Environmental Assessment Report

Summary Environmental Impact Assessment
Project Number: 41939-01
February 2008

Thailand: Biomass Power Project

Prepared by Biomass Electricity Company Limited for the Asian Development Bank (ADB)

CURRENCY EQUIVALENTS
(as of 31 December 2007)

Currency Unit	–	baht (B)
B1.00	=	$0.0296
$1.00	=	B33.8

ABBREVIATIONS

ADB	–	Asian Development Bank
BECO	–	Biomass Electricity Co. Ltd.
CFB	–	Circulating Fluidized Bed
CO_2	–	carbon dioxide
EGAT	–	Electricity Generating Authority of Thailand
EIA	–	environmental impact assessment
EMU	–	environmental management unit
EMP	–	environmental management plan
ESP	–	electrostatic precipitator
NO_2	–	oxides of nitrogen measured as nitrogen dioxides
ONEPP		Office of Natural Resources and Environmental Policy and Planning
NPS	–	National Power Supply Company Limited
pH	–	potential of hydrogen, measurement of acidity or alkalinity of liquid
PM_{10}	–	particulate matter of 10 microns in size or less
SEIA	–	Summary environmental impact assessment
SO_2	–	sulfur dioxide
TSP	–	total suspended particulates
304-IP	–	Industrial Park on Highway 304

WEIGHTS AND MEASURES

^oC	–	degree Celsius
dB(A)	–	decibel acoustic
ha	–	hectare
km	–	kilometer
kV		kilovolt
m	–	meter
m^3	–	cubic meter
m^3/hr	–	cubic meter per hour
mg/l	–	milligram/liter
mm		millimeter
t	–	ton
tpd	–	ton per day
MW	–	megawatt
ppm	–	parts per million

NOTE

In this report, “$” refers to US dollars.

CONTENTS

Map 1

08-0511 R. Marmita

I. INTRODUCTION

1. The Biomass Power Project (the Project) is developed by the Biomass Electricity Co. Ltd. (BECO) to supply the 304 Industrial Park (304-IP) on Highway 304, and sell the remaining power to the Electricity Generating Authority of Thailand (EGAT) under the small power producer program. The power plant has a total capacity of 165 megawatts (MW), of which 15 MW will be for internal consumption, 60 MW for the 304-IP, and 90 MW for EGAT. The Project will also sell steam to some industries in the 304-IP.[1] The Project will use rice husks as the primary fuel, and waste wood and wood chips as secondary fuels. The Project has arrangements with rice mills and wood processing industries to ensure adequate long-term supply of rice husks and waste wood.

2. The Project is to be located in the 304-IP, about 150 kilometers (km) east of Bangkok (Map 1). The core project site, where the power plant is to be located, comprises 16.35 rais[2] (2.62 hectares [ha]) of vacant land adjacent to the existing 300 MW power plant of the National Power Supply Company Limited (NPS).[3] In addition, the Project has acquired 62.65 rais (10.024 ha) to be reserved for emission control in compliance with permissible emissions per unit area (para. 50). The 304-IP has a total area of about 2,762 rais (441.92 ha), of which 1,853 rais (296.48 ha) are occupied by 66 factories (as of August 2007). Of these 66 factories, 16 have a total of 45 emission stacks. Emissions from these point sources were included in the study of the Project's impact on air pollution.

3. The assessment of the Project's environmental and social impacts was conducted from January to August 2005. The environmental impact assessment (EIA) report was submitted to the national EIA authority, the Office of Natural Resources and Environmental Policy and Planning (ONEPP) on 22 August 2005. Subsequently, four supplementary documents were submitted to ONEPP, the last one on 28 August 2007, to clarify and provide additional details on operations. The Project is expected to receive environmental clearance from ONEPP soon. The Project has received all permits required for various operations from the concerned national and provincial authorities. It is now ready for implementation.

4. BECO prepared this summary environmental impact assessment for the use of the Asian Development Bank (ADB) in line with ADB's environmental and social safeguard policies and information disclosure for environmental category A[4] projects. The report summarizes and consolidates the major findings and recommendations presented in all five EIA documents.

II. DESCRIPTION OF THE PROJECT

A. Project Facilities

5. The project facilities to be constructed by BECO include the power plant and some support facilities. As the project site is adjacent to the NPS power plant, the project power plant will utilize some of the NPS power plant facilities, including water demineralization plant and storage areas for rice husks, waste wood, and wood chips. The project power plant will also use existing infrastructure and services provided by the 304-IP, including access road, drainage system, water supply, and wastewater management system.

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[1] The 304-IP is currently supplied by a 300 MW coal-fired power plant owned and operated by the National Power Supply Co., Ltd.

[2] A rai is a unit of area measurement in Thailand. One rai is equal to 1,600 square meters. One hectare is equal to 6.25 rais.

[3] BECO and NPS are allied companies within the AA Alliance group of companies.

[4] Projects in environmental category A are projects that would result in significant environmental impacts if proper mitigation measures are not included in the design, construction, and operation.

6. **Power Plant**. The power plant will be a single unit of circulating fluidized bed (CFB) boiler furnace and steam turbine generator. The CFB boiler furnace will be designed specifically for burning rice husks and wood waste. Diesel oil will be used only for start-up and flame stabilization. Figure 1 provides a process flow chart of the power plant. Figure 2 shows the basic plant layout. Table 1 summarizes the main design and operating data.

Table 1: Summary of the Main Design and Operating Data of the Power Plant

Item	Unit	Design Value
Annual production capacity	GWh	1,224
Number of operating days per annum	days	350
Number of operating hours per annum	hours	8,400
Average production per day	MWh	3,600
Plant efficiency	%	36
Design production capacity	MWe	150 net
Steam production, MCR	Kg/sec	150
Rice husk heating value	MJ/kg	19.9
High pressure steam, pressure	bar	162
High pressure steam, temperature	^{o}C	540
Flue gas temperature	^{o}C	140
Steam generation	MT	540

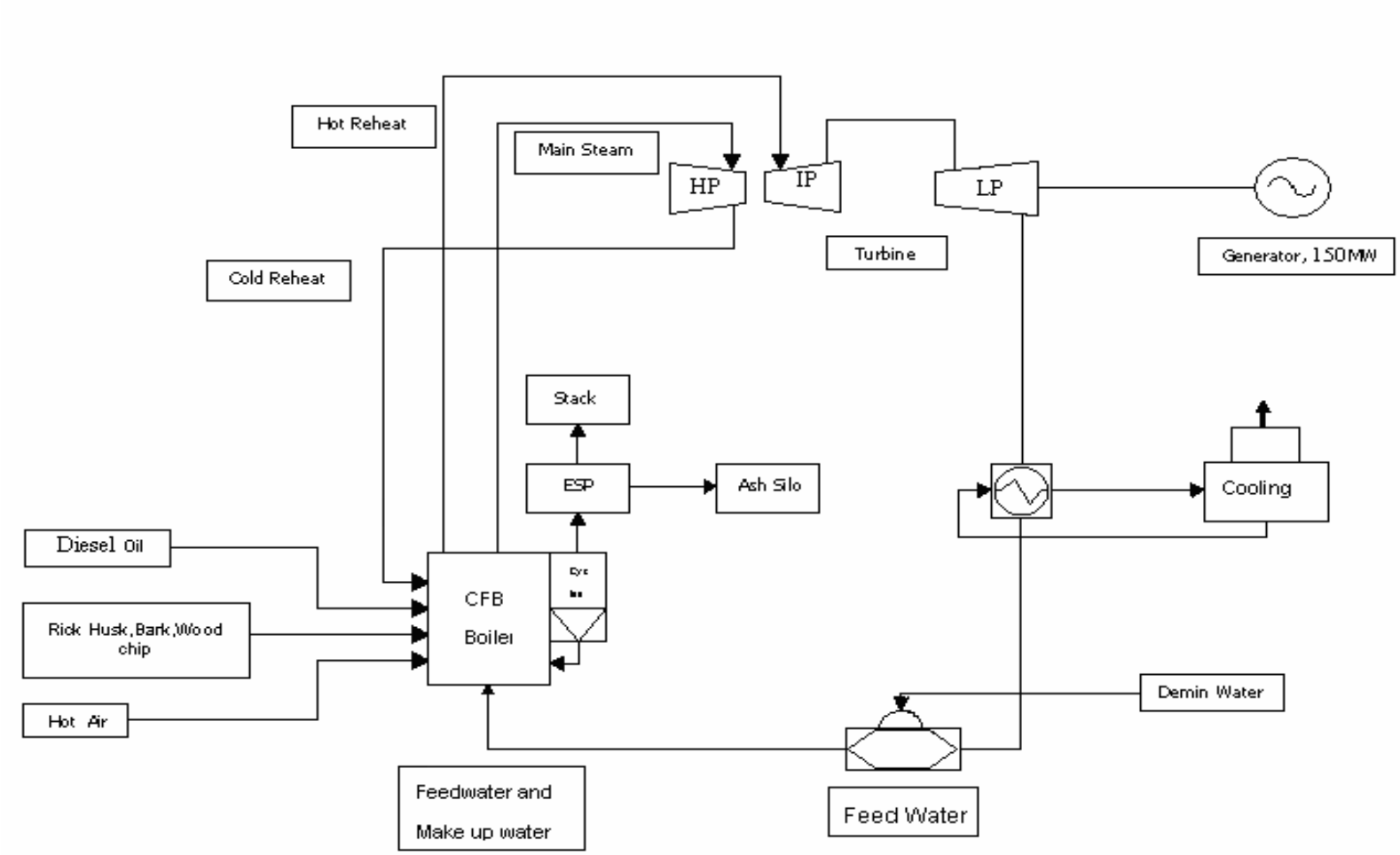
^{o}Celcius = degree Celsius, GWh = gigawatt-hour, Kg/sec = kilogram per second, MCR = maximum continuous rating, MJ/kg = mega joules per kilogram, MT = metric ton, MWe = megawatt-electricity, MWh = megawatt-hour.
Sources: EIA Reports, 2005-2007.

7. **Distribution System.** The distribution system will comprise (i) three transformers, one each for increasing the 13 kilovolt (kV) output voltage to 115 kV for feeding the electricity to the existing EGAT system, for increasing the 13 kV output voltage to 22 kV for feeding the electricity to the 304-IP system, and for system start-up and emergency; and (ii) a switchyard for feeding the electricity through 115 kV double-circuit transmission lines to the EGAT substation about 1 km away, and through 22 kV double-circuit transmission lines to supply electricity to the 304-IP system. All the transformers will be force oil, force air cool design, which do not use PCB (polychlorinated biphenyl).[5]

8. **Cooling Water System.** The power plant will use a closed cooling water system with seven mechanical induced draft cooling towers with a circulating water flow of 25,000 cubic meters (m^3)/hour. The cooling towers will require about 12,068 m^3/day of makeup water to compensate for evaporation and drift losses (total about 10,344 m^3/day), and for part of the cooling water (about 1,724 m^3/day) that has to be discharged from the cooling system (known as cooling tower blow down). The water for cooling will be purchased from the effluent reservoir of the 304-IP.

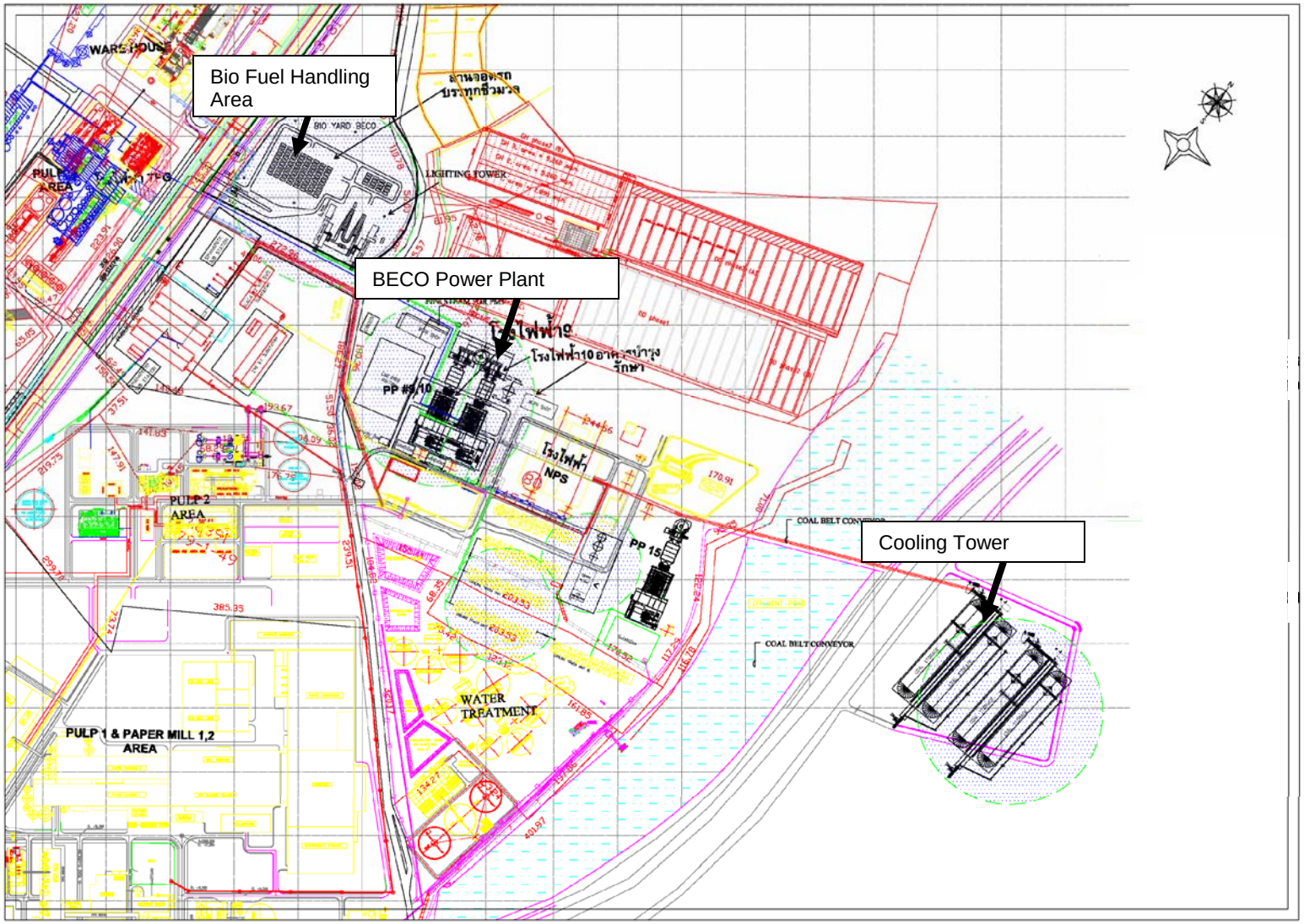
[5] A synthetic, organic chemical once widely used in electrical equipment. It is highly poisonous and carcinogenic, and can accumulate in the food chain.

Figure 1: Process Flow Chart of the Power Plant



CFB = Circulating Fluidized Bed, demin = demineralized, ESP = electrostatic precipitator, HP = high pressure, IP = intermediate pressure, LP = low pressure.
Source: Biomass Electricity Company Limited.

Figure 2: Basic Plant Layout



Source: Biomass Electricity Company Limited.

B. Design and Construction

1. Design

9. The design of the power plant and support facilities will strictly follow the applicable international and/or national standards, whichever are approprite. The project area is not seismically active. The design will thus require a minimum safety factor for lateral ground movement.

2. Construction

10. The construction will be completed within about 24 months, of which about 10 months will be for erection of power plant equipment. The construction will require a maximum of about 300 workers. About half or more of the required workers will be recruited from nearby areas to minimize the need for temporary worker accomodations.

11. The site for the power plant is fairly graded with minimum undulation and will require nominal filling and grading to about 0.5 meters (m) above the existing ground level. Filling materials, mainly laterite soil, will be sourced from nearby areas.

12. Civil works under the Project will involve construction of (i) a steel and concrete structure to house the power plant equipment, (ii) control rooms and administrative office, (iii) various support facilities, and (iv) such facilities as internal road and parking space. Mechanical and electrical works will involve on-site fabrication, assembly, installation and erection of power plant equipment, control system, power system, and various utility systems. Construction materials and plant equipment will be hauled by trucks to the project site. About 20 truck trips per day will be required for transport of materials and equipment and about 15 bus trips per day for worker transport during construction.

C. Material Inputs and Outputs during Operation

1. Inputs

13. Major material inputs are rice husks and supplementary fuels, water, and small quantities of some chemicals. Table 2 presents the quantities of material inputs required by the project power plant.

14. **Fuel.** BECO has secured the long-term supply of rice husks from rice mills affiliated with the holding company. Waste wood and wood chips will be supplied by three pulp mills inside the 304-IP under the same holding company. During the initial years of operation, the fuel composition will be 90% rice husks and 10% waste wood fuels. This composition will be gradually changed to 75% rice husks and 25% waste wood, and eventually to 75% rice husks and 25% wood chips.

15. **Water.** The NPS power plant will supply the project power plant with demineralized water. Water for the cooling water system and other uses will be supplied by the 304-IP.

Table 2: Material Inputs Required for Power Plant Operation

Materials	Quantity	Use
Rice husks (tons/day)	1,977–2,372	Primary fuel
Wood chips (tons/day)	708	Secondary fuel
Wood waste (tons/day)	1,206	Secondary fuel during the initial period of operation
Diesel oil (tons/year)	45	Start-up and flame stabilization
Sand (tons/day)	7.94	Heating medium in CFB boiler furnace
Urea solution (m^3/day)	5	Reduction of NO_2
Various chemicals		Cooling water quality control and corrosion control
Cooling water (m^3/day)	12,068	Makeup water for cooling tower system
Piped water supply (m^3/day)	107	Process use (100 m^3/day) and office consumption (7 m^3/day)
Demineralized water (m^3/day)	3,110	Steam production

CFB = Circulating Fluidized Bed, m^3 = cubic meter, NO_2 = nitrogen dioxide.
Sources: EIA Reports, 2005-2007.

2. Outputs

16. The major outputs from the power plant, in addition to gaseous emissions and wastewater, are bottom ash and fly ash. The power plant will produce about 424 tons per day (tpd) of ash comprising about 74 tpd of bottom ash (about 20%) and 350 tpd of fly ash (80%). All ash will be used for cement production by Siam City Cement (Appendix 1). Bottom ash collected in the bottom ash hopper below the boiler furnace will be pneumatically conveyed to the bottom ash silo (150 m^3 capacity). Similarly, fly ash collected in the hoppers of the electrostatic precipitators will be pneumatically conveyed to the fly ash silo (600 m^3 capacity). Both bottom ash and fly ash will be regularly transported by covered trucks to a cement industry user as is currently practiced by the adjacent NPS power plant.

D. Land Acquisition and Resettlement

17. Land acquisition and resettlement is not an issue as the Project is located in the 304-IP.

E. Project Schedule and Contracts

18. The Project will be constructed through a number of contract packages to be implemented by reputed international and local contractors and suppliers with good track records. Figure 3 provides a tentative schedule for project implementation. The construction is expected to commence in May 2008. The Project is scheduled for commission by January 2010 and for full commercial operation by April 2010.

F. Project Management and Operation

19. BECO will be responsible for the overall management of project implementation, both construction and operation. Project implementation will be the responsibility of a project manager. Figure 4 provides an organization chart for project implementation during construction. During full commercial operation, the power plant will require about 60 staff. Figure 5 provides an organization chart for power plant operation.

III. DESCRIPTION OF THE ENVIRONMENT

A. Physical Environment

1. Overview of the Project Area

20. The 304-IP is located in Prachinburi Province, about 150 km east of Bangkok. It is linked with Bangkok and other areas by Highway No. 304. The 304-IP and surrounding areas within a 5-km radius (the study area) are rolling plain with infertile soil and limited water resources. The study area has been developed for industrial use, but a large part is still used for growing cash crops, especially cassava. The study area has no sensitive areas such as national parks; wildlife sanctuaries; biosphere reserves; historical and cultural sites; defense installations; or places of historical, religious, and cultural importance. The study area includes 17 villages with a total of about 3,888 households. The nearest village to the project site is Buyaibai, about 1.34 km southeast of the power plant site.

2. Climate

21. Climatic conditions of the study area were identified from data routinely collected by the meteorological station at Kabinburi, about 12 km from the project site. The data covers 30 years from 1971 to 2000.

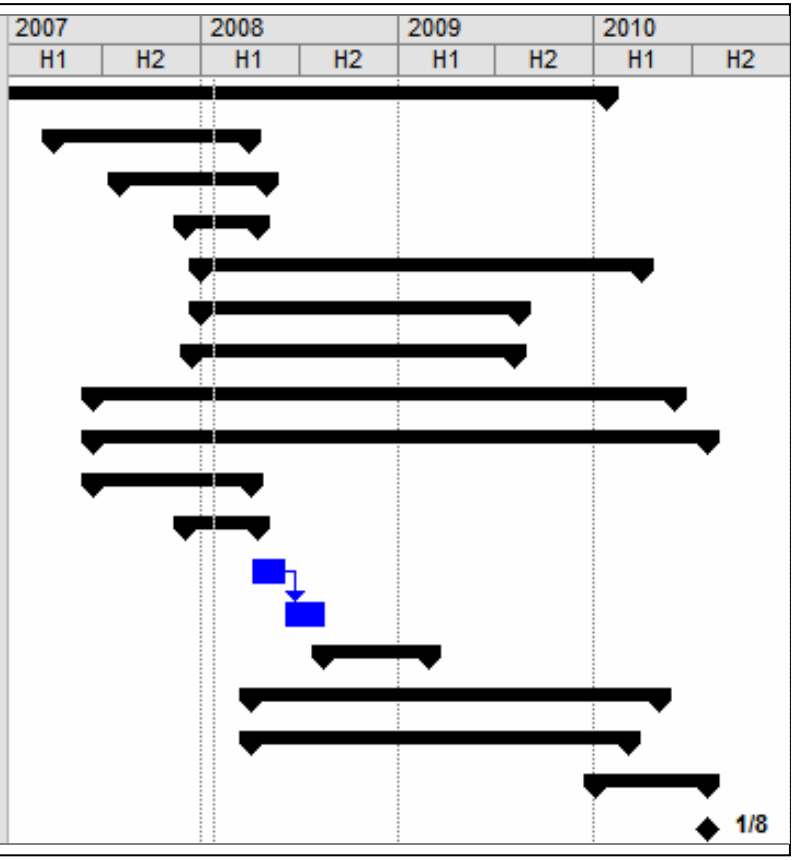
22. The climate of the study area in general is characterized by two distinct seasons: (i) dry season from November to April, and (ii) rainy season from May to October. Monthly mean temperatures are relatively uniform throughout the year, varying from 25.5 to 29 degrees Celsius (^{o}C) with mean maximum temperatures between 31.7^{o}C and 36.9^{o}C, and mean minimum temperatures of 19.4^{o}C–24.9^{o}C Extreme maximum temperatures are normally experienced in April with temperatures above 40^{o}C (42.9^{o}C recorded). Extreme minimum temperatures are normally on record in December with temperatures as low as 8.5^{o}C.

23. The study area receives rains from the southwest monsoon with more frequent rainfall from July to September. The average annual rainfall over the record period was 1,662.2 millimeters (mm) with an annual average daily rainfall of 132.8 mm. Rainfall is most intense in August with an average total of 314.5 mm. December has the least amount with an average total rainfall of only 5.3 mm.

24. The prevailing wind directions in the study area are (i) from October to January northeasterly, and (ii) from February to September westerly. An exception is April in which southwesterly winds are dominant. Monthly average wind speeds varied from 1.0–3.1 knots. The maximum wind speed on record was 99 knots in October.

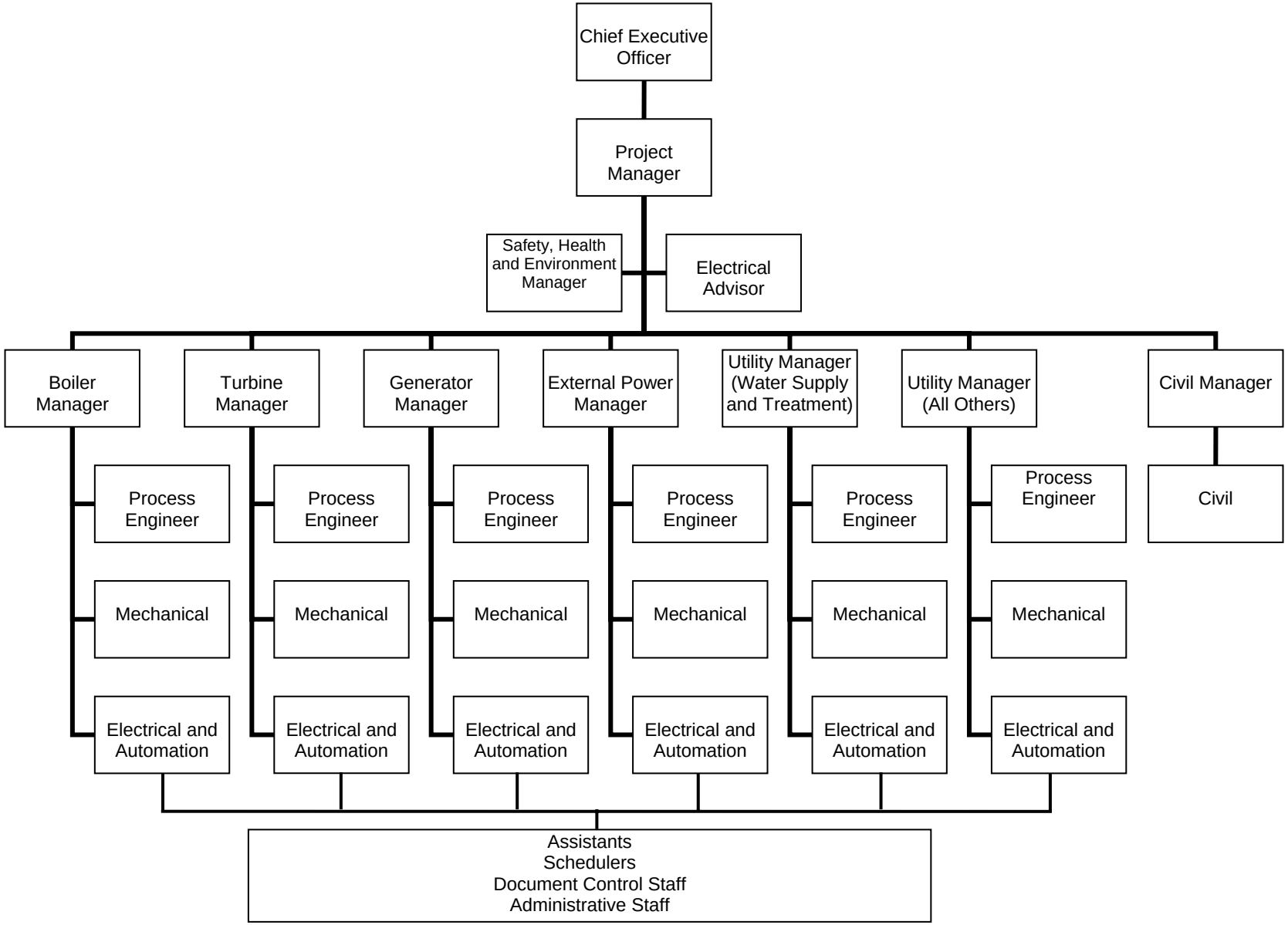
Figure 3: Tentative Implementation Schedule

Task Name	Start	Finish
1. Permits & Licenses	Mon 1/8/05	Sat 23/1/10
2. Supply chain agreement	Sun 1/4/07	Fri 28/3/08
3. Funding	Wed 1/8/07	Mon 28/4/08
4. Civil Procurement	Sun 2/12/07	Tue 15/4/08
5. Civil Works	Tue 1/1/08	Tue 30/3/10
6. Miscellaneous	Tue 1/1/08	Thu 13/8/09
7. BOP	Sat 15/12/07	Thu 6/8/09
9.Power Plant Unit 9	Fri 15/6/07	Sun 1/8/10
1. Machine Procurement	Fri 15/6/07	Tue 1/4/08
2. Civil Procurement	Sun 2/12/07	Tue 15/4/08
4. Machine Design Engineering	Wed 2/4/08	Sat 31/5/08
5. Civil design Engineering	Sun 1/6/08	Thu 14/8/08
6. Civil Construction	Fri 15/8/08	Wed 25/2/09
7. Boiler Island Fabrication and Delivery	Wed 2/4/08	Sun 2/5/10
8. Turbine Island Fabrication and Delivery	Wed 2/4/08	Sun 7/3/10
9. Coomissioning, Training and Test Run	Mon 4/1/10	Sun 1/8/10
10. COD	Sun 1/8/10	Sun 1/8/10



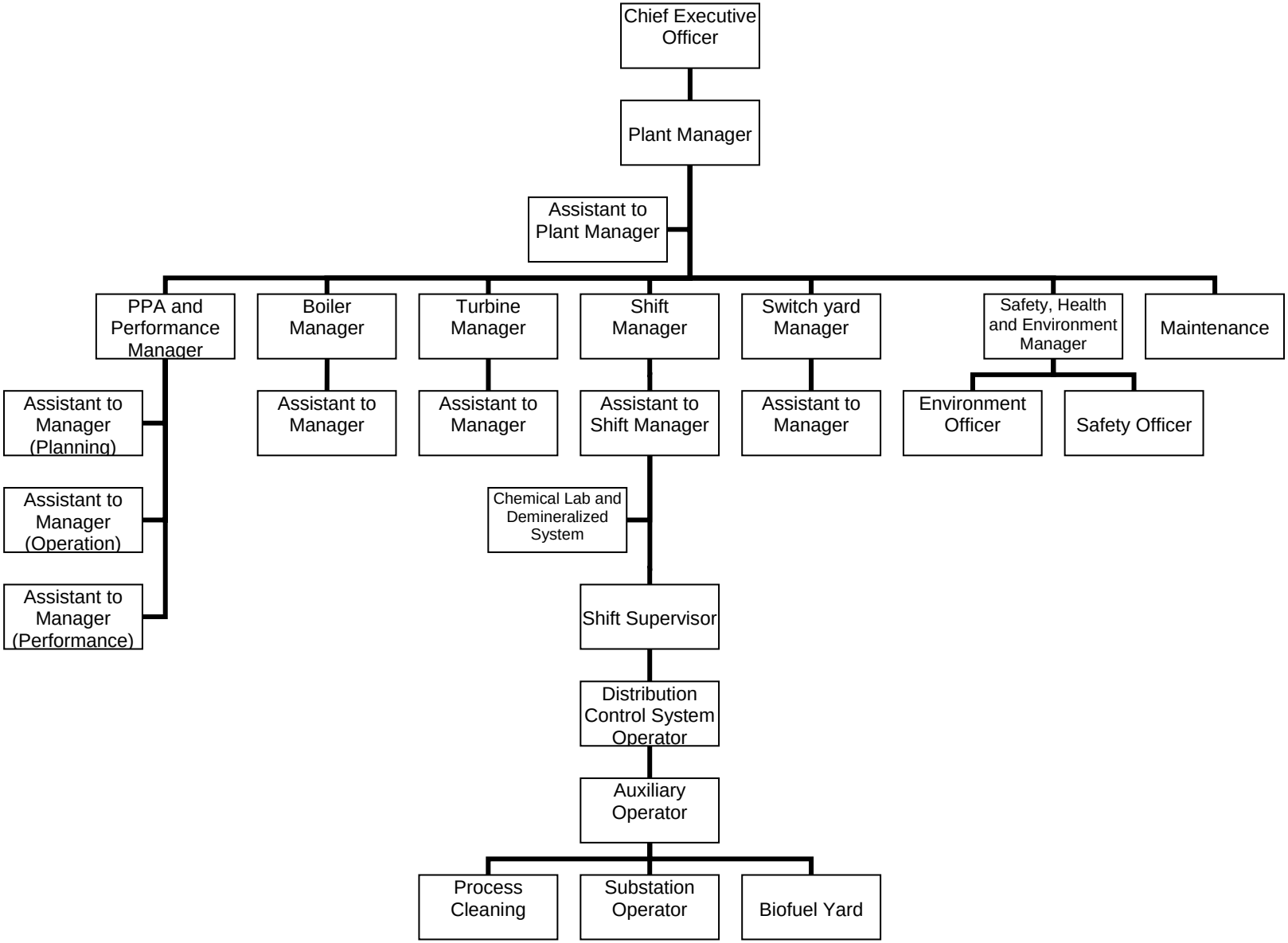
BOD = Balance of Plant, COD = Commercial Operation Date.
Source: Biomass Electricity Company Limited.

Figure 4: Organization for Project Implementation



Source: Biomass Electricity Company Limited.

Figure 5: Organization for Project Operation



Lab = laboratory, PPA = Power Purchase Agreement.
Source: Biomass Electricity Company Limited.

3. Drainage

25. The project area drains into various small tributaries of the Prachinburi River about 4 km from the project area. Flooding is not common in the project area. The area has two natural canals: Chalongwaeng Canal and Rung Canal. On their courses to the Prachinburi River, these canals are used for agriculture, fishery, and domestic purposes.

4. Water Resources

26. Due to its topography, the region in which the 304-IP is located has limited water resources. The 304-IP has three raw water reservoirs with a combined storage capacity of about 44 million m^3, adequate to meet the current water demand within the 304-IP of about 24.3 million m^3 per annum. The 304-IP obtains raw water from (i) diversion of flows from Chalongwaeng Canal during the high flow period from August to October; (ii) pumping from the two canals in June, July, November, and December; and (iii) pumping from the Prachinburi River at a rate of about 200,000 m^3/day during the rainy season. The water stored is adequate to meet water demand during the dry season.

5. Water Quality

27. **Surface Water.** The 304-IP has been conducting water quality monitoring at three stations: (i) SW1: Rung Canal upstream or before entering the 304-IP; (ii) SW2: Rung Canal downstream of the effluent storage pond of the 304-IP; and (iii) SW3: Chalongwaeng Canal in its 500 m reach in the 304-IP. The water quality parameters monitored are temperature, pH, biological oxygen demand, dissolved oxygen, oil and grease, total coliform bacteria, ammonia nitrogen, and nitrate nitrogen. The monitoring was conducted once every 3 months and only grab water samples were collected. The latest water quality data (Table 3) indicate that the water quality meets the water quality standards for class 3 water for agricultural use and consumptive use after appropriate treatment.

Table 3: Surface Water Quality, November 2007

Quality Parameter	Station SW1	Station SW2	Station SW3	Standards for Class III
Temperature	28	29	27.5	<40
pH	6.51	6.66	6.4	5.5-9.0
Dissolved oxygen	7.5	11.9	7.4	≥4.0
BOD_5	3.3	5.4	0.8	≤ 2.0
Total coliform bacteria	≥ 130,000	280	310	<20,000
Oil and grease	0.8	0	0	-
Nitrate nitrogen	0.73	0.32	0.58	<5.0
Ammonia nitrogen	0.24	0.23	0.20	< 0.5

BOD_5 = 5-day biological oxygen demand, pH = measure of acidity.
Sources: EIA Reports, 2005-2007.

28. **Groundwater.** Available data on groundwater quality from the Department of Mineral Resources indicate that groundwater in the study area has a high pH and high concentrations of iron and harness exceeding the permissible limits for drinking water.

6. Ambient Air Quality

29. The 304-IP has been conducting ambient air quality monitoring at seven stations selected considering their sensitivity to air quality (Table 4). The air pollutants monitored include (i) total suspended particles (TSP), (ii) particulate matter with size smaller than 10 microns

(PM_{10}), (iii) sulfur dioxide (SO_2), and (iv) nitrogen oxide (NO_2). The monitoring was conducted three times per year, normally in January, August, and December. In each monitoring, air samples were collected over a 24-hour period using continuous air samplers. Data obtained from the surveys in 2006 and 2007 are summarized in Table 5. The monitored air quality indicate that TSP, PM_{10}, SO_2, and NO_2, values were well within the national ambient air quality standards as well as World Bank guidelines for residential and rural areas (Appendix 2).

Table 4: Air Quality Sampling Stations

Station	Place	Distance from the Power Plant (kilometers)
A1	Office of 304-Industrial Park	3.80 southwest
A2	Poengpai Temple	3.98 southwest
A3	Buyaibai Temple	1.34 southeast
A4	Barn Toongparpas School	5.00 southeast
A5	Tatoom Health Service Office	4.00 northwest
A6	Koek Somsiao Village	2.00 northeast
A7	Barn Koek Kraton School	5.25 northeast

Sources: EIA Reports, 2005-2007.

Table 5: Ambient Air Quality Data for the Period 2002-2004

Station	PM10	TSP	SO2	NO2
A1	0.3-0.05	0.02-0.29	<0.001-0.023	<0.001-0.063
A2	0.02-0.04	0.03-0.30	<0.001-0.025	<0.001-0.018
A3	0.02-0.11	0.04-0.31	<0.001-0.025	<0.001-0.028
A4	0.02-0.11	0.03-0.22	<0.001-0.005	<0.001-0.029
A5	0.02-0.11	0.05-0.19	<0.001-0.011	<0.001-0.018
A6	0.02-0.09	0.03-0.11	<0.001-0.005	<0.001-0.029
A7	0.02-0.10	0.02-0.28	<0.001-0.122	<0.001-0.03

[a] PM10 and TSP in milligram per cubic meter.
[b] SO2 and NO2 in ppm.
Sources: EIA Reports, 2005-2007.

7. Noise

30. The 304-IP monitored ambient noise at air quality monitoring stations A1, A2, and A3. Noise was measured on an hourly basis continuously for 72 hours (the most recent measures are presented in Table 6). The monitored noise at all the locations was within the prescribed limits of the national noise standards and World Bank guidelines of 70 decibels acoustic (dB[A]).

Table 6: Latest Noise Monitoring May–June 2007

Station	24 Average, Leq dB(A)	L- max dB(A)
A1 (304-IP)	56.0	72.4
A2 (Poengpai Temple)	50.0	77.3
A3 (Buyaibai Temple)	57.8	100.1
Standard limit	70.0	115

dB(A) = decibel acoustic.
Sources: EIA Reports, 2005-2007.

8. Land Use

31. Land use in the study area (about 78.56 km^2) in Amphoe Srimahaphote and Kabinburi was established from interpretation of aerial photographs and ground truth surveys. Agricultural use is still dominant followed by industrial use (Table 7).

9. Soil

32. Soil in the project area is largely sandy and clay with low to medium water absorption capacity. This soil has low fertility and is suitable only for growing cash crops.

Table 7: Land Use Classification within 5 Kilometer Radius

Land Use Class	% of Total Area
Communities	3.88
Industrial areas	16.45
Agriculture	73.68
Other uses including water areas	5.99
Total	**100.00**

B. Biological Environment

33. The study area has no forests. The nearest protected forest is about 150 km away. The area has no rare terrestrial flora and fauna species. The two canals in the project area are not sensitive aquatic ecosystems and have no record of rare and endangered aquatic flora and fauna.

C. Sociocultural Environment

34. The area within a 5 km radius of the 304-IP has a total population of about 16,800 in 3,888 households. All the villages have electricity and basic social infrastructure and services including schools, health and medical services, access roads, water supply, telephone services, and public transportation. Agriculture is the main occupation of most households. Some household members work for industries in the area. The 304-IP is located in Tambon[6] Tatoom (or Tatoom District). Tambon Tatoom has a total area of 30,694 rais (about 4,911 ha) and comprises 10 villages with a total population of 9,379 in 2,172 households (2006 data). The overall population density was about 191 people per km^2. The average household size was about 4.32.

IV. ALTERNATIVES

35. **With and Without Project Alternatives.** The Project is needed to meet increasing electricity demand of industries in the 304-IP and to respond to the national policy on increasing the use of renewable energy to reduce overdependence on fossil energy. In 2006, electricity generated by natural gas accounted for about 66.2 % of total electricity production.

36. **Alternative Fuels.** Biomass fuels, such as rice husks and wood waste, are selected as the main nonfossil fuels to increase the share of renewable energy in electricity generation in Thailand. As BECO is a subsidiary of a large agro-industry conglomerate, which operates rice

[6] A tambon is the third tier of the local administration system in Thailand: the country has 76 provinces, each consisting of a number of amphoes, each amphoe consists of a number of tambons, each tambon consists of a number of villages.

mills and pulp mills,[7] rice husks, wood waste, and wood chips are the preferred biomass for the Project. The Project will therefore convert waste to energy, thus increasing the value chain of the conglomerate's business.

37. **Alternative Project Locations.** The 304-IP is the preferred project location considering (i) the electricity demand of industries in the 304-IP, (ii) the existing 115 kV transmission lines of EGAT only about 1 km away, (iii) surplus capacity of some utilities of the NPS power plant, (iv) the 304-IP is exclusively for industrial development, and (v) convenient access to rice husks and wood waste from the pulp mills in the 304-IP. These factors have ruled out other alternative sites outside the 304-IP.

38. **Alternative Cooling Systems**. As water resources are limited, a once-through cooling system is not technically and environmentally feasible. The closed cooling system is the only technically, environmentally, and financially viable alternative.

39. **Alternative Technologies**. CFB technology is widely adopted for small- and medium-scale power plants due to its advantages over other conventional mass combustion and fluidized bed technologies, particularly low emission of nitrogen oxides and carbon monoxide, relatively higher thermal efficiency, ease in control of sulfur dioxide, operating stability, flexible operations capable of burning several types of fuels, and easy maintenance.

V. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

A. Physical Environment

1. Impacts during Construction

40. The construction of the power plant and its support facilities will involve activities that will unavoidably create environmental disturbances normally encountered in major construction projects, such as traffic congestion, noise, dust, and gaseous emissions of construction equipment and vehicles. These disturbances during construction are transient and most are confined to the construction site. They can be minimized through good construction management practices and construction methods that minimize environmental disturbances.

41. **Air Pollution.** The major sources of air pollution during construction are (i) emissions from vehicles, generator sets, and heavy construction equipment; and (ii) fugitive dust from vehicle movement and soil excavation. Impacts will be minimized through established mitigation measures to be included in the construction contract for contractors to strictly implement. Such measures include (i) suppression of fugitive dust by water spraying, (ii) use of low emission vehicles and construction equipment, and (iii) good maintenance of engines.

42. **Noise**. Construction noise is created by vehicles, heavy equipment, and some construction activities such as erection of equipment and percussion piling. The 24-hour average noise levels at stations A2 and A3, the communities nearest the project site, during construction is predicted to be less than 70 dB(A). However, to minimize public disturbance, construction noise will be reduced through the use of various appropriate measures such as noise enclosures, noise walls, and speed restrictions for vehicles. Construction workers in areas with excessive noise will wear ear protection. Noise reduction and impact mitigation measures during construction will be prescribed in the construction contracts.

[7] The pulp mills use wood from eucalyptus tree plantations adjacent to the 304-IP.

43. **Oil and Chemical Spills**. Fuel oil and chemical storage facilities at the construction site will be designed with adequate protections for spillage, such as bund surrounding the oil tank, and fire accidents.

44. **Runoff.** During the early stage of construction, site grading and excavation could add considerable silt load into the surface runoff from the construction site, thereby contributing to the silting of the receiving water bodies. This problem will be minimized through such measures as (i) undertaking site grading and excavation for foundations and back filling during the dry season; and (ii) if called for, the silt-laden runoff will be retained in a settling basin to remove silt before discharging into the receiving waters.

45. **Construction Waste.** Construction waste will be collected and disposed of in the most environment friendly way. Metal wastes will be sold as scrap. Concrete and other inert materials that cannot be recycled will be buried in appropriate locations. Waste oils will be incinerated or recycled as appropriate. Hazardous or toxic wastes, if any, will be stored for disposal by qualified contractors. These requirements will be prescribed in the construction contracts.

46. **Human Waste.** The construction will require up to 300 workers. About half of the workers will be sourced from nearby villages. Thus the number of workers living on-site will be small. Toilets with septic tanks will be provided to take care of sewage. Collection and disposal of solid waste will be entrusted to the services provided by the 304-IP. Cleanliness of the worker camps including kitchen and canteens will be maintained. These waste management and sanitation requirements will be prescribed in the construction contracts.

47. With all mitigation measures and good construction management practices to be prescribed in all construction contracts and close supervision of the contractors, residual environmental disturbances will be small and will not have a significant impact on nearby communities.

2. Impacts during Operation

a. Air Pollution

48. **Adopted Control Technologies**. Emissions from the combustion of biomass in the CFB boiler furnace make up the major environmental issue of the project power plant during operation. The Project will adopt the best practicable technology to effectively control gaseous emissions (Table 8).

Table 8: Summary of Adopted Air Pollution Control Technologies

Pollutants	**Technology**	**Removal Efficiency** (%)
Particulates	Cyclones followed by four electrostatic precipitators in series	99.6
Sulfur dioxide	No need to control, fuels have low sulfur content	No control
Nitrogen dioxides ($NO_{2)}$	Low combustion temperature in CFB furnace, and selective noncatalytic reduction using urea to reduce NO_2 to nitrogen	47.0

CFB = Circulating Fluidized Bed, NO_2 = nitrogen dioxide.
Sources: EIA Reports, 2005-2007.

49. **Control Standards**. Air quality management in the 304-IP is based on national ambient air quality standards and emission standards, as well as the emission load per unit area. The last control measure takes into account the waste assimilative capacity of the air shed or the environmental carrying capacity of the 304-IP and has to be established in the EIA. Appendix 2 summarizes the ambient air quality standards, emission standards, and emission load,.

50. **Expected Emissions.** The emissions of TSP, SO_2, and NO_2 were calculated based on (i) characteristics of rice husks, wood waste, and wood chips (Appendix 3); (ii) three formulas of fuel mixes; (iii) expected removal efficiencies of the control technologies; and (iv) flue gas flow at 210.30 Nm^3/second. The results are summarized in Table 9. The emissions will be within the national emission standards and World Bank guidelines, except for TSP (Appendix 2, Table A2.2). TSP emissions for the maximum use of rice husks is estimated at 68 milligrams (mg)/m^3 compared to World Bank guidelines of 50 mg/m^3. However, the World Bank guidelines are for coal-fired power plants as no specific guidelines are available for biomass power plants. The national standards such as 120 mg/m^3 for TSP is considered more appropriate as they are specifically for biomass power plants. The emission load per unit area for TSP will also exceed the controlled area loading of 17.07 kg/day/rai. Therefore, BECO has acquired an additional area of 62.65 rais in the 304-IP to be used to reduce the area loading to the required level.

Table 9: Estimated Emissions during Operations

Fuel Mix (% rice husks, waste wood, and wood chips)	**TSP** (mg/m^3)		**SO_2** (ppm)	**NO_2** (ppm)
	Normal	**Blowing Soot**		
90, 10, 0	68	108	44	44
75, 25, 0	60	96	43	49
75, 0, 25	58	92	45	41
National emission standard	120		60	200

mg/m^3 = milligram per cubic meter, NO_2 = nitrogen dioxide, ppm = parts per million, SO_2 = sulfur dioxide, TSP = total suspended particulates,
Sources: EIA Reports, 2005-2007.

51. **Predicted Ambient Air Quality.** The flue gas will be discharged through a 120 m stack, 1.5 m in diameter. The impacts on ambient air quality in the study area were predicted using the Industrial Source Complex Short Term Model (ISCST3) of the Environmental Protection Agency of the United States. The data used were (i) established data on wind direction and speed, ambient temperature, and atmospheric stability; and (ii) the 2003 mixing height data obtained from Bang Na meteorological station, the only station close to the project area that has mixing height data. The prediction was made for three cases of emissions: (i) emissions from the project power plant; (ii) emissions from the power plant combined with emissions from existing industries in the study area including the 304-IP (16 industries with 45 stacks); and (iii) emissions from the power plant, emissions from existing industries in the study area, and anticipated emissions of future industries in the 304-IP and the new development phase of 304-IP. In each case, the predictions were made for the three formulas of fuel mixes.

52. The calculation results show that TSP is highest for the first fuel mix formula (90% rice husks, 10% wood waste); SO_2 is highest for the second fuel mix formula (75% rice husks, 25% wood waste), and NO_2 is highest for the third fuel mix formula (75% rice husks and 25% wood chips). Appendix 4 presents the highest values of ground level concentrations of the three pollutants under the three cases. All values are within the permissible maximum values prescribed in the national ambient air quality standards.

b. Wastewater Management

53. During operation, an average 2,068 m^3/day of wastewater will be generated comprising (i) 5 m^3/day of domestic wastewater generated by about 83 operations and office staff; (ii) 259 m^3/day of boiler blow down; (iii) 1,724 m^3/day of cooling tower blow down; and (iv) 89 m^3/day of process wastewater. Table 10 presents characteristics of these wastewaters and the treatment methods. The combined effluent will meet national effluent standards, which are comparable with World Bank guidelines.The combined treated effluent will be discharged into the effluent reservoir of the 304-IP. This reservoir has a storage capacity of 15 million m^3 and is used to store all treated effluent in the 304-IP. The water is used for irrigating eucalyptus plantations (23,000 rais or 3,680 ha) and green areas within the 304-IP (756 rais or 121 ha). Including this Project, the total volume of effluent within the 304-IP will be about 146,500 m^3/day compared with the total irrigation requirement of about 190,000 m^3/day. Therefore, the effluent will not be discharged into the canals inside the 304-IP. The effluent reservoir also receives effluent from other industries in the industrial park. Its ranges of characteristics (January to June 2004) are pH 7.08–8.72, suspended solids 4–34, total dissolved solids 328–2,346, oil and grease <2, biological oxygen demand 2.8–13.8, chemical oxygen demand 79–147, Cr6 <0.050, Cd <0.02, Pb <0.10, Ni <0.10, and Hg <0.0010 (all units are in mg/l). The effluent quality now would not have changed significantly from these as the number of industries has not increased significantly. Its use in irrigating the eucalyptus plantations will not create soil pollution problems.

Table 10: Characteristics of Wastewater

Source	Treatment	Flow[a]	Temp[b]	pH	BOD	SS	TDS	O&G
Office use	Package plant	5	27.3	5–9	20	30	250	
Boiler blow down	No	259	50–80	9–10		<60	1,500	
Cooling tower blow down	No	1,724	32–37	8–9		<30	2,500	
Process use	Oil separator	80	27–30	6–8		~100	<100	<1
Combined effluent of the Project		2,068	34–42	8.04–9.09	<20	36.47	2,276	<1
National industrial effluent standards			<40	5.5–9.0	<20	<50	<3,000	<5
World Bank guidelines				6–9	<50	<50		<20

BOD = biological oxygen demand, O&G=oil and grease, pH = measure of acidity, SS = suspended solids, TDS = total dissolved solids.
[a] Flows in cubic meters/day, concentrations in milligrams/liter.
[b] Temperature in degrees Celsius.
Sources: EIA Reports, 2005-2007.

c. Noise

54. The operation of the power plant will generate noise from the steam turbine generators and other rotating equipment, combustion-induced noise, flow-induced noise, and noise from the steam safety valves. All the equipment in the power plant will be designed/operated to have noise not exceeding 85 dB(A) measured at 1 meter from the equipment and at 1.2 m above the ground. Noise during operation is predicted to attenuate from 75 dB(A) at the power plant to about 65 dB(A) at the plant boundaries. The 24-hour average noise level during power plant operation is predicted at 66.8 dB(A) at station A2 and 61.60 dB(A) at station A3. These are below the permissible maximum of 70 dB(A) in the national noise standard. Nevertheless, noise will be further reduced through various measures. The steam turbine generators will be housed in closed buildings to reduce the transmission of noise to the outside environment. The inlet air

and exhaust gas streams will be provided with silencers for noise reduction. Operation and maintenance personnel working within the plant will be provided with adequate personal protection against noise. Also, all the measures will be taken to limit noise at the plant boundary within stipulated limits.

d. Dust from Rice Husk Storage

55. Effective measures will be implemented to suppress rice husk dust during the unloading and loading operations. Such measures will include water spraying, enclosed conveyors, and wind walls. Drainage from rice husk and wood fuel stockyards will be directed to a wastewater sump for sending to the central treatment plant of the 304-IP.

e. Ash Management

56. The power plant will generate about 424 tpd of ash. BECO has an agreement with Siam City Cement Industry Co. Ltd., to send all the ash to the cement plant. Part of the ash can also be used for nutrient supplement in the eucalyptus plantation owned by an affiliated company. If Siam City Cement for any reason will not be able to receive the ash, BECO will seek permission from the Department of Industrial Works to dispose of the ash in the landfill site authorized by the department. In doing so, BECO will also seek concurrence from the district administration in which the landfill site is located. Appropriate measures, as detailed in the environmental management plan (paras. 64–66) will be implemented to control ash spill and fugitive dust during transport, and during landfill operation. The communities surrounding the landfill site will be informed of the ash properties. Attempts will also be made to use the ash for soil improvement.

B. Biological Environment

57. The Project will not have any impacts on the biological environment

C. Sociocultural Environment

58. **Social and Cultural Conflicts.** Less than 150 construction workers will be housed within the construction site. As the construction site is in the 304-IP, social and cultural conflicts with local residents are not expected. During operation, about 83 people will be employed and will reside in residential areas near the 304-IP. Therefore, no social and cultural conflicts with local residents will result. The construction workers and power plant personnel will create demand for food and services, thus benefiting the local economy.

D. Induced Development

59. The demand for food and services created by the Project during construction and operation could induce development of the local economy.

E. Cumulative Impacts

60. The cumulative impact assessment focused on the effects of combined emissions from the project power plant and all other emission sources and it is decided that together they will not exceed the ambient air quality standards. The Project will impose no extra demand on water resources beyond the allocation by the 304-IP.

VI. ECONOMIC ASSESSMENT

A. Project Costs

61. **Financial Cost.** The development cost of the Project is estimated at B6,500 million (about $192 million equivalent). The annual operation and maintenance expenses are estimated at B300 million (about $9 million equivalent) at 2007 prices.

62. **Environmental Cost.** The environmental cost of the Project is related to the following: (i) 89 ha of land; (ii) about 2,068 m^3/day of water to be used in the cooling system and processes, and domestic consumption; and (iii) the discharge of air pollutants into the atmosphere including SO_2: 752 tons per annum, NO_2: 940 tons per annum, and CO_2: 500,000 tons per annum. While these environmental costs are difficult to quantify, the capital investment in pollution control is estimated at about B120 million (about $3.55 million equivalent). The annual operation and maintenance cost is estimated at about B330 million (about $9.76 million equivalent).

B. Project Environmental and Socioeconomic Benefits

63. The Project will generate about 1,224 gigawatt-hours of electricity per annum to support economic development of Thailand. Major environmental benefits of the Project include (i) reduction of about 0.685 million tons per annum of CO_2 emissions as compared to a coal-fired power plant of the same capacity (Appendix 5); and (ii) much reduced waste disposal volume and costs for dust and ash. Other socioeconomic benefits of the Project will include (i) increased employment, (ii) corporate income tax of about $59 million equivalent throughout the Project's life, (iii) value-added tax of about $11 million equivalent throughout the project life; and (iv) creation of business opportunities related to procurement of biomass fuels and other material inputs for the power plant.

VII. ENVIRONMENTAL MANAGEMENT PLAN

A. Objectives and Scope of Environmental Management

64. Environmental management will be an integral part of project construction and operation of the power plant. The objective of environmental management is to ensure full and cost-effective compliance with relevant environmental laws and regulations stipulated by the national and provincial authorities as well as the project financiers. The project environmental management will follow the generic management cycle of (i) plan, (ii) implement the plan (do), (iii) monitor and evaluate the implementation (check), and (iv) take corrective actions based on results of the monitoring and evaluation (act).

65. The project EIA prepared an environmental management plan (EMP), including environmental monitoring. The scope covers (i) air pollution control, (ii) wastewater management, (iii) noise abatement, (iv) traffic management, (v) drainage and flood protection, (vi) solid waste management, (vii) occupational health and safety management, and (viii) social management. Appendix 6 presents a summary of major management measures to be implemented in the EMP during project construction and operation. Implementation and monitoring responsibilities are also identified.

66. BECO will prescribe various impact mitigation measures in the construction contracts for implementation by the contractors. BECO will monitor and evaluate environmental performance

of the contractors as part of its project implementation management to ensure that all prescribed mitigation measures are fully implemented and function effectively. Based on results of the monitoring and evaluation, BECO will prescribe effective corrective actions for the contractors to carry out to ensure full compliance with the required environmental standards. During operation of the power plant and its support and associated facilities, BECO will efficiently and effectively operate all pollution control equipment and mitigation measures.

B. Organization for Project Environmental Management

67. BECO will establish an environmental management unit (EMU) to be responsible for the management of environmental, occupational health, and safety during construction and commercial operation of the power plant. The EMU will also have responsibility to coordinate with regulatory agencies and organizations that are responsible for environmental management of the associated facilities. The EMU organization chart during construction is included in the organization chart for project implementation management (Figure 4), while the organization chart during operation is included in the organization chart for power plant operations (Figure 5).

68. The EMU will be headed by a senior and qualified environment specialist with an engineering background and practical experience in environmental management of large industrial development projects comparable to the Project. At full functioning, the EMU will have about 10 staff comprising one environmental engineer, four chemists, one occupational health and safety specialist, and four well-trained staff for operation and maintenance of pollution control equipment. Before commissioning of the EMU, the recruited staff will receive theoretical and practical training in the NPS power plant to ensure adequacy of their technical competencies required for the tasks. The training will include operation and maintenance of various pollution control equipment inside and outside the power plant.

C. Monitoring, Evaluation, and Reporting

69. As required by the Ministry of Industry, a continuous emission monitoring system will be installed to monitor flue gas emissions (TSP, SO_2, and NO_2). The EMU will operate the system and carry out other monitoring tasks (Appendix 7). BECO will provide the monitoring results report to the Ministry of Industry (Department of Industrial Works) and the Pollution Control Department every 6 months.

70. The total investment in environmental management is estimated at about $0.15 million in 2007 prices, excluding the cost of air pollution control equipment to be supplied as part of the power plant. The annual operating expenses for implementing the environmental monitoring and evaluation program are estimated at about $30,000 equivalent in 2007 prices.

D. Occupational Health and Safety Management

71. BECO will prescribe in the construction contracts requirements for occupational health and safety of construction workers, and will closely monitor contractor performance.

72. For routine operation and maintenance of the power plant, BECO will prescribe and strictly implement well-established measures and practices to ensure effective management of occupational health and safety in compliance with applicable national laws and regulations and international practices for power plants. Regulations related to occupational health and safety management will be issued and strictly enforced. All personnel will receive training in

occupational health and safety practices. Safety drills will be periodically carried out. Safety and occupational health manuals or handbooks will be prepared as required.

VIII. PUBLIC CONSULTATION AND DISCLOSURE

73. Before the EIA, BECO held a public hearing on 9 May 2003. The public forum was attended by 1,024 participants consisting of 12 representatives of local government agencies and 1,012 people from 10 districts. Most of the participants (72.6%) came from Tambon Tatoom in which the 304 IP is located. In the public hearing, the project nature and scope was explained and opinions were sought from the participants through the open forum session and a structured questionnaire. Of the 1,024 questionnaire forms distributed, 1,071 forms were responded. A summary of the hearing is presented in Appendix 8. More than 80% of the participants gave positive response to the questions asked in the questionnaire. Major concerns and recommendations raised in the open forum were related to dust, local employment, community development, and mechanisms for public grievances during project implementation and operation. These concerns and recommendations were incorporated in the design of mitigation measures and project implementation and operations. BECO planned to set up a tripartite committee consisting of representatives of local government offices, community representatives and project representatives. The committee will meet monthly or more frequent if necessary to review complaints made by the people and take actions to redress the problems causing the complaints.

74. During the EIA, surveys were carried out in the study area within 5 km radius from the project site to establish information on the attitudes and opinions of the local government entities, community leaders and local people on the proposed project, and their main concerns regarding the project and environmental issues in general. The surveys covered: (i) heads of 5 health care offices, one local hospital, and the amphoe administration; (ii) 11 community leaders; and 369 household heads (about 10% of the total number of households. The surveys used both structured questionnaire and interviews. The surveyed persons were provided with information on: (i) project scope; (iii) potential environmental impacts; (iii) environmental management plan; and (iv) mitigation measures to be implemented. Most of the surveyed persons would not oppose to the project. All the three groups of stakeholders had common concerns on the potential impact of the project on air quality especially dust and particulates, and on the efficiency and effectiveness of environmental management to minimize the project impacts.

75. The survey findings were used for preparing a public relation plan for implementation before and during project construction and during routine operation of the power plant. BECO has implemented part of the public relation plan. The completed activities include:

(i) Holding formal and informal public meetings in each village to provide information on environmental management and clarify questions and issues raised in the meetings to allay the public concerns and build up their confidence in the project capacity in environmental management.
(ii) Disseminating information on the project to ensure the public had correct project information; and
(iii) Organizing study visits of similar power plants for community leaders and local people.

76. While the public consultation was conducted before the requirements of ADB Public Communication's Policy was mandated in 2006, BECO is nevertheless committed to the

concept of maximizing the benefits offered by the Project during construction and operations, in favor of local people, in general and affected people in particular. In this context, BECO will design and implement demand-driven community development programs, such as providing mobile health and medical services, participation in local cultural activities, and providing scholarships to students.

IX. CONCLUSIONS

77. The Project is a greenfield project initiated in response to the energy policy of the Government of Thailand to use renewable energy resources for electricity generation. The power plant will not require land acquisition as it is to be located in an industrial park that is not ecologically or culturally sensitive. Compared with a conventional coal-fired power plant of the same capacity, the Project will produce less CO_2, estimated at about 0.685 million tpa. At the same time, the Project will generate economic benefits from its power production, and environmental benefits from reduced emissions, and waste disposal as compared to a coal-fired power plant.

78. The Project is expected to have no major ecological impacts as it will adopt best practicable mitigation measures as detailed in the EMP, and effective pollution control technologies to minimize emissions and impacts on the environment. The fuel mix formula of rice husks and wood chips anticipates emissions within the permissible national ambient air quality standards and World Bank standards. During construction, the Project will require contractors to adopt best environmental management practices to minimize environmental disturbances such as emissions of heavy construction equipment and trucks, noise, and dust. The residual impacts will not reach nearby villages. The contractors will provide appropriate training to their workers in environment, safety, and health aspects of construction; and provide necessary protective measures to the workers to minimize safety risks.

79. BECO will establish an appropriate organization and an EMU for effective management of the environmental, occupational health, and safety aspects during construction and operation. The Project has formulated an effective EMP, including a monitoring program, which will be implemented by the contractors during construction under the supervision of BECO, and by BECO during operation as routine and integral activities of power plant operation. The Project will be able to fully comply with relevant national laws and regulations regarding environment, health, and safety.

LETTER FROM SIAM CITY CEMENT PCL TO RECEIVE ASH FROM THE BECO PROJECT
Translation of Letter

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Ref. Number Por Tor 177/2549
(Note: :Por Tor are thai letters equivalent to P T-Sermpol)

23 May 2006

Subject: Record of Understanding of the Intention to
Receive Ash from Biomass Combustion Process

To; Managing Director, Biomass Energy Company Limited

By this letter, Siam City Cement PCL wishes to record the understanding reached between Siam City Cement PCL and BECO on the disposal of ash from BECO's biomass power plant project. Siam City Cement PCL confirms that it has adequate capacity and is pleased to receive ash from BECO's biomass power plant project for use in its cement production. Preliminary information on the project are as follows:

1. The biomass power plant will be located in Tambon Tatoom, Amphoe Srimahabho, Prachinburi Province.
2. The biomass fuels will be a mix of wood wastes, wood chips and rice husks in proportions as stated in the project EIA report approved by the Office of Natural Resources and Environmental Policy and Planning.
3. The quantity of ash generated per day by the power plant will be as stated in the EIA report approved by the Office of Natural Resources and Environmental Policy and Planning.

The ash will have characteristics in line with the guidelines prescribed by Siam City Cement PCL as follows:

Chemical Composition (%)

Moisture	<30
Silica	45-80
Aluminum oxide	20-30
Iron oxide-Calcium oxide	<15
Magnesium oxide	<1.5
Sulfur trioxide	<2.5
Sulfur content	<2.5
Chloride content	<0.5

Heavy Metal (ppm)	
As	<100
Cr	<500
Cd	<50
Cu	<200
Pb	<500
Hg	<50

Siam City Cement PCL will be pleased to receive for its use the ash with characteristics that meet the above guidelines. BECO will transport and deliver the ash to the cement mill of Siam City Cement PCL located at Tambon Tabkwang, Amphoe Kaengkoi, Saraburi Province. BECO will submit the delivery schedule to Siam City Cement PCL at least 3 working days in advance of delivery. Siam City Cement PCL reserves the right to reject the delivered ash if characteristics of the ash are found to deviate significantly from the above guidelines and it could have adverse impacts on the cement production process.

Siam City Cement PCL is pleased to confirm the understanding. BECO may use this record of understanding for reference in other activities.

Yours sincerely,

Signed

Mr. Somnuk Jiangsiriwong
Manager, Sale and Marketing
EcoSiam, a Business Unit of Siam City Cement PCL.

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SUMMARY OF AIR POLLUTION CONTROL STANDARDS

Table A2.1: Ambient Air Quality Standards

Parameter	National Standard[a]	World Bank Guideline
TSP (mg/m^3)		
24-hour average	0.33	0.23[b] (0.25)[c]
Annual average	0.1	0.08 (0.0873)
PM_{10} (mg/m^3)		
24-hour average	0.12	0.15 (0.164)
Annual average	0.15	0.05 (0.055)
SO_2 (ppm)		
1-hour average	0.30 (780 micrograms/m^3)	
24-hour average	0.12 (0.3 mg/m^3)	0.15 mg/m^3 (0.164)
Annual average	0.04 (0.1 mg/m^3)	0.08 mg/m^3 (0.0873)
NO_2 (ppm)		
1-hour average	0.17 (0.32 mg/m^3)	
24-hour average	0.12 (0.3 mg/m^3)	0.15 mg/m^3 (0.164)

mg/m^3 = milligram per cubic meter, NO_2 = nitrogen dioxide, ppm = parts per million, SO_2 = sulfur dioxide, TSP = total suspended particulates.
[a] Volume at 1 atmosphere at 25 degrees Celsius.
[b] normal m^3 at 1 atmosphere at 0 degrees Celsius.
[c] m^3 at 1 atmosphere at 25 degrees Celsius.
Note: World Bank figures are derived from: World Bank. 1998. *Pollution Prevention and Abatement Handbook*. Washington, DC.
Sources: EIA Reports, 2005-2007.

Table A2.2: Emission Standards Applicable to Biomass Power Plants

Parameter	National Standard[a]	World Bank Guideline[b]
TSP (mg/m^3)	120[c]	50 (54.6)
SO_2 (ppm)	60	33 tpd[d]
NO_2 (ppm)	200	365

mg/m^3 = milligram per cubic meter, NO_2 = nitrogen dioxide, ppm = parts per million, SO_2 = sulfur dioxide, TSP = total suspended particulates
[a] Standards promulgated by the Ministry of Industry for biomass power plants.
[b] World Bank guidelines are for coal-fired power plants.
[c] Pollution Control Department prescribes 320 mg/m^3 for boilers burning biomass fuels.
[d] 0.2 tpd per MWe or 33 tons per day for 165 MW.
Sources: EIA Reports, 2005-2007.

Table A2.3: Maximum Emission Load in kg/day/rai for the 304-IP at 120 m Stack Height

Parameter	Estimated Load from Mathematical Model	Value Used
TSP	21.34	17.07
SO_2	67.74	54.19
NO_2	24.02	19.22

kg/day/rai = kilogram per day per rai, NO_2 = nitrogen dioxide, ppm = parts per million, SO_2 = sulfur dioxide, TSP = total suspended particulates.
Note: Value used is 80% of the estimated value.
Sources: EIA Reports, 2005-2007

CHARACTERISTICS OF BIOMASS FUELS

Parameter	Unit	Rice Husks	Wood Wastes	Wood Chips
Carbon	% by weight	22.7	24.1	33.5
Hydrogen	% by weight	1.7	3.6	3.5
Nitrogen	% by weight	0.3	0.2	0.8
Oxygen	% by weight	42.8	22.2	29.5
Sulfur	% by weight	0.04	0.02	0.04
Ash	% by weight	17.5	3.0	3.0
Moisture	% by weight	15	48	31
LHV	MJ/kg	12.74	6.97	11.90
HHV	MJ/kg	13.44	8.82	13.30
Density	kg/m^3	150	—	—

— = no data available, HHV = higher heating value, LHV = lower heating value, MJ = megajoule.

PREDICTED HIGHEST CONCENTRATIONS OF POLLUTANTS IN AMBIENT AIR AT GROUND LEVEL

(microgram/m^3)

Table A4.1: Emissions from the Project Power Plant Only

	TSP		SO_2			NO_2
Station	**24 hours**	**Annual**	**1 hour**	**24 hours**	**Annual**	**1 hour**
Maximum GLC	2.34	0.16	15.02	2.55	0.18	11.71
Distance from project site (km)	3.6	4.8	0.8	3.6	4.8	0.8
Direction from project site	North	East	East	North	East	East
Type of area	Agr	Agr	Reservoir	Agr	Agr	Reservoir
A1	1.24	0.023	9.03	1.35	0.025	7.04
A2	1.32	0.050	10.33	1.44	0.055	8.11
A3	0.56	0.004	6.67	0.61	0.004	5.23
A4	0.50	0.008	3.75	0.54	0.009	2.92
A5	0.84	0.009	7.17	0.91	0.009	5.61
A6	0.77	0.032	12.55	0.83	0.035	9.83
A7	1.90	0.107	7.33	2.07	0.117	5.74

km = kilometer, NO_2 = nitrogen dioxide, ppm = parts per million, SO_2 = sulfur dioxide, TSP = total suspended particulates.
Sources: EIA Reports, 2005-2007.

Table A4.2: Emissions from the Project Power Plant and from Existing Industries Within a 5 kilometer Radius of the Project Site

	TSP		SO_2			NO_2
Station	**24 hours**	**Annual**	**1 hour**	**24 hours**	**Annual**	**1 hour**
Maximum GLC	24.64	7.92	427.74	65.04	8.04	196.32
Distance from project site (km)	4.3	4.3	2.5	3.6	1.8	3.2
Direction from project site		Southwest	Southwest	North	Southwest	Southwest
Type of area	Agr	Agr	304-IP	Agr	304-IP	304-IP
A1	15.08	2.06	346.95	40.43	5.82	135.15
A2	10.09	1.08	253.19	46.85	5.59	123.25
A3	4.43	0.71	195.40	40.34	4.53	64.42
A4	5.32	0.57	113.61	17.80	0.98	56.32
A5	3.54	0.18	194.39	24.82	0.62	85.42
A6	6.14	0.96	338.89	35.54	5.46	154.09
A7	13.49	0.89	202.20	60.95	4.05	100.21

km = kilometer, NO_2 = nitrogen dioxide, ppm = parts per million, SO_2 = sulfur dioxide, TSP = total suspended particulates.
Sources: EIA Reports, 2005-2007.

Table A4.3: Emissions from the Project Power Plant, from Existing Industries within a 5 kilometer Radius of the Project Site, and from Future Industries

	TSP		SO_2			NO_2
Station	**24 hours**	**Annual**	**1 hour**	**24 hours**	**Annual**	**1 hour**
Maximum GLC	49.74	12.50	440.10	100.12	20.64	203.16
Distance from project site (km)	3.7	4.3	2.5	3.2	2.8	3.2
Direction from project site	Southwest	Southwest	Southwest	Northeast	Southwest	Southwest
Type of area	Agr	Agr	304-IP	Agr	304-IP	304-IP
A1	30.87	7.33	359.24	51.40	15.85	139.50
A2	20.11	6.86	272.25	65.18	16.73	130.0
A3	21.04	4.10	199.11	58.70	11.15	64.82
A4	31.66	3.59	196.59	42.62	6.37	73.56
A5	27.05	2.88	205.46	36.30	4.46	89.34
A6	19.42	3.54	344.47	62.12	11.42	156.07
A7	26.45	2.58	242.70	95.71	8.36	115.70

km = kilometer, NO_2 = nitrogen dioxide, ppm = parts per million, SO_2 = sulfur dioxide, TSP = total suspended particulates.
Sources: EIA Reports, 2005-2007.

Table A5: Calculation of CO2 of the Project and a Coal-Fired Power Plant

Item		
Basic Data		
Rice husk		
-Low heating value	12.74	MJ/kg
-carbon content	22.70	% by weight
Wood chips		
-Low heating value	11.9	MJ/kg
-carbon content	33.50	% by weight
Coal		
-Low heating value	21.8	MJ/kg (5,200 kcal/kg)
say	21.8	MJ/kg
-carbon content	48-76	% by weight
say	60.00	% by weight
Calculation		
Low heating value of rice husk mixed with wood chips (75% and 25%)	12.53	MJ/kg
Amount of biomass fuel used	939,637	metric ton per annum (tpa)
Amount of coal with equal energy	540,076	tpa
Carbon content of biomass fuel	25	% by weight
Amount of carbon in biomass fuel	137,179	tpa
Amount of carbon dioxide generated by biomass fuel	502,991	tpa
(Note 1 kg of carbon generates 3.67 kg of carbon dioxide)		
Amount of carbon in coal	324,045	tpa
Amount of carbon dioxide generated by coal	1,188,167	tpa
Saving in carbon dioxide by the Project	685,176	tpa

kg = kilogram, MJ/kg = mega joules per kilogram, tpa = ton per annum.
Sources: EIA Reports, 2005-2007.

SUMMARY OF MITIGATION MEASURES FOR MAJOR ENVIRONMENTAL IMPACTS IN THE ENVIRONMENTAL MANAGEMENT PLAN

Environmental Issue	Mitigation Measure
I. During Construction	
Fugitive dust, emissions from trucks and engine-driven construction equipment, noise, drainage, waste disposal, traffic congestion, and work safety and occupational health	These transient environmental disturbances will be mitigated by adopting well-established best practice in environmental management in construction, and good construction planning and management. All the measures will be prescribed in construction contracts to be implemented by contractors.
II. During Operation	
A. Air Pollution	
1. Emission loads per unit area	Acquire an additional area of about 62.65 rais to increase the total project area to 89 rais. This will bring the emission load per rai of TSP to be within the maximum permissible limit of 17.07 kg/day/rai.
2. NO_2 emission[8]	Incineration temperature control coupled with SNCR
3. Particulates (TSP,PM_{10})	• Cyclone followed by four electrostatic precipitators in series • A system will be established to shut down the operation in case of the electrostatic precipitator trip •
4. Fugitive dust during biomass transport, unloading and storage.	• Use enclosed conveyor system • Occasional water spraying of the rice husk storage, and tree planting for wind protection • Limit storage height to less than 6 meters • Limit speed of biomass fuel trucks in 304-IP to 30 km/hr • Maintain storage sites free of rice husk droppings
B. Water Pollution	
1. Process wastewater and cooling water blow-down	• Preliminary treatment in a holding pond to remove oil and grease before discharging to the central wastewater treatment system of 304-IP • Install a small package sewage treatment unit for treating office wastewater before discharging into the holding pond
C. Noise	• Noise protection equipment for operators in areas with excessive noise • Install noise reducing equipment for process equipment generating noise more than 85 dB(A) • Install noise protection barrier in working areas where noise exceeds 85 dB(A).

[8] Sulfur dioxide is not an issue as sulfur content of the biomass fuel is very low.

D. Other Wastes	
1. Hazardous and toxic wastes (HTC)	Establish a sound HTC management system covering systematic recording, reporting, collection and storage of HTC for proper disposal by authorized HTC handlers
2. Fly ash and bottom ash	Send to a cement plant for producing Portland cement
E. Occupational Health and Safety	
1. Occupational health and safety in work place.	Install equipment and institutionalize management and administrative measures to fully comply with all laws and regulations related to occupational health and safety requirements
2. Routine training of personnel	Provide regular training in safety and occupational health to all personnel with periodic drills

dB (A) = decibel acoustic, HTC = hazardous and toxic wastes, NO_2 = nitrogen dioxide, TSP = total suspended solids,
Sources: EIA Reports, 2005-2007.

MAJOR ENVIRONMENTAL MONITORING TASKS

Parameters		Monitoring Location	Period/Frequency
A.	**Air Pollution** 1. Emissions of TSP, NO_2, and SO_2	Stack, continuous emission monitoring system	Continuous
	2. Ambient air quality: 24 hr ground level concentration of PM_{10} and TSP; 1-hr average of NO_2 and SO_2; and wind speed and directions	Three stations - A7-Barn Koek Kraton School, upwind - A2-Poengpai Temple, downwind - A6-Koek Somsiao Village, downwind	Once every 6 months, continuous sampling for 3 days
B.	**Wastewater Management** Effluent flow rate and quality-pH, temperature, total dissolved solids, suspended solids, BOD, DO, oil and grease, and free chlorine	Effluent sump before draining into the central wastewater management system of the 304 IP.	Every 3 months
C.	**Ambient Noise Levels** Leq-1 hour, Leq-24 hour, Ldn, and L90	Two locations, at the northern and southern walls of the premise.	Twice a year, continuous measurement for 3 days
D.	**Hazardous Waste Management**	At generation sources and central storage area	Constantly keep detailed records on quantities and types of waste, report to regulatory authorities
E. **E1**	**Safety and Occupational Health** **Health Check-Up** Routine annual medical check-up for all workers Special tests for high risk groups for lung and hearing Additional checks for workers over 35 years old, covering blood cholesterol, blood sugar, uric acid, and ECG		Once a year
E2	**Work Environment** Noise (Leq-12 hours) Preparation of noise contours	At 1 meter from noise sources Power plant complex	Four times per year At least once every year during operation
	Thermal radiation Particulate matters Accidents and emergencies: causes, nature, number of injuries, extent of losses or damages, remedial measures taken Monitoring and evaluation of safety measures and safety training and emergency management drills	Boilers and generators Fuel feeding area of the boiler furnace Within the power plant complex Within the power plant complex	Once a year Once a year Immediately after the incidents Once a year
	Community relations: record complaints received from the communities, measures to address the complaints and results	Within the power plant complex and surrounding communities	Once a year

BOD = biological oxygen demand, DO = dissolved oxygen, ECG = electrocardiogram, NO_2 = nitrogen dioxide, pH = measure of acidity, ppm = parts per million, SO_2 = sulfur dioxide, TSP = total suspended particulates.
Sources: EIA Reports, 2005-2007.

SUMMARY OF THE MAIN PUBLIC HEARING

Date : 9 May 2003, from 0900 to 1300 hours
Venue : Convention Hall, Tawarawadi Resort Hotel, 304 Industrial Park

1. **Information on Participants.** Of the 1,124 participants, 12 represented various central and local government offices and 1,112 were from various communities (Table A8.1). As Tatoom is the district in which the 304-IP is located, the public hearing attracted more participants from this district than from districts further from the project site.

Table A8.1: Participants at Main Public Hearing

Community	Number of Participants	% of Total
Lard Takian	4	0.35
Tatoom	**816**	**72.6%**
Huawha	117	10.41
Nong Proeng	68	6.05
Barn Tarm	22	1.96
Krog Somboon	34	3.02
Dong Kratong Yarm	16	1.42
Hard Yang	12	1.07
Bang Koong	4	0.36
Srimahabho	19	1.69

2. **Public Invitation.** In line with the environmental impact assessment regulations, the public hearing with an open invitation to the public was announced about 15 days in advance through provincial, amphoe,[1] and district administration offices as well as in public places.

3. **Conduct of the Hearing.** In the public hearing, project information was exhibited in text, diagrams and pictures on display boards; and provided in documents handed out to participants. The public hearing started with the presentation of the project by Biomass Electricity Co. Ltd. (BECO) covering project scope, benefits, and environmental aspects. Subsequently, participants could raise questions and offer comments and opinions as well as recommendations. The participants were also requested to answer questions in the questionnaire distributed to the participants before the opening of the session.

4. **Questions Raised in the Forum.** Questions and comments raised by the participants in the forum can be arranged into three subject areas:

(i) **Local development/employment.** These included the following:

(a) Will there be employment opportunities for people with low education?
(b) The Project will generate more traffic on the 304 highway. Does the Project have a plan to widen the highway? This could be done through a community development project.

[1] Amphoe is the second level of local administration in Thailand: province, amphoes, tambons (district) and moobarns (villages).

(c) In transporting rice husks and wood chips, efforts should be made to minimize rice husks and wood chips dropping from trucks to ensure public safety and road cleanliness.
(d) What types of jobs will be created by the Project? What opportunities will local people have to gain employment from the company?
(e) Will there be other projects in the future? If there are, what types will they be?
(f) Will the electricity generated by the Project be widely distributed to local communities? And what will be other uses of the electricity?

(ii) **Project information.** These included the following:

(a) When will the Project be completed?
(b) How much will the project investment be? What will the majority of people think about this Project?
(c) Where is the project location?
(d) What are the quantities of fuel materials apart from rice husks and wood chips?
(e) Will the power plant have a good safety system?

(iii) **Environmental aspect.** Questions and comments include the following:

(a) The traffic is currently heavy during rush hours. Truck traffic during rush hours will not be desirable.
(b) What are the methods of waste treatment and disposal of the existing power plant?
(c) Would the Project be able to achieve 100% control of dust from the combustion of rice husks and wood chips?
(d) If during project implementation and operation, adverse impacts occur and affect local people, what can the affected people do to inform the company and get assistance?

5. **Opinions and Recommendations from the Participants.** These include the following:

(i) **Local development and employment.** These include

(a) appreciate the employment opportunities created by the Project,.
(b) local development benefits not to be compromised with good environment and public health,
(c) should consider providing employment to housewives older than 40,
(d) should give preference to local people in employment,
(e) good welfare and benefits should be given to employees,
(f) should have community development projects, and
(g) minimum wage should be adjusted to reflect the high cost of living, which is comparable Bangkok

(ii) **Organization of the public hearing.** Comments include
(a) should also distribute information on the public hearing through village and district chiefs or the local district administration offices,
(b) the discussions in the public hearing should have conclusions and should not be too lengthy, and

(c) should provide transportation for the participants.

(iii) **Other matters.** Comments include
(a) support the Project as it uses renewable energy;
(b) should organize public meetings every 3 or 6 months to enable people to know the development of the Project;
(c) should have policy to support employees to further their education;
(d) after completion of the Project, the 304 highway should be further developed;
(e) recognize benefits of the Project to local development but employees should be informed of the advantages and disadvantages of the Project;
(f) the public hearing supports the people's right to have project information and to question;
(g) the Project should give due consideration to public safety and environment;
(h) the project presentation was good;
(i) more details should be provided;
(j) should address public complaints consistently;
(k) support the Project but should take good care of environment and people's health;
(l) should provide community development and local employment and minimize environmental impacts;
(m) before project implementation should adequately prepare support infrastructure and facilities, such as roads and traffic, to minimize environmental disturbances and public nuisances during project implementation;
(n) should conduct field visits to enhance people's understanding and receive people's views on environmental problems;
(o) want to see a clear presentation with full disclosure of adverse impacts of the Project; and
(p) would implement recommendations received from the participants.

6. **Results of the Questionnaire.** The questionnaire sought answers from the participants to nine questions presented in Table A8.2.

Table A8.2: Questionnaire Questions and Answers

Question	Answer
1. Was the project information on the display board adequate?	84.03% considered the information adequate
2. Was the presentation of project information in the meeting clear enough?	83.38% considered the presentation clear enough
3. Were the documents provided to the participants adequate?	84.69% considered the documents adequate
4. Would local industries help create employment opportunities to local people?	91.59% agreed that local industrial development created employment opportunities to local people
5. Would the increase in the number of industries in the area expand local employment and contribute to local	88.05% agreed that the expansion of industries in the area will help expand employment and contribute to local

socioeconomic development?	development
6. Would you agree that this area has considerably developed over the past years resulting in increased household income and living standard?	87.77% agreed that this area had considerably developed resulting in increased income and living standards
7. Did this public hearing provide opportunity for questioning and commenting?	80.48% considered the open forum provided ample opportunities to raise questions and comments
8. Has your understanding of the project increased after the public hearing?	81.98% considered their understanding of the Project increased
9. Was the meeting orderly conducted?	87.30% were satisfied with the way the meeting was conducted