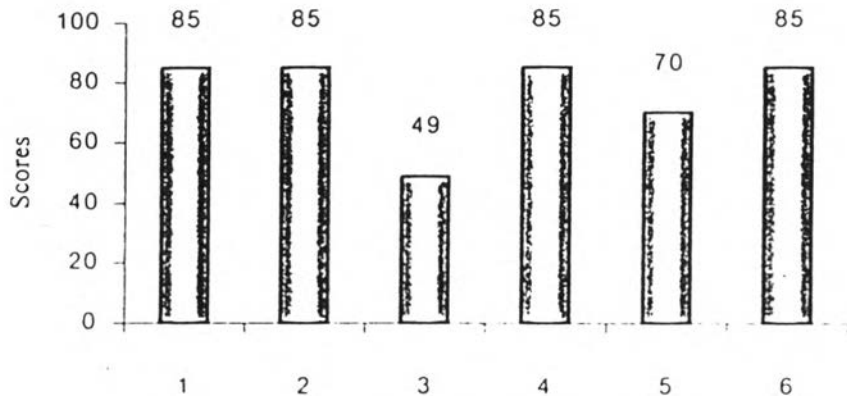


Figure 4.35: Community Ranking

According to figure 4.35, Sumutprakan, Chanthaburi, Kang and Chachoengsao have the score at 85, because those sites are acceptable distance from community areas. Furthermore, there is no community resistance. In the other hand, Chonburi has community resistance for waste disposal and many people in this area have complained about bad adores and fumes so their score is only 49.

13) Total Ranking

After considering of the location factor rating system. The summary score is shown in the following figure.

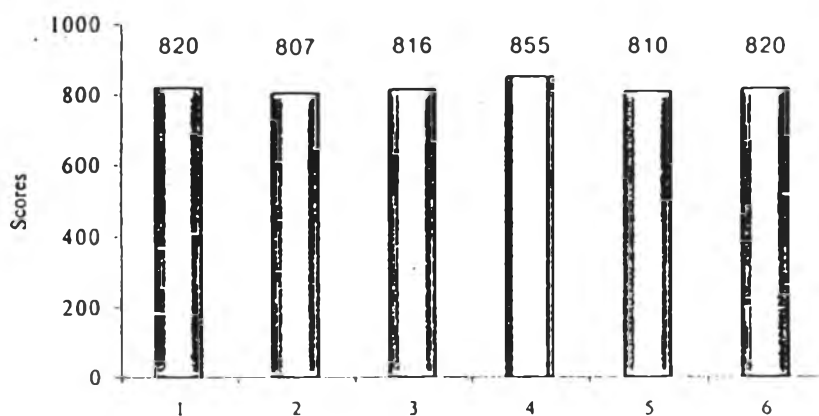


Figure 4.36: Summary ranking

It found that the highest score of the ranking is Wong Chan site in Rayong which has 855 score, the secondary are Chanthaburi and Sumutprakan.

4.5.4.2 Financial Evaluation

After considering of Location Factor Rating System, financial evaluation is also concentrated. According to the Least –cost theory of location, “ the site offering the least cost but assumes that the location chosen has no the demand for the product. (Von Thunen and Webert)

Preliminary estimates cost of new factory location can compute from summary of cost of buildings and equipment, land, grading, piling for plant, approach railroad, approach road, delivery expense on raw material from aboard. Include of fright on domestic raw material, fuel, and so on.(James M. Moore: 1962,62). The preliminary estimate costs of new factory of 6 alternative location are shown as the following table.

Table 4.21 : Financial evaluation

Expenditure	Sumutprakan 1	Chachoengsac 2	Chonburi 3	Rayong WangChan 4	Rayong Kang 5	Chanthaburi 6
Building and equipment	4,200,000	3,700,000	3,600,000	3,500,000	3,500,000	3,520,000
Land	4,500,000	3,500,000	3,000,000	2,700,000	4,700,000	3,000,000
Dredging	200,000	290,000	118,900	118,000	117,600	118,000
Piling for plant	350,000	360,000	340,000	325,000	331,000	335,000
Approach road	240,000	264,000	360,000	312,000	384,000	430,080
Freight on raw material	288,000	297,600	165,600	289,000	296,000	257,520
Fuel	175,000	165,000	145,000	157,000	158,000	159,943
Freight on Delivery	1,600,000	1,860,000	1,500,000	1,980,000	1,944,000	1,691,280
Power Supply(per/year)	450,000	415,000	390,000	400,000	400,000	410,000
Total	12,003,000	10,851,600	9,619,500	9,781,000	11,830,600	10,292,622

According to table 4.21 the fixed cost such as building and equipment, land or dredging and piling for plant of Sumutprakan and Chachoengsao quite higher than the others because these location locate near Bangkok so they will have high expenditure for fixes cost. In addition for Kang site, it has the highest cost because this site has more space area with 5,000 square meter so it sale at price 4.7 million bath. However, available cost such as delivery expense on raw, approach railroad,

approach road, of Chonburi site is the least because it stays near a Petro - station, and not far from railroad so these expenditure are low.

After consider of both fixed cost and variable cost, total preliminary estimates cost of new factory is shown in the following figure.

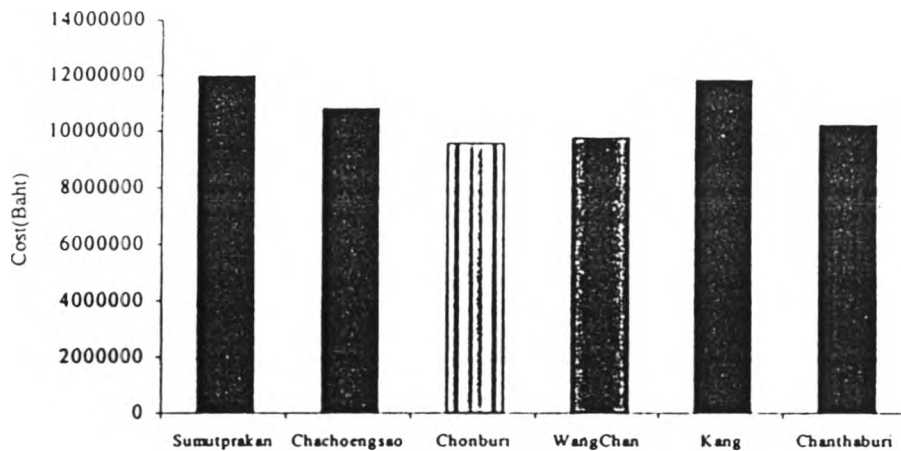


Figure 4.37: Financial evaluation

Figure 4.37 presents the total preliminary estimates cost of infectious waste incineration plant location which indicates that Chonburi site has the least preliminary estimate cost as is 9,619,500 baht, the secondary Wong Chan site, the estimate cost is 9,781,000 baht. Sumutprakan site has estimate cost about 12,003,000 baht. Chachoengsao uses 10,851,600 baht. For Kang and Chanthaburi site, have cost are as 11,830,600 and 10,292,622 baht, respectively.

Location Decision Making

Location Factor Rating System shows that Wong Chan is the most appropriate site; however, the financial system is determined that Chonburi site is the least preliminary estimate cost. In this case, I recommend that Wong Chan is more appropriate for ABC's plant location than Chonburi site because there is community problem at Chonburi now, many people do not please with the waste disposal in that area. In addition, the preliminary estimate cost of Wong Chan site is a little than Chonburi, so Wong Chan site is the most appropriate site for ABC Company.



Figure 4.38: Wong Chan Site
 Source: www.sabuy.com (2003)

4.6 Transportation Routing

According to the production program and sale forecasting in the previous chapter, in first year, ABC Company will have infectious waste 1.78 tons per day then increase to 2.5 tons in year 10. Therefore, ABC Company will use 2-refrigerator truck, which have 2 transportation routing in first year as are; Sumutprakan- Chachoengsao Route, and Chonburi – Chanthaburi Route in order to safe transportation cost. Then, in the year 5, it will increase transportation routing for Chanthaburi-Trat Route because of capacity increasing. The transportation routing are shown in the following items.

1) Sumutprakan- Chachoengsao Route

Because of Sumutprakan has a high volume of infectious wastes so ABC Company need to set the transportation routing to this province. This routing passes Bung Poo industrial Estate in order to receive the infectious waste from the industrials at nearby area. Then it will receive infectious waste at Aumpur Muang Sumutprakan for receive the wastes from hospitals at that zones. Next, it will get the infectious wastes from Bang Pa Kong Industrial estates and the hospitals in Chachoengsao. The total volume of infectious waste for this route is around 0.8-1.2 ton/day.

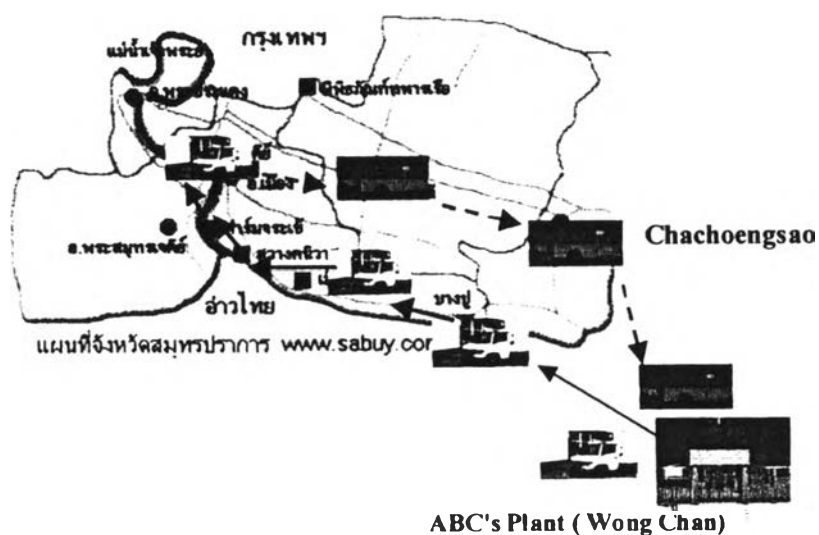


Figure 4.39: Sumutprakan- Chachoengsao Transportation

2) Chonburi – Chanthaburi Route

This route start from Rayong to receive the infectious wastes at hospitals in Chonburi because the ABC Company can not receive the infectious waste after 16.00 then it will receive the wastes from each industrial estate in Chonburi. Then it will go to Chanthaburi and come to get the wastes in hospitals in Rayong. Next, it will receive the infectious wastes from Industrial estate in Maptaput and the nearby industrial estate. The total infectious waste volume is about 0.9-1.2 ton/day. The transportation map is shown in the following figure.

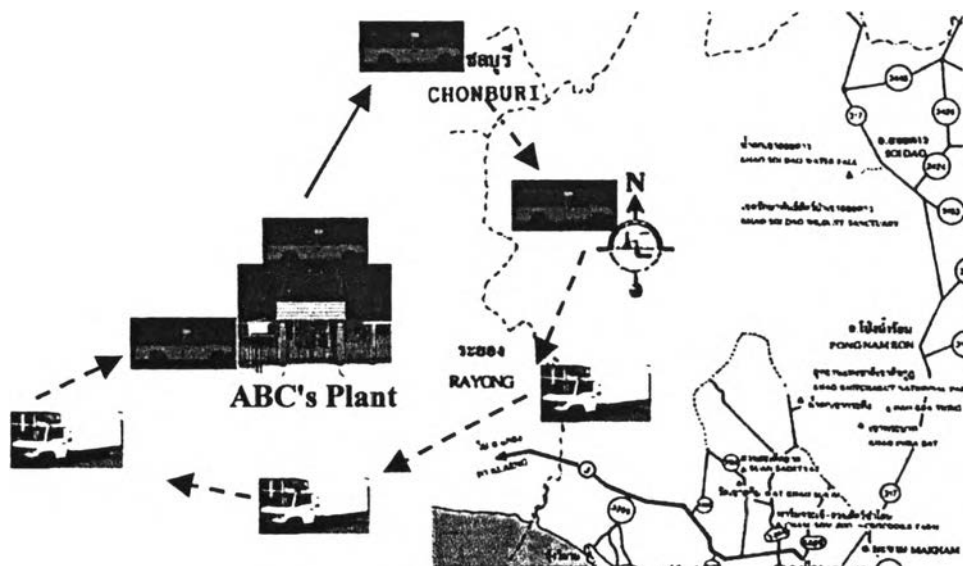


Figure 4.40: Chonburi- Chanthaburi Transportation

3) Chanthaburi- Trat Route

Since increasing capacity so in the year 5, ABC Company will increase transportation routing in order to serve the customer in Chanthaburi and Trat. The transportation route is shown in the following figure.

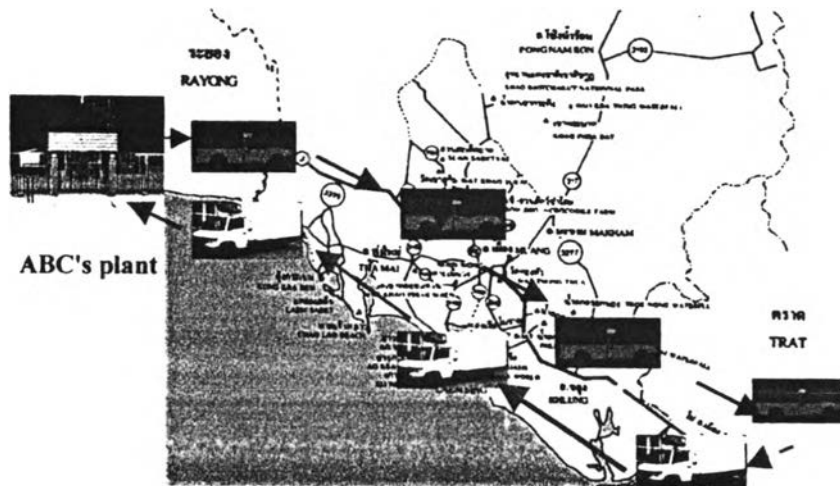


Figure 4.41: Trat Transportation

4.7 Plant Layout

ABC Company's layout is the most suitable method for infectious wastes incinerating plant. The advantages of process layout are;

- Better utilization of machines can result; consequently, and fewer machines are require.
- A high degree of flexibility exits relative to equipment or manpower allocation for specific tasks.
- Comparatively low investment in machines is required.
- The diversity of tasks offers a more interesting and satisfying occupation for the operator.
- Specialized supervision is possible. (Warwick Manufacturing Group: 2003)

The following figure presents plant layout of ABC Company.

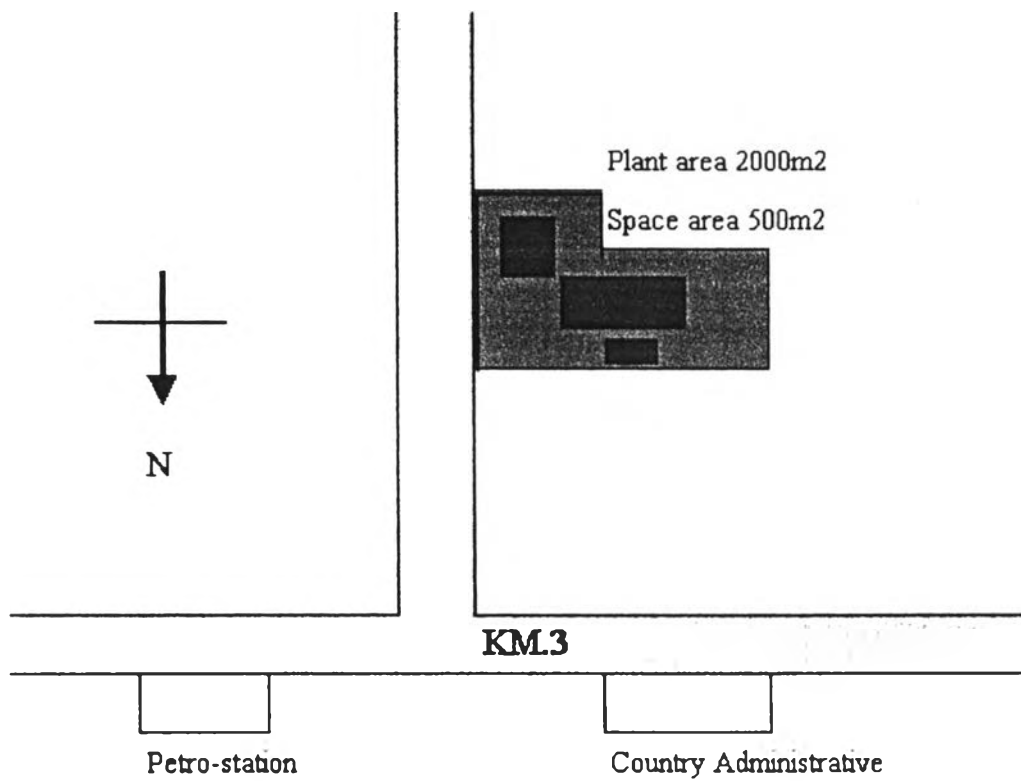


Figure 4.42: ABC's plant layout

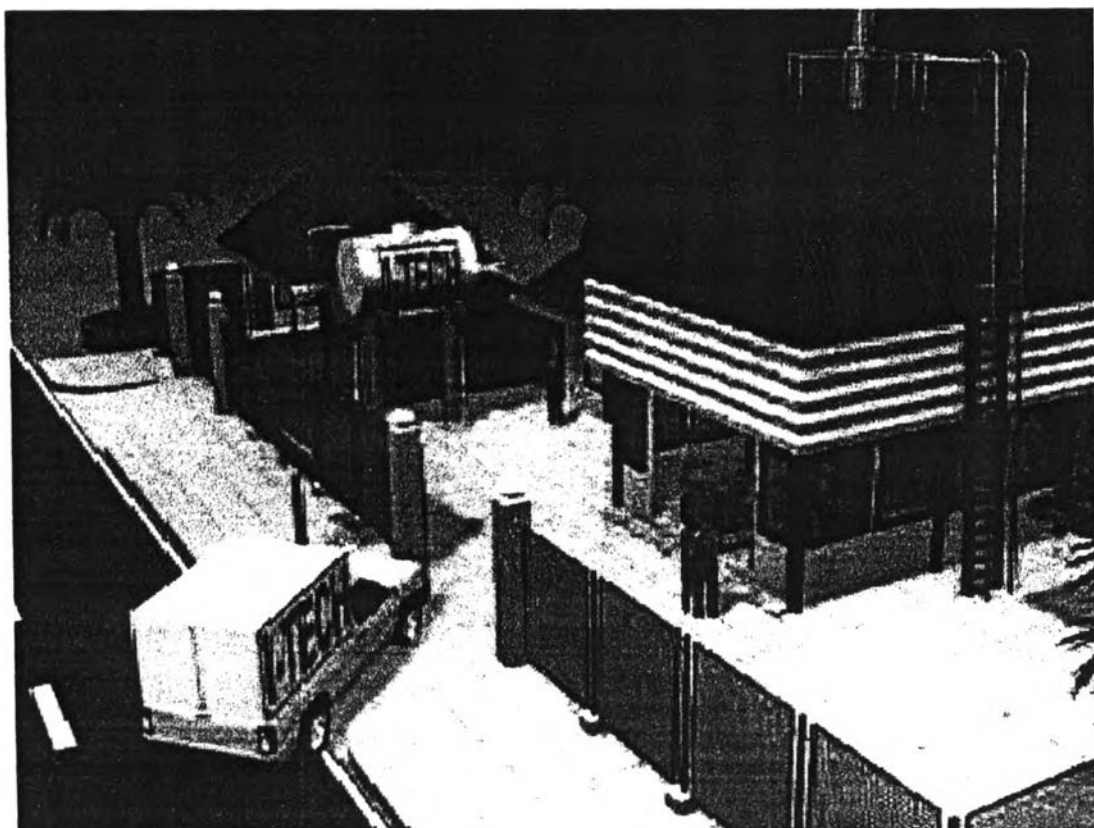


Figure 4.43: ABC's plant layout

□ **Ground Layout**

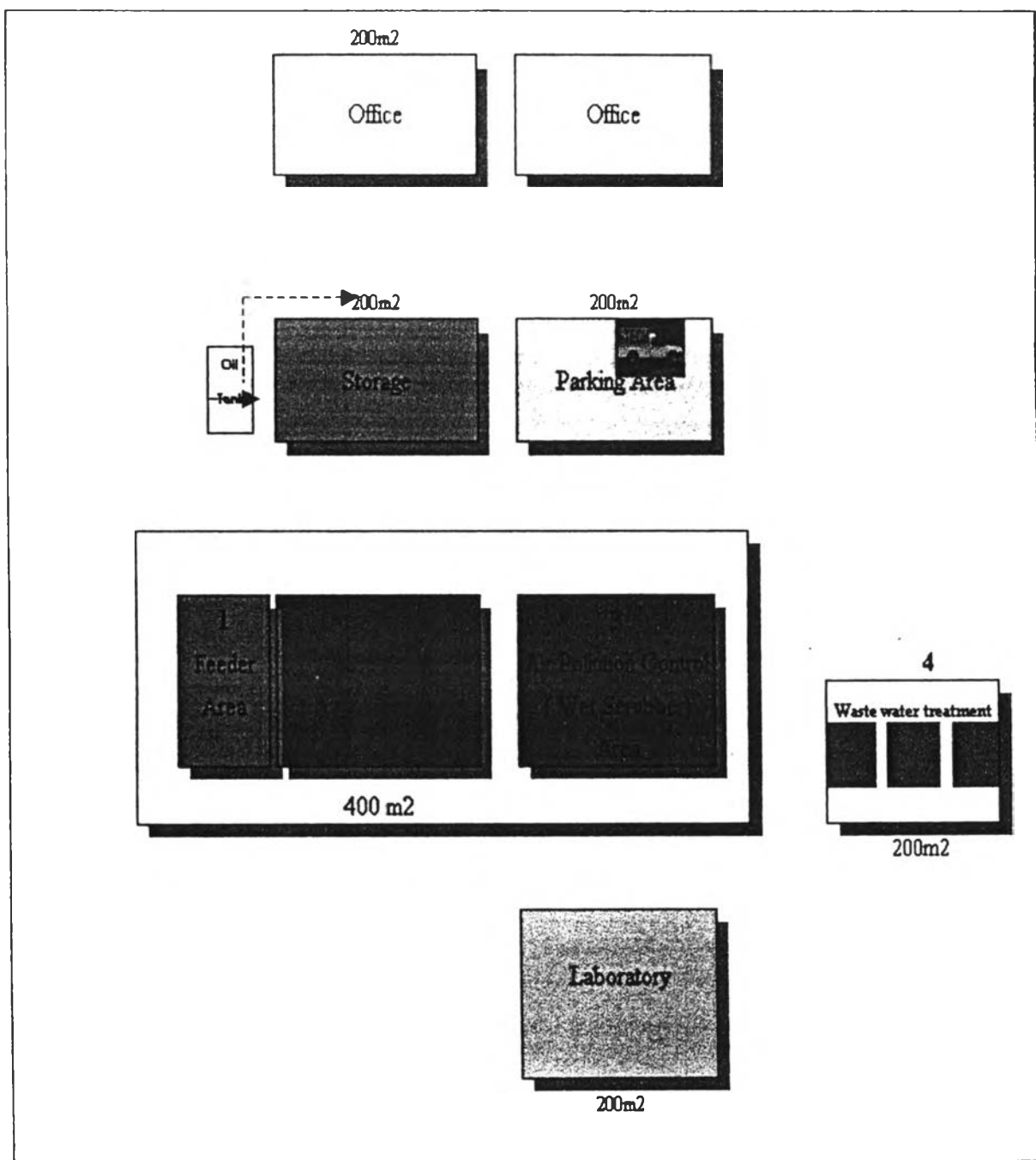


Figure 4.44: ABC's ground layout

□ Incinerating Layout

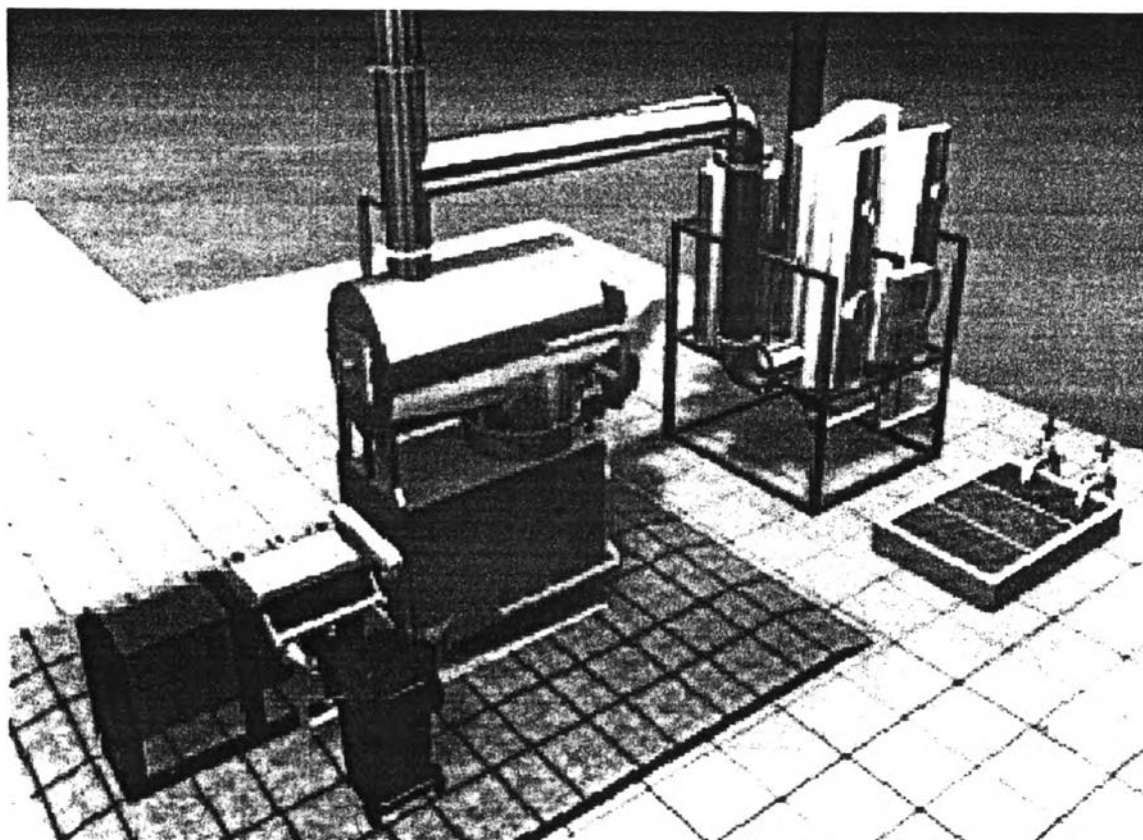


Figure 4.45: Plant Incinerating Layout (Graphic)

4.7 Raw Material

ABC Company uses diesel for its incinerator because it is safer than gas. In addition, people around the plant are also scared of gas bombs. The following table is presented potential local vendors which can supply diesel oil for ABC company in Thailand.

Table 4.22: Potential Local Vendors

Company	Capacity(KBD)
Thai Oil Refinery	188
Bangchak Refinery	91
Esso Refinery	121
Star Petroleum Refinery	131
TPI Refinery	56

Because the Control Air Incinerator consumes about 60 lit per day diesel so it will buy from any Chonburi oil service. However, Esso is the most near then ABC Company will buy diesel at this company.

4.8 Utility

Utilities that ABC Company will consider are electrical and water supply.

4.8.1 Electrical Supply

ABC Company consumes electrical 91 kW. The detail is shown in the following table.

Table 4.23: Electrical Supply

Item	Machine and Equipment	kW
1	Incinerator	40
2	Automatic Feeder	20
3	Air Pollution Control	13.5
4	Waste Water treatment	7.5
5	Air Condition	5
6	Other	5
	Sum	91

The electrical supply comes from Principle Electrical Authority of Thailand. ABC Company is a medium company so the rate of electrical price follows the time of use rate table below.

Table 4.24: Time of use Rate

Electrical Rate	Need of electrical Value(baht/kW)	Charge of Energy of electric		Service Charge (baht/month)
		Peak	Off peak	
More than 60kV	74.14	2.6136	1.1726	228.17
22-33kV	132.93	2.6950	1.1914	228.17
Less than 22 kV	210	2.8408	1.2246	228.17

Peak : Mon-Fri(9.00-22.00)

Off Peak: Mon-Fri(22.00-9.00), Sat, Sun

Source: Principle Electrical Authority of Thailand

ABC Company uses electric less than 22 kV on peak so it will pay electrical charge as is;

$$\begin{aligned}
 \text{Electrical charge} &= (210\text{baht/kW} \times 91\text{kW}) + (91\text{kW} \times 10\text{hr} \times 22\text{day} \times 2.8408\text{baht}) \\
 &\quad + 228.17\text{baht} \\
 &= 57,101 \text{ baht}
 \end{aligned}$$

4.8.2 Water Supply

ABC Company uses water supply from Provincial Waterworks. The rate of water supply is shown in the following table.

Table 4.25: Water supply

Water Consume (m3/month)	Water Consume (lit/month)	Baht/m3
		Minimum rate 50 baht
0-10	0-10,000	9.00
11-20	10,001-20,000	11.75
21-30	20,001-30,000	13.00

31-50	30,001-50,000	14.00
51-80	50,001-80,000	14.40
81-100	80,001-100,000	14.50
101-300	100,001-300,000	14.60
301-1000	300,001-1,000,000	14.70
1001-2000	1,000,001-2,000,000	14.80
2001-3000	2,000,001-3,000,000	14.90
More than 3001	More than 3,000,001	15.00

Source: Adapted from Provincial Waterworks

In case of ABC Company, it consumes about 720m³ per months so it will pay as in the following table.

Table 4.26: Price of Water Supply

Range	Range	Price/m ³	unit	Price
0-10	0-10,000	9	10	90
0-20	10,001-20,000	11.75	10	117.5
21-30	20,001-30,000	13	10	130
31-50	30,001-50,000	14	20	280
51-80	50,001-80,000	14.4	30	432
81-100	80,001-100,000	14.5	20	290
101-300	100,001-300,000	14.6	200	2920
301-1000	300,001-1,000,000	14.7	420	6174
Sum			720	10,433.50

Therefore, ABC Company will pay 10,433.50 baht/months.

4.9 Environmental Effect

Because of project investment in each project, it can not only focus on engineering, but it should also cover of environment effects. In the present time, both government and private sectors of incineration are concerned with this effect such as physical resource of Ecosystem, Ecological/Biological Resource, Human Use Values and quality of life.

4.9.1 Physical Resources of Ecosystem

Infectious waste incinerator services of ABC Company have little effect on the environment, because it has the inefficient Controlled Air Incinerator process. The process has helped ABC Company to pass the standard of air pollution controlled. The following table shows results of air pollution of the Controlled Air Incinerator.

Table 4.27: Sample Test

Parameter	Unit	Value	Standard
TSP	Mg/Nm ³	383	400
SO ₂	Mg/Nm ³	51.19	140
NO _x	Mg/Nm ³	266.0	470
CO	Mg/Nm ³	144.83	1000
HCL	Mg/Nm ³	less than 1.19	200
VCM	Mg/Nm ³	less than 0.01	2.8

After considering of environment effect, it is found that this project will not deteriorate the environment, Table 4.27 presents that the value of TSP, SO₂, NO_x, CO, HCL, VCM form Controlled Air Incinerator compared with the Emission Air standard from incinerator Stack from Ministry of Public Health.

In addition, ABC Company has wastewater treatment, which can treat the wastewater from incinerating process. Therefore, it can ensure that ABC Company extremity concerns and controls environment effects.

4.9.2 Ecological/ Biological Resources

The Controlled Air Incinerator of ABC Company does not effect human being and other living animal, both in water, air, soil, and etc.

4.9.3 Human Use Values

Human use values means bringing many resources both physical and biological to use. The following topics should be considered.

- For set infectious waste incinerating plant, it needs to use a water supply.
- For transportation and delivery, ABC Company needs to use highways, boat ways, railways.
- The plant needs to use electricity in order to run the incinerator and other process.
- When considering use of land, it was found that Wong Chan site at Rayong was the most suitable for the infectious waste plant.

4.9.4 Quality of life values

Because of plant setting in Wong Chan helps the local working population by hiring labor in this area. This also reduces the need for worker to migrate to Bangkok for work. In addition, infectious waste incinerating will improve quality of life by reducing air pollution, wastewater pollution, social and so on.

4.10 Economic And Social Study

When setting up a new plant, the impact on the incinerating area should be considered, such as social, economic, culture and environmental factors as shown in the following topic.

4.10.1 Valued Add

This project will have certain benefits for the surrounding community as follows.

□ **Valued Add to the land**

In setting up the plant thus volume of land is handled, since the land, the buildings, and all the equipment has been paid for.

□ **Valued Add in term of labor**

This is the benefit the local labor forces receive in terms of increased wage, bonus, and etc.

□ **Return on Capital**

This is profit from doing business, interests, depreciation, tax, and etc.

4.10.2 Economic Effect

Thailand economy is slowly recovering from recession since, the crash in 1997. When the new plant is set up, it will good for Thai economic as following items.

- More jobs will be available.
- There will be no need to import incinerator equipment from foreign companies.

4.10.3 Benefit for Customer

Infectious waste incinerating service of ABC Company can increase supply so price of service will decline because price-cutting in order to share market. Therefore, customers will get benefit form this cause.

4.10.3 Social Effect

Infectious waste incinerating service of ABC Company can reduce air pollution because of using Controlled Air Incinerator. Then total air pollution in Thailand will decline.