

Development strategy and the application of circulating fluidized bed combustion in power generation projects of Vietnam National Coal Corporation (VINACOAL)

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Abstract

Vinacoal's development plan of coal-fired power plants is described in this paper. The paper focuses on the project structure, project scope, form of investment, CFB technology and key boiler design features, plus current status of ongoing projects.

I. Overview of development of Coal-fired power plants in diversifying business Strategy of Vinacoal.

1.1 . Introduction

Vietnam National Coal Corporation (VINACOAL) is a state owned company founded in 1994 which boasts of more than 40 member companies. Its task is related to coal business and coal industry catering to development of domestic market, for export purposes as well as coal-based business development opportunities.

The aim of VINACOAL is at creating back-up basis for long term and steady development of Vietnam coal industry which will lead to supplying of more products for society by making full use of existing capability of the coal industry with geographical advantages and mineral resources available in the region. This action is to ensure creating more jobs and improving material and spiritual life of the workers, leading to contributions in regional and inter-regional economic structure in the overall development of multi-sectional economy. Apart from coal business, developing other businesses has been an important task and integral part in development strategy of VINACOAL. The main areas of business diversification of VINACOAL include: power generation (mainly coal-fired power plants), industrial explosives, construction materials, mechanical engineering and manufacture, transportation, sea port, information and environment technology, geological and geodetic survey services, investment consultancy, scientific and technological research and application, consumer goods, trading, tourism and other services. Among those businesses, power generation has been considered one of the most important strategies.

1.2 VINACOAL's development plan of coal-fired power plants

In the development of the coal industry, the power plants invested by Vinacoal and/or in cooperation with domestic or foreign companies will be built at mine-mouth in order to make full use of coal resources and available technical facilities and infrastructure, to

generate more electric energy for national economy and to improve coal production effectiveness.

It is projected that by the year of 2010, total installed capacity of the power plants invested by Vinacoal will reach over 1,000MW including 100MW Na Duong Thermal Power Plant (Lang Son); 100MW Cao Ngan Thermal Power Plant; 600MW Cam Pha Thermal Power Plant (stage 1: 300MW); 30MW Nong Son Thermal Power Plant (Quang Nam); 100MW Son Dong Thermal Power Plant (Bac Giang). After 2010, as planned, 300MW Uong Bi Thermal Power Plant, 200 MW Mao Khe Thermal Power Plant and 1000MW Mong Duong Thermal Power Plant to be built.

1.2.1.The Projects which Vietnam Government has decided on investment

(a) Na Duong Power Plant

The first thermal power plant project of Vinacoal is the Coal-fired Na Duong Power Plant capacity 100 MW. The project site is located approximately 200 km North of the centre of Ha Noi in District Loc Binh, Lang Son Province. The Plant shall be constructed near the San Vien Village in the area of the Na Duong coal mine that has been exploited for the last 40 years.

The Na Duong Power Plant based on the Circulating Fluidized Bed Technology consists of the following main systems:

- Two Units including Boilers - Turbines - Generators and Auxiliary equipments
- Storage and preparation plants for raw water and cooling water supply plants
- Storage, preparation and supply systems for coal, fuel oil and limestone
- Waste water treatment plant
- One common stack for both units
- Ash storage and handling system
- Required auxiliary systems, such as compressor station and fire fitting system
- Required plant buildings and administrative and social buildings

The required raw water for the plant operation and make-up water for closed cooling system shall be taken from Na Cay lake, which located approximately 1.5 km far from project Site.

The associated substations and transmission lines for connection to Na Duong Power Station shall be carried out by Electricity Corporation of Vietnam.

The power plant shall mainly use lignite coal of Na Duong coal mine and shall be designed for base load operation. The required coal for the plant operation will be exploited from Na Duong Coal Mine Area about 1 to 3 km far from the considered plant site. Coal of this mine is explored by opencast method. The coal shall be transported directly by trucks to the existing unloading hopper station in the existing screening plant and further with conveyor to the storage area at the plant site. The mine has enough capacity to supply the projected power plant for 40 years without any supply problems.

The contract for construction of Na Duong Coal-fired Thermal Power Plant was signed between VINACOAL and the EPC Contractor - Consortium of Marubeni Corporation (Japan) and LILAMA (Vietnam) - on 08 March 2002. According to the agreement in the contract, the contractor shall complete and put Unit 1 into commercial operation after 24 months (Unit 2: 27 months) from the effective date of the contract.

The Na Duong coal-fired power plant construction was started in April 2002 and the construction progress is as per schedule. The project is under construction and on schedule. It is planned to put Unit 1 into commercial operation by the April 2004.

(b). Cao Ngan Thermal Power Plant

Based on the Decision No.126/QD-TTg of February 12th, 1999 of the Prime Minister of the Government of the Socialist Republic of Vietnam, the Vietnam National Coal Corporation has made clear its intention of construction of 100 MW Cao Ngan coal-fired thermal power plant in the Quan Trieu precinct of Thai Nguyen Town. The new construction site is actually the old site of an old thermal power plant, namely Thai Nguyen power plant. The site faces Cau River in the north.

Cao Ngan Coal-fired Thermal Power Plant has a configuration similar to that of Na Duong Coal-fired Thermal Power Plant, including 2 units with net output of 50 MW each, using circulating fluidized bed boiler technology, closed circulating cooling system with forced-type cooling tower. Water for domestic and technological services as well as cooling purpose of the Cao Ngan Coal-fired Thermal Power Plant will be supplied from Cau river.

Coal supplied for Cao Ngan power plant is exploited from the two mines Khanh Hoa and Nui Hong and transported to the plant by the existing railway network to Quan Trieu station. At the station, the coal is stockpiled at a mixture of 1/1 and transferred to the plant by conveyors. It is planned that in the first 10 years, 1/1 mixture of the two mines' coal is fired, later on, when Khanh Hoa mine has gone out of coal, coal will be supplied to the plant from Nui Hong.

Limestone for the power plant will be supplied from local quarries such as Dong Bay, Ma Trong and Khanh Hoa quarries, some 6km away from the project site. Limestone will be pre-processed for a size varying from 0 to 7mm and will be trucked to the site. The plant will be equipped with a limestone unloading and handling system, which will prepare the delivered limestone for a required manner for feeding to the boilers.

As agreed between the governments of Vietnam and China, Cao Ngan Coal-fired Thermal Power Plant will be financed with soft loan from the Government of China, the EPC contractor also has been selected among other Chinese Bidders. On 16 May 2002 the Contract for construction of Cao Ngan Coal-fired Thermal Power Plant was signed between VINACOAL and Harbin Power Engineering Co. Ltd. (HPE). In accordance with the contract, the equipments of Cao Ngan Coal-fired Thermal Power Plant will be supplied from China. The design, manufacturing supervision, commissioning acceptance and

guarantee for CFB boiler in particular will be undertaken by Alstom (Germany)-subcontractor of HPE.

The Cao Ngan Thermal Power Plant started construction in November, 2002 and is planned Unit 1 will be put into operation at the beginning of 2005.

(c) Cam Pha Thermal power plant 300 MW.

According to the Decision No.129/QD-TTg of January 29th, 2003 of the Prime Minister of the Government of the Socialist Republic of Vietnam, the Cam Pha Thermal Power Plant will be constructed in the area of Cau 20, Cam Think Ward, Cam Pha Town, Quang Ninh Province. The Project owner is Cam Pha Thermal Power Joint-Stock Company (with major share of 55% contributed by VINACOAL).

The Cam Pha Thermal Power Plant will provide a net capacity of 300 MW electrical outputs in the first phase, which can be expanded to 600 MW by the installation of a second unit in the next implementation phase of the project.

The power plant will be operated in base load running 6,000 equivalent full load-operating hours per year. Each unit must also be capable of operating in part load according to the actual load scheme.

At present, most of CFBs with capacity of 300 MW or more have been only under installation, not yet put into commercial operation, therefore VINACOAL decided to select the configuration of 2 CFB boilers with capacity of 150 MW each and 1 turbine of 300 MW.

As fuel for the Cam Pha Thermal Power Plant, waste coal (slurry) from the Cua Ong Coal Preparation Company as well as Cam Pha dust coals No 6 will be used. As basis for design equipment the following mixer rate of coals are considered:

- 40 wt.-% waste coal (slurry)
- 60 wt.-% Cam Pha dust coals (No6)

An average lower heating value of 4,265 kcal/kg for this fuel mixture is achieved. Based on this heating value the coal consumption at 100 % boiler load amounts to approximately 83 t/h for each boiler unit.

In order to meet the required SO₂ emission standard of 500 mg per standard m³ in the flue gas, the total limestone consumption at 100 % boiler load will amount to approximately 6 t/h.

The International Bidding of Cam Pha Thermal Power Plant is being carried out by the project owner. This planned construction is to start by first quarter of 2004.

1.2.2. The Projects which Vietnam Government has allowed for the feasibility studies (130MW)

Currently, Vinacoal is preparing Feasibility Study for Son Dong with capacity 100 MW and Nong Son Thermal Power Plants with capacity 30 MW. It is planned to be submitted the Government for approval early 2004. Possible forms of investment for these projects: BT (Build – Transfer), Joint-Stock Company, Joint-Venture company with any interested investor.

1.2.3. The Projects which VINACOAL has proposed to Vietnam Government

Based on the Decision No.3917/VPCP-CN of August 12th 2003 of the Prime Minister of the Government of the Socialist Republic of Vietnam, the Vietnam National Coal Corporation has been allowed to carry out the study and then report it to the Ministry of Industry for consideration in order to propose to the Government for adding the following projects into the master plan for Vietnam Power Development for 2010 - 2020 (Master Plan No 6):

1. Mao Khe (Quang Ninh) – 2 x 100MW

Mao Khe Power Plant is located approx. 2 km far from existing Mao Khe coal mine, Dong Trieu District, Quang Ninh province. Low calorie anthracite coal (HHV is 4000 - 5000 Kcal/kg) supplied for Mao Khe power plant is exploited from the mine Mao Khe and transported to the plant by conveyer.

2. Dien Cong (Uong Bi – Quang Ninh) – 300MW

Dien Cong Power Plant is located at Dien Cong, Uong Bi town, Quang Ninh province. As fuel for Dien Cong Thermal Power Plant, low calorie anthracite from Uong Bi - Vang Danh coal basin will be used.

3. Mong Duong (Quang Ninh) – 2 x 500MW

Mong Duong thermal power plan is located near Mong Duong coal mine, Quang Ninh province. At least 2 units with capacity of minimum 500 MW each will be installed for this plant in order to be able to fire all the coal volume mined at Khe Cham coal mines 1, 2, 3 with total annual coal production up to 6 million tons. Unit 1 will be put into commercial operation in 2010. Therefore, preparation works should be carried out right from now on.

II. Application of CFB in the Power Plant Projects of Vinacoal.

As the first company other than EVN to start and go ahead with construction of power plants, Vinacoal implemented the most advanced and reliable technology in energy area for its power plants with respect to typical features of specific project. The application of CFB is an example.

CFB technology has most recognized advantages such as: able to burn a wide variety of fuels, suitable for low-grade coals with high sulfur content and low heat value. However,

CFB has not yet been studied and applied in thermal power plants in Vietnam although these power plants are burning anthracite of low volatiles.

In consideration of experience in CFB technology application in the world and based on the coal characteristics, Vinacoal selected CFB technology for Na Duong, Cao Ngan and Cam Pha Thermal Power Plants.

2.1 CFB boiler for Na Duong Project:

Design conditions

In Na Duong Thermal Power Plant, CFB COMPACT of Foster Wheeler is applied (see Figure 1). The boiler is to be designed and furnished based on the specifications listed in the Table 1.

The boiler will be designed to burn Na Duong lignite with very high sulfur content up to 6%. The characteristics of Na Duong lignite listed in the Table 2.

The boiler will be designed to reduce emissions of sulfur oxides by the injection of limestone into the furnace. The limestone analysis to be used for design listed in the Table No 3:

Guarantee:

Subject to the conditions contained in contract, the contractor makes the guarantees listed below. These guarantees are based on proper operation of the equipment at steady state Tb 100% MCR (= main steam flow of 201.5 t/h) load, firing the performance fuel specified in Table 2 with performance limestone at least as good as that specified in Table 3.

- a. Boiler Efficiency will not be less than 92.9 % based on LHV
- b. Limestone Consumption-limestone consumption required to control sulfur dioxide emissions at or below the guaranteed level will not exceed 14.4 t/h per boiler.
- c. Unburned carbon - unburned carbon in ash of each unit: $\leq 3\%$
- d. Emissions

When operating between 40 %MCR to 100% MCR load, the emission levels in the flue gas measured at the stack will not exceed the limits indicated in the Table No 1. Emissions are based on 25 °C, 101.3 kPa, 6% O₂, dry basis.

2.2 CFB boiler for Cao Ngan project

Design Conditions

Steam generators for Cao Ngan thermal power plant will be Circulating Fluid Bed Boiler (CFBB) with typical external cyclone (see figure 2) and designed to operate safe, efficiently and reliability based on the conditions listed in the Table 1. Steam generator supplier is Alstom Power Boiler GmbH in Stuttgart Germany. For Cao Ngan Project

ALSTOM Power Boiler GmbH has applied special design features as "Advanced cyclon", "Double Loop Seal", "Six Meter Refractory Lined Hopper", "In-Furnace Superheater Panels", "No External Heat Exchangers".

Main fuel for the power plant will be semi-anthracite of local coalfields, Khanh Hoa and Nui Hong. The fuel has a low heating value of 4500Kcal/kg and sulfur content up to 3% as listed in the Table 2. Fuel will be transported to the site by conveyers.

Guarantee:

Subject to the conditions contained in contract, the contractor makes the guarantees listed below.

- a. Boiler Efficiency will not be less than 91.78 % based on LHV, at 100%RO acc. to PTC4.1998 and Reference temp. Of 25 oC
- b. Limestone Consumption - limestone consumption for 100% rated output and achieving of the guaranteed SO₂ emission (According to reference coal and a limestone purity of 90%) will not exceed 3.9 t/h per boiler.
- c. Unburned carbon - unburned carbon in ash of each unit: $\leq 3,5 \%$ at 100%RO
- d. Emissions - The concentrations at outlet of stack when fired with any type of specified coal at 100% Rated Output will not exceed the limits indicated in the Table No 1. Emissions are based on 6% O₂, dry basis.

2.3 CFB boiler for Cam Pha project

In Cam Pha Thermal Power Plant, slurry from Cua Ong Coal Washing Plant and anthracite 6B - low grade dust coal will be burnt together, CFB technology will be adopted

The Circulating Fluid Bed Boiler (CFBB) designed to operate safe, efficiently and reliability based on the conditions listed in the Table 1.

Steam generator shall be capable of developing continuous rating with any coals having analysis and characteristics as described in the Table 2.

At this time, the bidding process for selection of the EPC Contractor has not yet been completed and consequently the sub-contractor for supplying CFB boiler to Cam Pha Thermal Power Plant has not yet been determined. However, it may assure that whoever the successful Bidder must meet the following requirements:

CFB steam generator subcontractor shall be boiler designers who have successful experiences in implementing overall design, manufacturing supervision, installation supervision and commissioning for at least two (2) coal-fired CFB boilers with capacity ≥ 100 MWe. These boiler units shall have at least 03 (three) years (36 months) of successful commercial operation as on the date of Bid Opening.

Apart from applying the state-of-art technology in CFB, Vinacoal has also applied other advanced technology in its power plants for desired productivity and environmental requirements.

III. Conclusion

Vinacoal is the first state-owned company to start with IPP development for national demand and its own steady development based on coal business. Vinacoal is seeking for cooperation with domestic and foreign investors in power plant development for increasing power demand in Viet Nam.

The Vietnam National Coal Corporation is willing to cooperate with any foreign investors to carry out the feasibility studies, to invest in development of the above mentioned Projects in the form of BT, Joint-Venture Company, Joint-Stock company, loan or credit with deferred payments in export coal or in cash.

Table 1: Technical Specifications of Na Duong, Cao Ngan and Cam Pha Thermal Power Plants

Type	Unit	CFB Boiler for Na Duong Project	CFB Boiler for Cao Ngan Project	CFB Boiler for Cam Pha Project
Name of Boiler Supplier		Sumitomo Heavy Industry (Foster Wheeler K.K)	Alstom (Germany)	To be selected in International Bidding
No. Of Unit		2	2	2 (two boiler for one 300 MW turbine)
Capacity each boiler (net)	MW	50	50	150
Main fuels		Na Duong lignite	Mixed Semi - anthracites Khanh Hoa, Nui Hong	Mixed slurry and Cam Pha dust coal No 6
Mixed rate of fuels		-	50/50	40/60
Main Steam at SH Outlet (at BMCR)				
Flow	T/h	205	238.7	500
Pressure	Kg/cm ²	131	95	172
Temperature	0 C	540	538	540
Temperature Feedwater at ECO Inlet	0 C	223	223	235
Ambient Conditions (for Guarantee Performance)				
Reference Air Temperature	0 C	27	27	24
Design Air Pressure	mBar	1007	1007	1007
Relative Humidity	%	82	82	84
Percent Blowdown	%	Nor. 3.0 / Max. 5.0	3.0	3.0
Vietnam Environment Standard (concentration at outlet of stack when fired with any type of specified coal at 100% Rated Output)				
SO ₂	mg/m ³ N	≤ 500*	≤ 500	≤ 120 **
NO _x	mg/m ³ N	≤ 1000*	≤ 300	≤ 240**
Dust	mg/m ³ N	≤ 100*	≤ 50	≤ 100**

* According to Vietnam Environment Standard TCVN 6995 -2001

Table 2: Characteristics of the coal for Na Duong, Cao Ngan and Cam Pha Thermal Power Plants:

Coal data as received	Na Duong	Cao Ngan	Cam Pha TPP	
	TPP	TPP	Cua Ong Slurry	Cam Pha dust coal No 6 B
Total moisture%	18.47	14.01	29.55	8.50
Ash%	26.76	26.68	20.10	38.00
Fixed C, %	27.16	49.70	45.77	47.53
Volatiles, %	27.61	9.61	4.58	5.97
C, %	37.88	51.72	46.21	47.61
H, %	2.89	2.08	1.72	2.61
N, %	1.26	0.95	0.57	0.80
S (total), %	5.43	2.34	0.42	0.65
O, %	7.31	2.22	1.43	2.03
HHV (Kcal/kg)	3.828	4.690	4.150	3.980
LVH (Kcal/kg)	3.565	4.500	4.061	3.855

Table 3: Characteristics of the Limestone for Na Duong, Cao Ngan and Cam Pha Thermal Power Plants:

Description	Unit	Na Duong TPP	Cao Ngan TPP	Cam Pha TPP
		Range	Range	Reference
CaO	Wt - %	50 – 55	49.87 - 51.37	53.57
MgO		0.5 - 5	1.21 - 1.32	1.52
Fe ₂ O ₃		0.1 – 2	0.88 - 1.01	0.130
SiO ₂		0.1 - 1	2.22 - 2.92	0.0030
Particle Size	Mm	5 – 10	10 -40	10 -40
Bulk Density				
Loose	Kg/m ³	1,500		2.65
Dense	Kg/m ³	2,000	2,520 - 2,590	2.68

Figure No 1: F.W Compact CFB boiler for Na Duong Project

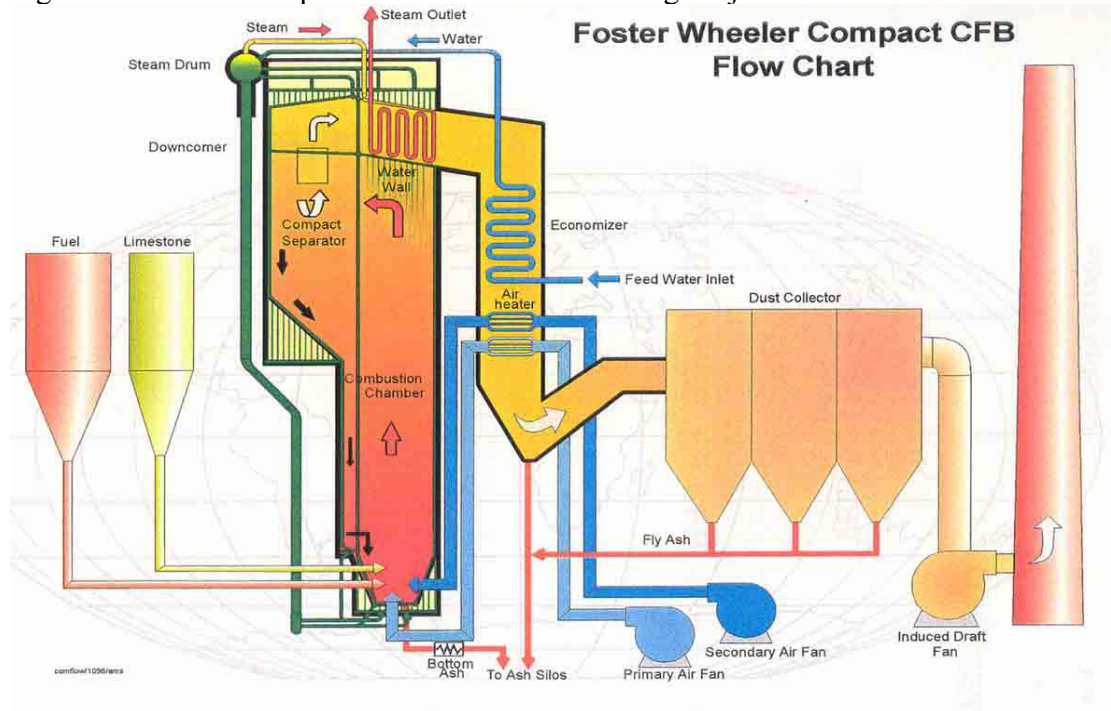


Figure No 2: Alstom CFB boiler for Cao Ngan Project.

