Chapter 11 Conceptual Design

Chapter 11 Conceptual Design

This chapter provides the basic concept for the design of the pilot plant, as well as the commercial plant, which constitutes the manufacturing part, an important portion of the extensive scope of work for the second-stage study of this project. The manufacturing flow was devised according to the design concept for the pilot plant stated in the subsequent paragraphs. Material and energy balances were developed for the manufacturing flow. A process flow diagram was prepared. With all these prepared, specifications for the major pieces of equipment were developed and the designing of facilities, manufacturing facilities as well as auxiliary facilities, was ushered in.

The pilot plant is designed to be able to produce lignite briquettes that meet the requirements of the market. The market should always come first and the role of the manufacturing arm is to satisfy the market, to the extent possible within the economic, technical and legal constraints. This is the basic principle uncompromisingly adhered to throughout this study.

The quality aspect of the market requirement as per related in Chapter 6 must be met. Another important requirement is economy. The product lignite briquettes intend primarily to be a substitute on competitive grounds for charcoal as household cooking fuel; the latter should naturally be a cheap commodity. For the lignite briquettes to be competitive with charcoal, the cost of the pilot plant, as well as that of the commercial plant, must be minimized, but only without in any way jeopardizing safety of construction and operation, or disrupting the environments, or sacrificing the quality of the product. To achieve the economy of production, the Thai conditions were given full consideration; to be more specific, unskilled labors instead of machines for routine works, Thai-made equipment instead of imported equipment, experience and skills of the operators instead of expensive automated mechanization were adopted in the design wherever appropriate. These principles were adhered to throughout the design works. However, the pilot plant will be the first of its kind in Thailand and should consist of all tried-out and proven machines; that is to say, the machines are

all imported.

The operation of the pilot plant will be semi-continuous in the sense that appropriate intermediate storage capacities will be provided between important operations to buffer the effect of either the upstream or downstream operation on the other. The operation of any of the machine may be accelerated, slowed down or even suspended, to the extent that the intermediate storage capacity can absorb without affecting the operation of the plant as a system. This would add to the flexibility of the operation and enable minor onstream maintenance and repairs of the machines.

The design concept incorporates the most up-to-date measures for maintaining safety and hygiene of the work place, for controlling the pollutions, and for minimizing the adverse effects upon the environments. All these started with the selection of the plant site, the selected site being immune to inundation, earthquakes, landslides or typhoons, being well remote from the residential areas. Bag filters are provided where necessary to contain dust. The de-smoker gas is burned as fuel at de-smoker furnace and the hot-air generator. The effluent water is treated before discharging. The machines, electric cable and equipment, and all auxiliary facilities meet accepted standards of Thailand and/or Japan. Adequate lighting is provided in the work place, office, control room, storage area, and key spots in the plant premises to facilitate works. There will be round-the-clock vigilance by the professional guards.

The above principles apply to the pilot plant and also to the 50,000-tons-per-year commercial plant assumed to startup following the pilot plant.

11-1 Manufacturing Flow

Figure 11-1, Manufacturing Flow, gives the skeleton of the manufacturing scheme proposed for the pilot plant and the commercial plant. The manufacturing flow consists basically of three streams up to the mixer: lignite, biomass and slaked lime streams.

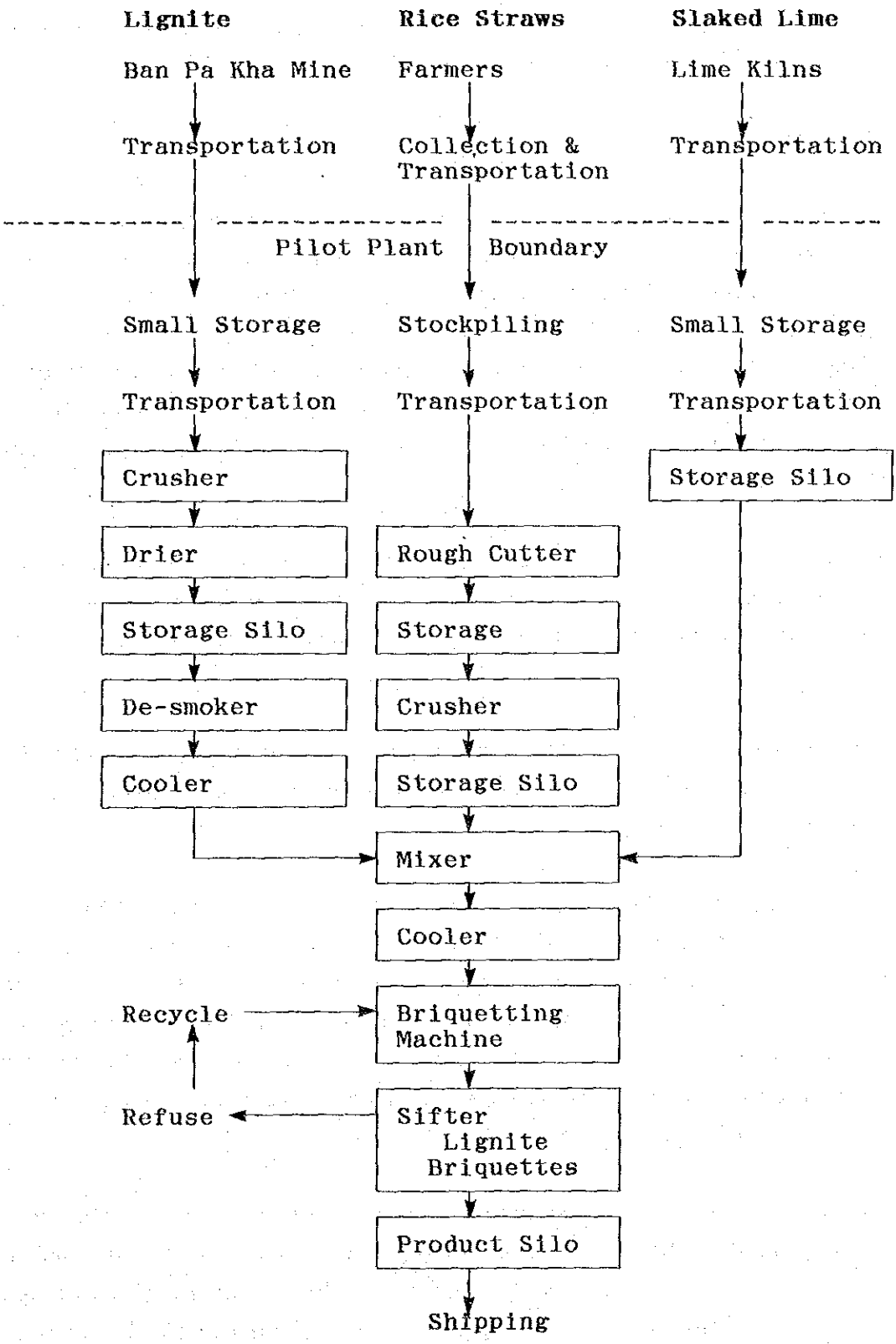


Figure 11-1 Manufacturing Flow

The manufacturing flows for the pilot plant and the 50,000-tons-per-year commercial plant are essentially the same.

11-1-1 Lignite Stream

The high-quality lignite is transported from the Ban Pa Kha mine to the stockyard in the plant site. This pilot plant project will have a truck of its own which will be used for the transportation of the lignite, rice straws and product briquettes. Lignite will be stored in the open. Because of the ready availability of lignite, there is no need to have a large stock of lignite at the plant. The capacity for stockpiling is equivalent to the consumption of 20 days and 3 days for the pilot plant and the commercial plant, respectively.

Lignite is transported from the stockyard to the plant inlet by unskilled labors. Lignite is fed to the crusher which grinds the lignite to two millimeters or smaller. The crushed lignite is dried in the drier.

As explained in Chapter 6, the manufacturing process has a provision for elimination of smoke or has the ability to produce smokeless or smoke-reduced lignite briquettes.

Elimination or reduction of smoke from the product lignite briquettes is done by partial removal of the volatile matter contained in the lignite. This is done by the facility designated as de-smoker in the manufacturing flow. Crushed and dried lignite is fed to the de-smoker where the lignite is heated to a predetermined temperature, 300 degrees Centigrade in the case of Ban Pa Kha lignite, to remove a portion of the volatile matter.

A typical design of the de-smoker is a multi-tube external heating furnace equipped with a device to rotate the tubes. The dried crushed lignite is fed to the tubes and slide down the inside of the slanted tubes while being heated. The gas generated from the lignite is used as fuel to heat the de-smoker. Normally, the amount of the de-smoked gas generated is sufficient for the de-smoking process. However, as a

backup for supplementing de-smoker gas, a facility for burning diesel fuel in place of de-smoker gas is provided. During the startup and shutdown periods when gas is not generated sufficiently, the backup fuel is burned. The hot effluent gas from the de-smoking furnace is used as heating media for the lignite drier. The excess de-smoker gas and a small amount of diesel fuel are burned to generate hot air to supplement the effluent gas for drying lignite.

The de-smoked lignite is cooled and blended with rice straws and slaked lime in the mixer. The thoroughly mixed blend is fed to the briquetting machine which mold the blend by compression into hard briquettes.

11-1-2 Biomass Stream

Rice straws are collected from the farmers and stored in the stockyard in the premises of the pilot plant. There are seasonal fluctuations in availability of rice straws. As a cushion against seasonal fluctuations in availability, a large capacity for inventory equivalent to the consumption of one month is provided. A shelter will be built to house rice straws to prevent them from getting wet in the rain. Rough cutters reduce the size of the straws to the length acceptable to the crusher. The crusher cuts the straws to two millimeters or less. The crushed rice straws are fed to the mixer where rice straws are blended with de-smoked lignite and slaked lime.

11-1-3 Slaked Lime Stream

Slaked lime will be purchased from lime kilns. Slaked lime will arrive at the plant site in the form of powder and will be stored and used without further treatment at the plant. Slaked lime is blended with de-smoked lignite and rice straws in the mixer.

11-1-4 Mixing and Briquetting

The hot de-smoked lignite, rice straws and slaked lime are mixed in the mixer. The greater portion of the moisture contained in the rice straws and slaked lime evaporates receiving heat from the hot de-

smoked lignite. The blend is cooled while losing heat for vaporizing moisture. The thoroughly mixed blend is ready for briquetting.

The blend is molded into hard briquettes by the briquetting machine. The heart of the briquetting machine is the two molding disks rotating in the opposite directions. As the blend is fed to the briquetting machine, the blend is sandwiched between the rotating disks and molded into briquettes under extremely high pressures generated as the surface of the two disks come closer. The biomass, rice straws, acts as the binder which holds firmly the particles together after the pressure is released; normally, addition of binders of adhesive nature is not required. The briquettes fresh from the briquetting operation have rims, which are removed in the sifter and recycled back to the briquetting machines. The finished briquettes are sent to the product silos.

11-1-5 Product Storage and Shipping

The finished briquettes are stored in the product silos from which the briquettes are loaded to trucks for shipping. The briquettes are shipped in bulk to the wholesalers or intermediate depots. The amount shipped is weighed on a truck scale. The trucks are covered for the transportation of briquettes just like the transportation of lignite.

11-1-6 Auxiliary Facilities

(1) Storage Facility

There will be adequate storage capacities for the raw materials, intermediate products and finished lignite briquettes.

1) Raw material

Table 11-1 gives the storage facilities for the raw materials.

Table 11-1 Storage Facility for Raw Material

	Lignite		Rice straws		Slaked lime	
	PP	CP	PP	CP	PP	CP
Capacity						
Days for consumption	20	3	30	30	10	10
Tons	212	530	74	1,230	9.2	153
Cubic meters	303	757	740	12,300	18.4	306
Facility	Concrete floor Retaining wall		Roofed shelter		Silo	

Note: PP and CP stand for pilot plant and commercial plant, respectively.

2) Briquettes and intermediate product

Table 11-2 gives the capacities planned for the product briquettes and intermediate products for both the pilot plant and commercial plant.

Table 11-2 Storage Facility for Briquettes and Intermediate Product

Intermediate product	Capacity (Hours)	Facility
Dried lignite	4	Steel silo
Crushed rice straws	4	Steel silo
Slaked lime	72	Steel silo
Product	**Capacity (Days)**	**Facility**
Lignite briquettes	15	Steel Silo & Stock house

(2) Utility facility

1) Electricity

A receiving facility of 200 KVA will be installed for the pilot plant at the plant site for receiving power. The transformer receives electricity at 22,000 volts and lowers it to 200 volts. The receiving facility will be expanded to 1,700 KVA when the commercial plant is installed. The wiring and switch gears, electric motors and lighting

facilities will be of water-proof type.

2) Water

A 3-inch pipe will be installed from the mine to the plant for a distance of 600 meters for receiving water. A cistern of 10 cubic meters will be installed for storage and maintenance of pressure. Hydrants will be installed at strategic points of the plant yard and storage yard.

3) Pneumatic air

A compressor of 100 and 300 liters per minute will be installed for the pilot plant and commercial plant, respectively.

(3) Building

The manufacturing facilities, product storage silos, storage yard for rice straws and slaked lime will be housed under roofed structures. An office, control room, canteen and toilet will be built adjacent to the plant shelter. The control room contains meters, switches of the machines and test equipment. The areas in square meter are given in Figures 11-7 and 11-8.

(4) Road, bridge and pavement

These facilities will be installed as shown in Figure 11-5.

11-1-7 Environmental Consideration

The pilot plant and commercial plant incorporate facilities to contain dusts to keep the work place clean and not hazardous. Bag filters are installed on the vents of the lignite drier, rice straws crusher, and mixer. Open sewage system with covers is provided to channel rain water and the effluent from bearing boxes to the ditch along the plant site. In the process of manufacturing lignite briquettes, there is no direct contact between water and the raw materials, intermediate products or lignite briquettes. Accordingly, there should be no foul water to be discharged from the plant. However, a detention pond of 10

cubic meters is provided at the outlet of the sewage system to the ditch to sediment and skim off tar, dusts, lubricating oil that may find their way into the discharging water. The sanitary sewage is not discharged to the outside of the site; it is absorbed in the ground. The gas from the de-smoker is burned in the de-smoker furnace; any excess gas is burned in the hot-air generator.

11-2 Material and Energy Balance

11-2-1 Material Balance

Table 11-3, Overall Material Balance, shows the material balance for the pilot plant developed to serve as the basis for the conceptual design. The basis for the material balance is the project scheme for the pilot plant given in Chapter 10, the capacity being 3,000 tons per year of lignite briquettes based upon round-the-clock 300 days operation a year.

Table 11-3 Overall Material Balance

(Unit: kilograms/hour)

	Input to System	Drier		De-smoker			Mixer		Brq. Mac.
		Moist	Lig	Moist	Gas	Lig	Moist	Blend	Briq't
Lignite									
Moist	132.4	118.8	13.6	13.6	-	-	-	-	-
Ash	37.6	-	37.6	-	-	37.6	-	37.6	37.6
VM	139.6	-	139.6	-	24.7	114.9	-	114.9	114.9
FC	131.6	-	131.6	-	-	131.6	-	131.6	131.6
Total	441.2	118.8	322.4	13.6	24.7	284.1	-	284.1	284.1
R. straws									
Moist	15.3	-	-	-	-	-	7.8	7.5	7.5
Ash	14.8	-	-	-	-	-	-	14.8	14.8
VM	59.6	-	-	-	-	-	-	59.6	59.6
FC	12.8	-	-	-	-	-	-	12.8	12.8
Total	102.5	-	-	-	-	-	7.8	94.7	94.7
S. Lime									
Moist	0.4	-	-	-	-	-	0.4	-	-
DSL	37.9	-	-	-	-	-	-	37.9	37.9
Total	38.3	-	-	-	-	-	0.4	37.9	37.9
G. Total	582.0	118.8	322.4	13.6	24.7	284.1	8.2	416.7	416.7

Note: Moist, Lig, Briq't, VM, FC, DSL stand respectively for moisture, lignite, briquettes, volatile matter, fixed carbon and dry slaked lime.

The effluent gas from the de-smoker is the volatile matter contained in the lignite and is therefore combustible. It is used as fuel to heat the de-smoker. The excess gas is burned in the hot air generator. The material balance of this gas is shown in the subsequent section.

11-2-2 Energy Balance

Table 11-4 shows the overall energy balance for the pilot plant. The energy balance excludes mechanical energy, heat of friction for example, supplied to the system by the electric motors. However, the energy of compression supplied at the briquetting machine and resulting in a rise in temperature of the briquettes is included. The base level of energy is the normal states of the inputs at 25 degrees Centigrade.

Table 11-4 Overall Energy Balance

(Unit: 10^3 Kcal/hour)

	Input	Output
Input		
Feed		
Lignite	0.0	-
Rice straws	0.0	-
Slaked lime	0.0	-
Heat of combustion	104.8	-
Hot air generator		
Heat of combustion, gas	23.4	
Heat of combustion, oil	49.6	
Heat of compression	3.7	-
Air to the furnace	0.0	-
Output		
Drier vent	-	133.6
Heat of decomposition		20.8
Mixer vent		5.0
Cooler-1 vent		4.2
Cooler-2 vent		6.2
Lignite briquette	-	11.7
Total	181.5	181.5

11-2-3 Bases for Material and Energy Balance

Table 11-5 lists the analyses on which the material and energy balances

have been developed. Reference should be made to the process flow diagram for other bases.

Table 11-5 Base for Material and Energy Balance

(Unit: weight percent)

	Lignite		Rice	Slaked	Lignite
	ROM	Dry base	straws	lime	briquettes
Moist.	30.0	-	14.9	1.0	1.8
Ash	8.5	12.2	14.4	-	21.7
VM	31.7	45.2	58.2	-	41.8
FC	29.8	42.6	12.5	-	34.7
Dry lime	-	-	-	99.0	-
Total	100.0	100.0	100.0	100.0	100.0

Note: ROM, Moist, VM, FC stand respectively for run of mine, moisture, volatile matter and fixed carbon.

11-3 Utility Balance

11-3-1 Fuel Balance

Normally, de-smoker gas is burned in the de-smoker furnace to heat the lignite; however, during the processes of startup and shutdown or any other occasions when gas is not generated enough, diesel fuel is used. Table 11-6 shows the fuel balance for the pilot plant.

Table 11-6 De-smoker Gas Material Balance

(Unit: kilograms/hour)

	Generation			Consumption	
	Moist	Gas	Total	Furn.	Incinerator
De-smoker gas					
Carbon	-	17.2	17.2	14.0	3.2
Hydrogen	-	3.0	3.0	2.5	0.5
Oxygen	-	4.0	4.0	3.3	0.7
Nitrogen	-	0.5	0.5	0.4	0.1
Moisture	13.6	-	13.6	-	-
Total	13.6	24.7	38.3	20.2	4.5
Diesel fuel					5.2
Total	13.6	24.7	38.3	20.2	9.7

Note: Moist and Furn. stand for moisture and furnace, respectively.

11-3-2 Utility Balance

The lignite briquette plants use electricity as process utility. Water is used for fire-fighting, sanitary purpose, and a very small amount for cooling bearings. Compressed air is used as necessary. Table 11-7 gives the utility balance for the pilot plant.

Table 11-7 Overall Utility Balance

(Unit: Average kw)

Input		Output	
Electricity	122	Power	112
		Lighting & others	10
Water	normally none	Cooling	normally none

11-3-3 Duty Specifications

Table 11-8 shows the duty specifications for the major facilities of the pilot plant. These duty specifications reflect themselves in the sizing of the machines and equipment shown in Tables 11-15 and 11-16.

Table 11-8 Duty Specifications

	Normal	Maximum
Lignite drier		
Heat duty, 10^3 Kcal/hour	74.9	90.0
Lignite, kg/hour	441.2	530
Hot gas, kg/hour	1,950	2,340
De-smoker		
Heat duty, 10^3 Kcal/hour	52.0	62
Lignite, kg/hour	322.4	387
Fuel gas, kg/hour	33.8	41
Air, kg/hour	1,391	1,670
Mixer		
Heat duty, 10^3 Kcal/hour	5.0	6
De-smoked lignite, kg/hour	284.1	341
Rice straws, kg/hour	102.5	128
Slaked lime, kg/hour	38.3	46
Cooler-1		
Heat duty, 10^3 Kcal/hour	4.2	5
De-smoked lignite, kg/hour	284.1	340

Table 11-8 Duty Specifications (Continued)

	Normal	Maximum
Cooler-2		
Heat duty, 10^3 Kcal/hour	6.2	7.2
Blend, kg/hour	416.7	500
Briquetting machine		
Blend, kg/hour	595.3	714
Sifter		
Briquettes, kg/hour	595.3	714
Refuse, kg/hour	178.6	214
Hot air generator		
Heat duty, 10^3 Kcal/hour	73.0	88
Gas, kg/hour	4.5	5.4
Diesel fuel, kg/hour	5.2	6.4
Air, kg/hour	863.0	1,035

11-4 Process Flow

The process flow diagram is shown on Figure 11-2.

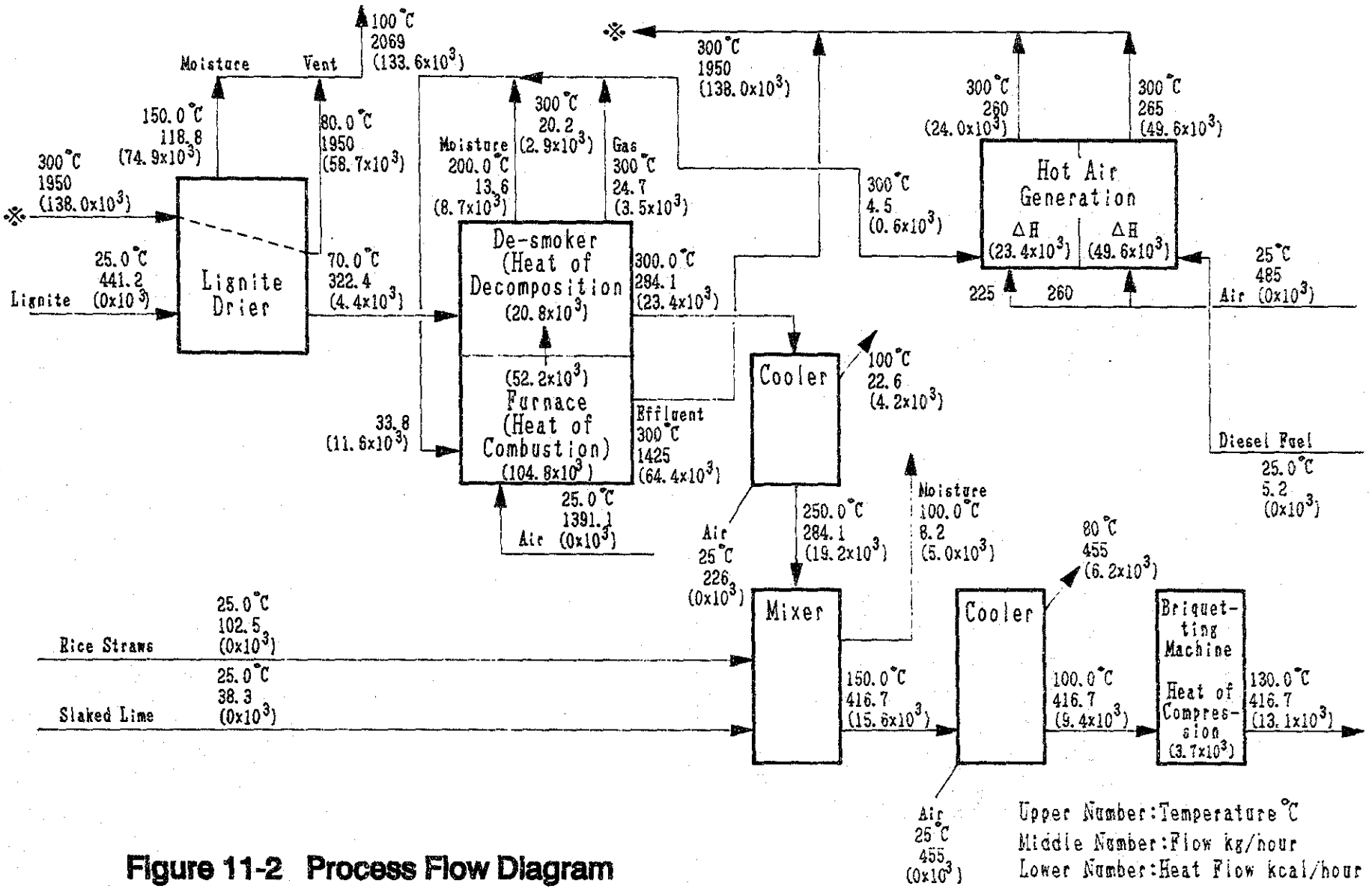


Figure 11-2 Process Flow Diagram

11-5 Production Facility

In conformity with the process design of the conceptual design, the manufacturing facilities of the lignite briquette plant are planned as follows. As shown in Figure 11-3, the lignite briquette plant consists of raw material receiving facilities for lignite, rice straws and slaked lime, storage facilities, a lignite crusher, driers, a de-smoking facility, rice straws crusher for secondary crushing, a slaked lime feeding facility, mixer, briquetting machine, sifter, product storage facility and shipping facility.

11-5-1 Outline of Facility

(1) Raw Material Receiving Facility

The raw materials -- lignite, rice straws and slaked lime -- sent from each source of supply by trucks are received at the plant site. These raw materials are normally weighed on the truck scale of the plant.

(2) Lignite Storage Facility

As the mine is adjacent to the plant, it is not necessary to store lignite in a large amount. For the production of 3,000 tons per year and 50,000 tons per year, the stockyard will have capacities equivalent to the consumption for 20 days and 3 days, respectively. The selected storage place drains well, an attribute necessary for the rainy season.

(3) Rice Straws Storage Facility

As mentioned in 11-8, Stockyard, a storage house of simple frame-structure will be built for storing rice straws. The storage capacity will be equivalent to the consumption of about one month for both 3,000 or 50,000 tons per year capacities. Both rice straws as received and those after primary crushing will be stored in the simple roofed storage house.

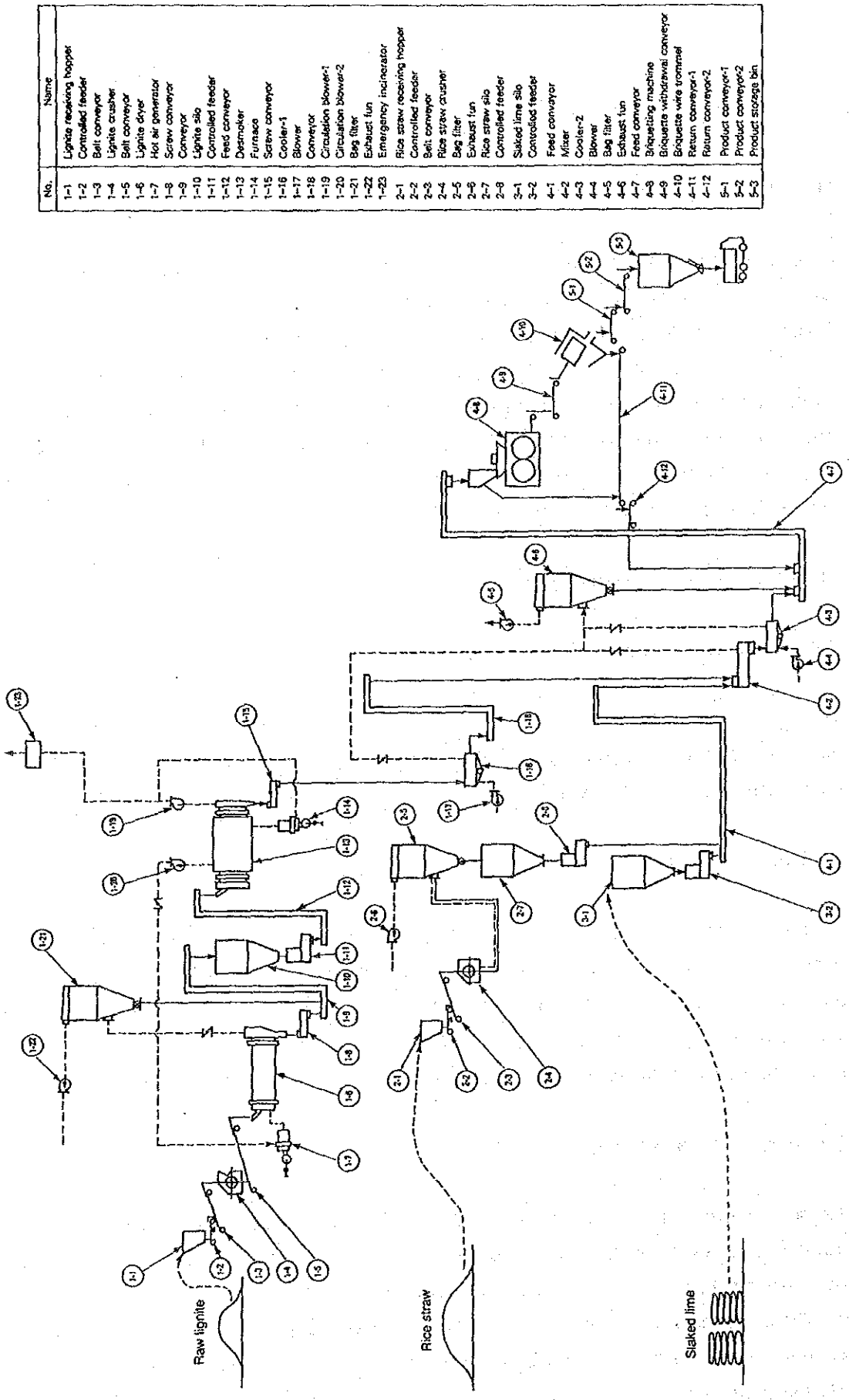


Figure 11-3 Mechanical Flow of Pilot Plant

(4) Slaked Lime Storage Facility

Slaked lime is stored in the simple roofed storage house. The storage capacity is equivalent to the consumption of 10 days.

(5) Storage, Facility, Crusher and Dryer for Lignite

The raw material lignite is transported from the place of storage of the plant and fed to the lignite hopper which channels the lignite to the crusher. The crusher reduces the lignite lumps to particles of less than two millimeters. The moisture of the crushed lignite is reduced from 30 to 4.2 percent by the drier. The hot exhaust gas from the de-smoking furnace is used as heating medium for the drier. The temperature of the heating medium is 300 degree Centigrade and the hold-up time is about 25 minutes. After mixed with air to lower the temperature to 150 degree Centigrade or lower, the gas is vented to atmosphere after passing a bag filter which traps dusts. The dried lignite is stored in a silo.

(6) Lignite Constant Feeder

A controlled volume of dried lignite is withdrawn from the silo and fed to the de-smoker.

(7) De-smoker

The dried crushed lignite is fed to the de-smoker where the lignite is heated to 250 to 300 degree Centigrade for about 30 minutes. About 18 percent of the volatile matter is removed. The de-smoker gas is burned in the de-smoker furnace. The exhaust gas from the de-smoker furnace is used as a heating medium for the lignite drier. The excess de-smoker gas is burned in the hot air generator for producing hot air for lignite drying.

(8) Rice Straws Storage and Crushing Facility

Rice straws already crushed to 40 millimeters or shorter by the primary

crushers are transported from the place of storage to the rice straws hopper. The rice straws are drawn by a conveyer to the secondary crusher which cuts the rice straws to less than two to three millimeters. A bag filter is provided at the outlet of air to arrest dust.

(9) Rice Straws Feeder

The crushed rice straws are stored in a silo from which a controlled volume is withdrawn by a feeder and fed to the mixer.

(10) Slaked Lime Storage Facility and Feeder

Slaked lime is stored in the storage house as received. Slaked lime is brought to the hopper from which a controlled quantity is withdrawn and fed to the mixer.

(11) Mixer

The main raw material, de-smoked lignite, and the sub-raw materials -- crushed rice straws and slaked lime -- are blended in the mixer. In con tact with the de-smoked lignite of high temperatures, the rice straws and slaked lime lose a good portion of the moisture and are partly dried. The gas, consisting chiefly of moisture, generated from the mixer is vented through a bag filter which traps dust. The gas is mixed with air to reduce the temperature to lower than 150 degree Centigrade if necessary.

(12) Briquetting Machine

The mixed feed is fed to the briquetting machine to be molded into briquettes under a high pressure.

(13) Sifter and Storage Facility

The briquettes fresh from the briquetting machine have burrs which are removed and recycled to the briquetting machine. The finished lignite briquettes are stored.

(14) Shipping Facility

The finished lignite briquettes are loaded from the storage silos on to trucks and weighed on the truck scale. The lignite briquettes are shipped from the plant to the market. The amount of shipment is 10 and 167 tons per day for the 3,000 and 50,000 tons per year production, respectively.

(15) Test Equipment

A breaking strength tester, scales, sieves and an oven will be provided for testing the raw materials and product. The feed lignite is tested for particle size and moisture. The product lignites are tested for the following items.

(1) Appearance
The ratio of cracked and otherwise deformed lignite briquettes should be less than 10 percent.

(2) Breaking strength test
The breaking strength is measured by the breaking strength tester.

(3) Ignition test
Ease or difficulty of ignition is tested.

(4) Combustion test
The combustibility is tested.

11-5-2 Pollution Control and Safety Measures

(1) Pollution Control

The gas from the de-smoker, dusts generated at various machines and noises the machines produce would cause problems if not addressed properly. The de-smoker gas is burned in the de-smoker furnace and the hot-air generator. Dusts come from lignite and rice straws. Bag

filters are installed at the vapor side outlets of the lignite drier, the rice straws crusher and the mixer. The dusts permeating from the briquetting machine and other machines are induced locally and vented to atmosphere through a filter. The operators should wear dust masks when cleaning machines or doing works that could generate dusts. Silencers will be installed at air inlets to blowers. Lubricating oil and tar carried by rain water are trapped in the detention pond placed at the outlet of the sewage system.

(2) Safety Measure

1) Fire Prevention

Hydrants are installed around the plant and storage house for raw materials for fire fighting. A cistern will be installed for storing water for early fire extinguishing. An eyewashing faucet and an emergency shower are also provided.

2) Anti-accident Measure

The main machines and equipment incorporate due measures for prevention of explosion and electric shocks. The rotary machines and belts are equipped with guard covers. Oxygen masks, air line masks and fire proof cloth are provided for emergency rescue.

11-6 Utility and Auxiliary Facility

Tables 11-9 and 11-10 show consumption of utility and fuel for the pilot plant and commercial plant, respectively.

The electric facilities consist of a receiving facility, cables for the electric motors, a switch board, a control panel, facilities for lighting and ground connections.

The fuel facilities are the gas piping for the de-smoker furnace, gas burners, a tank for diesel fuel, the piping for diesel fuel to the air heater, the piping for backup diesel fuel to the de-smoker furnace and oil burners. Electricity is used for boiling water at the office and lignite briquettes will be used for cooking for employees.

Water is used for drinking, cooking, shower and lavatories for employees, and cleaning of the work place.

Table 11-9 Utility and Fuel for Pilot Plant

	Motor Installed capacity (kw)	Electricity Consumption (kw)	Fuel Diesel oil (kg/h)	Water (kg/h)
1. Lignite drying, crushing	51.15	35.81	5.2	
2. Rice straws drying, crushing	48.80	34.16	-	
3. Slaked lime receiving facility	0.75	0.53	-	
4. Mixing, briquetting, trommeling	60.65	42.45	-	
5. Storage and shipping	3.0	2.10		
6. Lighting	10.0	7.0	-	
7. Others	-	-	-	
Total	174.35	122.05	5.2	1.0

Table 11-10 Utility and Fuel for Commercial Plant

	Motor Installed capacity (kw)	Electricity Consumption (kw)	Fuel Diesel oil (kg/h)	Water (kg/h)
1. Lignite drying, crushing	233.65	163.56	86.7	
2. Rice straws drying, crushing	305.10	213.57	-	
3. Slaked lime receiving facility	1.50	1.05	-	
4. Mixing, briquetting, trommeling	377.05	263.93	-	
5. Storage and shipping	3.70	2.59		
6. Lighting	10.0	7.0	-	
7. Others	-	-	-	
Total	931.00	651.70	86.7	1.0

11-7 Outline of Buildings and Auxiliary Facility

As a general rule, the civil and construction works will be undertaken by local constructors using locally procured materials. Major specifications of the buildings and auxiliary facilities are shown as follows:

(1) Plant and the Structure

Base/floor:	Reinforced concrete
Pillar/beam:	Steel frames
Roof:	Asbestos slate shingles for roofed portions only

(2) Office and Lavatories

Base/floor:	Reinforced concrete
Pillar/beam:	Reinforced concrete
Wall:	Concrete blocks
Roof:	Asbestos plate

(3) Truck scale room

Base/floor:	Reinforced concrete
Pillar/beam:	Reinforced concrete
Wall:	Concrete blocks
Roof:	Asbestos plate

(4) Guard post

Base/floor:	Reinforced concrete
Pillar/beam:	Reinforced concrete
Wall:	Concrete blocks
Roof:	Asbestos plate

(5) Storage houses for raw materials

Base/floor:	Reinforced concrete
Pillar/beam:	Steel frames
Roof:	Asbestos slate shingles

(6) Water tank: Carbon steel

(7) Oil tank: Carbon steel with steel beam reinforcing

(8) Foundations for machine: built of reinforced concrete

(9) Lighting

Plant: 200 to 300 luxes

Office: 100 to 500 luxes

Roof: 10 to 20 luxes

(10) Ventilation: Natural ventilation, limited forced ventilation

(11) Pavement

Access road, plant road: Surfaced with gravel, asphalt or blacktop.

The sizes of the major facilities are shown in Table 11-11.

Table 11-11 Size and Capacity of Major Facility

		Size and Capacities, tons/year	
		3,000	50,000
1.	Raw material storage		
	Coal storage area, m^2	100	230
	Rice straws storage area, m^2	300	3,800
	Slaked lime storage area, m^2	10	200
	Total	410	4,230
2.	Plant		
	Briquette production plant, tons/day	10	167
	Floor area, m^2	800	3,000
3.	Common facilities		
	Office occupants, persons	11	11
	Floor area, m^2	142.5	-
	Truck scale room, m^2	9	-
	Guard post, m^2	6	-
	Control room with laboratory, m^2	49	49
4.	Supplementary facilities		
	Diesel oil tank, m^3	1.5	20
	Power supply system, KVA	200	1,500
5.	Infrastructure		
	Outdoor Paving area, m^2	3,300	5,740
	Piping on the premises, meter	600	-

11-8 Stockyard

There are stockyards for lignite, rice straws and slaked lime, and the products.

11-8-1 Lignite

As the source of supply is adjacent to the site selected for the lignite briquette plant, it is not necessary to have a large storage facility. A minimum amount of lignite will be stored for emergency, an amount equivalent to the consumption of 20 days and 3 day for the pilot plant and the commercial plant, respectively.

11-8-2 Rice Straws

(1) Pilot Plant

1) Block of Rice Straws

The storage capacity for rice straws is one month. For the production of 3,000 tons lignite briquettes per year, the stocks of rice straws are:

0.42 tons/hour x 0.246 tons/ton x 24 hours/day x 30 days/month
= 74.39 tons/month

Rice straws will be compacted to blocks as shown in Figure 11-4. Using the bulk density of rice straws of 0.123 tons/m^3 obtained by the field survey, the volume of rice straws is obtained as:

74.39 tons/month / 0.123 tons/m^3 = 605 m^3

Rice straws come in blocks measuring 1.0 meter in length, 0.5 meters in width and 0.3 meters in height, the volume of rice straws per block is:

1 x 0.5 x 0.3 = 0.15 m^3

The number of blocks of rice straws is:

605 m^3/month / 0.15 m^3/piece = 4,033 pieces/month

Eight blocks will be loaded on a pallet of 1.0 meter x 1.0 meter in four tiers as shown in Figure 11-4. When three pallets supporting a total of 24 blocks are placed in three tier one upon the other, the volume is:

1.0 meter wide x 1.0 meter deep x 4.2 meters high = 4.2 m^3

This is the volume of one storage unit. The number of the storage units is:

4,033 pieces/month / 24 pieces/storage unit
= 168 storage units/month

Allowing 10 centimeters between the storage units, the area necessary for storage is :

1.1 m x 1.1 m = 1.21 m^2

The area of the rice stockyard is:

168 x 1.21 m^2 = 203.28 = 204 m^2

2) Cut Rice Straws

The straws after primary crushing will be stored for three days. The storage of the rice straws is:

0.42 tons/hour x 0.246 tons/ton x 24 hours/day x 3 days
= 7.44 tons

The volume is:

7.44 tons / 0.123 tons/m^3 = 60.48 = 61 m^3

Lignite will be piled to three meters and therefore a lot of 20 m^2 is required.

(2) Commercial Plant

When the production is 50,000 tons/year, the storage of rice straws for one month is:

6.95 tons/hour x 0.246 tons/ton x 24 hours/day x 30 days
= 1,231 tons

The required area is calculated to be about 2,490 m^2 in a manner similar to that employed above in (1).

The area required for rice straws storage is as follows:

Table 11-12 Required Storage Area for Rice Straws

(Unit: m^2)

Lignite briquette production, tons/y	Rice straws storage	Primary crushing of rice straws	Allowance	Total
3,000	204	20	26	250
50,000	3,364	334	102	3,800

11-8-3 Slaked Lime

The storage of slaked lime will be for 10 days. When the production is 3,000 tons/year, the storage of slaked lime is:

0.0919 tons/ton x 10 tons/day x 10 days = 9.19 tons = 9.2 tons

One sack of slaked lime weighs 25 kilograms and measures 70 cm x 40 cm x 20 cm. The number of the sacks is:

9,200 kilograms / 25 kilograms/sack = 368 sacks

The sacks are piled in 10 tiers, the required area is:

0.7 x 0.4 x 36.8 = 10.304 = 10.0 m^3, or 2 x 5 meters

The area required for slaked lime storage is:

2 meters x 5 meters for 3,000 tons/year, and
10 meters x 20 meters for 50,000 ton/year.

11-8-4 Inventory Days

The required storage is given in Table 11-13.

Table 11-13 Inventory Days for Raw Material Storage

(Unit: days)

Lignite briquette production, tons/year	Lignite	Rice straws	Slaked lime
3,000	20	30	10
50,000	3	30	10

The area required for raw material storage is given in Table 11-14.

Table 11-14 Required Storage Area for Raw Material

(Unit: m^2)

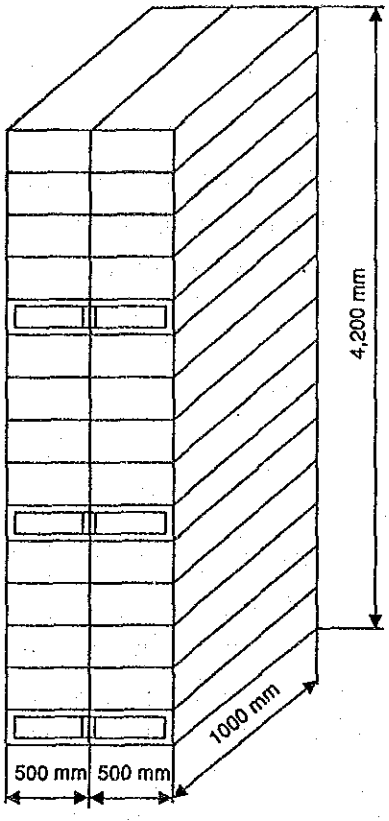
Lignite briquette production, tons/year	Lignite (1)	Rice straws	Slaked lime	Total
3,000	10	300	10	410
50,000	230	3,800	200	4,230

Note: (1) Stock height, meter: 3.3
Bulk density, tons/m^3: 0.7

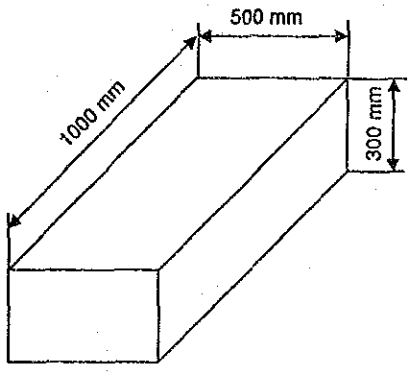
11-8-5 Capacity for Inventory of Product

The planned stocks are as follows:

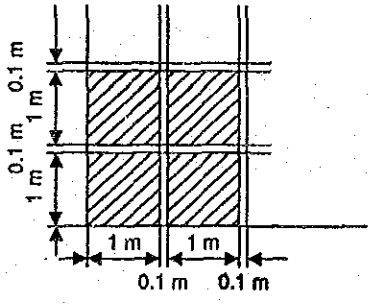
3,000 tons/year	15 days	150 tons
50,000 tons/year	15 days	2,500 tons



3 Stage pallet



Minimum unit of rice straw
to be loaded on pallet



Typical layout for rice straw's storage

Figure 11-4 Piles of Rice Straws Blocks

11-9 Plot Plan and Layout

Figure 11-5 shows the plots of the plant yard. Figure 11-6 shows the layout plan. Figure 11-7 shows the office building; and Figure 11-8 shows the operator and control room, the guard post and measuring room.

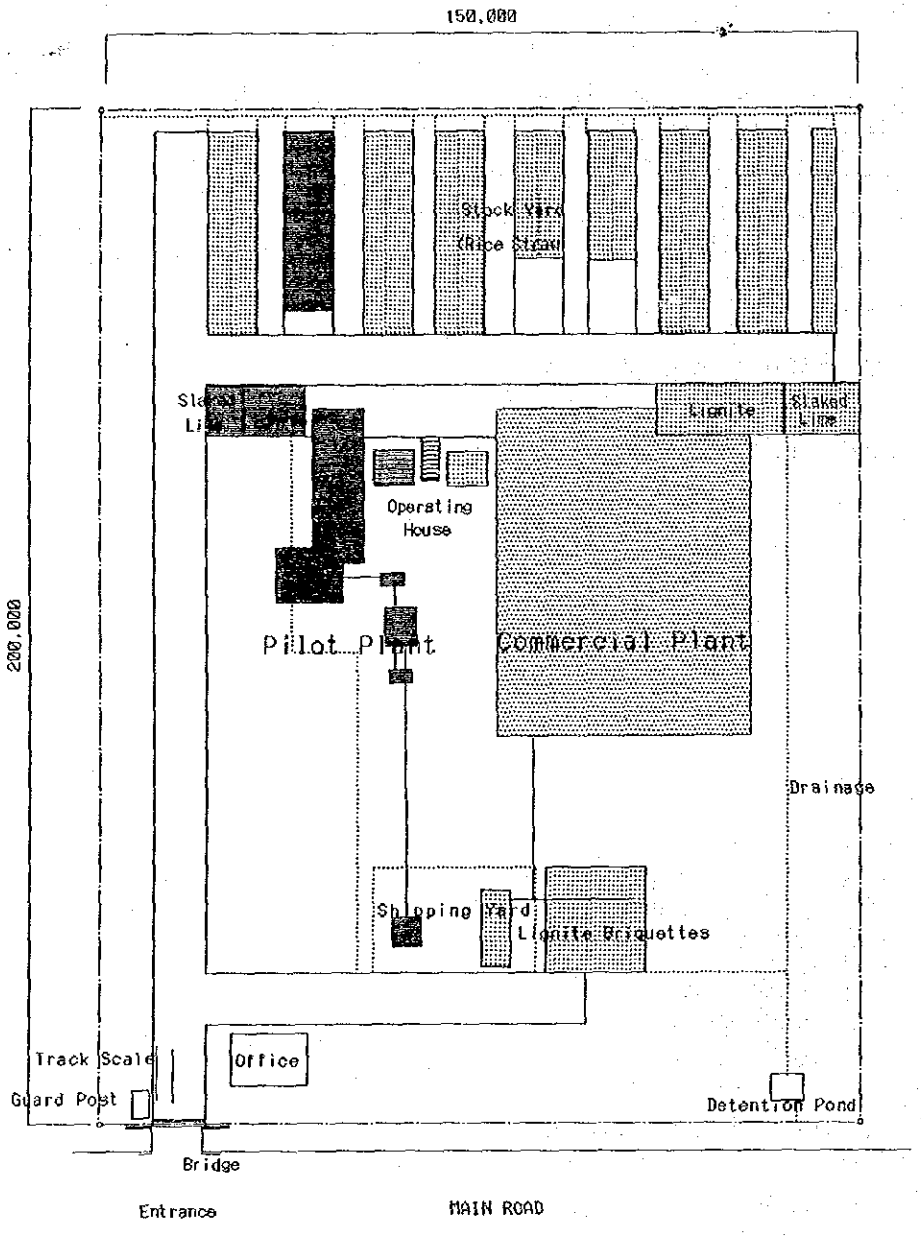


Figure 11-5 Plot Plan

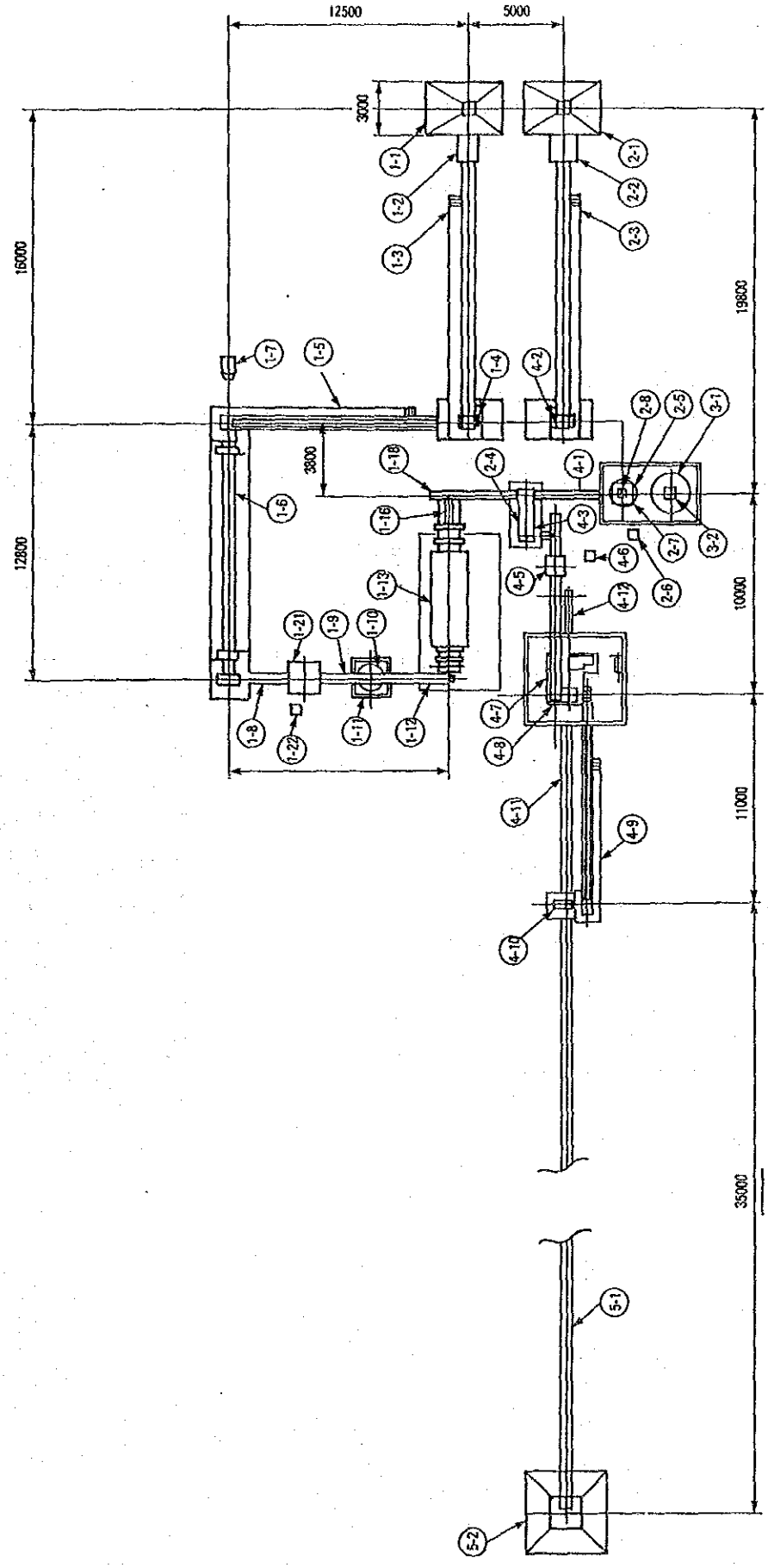


Figure 11-6 Layout of Pilot Plan

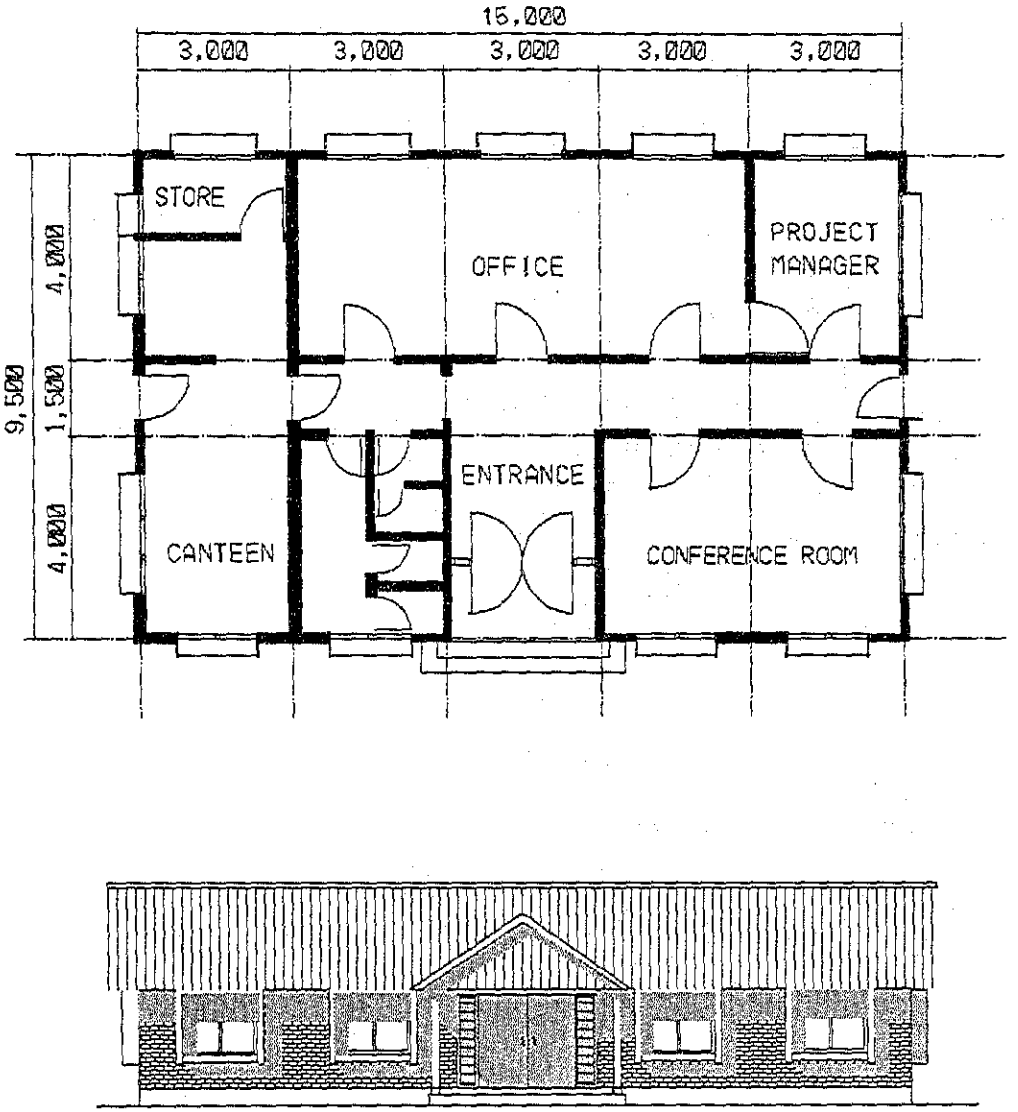


Figure 11-7 Office Building

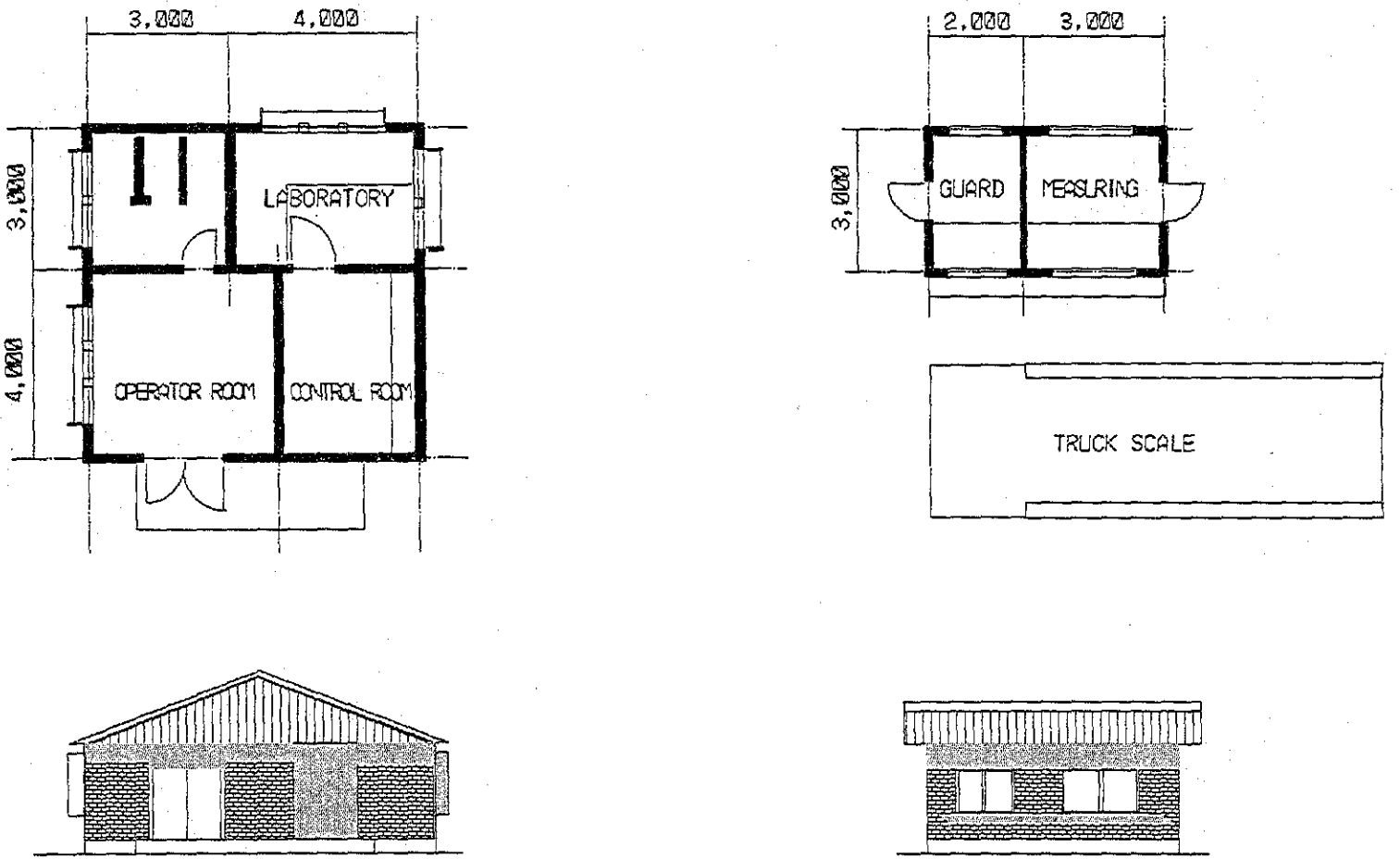


Figure 11-8 Operator and Control Room, Guard Post and Measuring Room

11-10 List of Major Equipment

Tables 11-15 and 11-16 list major equipment of the pilot plant and the commercial plant, respectively.

Table 11-15 Main Equipment List for Pilot Plant

1. Coal drying, curing section

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
1-1	Lignite receiving hopper	Capacity	$5m^3$	1		
		Steel plate				
		Vibrator		2	0.15kW x 2	
1-2	Controlled feeder	Constant feeder		1	1.5kW	
		Belt width	450mm			
		Belt length	2,800mm			
1-3	Belt conveyor	Belt width	400mm	1	0.75kW	
		Actual length	14.0m			
		Lift	3.5m			
1-4	Lignite crusher	Through put	0.5tons/h			
		Hammer crusher		1	11kW	
		Rotary Dia. x width	600 x 300mm			
1-5	Belt conveyor	Belt width	400mm	1	0.75kW	
		Actual length	13.5m			
		Lift	3.5m			
1-6	Lignite dryer	Rotary dryer		1	11kW	moisture 30%
		Heat load	90,000kcal/h			to 4.8% load:
		Diameter	0.7m			0.53tons/h(max.)
		Length	12.0m			
1-7	Hot air generator	Diesel				
		Effective heat load	88,000kcal/h	1	0.75kW	
		Fuel consumption rate	13.6kg/h			
	Dilute blower	Flow volume rate	$40m^3$/min.	1	2.2kW	
		Static pressure	100mmAq			
1-8	Screw conveyor	Screw dia.	300mm	1	0.75kW	
		Length	3,000mm			
1-9	Conveyor	Pot conveyor		1	0.75kW	
		Bucket volume	1.5lit.			
		Chain velocity	14m/min.			
		Length	6.0m			
		Lift	6.0m			
1-10	Lignite silo	Capacity	$2m^3$	1		
		Dia.	1.4m			
		Height	2.7m			
1-11	Controlled feeder	Table feeder	Max. $3.6m^3$/h	1	1.5kW	
1-12	Feed conveyor	Pot conveyor		1	0.75kW	
		Bucket volume	1.5lit.			
		Chain speed	14m/min.			
		Length	5.5m			
		Lift	5.5m			
1-13	Desmoker	Multi pipe outer heat type kiln		1	3.75kW	
		Multi pipe dia.x length	320mm x 4,800mm x 6			
		Drum dia.x length	1,250mm x 6,000mm			
		r.p.m.	0.5 to 2.0rpm			
1-14	Furnace	Diesel				
		Effective heat load	104,000kcal/h	1	0.75kW	
		Fuel consumption rate	10.3kg/h			
		Dilute Blower, Flow	$3m^3$/min.	1	0.75kW	
		Static press.	650mmAq			

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
1-15	Screw conveyor	Screw dia.	300mm	1	0.75kW	
		length	3,000mm			
1-16	Cooler	Vibrating Cooler		1	0.2kW x 2	
		Head load	5,000kcal/h			
		Traf size	W300mm x 1,200mm			
1-17	Blower	Blower	$5m^3$/min.	1	0.4kW	
		Static press.	100mmAq			
1-18	Conveyor	Pot conveyor (High temp. spec)		1	0.75kW	
		Bucket volume	1.5lit.			
		Chain speed	14m/min.			
		Length	7.5m			
		Lift	5.5m			
1-19	Circulating blower -1	Flow rate	$0.5m^3$/min.	1	0.4kW	
		Static press.	200mmAq			
1-20	Circulating blower -2	Flow rate	$40m^3$/min.	1	1.5kW	
		Static press.	100mmAq			
1-21	Bag filter	Filter area	$40m^3$	1		
		Draw down method	Jet air type			
		Required flow rate	79N lit./min.			
		press.	$5kg/cm^2$			
		Compressor		1	1.5kW	
		Rotary valve	dia.150mm	1	0.75kW	
1-22	Exhaust fun	Flow rate	$40m^3$/min.	1	7.5kW	
		Static press.	400mmAq			
1-23	Emergency Incinerator	Heat duty	128.2 x 10^3kcal/h	1		

2. Rice straws drying, curing section

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
2-1	Rice straw receiving hopper	Capacity	$5m^3$	1		
		Steel plate				
		Vibrator		2	0.15kW x 2	
2-2	Controlled feeder	Constant feed wire		1	1.5kW	
		Belt width	600mm			
		Belt length	2,800mm			
2-3	Belt conveyor	Belt width	400mm	1	0.75kW	
		Actual length	14.0m			
		Lift	3.5m			
2-4	Rice straw crusher	Pinmill		1	37kW	
		Through put	0.12tons/h			
		Rotary Dia.	600mm			
		Speed	2,700rpm			
2-5	Bag filter	Filter area	$50m^2$	1		
		Draw down method	Jet air type			
		Required flow rate	105N lit./min.			
		press.	$5.0kg/cm^2$			
		Compressor		1	1.5kW	
		Rotary valve	dia.150mm	1	0.75kW	

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
2-6	Exhaust fun	Flow rate	50m^3/min.	1	5.5kW	
		Static press.	300mmAq			
2-7	Rice straw silo	Capacity	4m^3	1		
		Dia.	1.4m			
		Height	3.9m			
2-8	Controlled feeder	Table feeder	Max. 3.6m^3/h	1	1.5kW	

3. Slaked lime receiving section

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
3-1	Slaked lime silo	Capacity	10m^3	1		
		Dia.	2.2m			
		Height	3.5m			
3-2	Controlled feeder	Table feeder	Max. 0.3m^3/h	1	0.75kW	

4. Mixing, briquetting, trommeling section

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
4-1	Feed conveyor	Pot conveyor		1	0.75kW	
		Bucket volume	1.5lit.			
		Chain speed	14m/min.			
		Horizontal length	7.5m			
		Lift	5.5m			
4-2	Mixer	Through put	0.43tons/h			
		Paddle mixer		1	3.7kW	
		Paddle dia.x length	250mm x 2,500mm			
		Revolution	50rpm			
		Effective capacity	0.1m^3			
4-3	Cooler	Vibrating cooler		1	0.2kW x 2	
		Heat load	8,000kcal/h			
		Traf size W	300mm			
		L	1,200mm			
4-4	Blower	Flow rate	35m^3/min.	1	3.7kW	
		Static press.	300mmAq			
4-5	Bag filter	Filter area	20m^2			
		Draw down method	Jet air type			
		Required flow rate	42N lit./min.			
		Press.	4.2kg/cm^2			
		Compressor		1	0.75kW	
		Rotary valve	dia.150mm	1	0.75kW	
4-6	Exhaust fun	Flow rate	35m^3/min.	1	3.7kW	
		Static press.	300mmAq			

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
4-7	Feed conveyor	Pot conveyor		1	0.75kW	
		Bucket capacity	1.5lit.			
		Chain speed	14m/min.			
		Horizontal length	9.0m			
		Lift	6.5m			
4-8	Briquetting machine	Briquetting machine		1	37kW	
		Throuth put	0.6tons/h			
		Roll dia.	520mm			
		Roll width	78mm			
		Revolution	8rpm			
		Briquette figure	Almond type (37 x 21 x 13mm)			
		Screw feeder		1	5.5kW	
		Oil pressure unit		1	2.2kW	
		Belt conveyor		1	1.0kW	
4-9	Briquette withdrawal conveyor	Belt width	400mm	1	0.75kW	
		Actual length	12.2m			
		Lift	3.3m			
4-10	Briquette wire trommel	Trommel		1	1.5kW	
		Through put	0.6tons/h			
		Drum Dia.	400mm			
		Drum length	800rpm			
		Pitch	10mm			
4-11	Return conveyor -1	Belt width	400mm	1	0.75kW	
		Actual length	12.7m			
		Lift	1.0m			
4-12	Return conveyor -2	Belt width	400m	1	0.75kW	
		Actual length	7.1m			
		Lift	2.2m			

5. Storage and loading section

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
5-1	Product conveyor -1	Belt width	400mm	1	1.5kW	
		Actual length	36.2m			
		Lift	9.4m			
5-2	Product conveyor -2	Belt width	400mm	1	0.75kW	Reversible
		Actual length	9.4m			
		Lift	0m			
5-3	Product storage bin	Capacity	$100m^3$	1		
		4,000o x 4,000o	Steel Plate			
		Height	7.3m			
		Loading method	cut-gate	1		

Table 11-16 Main Equipment List for Commercial Plant

1. Coal drying, curing section

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
1-1	Lignite receiving hopper	Capacity	$10m^3$	1		
		Steel plate				
		Vibrator		2	0.15kW x 2	
1-2	Belt feeder	Belt width	750mm	1	2.2kW	
		Belt length	4.0m			
		Belt speed	5.0m/min.			
		Handling volume	$20m^3/h$			
1-3	Bucket elevator	Lift	21m	1	3.7kW	
		Bucket capacity	15.7lit.			
		Chain speed	25.0m/min.			
1-4	Raw lignite bin	Capacity	$85m^3$	1		For 8hrs
		Diameter	5.0m			
		Height	7.4m			
1-5	Controlled feeder	Constant feeder		1	1.5kW	
		Belt width	750mm			
		Belt length	2,800mm			
1-6	Belt conveyor	Belt width	400mm	1	0.75kW	
		Actual length	16.0m			
		Lift	4.0m			
1-7	Lignite crusher	Through put	8.5tons/h			
		Hammer crusher		1	30kW	
		Roter dia. x width	750 x 450mm			
1-8	Belt conveyor	Belt width	400mm	1	1.5kW	
		Actual length	20.0m			
		Lift	5.0m			
1-9	Lignite dryer	Rotary dryer				
		Heat load	1,530,000kcal/h			
		Dia.	2.60m	1	30kW	
		Length	18.0m			
1-10	Hot air generator	Lignite furnace		1	1.5kW	
		Effective heat load	1,500,000kcal/h			
		Coal consumption rate	680kg/h			Thermal
	Dilute blower	Flow volume	$280m^3/min.$	1	11kW	efficiency
		Static pressure	100mmAq			50%
1-11	Screw conveyor	Screw dia.	350mm	1	0.75kW	
		length	3,000mm			
1-12	Conveyor	Pot conveyor		1	3.7kW	
		Bucket capacity	8.5lit.			
		Chain speed	15m/min.			
		Horizontal length	8.0m			
		Lift	8.0m			
1-13	Lignite silo	Capacity	$35m^3$			
		Diameter	3.8m			
		Height	5.5m			
1-14	Controlled feeder	Table feeder		2	3.7kW x 2	
		Cap. Max.	$20m^3/h$			

No.	Equipment name	Main specifications	Quantity	Motor	Remarks
1-15	Feed conveyor	Pot conveyor			
		Bucket capacity 6.4lit.			
		Chain speed 14m/min.			
		Horizontal length 8.0m			
		Lift 8.0m			
1-16	Desmoker	Multi pipe outer heat type kiln	1	11kW x 2	
		Multi pipe dia.350 x 12			
		Drum dia.x length 2,640mm x 11,000mm			
		r.p.m.			
1-17	Furnace	Lignite furnace	2	0.75kW x 2	
		Effective heat value 850,000kcal/h			
		Lignite fuel consumption 350kg/h			
		Dilute blower, Flow $140m^3/min.$	2	3.7kW x 2	
		Static press. 100mmAq			
1-18	Screw conveyor	Screw dia. 300mm	2	0.75kW x 2	
		Screw length 3,000mm			
1-19	Cooler	Vibrating cooler			
		Heat load 85,000kcal/h			
		Traf size W750mm x 4,000mm	1	3.7kW	
1-20	Blower	Flow rate $90m^3/min.$			
		Static press. 100mmAq	1	3.7kW	
1-21	Conveyor -2	Pot conveyor (for high temp.)	1	5.5kW	
		Bucket capacity 8.5lit.			
		Chain speed 15m/min.			
		Horizontal length 8.0m			
		Lift 8.0m			
1-22	Circulating blower	Flow rate $10^3/min.$	2	0.75kW x 2	
		Static press. 100mmAq			
1-23	Circulating blower	Flow rate $610m^3/min.$	2	11kW x 2	
		Static press. 100mmAq			
1-24	Bag filter	Filter area $310m^2$	1		
		Draw-down method Jet air type			
		Required flow rate 590N lit./min.			
		Required press. $5kg/cm^2$			
		Compressor	1	11kW	
		Screw conveyor dia.240mm	1	1.5kW	
1-25	Screw conveyor	Screw dia. 300mm	1	0.75kW	
		Screw length 3,000mm			
1-26	Exhaust Fun	Flow rate $610m^3/min.$	1	55kW	
		Static pressure 300mmAq			
1-27	Emergency Incinerator	Heat duty 2135.8 x 10^3kcal/h	1		

2. Rice straws drying, curing section

No.	Equipment name	Main specifications	Quantity	Motor	Remarks
2-1	Rice straw receiving hopper	Capacity $10m^3$	1		
		Steel plate			
		Vibrator	2	0.15kW x 2	

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
2-2	Belt feeder	Belt width	1,200mm	1	2.2kW	
		Belt length	4.0m			
		Belt speed	2.5m/min.			
		Handling volume	$30m^3$/min.			
2-3	Bucket elevator	Lift	22m	1	2.2kW	
		Bucket capacity	15.7lit.			
		Chain speed	15m/min.			
2-4	Belt conveyor	Belt width	400m			
		Actual length	7.0m			
		Lift	0m			
2-5	Material bin	Capacity	$50m^3$	3		For 8hrs
		Diameter	4.2m			
		Height	5.4m			
2-6	Controlled feeder	Belt feeder		3	1.5kW x 3	
		Belt width	750mm			
		Belt length	2,800mm			
2-7	Belt conveyor	Belt width	400mm	3	0.75kW x 3	
		Actual length	16.0m			
		Lift	4.0m			
2-8	Rice straw crusher	Pin mill		3	90kW x 3	
		Through put	2.0tons/h			
		Roter diameter	900mm			
		Revolution	2,000rpm			
2-9	Screw conveyor	Screw diameter	200mm	3	0.4kW x 3	
		Screw length	1,500m			
2-10	Belt conveyor	Belt width	400mm	1	0.75kW	
		Actual length	7.0m			
		Lift	0m			
2-11	Bucket elevator	Lift	24m	1	2.2kW	
		Bucket capacity	15.7lit.			
		Chain speed	15m/min.			
2-12	Rice straw silo	Capacity	$70m^3$	1		For 4hrs
		Diameter	4.7m			
		Height	9.3m			
2-13	Controlled feeder	Table feeder	Max. $40m^3$/h	1	5.5kW	
2-14	Bag filter	Filter area	$50m^2$	1		
		Draw-down method	Jet air type			
		Required flow rate	105N lit./min.			
		Required pressure	$5kg/cm^2$			
		Compressor		1	1.5kW	
		Screw conveyor	dia.240mm	1	0.75kW	
2-15	Exhaust fan	Flow rate	$100m^3$/min.	1	11kW	
		Static press.	300mmAq			

3. Slaked lime receiving section

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
3-1	Slaked lime silo	Capacity	150m^3	1		
		Dia.	6.0m			
		Height	9.3m			
3-2	Controlled feeder	Table feeder	Max. 3.6m^3/h	1	1.5kW	

4. Mixing, briquetting, trommeling section

No.	Equipment name	Main specifications		Qantity	Motor	Remarks
4-1	Feed conveyor	Belt length	400mm	1	1.5kW	
		Actual length	27.1m			
		Lift	4.7m			
4-2	Mixer	Paddle mixer		2	22kW x 2	2-stage
		Through put	3.7tons/h			
		Paddle dia.x length	450mm x 3,000mm			mixing
		Revolution	27rpm			6,000kg x 2
		Effective capacity	0.7m^3			=12,000kg
4-3	Cooler	Vibrating cooler		1	3.7kW	
		Heat load	136,000kcal/h			
		Traf size	W750mm x 4,000mm			
4-4	Blower	Flow rate	140m^3/min	1	5.5kW	
		Static press.	100mmAq			
4-5	Bag filter	Fiter area	120m2	1		
		Draw-down method	Jet air type			
		Required flow rate	236N lit./min.			
		Required press.	5kg/cm^2			
		Compressor		1	3.7kW	
		Rotary valve	dia.240mm	1	0.75kW	
4-6	Exhaust fun	Flow rate	25m^3/min.	1	22kW	
		Static press.	300mmAq			
4-7	Feed conveyor	Pot conveyor		1	5.5kW	
		Bucket capacity	8.5lit.			
		Chain speed	15m/min.			
		Horizontal length	6.0m			
		Lift	12.0m			
4-8	Intermediate bin	Capacity	65m^3	1		
		Steel plate	Width x length x height 3,000mm x 6,000mm x 7,000mm			
4-9	Feeder	Belt width	600mm	2	2.2kW x 2	
		Belt length	4.0m			
		Belt speed	3.0m/min.			
		Handling volume	8.0m^3/h			
4-10	Feed conveyor	Pot conveyor				
		Bucket capacity	8.5lit.			
		Chain speed	15m/min.			
		Horizontal length	8.5m			
		Lift	7.5m			

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
4-11	Briquetting machine	Briquetting machine		2	110kW x 2	
		Through put	5tons/h			
		Roll diameter	800mm			
		Roll width	165mm x 2			
		Revolution	10rpm			
		Briquette figure	Almond type			
		Briquette size	37mm x 21mm x 13mm			
		Screw feeder		4	7.5kW x 4	
		Oil pressure unit		2	3.7kW x 2	
		Belt conveyor		2	0.75kW x 2	
4-12	Briquette withdrawal conveyor	Belt width	400m	2	1.5kW x 2	
		Actual length	13.1m			
		Lift	3.3m			
4-13	Briquette wire trommel	Trommel		2	5.5kW x 2	
		Through put	5tons/h			
		Drum dia.	900mm			
		Drum length	1,200mm			
		Pitch	10mm			
4-14	Return conveyor -1	Belt width	400mm	2	0.75kW x 2	
		Actual length	17.7m			
		Lift	1.2m			
4-15	Return conveyor -2	Belt width	400mm	2	0.75kW x 2	
		Actual length	7.3m			
		Lift	2.2m			

5. Storage and loading section

No.	Equipment name	Main specifications		Quantity	Motor	Remarks
5-1	Product conveyor -1	Belt width	400mm	1	0.75kW	
		Actual length	9.0m			
		Lift	2.2m			
5-2	Product conveyor -2	Belt width	400mm	1	2.2kW	
		Actual length	54.9m			
		Lift	14.5m			
5-3	Product conveyor -4	Belt width	400mm	1	0.75kW	Reversible
		Actual length	9.4m			
		Lift	0m			
5-4	Product storage bin	Capacity	$100m^3$ x 3	1		
		Loading method	cut gate	3		

6. Auxiliary equipment

No.	Equipment name	Main specifications	Quantity	Motor	Remarks
6-1	Air compressor	Capacity 300lit./min.	1	7.5kW	Include air dryer, mist separator

7. Test apparatus

No.	Equipment name	Main specifications	Quantity	Motor	Remarks
7-1	Tablet tester		1		
	Electric balance	Max. 100kg	1		
	Unconfined compression tester		1		
	Portable gas analyzer kit for burning gas		1		
	Slide caliper		1		
	Miscellaneous		1		

Chapter 12 Plant Construction

Chapter 12 Plant Construction

12-1 Present Situations of Machine Industry and Construction Work

12-1-1 Machine Industry

The capability of the Thai industry has risen remarkably in recent years. Most large pieces of equipment required for the industrial activities are, however, still imported. The Thai machine industry is not fully capable of manufacturing large machines. The light machine industry operates mainly in Bangkok. Plants to manufacture machinery for oil refining and petrochemical plants have recently started on the outskirts of Bangkok.

Of these machine manufacturers, the manufacturers with experiences in the production of machines and equipment related with lignite briquettes were investigated.

12-1-2 Civil Engineering and Construction

Reflecting the recent rapid growth of economy, the construction industry of Thailand shows a growth rate of nearly 20 percent, exhibiting construction booms in various places.

In Bangkok and its suburbs, tall buildings like hotels, office buildings and apartment houses are constructed for the purpose of redevelopment; plants are constructed in industrial zones. This has resulted in a steep rise in construction cost and shortage of a number of construction materials and mechanical parts. This tendency is considered to persist for the next two or three years.

While the construction works are executed generally by local construction companies, foreign companies often participate in large-scale construction works, often jointly with local construction companies. The buildings are mostly designed by local design offices. The popular designs are of reinforced concrete with external walls finished with concrete blocks or bricks. Large construction machines such as large

cranes and concrete mixers are used on building sites in Bangkok. External scaffoldings and frame supports are made of steel. The capability for using modern methods is seen in action in Bangkok.

In Chiang Mai near the planned site for the plant, wooden scaffoldings and frame supports are used on most building sites. The construction precision is not high enough with them. Large construction machines are rarely seen. The construction companies there have not enough experience in construction of steel-frame buildings. The construction materials and equipment are transported mostly from Bangkok; they are relatively expensive. On the other hand, labor cost and other expenses are generally low.

12-2 Possibility of Local Procurement

12-2-1 Evaluation of Machine Manufacturers

The following machine manufacturers were visited by the study team:

Wongwaiwit Machine Tool Co., Ltd.
Weeliam (Thailand) Co., Ltd. and its group
S. W. Group of Companies
Visavakit Patana Corp., Ltd.
Unimit Engineering Co.
Thai Meidensha Co., Ltd.
Sino-Thai Engineering and Construction Co., Ltd.
UNIMIT Engineering Co., Ltd.
Sakol Plan Co., Ltd.
The International Engineering Co., Ltd.
KSS Construction Company Limited
USA Economic Development Co., Ltd.

Of these, the following three manufacturers have been selected as sources of procurement.

(1) Weeliam (Thailand) Co., Ltd. and its group

The profile of this company as of fiscal 1990 is as follows:

Capital, million bahts:	5
Established:	1948
Employees:	300
Sales, million bahts:	350
Location: 22/1 Petkasem 49 Bkk. 10160	
Factory floor area including store, m^2:	6,700
Administration Office, m^2:	200
Engineering & Drafting Department, m^2:	200
Yard area, m^2:	1,200

The company had supplied silos, hoppers, conveyers and other pieces of equipment to the coal washing plant of the Ban Pa Kha mine. Weeliam has a demonstrated capability in manufacturing machines related with lignite. Weeliam also manufactures lignite crushers and trommels. The coal washing plant has been in operation since February, 1991. The study team consider Weeliam capable of manufacturing such kinds of machines on the ground of their past performance, the facilities they have, and the results of inspections by the study team of their factory. However, like other Thai manufacturers, the company is disproportionately weak in design capability compared with its manufacturing capability. Therefore, it is necessary to provide them with design drawings.

Weeliam Co. has the following machinery and equipment:

Equipment

1.	Forming & Cutting	Unit
	500 Tons Hydraulics Press	2
	250 Tons Hydraulics Press	1
	50 Tons Hydraulics Press	2
	50 Tons Eccentric Punch	2
	100 Tons Peddinghaus Shearing Punching & Notching	1
	Plate Rolling M/c Thk. 30 mm. max. x 3000 mm	1
	Plate Rolling M/c Thk. 20 mm. max. x 2400 mm	1
	Plate Rolling M/c Thk. 10 mm. max. x 1200 mm	1
	Hi-Cut Fibre	2

	EXSELE Circular saw max. cutting dia. 160 mm	1
	Automatic Roller assembly unit	3
2.	Welding & Cutting Torch	
	500 A MIG Welding M/c	3
	TIG Welding M/c	1
	Plasma Welding M/c	1
	800 A Welding M/c	1
	600 A Welding M/c	1
	500 A Welding M/c	8
	300 A Welding M/c	40
	Oxy-Set	30
3.	Machine Shop	
	7.00 M.Working Length 1.8 M.Dia. Lathe	1
	12-16 Ft. Lathe	7
	5-10 Ft. Lathe	13
	3-Ft. Turret Lathe	2
	27-In. Shaper	4
	5-Ft. Horizontal Planer	1
	10-Ft. Horizontal Planer	1
	3-Ft. Horizontal Boring M/c	3
	TMC Horizontal Boring M/c	1
	(Max. working length of 5.6 M.long x 2.5 M.high x 4.5 M.wide	
	Max. allowable work piece wt.of 500 tons)	
	3-Ft. Vertical boring M/c	1
	5-Ft. Radial Drilling M/c	1
	3-Ft. Radial Drilling M/c	3
	1000 mm. Dia. Vertical Slotter	1
	1000 mm. Dia. Vertical Turning	1
	8-Ft. Table Milling M/c	1
4.	Lifting Equipment	
	30-Tons Elec. Overhead Traveling Crane	1
	10-Tons Elec. Overhead Traveling Crane	3
	8-Tons Elec. Overhead Traveling Crane	1
	5-Tons Elec. Overhead Traveling Crane	16

5.	Mobile Crane	
	20-Tons Mobile Crane	1
	28-Tons Mobile Crane	1
	35-Tons Mobile Crane	1
6.	Miscellaneous	
	Sand Blasting M/c	1
	Mobile Air compressor	1
	Woven Wire Making M/c	2
	Expanded Metal Making M/c	1

(2) Visavakit Patana Corp., Ltd.

The outline of this company as of fiscal 1990 is as follows:

Capital, Bahts:	400,000
Established:	1979
Employees:	300
Sales, million bahts:	130
Location: H.D. 215/148-149 Pracharad Ird Bangkok 10800	
The total area of the factory, m^2:	8,800

The production capacity of the factory is 200 tons per month. The company is also capable of installing machines and tools. The company conducts the following services:

(1) Engineering work
Based on the master drawings supplied by the clients, the company develops manufacturing and processing drawings.

(2) Fabrication work
The fabrication work includes the following:
- Storage tank
- Piping works
- Pressure vessel
- Steel structure
- Process equipment

Material handling equipment
Duct works
Steel plate fabrication
Water & waste water treating equipment
Boiler

(3) Construction work

The construction work includes the following:

Civil work
Erection work
Installation work

Visavakit Patana Corp., Ltd. has the following machinery and equipment:

		Unit
1.	Crane & Hoist	
	Truck Crane "Tadano TL. 1500" 15 Ton-capacity	2
	Overhead Crane 10 ton-capacity	3
	Overhead Crane 5 ton-capacity	4
	Overhead Crane 2 ton-capacity	2
	Winch 2 ton-capacity	5
	Chain Hoist 10 ton-capacity	2
	Chain Hoist 3 ton-capacity	3
	Chain Hoist 1 1/2 ton-capacity	4
	Lever Block 1 1/2, 3 ton-capacity	15
	Rail Road Jack 20 ton-capacity	7
2.	Hydraulic Press	
	Hydraulic Press Brake 450 ton-capacity	1
	Vertical Hydraulic Press 400 ton-capacity	1
	Hydraulic Jack 60 ton-capacity	4
	Hydraulic Jack 50 ton-capacity	8
	Hydraulic Jack 10 ton-capacity	12
	Hydraulic Jack 15 ton-capacity	8
3.	Welding Machine	
	Automatic Submerged Arc Welding Machine 650 A	5
	MIG Welding Machine 650 A AC/DC	5

	TIG Welding Set 300 A AC/DC	1
	Welding Transformer 300 A-AC	78
	Welding Transformer 400 A-AC	17
	Welding Transformer 500 A-AC	35
	Generator 250 A-AC/DC	4
4.	Cutting & Punching Equipment	
	Sheet Metal Cutting & Forming Machine	3
	Power Punching Machine 45 tons	1
	Portable Hydraulic Puncher 45 ton capacity	4
	Automatic Gas Cutting Machine	11
	Electric Fiber Cutting Machine dia.16"	2
	Power Hack-saw	3
	Flanging Machine 16 mm. thickness x 9,000 m. diameter	1
	Hydraulic Guillotine Shearing Machine 3,100 x 13 mm	1
5.	Bending & Rolling Machine	
	3-Roller Plate Bending Machine 8' x 7/8" Capacity	1
	3-Roller Plate Bending Machine 5' x 1/8" Capacity	1
	3-Roller Plate Bending Machine 10' x 1 1/2" Capacity	1
6.	Air Compressor	
	150 CFM x 115 psi	4
7.	Lathe	
	Dia.60" x 15' length	1
	Dia.24" x 6' length	1
8.	Treading Machine	
	Pipe Dia.1/8"-dia.3"	1
9.	Drilling Machine	
	Electro-pneumatic Hammer Drill dia.1/4" - dia.1 1/4"	4
	Electric press Drilling Machine dia.1/8" - dia.1/4"	6
	Magnetic Press Drill dia.1/8" - 1 1/4"	12
	Radrail Drill dia.2"	1

10.	Water Pump	
	Submersible Pump dia.2"	8
11.	Testing Equipment	
	Hydrostatic Testing Pump 75 kg/cm²	1
	Hydrostatic Testing Pump 25 kg/cm²	1
	Vacuum Testing Equipment	2
12.	Manual Equipment	
	Grinding Machine dia.7"	96
	Grinding Machine dia.4"	115
	Gas Cutting Torch	188
	Electric handy Drill dia.1/8" - 1/4"	24
	Sand Disc Machine dia.7"	
13.	Surveying Equipment	
	Automatic Level accuracy ±1: 500,000	2
	Digital Theodolite accuracy 20 second	3
	Automatic Universal Theodolite Wild T2	2

(3) Unimit Engineering Co.

The outline of this company as of fiscal 1990 is as follows:

Established:	1989
Employees:	161
Location:	109/92-95 M0018 501 Suksawat 66. Suksawat Road

The line of the products is essentially the same as that of Visavakit Patana Corp., Ltd. Unimit Engineering is now very busy manufacturing machinery much in demand now for oil refining and petrochemical plants.

The factory has a production capacity of 200 tons per month.

12-2-2 Imported Equipment Versus Domestic Equipment

The possibility of manufacturing in Thailand the machinery and steel

frame for the planned plant is discussed below.

As shown in Table 12-1, some of the machinery, tools and materials for the planned plant will be imported but others will be domestically manufactured for the reasons explained below.

(1) Imported Machinery

The equipment in this category falls into the following two classes.

(1) Equipment the production of which requires a very advanced technology for design and manufacturing owned only by certain companies.

(2) Equipment which cannot be manufactured by Thai makers, because of the designs incorporating proprietary know-how not to be disclosed to the Thai manufacturers.

The briquetting machine and desmoker with furnace fall into the former category.

1) Briquetting Machine

It is not appropriate to plan to manufacture locally the briquetting machine for the following reasons:

(1) The briquetting machine requires advanced processing and assembly technologies.

- A very high precision is necessary for matching certain parts of the roll tires and roll shafts.

- An advanced technology for surface treatment is used for processing, hardening and polishing of pockets of roll tires.

- The manufacture of the reduction gears used for the briquetting machine is limited to a few speciality manufacturers.
- Assembling adjustment of roll tires and roll shafts requires

skills owned only by the present manufacturers.

(2) Materials and parts are difficult to obtain.

- It would be difficult to procure special steel alloys for roll tires and roll shafts.

- It is difficult to procure large-sized bearings in Thailand.

- Hydraulic machinery for high pressure is difficult to procure.

- It is difficult to procure necessary instruments used in the control system adopted.

(3) It is difficult to design machinery and electric-related equipment.

- As manufacturers have their own know-how, the design drawings are not disclosed.

- It is difficult to design and produce automatic control-related equipment.

2) Desmoker with furnace

The process design, equipment design, design of temperature control system and manufacture of equipment all require experience.

3) Other Equipment

As manufacturers have their own know-how about the following equipment; the design drawings will not be disclosed.

Feed conveyer
Controlled feeder
Bag filter
Exhaust fan
Rice straw crusher
Mixer

Cooler
Bucket elevator
Chain conveyer

(2) Domestic Equipment

It is possible to manufacture in Thailand the machinery and tools other than those mentioned above and also to process steel frames, with the supply of the detail drawings to Thai makers.

The detail design drawings must be supplied for the following reasons:

None of the companies investigated except Sino-Thai Engineering and Construction Co., Ltd. has a particular division or a team of engineers to produce master drawings, or detail drawings, for detail designs. The managements of these companies interviewed show little interest in positively training engineers of this kind or undertaking the designs. On the basis of the supplied master drawings, they draw up material processing drawings but not detail drawings.

Sino-Thai Engineering and Construction Co., Ltd. is not interested in a small-scale project of this kind.

It is necessary to supply manufacturers with the detail drawings to enable them to manufacture machinery and tools or to process steel frames.

12-2-3 Civil Engineering and Construction Works

The following two companies for civil engineering and construction works were visited to obtain information on the civil engineering and construction works in Thailand.

Arun Chai Serof Consulting
Sino-Thai Engineering and Construction

In addition, the Engineering Division of NEA provided information. The capabilities of Thai companies in these fields may be summarized as follows.

(1) Engineering

The civil engineering and construction works in Thailand are mostly designed by domestic engineering companies. They are generally capable enough in this field. Major construction companies also have engineering divisions. Therefore, the designs for the civil engineering and construction works for this project could be entrusted to local engineering companies.

(2) Execution of Construction

There are many construction companies, small and large, with sufficient technical capability. The civil engineering and construction works represent only a small fraction of this project, requiring only plain technology. Accordingly, local constructors are capable enough for these works.

12-2-4 Engagement of Local Companies

Based on the result of the survey, the following basic principle is established as to the engagement of the Thai companies.

(1) Basic and Detail Designs

There is no lignite briquette plant using a high-pressure molding process in Thailand. Thai manufacturers have no experience in design or production of equipment for lignite briquette plants. There is no Thai company that could provide the basic design for this project. As was explained previously, there is not enough design capability in Thai machine manufacturers because of their engineers not given enough opportunities to have their design capabilities developed. The basic design as well as detail designs, therefore, should be supplies from abroad.

(2) Production Capacity of Machinery

It is possible to produce in Thailand such general-purpose machinery and equipment as silo, hopper, conveyer, lignite crusher, trommel and primary rice straws crusher on condition that the detail design drawings are supplied. The fabrication of steel structure is also possible in Thailand, if the detail design drawings are supplied.

(3) Local Construction Capacity

Local companies are capable of assembling and installing machinery and steel structures. Local companies could also design and execute civil engineering and construction works.

(4) Transportation of Materials

Local companies will be used.

The basic principals of above (2),(3) and (4) are based on the actual performances of the local companies surveyed.

12-3 Procurement of Construction Materials

12-3-1 Plant Machinery

The result of the field survey indicates that certain pieces of machinery could be locally procured. However, as the pilot plant is a small plant and it does not make a significant difference in cost whether certain pieces of machinery are procured locally or they are procured entirely form abroad. Therefore, it is recommended that the pilot plant consist of all imported machines.

The commercial plant will be an optimum combination of the machines domestically and internationally procured. Table 12-1 shows the combination of machinery and equipment to be domestically procured and imported.

Table 12-1 Imported Versus Domestic Equipment

Imported	Locally supplied
Briquetting machine	Lignite receiving hopper
Feed conveyer	Belt feeder
Bucket elevator	Raw lignite silo
Controlled feeder	Belt conveyer
Chain conveyer	Screw conveyer
Bag filter	Lignite crusher
Exhaust fan	Lignite silo
Rice straws crusher	Rice straw receiving hopper
Mixer	Material bin
Desmoker with Furnace	Intermediate hopper
Cooler	Screw feeder
	Three distributor
	Rice straw silo
	Slaked lime silo
	Raw material feeder
	Briquette withdrawal conveyer
	Briquette wire trommel
	Return conveyer
	Product conveyer
	Product storage silo
	Incinerator

12-3-2 Civil and Construction Materials

Civil and construction materials of any kinds, except for speciality products, are available in Thailand. This project will use only small quantities of ordinary civil and construction materials of limited kinds all available in Thailand. The conditions for procurement of main construction materials are explained below.

(1) Cement

The domestic production and marketing systems are well organized. The quality of cement is generally good.

(2) Ready mixed cement

The supply system is well established in Bangkok and its surroundings. A number of concrete mixers are seen running there. In other areas, ready mixed concrete is not generally available. There, stationary concrete mixers are placed on the construction sites.

(3) Steel materials

More than 80 percent of iron and steel materials are imported. Though no difficulty in the procurement of steel bars is anticipated, some iron and steel products are in short supply. Thick steel plates are all imported.

(4) Wood products

Structural and finishing materials are procurable domestically. A variety of laminated sheets are also produced in Thailand. Their prices have been rising since lumbering was restricted.

(5) Blocks/bricks

These products are in general use. Products of good quality are available.

(6) Asbestos products

The products of good quality are generally used and available.

(7) Doors and windows

Steel doors and windows are domestically produced and also imported mainly from Asian countries. Wooden fittings are domestically produced.

(8) Piping materials

Steel, P.V.C. and asbestos-cement, other pipes of good quality are domestically produced.

(9) Electric wiring materials

Ordinary domestic products are available.

(10) Lighting apparatus

Ordinary domestic products are available. Many imported products are also on the market.

(11) Sanitary equipment

They are domestically produced and easily procurable.

(12) Kitchen equipment
Ready-made products other than sinks are not generally used.

(13) Air conditioning equipment
Imported products are on the market.

(14) Communication equipment
Some are domestically produced, but imported products are in general use.

(15) Fire-fighting facilities
ibid.

12-4 Laws and Rules Governing Design and Construction

12-4-1 Construction Work

The design and construction works related to this project are regulated by the following laws and rules.

(1) Design Standards
The control of the Construction of Building Act, 1979
Notification of the Ministry of Interior
City and Town Planning Act, 1975
Reconstruction of the Fire Area Control Act, 1933
Risk Act, 1953

(2) Construction Engineer
Act of the Architectural Profession, 1965
Act of the Engineering Profession, 1962

(3) Constructor
Construction Profession Act, 1979

(4) Safety Standards
1) Construction work
Construction Safety Regulations

2) Electric work
Provincial Electricity Authority Act. BE.2503
Thai standard for Electrical Safety, 1982

12-4-2 Material Standard

The industrial products are standardized on the basis of the Thai Industrial Standards legislated by the Thai Industrial Standard Bureau.

These standards generally conform to those of the American Society for Testing and Materials, ASTM. However, the materials conforming to the British Standards, BS, or the Japan Industrial Standards, JIS, can be used on approvals by the architects or the registered engineers qualified by the Act of the Architectural Profession or the Act of the Engineering Profession.

12-4-3 Application Procedure for Building Permit

Application for building permits shall be filed with the Provincial Civil Work Office by the above-mentioned architects or registered engineers.

The construction of buildings constituting a part of a manufacturing plant requires an approval by the Provincial Industry Office. Other registrations are as follows:

(1) Connection with highways:
the Department of Highway

(2) Discharge to irrigation canals:
the Department of Irrigation

(3) Electric power supply:
the provincial Electricity Authority

12-5 Implementation and Type of Construction Contract

12-5-1 Method for Execution of the Project

A project owner for the execution of the project will be established for this project. The project will be executed in the following sequence:

(1) Establishment of the entity, project owner
(2) Selection of the consultant, preparation of tender document, execution of tender
(3) Selection of the process licenser and execution of basic design
(4) Selection of the contractor
(5) Detail design
(6) Procurement of machinery, equipment and materials
(7) Construction and installation
(8) Completion and test operation

Figure 12-1 Shows the recommended organization for the execution of the plant construction.

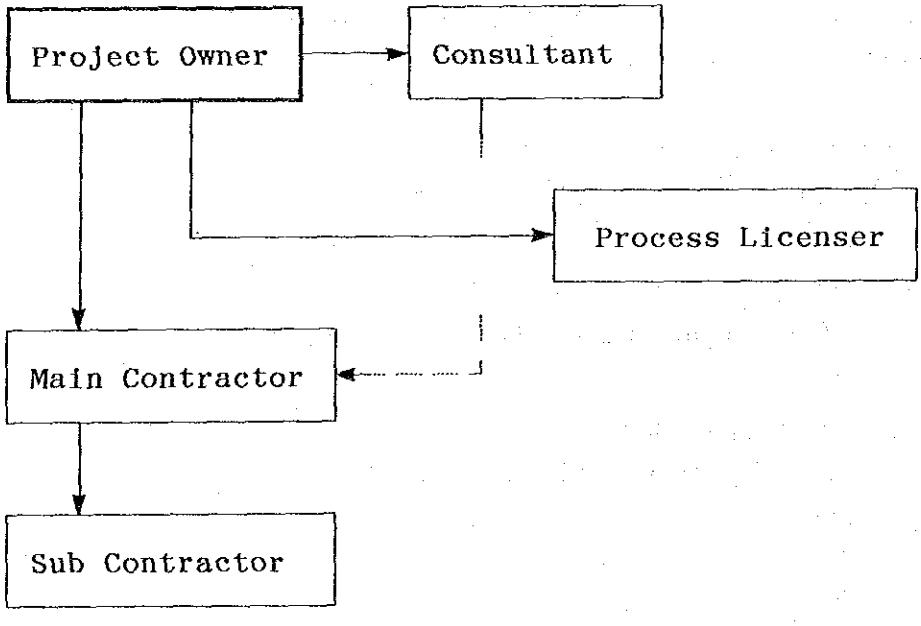


Figure 12-1 Organization for Plant Construction

Note: Roles

Roles of Consultant

(1) Preparation of Instruction to Bidder

(2) Evaluation of tenders

(3) Construction management

Roles of Process Licenser

(1) Basic design

(2) Startup operation

(3) Supervision of the operation

Roles of the Main Contractor

(1) Management of construction

(2) Procurement

(3) Construction work at site

(4) Transportation

(5) Startup

Roles of sub-contractors

(1) Civil and building work

(2) Installation and erection work

(3) Fabrication work

12-5-2 Contract for Construction

The contracts for project execution may be broadly broken down into lump-sum contracts and cost-plus-fee contracts, according to the payment of the contract fee. The execution of this project would require coordinating a variety of fields of work: design, procurement of machinery and materials, installation of machinery, civil engineering and construction works, transportation, test operation. A lump-sum contract covering the entire scope of these works would be expected to be far more efficient for this project and is therefore recommended.

The above recommendation is based upon the following advantages of the lump-sum contract and disadvantages of the cost-plus-fee contract.

The advantages of lump-sum contracts are as follows:

(1) As the entire project could be grasped in a clearer perspective in advance, it easier for the contractor to plan the overall execution of construction and also easier for the owner to make more accurate estimate of the cost.

(2) The owner is assured of the entire project execution at a lump-sum fixed price.

(3) It is possible to hold one single contractor responsible for the execution of the entire scope of the construction work.

(4) A public competitive tender is possible.

(5) The evaluation of tenders is easier.

(6) Once the contract is sealed, the owners would not be bothered with tedious details until the completion of the project.

Disadvantages of the cost-plus-fee contract are as follows:

(1) It is more difficult for the owner to estimate the total cost.

(2) The owner has to examine and approve every man-power consumption and expense submitted by the contractor. The owner has to assign to this job a staff capable of evaluating these and discussing them with the contractor. This could be an additional burden on the part of the owner.

(3) The tender is not at a fixed price is more difficult to evaluate.

(4) There is no incentive on the part of the contractor to complete the construction sooner and economically. The execution schedule tends not to be punctual.

12-5-3 Organization for Execution of the project

(1) Project Owner

The project owner will be either NEA itself or a public corporation established under NEA for the following reasons:

(1) NEA is responsible for the development of this kind of substitute energy.

(2) A state organizations is in a better position to preserve and develop technology than private enterprises in the case of Thailand.

(2) Consultant

The consultant is selected by the project owner. The consultant will on behalf of the project owner draw up tender documents necessary to select a contractor and invite tenders. The consultant then evaluates the tenders presented by bidders and selects the right one. In addition, the consultant will assist the project owner in negotiations with the bidder and in sealing the contract with them.

The consultant will also overview the construction on behalf of the project owner. This job includes approval of drawings presented by the contractor, consultation before starting construction work, approval of materials and mechanical equipment, inspection of machinery upon installation, inspection of the civil engineering and construction works, and supervision of test operation and completion.

Consultants need to meet the following qualifications:

(1) Knowledge and experience in lignite briquette production

(2) Knowledge and experience in project execution on affairs including quality control, management of budget and schedule, and methods to execute projects.

(3) Business experience in Thailand.

(3) Process Licenser

The project owner shall employ a process licenser capable of process guarantee. The process licenser will supervise test operation and initial normal operations.

(4) Contractor

1) Detail design

The contractor develops specifications for procurement of equipment and detailed design drawings based on the basic design. In the case machines are procured from Thai makers, the detail design drawings must be given to the makers by the main contractor.

2) Procurement

The machinery and equipment are procured domestically as well as abroad. The contractor must be capable of satisfactorily accomplishing domestic and international procurement.

3) Construction

The contractor will most likely subcontract the civil, building and installation works to local companies. The main contractor manages the construction budget, construction schedule, quality control; the subcontractors familiar with local conditions are employed for actual shop fabrication and field construction works.

4) Qualifications for Main Contractor

(1) To be capable of and to have experience in overall execution ranging from detail design, machinery and material procurement, transportation and construction on the basis of the basic design provided by the process licenser. Experience and proficiency in small-scale project is desirable.

(2) To have business experience in Thailand or countries in similar

conditions.

(3) To be capable of efficiently executing a project involving importation of equipment and machinery from abroad. The pilot plant project will import production equipment and machinery.

12-6 Construction Schedule

The overall schedule includes, among others, the basic design by the process licenser, preparation of the tender documents by the consultant, invitation of the tenders and selection of the contractor. Figure 12-2 shows the construction schedule from the contact with the contractor, or the beginning of construction work, to the completion of the test operation.

Major works after the selection of the contractor are estimated to require the following periods:

	month
Detail design	3
Field survey	1
Inquiry to makers	1
Production of machinery and equipment	8
Marine transportation/customs clearance/ local transportation	2
Field installations, electric construction works	4
Civil works and building construction	6
Test operation	1

As the above works will be partly overlapping with each other, the whole construction is estimated to take 18 months up to the transfer of the plant to the owner after the test operation.

The project owner will employ the process licenser for basic design which will take 2 months before inviting tenders to select contractor.

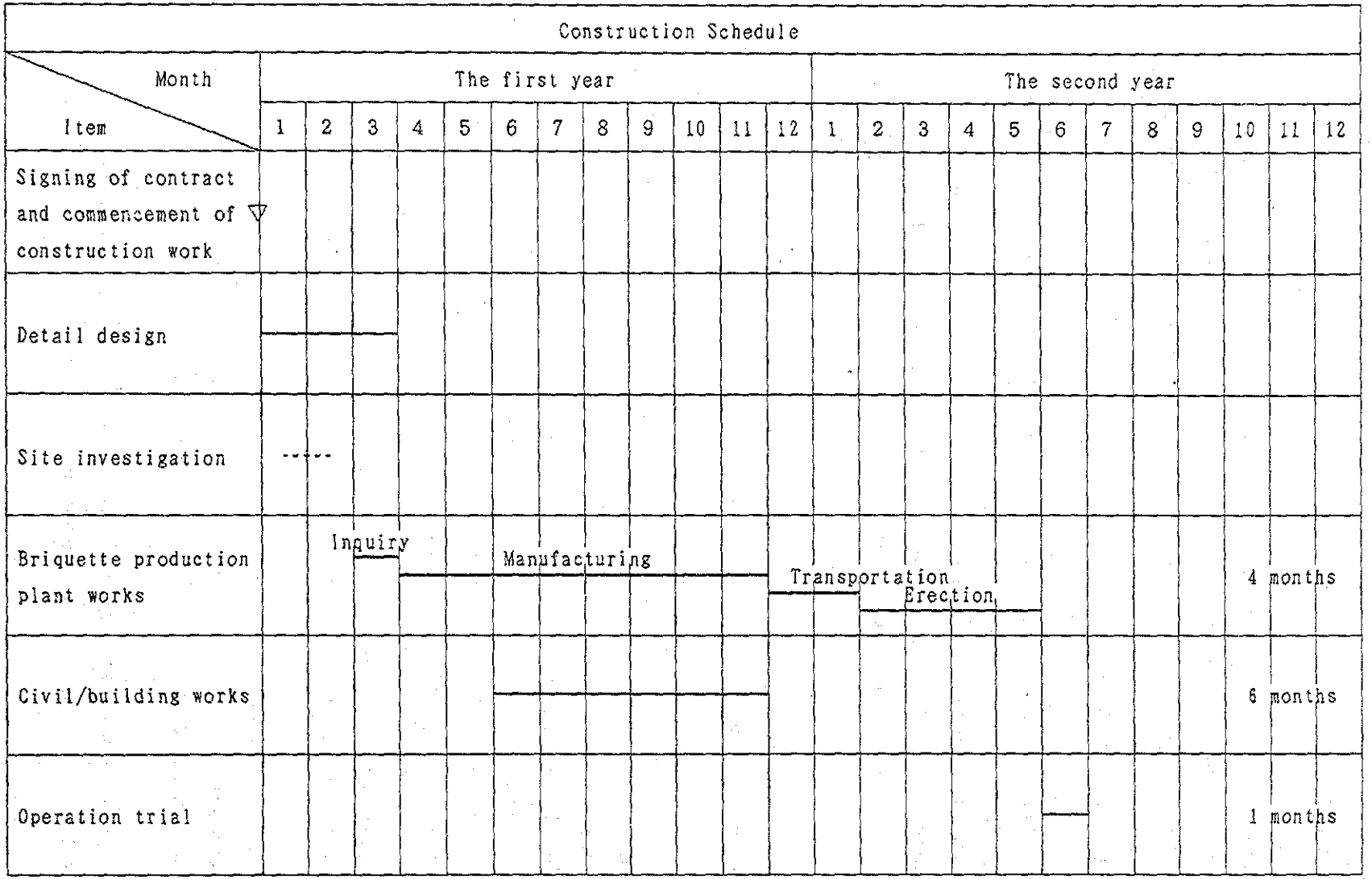


Figure 12-2 Construction Schedule

12-7 Unit Cost of Construction and Estimate of Construction Cost

12-7-1 Unit Cost

Unit costs for major construction works are shown in Table 12-2.

12-7-2 Estimation for Construction Cost

The costs of the pilot plant and the commercial plant are estimated as shown in Table 12-3 (1) and Table 12-3 (2), respectively.

(1) Basis of Prices

The estimation of the construction costs is based on the prices of 1990.

(2) Machinery and Equipment

Breakdown for the third item "Machinery and equipment" in Table 12-3 (1), is shown below.

(Unit: 1,000 yen)

		FOB Cost Machinery	Transportation	Sub total
(1)	Lignite, drying and crushing section	67,659	2,146	69,805
(2)	Rice straw, crushing section	11,013	437	11,450
(3)	Slaked lime receiving section	1,416	45	1,461
(4)	Mixing briquetting, trommeling section	39,998	969	40,967
(5)	Storage and loading section	6,125	994	7,119
(6)	Auxiliary equipment	590	24	614
(7)	Test apparatus	4,916	200	5,116
	sub total	131,717	4,815	136,532

Table 12-2 Unit Price List for Construction Material (1)

Unit : Bahts

No.	Item	Description	Unit	Unit Price	Remark
1.	Ready Mixed Concrete	180kg	m^3	1,180	
		210kg	m^3	1,220	
		240kg	m^3	1,260	
2.	Concrete Block				
	Concrete Block	19x39x7cm	No.	3.75	
		19x39x9cm	No.	5.50	
	C-PAC Block	19x39x9cm	No.	5.50	(No.C4-11) 10.3kg/unit
		19x39x9cm	No.	8.50	(No.C8-1) 16.7kg/unit
	D.A. Block	19x39x9cm	No.	11	(No.DA-109) Water Proof type
3.	Brick				
	Building Brick	7x16x3.5cm		650	
	Cholburi Brick	7x16x3cm			
	C.M. Hollow Brick	14.5x29x8cm	No.	4.95	(No.10B 5)
	Fire brick	11.5x23x7.6cm	No.	20.80	(No.ST-76, SK-30)
4.	Precast Concrete Pile				
	Hollow Hexagonal Section (KTC)	15x15cmx5m	No.	250	
	Square Section	0.23x0.13x6.00m	No.	530	
		0.40x0.40x21.00m	No.	14,334	
		0.40x0.40x25.00m	No.	17,950	
	I-shape Section	0.13x0.13x6.00m	No.	432	
		0.35x0.35x24.00m	No.	10,695	
		0.40x0.40x21.00m	No.	11,130	
	Hollow Round Pile	Dia.=0.25x21.00m	No.	5,040	
		Dia.=0.60x21.00m	No.	25,269	
		Dia.=0.80x21.00m	No.	-	
5.	Fence Post				
	Precast concrete	3"x3" Length 2.50m	No.	105	
		4"x4" Length 3.00m	No.	130	

Table 12-2 Unit Price List for Construction Material (2)

Unit : Bahts

No.	Item	Description	Unit	Unit Price	Remark
6.	Structural Steel				
	Angle	3x40mm	No.	145	
		4x40mm	No.	158	
		4x50mm	No.	253	
		10x90mm	No.	1,065	
		10x100mm	No.	1,217	
	Channel Steel	75x45mm	No.	593	
		100x50mm	No.	750	
	Light Channel Steel	44x38x1.6mm	No.	133	
		80x40x2.0mm	No.	210	
	C-Shape (Light Lip Channel Steel)	100x50x2.3mm	No.	330	
		150x50x3.2mm	No.	647	
	Round Bar	6mm	ton	13,500	
		9mm	ton	12,876	
		12mm	ton	12,234	
		15mm	ton	11,934	
		19mm	ton	11,934	
		25mm	ton	11,934	
	Deformed Bar SD.30	10mm	ton		
		12mm	ton	12,367	
		16mm	ton	12,167	
		20mm	ton	12,167	
		25mm	ton	12,167	
	Defoemed Bar SD.40	10mm	ton		
		12mm	ton	12,600	
		16mm	ton	12,434	
		20mm	No.	12.434	
		25mm	No.	12,434	
		28mm	No.	12,434	
7.	Wood	(1"/2x2")x2-4m	Cu.Feet	220	Finish surface
		(1"/2x6")x2-4m	Cu.Feet	247	Finish surface
		(1"x1")x4m	Cu.Feet	210	
		(5"x5")x6m	Cu.Feet	258	Chemical Add

Table 12-2 Unit Price List for Construction Material (3)

Unit : Bahts

No.	Item	Description	Unit	Unit Price	Remark
	Hard Wood	(1/2"x2")x2-4m	Cu.Feet	420	
		(2"x6")x3-6m	Cu.Feet	470	
	Teak	1/2"x1"x3	Cu.Feet	474	Class 2
		1/2"x3"x6.5	Cu.Feet	742	
		3/4"x2"x3	Cu.Feet	634	
		3/4"x4"x6.5	Cu.Feet	798	
		1"x1"x5	Cu.Feet	509	
		1"x2"x5	Cu.Feet	637	
		2"x8"x6.5	Cu.Feet	968	
		2"x10"x6	Cu.Feet	1,092	
8.	Asbasto Cement Pipe (Length 4m)	Dia.=10cm	No.	120	
		Dia.=15cm	No.	205	
		Dia.=20cm	No.	310	
	Asbasto Cement Pipe Elbow	Dia.=10cm	No.	12	
		Dia.=15cm	No.	21	
		Dia.=20cm	No.	32	
9.	Concrete Pipe	Dia.=0.30m	No.	185	Class 3, Lengh 1m
		Dia.=0.40m	No.	245	
		Dia.=0.50m	No.	300	
		Dia.=0.30m	No.	255	Class 2
		Dia.=0.40m	No.	300	
		Dia.=0.50m	NO.	350	
10.	Sewage Pipe	Dia.=1.00x2.50m	No.	4,515	
11.	Light Gauge Steel Pipe Hollow Square Section	1/2"x1/2"x0.45mm	No.	39	
		3/4"x3/4"/0.9mm	No.	68	
		1"x1"x1.0mm	No.	90	
	Steel Pipe (Length 6.00m)	Dia.=1/2" t=1.2	No.	35	
		Dia.=3/4" t=1.2	No.	48	
		Dia.=1" t=1.6	No.	78	

Table 12-2 Unit Price List for Construction Material (4)

Unit : Bahts

No.	Item	Description	Unit	Unit Price	Remark
12.	Galvanized Steel Pipe (Length 6.00m)				
		1/2"	No.	175	
		3/4"	No.	226	
		3"	No.	1,123	
		4"	No.	1,635	
	Alminium Pipe (Length 6.00m)	Dia.=1" t=1.4	No.	155	
		Dia.=1/2" t=0.7	No.	55	
		Dia.=3/4" t=0.7	No.	85	
13.	PVC Pipe D-Plast	1 1/2"	No.	80	For water supply
		2"	No.	120	
		3"	No.	265	
		4"	No.	425	
14.	Thai Pipe	1 1/4"	No.	66	For water supply
		1 1/2"	No.	80	
		3"	No.	265	
		4"	No.	425	
15.	Asbestos Cement Pipe	Dia.=100mm L=4.0mm	No.	280	For water supply Class 15
		Dia.=150mm L=5.0mm	No.	556	
		Dia.=200mm L=5.0mm	No.	963	
16.	Chain Link Mesh Parallel	1 1/2"	m^2	79.50	
		2"	m^2	60	
		1 1/2"	m^2	90	
		2"	m^2	67.75	
17.	Square Type Parallel	1 1/2"	m^2	77	
		2"	m^2	62.50	
		1 1/2"	m^2	91	
		2"	m^2	73	

Table 12-2 Unit Price List for Construction Material (5)

Unit : Bahts

No.	Item	Description	Unit	Unit Price	Remark
18.	Welded Square Type				
	Parallel	13mm (1/2")	m	33	
		19mm (3/4")	m	30	
		25mm (1")	m	30	
		31mm (1 1/4")	m	28	
19.	Mosquete Mesh				
	Aluminium	90cmx30.48m	roll	1,920	
20.	Zinc Coating Steel Mesh	No.15 L=72m		21.25	
21.	Fiber Glass				
	Microfiber Standard type		roll	1,800	
	Aluminium Foil		roll	2,110	
22.	Poly Form 1" type		sheet	32.50	
	2" type		sheet	64.50	
23.	Alminium Foil	1.25x60.00m	roll	1,400	
		1.25x60.00m	roll	2,500	
24.	Asbestos Cement Sheet				
	Large	102x120cm	sheet	108	cement color
		102x150cm	sheet	137	
	Small	54x120cm	sheet	32	
		54x120cm	sheet	42	
25.	Asbestos Cement Boad	4mm	sheet	118	
		6mm	sheet	171	
		8mm	sheet	221	
26.	Galvanized Steel Sheet	0.20mm	sheet	98	
		0.25mm	sheet	106	
		0.30mm	sheet	130	
		0.35mm	sheet	152	
		0.45mm	sheet	-	

Table 12-2 Unit Price List for Construction Material (6)

Unit : Bahts

No.	Item	Description	Unit	Unit Price	Remark
27.	Stainless Steel	2mm	sheet	3,150	
		3mm	sheet	4,700	
		4.5mm	sheet	7,035	
28.	Plywood				
	Interia Y/Y	4mm	sheet	181	
		6mm	sheet	264	
		10mm	sheet	429	
		15mm	sheet	638	
		20mm	sheet	828	
29.	Exteria Class A	4mm	sheet	237	
		6mm	sheet	386	
		10mm	sheet	553	
		15mm	sheet	781	
		20mm	sheet	981	
30.	Hard Board				
	Standard type	3mm	sheet	73	
		4mm	sheet	94	
		5mm	sheet	115	
		6mm	sheet	140	
31.	Acoustic Board	60x60cm	sheet	38	
		60x120cm	sheet	70	
		60x224cm	sheet	125	
32.	Chip Board Y/Y type	12mm	sheet	310	
		15mm	sheet	395	
33.	Plastic Boad	2mm	sheet	690	
		3mm	sheet	1,100	
		6mm	sheet	2,230	

Table 12-2 Unit Price List for Construction Material (7)

Unit : Bahts

No.	Item	Description	Unit	Unit Price	Remark
34.	Laminated Plastic Board				
	Formica (Italy)	1.0mm	sheet	550	White
	(Thai)	0.8mm	sheet	460	
	(Thai)	0.8mm	sheet	320	White
35.	Glass				
	Clear Sheet	3mm 36"x60"		13	not including installation cost
		5mm 36"x60"		28	
		6mm 30"x60"		31	
	Texture	5mm 36"x76"		24	
	Graylite	5mm 48"x84"		37	
36.	Celo Creete	1/2 inch	sheet	155	
		1 inch	sheet	195	
		2 inch	sheet	314	
37.	Stone				
	Marble				
	Pink	30x30x2cm	m^2	1,050	
	Pigeon gray	30x30x2cm	m^2	850	
	White gray	30x30x2cm	m^2	1,050	
	Granite				
	Yellow, Brown	30x30x2cm	m^2	2,300	
	Pink	30x30x2cm	m^2	2,300	
38.	Wall Paper				
	Vinyl type	$5m^2$/roll	roll	300	
39.	Gloss Paint				
	Sigma	1 gallon		350	
	ICI	1 gallon		560	
	Fun Brand	5 gallon		320	
	Pan mastic	1 gallon		580	
	Emulsion Paint				
	Sigma	1 gallon		235	Sigmawall Interia
		5 gallon		360	Sigmawall Exteria

Table 12-2 Unit Price List for Construction Material (8)

Unit : Bahts

No.	Item	Description	Unit	Unit Price	Remark
	Fun Brand	1 gallon		150	Interia
		5 gallon		780	Exteria
	Anti-Rust Paint				
	Rust Oleum		gallon	760	
	Sigma		gallon	290	
40.	Steel Door and Window				
	Steel door with blind			8,100	
	Double steel window	60x60cm		1,340	
		98x120cm		3,750	
41.	Alminium Door and Window				
	Alminium window	60x60cm		1,600	
	Double Alminium Window	98x120cm		4,750	
	Aliding Almi. Window	120x200cm		3,350	
	Alminium Lowvers	4.5 inch 6 Louvers		290	
42.	Wood Door and Window				
	Wood Door Y/Y	80x200cm	sheet	480	Interia
	S/S	80x200cm	sheet	675	Interia
	Teak door	80x200cm		1,675	
	Hard wood door	80x200cm		550	
	Hard Wood Window Frame	80x130cm		817	
43.	Nut and Bolt				
	Nut (Wood work)	12.70mm	kg	25	
		19.05mm	kg	24	
	Nail	4, 3, 2 1/2"	kg	20	
		2 - 1 1/2"	kg	22	
	Concrete nail	3" - 4"	kg	290	
44.	Portland Cement				
	Tiger Brand (Retail)				
	(Ex-Factory)		ton	1,234	

Table 12-2 Unit Price List for Construction Material (9)

Unit : Bahts

No.	Item	Description	Unit	Unit Price	Remark
45.	Aggregate				
	Rough Sand			215	
	Sand			215	
	Sand for Site leveling			150	
	Stone No.1			300	
	Stone No.2			300	
	Earth			215	
46.	Quantity Meter	1/2"		640	
		3/4"		815	
		1"		1,285	
47.	Gate Valve	1/2"		229	
		3/4"		268	
		1"		372	
		1 1/4"		453	
48.	Basin cock	1/2"	No.	29	
		3/4"	No.	35	
49.	Sewage Areation Treatment System				Not included installation fee with accessory
	SAT Model GK.100		set	21,500	10 person
	MA.576		set	71,800	50 person
50.	Water tank				
	Golvanized Steel Tank	1.20x1.20x1.20m		3,800	
	Plastic Cylinder Tank	2,500 l		10,800	
51.	Electric Supply Accessories				
	P.V.C. 60' 250 Volt	2x4.0m^2	roll	970	
		2x2.5m^2	roll	610	
	750 Volt	2x.25m^2	roll	1,843	
		2x.6m^2	roll	2,721	

Table 12-2 Unit Price List for Construction Material (10)

Unit : Bahts

No.	Item	Description	Unit	Unit Price	Remark
52.	Lighting Accessories				
	Switch (Single)		No.	30	
	Socket (Single)		No.	31	
	Cirkit Breaker 1P		set	110	
	Fluorescent Lamp	40w	No.	175	
	Incandescent Lamp	60w	No.	72	
53.	Toilet Fixture				
	Toilet seat (Thai style)			311	No.TF-100
				270	C 204
	Toilet seat (Water style)		set	2,347	No. TF-2106
			set	2,930	C 179
	Wall urinal		set	617	No.TF-412
	Bidet		set	2,156	No.TF-5002
	Lavatory		set	424	No.TF-911

Table 12-3 (1) Cost Estimation of Pilot Plant

	Foreign Portion Cost (Unit: 10^3Yen)	Foreign Portion Cost (Unit: 10^3Bahts)	Domestic portion Cost (Unit: 10^3Bahts)	Domestic portion Tax & duty (Unit: 10^3Bahts)	Domestic portion Total (Unit: 10^3Bahts)	Total cost Unit: 10^3Bahts
1. Land acquisition	0	(0)	0	0	0	0
2. Site preparation	0	(0)	961	32	993	993
3. Machinery and equipment	*1 136,532	(24,824)	665	22	687	25,511
			-	*2 4,294	4,294	4,294
4. Inland transportation	0	(0)	396	13	409	409
5. Vehicles	0	(0)	2,543	84	2,627	2,627
6. Erection	0	(0)	3,060	101	3,161	3,161
7. Structures and civil work	0	(0)	5,441	180	5,621	5,621
8. Electrical work	0	(0)	4,406	146	4,552	4,552
9. Engineering	29,705	(5,401)	382	*3 190	572	5,973
10. Supervision	3,581	(651)	0	*4 21	21	572
11. Commissioning	2,453	(446)	0	*5 15	15	461
12. Physical contingency	8,614	(1,566)	892	255	1,147	2,713
Total Plant Cost (1990 price)	180,885	(32,888)	18,746	5,353	24,099	56,987
Price contingency	6,578	(1,196)	3,051	276	3,327	4,523
Total Plant Cost (Current Price Base)	187,463	(34,084)	21,797	5,629	27,426	61,510

Note: 1. *1 Cost is CIF value
2. *2 Tax and duty (17.3% of CIF value) of machinery and quipment (foreign portion)
3. *3 Include Business tax 3.3% of Engineering cost (foreign portion)
4. *4 Business Tax 3.3% of supervising fee
5. *5 Business Tax 3.3% of commissioning cost

Table 12-3 (2) Cost Estimation of Commercial Plant

	Foreign Portion Cost (Unit: 10^3Yen)	Foreign Portion Cost (Unit: 10^3Bahts)	Domestic portion Cost (Unit: 10^3Bahts)	Domestic portion Tax & duty (Unit: 10^3Bahts)	Domestic portion Total (Unit: 10^3Bahts)	Total cost Unit: 10^3Bahts
1. Land acquisition	0	(0)	0	0	0	0
2. Site preparation	0	(0)	0	0	0	0
3. Machinery and equipment	*1 361,535	(69,370)	39,004	1,287	40,291	109,661
				*2 12,000	12,000	12,000
4. Inland transportation	0	(0)	846	28	874	874
5. Vehicles	0	(0)	4,238	140	4,378	4,378
6. Erection	0	(0)	10,013	330	10,343	10,343
7. Structures and civil work	0	(0)	21,389	706	22,095	22,095
8. Electrical work	0	(0)	9,698	320	10,018	10,018
9. Engineering	29,705	(5,401)	477	*3 194	671	6,072
10. Supervision	3,581	(651)	0	*4 21	21	672
11. Commissioning	2,453	(446)	0	*5 15	15	461
12. Physical contingency	20,862	(3,793)	4,283	753	5,036	8,829
Total Plant Cost (1990 price)	438,136	(79,661)	89,948	15,794	105,742	185,403
Price contingency	39,397	(7,163)	37,191	2,386	39,577	46,740
Total Plant Cost (Current Price Base)	477,533	(86,824)	127,139	18,180	145,319	232,143

Note:
1. *1 Cost is CIF value
2. *2 Tax and duty (17.3% of CIF value) of machinery and quipment (foreign portion)
3. *3 Include Business tax 3.3% of Engineering cost (foreign portion)
4. *4 Business Tax 3.3% of supervising fee
5. *5 Business Tax 3.3% of commissioning cost

(3) Transportation

The unit price of transportation used for estimating the costs of the imported items is 11,030 yen/m^3, on the assumption that these are imported from Japan, which consists of the following items:

(1) Shipping charges in Japan,
(2) Ocean freight cost (from Yokohama Port to Bangkok Port),
(3) Port duties and other expenses at Bangkok Port,
(3) Marine insurance.

(4) Tax and Duty

The tax and duty on the machines, equipment, and materials into Thailand is assumed to be 17.3 percent rate on CIF values. These consist of the following items:

(1) Import duty:	5 percent on CIF value
(2) Ministry of Commerce fee:	0.5 percent of CIF value
(3) Net sales tax:	9 percent of (CIF value + Import duty + Standard profit (assumed to be 13.7 percent on CIF value)) A discount of 2 percent could be allowed if payment is made in cash.
(4) Municipal tax:	10 percent on net sales tax

The total customs duty for the imported machinery and equipment, foreign portion, is 4,294,000 Bahts.

The business tax of 3.3 percent is added to the prices of domestic items.

(5) Engineering Fee

Engineering fees for both the pilot plant and the commercial plant are estimated on the basis of the following conditions: The basic design is executed in foreign country. The plants, machines and equipment, steel

structures are designed abroad. The civil and building works are designed in Thailand.

(6) Supervising Fee

The cost for supervisory works by expatriate engineers on the plant and machine during the plant construction period are estimated on the following conditions:

Pilot plant:	1.5 man-month
Commercial plant:	1.5 man-month

(7) Commissioning

A cost for an expatriate supervisor for one-month is included in the estimation.

(8) Physical Contingency

The physical contingency is assumed at 5 percent of the total plant costs.

(9) Price Contingency

For the imported and domestic supplies, one and four percent per year of price contingency are assumed, respectively.

(10) Land Acquisition

This cost estimation does not include the cost for land acquisition.

(11) Earth Grading Work

The entire site for both the pilot plant and the commercial plant will be graded at the time of constructing the pilot plant.

(12) Equipment to be locally purchased

The prices of the following pieces of equipment to be procured separately from the machines are estimated as follows.

	Cost (Unit: 1,000 Bahts)
Cistern	94
Fire extinguisher	19
Primary cutter	37
Truck scale	515
Total	665

(13) Inland Transportation

The unit cost for the inland transportation of imported equipment from Bangkok Port to plant site is 950 Bahts/m^3.

Prices of the local supplies include transportation cost to the site.

(14) Vehicle

	Cost (unit: 1,000 Bahts)
Truck (one)	1,650
Micro bus (one)	893
Total	2,543

(15) Erection Work

This means the installation work of machine and equipment at site.

(16) Structure and Civil Work

The structure and civil work consist of the following works.

	Cost (Unit: 1,000 Bahts)
Building work	1,849
Civil work (incl. foundation of machine)	925
Fabrication of steel structure	1,294
Steel structure assembly at site	555
Water piping and pumps	818
Total	5,441

(17) Electrical work

The electrical work consists of the following works.

	Cost (Unit: 1,000 Bahts)
Power panel, operation panel, electrical equipment	1,108
Power receiving	595
3km power supply line	935
Electrical work	1,534
Telephone wiring and inspection	234
Total	4,406

12-7-3 Cost for Structure and Civil Works

Table 12-3 shows the costs of structure and civil works estimated on the basis of the unit prices shown in Table 12-2 obtained during the field survey.

The civil costs cover the following works.

(1) Site adjustment work
(2) In-site blacktop pavement
(3) Simple fence construction
(4) Sanitation tank construction
(5) Drainage work

The survey of the site and soil investigation are not included in the cost assuming that NEA will conduct such works.

12-7-4 Engineering and Other Expenses

The engineering and other expenses are shown in Table 12-4.

Table 12-4 Engineering and supervisor cost

(1) Engineering fee

	Pilot Plant		Commercial Plant	
Item	Foreign (yen)	Local (Baht)	Foreign (yen)	Local (Baht)
Plant & machinery	29,705,000	-	29,705,000	-
Civil/building	-	382,000	-	477,000
Total	29,705,000	382,000	29,705,000	477,000

(2) Supervisor fee

	Pilot Plant		Commercial Plant	
Item	Foreign (yen)	Local (Baht)	Foreign (yen)	Local (Baht)
Plant & machinery	3,581,000	-	3,581,000	-
Total	3,581,000	-	3,581,000	-

Chapter 13 Total Capital Requirement

Chapter 13 Total Capital Requirement

This chapter presents the total capital requirement of the pilot plant envisaged in this study. The pilot plant will produce 3,000 tons per year of lignite briquettes feeding the lignite of the Ban Pa Kha mine as a major raw material.

The pilot plant is to be constructed and started up well ahead of the commercial plant, which is also envisaged in this feasibility study, primarily for the purposes of developing the market and establishing the production technology. As mentioned repeatedly throughout this report, the pilot plant per se is expected to be financially unfeasible; therefore, the financial feasibility of the pilot plant project is evaluated in terms of whether or not the investment in the pilot plant could be recovered in the subsequent commercial stage.

Accordingly, the financial feasibility must be studied not only with the pilot plant itself, but in combination with the commercial plant as well. In addition to Case 1, which represents only the pilot plant, Case 2 and Case 3 are conceived incorporating a commercial plant of 50,000 tons per year capacity. Case 2 represents a scenario including both the pilot plant and the commercial plant; while Case 3 represents only the commercial plant. The pilot plant and commercial plant have a capacity of 3,000 and 50,000 tons per year, respectively; both plants will be installed on the same site. Total capital requirements are estimated for both the pilot plant and the commercial plant.

13-1 Outline of Total Capital Requirement

The total capital requirement is the total investment required until the start of normal operation; and in this study, the total capital requirement is defined as the sum of the plant cost, preoperating cost, initial working capital and the interest accruing during the construction period.

13-2 Major Premises

The followings are major premises on which the total capital requirement is calculated.

(1) Price Base

In accordance with an agreement established between NEA and the JICA study team during the field survey and recorded in the Progress Report, and in commensurate with the accepted standards, the financial feasibility of the project is analyzed on a constant price base, on the price level of 1990 in the case of this study, in order to avoid obscuring the results of financial analysis in a mist of uncertainty associated with estimating the rates of inflation for a number of cost and price items.

The total capital requirement is calculated on two bases: constant price base on the price level of 1990 and current price base, the latter meaning the price level of the time when expenditure is actually made. The total capital requirement on the current price base is calculated by adding inflation portions to the total capital requirement on the constant price base of 1990. The inflation portions are calculated by applying inflation rates of four percent and one percent to the domestic supplies and foreign supplies, respectively, until the expenditure is actually made.

(2) Currency and Exchange Rates

The costs of the foreign supply portion are first estimated in yen and then converted into Baht at an exchange rate of 5.5 yen to one Baht, while the costs of the local supply portion are estimated in Baht.

13-3 Total Capital Requirement for the Pilot Plant (Case 1)

The total capital requirement for the pilot plant is summarized in Table 13-1.

Table 13-1 Total Capital Requirement of Pilot Plant

(Unit: 1,000 Bahts)

	1993		1994		Total
	Currency		Currency		
	Local	Foreign	Local	Foreign	
Plant Const. Cost	4,622	13,545	19,478	19,342	56,987
Preoperating Cost	320	5,455	480	0	6,255
Initial W/Capital	0	0	814	1,303	2,117
Price Contingency	471	575	3,087	839	4,972
IDC (Current Price)	532	0	4,614	0	5,146
Current Price Base	5,945	19,575	28,473	21,484	75,477
IDC (Constant Price)	286	0	2,398	0	2,684
1990 Constant Price	5,228	19,000	23,170	20,645	68,043

13-3-1 Plant Cost

As the estimation of the plant costs is explained in Chapter 12, the estimated cost of the pilot plant only is summarized here in Table 13-2.

Table 13-2 Construction Cost of Pilot Plant

(Unit: 1,000 Bahts)

	1993		1994		Total
	Currency		Currency		
	Local	Foreign	Local	Foreign	
Plant Const. Cost	4,402	12,900	18,550	18,421	54,273
Physical Contingency	220	645	928	921	2,714
Price Contingency	431	410	2,896	786	4,523
Current Price Base	5,053	13,955	22,374	20,128	61,510
1990 Constant Price	4,622	13,545	19,478	19,342	56,987

13-3-2 Preoperating Cost

The preoperating cost represents the costs incurred before the start of normal operation of the pilot plant, and it generally consists of the fee for a basic design, fees for retaining consultants, cost of training the operators, and personnel expenses for the staff and operators to be employed by the entity to own and execute the construction and

operation of the plant, and the cost for the test operation immediately before the commissioning. In the case of this study, the cost of training the operators is not included in the preoperating cost but in the plant cost.

(1) Basic Design Fee

For the execution of plant construction, it is necessary first of all to employ a process licenser to prepare a basic design. The fee for the basic design is estimated at 1,818 thousand Bahts, or 10 million yen, in foreign currency portion and 160 thousand Bahts in the domestic currency portion. The basic design starts six months before the commencement of construction work, or the award of contract to the contractor, and takes three months to complete.

(2) Consultant Fee

Based on the basic design, a set of tender documents are prepared and inquiries are made to prospective contractors. A contractor will be selected by means of (a) public tender(s) and evaluation of the bids submitted by the tenderers. A consultant, owner's consultant, will be retained to assist the project owner in the preparation of the tender documents, inquiries to the candidate contractors, (a) public tender(s), evaluation and selection of the contractor, management of the selected contractor.

The consultant is assumed to be an expatriate and will be employed for 24 months from 6 months before the commencement of plant construction until the completion of the construction, but not on a continuous term.

The costs for the owner's consultant will be 3,636 thousand Bahts, or 20 million yen, in the foreign currency portion and 160 thousand Bahts for domestic currency portion.

(3) Training and Man-Power Costs

The personnel training costs mean the cost of an instructor to train in

Thailand the plant operators, 20 persons in all, for a period of one month. This cost is counted in the commissioning cost of the estimated plant cost given in Chapter 12 and is not included in the preoperating cost. The man-power cost incurred by the employees during the construction period is included in the personnel expenses borne by the project promoter. The Man-power cost is calculated on the basis of the employment plan shown in the following Table 13-3.

Table 13-3 Manning Schedule and Man-power Cost

	1994 Unit: Persons					Unit Cost	Yearly
	I	II	III	IV	Total	(Bht/M)	(1,000 Bahts)
Engineer	1	1	1	1	1	15,000	180
Supervisor			1	1	1	10,500	63
Foreman*				1	1	7,500	8
Operator*				20	20	5,250	105
Unskilled Labor*				18	18	2,500	45
Price Contingency							68
Current Price Base							469
1990 constant price	1	1	2	41	41		401

Note: * Employed in December 1994

(4) Test Run Costs

The period of test run will be one month, of which the latter 0.5 months are for loaded operation of the plant consuming raw materials and utilities. The running rate during the loaded test operation is supposed to be 25 percent of the plant capacity, or an average of 6 hours a day, and the average consumption of raw materials and utilities is to be 100 percent when the plant is running. The lignite briquettes to be produced during the test run period are 37.5 tons and they will be distributed free of charge for the purpose of sales promotion. Personnel expenses during the test operation are for expatriate instructors and Thai plant operators. The costs for expatriate engineers are included in the plant cost, and the expenses for the plant operators for the test operation are counted in the cost of man-power before the start of plant operation. Therefore, these costs are not included in the

preoperating cost. The cost for test operation are shown below in Table 13-4.

Table 13-4 Test Operation Cost

	Unit Consumption	Unit Price	Cost (Bhts/T of LB)	(1,000 Bhts/y)
Raw material				
Lignite	1.059 T	550 Bhts/T	582	22
Rice Straws	0.246 T	500 Bhts/T	123	5
Slaked Lime	0.092 T	2,500 Bhts/T	230	9
Utility				
Electricity				
Variable Charge	293 kWh	1.23 Bhts/kWh	360	14
Fixed Charge	140 (kW)	174 Bhts/kW/Month		24
Fuel	12.48 kg	9.88 Bhts/kg	123	5
Price Contingency				11
Current Price Base				90
1990 Constant Price				79

(5) Summary of Preoperating Cost

Table 13-5 summarizes the preoperating cost.

Table 13-5 Preoperating Cost

(Unit: 1,000 Bahts)

	1993		1994		Total
	Currency		Currency		
	Local	Foreign	Local	Foreign	
Consultant Fee	320	5,455	0	0	5,775
Manpower Cost	0	0	401	0	401
Test Operation Cost	0	0	79	0	79
Price Contingency	40	165	82	0	287
Current Price Base	360	5,620	562	0	6,542
1990 Constant Price	320	5,455	480	0	6,255

13-3-4 Initial Working Capital

The initial working capital is the funds that the operating company

needs in order to ensure smooth operation of the plant. This study counts the following items as the initial working capital.

(1) Cash in Hand

The amount of cash equivalent to man-power cost for two months, or 447 thousand Bahts, is reserved as cash in hand.

(2) Raw materials Inventory

Inventories of 20, 30 and 10 days for the first year's throughputs are reserved for lignite, rice straws and slaked lime, respectively, prior to the start of normal operation. As the unit prices of lignite, rice straws and slaked lime are 550, 500 and 2,500 Bahts per ton, respectively, the cost for the inventory is 131 thousand Bahts.

(3) Spareparts

Five ercent of the prices of foreign machines and equipment is counted. The customs duties and charges are counted as domestic expenses.

(4) Summary of Initial Working Capital

Table 13-6 summarizes the initial working capital.

Table 13-6 Initial Working Capital Requirement

(Unit: 1,000 Bahts)

	1994		Total
	Local Currency	Foreign Currency	
Cash in Hand	447	0	447
Raw Material Inventory			
Lignite	93	0	93
Rice Straws	30	0	30
Slaked Lime	18	0	18
Total	141	0	141
Spare Parts	226	1,303	1,529
Price Contingency	109	53	162
Current Price Base	923	1,356	2,279
1990 Constant Price	814	1,303	2,117

13-3-5 Financing Plan

The financing plan for this project is not determined yet. For the purpose of this study, it is assumed that, based on the field survey and discussions with NEA, 60 percent of the plant cost and the preoperating cost, and the total of the interest during construction and the initial working capital will be financed by a long-term loan of appropriate terms and conditions; and the rest is supplied by the equity.

The conditions for the long-term loan are assumed to be as below in accordance with the results of interviews with Thai banks.

Interest rate:

The real interest rate: 9.0 percent per year on constant price base, or 16.0 percent per year on current price base

The real interest rate, or interest rate on constant price base, is obtained by subtracting inflation rate from the nominal interest rate.

Terms of repayment: 10 years, or 10 installments

Grace period: two years after the start of plant operation

Repayment method: repayment by equal installments

Table 13-7 and Table 13-8 show estimated interests during construction based upon the above conditions on current price base and constant 1990 price base, respectively.

Table 13-7 Interest During Construction (Current Price)

(Unit: 1,000 Bahts)

	1993		1994		Total
Equity	13,583		17,563		31,146
Debt	11,937		32,394		44,331
Total	25,520		49,957		75,477
Debt	July 1	Dec. 1	March 1	Dec. 1	Total
Disbursement	5,703	5,702	19,446	8,334	39,185
IDC	456	76	2,593	111	3,236
IDC for 1993 Debt				1,910	1,910
Total		11,937		32,394	44,331

Table 13-8 Interest During Construction (Constant Price as of 1990)

(Unit: 1,000 Bahts)

	1993	1994	Total
Equity	13,042	16,008	29,050
Debt	11,186	27,807	38,993
Total	24,228	43,815	68,043

	July 1	Dec. 1	March 1	Dec. 1	Total
Debt					
Disbursement	5,450	5,450	17,786	7,623	39,309
IDC	245	41	1,334	57	1,677
IDC for 1993 Debt				1,007	1,007
Total		11,186		27,807	38,993

13-4 Total Capital Requirement for Commercial Plant (Case 2 and Case 3)

Total capital requirement is developed for Case 2, where the pilot plant of 3,000 tons per year plus the commercial plant of 50,000 tons per year are installed on the same site, and Case 3, which represents the commercial plant only without installing the pilot plant.

Table 13-9 shows the capital requirements for Case 2 and Case 3 on the constant price base of 1990.

(1) Plant Cost

As the plant costs are discussed in Chapter 12, the estimated costs only are shown for Case 2 and Case 3 in Table 13-10.

Table 13-9 Total Capital Requirement for Case 2 and Case 3

(Unit: 1,000 Bahts)

	Local Currency	Foreign Currency	Total
Case 2			
Plant Construction Cost	129,843	112,546	242,389
Preoperating Cost	2,787	10,910	13,697
Initial W/Capital	3,165	4,944	8,109
IDC	10,956	0	10,956
1990 Constant Price	146,751	128,400	275,151
Case 3			
Plant Construction Cost	105,743	79,659	185,402
Preoperating Cost	1,987	5,455	7,442
Initial W/Capital	2,351	3,641	5,992
IDC	8,272	0	8,272
1990 Constant Price	118,353	88,755	207,108

Note: Case 2 and Case 3 represent Pilot Plant + Commercial Plant and Commercial plant only, respectively.

Table 13-10 Plant Construction Cost of Case 2 and Case 3

(Unit: 1,000 Bahts)

	Local Currency	Foreign Currency	Total
Case 2			
Plant Construction Cost	123,660	107,187	230,847
Physical Contingency	6,183	5,359	11,542
1990 Constant Price	129,843	112,546	242,389
Case 3			
Plant Construction Cost	100,708	75,866	176,574
Physical Contingency	5,035	3,793	8,828
1990 Constant Price	105,743	79,659	185,402

Note: Case 2 and Case 3 represent Pilot Plant + Commercial Plant and Commercial plant only, respectively.

(2) Preoperating cost

1) Consultant fees

The consultant fees for Case 2 and Case 3 are the same as that of Case 1 discussed before.

2) Training and Man-Power Costs

As in Case 1, for both Cases 2 and 3, the cost of instructors to train plant operators, 20 persons for one month, is counted in the commissioning cost of the plant cost given in Chapter 12. The man-power cost for the employees during the training is included in the personnel expense during the construction period for the employees hired by the project promoter. The man-power cost is calculated on the basis of the employment plan shown in Table 13-11.

Table 13-11 Manning Schedule

	1999 Unit: Persons					Unit Cost	Yearly Cost
	I	II	III	IV	Total	(Bht/M)	(1,000 Bahts)
Engineer	3	3	3	3	3	15,000	540
Supervisor			1	1	1	10,500	63
Foreman*				1	1	7,500	8
Operator*				20	20	5,250	105
Unskilled Labor*				18	18	2,500	45
Total (1990 Price)	3	3	4	43	43		761

Note: * Employed in December 1999

3) Test Run Cost

As in Case 1, the period of the test operation for Case 2 and Case 3 is one month, of which 0.5 months are for loaded operation consuming the raw materials and utilities. The running rate during the loaded operation is supposed to be 25 percent of the plant capacity, and the consumption of raw materials and utilities is to be 100 percent for the 25 percent period. The test operation will produce 625 tons of lignite briquettes which will not be sold as finished products. Table 13-12 summarizes the cost of test operation.

(3) Initial Working Capital

The initial working capital for Case 2 and Case 3 is as follows.

Table 13-12 Test Operation Cost

	Unit Consumption	Unit Price	Cost (Bhts/T of LB)	(1,000 Bhts/y)
Raw material				
Coal	1.059T	550 Bhts/T	582	364
Rice Straws	0.246T	500 Bhts/T	123	77
Slaked Lime	0.092T	2,500 Bhts/T	230	144
Utility				
Electricity				
Variable Charge	93 kWh	1.23 Bhts/kWh	114	71
Fixed Charge	745 (kW)	174 Bhts/kW/Month		130
Fuel	12.48 kg	9.88 Bhts/kg	123	77
Total (1990 Price)				863

1) Cash in hand

An amount of cash equivalent to man-power cost of 2 months, or 689 thousand Bahts required for incremental personnel for plant operation is reserved as cash in hand for Case 3. In Case 2, this amount is added to the cash in hand for the pilot plant of Case 1.

2) Raw material inventory

Inventories of 3, 30 and 10 days for the first year's throughputs are reserved for lignite, rice straws and slaked lime, respectively, prior to the start of commercial operation. The unit prices are 550, 500 and 2,500 Bahts per ton for lignite, rice straws and slaked lime, respectively. The total cost of the inventories is 1,031 thousand Bahts for Case 3. In Case 2, this cost of inventory is added to the cost of inventory of the pilot plant.

3) Spareparts

An amount equivalent to five percent of the prices of foreign machines and equipment is prepared as working capital. The customs duties and charges are counted as domestic expenses.

(4) Financing Plan

The financing plans for Case 2 and Case 3 are as follows.

Interest rate: 9.0 percent per year on constant price base
Terms of repayment: 10 years, or 10 installments
Grace period: two years after the start of plant operation
Repayment method: repayment by equal installments

Table 13-13 shows the interest during construction calculated on the above conditions.

Table 13-13 Interest During Construction

(Unit: 1,000 Bahts)

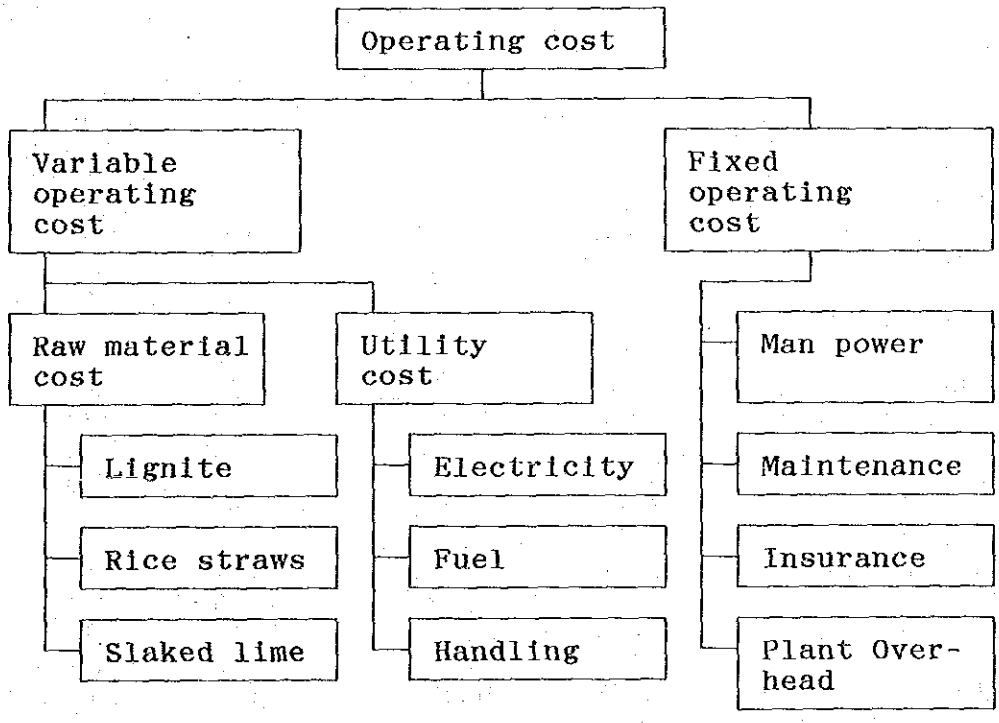
	1993	1994	1998	1999	Total
Case 2					
Equity	13,042	16,008	25,124	56,480	110,653
Debt	11,186	27,807	29,784	95,720	164,498
(IDC)	(286)	(2,398)	(762)	(7,510)	(10,956)
Total	24,228	43,815	54,908	152,201	275,151
Case 3					
Equity			25,124	56,480	81,604
Debt			29,784	95,720	125,504
(IDC)			(762)	(7,510)	(8,272)
Total			54,908	152,200	207,108

Chapter 14 Operating Cost

Chapter 14 Operating Cost

The operating costs for the production of lignite briquettes may be divided into two categories as explained below: variable cost and fixed cost. These cost items are schematically shown below.

The variable cost of this project consists of the cost of raw materials: lignite, rice straws and slaked lime, the cost of utilities: electricity and fuel, and the cost of handling the raw materials. The fixed cost consists of the cost of man-power, the cost of maintenance of machinery and equipment, the cost for insurance and other miscellaneous items not relating directly to the operating rate of the plants.



Section 14-1 presents the basic conditions for calculating the operating costs; Section 14-2 gives the operating costs for the pilot plant of 3,000 tons per year as Case 1; Section 14-2 presents the operating costs for Case 2, where a commercial plant with a capacity of 50,000 tons per year will follow the pilot plant, and Case 3, where the commercial plant alone is installed without being preceded by the pilot plant.

14-1 Basic Conditions

In accordance with the understanding between NEA and the study team, all costs and prices are based on constant price base of 1990, meaning that the inflation factors are excluded from the calculation in order to eliminate ambiguity from the results of the financial analysis that may be caused by uncertainty associated with forecasting rates of inflation for various items.

14-2 Operating Cost for Pilot Plant (Case 1)

Table 14-1 summarizes operating costs for the pilot plant as Case 1.

Table 14-1 Operation Cost for the Pilot Plant

(Unit: Bahts/T)

	At 80% Operation		At 100% Operation	
	Bahts/T*	Annual	Bahts/T*	Annual
Raw Material Cost				
Lignite	582	1,398	582	1,747
Rice Straws	123	295	123	369
Slaked Lime	230	552	230	690
Total	935	2,245	935	2,806
Variable Cost				
Electricity				
Variable Portion	360	864	360	1,080
Fixed Portion	122	293	98	293
Water	0	0	0	0
Fuel	123	296	123	370
Total	605	1,453	581	1,743
Fixed Cost				
Manpower Cost	1,118	2,682	894	2,682
Maint. & Insurance	760	1,824	760	1,824
Plant Overhead	838	2,012	838	2,012
Total	2,715	6,517	2,712	6,517
Total Operation Cost	4,256	10,215	3,689	11,066

Note: * Bahts per ton of lignite briquettes

The bases employed for the calculation of the above operating costs are explained below.

14-2-1 Variable Cost

The following conditions are applied to the development of the costs of raw materials and utility.

(1) Raw material Cost

1) Lignite

The project uses Ban Pa Kha lignite as a principal raw material. The lignite is supplied at a price of 550 Bahts per ton to the plant, and transported to the plant by the truck, drivers and unskilled labors belonging to the pilot plant. The unit consumption of lignite is 1.059 tons per ton of lignite briquettes. Accordingly, the annual cost of lignite is 1,747 thousand Bahts for the production of 3,000 tons per year of lignite briquettes.

2) Rice Straws

Rice straws required are 0.246 tons per ton of lignite briquettes. The farmers' price of rice straws is 500 Bahts per ton; therefore, the annual cost is 369 thousand Bahts. Rice straws are transported to the plant site by the truck, drivers and labors belonging to the pilot plant.

3) Slaked lime

Slaked lime required is 92 kilograms per ton of lignite briquettes. The price of slaked lime including transportation cost to the plant is 2,500 Bahts per ton; therefore, the annual cost is 690 thousand Bahts.

(2) Utility Cost

1) Electricity

The plant requires 140 kilowatts for lignite briquette production and plant office use. The tariff on electric power is 174 Bahts per kilowatt per month on receiving demand and 1.23 Bahts per kilowatt hour consumed. The annual consumption of electricity by the plant is 879 MWh; therefore, the cost of electricity is 1,373 thousand Bahts per year.

2) Water

The plant does not consume process water. Water is used for hygienic purposes, cleaning and fire fighting. There will be no charge for water supply. Accordingly, annual water cost is zero. The amount of drinking water is small. The cost of drinking water is included in the plant overhead.

3) Fuel Cost

Diesel fuel oil is required as supplement for heat required for drying lignite. The consumption is 12.48 kilograms per ton of lignite briquettes. The price is 9.88 Bahts per kilograms; therefore, the annual cost is 370 thousand Bahts.

(3) Handling Cost

The lignite and rice straws to be fed to the plant will be transported by truck. The costs of the vehicle, drivers, and labor belonging to the plant are included in the cost items of depreciation of vehicles, fuel for the truck, and man-power cost of drivers and labors.

14-2-2 Fixed Cost

The fixed cost consists of man-power cost, maintenance cost, insurance cost, and plant overhead cost.

(1) Man-power

Based on the manning program for the plant given in Chapter 10, the man-power cost is calculated to be 2,682 thousand Bahts per year by applying salaries and wages as shown in Table 14-2.

(2) Maintenance Cost

The maintenance cost consists of labor and sparepart costs. The maintenance of the machines and equipment is done in two ways; small maintenance works by the plant operators in daily maintenance and large maintenance work by periodical turnarounds. The annual maintenance

costs are estimated at 1,425 thousand Bahts.

Table 14-2 Manpower Cost

	Monthly Manpower Cost (Bahts/M)			Yearly Cost (1,000Bhts/y)	
	Salary	Benefits	Total	Person	Cost
General Manager	30,000	15,000	45,000	0	0
Department Head	15,000	7,500	22,500	1	270
Engineer	10,000	5,000	15,000	1	180
Supervisor	7,000	3,500	10,500	1	126
Foreman	5,000	2,500	7,500	1	90
Operator	3,500	1,750	5,250	20	1,260
Driver	3,000	1,500	4,500	2	108
Unskilled Labor	2,500	0	2,500	18	540
Staff/Accountant	3,500	1,750	5,250	1	63
Secretary & Clerk	2,500	1,250	3,750	1	45
Total					2,682

(3) Insurance Cost

The plant will be insured against fire. The insurance fee is equivalent to 0.7 percent of the plant cost, or 399 thousand Bahts per year.

(4) Plant Overhead Cost

The plant overhead cost covers various expenses such as office supplies, communication, travels and other indirect costs. For the purpose of calculating production cost, the annual plant overhead costs are set at 2,012 thousand Bahts for Cases 1, or equivalent to 75 percent of the direct labor cost, in accordance with an agreement between NEA and the study team.

14-3 Operating Cost for Commercial Plants (Case 2 and Case 3)

Case 2 installs a commercial plant of 50,000 tons per year following the pilot plant, whereas Case 3 the commercial plant only.

Table 14-3 summarizes the operating costs for both cases.

Table 14-3 Operation Cost for Case 2 and Case 3

(Unit: Bahts/T)

	Case 2 at Full Operation		Case 3 at Full Operation	
	Bahts/T*	Annual	Bahts/T*	Annual
Raw Material Cost				
Lignite	582	30,870	582	29,123
Rice Straws	123	6,519	123	6,150
Slaked Lime	230	12,190	230	11,500
Total	935	49,579	935	46,773
Variable Cost				
Electricity				
Variable Portion	130	6,862	116	5,781
Fixed Portion	35	1,848	31	1,556
Water	0	0	0	0
Fuel	123	6,535	123	6,165
Transportation	174	9,225	185	9,225
Total	462	24,470	455	22,727
Fixed Cost				
Manpower Cost	129	6,813	83	4,131
Maintenance & Ins.	146	7,757	119	5,966
Plant Overhead	96	5,110	62	3,098
Total	371	19,679	264	13,195
Total Operation Cost	1,768	93,728	1,654	82,658

Note: * Bahts per ton of lignite briquettes

14-3-1 Variable Cost

To obtain the variable costs, the prices of the raw materials and utility are calculated as follows.

(1) Raw Material Cost

The raw material costs are estimated on the following conditions.

1) Lignite

As is the case with Case 1, the lignite price and unit the consumption are 550 Bahts and 1.059 tons per ton of lignite briquettes produced, respectively, for both Case 2 and Case 3. Accordingly, the annual cost of lignite is 30,807 thousand Bahts for the production of 53,000 tons per year of lignite briquettes for Case 2, and 29,123 thousand Bahts for that of 50,000 tons per year for Case 3.

2) Rice Straws

Rice straws required are 0.246 tons per ton of lignite briquettes. The farmers' price of rice straws is 500 Bahts per ton; therefore, the annual cost is 6,519 thousand Bahts in Case 2 and 6,150 thousand Bahts in Case 3.

3) Slaked Lime

Slaked lime required is 92 kilograms per ton of lignite briquettes. The price of slaked lime including transportation cost to the plant is 2,500 Bahts per ton; therefore, the annual cost is 12,190 thousand Bahts in Case 2 and 11,500 thousand Bahts in Case 3.

(2) Utility Cost

1) Electricity

Case 2 and Case 3 consume 885 and 745 kilowatts of electricity, respectively, for the production of lignite briquettes and office use. The tariff on electric power is 174 Bahts per kilowatt per month on receiving demand and 1.23 Bahts per kilowatt hour consumed. The annual consumptions and charges are 5,579 MWh and 8,710 thousand Bahts for Case 2, and 4,700 MWh and 7,337 thousand Bahts for Case 3.

2) Water

The plant does not require process water. Water is used for hygienic, living and fire fighting only. There will be no charge for water. Accordingly, annual water cost is zero. The amount of drinking water is small. The cost of drinking water is included in the plant overhead.

3) Fuel Cost

Diesel fuel is burned as supplement to the heat for drying lignite. The unit consumption is 12.48 kilograms per ton of lignite briquettes. The price is 9.88 Bahts per kilogram; therefore, the annual cost is 6,535 thousand Bahts in Case 2 and 6,165 thousand Bahts in Case 3.

(3) Handling Cost of Raw Material

The lignite to be fed to the plant will be transported using the truck,

drivers, and personnel belonging to the plant. The cost is included in the cost items of depreciation of vehicles, fuel for the trucks, and man-power. The rice straws will be transported to the plant by a contracted transportation company in both Case 2 and Case 3. The costs is calculated to be 9,225 thousand Bahts in Case 2 and Case 3.

14-3-2 Fixed Operating Cost

The fixed operating cost consists of man-power cost, maintenance cost, insurance cost, and plant overhead cost.

(1) Man-power Cost

Based on the organization program for the plant shown in Chapter 10, the man-power cost is calculated to be 6,813 thousand Bahts and 4,131 Bahts per year for Case 2 and Case 3, respectively, applying the salaries and wages as shown in Table 14-4.

Table 14-4 Manpower Cost

	Monthly Cost	Yearly Cost (Case 2)		Yearly Cost (Case 3)	
	(Bahts/M)	Person	1,000 Bahts/Y	Person	1,000 Bahts/Y
General Manager	45,000	1	540	1	540
Department Head	22,500	3	810	2	540
Engineer	15,000	4	720	3	540
Supervisor	10,500	2	252	1	126
Foreman	7,500	2	180	1	90
Operator	5,250	40	2,520	20	1,260
Driver	4,500	6	324	4	216
Unskilled Labor	2,500	36	1,080	18	540
Staff/Accountant	5,250	4	252	3	189
Secretary & Clerk	3,750	3	135	2	90
Total			6,813		4,131

(2) Maintenance Cost

The maintenance cost consists of the cost of spareparts and that of man-power. Small maintenance works are done by the operating staff on a daily base and large maintenance works are done during the turnaround. The annual maintenance cost is equivalent to 2.5 percent of plant cost, or 6,060 thousand and 4,661 Bahts in Case 2 and Case 3, respectively.

(3) Insurance Cost

The insurance cost is equivalent to 0.7 percent of plant cost, or 1,697 thousand and 1,305 thousand Bahts per year in Case 2 and Case 3, respectively.

(4) Plant Overhead Cost

The plant overhead cost covers various expenses such as office supplies, communication, travels and other indirect costs. For the purpose of calculating production cost, the annual plant overhead costs are set at 5,110 thousand Bahts for Case 2 and 3,098 thousand Bahts for Case 3, or equivalent to 75 percent of the direct labor cost, in accordance with an agreement between NEA and the study team.

Chapter 15 Financial Analysis

Chapter 15 Financial Analysis

This chapter studies the financial feasibility of three cases; Case 1 representing a pilot plant of 3,000 tons per year only, Case 2 a commercial plant of 50,000 tons per year in addition to the pilot plant on the same site, including a scenario in which the pilot plant terminates operation on starting up of the commercial plant, and Case 3 a 50,000-ton-per-year commercial plant only, without installing the pilot plant.

15-1 Method of Financial Analysis

(1) Financial Statements

The financial evaluation is conducted in a manner which is universally applied to evaluation of industrial investment projects. To be specific, the following statements are developed as indicators of the financial standings of the project, such as ordinary profit or loss, and cash position in each year. As a measure to assess profitability of investment, financial internal rates of return of discounted cash flows are calculated.

Cost of Goods Sold
Profit Loss Statement
Fund Flow Statement
Balance Sheet Statement

(2) Financial Internal Rate of Return (FIRR)

In this study, as indicators of financial profitability of the project, Financial Internal Rate of Return on Investment (FIRROI) and Financial Internal Rate of Return on Equity (FIRROE), on both before-tax and after-tax bases, are calculated to evaluate the financial viability of the project. FIRROI is defined as an index of profitability of an investment project assuming that all the funds for investment is paid by the investor's own fund without drawing upon finances. It is considered as an index of profitability of the project, excluding the effects of the terms and conditions of loans and the debt to equity ratio. FIRROE

indicates the profitability of the invested capital itself rather than the entire investment under a given set of assumed terms and conditions of financing.

The internal rate of return is calculated according to the formula shown below.

$$\text{Sigma } (I=1 \text{ to } N)\frac{\text{CFE of } I}{(1+R)^I} = 0$$

where:

	FIRROI		FIRROE
(CFE)=	- Investment	(CFE)=	- Equity
	+ Revenue		+ Revenue
	- Operating Costs		- Operating Costs
	- Income Tax		- Interest
	- W/C Increase		- Income Tax
	+ Salvage Value Return		- Repayment of Debt
			- W/C Increase
			+ Salvage Value Return
R:	FIRROI		FIRROE
I:	Count of year		Count of year

15-2 Financial Analysis for the Pilot Plant

15-2-1 Major Premises and Inputs

This section explains major premises for and inputs to the financial analysis.

(1) Project Life

The project life is defined as the period from the start of preparation for bidding until the termination of the operation, consisting of the

following phases:

Preparation for Bidding: 6 months
Construction Period: 1.5 years
Operation Period: 20 years

(2) Price Base

The calculations are done in Thai Bahts on the basis of the constant price and cost of 1990 throughout the financial evaluation. The prices and costs estimated in Japanese Yen are converted into Bahts by using the following exchange rate:

1 Baht = 5.5 yen.

(3) Production and Sales Plan

Table 15-1 shows the production and sales plan of lignite briquettes. 15-2 summarizes the ex-plant price of lignite briquettes developed as a result of the market study in Chapter 5.

Table 15-1 Sales Plan of Lignite Briquettes

(Unit: Tons)

	1995	1996	1997 /2013	2014
Initial Inventory	0	120	150	150
Production	2,400	3,000	3,000	3,000
Final Inventory	120	150	150	0
Sales Volume	2,280	2,970	3,000	3,150

Table 15-2 Price of Lignite Briquettes

(Unit: Bahts/kg)

1995	2000	2005	2010
2.17	2.24	2.35	2.49

(4) Taxes

1) Sales Tax

One percent of the revenue is levied as sales tax on lignite briquettes.

2) Income Tax

A 35 percent corporate income tax is levied against net income before tax. However, in accordance with a preferential treatment provided by the Board of Investment of Thailand, this project will be exempted from the income tax for a period of eight years after the start of normal operation. In addition, a loss can be carried forward for five years to deduct from the taxable income.

(5) Depreciation and Amortization

The depreciation rates according to the tax law of Thailand are as follows:

Item	Depreciation Method	Salvage Value
Depreciation		
Machinery and Equipment	10 years straight line	0
Civil and Building	15 years straight line	0
Vehicle	8 years straight line	0
Amortization		
Preoperating cost	5 years straight line	0
Interest during Construction	5 years straight line	0

(6) Running Working Capital

The running working capital is the funds required for maintenance of the daily operation. In this study, the running working capital is defined as the balance between the current assets and the current liabilities, the former minus the latter, as explained below.

1) Current assets

(1) Cash in hand

The amount of cash equivalent to the man-power cost of two month is reserved.

(2) Raw materials inventory

Lignite equivalent to the requirements for 20 days, rice straws for 30 days, and slaked lime for 10 days, are reserved as inventory. The value of the inventory of raw materials is calculated by multiplying the amounts of inventory by unit costs of the individual raw materials.

(3) Products inventory

Lignite briquettes equivalent to the production of 15 days are reserved as inventory. The value of product inventory is calculated by multiplying the amount of inventory by unit production costs of lignite briquettes.

(4) Account receivable

Sales revenue of two months is counted as account receivable assuming that sales proceeds of lignite briquettes are collected two months after the sales.

2) Current liabilities

(1) Account Payable

The costs of raw materials equivalent to 2-month requirement are counted as account payable.

(7) Financing Plan

As discussed in Chapter 13, in accordance with the agreement between NEA and the study team established during the field survey, it is assumed that 60 percent of the total plant cost and 100 percent of the interest during construction are covered by a long-term loan, and the rest of the capital requirement by the own fund. The terms and condi-

tions of the long-term loan are as follows:

Interest rate: 9.0 percent per year
Repayment: 10 years/10 times
Grace period: 2 years after the start of plant operation

In the case that there is a shortage of funds during the normal operation period, the shortage is covered by a short-term loan on the following terms and conditions.

Interest rate: 9.0 percent per year
The terms of repayment: 1 year, or repaid in the year following the loan is introduced.

(8) Total Capital Requirement

Table 15-3 shows the summary of total capital requirements based on the constant price of 1990, given in Chapter 13.

Table 15-3 Total Capital Requirement for Pilot Plant

(Unit: 1,000 Bahts)

	1993		1994		Total
	Currency		Currency		
	Local	Foreign	Local	Foreign	
Plant Const. Cost	4,622	13,545	19,478	19,342	56,987
Preoperating Cost	320	5,455	480	0	6,255
Initial W/Capital	0	0	814	1,303	2,117
Current Price Base	5,945	19,575	28,473	21,484	75,477
IDC	286	0	2,398	0	2,684
1990 Constant Price	5,228	19,000	23,170	20,645	68,043

(9) Cost of Goods Sold and Other Expenses

Table 15-4 shows the costs of goods, general expenses and capital costs. The general expenses include, in addition to those directly related to the production of lignite briquettes, expenses for marketing activities, office expenses, fuel for vehicles, and other miscellaneous

expenses.

Table 15-4 Cost of Goods Sold and Other Expenses

(Unit: 1,000 Bahts)

	1995 80% Operation	1996 100% Operation
Raw Material Inventory at Beg.	141	176
Raw Material Purchased	2,280	2,806
Raw Material Inventory at End	176	176
Raw Material Cost	2,245	2,806
Variable Cost	1,453	1,743
Fixed Cost	6,517	6,517
Depreciation & Amortization	7,254	7,254
Production Cost	17,470	18,470
Finished Product Inventory at Beg.	0	878
Finished Product Inventory at End	879	922
Cost of Goods Sold	16,596	18,279
Expenses		
General Expense	4,180	5,078
Interest for Loans	3,509	4,407
Cost Of Goods Sold & Expenses	24,285	27,764

15-2-2 Results of Financial Analysis (Case 1)

(1) Financial Statements

The results of financial analysis based on the above premises and inputs are summarized in the following financial statements developed in the form of computer output attached to the end of this chapter.

Cost of Goods Sold
Profit and Loss Statement
Found flow statement
Balance sheet

These financial statements are explained below.

1) Cost of Goods Sold

The cost of goods sold is defined as the total of operating cost plus depreciation cost. The average cost of goods sold is approximately Bahts 7.3 and 3.7 per kilogram in the first and final years, respectivly.

2) Profit and Loss Statement

Loss will be registered during the entire period of the operation. Profits are not generated. The sum of the loss for the 20 years will exceed 492 million Bahts.

3) Cash Flow Table

As there is a shortage of funds from the operation, the project may be considered to be unprofitable.

4) Balance Sheet

The balance sheets indicate loss from this project. The short-term loan to recover loss at the end of the project year amounts to 463 million Bahts.

(2) Financial Internal Rate of Return, FIRR

As is obvious from the fund flow statements, the financial internal rates of return on both investment and equity, FIRROI and FIRROE, obtained for the pilot plant are negative for both before and after tax. This may be interpreted as indicating that the pilot plant itself is not considered as adequate from the standpoint of financial feasibility.

(3) Break Even Point (BEP)

This indicator is a ratio of the price of product required to recover the cost of production to the actual price of product, and is given by: BEP = Total Cost/Sales Revenue. When this indicator is greater than one, a loss is registered. Table 15-5 gives break even points for selected years.

Table 15-5 Break Even Point

(Unit: percent)

1995	2000	2005	2010
4.24	3.79	3.90	5.08

15-3 Financial Analysis of the Commercial Plants (Case 2 and Case 3)

As the sensitivities of financial analysis for the pilot plant, the cases of installing commercial plant are studied.

15-3-1 Major Premises and Inputs

The major premises and inputs used for the financial analysis are given below.

(1) Project Life

The conditions are the same as Case 1. However, the operation period for the financial evaluation for Case 3 is from 2000 to 2010.

(2) Price Base

The conditions are the same as Case 1.

(3) Production and Sales Plan

Table 15-6 shows production and sales plan for Case 2 and Case 3. Table 15-7 gives ex-factory netback prices of lignite briquettes developed as a result of the market survey described in Chapter 5.

(4) Taxes

1) Sales Tax

The conditions are the same as Case 1.

2) Income Tax

The conditions are the same as Case 1.

Table 15-6 Sales Plan of Lignite Briquettes

(Unit: Tons)

	1995	1996	1997 /1999	2000	2001	2002 /2013	2014
Case 2							
Initial Inventory	0	120	150	150	2,150	2,650	2,650
Production	2,400	3,000	3,000	43,000	53,000	53,000	53,000
Final Inventory	120	150	150	2,150	2,650	2,650	0
Sales Volume	2,280	2,970	3,000	41,000	52,500	53,000	55,650
Case 3							
Initial Inventory				0	2,000	2,500	2,500
Production				40,000	50,000	50,000	50,000
Final Inventory				2,000	2,500	2,500	0
Sales Volume				38,000	49,500	50,000	52,500

Table 15-7 Price of Lignite Briquettes

(Unit: Bahts/kg)

1995	2000	2005	2010
2.17	2.24	2.35	2.49

(5) Depreciation and Amortization

The conditions are the same as Case 1.

(6) Running Working Capital

The working capital is the same as Case 1 except for the followings.

1) Current Asset

(1) Raw materials inventory

Lignite equivalent to the requirements for 3-day operation is reserved as an inventory. The inventories of rice straws and slaked lime are the same as those for Case 1, 30 days for the former and 10 days for the latter. The value of inventory of raw materials is calculated by multiplying the amounts of inventory by the individual unit costs.

(7) Financing Plan

The conditions are the same as Case 1.

(8) Total Capital Requirement

Table 15-8 gives the summary of the total capital requirements based on the 1990 constant price base developed in Chapter 13.

Table 15-8 Total Capital Requirement For Case 2 and Case 3

(Unit: 1,000 Bahts)

	Local Currency	Foreign Currency	Total
Case 2			
Plant Construction Cost	129,843	112,546	242,389
Preoperating Cost	2,744	10,910	13,654
Initial W/Capital	3,165	4,944	8,109
IDC	10,956	0	10,956
1990 Constant Price	146,708	128,400	275,108
Case 3			
Plant Construction Cost	106,786	79,659	186,445
Preoperating Cost	1,944	5,455	7,399
Initial W/Capital	2,351	3,641	5,992
IDC	8,346	0	8,346
1990 Constant Price	119,427	88,755	208,182

(9) Cost of Goods Sold

Table 15-9 gives cost of goods sold and other expenses for Case 2 and Case 3. The general expense includes, in addition to those associated with the operation of the plants, the expenses for public relations, office supplies, fuel for the vehicles.

Table 15-9 Cost of Goods Sold and Other Expenses for Case 1 & Case 2

(Unit: 1,000 Bahts)

Case / Year	Case 2 2005	Case 3 2005
Raw Material Inventory at Beg.	3,117	2,940
Raw Material Purchased	49,579	46,773
Raw Material Inventory at End	3,117	2,940
Raw Material Cost	49,579	46,773
Variable Cost	24,470	22,727
Fixed Cost	19,679	13,162
Depreciation & Amortization	18,275	17,882
Production Cost	95,275	100,543
Finished Product Inventory at Beg.	5,994	5,184
Finished Product Inventory at End	5,600	5,027
Cost of Goods Sold	112,397	100,700
Expenses		
General Expense	1,703	1,033
Interest for Loans	18,329	7,907
Cost of Goods Sold & Expenses	132,429	109,640
(Cost per kilogram)	2.4	2.19

15-3-2 Results of Financial Analysis (Case 2)

(1) Financial Statements

The results of financial analysis based on the above premises and inputs are summarized in the following financial statements developed in the form of computer output attached to the end of this chapter.

Cost of Goods Sold
Profit and Loss Statement
Fund flow statement
Balance sheet

(2) Financial Internal Rates of Return, FIRR, Case 2

Table 15-10 shows the financial rates of return on investment and that on equity for both before and after tax obtained for Case 2.

Table 15-10 FIRR of Case 2

FIRROI		FIRROE	
Before Tax	After Tax	Before Tax	After Tax
4.1	3.5	-	-

The profitability of the project (Case 2) as indicated by FIRR's is not good enough to justify promotion of this case solely from the standpoint of financial feasibility. As a means of improving the financial feasibility of this case, an additional case, Case 2-1, which assumes suspension of the operation of the pilot plant on starting up of the commercial plant, is studied.

(3) Financial Analyses (Case 2-1)

1) Financial statements (Case 2-1)

The results of financial analysis based on the above premises and inputs are summarized in the following financial statements developed in the form of computer output attached to the end of this chapter.

Cost of Goods Sold
Profit and Loss Statement
Fund Flow Statement
Balance Sheet

2) Internal rate of Return (Case 2-1)

Table 15-11 shows financial internal rates of return, FIRR's, obtained for Case 2-1.

Table 15-11 FIRR of Case 2-1

FIRROI		FIRROE	
Before Tax	After Tax	Before Tax	After Tax
5.7	4.6	2.4	-

3) Break Even Point

The breakeven points are shown below.

(Unit: percent)

1995	2000	2005	2010
4.24	1.33	1.01	0.74

15-3-3 Results of Financial Analysis (Case 3)

(1) Financial Statements (Case 3)

The results of financial analysis based on the above premises and inputs are summarized in the following financial statements developed in the form of computer output and attached to the end of this chapter.

Cost of Goods Sold
Profit and Loss Statement
Fund Flow Statement
Balance Sheet

The summary of each financial statement are given in the following:

1) Cost of Goods Sold

The cost of goods sold is defined as the sum of operating and depreciation costs. The average cost of goods sold is approximately Bahts 2.3 and 1.7 per kilogram in the first and in the final years, respectively.

2) Profit and Loss Statement

Loss will be registered during the initial three years of the operation. Profits are generated after that. On the 9th year, the project begins paying tax on expiration of the tax-holiday incentive. The sum of the profits after tax for the 15 years will exceed 169 million Bahts.

3) Cash Flow Table

Although there is a shortage of funds for the initial year of commercial operation, there will be expected a cash surplus from the 2nd

year. The project may be considered to be profitable. The total cash surplus at the end of the 15th year amounts to 250 million Bahts.

4) Balance Sheet

The balance sheets indicate good profitability of this project. The reserved cash at the end of the project year amounts to 250 million Bahts.

(2) Internal Rate of Return and Pay-Back Period

Table 15-12 gives FIRROI and FIRROE before and after tax as a measure for the profitability of investment.

Table 15-12 FIRR of Case 2-1

FIRROI		FIRROE	
Before Tax	After Tax	Before Tax	After Tax
11.6	10.0	14.3	11.7

(3) Major Financial Indicators

1) Debt Service Coverage Ratio (DSR)

DSR is an indication of the capability for repaying a loan, and is defined by the following equation.

DSR = (Profit after Tax + Depreciation + Interest - Increase of WC) /
(Repayments + Interests)

A DSR of more than one indicates that the fund generated by the operation is sufficient to meet the liability to honor the payment of principal and interest of the loan. Case 3 requires introduction of additional funds for the first year of operation as indicated by DSR's less than one. However, if the shortages are made up for by a short-term loan of the assumed conditions, the available cash exceeds the amount required for debt service from the second year on. In view of this,

this project may be classified as capable of repaying the long-term loan.

2) Break Even Point (BEP)

The BEP is calculated by the following equation.

BEP = Total production Cost / Sales Revenue

This indicates the product price at which sales revenue is equal to production cost. In other words, a loss is registered in the case that BEP exceeds 1.0. In the case of this project, the average BEP is 0.87.

(4) Sensitivity Analysis

The sensitivity of the financial rates of return to the variations of important parameters is studied. The parameters varied and the ranges of variation are as follows:

Price of product	plus and minus 10 percent
Plant construction cost	plus and minus 10 percent
Cost of raw materials	plus and minus 20 percent
Financing condition	Interest rates, 5 and 16 percent
Debt/Equity ratio	Equity, 20 and 40 percent
Operation rate(%)	

Case	A	B	C
1st year	20	30	40
2nd year	40	50	60
3rd year	60	70	80
4th year	80	90	100
5th year	100	100	100

The results of the sensitivity analysis are as follows.

1) Sensitivity to Product Price

Variation of this parameter greatly affects the profitability of the project. FIRROI (after tax) and FIRROE (after tax) increase by 5.2 and