2 Feature of the Fha Lai Thermal Power Joint-stock Company

English name	: Pha Lai Thermal Power Joint-Stock company
Vietnam name	: Công ty Cổ phần Nhiệt điện Phả Lại
Abbreviation	: PLPC
Establishment of a company	: January 26, 2006
Location	: Fha Lai (65km west of Hanoi)
Rated capacity	: Fha Lai I 440MW (110 MW/unit)
	: Fha Lai II 600MW (300 MW/unit)
Actual fuel	: coal
Annual operating time	: Fha Lai I 7600 hours (average of all units from 2006 to 2009)
	: Fha Lai II 7900 hours (average of all units from 2006 to 2009)

Figure 2-1 Overview of Pha Lai downtown
(Pha Lai power plant presents in center of this picture.)

Figure 2-2 Overview of Pha Lai I thermal power plant

Figure 2-3 Overview of Pha Lai II thermal power plant

2.1 Corporate development

Pha Lai thermal power joint-stock company has two plants which are “Pha Lai I” and “Pha Lai II”.

Pha Lai I was constructed by former Soviet capital and is composed of 4 units named as #1, #2, #3 and #4. The electricity generating capacity is 440 MW totally. The construction start date was May 17 in 1980. Then the construction of the generating units was gradually completed between 1983 and 1986. In the earliest year, they had been operated only for dry season. However, they were improved against the tight domestic status of power supply and have been operated through a whole year.

For the construction of Pha Lai II, Japan's Overseas Economic Co-operation Fund (OECF) helped to provide funding. Additionally Sumitomo Corp., Mitsui Babcock Engineering Ltd, Stone & Webster Corp. and Hyundai Engineering & Construction Co. technically cooperated to construct this new plant. Pha Lai II is composed of two units named as #5 and #6 and the rated capacity is 600 MW totally. The construction start date was June 8 in 1998. Then the construction of unit #5 and unit #6 were completed December 28 in 2002 and March 14 in 2003, respectively. The most specific character of these units is the structure of boilers. The boilers are based on an anthracite coal-fired plant in china and had been optimized to the coals mined in Viet Nam by studying at a laboratory in U.K. By these efforts, both an effective electricity generation and the decrease of exhaust gas were actualized in Pha Lai II. Currently, Pha Lai thermal power joint-stock company totally generates 1040MW that is one of the largest plant capacities in Veit Nam.

The company has total stuff strength of 1400 employees, and female employees occupy about 30%. This plant was originally EVN-owned national enterprise but it has been converted to joint-stock company according to a policy of Viet Nam government on March 30, 2005.

2.2 Specifications of major equipments in the plant

Specifications of major equipments are described below (Table 2.2-1, Table 2.2-2, Table 2.2-3, Table 2.2-4, Table 2.2-5, Table 2.2-6). Features of boiler, turbine, generator and control room are shown in Figure 2.2-1, Figure 2.2-2, Figure 2.2-3, Figure 2.2-4, Figure 2.2-5, Figure 2.2-6, Figure 2.2-7, Figure 2.2-8, Figure 2.2-9 and Figure 2.2-10.

Table 2.2-1 Boiler specifications

items	specifications	
	Pha Lai I	Pha Lai II
Maker	Russia	Mitsui babcock (UK)
Type	Outdoor, single drum and natural circulation EK3-220-100-10C	Outdoor, single drum and natural circulation
Combustion system	Two-stage corner firing type	Downshot firing type
Superheater output pressure	100 kgf/cm^2	174.1 kgf/cm^2
Superheater output temperature	540 deg C	541 deg C
Steam flow	220 ton/h	875 ton/h
Efficiency	86.05%	88.5%
Mill type	Tube-type mill	Tube-type mill

Pha Lai I and Pha Lai II has 8 boilers (2 boiler /a unit) and 2 boilers (one boiler / a unit), respectively.

Table 2.2-2 Turbine specifications

items	specifications	
	Pha Lai I	Pha Lai II
Maker	Russia	General Electric (USA)
Type	K-100-90-7	270T 422/423
Output	110 MW	300 MW
Major steam pressure	90 kgf/cm^2	169kgf/cm^2
Major steam temperature	535 deg C	538 deg C
Turbine efficiency	39%	45.1%

Pha Lai I and Pha Lai II has 8 boilers (2 boiler /a unit) and 2 boilers (one boiler / a unit), respectively.

Table 2.2-3 Generator specifications

items	specifications	
	Pha Lai I	Pha Lai II
Maker	Russia	General Electric (USA)
Type	TBF-120 -2T3	290T 422/423
Output	141 MVA	396 MVA
Votage	14200 V	19000 V
Currency	7700 A	12033 A
Rotating speed	3000 rpm	3000 rpm
Frequency	50 Hz	50 Hz

There are 4 generators in the plant.

Table 2.2-4 Coal specifications

items	specifications	
	Pha Lai I	Pha Lai II
Consumption	158600 ton/hour	1644000 ton/hour
Calorific value	5035 kcal	5080 kcal
Standard rate of coal use	439 g/kWh	320 g/kWh

Table 2.2-5 Specifications of fans and of pomps in Pha Lai I

items (equipped number)	specifications			
	Output (kW)	Pressure	Current (A)	Flow rate (m^3/hour)
FDF (2/boiler)		496	-	73.5
IDF (2/boiler)	630	295 kg/ m^2	77	308000
Powdered coal air blower (4/biler)	-	-	-	108000
CP (2/unit and additional 1)	250	169 mH_2O	-	320
BFP (2/unit and additional 1)	1720	150 kg/ m^2	-	270
CWP (2/unit and additional 2)	2000	17 mH_2O	-	32400

Table 2.2-6 Specifications of fans and of pomps in Pha Lai II

items (equipped number)	specifications			
	Output (kW)	Pressure	Current (A)	Flow rate (m^3/hour)
FDF (2/boiler)	876	525.56 mmH_2O	-	602280
PAF (2/boiler)	788	1680.6 mmH_2O	-	181440
IDF (2/boiler)	955	324.27 mmH_2O	-	855036
CP (2/unit)	700	220 mH_2O	75	820
BFP (3/unit and additional 1)	4500	211.35 bar	450	573
CWP (2/unit and additional 1)	1200	-	128	-

Figure 2.2-1 Overview of boilers in Pha Lai I


Figure 2.2-2 Turbine and generator in Pha Lai I


Figure 2.2-3 Turebine in Pha Lai I

Figure 2.2-4 Generator in Pha Lai I

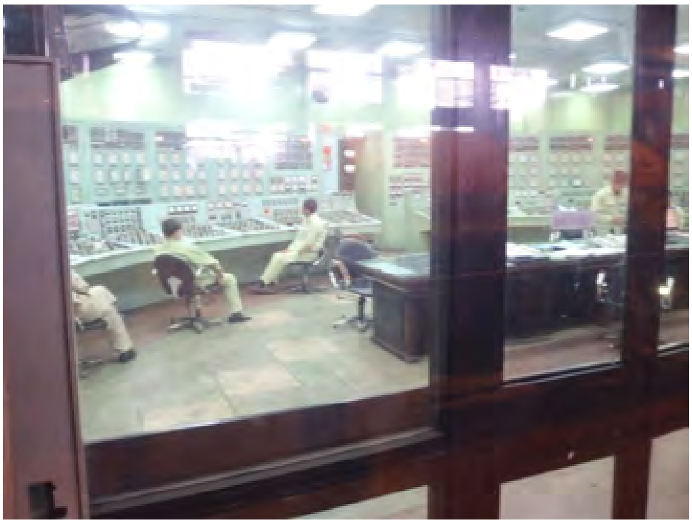

Figure 2.2-5 Control room in Pha Lai I

Figure 2.2-6 Overview of boilers in Pha Lai II

Figure 2.2-7 Turbine and generator in Pha Lai II

Figure 2.2-8 Turebine in Pha Lai II

Figure 2.2-9 Generator in Pha Lai II

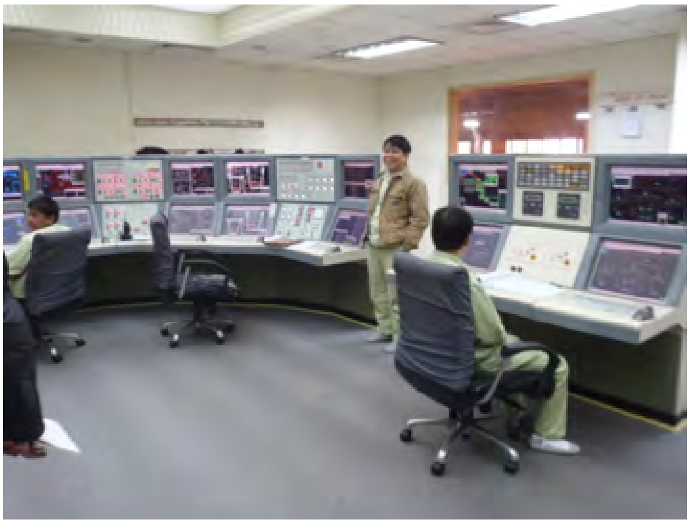

Figure 2.2-10 Control room in Pha Lai II

2.3 Features and characteristics of systems

(1) Fuel systems

Fuel

75% of fuels used in this plant are transferred from Hong Gai and Mao Khe by a water route and the others are transferred from Vang Danh, where is a north region in Viet Nam, by coal cars (Figure 2.3-1 and Figure 3.3-2). Designated values of coal characteristics in this plant are described below. However, coals actually used in the plant are lower grades than described below (Figure 2.3-3).

Type:	Anthracite coal
Calorific value:	5035 kcal/kg
Ash contents:	28.3%
Moisture:	9.65%
Oxygen contents:	2.22%
Hydrogen contents:	2.32%
Sulfur contents:	0.73%
Nitrogen contents:	0.4%
Fixed carbon:	56.38%

Figure 2.3-1 Coal transfer by coal carriers

Figure 2.3-2 Coal cars

Figure 2.3-3 Anthracite coal used in PLPC

Coal hoisting methods

In coal pier for Pha Lai I, there are 5 coal unloaders classified to "Rope Balance Type Level Luffing Crane" (Figure 2.3-4). Coals on coal carriers are hoisted by clamshell buckets and are thrown into a receiving hopper for belt conveyors. Then, they are conveyed to a coal banker or coal storage yards.

In coal pier for Pha Lai II, there are 4 coal unloaders classified to "Crab-trolley Type Portal Bridge Crane" (Figure 2.3-5). Coals on coal carriers are hoisted by clamshell buckets and are directly thrown onto a receiving conveyor. Then they are conveyed to a coal banker or coal storage yards.

Coals transferred by coal cars are directly thrown onto conveyor by tilting wagon in both case of Pha Lai I and Pha Lai II

The operation is triple shift system on a round-the-clock basis, regardless of the weather.

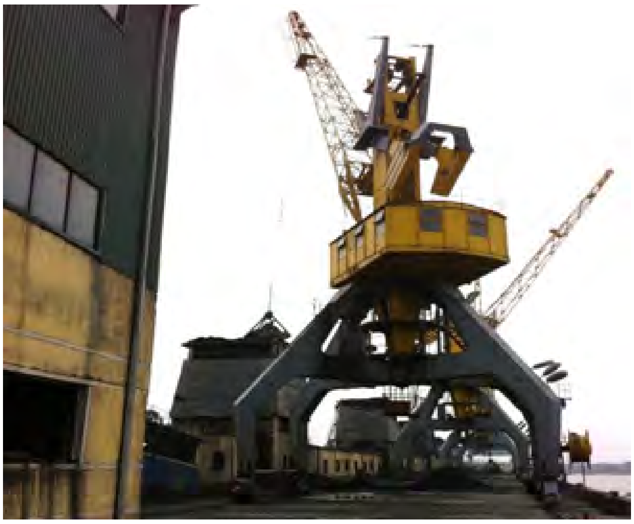

Figure 2.3-4 “Rope Balance Type Level Luffing Crane” unloader

Figure 2.3-5 “Crab-trolley Type Portal Bridge Crane” unloader

Figure 2.3-6 Overview of coal-hoisting at a coal pier

Coal storage yard

The capacity of Pha Lai I is 120000 ton totally (Two roofed yards can stock 70000 ton and two hypethral yard can stock 50000 ton). The yards have been bulldozed to maintain.

The capacity of Pha Lai II is ca. 350000 ton totally (Four roofed yards can stock 137200 ton and two hypethral yard can stock 214000 ton). There are two stackers, two reclaimers and a stacker/reclaimer in the stock yards.

Because of low contents of volatile matter in stored coal, there is no risk for loss of calories. Coals in roofed yards and hypethral yard have been used without distinguishing between rainy season and dry season.

Figure 2.3-7 Roofed coal storage yard

Figure 2.3-8 Hypethral coal storage yard

Conveyor-belt machinery

Pha Lai I and Pha Lai II have independent conveyor system. Both conveyors are composed of three types of lines which connect between the coal-hoisting place and the coal bunker (Figure Figure 2.3-9), between coal-hoisting place and the stock yard, and between the stock yard and the coal bunker (Figure 2.3-10). All lines have two conveyors, and one of them can be selected by an arm type damper attached to a conveyor chute. Therefore, at least one conveyor is available for coal transfer even in case of a conveyor-belt trouble.

The thickness of the belts has been well observed and managed. The other troubles also have been well fixed. Therefore, critical problem does not exist in a present operation.

A lot of powdered coal has been accumulated in the conveyoir room. It has also been accumulated and bound to various detection equipments and coal carrier machines in the conveyor room.

Coal is thrown into a bunker by downing a scraper which has been attached above each conveyor.

Figure 2.3-9 Belt conveyor in a roofed coal yard

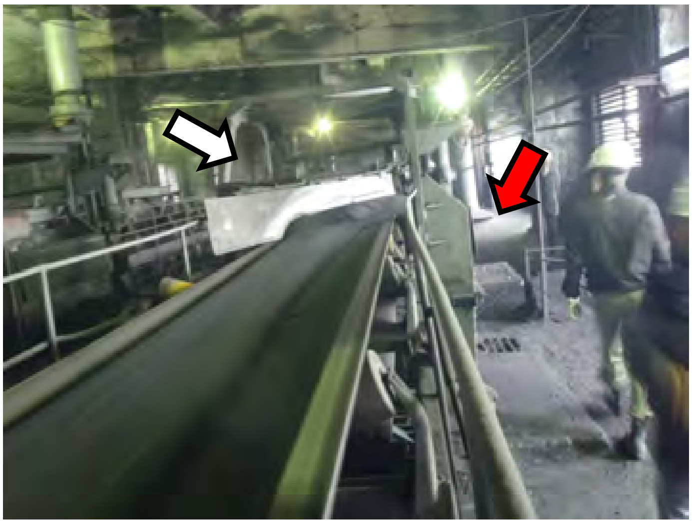

Figure 2.3-10 Overview of coal-throwing to coal bunker
(A white arrow indicates a scraper. A red arrow indicates an opening mouth of a bunker)

Coal bunker

Pha Lai I has 8 bunkers (Figure 2.3-11). The capacity is 360 m^3 per a bunker. Additionally, there is a sub-bunker at the downstream of coal particle separators.

Pha Lai II has 8 bunkers (Figure 2.3-12). The capacity is 250 m^3 per a bunker. Additionally, there is a sub-bunker at the downstream of coal particle separators.

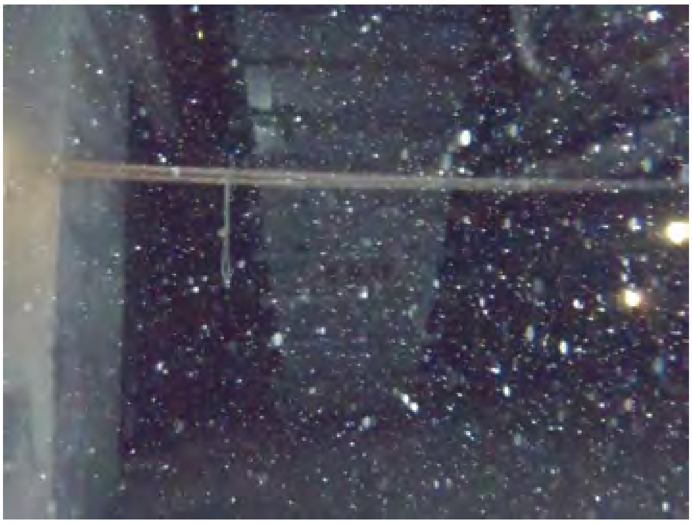

Figure 2.3-11 Coal bunker in Pha Lai I

Figure 2.3-12 Coal bunker in Pha Lai II

Coal feeder

Belt feeder-type coal feeder is equipped at the outlet of each coal banker in both Pha Lai I and Pha Lai II (Figure 2.3-13 and Figure 2.3-14). Rotational speed of the belt feeder is possible to control.

Figure 2.3-13 Coal feeder in Pha Lai I

Figure 2.3-14 Coal feeder in Pha Lai II

Mill

Tube type mills have been equipped in both Pha Lai I and Pha Lai II (Figure 2.3-15 and Figure 2.3-16).

Mills in Pha Lai I has 1600 kW of motor output and 33.1 ton/h of mill capacity, and includes totally 65.5 ton of steel ball indenters that are 40 mm in diameter. Pulverized coals are ca. 90 μm in diameter. Mill temperature is 110 to 120 deg. C.

Mills in Pha Lai II has 1400 kW of motor output and 48.8 ton/h of mill capacity, and includes totally 95 ton of steel ball indenters that are 40mm in diameter. Pulverized coals are ca. 90 μm in diameter. Actual mill temperature is 110 to 120 deg. C but it is ca 30 deg C. lower than its designed value.

Figure 2.3-15 Tube type mill in Pha Lai I

Figure 2.3-16 Tube type mill in Pha Lai II

Coarse powder Separator and cyclone separator

These separators classify the pulverized coals according to the sizes, and have been placed at downstream of fuel pipes in both Pha Lai I and Pha Lai II (Figure 2.3-17). Coarse coal dissociated by the coarse powder separator is back to mill again. Coarse coal dissociated by cyclone separator is transferred to facing burners and the fine coal is transferred to diagonal burners. Every two hour, coal samples are taken at sub-bunker locating the downstream of cyclone, to analyze the physical character.

Figure 2.3-17 Cyclone separator in Pha Lai I

Powdered coal air blower

Powdered coal distributed by cyclone separator is transferred to a sub-bunker, a mill or a boiler by this equipment. The coal destination is selected by the condition of boiler operation on various cases. Two powdered coal air blower has been equipped by each boiler (Figure 2.3-18).

Figure 2.3-18 Powdered coal air blower in Pha Lai II

(2) Draft systems

FDF (forced draft fan)

FDF supplies air to boilers for fuel burning.

Each unit has two FDFs in Pha Lai I (Figure 2.3-19). A centrifugal type fun is equipped and the efficiency is 93%.

Each boiler has two FDFs in Pha Lai II (Figure 2.3-20). An axial flow type fun is equipped and the efficiency is 86%. The air flow rate is adjusted by a flow control of rotating blade.

Figure 2.3-19 Forced draft fan in Pha Lai I

Figure 2.3-20 Forced draft fan in Pha Lai II

PAF (primary air fun)

PAF provides fuel to burners by giving an air pressure to coal powder.

It is not equipped to Pha Lai I.

Pha Lai II has 2 PAFs per a boiler (Figure 2.3-21). The revolution is 1490 rpm. The air flow rate is adjusted by a flow control fin locating a suction head of PAF.

Figure 2.3-21 Primary air fan in Fha Lai II

IDF (induced draft fan)

IDF pumps a stack gas in flue to chimney.

A unit of Pha Lai I has two IDFs (Figure 2.3-22). The revolution is 750 rpm. The fan efficiency is 80%. It has been under overloaded operation because there has been an air leakage at some parts of flue.

Each boiler has two IDFs in Pha Lai II, which are centrifugal type fun (Figure 2.3-23). The efficiency is 82.2%. The revolution is adjustable between 450 rpm and 750 rpm. Additionally, the air flow rate is also adjusted by a control fin locating a suction head.

Figure 2.3-22 Induced draft fan in Pha Lai I

Figure 2.3-23 Induced draft fan in Pha Lai II

AH (air heater)

AH pre-heats air for boiler combustion, utilizing heat of combustion gas.

Pha Lai I has adopted a tube type structure (Figure 2.3-24).

Pha Lai II has adopted a Ljungstrom-type air-preheater (Figure 2.3-25). It has equipped SDS sensor drive system which can automatically fill interspaces of sealed portion. However, the element part of the AH have been damaged and air leakage have occurred.

Figure 2.3-24 Air heater in Pha Lai I

Figure 2.3-25 Air heater in Pha Lai II

Sootblower

Sootblower sprays a continuous fountain of steam in boiler and removes fly ash and clinker being deposited to heating surface of boiler insides.

Pha Lai I has rotary sootblowers which are operated once a day (Figure 2.3-26).

Pha Lai II has equipped sootblowers for boiler and AH (Figure 2.3-27). The boiler sootblower and AH sootblowers have been operated twice a week and at a proper timing, respectively. However, the elements of AH has ash erosion.

Figure 2.3-26 Sootblower for boilers.

Figure 2.3-27 Sootblower for AH in Pha Lai II

(3) Circulating water systems

Water intake equipment

River water has been used for circulating water. Temperature of the river water is 32 deg C in summer and 19 deg C in winter. The average is ca. 23 dig. C. Raw water contains a lot of pet bottle, vinyl product, can and wood chip (Figure 2.3-28). To remove these, Pha Lai I has 8 bar screens and 4 rotary screens and Pha Lai II has 10 bar screens and 5 rotary screens (Figure 2.3-29, Figure 2.3-30, Figure 2.3-31 and Figure 2.3-32).

Figure 2.3-28 Feature of water intake

Figure 2.3-29 Bar screen of Pha Lai I

Figure 2.3-30 Rotary screen of Pha Lai I

Figure 2.3-31 Bar screen of Pha Lai II

Figure 2.3-32 Rotary screen of Pha Lai II

CWP (circulating water pump)

CWP pumps river water up form intake to supply chilling water to steam condensers.

Pha Lai I has 4 CWPs including a backup pump and a pump under repairing (Figure 2.3-33). These are available over 0.5 m in water level. The river water temperature in summer increase to 32 deg C. but only two pumps are operated. Also in case that steam condensers cannot get enough vacuum level, additional pumps are not operated. Current recognition in PLPC is that the operation of third pump is insignificant to increase vacuum level of steam condensers.

Pha Lai II has 5 CWPs, which can be adjusted to optimal motor revolutions by VVVF inverter (Figure 2.3-34). Usually two CWPs have been used for one unit, and one CWP has been prepared as backup.

Figure 2.3-33 Circulating water pump in Pha Lai I

Figure 2.3-34 Circulating water pumps in Pha Lai II

(4) Condensate water system

CP and CBP (condensate pump and condensate booster pump)

CP distills steam condensate from hot wells and pump to a deaerator and a low pressure feed water heater.

Pha Lai I has three CP per a unit (one for backup. Figure 2.3-35). The revolution is 1480 rpm. The fan efficiency is 76%.

Pha Lai II has two CP per a unit (Figure 2.3-36). The revolution is 1486 rpm. The fan efficiency is 80%. Additionally, Pha Lai II has 2 CBP per a unit (Figure 2.3-37).

Figure 2.3-35 Condensate pump in Pha Lai I

Figure 2.3-36 Condensate pump in Pha Lai II

Figure 2.3-37 Condensate booster pump in Pha Lai II

(5) Feedwater system

BFP (boiler feed pump)

BFP plunges feedwater into a boiler by giving high pressure.

Pha Lai I has one BFP per a unit (Figure 2.3-38). The revolution is 2970 rpm. The efficiency is 76%.

Pha Lai II has two BFPs per a unit (Figure 2.3-39). The revolution is 1491 rpm. The efficiency is 82%.

Figure 2.3-38 Boiler feed pump in Pha Lai I

Figure 2.3-39 Boiler feed pump in Pha Lai II

Steam drum

Both Pha Lai I and Pha Lai II have a drum on the top of each boiler, which separates water and steam to take out the steam (Figure 2.3-40).

Figure 2.3-40 Steam drum of Pha Lai II

Condenser cleaning equipment

To clean up condensate pipe, sponge balls and/or carbon random balls are circulated by this equipment.

Pha Lai I does not have the system. Pha Lai II has it which is sponge ball-type cleaner (Figure 2.3-41). The condensate pipe of Pha Lai II is made of SS304 stainless.

Figure 2.3-41 Condenser cleaning equipment of Pha Lai II

2.4 Environmental efforts

(1) Chimney

Chimneys of both Pha Lai I and Pha Lai II have 200 m in height (Figure 2.4-1).

Figure 2.4-1 Chimneys of Pha Lai I (left) and Pha Lai II (right)

(2) Electrostatic precipitator

Soot dusts included in exhaust gas is removed by this equipment.

Both Pha Lai I and Pha Lai II have a dry electrostatic precipitator (Figure 2.4-2 and Figure 2.4-3).

Figure 2.4-2 Electrostatic precipitator in Pha Lai I

Figure 2.4-3 Electrostatic precipitator in Pha Lai II

(3) Flue-gas desulfurization equipment

To remove sulfur oxides from exhaust gas, Pha Lai II has wet flue-gas desulfurization equipment (Figure 2.4-4).


Figure 2.4-4 Wet flue-gas desulfurization equipment in Pha Lai II

(4) Wastewater treatment facility

For both plants, starting drainage, desulfurization drainage, oil-containing wastewater and domestic wastewater has been treated by a facility for wastewater treatments (Figure 2.4-5). Chemical oxygen demand, hydrogen-ion concentration and suspended solids of treated water have been ministered on a steady basis, and have met environmental criteria in Viet Nam. Additionally an external organization checks the wastewater quality once in every three month.


Figure 2.4-5 Drainage tank

(5) Plant tree

Since the operation start of Pha Lai I, this power plant makes an effort for greening in the establishment (Figure 2.4-6 and Figure 2.4-7). There is a section for managements of plant trees, and timber and lawns have been well-pruned.

Figure 2.4-6 Courtyard of the office building in Pha Lai I

Figure 2.4-7 Courtyard of the office building in Pha Lai II

2.5 Organizations

The organization chart of PLPC is shown in Figure 2.5-1, and each role is described below.

Department of labor service

- Carrying out works about payroll, welfare, reward, punishment, recruitment and work training

- Advice to the president about the above affairs
- 18 people belonging totally

Department of finance and account

- Management of each kind of funds, according to legislations
- Accounting service
- 16 people belonging totally

Department of techniques

- Planning of safety operation, constructions and plant management
- Conservation of operation records and decision of operation methods
- Estimation and order for equipment repairs
- 28 people belonging totally

Department of general affair

- Security
- Affairs on various insurance
- Managements of company-owned cars and parking space
- Affairs on recompenses and causes
- Planting trees
- Conservation of the corporation seal
- Administrative proceedings and the other operational coordination
- 143 people belonging totally

Department of material planning

- Planning, purchasing and conservation about materials, tools, equipment and stationeries
- Salvage procedure of equipments and installations
- 70 people belonging totally

Department of extinguishing fire and security

- Security enforcement in the company
- Works for gate keeper
- Installations and conservations of fire extinguishers
- 74 people belonging totally

Fuel block

- Operations and managements of all lines for the fuel delivery
- Sample collection for analyses
- Acceptance of coal and oil
- 257 people belonging totally

Chemical block

- Management of equipments and installations for waters
- Analyses of coal, oil, water, steam and exhaust gas
- Acceptance of chemicals used in the plant
- 63 people belonging totally

Operation block #1

- Operations and managements for all major equipments in the plant
- Management of domestic wastewater in the plant
- Test and adjustment of boiler and the related equipments
- 262 people belonging totally

Operation block #2

- Operations and managements for equipment not occupied by operation block #1
- Acceptance of chemicals related to this block
- Acceptance of coal, oil and limestone related to this block
- 262 people belonging totally

Electricity and measurement device block

- Constructions, operations and maintenances of electrical facilities and measurement facilities
- Maintenances and managements of communication networks in the company.
- 146 people belonging totally

Subsidiary production block

- Preservations and managements of fly ash and clinker
- Production of plaster
- Operations of heavy equipments
- 24 people belonging totally

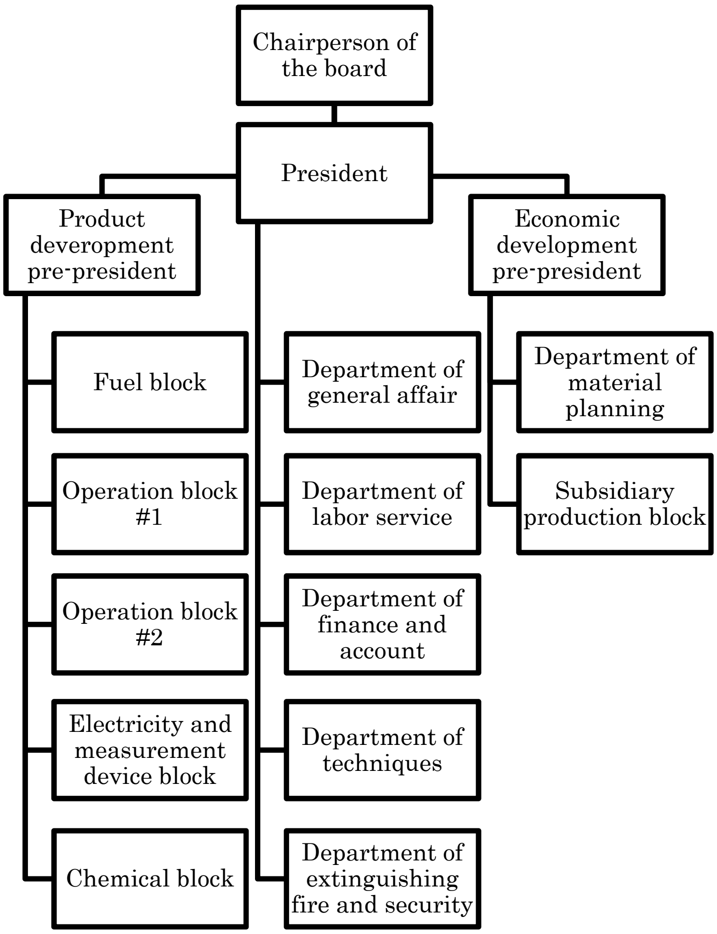

Figure 2.5-1 Organization diagram of Pha Lai thamal power plant joint stock company

3 Feature of the Uong Bi Thermal Power Joint-stock Company

English name	: Uong Bi Thermal Power Joint-Stock company
Vietnam name	: Công ty Cổ phần Nhiệt điện Uông Bí
Abbreviation	: UBPC
Establishment of a company	: June 30, 2010
Location	: Uong Bi (100 km west of Hanoi)
Rated capacity	: Uong Bi 5/6 110MW (55 MW/unit)
	: Uong Bi 7 300MW (300 MW/unit)
Actual fuel	: coal
Annual operating time	: Uong Bi 5 6500 hours (average of all units from 2006 to 2009)
	: Uong Bi 6 7900 hours (average of all units from 2006 to 2009)
	: Uong Bi 7 unknown

Figure 3-1 Overview of Uong Bi 5/6

Figure 3-2 Overview of Uong Bi 7

Figure 3-3 Overview of Uong Bi 8 (under constructing)

3.1 Corporate development

Uong Bi coal fired plant was established by aid of Soviet Union. It had 4 units of boiler-turbine- generator systems named as Uong Bi 1/4. The construction of Uong Bi 1/4 was started May 16 in 1961 and was completed in 1963. However, they have been discarded and the other new units (Uong Bi 5/6 and Uong Bi 7) have a role of electricity generation, now.

The construction of Uong Bi 5/6 was started in 1973. Then Uong Bi 5 and Uong Bi 6 completed the constructions July 1 in 1975 and June 5 in 1978, respectively. During early term of Uong Bi 5 operation start, it had only 50 MW of rated capacity but it was improved to 55 MW as same as Uong Bi 6 in 1977.

The construction of Uong Bi 7 was started by the own capital of Viet Nam May 26 in 2002.

The operation start was November 27 and the rated capacity is 300 MW. By the construction of this unit, the plant has been possible to generate 410 MW totally. Now the company has total stuff strength 1600 employee. This plant was originally EVN-owned national enterprise but it has been converted to joint-stock company June 30 in 2010, according to a policy of Viet Nam government.

3.2 Specifications of major equipments in the plant

Specifications of major equipments are described below (Table 3.2-1, Table 3.2-2, Table 3.2-3, Table 3.2-4, Table 3.2-5 and Table 3.2-6). Features of boiler, turbine, generator and control room are shown in Figure3.2-1, Figure3.2-2, Figure3.2-3, Figure3.2-4, Figure3.2-5, Figure3.2-6, Figure3.2-7, Figure3.2-8, Figure3.2-9 and Figure3.2-10.

Table 3.2-1 Boiler specifications

items	specifications	
	Uong Bi 5/6	Uong Bi 7
Maker	Russia	Russia
Type	ПК20-3	unknown
Combustion system	Oppose firing type (4 burners)	2 steps oppose firing type (16 burners)
Superheater output pressure	100 kg/cm^2	197.4 kgf/cm^2
Superheater output temperature	540 deg C	543 deg C
Steam flow	110 ton/h	137.6 ton/h
Efficiency	90.65%	87.66%
Mill type	Tube-type mill	Tube-type mill

Uong Bi 5/6 and Uong Bi 7 have 4 boilers (2 boiler /unit) and 1 boiler (one boiler / unit), respectively.

Table 3.2-2 Turbine specifications

items	specifications	
	Uong Bi 5/6	Uong Bi 7
Maker	Russia	Russia
Type	K-50-90-3/4	unknown
Output	55 MW	303 MW
Major steam pressure	90 kgf/cm^2	171kgf/cm^2
Major steam temperature	535 deg C	538 deg C
Steam flow	220 ton/h	848.2 ton/h
Turbine efficiency	44%	unknown

Uong Bi 5/6 and Uong Bi 7 have 2 turbines and 1 turbine, respectively.

Table 3.2-3 Generator specifications

items	specifications	
	Uong Bi 5/6	Uong Bi 7
Maker	Russia	Russia
Type	ТВФ-60-2Т	ТВВ-320-2Т3
Output	55 MW	300MW
Votage	6300 V	19000 V
Currency	6310 A	10830 A
Rotating speed	3,000 rpm	3,000 rpm
Frequency	50 Hz	50 Hz

Uong Bi 5/6 and Uong Bi 7 have 2 generators and 1 generator, respectively.

Table 3.2-4 Coal specifications

items	specifications	
	Pha Lai I	Pha Lai II
Consumption	unknown	137.6 ton/hour
Calorific value	6020 kcal	4961 kcal

Table 3.2-5 Specifications of fans and of pumps in Uong Bi 5/6

items	specifications			
(equipped numbers)	Output (kW)	Pressure	Current (A)	Flow rate (m^3/hour)
FDF (1/unit)	200	379 mmH_2O	25.5	123600
IDF (1/unit)	260	258 mmH_2O	33	170000
Powdered coal air blower (2/unit)	160	680 mmH_2O	19.3	33100
CP (2/unit)	105	12.3 kg/cm^2	-	160
BFP (2/unit & additional 1)	1720	159 kg/ cm^2	226	270
CWP (1/unit & additional 1)	2000	258 kg/ cm^2	226	170 ton/h

Table 3.2-6 Specifications of fans and of pomps in Uong Bi 7

items	specifications			
(equipped numbers)	Output (kW)	Pressure	Current (A)	Flow rate (m^3/hour)
FDF (2/unit)	800	335.5 kgf/cm^2	-	564300
IDF (2/unit)	1600	465 kgN/m^3	-	865900
CP (2/unit & additional 1)	105	12.3 kg/cm^2	-	160
BFP (3/unit & additional 1)	1720	150 kg/cm^2	-	270
CWP (2/unit)	1800	17.27 mmH_2O	231.5	5845
PAF (4/unit)	160	220 kg/m^2	290	76200

Figure 3.2-1 Overview of boilers in Uong Bi 5/6

Figure 3.2-2 Turbine and generator in Uong Bi 5/6

Figure 3.2-3 Turebine in Uong Bi 5/6

Figure 3.2-4 Generator in Uong Bi 5/6

Figure 3.2-5 Control room in Uong Bi 5/6

Figure 3.2-6 Overview of boilers in Uong Bi 7

Figure 3.3-7 Turbine and generator in Uong Bi 7

Figure 3.2-8 Turebine in Uong Bi 7

Figure 3.2-9 Generator in Uong Bi 7

Figure 3.2-10 Control room in Uong Bi 7

3.3 Features and characteristics of systems

(1) Fuel systems

Fuel

Anthracite coals used in this plant are transferred by coal cars from Vang danh where is a north region in Viet Nam (Figure 3.3-1). Characteristics of the coal have been analyzed in the plant on a routine basis.

Uong Bi 5/6 has consumed grade 4B coal of 1000 ton/unit/day. Designated values of the coal characteristics are shown below.

Calorific value:	6050 kcal/kg
Ash contents:	24%
Moisture:	8%
Volatile matter content	6.5%
Sulfur contents:	0.6%

Uong Bi 7 has consumed grade 5A coal of 3000 ton/unit/day. Designated values of the coal characteristics are shown below.

Calorific value:	5500 kcal/kg
Ash contents:	30%
Moisture:	8%
Volatile matter content	6.5%
Sulfur contents:	0.6%

However, the qualities of supplied coals have become poor gradually and actual calorific values of Uong Bi 5/6 and Uong Bi 7 are 5,200 ～5,400 kcal/kg and 4,750～4,830 kcal/kg, respectively.

Figure 3.3-1 Coal cars

Coal acceptance methods

In this plant, all used coal has been transferred by coal cars. Coal cars open side hatch after stopping in an acceptance yard (Figure 3.3-2 and Figure 3.3-3). Then, flushed out coal has been entered into an underground hopper and has been transferred by belt conveyor to bunkers or coal yards (Figure 3.3-4 and Figure 3.3-5).

Figure 3.3-2 Coal cars in an acceptance yard

Figure 3.3-3 Appearance of the coal acceptance

Figure 3.3-4 Overview of underground hopper

Figure 3.3-5 Coal transfer by belt conveyor under ground

Coal storage yard

The capacity of Uong Bi 5/6 is 20000 ton totally (Figure 3.3-6).

The capacity of Uong Bi 7 is 30000 ton totally (Figure 3.3-7).

Because of low contents of volatile matter in stored coal, there is no risk for loss of calories. The roofed yards have sidewall. Therefore, it can prevent rain water from the sides.

Figure 3.3-6 Roofed coal storage yard in Uong Bi 5/6

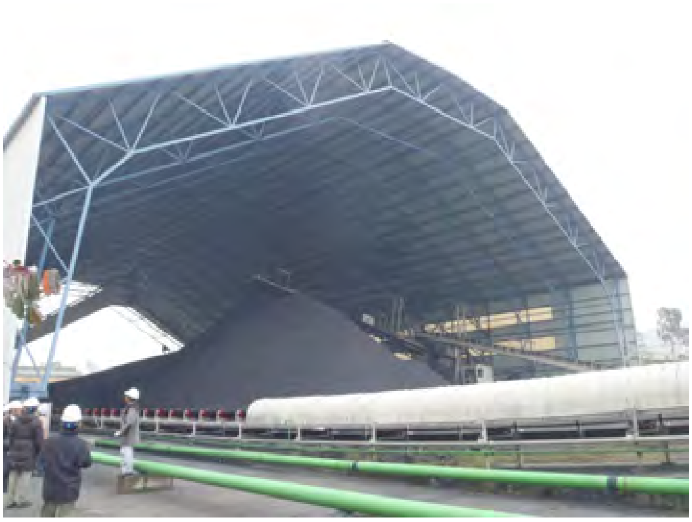

Figure 3.3-7 Roofed coal storage yard in Uong Bi 7

Figure 3.3-8 Dome-type coal storage yard in Uong Bi 8 (under construction)

Conveyor-belt machinery

Uong Bi 5/6 and Uong Bi 7 have independent conveyor system (Figure 3.3-9 and Figure 3.3-10). Both conveyors are composed of three types of lines which connect between the coal-hoisting place and the coal bunker, between coal-hoisting place and the stock yard, and between the stock yard and the coal bunker. Conveyor-belts in Uong Bi 7 are new and have no erosions. They placed indoor for water resources.

Figure 3.3-9 Belt conveyor in a roofed coal yard

Figure 3.3-10 Appearance of belt conveyor operation

Coal bunker

Uong Bi 5/6 has 2 bunkers per a boiler (Figure 3.3-11). The capacity is 200 m^3 per a bunker. Additionally, there is a sub-bunker at the downstream of coal particle separators and the capacity is 140 m^3.

Uong Bi 7 has 2 bunkers (Figure 3.3-12). The capacity is 400 m^3 per a bunker. Additionally, there is a sub-bunker at the downstream of coal particle separators and the capacity is 300 m^3 (Figure 3.3-13).

Figure 3.3-11 Coal bunker in Uong Bi 5/6

Figure 3.3-12 Coal bunker in Uong Bi 7

Figure 3.3-13 Sub-bunker in Uong Bi 7

Coal feeder

Belt feeder-type coal feeder is equipped at the outlet of each coal banker in both Uong Bi 5/6 and Uong Bi 7 (Figure 3.3-14 and Figure 3.3-15). Rotational speed of the belt feeder is possible to control for adjusting coal supply.

Figure 3.3-14 Coal feeder in Uong Bi 5/6

Figure 3.2-15 Coal feeder in Uong Bi 7

Mill

Tube type mills have been equipped in both Uong Bi 5/6 and Uong Bi 7 (Figure 3.3-16 and Figure 3.3-17).

Mills in Uong Bi 5/6 has 380 kW of motor output and includes totally 28 ton of steel ball indenters.

Mills in Uong Bi 7 has 1600 kW of motor output and includes totally 93 ton of steel ball indenters.

Pulverized coals are ca. 90 μm in diameter in both. Abrasions are significant at the tubes passing pulverized coals. They are arbitrarily fixed by partial exchange or welding.

Figure 3.3-16 Tube type mill in Uong Bi 5/6

Figure 3.3-17 Tube type mill in Uong Bi 7

Coarse powder Separator and cyclone separator

These separators classify the pulverized coals according to the sizes, and have been placed at downstream of fuel pipes in both Uong Bi 5/6 and Uong Bi 7 (Figure 3.3-18, Figure 3.3-19 and Figure 3.3-20). Coarse coal dissociated by the coarse powder separator is back to mill again. Coarse coal dissociated by cyclone separator is transferred to facing burners and the fine coal is transferred to diagonal burners. Every two hour, coal samples are taken at sub-bunker locating the downstream of cyclone, to analyze the physical character.

Figure 3.3-18 Cyclone separator in Uong Bi 5/6

Figure 3.3-19 Coarse powder Separator in Uong Bi 7

Figure 3.3-20 Cyclone separator in Uong Bi 7

Powdered coal air blower

Powdered coal distributed by cyclone separator is transferred to a sub-bunker, a mill or a boiler by this equipment. The coal destination is selected by the condition of boiler operation on various cases. Two powdered coal air blower has been equipped by each boiler in Uong Bi 5/6 and Uong Bi 7 (Figure 3.3-21 and Figure 3.3-22).

Figure 3.3-21 Powdered coal air blower

Figure 3.3-22 Powdered coal air blower

(2) Draft systems

FDF (forced draft fan)

FDF supplies air to boilers for fuel burning.

Each unit has two FDFs in Uong Bi 5/6 (Figure 3.3-23). Centrifugal type funs are equipped.

Uong Bi 7 has two FDFs, which are entrifugal type (Figure 3.3-24).

Figure 3.3-23 Forced draft fan in Uong Bi 5/6

Figure 3.3-24 Forced draft fan in Uong Bi 7

PAF (primary air fun)

PAF provides fuel to burners by giving an air pressure to coal powder. It is not equipped to Uong Bi 5/6.

Uong Bi 7 has 4 PAFs (Figure 3.3-25).

Figure 3.3-25 Primary air fan in Uong Bi 7

IDF (induced draft fan)

IDF pumps a stack gas in flue to chimney.

A unit of Pha Lai I has one IDF which is a centrifugal type fun (Figure 3.3-26).

Uong Bi 7 has two IDFs which are centrifugal type (Figure 3.3-27).

Figure 3.3-26 Induced draft fan in Uong Bi 5/6

Figure 3.3-27 Induced draft fan in Uong Bi 7

AH (air heater)

AH pre-heats air for boiler combustion, utilizing heat of combustion gas. All units have adopted a tube type structure (Figure 3.3-28).

Figure 3.3-28 Air heater in Uong Bi 7

Sootblower

Sootblower sprays injected steam in boiler and removes fly ash and clinker being deposited to heating surface of boiler insides.

Uong Bi 7 has rotary sootblowers and deslaggers (Figure 3.3-29 and Figure 3.3-30). Inside wall of boiler has been eroded by the injected steam.

Figure 3.3-29 Rotary sootblower in Uong Bi 7

Figure 3.3-30 Deslagger in Uong Bi 7

(3) Circulating water systems

Water intake equipment

River water has been used for circulating water. Water intake is located at 1.7 km point from the plant. The water conveyance is done by dedicated water lines along the river (Figure 3.3-31). Raw water contains a lot of pet bottle, vinyl product, can and wood chip. To remove these, Uong Bi 5/6 has 2 rotary screens and Uong Bi 7 has 2 rotary screens, without a bar screens (Figure 3.3-32).

Figure 3.3-31 Water line to the plant

Figure 3.3-32 Rotary screens

(Left two ones are for Uong Bi 7, following two ones are Uong Bi 5/6 and right two ones are for new Uong Bi 8.)

CWP (circulating water pump)

CWP pumps river water up form intake to supply chilling water to steam condensers.

Uong Bi 5/6 and Uong Bi 7 have 2 CWPs each (Figure 3.3-33, Figure 3.3-34 and Figure 3.3-35).

Figure 3.3-33 Feature of the establishment for circulating water pump

(Yellow ones are for new Uong Bi 8.)

Figure 3.3-34 Circulating water pump for Uong Bi 5/6

Figure 3.3-35 Circulating water pump for Uong Bi 7

(4) Condensate water system

CP (condensate pump)

CP distills steam condensate from hot wells and pump to a low pressure feed water heater (Figure 3.3-38) and a deaerator (Figure 3.3-39).

Uong Bi 5/6 has two CP per a unit (Figure 3.3-36). Uong Bi 7 has three CPs which include a backup (Figure 3.3-37).

Figure 3.3-36 Condensate pump in Uong Bi 5/6

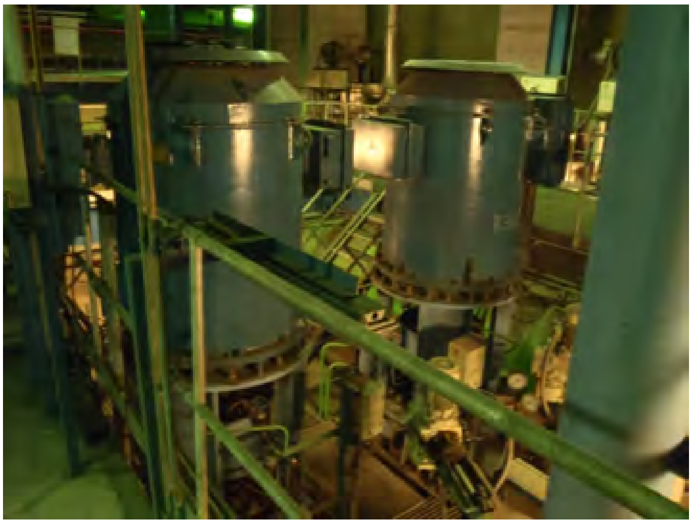

Figure 3.3-37 Condensate pump in Uong Bi 7

Figure 3.3-38 Low pressure feed water heater in Uong Bi 7

Figure 3.3-39 Deaerator in Uong Bi 7

(5) Feedwater system

BFP (boiler feed pump)

BFP plunges feedwater into a boiler by giving high pressure.

Uong Bi 5/6 has two BFP per a unit (Figure 3.3-40).

Uong Bi 7 has three BFPs including a backup pump (Figure 3.3-41).

Figure 3.3-40 Boiler feed pump in Uong Bi 5/6

Figure 3.3-41 Boiler feed pump in Uong Bi 7

Steam drum

Both Uong Bi 5/6 and Uong Bi 7 have a drum on the top of each boiler, which separates water and steam to take out the steam (Figure 3.3-42).

Figure 3.3-42 Steam drum of Uong Bi 7

Condenser cleaning equipment

To clean up condensate pipe, sponge balls and/or carbon random balls are circulated by this equipment.

Uong Bi 5/6 does not have the system. Uong Bi 7 has it which is sponge ball-type cleaner (Figure 3.3-43). The condensate pipe of Uong Bi 7 is made of titanium and is cleaned up every day.

Figure 3.3-43 Condenser cleaning equipment of Uong Bi 7

3.4 Environmental efforts

(1) Chimney

A chimney of Uong Bi 5/6 is low (70 m). Uong Bi 7 has a 200 m chimney (Figure 3.4-1).

Figure 3.4-1 Chimneys in Uong Bi power plant
(Left; for Uong Bi 7, Center; for Uong Bi 5/6, Right ; for Uong Bi 8)

(2) Electrostatic precipitator

Soot dusts included in exhaust gas is removed by this equipment.

Both Uong Bi 5/6 and Uong Bi 7 have a dry electrostatic precipitator, respectively. (Figure 3.4-2 and Figure 3.4-3). Uong Bi 5/6 extended it in 2005.

Figure 3.4-2 Electrostatic precipitator in Uong Bi 5/6

Figure 3.4-3 Electrostatic precipitator in Uong Bi 7

(3) Flue-gas desulfurization equipment

To remove sulfur oxides from exhaust gas, Uong Bi 7 has flue-gas desulfurization equipment (Figure 3.4-4).

Figure 3.4-4 Flue-gas desulfurization equipment in Uong Bi 7

(4) Wastewater treatment facility

Starting drainage, desulfurization drainage, oil-containing wastewater and domestic wastewater has been treated by a facility for wastewater treatments (Figure 3.4-5). Chemical oxygen demand, hydrogen-ion concentration and suspended solids of treated water have been ministered on a steady basis, and have met environmental criteria in Viet Nam.

Figure 3.4-5 Wastewater treatment facility

(5) Plant tree

This power plant company makes an effort for greening in the establishment. There is a personnel for plant tree, and timber and lawns have been well-pruned (Figure 3.4-6).

Figure 3.4-6 Courtyard of the office building

3.5 Organizations

The organization chart of PLPC is shown in Figure 3.5-1.

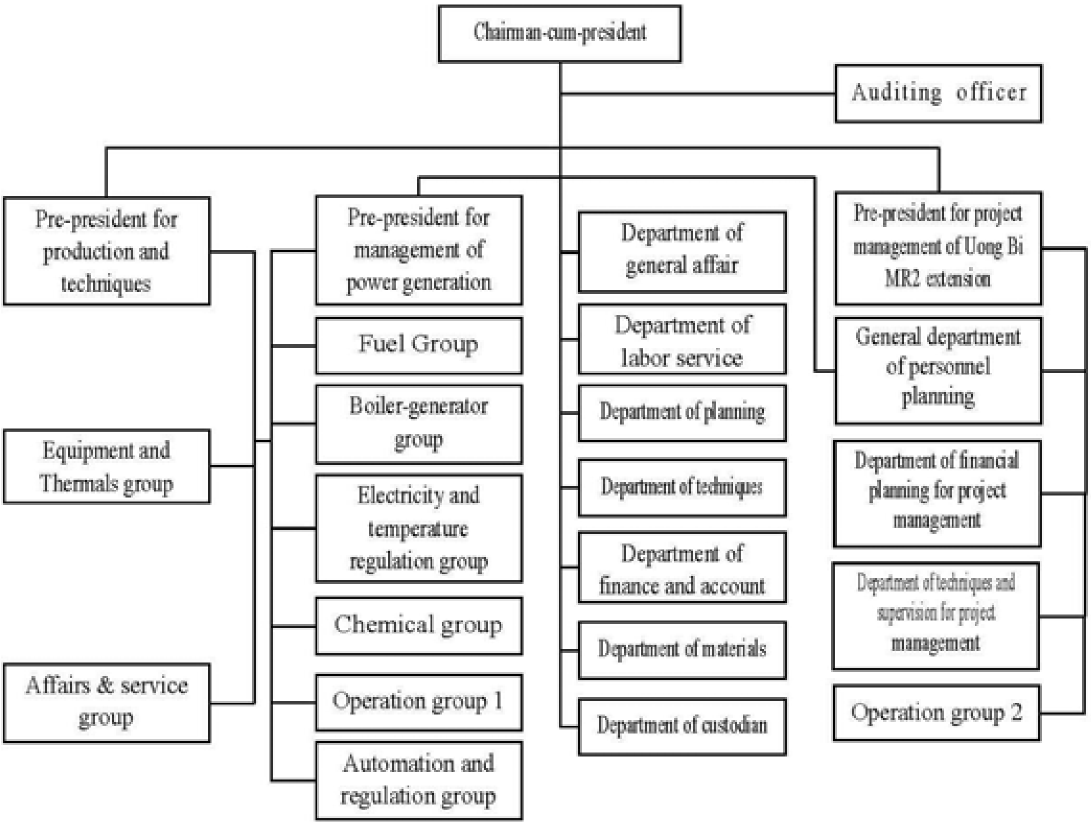

Figure 3.5-1 Organizational diagram of Uong Bi thermal power joint-stock company.

Appendix 2
Operations and Maintenance of the Power Plants

1. Operation of the Ninh Binh Thermal Power Plant

1.1 Ninh Binh Thermal Power Plant operating status and setup for operation management

Table 1.1-1 presents data for operation of the Ninh Binh Thermal Power Plant in recent years. With a total output of 100 MW, the plant does not have the largest capacity in all of Vietnam, but the capacity factor has stayed above 80 % in the case of each unit as a reflection of the domestic situation, i.e., chronic power supply shortage. The units are also being operated for close to 8,000 hours a year. As these figures indicate, the plant has a very high working rate.

Table 1.1-1 Ninh Binh Thermal Power Plant operating data

No.	Name of Power Plant & Unit No.		Ninh Binh TPP			
			#1	#2	#3	#4
1	Year in operation		5-1974	12-1974	11-1975	3-1976
2	Output (MW)	Actual	25.0	25.0	25.0	25.0
		Design	25.0	25.0	25.0	25.0
3	Capacity Factor (%)		0.93	0.86	0.87	0.79
4	Generating End Efficiency (%)	Actual	22.1	22.0	22.9	22.7
		Design	26.1 (η_{lo}*η_{may}*η_{dien}* η_{tt}=0.96)			
5	Operating hours (hrs/yr)					
	in 2005		8,474	8,164	6,769	7,104
	in 2006		8,506	8,286	8,553	8,155
	in 2007		8,485	7,765	7,664	7,388
	in 2008		7,490	8,405	8,344	7,213
	in 2009		8,451	7,948	7,961	7,216

At just over 20 %, the rate of generating-end efficiency is below the design rate (26.1 %), but could not be termed low, considering that the plant is an old one that has been operating for some 40 years. On the contrary, the rate can stand comparison with those in other developing countries.

A study carried out in 2005 ("Pilot Studies for Knowledge Assistance for Improving Operation & Maintenance of Coal-Fired Thermal Power Plants in Northern Vietnam", August 2005, JBIC) estimated the rate of generating-end efficiency at about 21 %, approximately the same as in this study. It consequently appears that plant efficiency was maintained in the range of 20 to 25 % for the past few years. Although it would be difficult to compare and assess the findings of this study with those in 2005 owing to differences in the measurement conditions, it may be concluded that the operation has remained comparatively stable as a result of improvements made since 2000, and particularly the replacement of make-up water heaters and steam condenser capillary tubes (made over the years 2005 to 2007) in addition to the replacement of rotary coal classifiers (made in 2000, for further pulverization of the coal).

The setup for operation of the Ninh Binh Thermal Power Plant consists of three alternating groups for each unit. Each group is divided into subgroups for electrical facilities, turbine facilities, and boilers. The electrical and machine subgroups operate out of different control rooms.
Management of plant operating performance is under the jurisdiction of the Security Technology Department. Work such as analysis of coal properties required for calculating plant efficiency is performed by the Chemical Management Department. While some of the operating data are recorded by so-called operating log units, almost all are recorded by personnel who take readings from meters every hour, on the hour. These data provide the basis for calculating the plant efficiency on each shift. Experts in performance management in the Maintenance Technology Department calculate the average monthly plant efficiency.
These records are forwarded to the EVN along with data for generated (electrical energy) output. The EVN uses them to make comprehensive analyses together with the records for operation of other thermal power plants in Vietnam, as well as to identify issues and conduct studies to find measures for improvement.
At the Ninh Binh Thermal Power Plant, each subgroup frequently makes the rounds to collect a lot of operating data. Nevertheless, even if these data fall below the design levels, the plant remains in operation as long as the operating limits are not exceeded. Nearly 40 years have passed since the Ninh Binh Thermal Power Plant was placed into operation, making it the oldest coal-fired thermal power plant owned by the EVN. Its facilities are consequently fairly aged, and a certain decline in efficiency is apparently tolerated. In addition, the domestic circumstance of chronic power shortage presumably lies behind a tendency to disregard a drop in plant efficiency, provided that efficiency remains high enough to assure rated output. This is a point of difference from target-based management, in which the idea is to make an advance determination of points where plant efficiency is at its highest and manage the operation while controlling the plant so that it does not deviate too far from these points.

1.2 Analysis of the current status of boiler facility operation

The Ninh Binh Thermal Power Plant is equipped with Chinese-made indoor single-drum natural circulation boilers. Table 1.2-1 presents data for the operation of the boiler facilities. The boiler efficiency is in the range of 80 to 84 %. This is below the design level, but is on a par with or slightly better than the figures in the 2005 study. Considering the influence of deterioration with the passage of time, the boiler operation may be regarded as remaining basically favorable.

Table 1.2-1 Operation of boiler facilities

No.	Name of Power Plant & Unit No.		Ninh Binh TPP #1	#2	#3	#4
1	Boiler Efficiency (%)	Actual	82.39	83.10	83.66	81.44
		Design	90.1			
2	Actual Temperature (°C) –AH1					
	Gas in / Gas out			245/155	250/150	246/155
	Air in / Air out			33/185	38/185	40/180
	Actual Temperature (°C) –AH2					
	Gas in / Gas out			485/310	468/315	463/333
	Air in / Air out			185/365	185/361	180/343
	As design basis (°C)					
	Gas in / Gas out		467/137			
	Air in / Air out		30/375			
3	Coal Composition (w%)					
	Carbon design basis / Actual Value		62.8 /58-65			
	Hydrogen design basis / Actual Value		2.2 / 2 - 2.5			
	Oxygen design basis / Actual Value		1.5 / 2 - 2.5			
	Nitrogen design basis / Actual Value		0.4 / 0.3 - 0.5			
	Sulfur design basis / Actual Value		0.4 / 0.5 – 0.8			
	Ash design basis / Actual Value		22.0 – 26 / 22 – 32			
	Moisture design basis / Actual Value		11 /7 – 11			
	Calorific value L.H.V (kcal/kg) design basis / Actual Value		5,500/ 5,000 – 5,500			
4	Remaining Carbon in Ash (%)		15-20			

The conceivable factors behind a decline in boiler efficiency include incomplete combustion for various reasons (e.g., use of low-grade coal and insufficient coal pulverization), a decline in thermal conductivity in boilers (due to adhesion of iron or copper scales inside steam generation tubes, because of deterioration with age), and a decline in heat exchange rate on air heaters (due to impairment of transfer caused by grime inside heat transfer tubes and drain corrosion on low-temperature parts).

At the Ninh Binh Thermal Power Plant, an extremely high proportion (15% to 20%) of the ash consists of uncombusted material. This incomplete combustion is linked to an increase in loss and decrease in boiler efficiency. At about 90 µm, the coal particle diameter is sufficiently small. The study also found that the plant has been taking its own steps for adjustment of combustion by adjustment of the combustion gas flow rate. It is thought that efficiency is being affected by the required use of comparatively low-grade coal in domestic thermal power plants in keeping with the national energy policy.

The temperature on the gas inlet of the air heater reaches a maximum of 485 °C as compared to the design figure of 467 °C. It may be inferred that a decline in thermal conductivity in the boiler per se is making the heat exchange insufficient, and that this is resulting in emission of high-temperature combustion gas and decline in boiler efficiency. It may also be inferred that the thermal efficiency is being lowered in the air heater considered separately. This is because, although the heater was designed for a rise of 345 °C in the combustion-use air temperature, the actual rise is about 330 °C. As a result, the outlet gas temperature on the air heater is about 150 °C, more than 10 °C higher than the design level (137 °C). This insufficient heat exchange is a factor behind decline in the boiler efficiency.

At the Ninh Binh Thermal Power Plant as well, coal pulverization is well under way thanks to steps such as replacement of rotary classifiers. The study confirmed that the coal was sufficiently pulverized; the particle diameter was found to be about 90 μm. In addition, the plant participated in a project of investigation and research with the country's Bach Khoa University to discover the optimal control of combustion through control of the revolution speed of coal-sending blowers, and is already putting the results into practice. In this arrangement, operators change the revolution speed of the fan on one of the four blowers by hand in line with the amount of airflow, and the speeds on the fans on the remaining three also undergo a corresponding change.

As the above indicates, the Ninh Binh Thermal Power Plant is taking approaches to reduce the level of uncombusted substances in ash. These approaches appear to have been reducing this level and improving combustion efficiency in recent years.

The decrease in thermal conductivity in the boilers themselves and reduction of the heat exchange rate in air heaters are caused mainly by the impairment of heat transfer due to grime and corrosion accumulated in pipes over the years. Efficiency in this aspect could presumably be increased with comparative ease by actions such as periodic cleaning.

1.3 Analysis of the current status of turbine facility operation

Table 1.3-1 shows data for turbine efficiency and the operating record of major equipment at the Ninh Binh Thermal Power Plant. As in the case of boilers, assurance of output takes precedence over efficiency, and the plant tolerates turbine operation below design levels as long as it does not serious affect the overall operation.

At the Ninh Binh Thermal Power Plant, the actual figures for main steam pressure, main steam temperature, and degree of condenser vacuum are all below the rated levels. As a result, the overall turbine efficiency is also low.

Table 1.3-1 Operation of turbine facilities

	Name of Power Plant & Unit No.		Ninh Binh TPP			
			#1	#2	#3	#4
1	Turbine Efficiency (%)	Actual	27.6	27.0	28.2	28.1
		Design	31			
2	Main Steam					
	Pressure (kg/cm^2)	Actual※1	36.2	36.2	36.2	36.2
		Design	37	37	37	37
	Temperature (°C)	Actual	440	442	442	444
		Design	450	450	450	450
	Flow Rate (Ton/hr)	Actual	120	120	110	120
		Design	130	130	130	130
	Superheater Spray Flow Rate (Ton/hr)	Actual	18/18	20/24	32/32	32/32
		Design	32/32	32/32	32/32	32/32
3	Condenser					
	Vacuum (mmHg)	Actual	690	670	685	690
		Design	716	716	716	716
4	Make-up Water					
	Pressure (kg/cm^2)	Actual	1.4	1.4	1.4	1.4
		Design				
	Temperature (°C)	Actual	23.5	23.5	23.5	23.5
		Design				
	Flow Rate (Ton/hr)	Actual	8	8	8	8
		Design				
5	Boiler Feed Water					
	Pressure (kg/cm^2)	Actual	56	56.5	56	56
		Design	57	57	57	57
	Temperature (°C)	Actual	170	169.9	170	170.5
		Design	172	172	172	172
	Flow Rate (Ton/hr)	Actual	120	125	125	121
		Design	130	130	130	130
※1 Main steam pressure after superheater outlet						

In the study, Ninh Binh Thermal Power Plant personnel were questioned about this area. They replied that, while they knew it would be better for improvement of the turbine efficiency to keep operating the levels close to the design ones, they were apprehensive that application of more stress from higher temperatures and pressures to pipe could also damage the equipment, considering the impact of deterioration with the passage of time. For this reason, they tolerated operation at main steam temperatures and pressures below the rated ones, even though aware of the resultant decline in turbine efficiency.

The Ninh Binh Thermal Power Plant extracts water to cool equipment from a river in the vicinity. The effect of a rise in water temperature on the degree of condenser vacuum is becoming a major problem. In the summer, the river water temperature sometimes reaches 37 °C.

1.4 Analysis of the current status in operation of environmental facilities

In Vietnam, the main sources of emissions of atmospheric pollutants are motorbikes and automobiles (mainly in cities), and industrial operations including thermal power plants. Air pollution due to gas emissions is a serious problem particularly in cities. Concentrations of soot, lead, CO (carbon monoxide), NO_X (nitrogen oxides), HC (hydrocarbons), SO_2 (sulfur dioxide), and other pollutants are steadily rising.

Table 1.4-1 shows the air pollutants contained in the flue-gas emissions from the Ninh Binh Thermal Power Plant. In Vietnam, it is thought that many local firms are not taking measures to prevent air pollution, in spite of the fact that there are problems due to pollution in the vicinity of industrial estates and thermal power plants fired with coal.

A previous study ("Prospects for Installation of Measuring Equipment for Stack Outlet Emissions at Ninh Binh Thermal Power Plant", October 2005, JBIC and others) also found that plant personnel had a good knowledge of measures for environmental preservation, and that the environment-related engineers were sufficiently aware of procedures for measurement, analysis, and assessment of emissions. Awareness of environmental preservation among plant personnel is therefore considered very high.

Table 1.4-1 Operation of environmental facilities

	Name of Power Plant & Unit No.	Ninh Binh TPP			
		#1	#2	#3	#4
1	Flue Gas at ECO out				
	O_2 (vol%)	1.65 – 3.07			
	CO_2 (vol%)	17.1 – 18.43			
	SO_2 (mg/Nm^3,wet)	282 – 307			
	NO_x(mg/Nm^3,wet)	335 – 363			
2	Flue gas at stack out				
	Gas flow rate (Nm^3/hr,wet)	200,000 – 205,000			
	Temperature (°C)	130			
	Particulate (mg/Nm^3,wet)	254.7	218.5	327.4	223.6
	SO_2 (mg/Nm^3,wet)	824.7	860.4	927.1	838.5
	NOx(mg/Nm^3,wet)	80.4	87.5	127.2	91.7

Note: Environmental regulation for flue gas of Thermal Power Plant as below,
PM (Particulate Matters) :400mg/Nm3, NO_X :1,000mg/Nm3, SO_X:1,500mg/Nm3

In this study, too, it was found that, unlike other power plants, the Ninh Binh Thermal Power Plant is actively promoting investment on environmental measures in order to alleviate environmental impact in addition to measuring emissions of atmospheric pollutants. These measures include construction of a stack 130 meters tall, installation of more electrostatic precipitators, and adoption of low-NOx burners.

As a result, confirmed levels for emission concentrations of soot, NO_X, and SO_2 all meet the environmental standards applied in Vietnam, as shown in Table 1.4-1.

Table 1.4-1 also indicates, however, that there must be some doubt about the credibility of the measurements themselves. For example, there are big differences between the SO_2 and NO_X emission levels at the ECO outlet and stack outlet. This issue is not confined to instruments for environmental measurement. Accurate determination of plant efficiency is an absolute prerequisite for performance of proper maintenance on the instruments. At present, the general rule is to fix or replace such instruments when they break down. It was found that many instruments have been in use since the plant was started up nearly 40 years ago. Plant personnel should consider the proper period of maintenance work because maintenance of instrument credibility through regular correction is essential for determination of plant efficiency.

1.5 Analysis of the current status in turbine facility maintenance

(1) Overall

The plant has been operating for more than 35 years and shows some deterioration, but the site is in good order. None of the turbine facilities showed signs of abnormality as viewed from the outside. There was leakage at the shell-side safety valve of the high-pressure 2HTR on Turbine 4, but it was minor and could be handled on the occasion of shutdown for repair of other equipment.

Figure 1.5-1 High-pressure 2HTR

(2) Main turbine

The main turbine underwent work for replacement and repair of the final 12-stage rotor blades from 2000 to 2002. The reason for the work was blade corrosion. Purchases have already been made for replacement of the 11th and 10th stages. For other blades, the plant has not made replacements or performed welding or other repairs since the start of operation. The amount of scale adhering to the turbine blades is reportedly not very significant. Detailed records have not been kept on the situation as regards corrosion. Data have been recorded for the gap between the outer shroud perimeter and the radial fan of the outer wall, and the gap between the shaft and labyrinth packing. These items are being managed within the permissible limits.

Figure 1.5-2 Main turbine

(3) Feed water heaters

The tubes on the high-pressure feed water heaters (1 and 2) were replaced over the years 2001 - 2005. Before this replacement, there was leakage at the welds on the pipe plates and tubes. At present, none are plugged. The plant does not perform preventive maintenance for leaks from tubes, which are maintained only after occurrence. It has no experience in washing the tubes.

Figure 1.5-3 Feed water heaters

(4) Condensers

The plant previously used aluminum brass piping for the condenser tubes, but made a gradual switch to cupronickel pipes over the years 2005 - 2010 due to the increase in the number plugged. Thereafter, it experienced the first tube leak on Unit 4 in August 2010. The Ninh Binh plant draws water from a river, and the water temperature rises to about 37 degrees in the summer. In addition, the diameter of the water circulation pipes is small. Although there is margin for installation of more CWP units, the pipe pressure loss prevents a sufficient flow of circulating water even with the start up of additional CWPs. This lowers the degrees of vacuum in the condenser, which is unable to maintain rated output. (There are a total of four CWP units, two with an output of 800 kW and two with one of 520 kW. Depending on the water temperature, only one 800-kW unit may be operated. The plant may also run one 800-kW unit and one or two 520-kW units, but it never runs all units at the same time.) However, it is a particular condition for the limited time only during summer, and the plant has not taken any particular measures in this area. The condenser capillary tubes are cleaned by washing (by back-washing and with regular brushes and rubber brushes) during shutdown for maintenance every three months, at the time of periodical inspections. For condenser capillary tubes as well, it does not perform preventive maintenance for leaks, but merely makes repairs when they occur.

Figure 1.5-4 Condenser

2 Operation of the Pha Lai Thermal Power Plant

2.1 Pha Lai Thermal Power Plant operating status and setup for operation management

The Pha Lai Thermal Power Plant consists of the Pha Lai I Thermal Power Plant built in the early 1980s and the Pha Lai II Thermal Power Plant built in early 2000. The rated output of the Pha Lai I Thermal Power Plant is 440 MW (110 MW x 4), while the rated output of the Pha Lai II Thermal Power Plant is 600 MW (300 MW x 2).

Table 2.1-1 and Table 2.1-2 respectively present data for operation of the Pha Lai I Thermal Power Plant and the Pha Lai II Thermal Power Plant in recent years. Reflecting the domestic situation, i.e., chronic power supply shortage, the units are being operated at relatively a high working rate.

Table 2.1-1 Pha Lai I Thermal Power Plant operating data

No.	Name of Power Plant & Unit No.		Pha Lai I TPP			
			#1	#2	#3	#4
1	Year in operation		1983	1984	1985	1986
2	Output (MW)	Actual	90	85	100	100
		Design	110	110	110	110
3	Capacity Factor (%)		—	—	—	—
4	Generating End Efficiency (%)	Actual	28.3	30	29.09	28,57
		Design	32.5			
5	Operating hours (hrs/yr)					
	in 2005		7,567	7,426	6,904	6,338
	in 2006		7,902	7,765	7,559	7,756
	in 2007		8,384	6,649	8,476	7,980
	in 2008		6,434	6,599	7,891	8,228
	in 2009		8,656	8,269	8,558	7,087

Table 2.1-2 Pha Lai II Thermal Power Plant operating data

No.	Name of Power Plant & Unit No.		Pha Lai II TPP	
			#5	#6
1	Year in operation		2001	2002
2	Output (MW)	Actual	290	295
		Design	300	300
3	Capacity Factor (%)		89.5	89.4
4	Generating End Efficiency (%)	Actual	35.18	35.42
		Design	38.1	38.1
5	Operating hours (hrs/yr)			
	in 2005		7,627	8,159
	in 2006		7,561	7,312
	in 2007		6,871	8,331
	in 2008		8,216	7,780
	in 2009		8,565	8,434

At below 30 %, the rate of generating-end efficiency of the Pha Lai I Thermal Power Plant is below the design rate (32.5 %). It seems that maintaining the design efficiency is difficult considering the old plant that has been operating for more than 25 years and the difficulty in performing effective maintenance as stopping the plant for periodic regular checks and repairs is difficult due to chronic power supply shortage. In particular, the efficiency of the unit 1 and the unit 2, which have been operating for nearly 30 years, has significantly declined.

On the other hand, at around 35 %, the rate of generating-end efficiency of the Pha Lai II Thermal Power Plant is also below the design rate (38.1 %). Although the Pha Lai II Thermal Power Plant is a state-of-the-art Thermal Power Plant, no major overhaul have been performed on the plant because there have been no such opportunities due to tight domestic electric power supply since the start of its operation.

The setup for operation of the Pha Lai Thermal Power Plant consists of three alternating groups for each unit. Each group is divided into subgroups for electrical facilities, turbine facilities, and boilers. The electrical and machine subgroups operate out of different control rooms.

Management of plant operating performance is under the jurisdiction of the Technology Department. The plant efficiency is independently calculated before the start of periodical inspections for comparison between before and after the periodical inspections, but after the periodical inspections, the calculation of efficiency will be commissioned to an external specialty company. At the Pha Lai I Thermal Power Plant, the operating data are recorded by personnel who take readings from meters every hour, on the hour. On the other hand, at the Pha Lai II Thermal Power Plant, in addition to recording of the operating data by personnel, major operation values of units are automatically recorded by the operating log units.

According to the results of questioning of Pha Lai Thermal Power Plant personnel, they knew efficiency calculation such as those on boiler efficiency and turbine efficiency and parameters to affect the efficiency (e.g. temperature of flue gas). However, it is inferred that due to extreme tight domestic electric power supply situation, they cannot help giving priority to the operation of units over and cannot maintain and improve the efficiency through appropriate maintenance.

2.2 Analysis of the current status of boiler facility operation

The Pha Lai I Thermal Power Plant is equipped with boilers made in former Soviet Union. Table 2.2-1 presents data for the operation of the boiler facilities. The boiler efficiency is in the range between 84.4 % and 85 %, which is slightly below the design level. Considering the influence of deterioration with the passage of time, the boiler operation may be regarded as remaining basically favorable.

Table 2.2-1 Operation of Pha Lai I Thermal Power Plant boiler facilities

No.	Name of Power Plant & Unit No.		Pha Lai I TPP			
			#1	#2	#3	#4
1	Boiler Efficiency (%)	Actual	85.0	84.8	85.0	84.4
		Design	86.06			
2	Actual Temperature (°C) –AH					
	Gas in / Gas out		550/140	550/140	550/140	550/140
	Air in / Air out		30/400	30/400	30/400	30/400
	As design basis (°C)-AH					
	Gas in / Gas out		553/133	553/133	553/133	553/133
	Air in / Air out		23/410	23/410	23/410	23/410
	Actual Concentration of O_2 in flue gas (vol %) –AH					
	ECO out / AH out		42/32	42/32	42/32	42/32
	As design basis (vol %)					
	ECO out / AH out		40/31	40/31	40/31	40/31
3	Coal Composition (w%)					
	Carbon design basis / Actual Value		56.8			
	Hydrogen design basis / Actual Value		2.2/2.32			
	Oxygen design basis / Actual Value		2.22			
	Nitrogen design basis / Actual Value		0.4			
	Sulfur design basis / Actual Value		0.73			
	Ash design basis / Actual Value		28.3/29.5			
	Moisture design basis / Actual Value		9.5			
	Calorific value L.H.V (kcal/kg) design basis / Actual Value		5,035/5,000			
4	Remaining Carbon in Ash (%)		16-18			

According to the results of questioning of Pha Lai Thermal Power Plant personnel, there are two major conceivable factors behind a decline in boiler efficiency at the Pha Lai I Thermal Power Plant.

One factor is a decline in thermal conductivity in boilers due to adhesion of scale to boiler heat transfer tubes with deterioration with age, and the other factor is air suction from air heaters.

Meanwhile, the temperature at the gas inlet of the air heater reaches a maximum of 550 °C as compared to the design figure of 553 °C, indicating that the difference with the design figure is not so large. In contrast, the inlet air temperature of the air heater is 30 °C (23 °C on design level), and the outlet air temperature is 400 °C as compared to the design figure of 410 °C. Although the effects of poor heat transfer of the boiler per se is possible, it may be inferred that the deterioration of performance of the air heater is a major factor behind decline in the boiler efficiency. In addition, it is thought that the factors for deteriorating the performance of the air heater considered separately are air suction and poor heat transfer due to dirt and corrosion of pipes because of deterioration with age.

Moreover, the questioned personnel replied that they do not conduct a management of the performance on air heater considered separately as mentioned above.

The Pha Lai II Thermal Power Plant is equipped with Russia-made boilers. Table 2.2-2 presents data for the operation of the boiler facilities. The boiler efficiency is in the range between 84.8 % and

84.9 %. Considering it is a state-of-the-art plant, the boiler operation may be regarded as remaining basically favorable.

Table 2.2-2 Operation of Pha Lai II Thermal Power Plant boiler facilities

No.	Name of Power Plant & Unit No.		Pha Lai II TPP	
			#5	#6
1	Boiler Efficiency (%)	Actual	84.8	84.9
		Design	88.5	
2	Actual Temperature (°C) –AH			
	Gas in / Gas out		20.7/327	20/330
	Air in / Air out		400/123	409/126
	As design basis (°C)-AH			
	Gas in / Gas out		27/339	27/339
	Air in / Air out		391/126	391/126
	Actual Concentration of O_2 in flue gas (vol %) –AH			
	ECO out / AH out		2.4/4.9	2.2/4/7
	Actual Concentration of O_2 in flue gas (vol %) –AH			
	ECO out / AH out		3.7/4.7	3.6/4.7
3	Carbon design basis / Actual Value		56.5/55.8-58.3	
	Hydrogen design basis / Actual Value		1.41/1.39-1.43	
	Oxygen design basis / Actual Value		1.69/1.68-1.71	
	Nitrogen design basis / Actual Value		1.69/1.68-1.71	
	Sulfur design basis / Actual Value		0.5/0.49-0.52	
	Ash design basis / Actual Value		30.32/28-31.3	
	Moisture design basis / Actual Value		9/8.5-10	
	Calorific value L.H.V (kcal/kg) design basis / Actual Value		4,950/4,920-5,025	
4	Remaining Carbon in Ash (%)		14-18	

The same tendency as the Pha Lai I Thermal Power Plant has been seen in the Pha Lai II Thermal Power Plant, and it may be inferred that the decline of efficiency of the air heater is a major factor behind decline in the boiler efficiency.

Moreover, the questioned personnel replied that with increase of load of the mill, the plant is operating by using all the units instead of securing one backup unit, and as a result, the plant efficiency has decreased due to increase of load within the plant.

2.3 Analysis of the current status of turbine facility operation

Table 2.3-1 and Table 2.3-2 respectively show data for turbine efficiency and the operating record of major equipment at the Pha Lai I Thermal Power Plant and the Pha Lai II Thermal Power Plant. As in the case of boilers, turbine efficiency is slightly lower than rated efficiency at both plants.

In particular, there is significant decline in condenser vacuum at both plants, and this has had large effects on decline in turbine efficiency. Moreover, a decline in the degree of condenser vacuum due to the effect of a rise in river water temperature in the summer is becoming a major problem.

Moreover, troubles in facilities have had effects on decline in efficiency, which include decline in heat exchange by the dirt of pipes because of lack of cleaning of condenser pipes caused by troubled dust collector, and the effects of air suction into the condenser due to deterioration with age.

In the study, Pha Lai Thermal Power Plant personnel were questioned about this area. They replied that, while they knew these sorts of facility troubles, it is difficult to stop the units for maintenance due to tight domestic power supply situations.

In particular, regarding the Pha Lai II Thermal Power Plant, simple inspections (inspection interval: 2 years) were performed only once and no major inspections (inspection interval: 4 years) have been performed since the start-up. In addition, the units are repaired by stopping the operation only for a short period when the load is relatively low, and the units are in almost continuous operation throughout the year, which makes it difficult to perform appropriate maintenance.

Table 2.3-1 Operation of Pha Lai I turbine facilities

	Name of Power Plant & Unit No.		Pha Lai I TPP			
			#1	#2	#3	#4
1	Turbine Efficiency (%)	Actual	34.0	36.4	35.8	34.3
		Design	39.0			
2	Main Steam					
	Pressure (kg/cm^2)	Actual	95	95	94	95
		Design	100	100	100	100
	Temperature (°C)	Actual	535	535	535	535
		Design	540	540	540	540
	Flow Rate (Ton/hr)	Actual	210	210	210	210
		Design	220	220	220	220
	Superheater Spray Flow Rate (Ton/hr)	Actual	0-10	0-10	0-10	0-10
		Design	0-10	0-10	0-10	0-10
3	Condenser					
	Vacuum (mmHg)	Actual	670	650	650	670
		Design	721	721	721	721
4	Make-up Water					
	Pressure (kg/cm^2)	Actual	15.0	15.5	16.0	15.6
		Design	16.0	16.0	16.0	16.0
	Temperature (°C)	Actual	42.0	43.0	44.0	44/0
		Design	—	—	—	—
	Flow Rate (Ton/hr)	Actual	322	318	321	321
		Design	320	320	320	320
5	Boiler Feed Water					
	Pressure (kg/cm^2)	Actual	165	165	165	164
		Design	165	165	165	165
	Temperature (°C)	Actual	155	154	156	154
		Design	158	158	158	158
	Flow Rate (Ton/hr)	Actual	266	265	265	266
		Design	270	270	270	270

Table 2.3-2 Operation of Pha Lai II turbine facilities

	Name of Power Plant & Unit No.		Pha Lai II	
			#5	#6
1	Turbine Efficiency (%)	Actual	42.9	43.2
		Design	45.1	45.1
2	Main Steam			
	Pressure (kg/cm^2)	Actual	173.8	174.2
		Design	174.6	174,6
	Temperature (°C)	Actual	541	541
		Design	541	541
	Flow Rate (Ton/hr)	Actual	877.5	878.7
		Design	921.8	921.8
	Superheater Spray Flow Rate (Ton/hr)	Actual	22.4	21.5
		Design	20.0	20.0
3	Condenser			
	Vacuum (mmHg)	Actual	650	600
		Design	721	721
4	Make-up Water			
	Pressure (kg/cm^2)	Actual	1.0	1.0
		Design	15.3(Max)	15.3 (Max)
	Temperature (°C)	Actual	25.0	25.0
		Design	16.0	16.0
	Flow Rate (Ton/hr)	Actual	27	27
		Design	170(Max)	170(Max)
5	Boiler Feed Water			
	Pressure (kg/cm^2)	Actual	216	218
		Design	221.4	221.4
	Temperature (°C)	Actual	168	169
		Design	170	170
	Flow Rate (Ton/hr)	Actual	520x2	520x2
		Design	525x2	525x2

2.4 Analysis of the current status in operation of environmental facilities

Table 2.4-1 and Table 2.4-2 show the air pollutants contained in the flue-gas emissions from the Pha Lai I Thermal Power Plant and the Pha Lai II Thermal Power Plant.

In Vietnam, the main sources of emissions of atmospheric pollutants are motorbikes and automobiles (mainly in cities), and industrial operations including thermal power plants. Air pollution due to gas emissions is a serious problem particularly in cities. Concentrations of soot, lead, CO (carbon monoxide), NO_X (nitrogen oxides), HC (hydrocarbons), SO_2 (sulfur dioxide), and other pollutants are steadily rising.

Despite such problems, however, many companies have reportedly taken no measures against air pollution in Vietnam.

As for the Pha Lai Thermal Power Plant, there are no records of the measurements of flue gas at the stack outlet for the old Pha Lai I Thermal Power Plant, but the measurement of flue gas at the stack outlet have been performed for the Pha Lai II Thermal Power Plant, which have met the environmental quality standards in Vietnam.

However, not only instruments for environmental measurement but measuring instruments used within the power plant have generally deteriorated, and regular instrument calibration is insufficient. Plant personnel should consider the proper period of maintenance work because maintenance of instrument credibility through regular correction is essential for determination of plant efficiency.

Table 2.4-1 Operation of Pha Lai I environmental facilities

	Name of Power Plant & Unit No.	Pha Lai I TPP			
		#1	#2	#3	#4
1	Flue Gas at ECO out				
	O_2 (vol %)	3.8 – 5.7			
	CO_2 (vol %)	14.9 – 17.1			
	SO_2 (mg/Nm^3,wet)	506-565			
	NO_X (mg/Nm^3,wet)	669-792			
2	Flue gas at stack out				
	Gas flow rate (m^3/h)	308			
	Temperature (°C)	110			
	Particulate (mg/Nm^3,wet)	—	—	—	—
	SO_2 (mg/Nm^3,wet)	—	—	—	—
	NO_X (mg/Nm^3,wet)	—	—	—	—

Note: Environmental regulation for flue gas of Thermal Power Plant as below,
PM (Particulate Matters) :400mg/Nm3, NO_X :1,000mg/Nm3, SO_X:1,500mg/Nm3

Table 2.4-2 Operation of Pha Lai II environmental facilities

	Name of Power Plant & Unit No.	Pha Lai II TPP	
		#5	#6
1	Flue Gas at ECO out		
	O_2 (vol %)	2.4	2.2
	CO_2 (vol %)	17.1	16.8
	SO_2 (mg/Nm^3,wet)	1290	1287
	NO_X (mg/Nm^3,wet)	285	278
2	Flue gas at stack out		
	Gas flow rate (m^3/h)	1086499	1098006
	Temperature (°C)	97	96
	Particulate (mg/Nm^3,wet)	95	94
	SO_2 (mg/Nm^3,wet)	504	503
	NO_X (mg/Nm^3,wet)	285	278
Note: Environmental regulation for flue gas of Thermal Power Plant as below,PM (Particulate Matters) :400mg/Nm3, NO_X :1,000mg/Nm3, SO_X:1,500mg/Nm3			

2.5 Analysis of the current status in turbine facility maintenance

(1) Overall

Pha Lai I

The turbine facilities have been operating for nearly 30 years and have shown some deterioration. Deterioration was seen in valves and there was occasional leak of steam from gland parts and bonnet flanges.

Figure 2.5-1 Pha Lai I turbine building

Pha Lai II

Since the turbine facilities are relatively new with the operation continuing for 10 years, the on-site conditions are favorable. No abnormalities were detected as far as the appearance of turbine facilities is concerned. Built under the ODA program of Japan, the turbine equipment has orderly arrangement similar to one in Japan.

Figure 2.5-2 Pha Lai II turbine building

(2) Main turbine

Pha Lai I

According to the plant personnel, as to the main turbine, blade tips and sealing fins of gland are regularly replaced, but no repairs were made to the rotor blades and stator vanes. Detailed checks are commissioned to an external company and there were no records of checks available at the plant. Only visual checks on the gaps in blade tips and sealing fins of gland are performed at the plant. The low-pressure final stage of rotor blades at the unit 2 was damaged and its replacement has been planned. Despite the damaged rotor blades, the turbine is continuing its operation. Rotor blades of other units have been also corroded, and their sequential replacement has been planned. Scale has also adhered to the turbine blades.

Figure 2.5-3 Main turbine

Pha Lai II

The turbine facilities have been operating for 10 years, but no overhaul inspections have been performed on the main turbine due to tight supply of electric power. Although full checks were planned in 2009, they have not yet been performed up till now. According to the plant personnel, the suction of substantial amount of air from the low-pressure gland part was detected during the checks performed by the plant, and the seals of gland part will be replaced when the plant stops operation next time. The plant personnel were aware that there might have been substantial leak of steam from blade tips and the seals of rotors inside the turbine. The adhesion of scale was detected from the low-pressure manhole when the low-pressure blades were checked. It is possible that there are corrosion of rotor blades and adhesion of scale to the stator vanes.

Figure 2.5-4 Main turbine

(3) Feed water heaters

According to the plant personnel, checks and repairs have been commissioned to an external company and the power plant does not manage the records of plugging. Although the conditions of wall thickness of capillaries have been managed for the Pha Lai I Thermal Power Plant, no details were confirmed because the management has been commissioned to an external company. All tubes for low-pressure heaters and part of the tubes of high-pressure heaters were replaced 10 years ago. During the simple checks conducted once in two years, the inside of capillaries is washed with water ($10kg/cm^2$). (No checks have been performed on the heaters at the Pha Lai II Thermal Power Plant.) The plant does not perform preventive maintenance of the feed water heaters, which are repaired only after occurrence of troubles.

Figure 2.5-5 Pha Lai I feed water heaters

(4) Condensers

According to the plant personnel, the amount of air suction is measured both at the Pha Lai I Thermal Power Plant and the Pha Lai II Thermal Power Plant, and they considers a large amount of air suction problems. However, no management records of the location and the amount of air suction were confirmed.

Pha Lai I

According to the plant personnel, all condenser capillaries were replaced 10 years ago without changing their material (aluminum brass tube). Current plugging conditions could not be confirmed at the plant. The ball cleaning system is not installed, while the cleaning of capillaries is performed with brush cleaning once in two years. It can be inferred that the thermal power plant has been forced to operate in a state where the condenser vacuum has fairly deteriorated. The plant does not perform preventive maintenance against possible leaks from condenser capillaries, which are repaired only after occurrence of troubles (breakdown maintenance).

Figure 2.5-6 Condensers

Pha Lai II

SUS304 is used as the material of condenser capillaries while the ball cleaning system is installed to clean the balls every day. However, the management of ball size has not been carried out, and with the continuation of use of balls, the size has become smaller and balls are discharged from the screen. The plant does not perform preventive maintenance of the condenser, which will be repaired only after occurrence of troubles (breakdown maintenance).

Figure 2.5-7 Ball cleaning system

Other facilities

(1) Water quality monitor

The silica meters of water treatment facilities are broken down and not used. The continuing use of water quality monitors including silica meters is difficult without regular checks and replacement of parts. According to the plant personnel, the indicator of pH meter was not stable and deviated from the manually analyzed values. However, with the arrangement of water quality control manuals, the control values are fixed and manual analysis is performed every 8 hours. Therefore, it can be considered that the water quality is maintained at the level that poses no problems.

Figure 2.5-8 Silica meter that is broken

(2) Plant automation

The automation of the Pha Lai II Thermal Power Plant has been promoted with the introduction of the design that allows automatic start/stop. Due to malfunctions of equipment, however, the conditions for progressing the sequence have not been secured. Therefore, the unit is actually started by manually operating the automatic valves and starting the equipment.

3. Operation of the Uong Bi Thermal Power Plant

3.1 Uong Bi Thermal Power Plant operating status and setup for operation management

The Uong Bi Thermal Power Plant has a long history; The unit 1 started being constructed in 1961 and started its operation in 1963. The units built in the initial period - the unit 1 to the unit 4 - had total output of 48 MW (12 MW x 4 units), but they were already abolished.

At present, the Uong Bi Thermal Power Plant consists of the unit 5 that started its commercial operation in 1975, the unit 6 that started its operation in 1978, and the unit 7 that started its operation in 2009. In the adjacent establishment, the construction of the unit 8 has been underway with the aim for starting its operation in August 2011.

When it was built, the output of the unit 5 was 50 MW, but it was increased to 55 MW the same rated output as the unit 6. The output of the unit 7 is 300 MW, while the output of the unit 8 under construction is 330 MW.

Table 3.1-1 presents data for operation of the Uong Bi Thermal Power Plant in recent years. Reflecting the domestic situation, i.e., chronic power supply shortage, the units are being operated at relatively a high working rate.

Table 3.1-1 Uong Bi Thermal Power Plant operating data

No.	Name of Power Plant & Unit No.		Uong Bi TPP #5	Uong Bi TPP #6	Uong Bi TPP #7
1	Year in operation		1975	1978	2009
2	Output (MW)	Actual	55	55	285
		Design	55	55	300
3	Capacity Factor (%)		—	—	—
4	Generating End Efficiency (%)	Actual	—	—	—
		Design	35.65	35.65	39.14
5	Operating hours (hrs/yr)				
	in 2005		5,196	8,323	—
	in 2006		7,978	7,915	—
	in 2007		7,954	6,450	—
	in 2008		5,651	8,572	—
	in 2009		5,827	8,322	—

In this study, no data about the rate of generating-end efficiency of the Uong Bi Thermal Power Plant were available. The unit 5 and the unit 6 of the Uong Bi Thermal Power Plant are the plants that have been operating for more than 30 years. Due to old equipment and chronic power supply shortage, it is difficult to stop the plant for regular checks and repairs and conduct effective maintenance, and, therefore, maintaining design efficiency seems to be difficult. Moreover, it is inferred that sufficient efficiency cannot be maintained for the unit 7 because the generation of clinker makes operating the boilers at rated levels difficult.

The setup for operation of the Uong Bi Thermal Power Plant consists of three alternating groups for each unit. Each group is divided into subgroups for electrical facilities, turbine facilities, and boilers. The electrical and machine subgroups operate out of different control rooms.

3.2 Analysis of the current status of boiler facility operation

The unit 5 and the unit 6 of the Uong Bi Thermal Power Plant are equipped with boilers made in former Soviet Union. Table 3.2-1 presents data for the operation of the boiler facilities. The boiler efficiency is in the range of from 74 % to 82 %, which is significantly lower than the design efficiency of 90.6 %.

According to the on-site study of the unit 6 in operation, it is obvious that the efficiency has largely fallen due to the age-related deterioration as seen in the leak of steam and gas at several points.

In addition, against the design heating value of coal used as fuel for the unit 5 and the unit 6 being 6,020 (kcal/kg), the actually used heating value totaled 5,200 to 5,400 (kcal/kg), which shows the problem that the design boiler output has not been obtained.

Therefore, the Uong Bi Thermal Power Plant has been repeating tests using various types of coal in order to achieve more efficient operation, but the good results do not seem to have been obtained.

Table 3.2-1 Operation of Uong Bi Thermal Power Plant boiler facilities

No.	Name of Power Plant & Unit No.		Uong Bi TPP		
			#5	#6	#7
1	Boiler Efficiency (%)	Actual	74.0-82.0		86.0
		Design	90.6		86.0
2	Actual Temperature (°C) –AH				
	Gas in / Gas out		327/125	327/125	—
	Air in / Air out		30/300	30/300	—
	As design basis (°C)-AH				
	Gas in / Gas out		376/121	376/121	—
	Air in / Air out		40/316	40/316	—
	Actual Concentration of O_2 in flue gas (vol %) –AH				
	ECO out / AH out		2.6/3.2	2.6/3.22	—
	As design basis (vol %)				
	ECO out / AH out		—	—	—
3	Coal Composition (w%)				
	Carbon design basis / Actual Value		73.6/66.4		59.0/64.29
	Hydrogen design basis / Actual Value		1.3/1.36		1.09/1.44
	Oxygen design basis / Actual Value		2.2/0.44		1.14/0.44
	Nitrogen design basis / Actual Value		0.2/0.037		0.85/0.037
	Sulfur design basis / Actual Value		0.4/0.85		0.85/10.96
	Ash design basis / Actual Value		16.8/24		27.69/24.4
	Moisture design basis / Actual Value		5.5/8.5		9.4
	Calorific value L.H.V (kcal/kg) design basis / Actual Value		6,020/5,200-5,400		4,961/5,027
4	Remaining Carbon in Ash (%)		—		6.0-9.0

Meanwhile, the unit 7 of the Uong Bi Thermal Power Plant, which stated operation in 2009, is equipped with China-made boilers. There are a lot of generation of clinker and fall of clinker being accumulated on the furnace walls has caused damage to the steam generation tubes and burner trip, resulting in frequent occurrence of the cases leading to MFT (main fuel trip).

Generally, clinker has a high rate of alkali in ash and when the melting point of ash is low, the amount of clinker adhered to the furnace walls tends to increase, but effective measures to control the generation of clinker have not been found. In the Uong Bi Thermal Power Plant, tests have been repeatedly conducted such as increasing the number of the use of soot blower and combustion adjustment. As a result, the plant personnel have judged that by controlling the output to 280 to 290MW, it can restrain the generation of clinker relatively well and continue the most stable operation. Therefore, despite the plant that started operation just a while ago, the unit 7 is continuing its operation in a state that is below the rated output (300 MW).

However, it is necessary to stop the unit for removing clinker once in several months. This has large effects on the operation of the plant and requires the use of fuel whose unit price is high for restarting the unit, which poses big problems from the prospect of economic efficiency.

3.3 Analysis of the current status of turbine facility operation

Table 3.3-1 shows data for turbine efficiency and the operating record of major equipment at the Uong Bi Thermal Power Plant. As in the case of boilers, turbine efficiency is lower than rated efficiency at the Uong Bi Thermal Power Plant.

Maintenance such as replacement of blades has been conducted on the unit 5 and the unit 6. However, in addition to significant deterioration with the passage of more than 30 years since the construction of the plant, tight domestic electric power supply situations have affected power plants in Vietnam and it is extremely difficult for the Uong Bi Thermal Power Plant to secure sufficient stopping period for (regular) checks and repairs required for the maintenance of equipment. As a result, there is the leak of steam seen in many parts.

In addition, there is significant decline in condenser vacuum at the Uong Bi Thermal Power Plant, and this has had large effects on decline in turbine efficiency. In particular, decline in the degree of condenser vacuum due to the effect of a rise in river water temperature in the summer is becoming a major problem.

Moreover, because the heating value of coal used at the plant is largely less than the design level, the Uong Bi Thermal Power Plant has not obtained boiler output that reaches the design level. As a result, the main steam pressure and the main steam temperature are less than the rated values, which has become one of the factors for causing a decline in the efficiency.

Meanwhile, the turbine operation at the unit 7 may be regarded as remaining relatively favorable. However, there are reports of troubles that may affect the future operations such as partial damage to condenser capillaries, and, therefore, it is desirable to conduct appropriate maintenance.

Table 3.3-1 Operation of Uong Bi turbine facilities

	Name of Power Plant & Unit No.		Uong Bi TPP		
			#5	#6	#7
1	Turbine Efficiency (%)	Actual	31-34	31-34	—
		Design	44	44	45.79
2	Main Steam				
	Pressure (kg/cm^2)	Actual	85-89	85-89	170
		Design	100	100	176
	Temperature (°C)	Actual	530-535	530-535	518
		Design	535	535	538
	Flow Rate (Ton/hr)	Actual	220	220	840
		Design	220	220	871
	Superheater Spray Flow Rate (Ton/hr)	Actual	—	—	56
		Design	—	—	-
3	Condenser				
	Vacuum (mmHg)	Actual	720	720	—
		Design	734	734	—
4	Make-up Water				
	Pressure (kg/cm^2)	Actual	—	—	—
		Design	—	—	—
	Temperature (°C)	Actual	—	—	—
		Design	—	—	—
	Flow Rate (Ton/hr)	Actual	—	—	—
		Design	320	320	—
5	Boiler Feed Water				
	Pressure (kg/cm^2)	Actual	140-150	140-150	187
		Design	150	150	—
	Temperature (°C)	Actual	200-234	200-234	235
		Design	215	215	251
	Flow Rate (Ton/hr)	Actual	110-115	110-115	865
		Design	110	110	900

3.4 Analysis of the current status in operation of environmental facilities

In this study, sufficient data about air pollutants emitted from the Uong Bi Thermal Power Plant were not available. Air pollution due to industrial operations including thermal power plants is a serious problem in Vietnam. Concentrations of soot, lead, CO (carbon monoxide), NO_X (nitrogen oxides), HC (hydrocarbons), SO_2 (sulfur dioxide), and other pollutants are steadily rising.

Therefore, it is desirable to install measuring instruments at an early date and establish the setup for appropriate control of the emissions of air pollutants.

3.5 Analysis of the current status in turbine facilities maintenance (Uong Bi Thermal Power Plant)

(1) Overall

Uong Bi unit 5 and 6

The turbine facilities have been operating for more than 30 years and have considerably deteriorated. With the leak of steam seen from valves and feed water heaters, the facilities are in considerably difficult conditions.

Figure 3.5-1 Uong Bi unit 5 and 6 main building (Turbine foundation and its surroundings)

Uong Bi unit 7

The turbine facilities have been operating for less than two years and no overall problems were detected as far as the appearance is concerned.

Figure 3.5-2 Uong Bi unit 7 main building

(2) Main turbine

Uong Bi unit 5 and 6

The main turbine of the unit 5 was under regular checks. The replacement of part of stator vanes was planned but it would take some time until vanes will be delivered, according to the plant personnel. The 18-stage rotor blade of the unit 5 was replaced in 2008, while the 22-stage rotor blade of the unit 6 was replaced in 2000.

Figure 3.5-3 Uong Bi unit 5 and 6 main turbine

Uong Bi unit 7

There were problems of vibration when the main turbine in operation as well as differential expansion in the turbine. The problems of vibration were solved by adjusting the opening and closing timing of the steam governing valve and balance shot, while the problems of differential expansion were solved by making assure that the designed casing warming and starting schedule are observed, according to the plant personnel. High-pressure 17 stages, intermediate pressure 15 stages and low-pressure four stages (double flow).

Figure 3.5-4 Uong Bi unit 7 main turbine

(3) Feed water heaters

The entire high-pressure (HP) No. 6, 7 and 8 heaters of the unit 5 were replaced. And the tubes of high-pressure (HP) No. 6, 7 and 8 heaters of the unit 6 were replaced in 2003. The power plant manages the records of plugging. There was the leak of steam from the feed water heater of the unit 6, and it can be inferred that the heater has considerably deteriorated. The plant does not perform preventive maintenance of feed water heaters, which are repaired only after occurrence of troubles.

Figure 3.5-5 Uong Bi unit 5 and 6 feed water heaters and its surroundings

(4) Condensers

Uong Bi unit 5 and 6

All the capillaries of the unit 5 were replaced with new ones made from brass tube in 2000. The capillaries of the unit 6 were also replaced in the past. The power plant manages the records of plugging, and when the allowed value (12 %) is exceeded, capillaries are replaced. When the conditions of condenser vacuum have deteriorated, the condenser is cleaned by back washing. Moreover, the condensers are cleaned during regular checks that are performed every two and four years. The plant does not perform preventive maintenance of condensers, which are repaired only after occurrence of troubles.

Figure 3.5-6 Uong Bi unit 5 and 6 condensers

Uong Bi unit 7

Titanium tubes are used for condenser capillaries, while the ball cleaning system is installed to clean the balls every day. However, the management of ball size has not been carried out, and with the continuation of use of balls, the size has become smaller and balls are discharged from the screen.

Figure 3.5-7 Uong Bi unit 7 condensers

Other facilities

(1) Water quality monitor

The water quality automatic monitoring instrument is installed in the unit 7. According to the plant personnel, since advanced knowledge and technique are required for the maintenance of water quality meter, they cannot make full use of the meter. However, with the arrangement of water quality control manuals, the control values are fixed and manual analysis is performed every 2 hours. Therefore, it can be considered that the water quality is maintained at the level that poses no problems.

(2) Plant automation

The unit 7 is a unit that allows automatic start/stop, but such mechanism cannot be used due to the problems of software. The details of the problems are unknown.