Approach to Overseas EPC Project

— Technical Features of MidAmerican Project in the U.S. —

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OVERVIEW: Hitachi has been awarded a contract for an overseas EPC (engineering, procurement and construction) project. This opportunity has provided us with a wealth of experience. In February 2003, Hitachi was asked by MidAmerican Energy Company in Iowa U.S., through Mitsui & Co. Energy Development, Inc., to execute the EPC of the Council Bluffs Energy Center, Unit 4, an 870-MW (gross) capacity power plant. This is the first large-capacity coal-fired EPC project for Hitachi in the U.S. This paper describes the technical features of the Council Bluffs Energy Center, Unit 4 project. This plant adopts PRB (powder river basin) coal-fired super critical once-through, sliding pressure, BHK (Babcock-Hitachi K.K.)-type Benson boiler under steam condition of 25.3 MPa·g, 566/593°C, a four-flow tandem compound turbine, with long 40-inch last stage blades, the largest-class two-pole generator, and cooling towers for circulating water. In addition, we adapted a De-NO_x unit, a DFGD (dry flue gas desulfurization) unit, and highly efficient fabric-filter dust bags to satisfy the environmental regulations. Hitachi established a construction team to complete the plant within 45 months from the NTP (notice to proceed) to the S/C (substantial completion) phases. Advanced supercritical technology coal-fired power plants have not been constructed in the US. for at least 20 years. Working in close cooperation with MidAmerican Energy Company, the construction is now in progress.

INTRODUCTION

BASED on its accumulated expertise and practical experience, Hitachi was awarded an EPC (engineering, procurement and construction) contract to build the Council Bluffs Energy Center's Unit 4, a highly efficient 870-MW (gross) capacity coal-fired power

Fig. 1—Photo of Project Construction in Progress, May 2005.
Boiler steel frame construction is almost completed, and condenser installation work is now in progress.

plant (see Fig. 1). The construction of Unit 4 commenced in September 2003. Erection of the structural steel boiler started in June 2004 and the construction is progressing. This paper describes the technical features of the turbine, generator, boiler, AQCS (air quality control system), and construction plans.

PROJECT OVERVIEW AND TECHNICAL FEATURES

MidAmerican Energy Company is the largest utility company in Iowa. Council Bluffs Energy Center, Unit 4 is located in Council Bluffs, as shown in Fig. 2. Table 1 summarizes the main specifications.

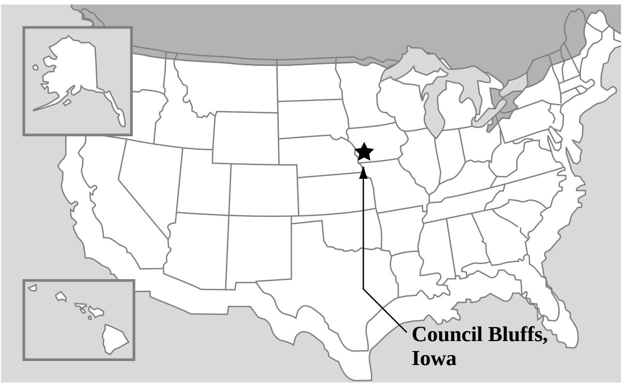

Fig. 2—Location of Council Bluffs City, Iowa.
The plant is located on the outskirts of Council Bluffs in the state of Iowa in the U.S.

The scope of work is summarized as follows:

(1) Turbine island
- (a) Turbine-generator
- (b) Condensate system (condenser, extraction pumps, vacuum pumps, polisher, etc.)
- (c) Feedwater heating system (pumps, feedwater heater, deaerator, etc.)
- (d) Electrical, instruments, and control

(2) Boiler island
- (a) Boiler proper (burner, superheater, etc.)
- (b) Ash handling system
- (c) Coal handling system

(3) Air quality control island
- (a) De-NO_x system
- (b) Flue gas desulfurization unit
- (c) Fabric filter

(4) BOP (balance of plant)
- (a) Well and well pumps
- (b) Well water clarifier
- (c) Water treatment unit

(5) Civil engineering and architecture
- (a) Turbine building
- (b) Boiler building
- (c) Administration building
- (d) Warehouse
- (e) Maintenance building
- (f) Stack

TABLE 1. Main Power Plant Design Specifications
Basic design conditions and key specifications for the boiler, turbine, and generator are shown.

Item			Unit	Council Bluffs Energy Center, Unit 4
Basic design conditions	Rated output		MW	870 (gross)
	Steam conditions		MPa·g	25.3
			°C	566/593
	Fuel		—	Coal (PRB coal)
Key conditions	Boiler	Type	—	Supercritical once-through boiler with sliding pressure operation
		Steam pressure	MPa·g	26.2
		Steam temperature	°C	570/595
		Max. continuous rating	t/h	2,530
	Turbine	Type	—	Tandem compound 4-flow exhaust
		Rotational speed	r/min	3,600
		Condenser vacuum	mmHg	722
	Generator	Type	—	Cylindrical rotor type, synchronous alternator
		Capacity	MVA	1,025

PRB: powder river basin

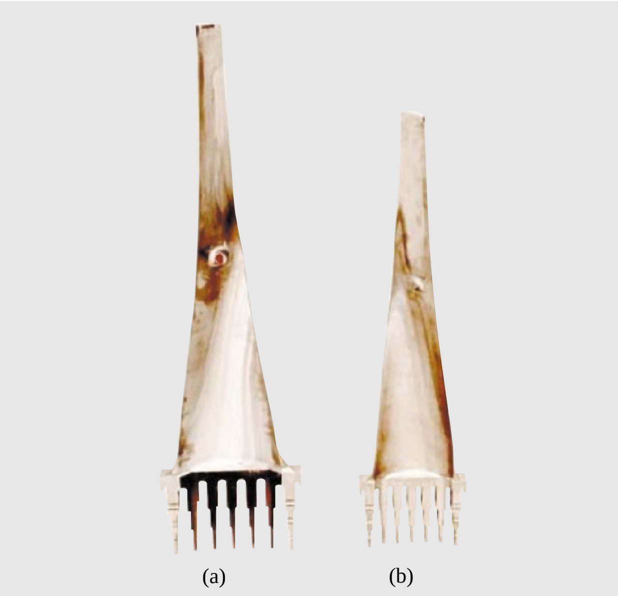

Fig. 3—40-inch (about 102-cm) Last Stage Blade (a), and 33.5-inch (about 85-cm) Last Stage Blade (b) with CCB (continuous cover blade) Construction for 60 Hz Use.
The steam turbine for this project uses 40-inch last stage blades.

Fig. 4—High-pressure Turbine Blades with CCB.
Blades are interconnected by tip covers.

STEAM TURBINE

Structure of Steam Turbine

The electrical output of the steam turbine unit for this project is 870 MW, which is the largest Hitachi steam turbine produced for service outside of Japan.

The turbine layout is TCDF-40 [tandem compound double flow with 40-inch LSBs (last stage blades)].

Fig. 3 shows the 40-inch (about 102-cm) blade.

Technical Specifications of Steam Turbine

High-temperature material was used in the primary parts of the steam turbine to meet the high thermal conditions (main steam pressure: 25.3 MPa·g, main steam/reheat steam temperature: 566/593°C).

For example, we used 9 Cr-forged steel for the following parts: body of main stop valve, main steam control valve, and combined reheat valve,main & reheat steam lead piping.

Additionally, 12-Cr steel was used in the following parts: HP/IP rotors, HP/IP internal casings, and diaphragm for HP/IP sections.

To improve efficiency and reliability, we applied a CCB in the moving blades in the HP & LP (high pressure & low pressure) sections of the turbine. Fig. 4 shows a typical HP rotor with CCB-type blades.

To improve efficiency, an AVN (advanced vortex nozzle) was used in the nozzle blades in each section of the turbine.

GENERATOR

Features of Generator

The generator for the MidAmerican Project is rated at 1,025-MVA which is among the largest Hitachi two-pole generators designed for thermal power plants. The capacity of this generator is one of the largest generators that have ever been manufactured in our factory. Development of this generator is based on our advanced technology as well as a well-verified new technology.

Applied Technologies

In Table 2, the technologies used to obtain large capacity generators are shown. Some examples are described as follows.

Rotor

In general, the generator output increases in proportion to the square of the rotor diameter. The stress in the rotor part increases in a similar way. Therefore, a high strength and fracture resistant rotor shaft material is required under high-stress conditions. Recently we developed and applied the high-tensile-strength (1,000-N/mm^2 class) rotor materials. This material has high purity and high-tensile strength, without segregation and embrittlement, because it is deacidified by vacuum treatment and ladle refinement.

Stator

We need to improve the gas cooling ability in extremely large capacity generators because huge

TABLE 2. Technical Issues and Applied Technologies for Large Capacity generator
Technologies overcoming the challenges of increased capacity (increased current and size) were applied to the 1,025-MVA capacity generator.

Technical issues		Applied technologies
Increased current	Stator winding cooling	Mixed strand stator winding Structure with non-separated water path from current path Water cooling for connector separated from windings Large-diameter insulation hose
	Stator winding end support structure	Tetra-lock structure
	Stator core end structure	Shield core, copper-plate shield
	Rotor winding cooling	Direct H_2 cooling field lead
	H_2 gas cooler structure	Top dome cooler structure
	Bushing	Hydrogen direct cooling bushing
Increased size	Rotor shaft material	High-strength and fracture toughness material
	End-ring material	High-strength 18Mn-18Cr steel
	Rotor vibration	Reduction of vibration sensitivity
	Rotor cross-sectional shape	Stress reduction through optimum design
	Stator frame	Compact frame
	Large diameter bearings	Elliptic bearing with central groove

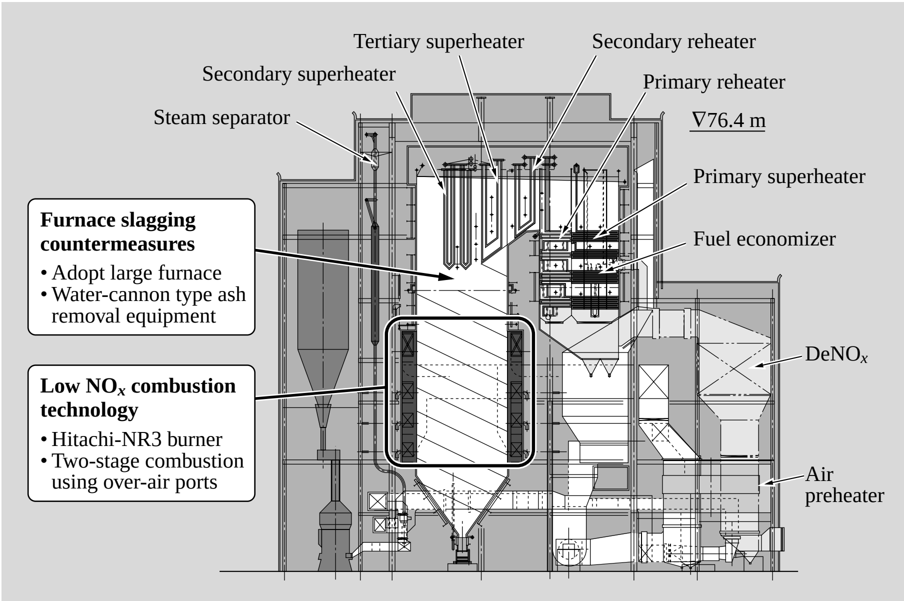

Fig. 5—Cross-sectional View of Council Bluffs Energy Center, Unit 4 Boiler.
The design closely follows the latest large-capacity supercritical Benson boiler technology.

losses occur. Therefore, we used 0.52-MPa·g hydrogen for better cooling, the same as is used in four-pole type large turbine generators (1,500-MVA class). The coolers are not the vertical type that is standard in two-pole generators, but the top dome type commonly used in four-pole type generators, which enabled us to obtain a compact stator frame structure. In addition, we directly cooled the rotor windings using hydrogen and the stator windings using water to achieve high reliability, as done in other large generators.

BOILER AND AQCS

Boiler Equipment

The furnace of boiler was designed for PRB (powder river basin) coal, where the ash slagging characteristics are extremely demanding. PRB coal ash is glassy and hard, and difficult to remove from the furnace efficiently using conventional steam or air blowers. We plan to install water-cannon type ash removal equipment, considering the furnace capacity. By monitoring the heat flux in each part of the furnace water wall, the dirty parts can be effectively cleaned using water cannon type removal by changing the water flow direction. This cleaning system reduces the temperature rise of the furnace exit gases during PRB coal firing. In the combustion system, the large capacity new Hitachi-NR3 burner uses an in-flame NO_x reduction system with a high temperature reducing flame. The burner combustion and two-stage AAP (after air port) combustion enables us to reduce

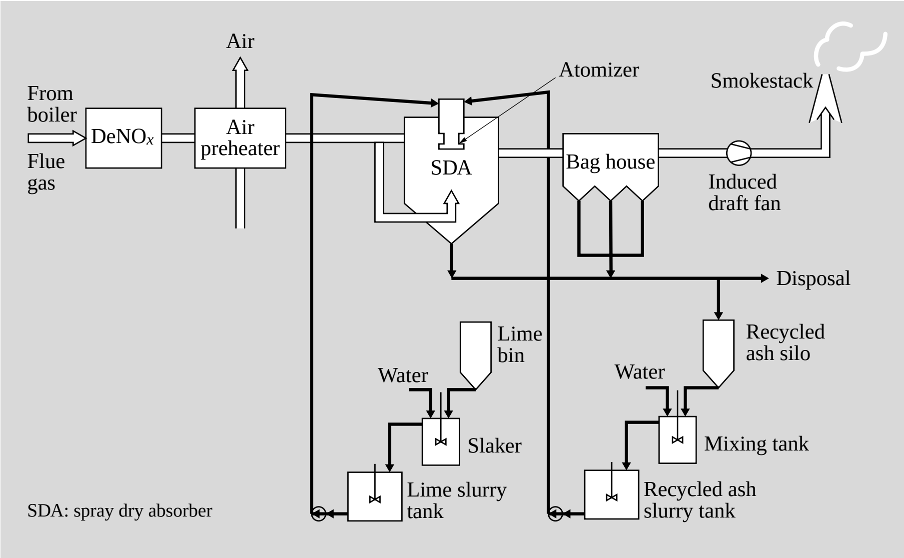

Fig. 6—Schematic of Environmental Equipment.
Schematic of the NO_x removal and desulfurization systems is shown.

TABLE 3. Main NO_x Removal System Planned Specifications
Rather than conventional ammonia, urea for obtaining hydrolyzed ammonia gas is employed as a reducing agent.

Item	Specification
NO_x removal system	Dry SCR method
Ammonia system	Urea hydrolysis method
Designed inlet NO_x concentration	128 ppmvd (6% O_2 base)
Designed operation temperature	380°C
Inlet SO_x concentration	752 ppmvd (6% O_2 base)
Dust concentration	11.6 g/Nm^3
Outlet NO_x concentration	42 ppmvd (6% O_2 base)
Outlet leakage NH_3 concentration	2 ppmvd (3% O_2 base)
SO_2 oxidation rate	Less than 3%

SCR: selective catalytic reduction
ppmvd: parts per million volume distribution

TABLE 4. Main DFGD system planned specifications
Dust collector employs a pulse jet bag filter.

Item	Unit	Specification
SDA		
No. of units	—	3
Diameter	m	17.2
Fuel gas residence time	s	10
Atomizer motor output	kW	745.7
Outlet temperature	°C	72
Approach temperature difference	°C	17
Slurry concentration	%	30
Bag filter		
Type	—	Pulse jet
Gas to close ratio	m/min	1.0
Slaker		
No. of units	—	2
Capacity	t/h	5.4
Lime	—	Pebble lime

NO_x in exhaust gases.

A side view of this boiler is shown in Fig. 5. The boiler design is based on the latest technology for large capacity supercritical pressure Benson boilers, established in domestic plants in Japan.

AQCS

To satisfy the environmental regulations, the AQCS consists of a De-NO_x and DFGD (dry flue gas desulfurization) system, as shown in Fig. 6.

Table 3 shows the specifications of the SCR (selective catalytic NO_x reduction) system. The PRB coal contains high calcium and high catalyst poisons, and the dust easily sticks to the catalyst. This SCR system uses a Hitachi plate-type catalyst that has a higher resistance to dust plugging and has been modified to achieve higher durability in PRB-fired gas. The catalyst reactor is designed to be compact, with special flue-gas mixers upstream of the reactors. This mixer accelerates NH_3 mixing with the flue gases for a short residence time. This SCR system operates using a harmless urea instead of the toxic NH_3 normally used. This urea process has been applied in SCR systems in the U.S. since 2000, due to the safety requirements of toxic substance handling. In this process, the urea is diluted to a 40% urea/water solution, which is hydrolyzed into NH_3. We adopted U2A* system of Wahlco, Inc., which is used in dozens of commercial plants. Its performance and reliability are proven in the U.S.

* U2A is a trademark or a registered trademark of Wahlco, Inc.

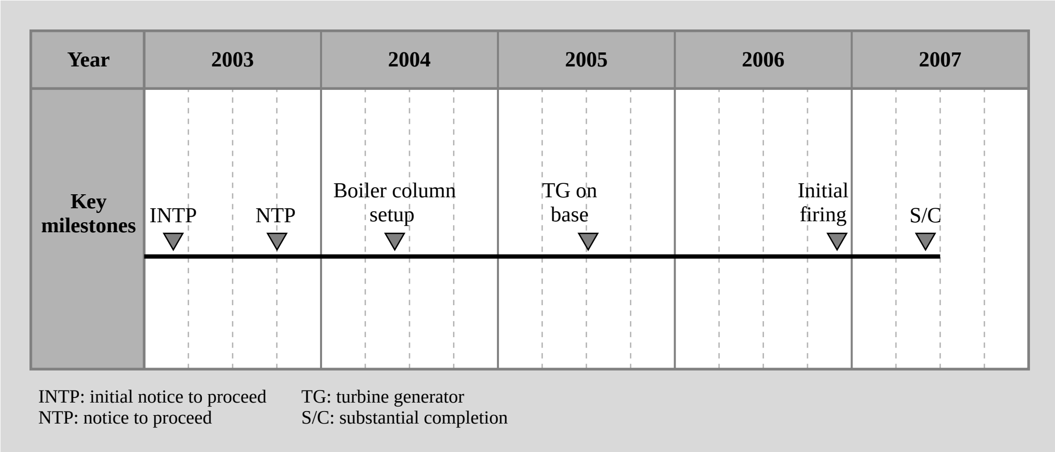

Fig. 7—Key Project Processes.
Construction period is specified: 45 months from NTP until S/C.

The major design features of the DFGD system are shown in Table 4. Flue gas is fed from the boiler air heaters to the SDAs (spray dryer absorbers) to remove SO_2. Three SDAs are supplied to treat all the flue gases from the Unit 4 boiler. One rotary atomizer with a 1,000 HP motor is used as an integral part of the SDA vessel. The atomizer slurry feed, which is a mixture of lime slurry and recycled ash slurry, is fed to the atomizers and atomized in the SDA to form a cloud of extremely fine mist. Heat from the flue gas evaporates the moisture in the slurry cloud and lowers the flue gas temperature, while the alkaline slurry simultaneously absorbs SO_2 from the flue gas. The SDA outlet gas temperature is controlled at about 17°C above the adiabatic saturation (dew point) temperature.

Treated flue gas exiting the SDA vessels is directed to the bag filter trains, which are equipped with the fabric bags to separate the solids (fly ash and calcium/sulfur compounds) entrained in the flue gas. The bag filter train, a pulse-jet cleaning type, consists of 16 compartments. The cleaning operation is controlled by either a pressure drop or a preset time interval. Compartment isolation is accomplished by closing the outlet damper to a compartment when broken bags are detected. The reagent preparation system consists of two independent slurry systems, the lime and recycled slurry preparation. Pebble lime from the storage silo is fed to the lime slakers, where the lime is “slaked” or hydrated.

The solids are collected on the filter bags, which contain unreacted calcium hydroxide, and can be utilized as recycle slurry to react and absorb SO_2 from the flue gas.

PROJECT SCHEDULE AND CONSTRUCTION PLAN

Project Schedule

Fig. 7 shows the project timelines and key milestones. The period between NTP (notice to proceed) and S/C (substantial completion) is 45 months. Boiler structural steel erection was started in June 2004, boiler top girders were set in February 2005, and the construction is now in progress.

Construction Plan

In order to maintain the construction schedule, we adopted both technical and contractual provisions. Some examples of the technical provisions are:

(1) Construction has been synchronized with the erection of the steel structure, which involves delivering and installing boiler pressure parts, ductwork, the coal silo, piping, support, valve station, and other ancillary equipment and systems simultaneously.

(2) The HP (high pressure) turbine and IP (intermediate pressure) turbine installation period was reduced by installing the HP and IP turbines in one assembled body, which was assembled at the factory before being transported by ships and barges.

(3) A barge-unloading facility was constructed on site in order to transport large blocks of equipment by barges on the Mississippi and Missouri rivers.

Some examples of contractual provisions are:

(1) Civil construction work and equipment installation work were purchased from one construction company. This makes the transition from civil construction work to equipment installation work easy.

(2) All the installation contracts for the structural steel, equipment, piping, cabling, and other ancillary

equipment were purchased from one construction company. This makes it easy to coordinate the installation work schedule.

CONCLUSIONS

This paper gives a summary of the technical features of the turbine, generator, boiler, AQCS, and construction plans for the Council Bluffs Energy Center's Unit 4. Working in close cooperation with MidAmerican Energy Company, the construction phase is now in progress, and the plant will be substantially completed by June 2007.

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