495-MW Capacity Genesee Power Generating Station Phase 3: First Supercritical Pressure Coal-fired Power Plant in Canada

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OVERVIEW: In 2001 Hitachi, Ltd. and Babcock-Hitachi K.K. were contracted by EPCOR Power Development Corporation of Alberta, Canada to oversee the engineering and construction of Genesee Power Generating Station Phase 3, a 495-MW-capacity coal-fired power plant that is scheduled to become operational in the first quarter of 2005. This paper presents an overview of the Genesee Phase 3 project. Given the relative abundance and low cost of coal in the province of Alberta, it was decided early based on economic and environmental considerations that the new third unit would employ supercritical-pressure pulverized coal combustion technology. In addition to the high efficiency supercritical-pressure boiler and turbine, adverse impact on the environment is minimized through the use of low nitrogen oxides (NO_X) burners, a dry FGD (flue gas desulphurization) unit, and a high-efficiency dust-collection system using a fabric filter baghouse. Based on a proven track record in building a number of supercritical coal fired plants, Hitachi, Ltd. and Babcock-Hitachi K.K. will execute all EPC (engineering, procurement, and construction) enabling seamless integration between the boiler and turbine. In addition, much of the design detail is based on a 500-MW reference plant, thus enabling the plant to be substantially completed in the first quarter of 2005.

INTRODUCTION

TO meet the demand for expanding energy requirements, Alberta has turned to coal-fired generation to reduce dependence on high-cost natural gas and to supercritical-pressure coal combustion to mitigate environmental impact by reducing greenhouse gas emissions.

The trend in power plant construction in North America from the 1970s through the 1990s has been toward nuclear and combined cycle plants with little emphasis on coal fired technology. Over the same timeframe, Hitachi continued to gain experience in the development and deployment of supercritical-pressure coal fired technology to meet the demand for high efficiency coal fired power plants growing out of special circumstances in Japan: high fuel prices, exacting plant siting requirements, and very strict environmental requirements.

Based on its accumulated expertise and practical experience, Hitachi was awarded the contract to build 495-MW Genesee Power Generating Station Phase 3, the first supercritical-pressure coal fired plant to be built in Canada. This is also the first time Canada has awarded a complete EPC (engineering, procurement, and construction) package contract to execute all engineering, procurement and construction, an

Photo by Mr. Dave Conlin, Power Projects Director, EPCOR Power Development Corporation.

Fig. 1—Genesee at Sunset, December 2003.
The Unit 3 boiler house and flue gas desulphurization unit under construction can be seen on the right.
Continuing in operation, Units 1 and 2 can be seen behind the stack of Unit 3.

approach that ensures tight integration between the boiler and turbine and the shortest possible construction schedule.

After taking over from Hitachi, EPCOR Power Development Corporation and TransAlta Energy Corporation will own Genesee Phase 3 in a 50/50 joint venture.

PLANT OVERVIEW AND TECHNICAL FEATURES

Main Specifications

Drawing on Hitachi's expertise in advanced combustion technologies and adopting the latest most efficient turbine, Genesee Phase 3 uses supercritical-pressure pulverized coal combustion, the first unit of its kind in Canada. The new unit is 10% more efficient than the existing Genesee units while also being much friendlier to the environment by reducing emissions of CO_2, sulphur dioxide (SO_2), nitrogen oxides (NO_x), and particulate and associated mercury emissions. In addition, design of the third unit was optimized to share facilities with the existing units as much as possible including the coal handling facilities, demineralized water supply system, waste water treatment facilities, and circulating water canal. Table 1 summarizes the main specifications.

TABLE 1. Plant Specifications
Boiler and turbine-generator specifications are shown.

Boiler	Type	Coal fired supercritical once-through BHK (Babcock-Hitachi K.K.)-type Benson boiler with sliding pressure operation (Sliding pressure range: 35-95% load)
	Max. continuous rating	1,450,000 kg/h
	Steam conditions	25.0 MPa (G) / 570°C / 568°C
	Emission value (30 days rolling average)	NO_x: 115 ng/J at BMCR SO_2: 90 ng/J at 100% Load for S-% 0.32 coal Particulate: 13 ng/J at BMCR
	Manufacture	Babcock-Hitachi K.K.
Turbine	Type	Hitachi impulse type tandem compound double flow exhaust 40-inch last stage blade, reheat condensing turbine two-casing indoor use
	Rated output	495,000 kW (gross)
	Steam conditions	24.1 MPa (G) / 566°C / 566°C
	Speed	3,600 rpm
	Exhaust pressure	5.0 kPa (A)
	Governor type	Digital electro-hydraulic governor
	Manufacturer	Hitachi, Ltd.
Generator	Type	Totally enclosed, self-ventilated, forced lubricated, hydrogen cooled, cylindrical rotor type, synchronous alternator.
	Capacity	586 MVA
	Terminal voltage	22 kV
	Power factor	0.85 lagging
	Short circuit ratio	N.L.T. 0.50 at rated output
	Excitation system	Static-thyristor excitation system
	Manufacturer	Hitachi, Ltd.

Scope of Work

The boiler and turbine were provided as a complete package in accordance with the EPC contract (some tasks and facilities were excluded from the contract because they were provided directly by the client, EPCOR), an approach that not only reduced the construction schedule but also minimized the interface adjustment and modification work.

The scope of work is summarized as follows:

(1) Boiler Island
- (a) Boiler proper (burner, super heater, etc.)
- (b) Induced draft / primarily air / forced draft fan
- (c) Coal handling system (branch conveyor added to existing conveyor)
- (d) Ash handling system
- (e) Flue gas desulphurization unit and fabric filter (stack provided by EPCOR)

(2) Turbine Island
- (a) Turbine-generator set
- (b) Condensate system (condenser, extraction pumps, vacuum pumps, polisher, etc.)
- (c) Circulating water system (pump, screen, and auxiliary equipment)
- (d) Feedwater heating system (pumps, feedwater heaters, deaerator, etc.)
- (e) Auxiliary systems (instrument air compressor, chemical dosing equipment, etc.)

(3) Electrical Instrument and Control
- (a) 600-V motor control center (6.9-kV and upper switchgear to be provided by EPCOR)
- (b) Distributed control system [HMI (human-machine interface) to be provided by EPCOR]

(4) Civil Engineering and Architecture
- (a) Boiler-turbine building (ground level foundation provided by EPCOR)
- (b) Turbine-generator pedestal
- (c) Heating and ventilation system

(d) Elevator and lift devices
(e) Lighting and services

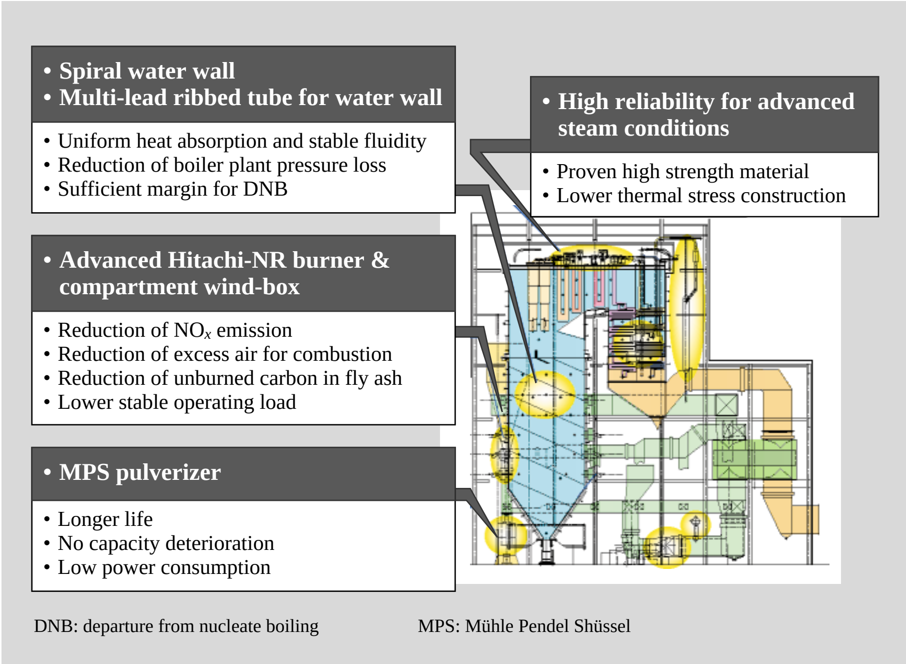

Fig. 2—Design Features of Sliding-pressure BHK-type Benson Boiler.
Supercritical sliding-pressure, BHK-type Benson boiler provides high reliability, high efficiency, flexible operation, and easy maintenance.

Technical Features of Boiler Plant

A supercritical sliding-pressure BHK-type Benson boiler was adopted for the Genesee Phase 3 project, the first time this type of boiler has been used in North America. Combining high efficiency, flexible operation, and excellent reliability with an advanced low NO_x combustion technology, this type of boiler is relatively environmentally friendly (see Fig. 2).

A very high standard of reliability is achieved thanks to uniform heat absorption and stable fluid flow and reduction of boiler plant pressure loss by using a spiral wall applying internally ribbed tube, together with proven high strength materials for the boiler pressure parts.

In addition, operability has been markedly simplified compared to conventional constant pressure once through boiler by eliminating the need for main system valve switching, and start-up time has also been dramatically shortened.

Moreover, the newest MPS-type system has been applied for the pulverizer that ensures longer life grinding and wear sections while featuring low vibration and low power consumption that prevents capacity from diminishing.

Achieving lower emissions is critically important for upgrading and enhancing combustion technology. By using the Hitachi's latest pulverized-coal burner (NR3) and 2-stage combustion, the already low NO_x combustion is reduced even further while unburned carbon in the ash is reduced. In addition, stable combustion is achieved at minimum load operation, and all environment limits and regulations are satisfied even without a NO_x removal system.

Technical Features of Steam Turbine

Hitachi has delivered more than 30 supercritical pressure condition steam turbines.

For the Genesee Phase 3 a double flow tandem compound/combined type high and intermediate pressure turbine was adopted; for the low pressure turbine, 40-inch last stage long blades with substantial practical operating experience were applied, and a very compact two-casing design was achieved (see Fig. 3).

Fig. 3—Turbine Installation.
High and intermediate pressure turbine rotor setting on the casing. The 40-inch-blade low-pressure turbine with inner casing and 586-MVA generator are shown behind it.

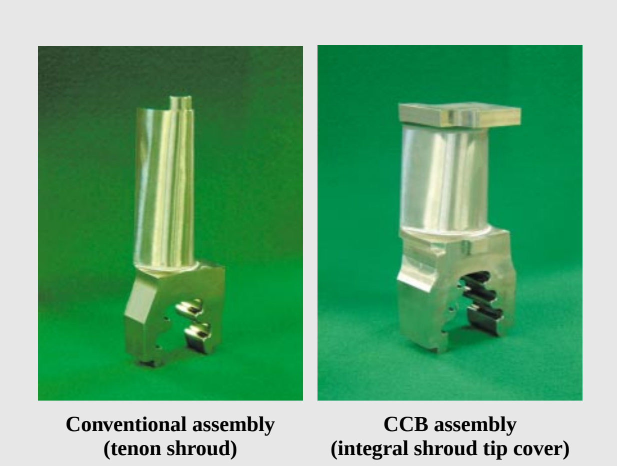

Fig. 4—Continuous Cover Blade Assembly for High-pressure Turbine.
For improving efficiency and reliability, CCB type is used in moving blades in high pressure section of turbine.

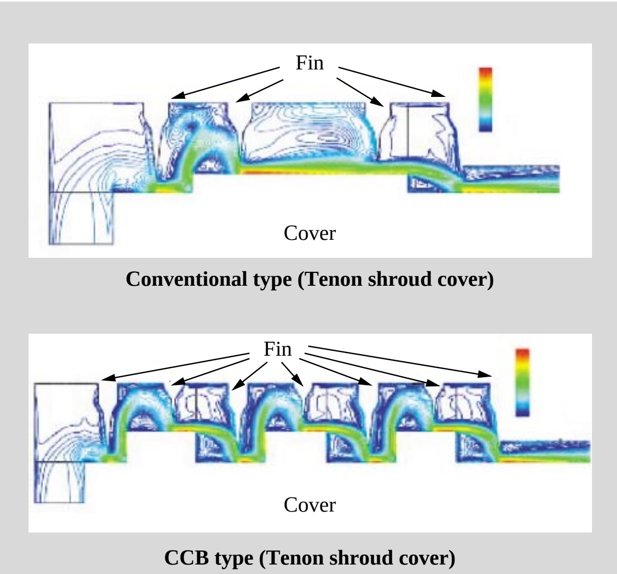

Fig. 5—Flow Analysis around Fin Tips of Conventional Versus CCB Structure.
When using CCB type blades, high-low type tip cover can be applied to blade. Using high-low type tip cover reduces steam leakage at tip fins and improves turbine efficiency.

A CCB (continuous cover blade) construction was applied to the high-pressure section of the turbine for enhanced performance and reliability. Fig. 4 shows how the CCB structure differs from the conventional tenon shroud blade structure. As illustrated in Fig. 5, the CCB construction is equipped with an integral shroud cover that substantially reduces steam leakage at the tips of the fins and improves turbine efficiency.

CFD (computerized fluid dynamics) analysis was used to optimize the dimensions and shape of the low-pressure exhaust hood to match the plant's steam conditions, as shown in Fig. 6. This greatly reduced pressure losses between the low-pressure turbine outlet and the condenser inlet, which further improved the turbine performance.

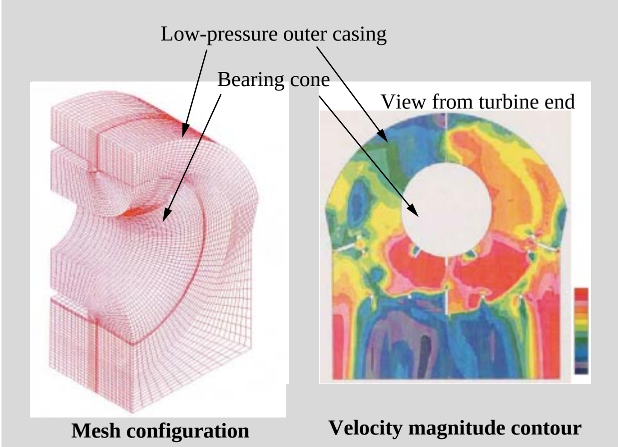

Fig. 6—Computerized Fluid Dynamic Analysis of Low-pressure Exhaust Hood.
Dimensions and shape of low-pressure exhaust hood are optimized for steam conditions by applying results of CFD analysis.

PROJECT SCHEDULE

Schedule Outline

Fig. 7 shows the project timeline and key milestone. The major installation work is now completed and the project has entered the commissioning phase.

PDM, PDS, and Advanced Boiler Plant Design Accelerate Construction Process

PDM (product data management) is a system for effectively managing the voluminous product data that flows back and forth during the lifecycle development of a plant from development and design to the actual fabrication and maintenance of the product. To strengthen the company's competitiveness by streamlining engineering, holding down costs, and shortening the project schedule, Babcock-Hitachi K.K. adopted PDM and a sophisticated PDS (plant design system) at an early stage in the project. The Genesee Phase 3 project was the first time this approach had been applied at the facility and has proved very effective in customizing the boiler plant to the client's needs (see Fig. 8).

All information regarding the boiler, boiler pressure parts and equipment, piping, support, structural steel, etc. was entered into the plant design system, and the

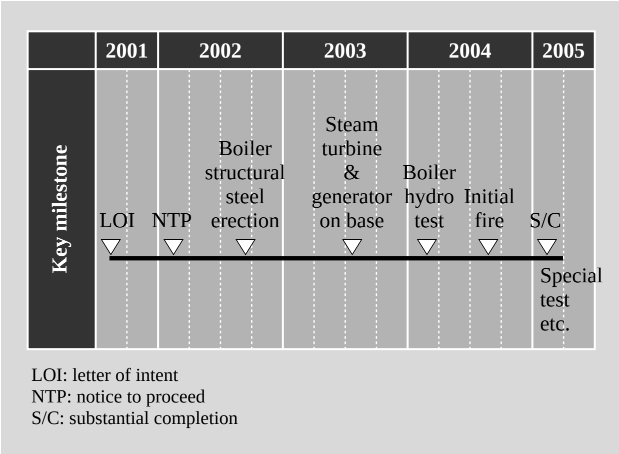

Fig. 7—Project Schedule.
Project began from NTP in January 2002 to S/C in first quarter of 2005.

Fig. 8—Boiler PDS Model.
Entering structural steel, the boiler, piping, support, and equipment in the 3D model is useful for developing the manufacturing design and for studying installation methods.

data has been enormously useful at every step of the project including configuration management, production design, tracking design changes, managing blueprints and plans, interference checking, tracking materials, site preparation, and installation work.

The design and deployment of the Genesee Phase 3 was based on the 500-MW-class supercritical-pressure Benson boiler that has been operating flawlessly at Nanao-Ohta Thermal Power Station Unit No. 1 (Ishikawa Prefecture) by Hokuriku Electric Power Co., Inc. By adopting this proven design, we could quickly present the boiler design data to the client and regulatory agencies, start actual work on the boiler sooner, and substantially reduce the time needed to construct the plant. Having a number of supercritical-pressure Benson boilers in the 500-MW to 1,000-MW capacity range to draw upon as reference plants, Babcock-Hitachi K.K. was able to deliver and startup the boiler for the Genesee Phase 3 in record time.

Reduced Boiler Fabrication Time through Synchronized Construction

Due to recent increase in the clients' demands for a compressed schedule, plant installation work has led to fundamental rethinking of practices that can reduce plant construction and delivery time while maintaining the highest standards of safety. For the first time in the North American market, we adopted the simultaneous construction method that Hitachi has been refining and perfecting since the early 1990s, and this enabled us to complete the project — from NTP (notice to proceed) to S/C (substantial completion) — in a shorter period of time frame.

As illustrated in Fig. 9, simultaneous construction involves delivering and installing boiler pressure parts, ductwork, the coal silo, piping, support, valve station, and other ancillary equipment and systems in parallel as the structural steel is being erected. Obviously to pursue this kind of synchronized approach one must make arrangements and take delivery of various equipment and systems while the structural steel is being erected, and this approach really only works for

Fig. 9—Boiler Simultaneous Construction.
The large-scale single coal silo that is fabricated at the factory is hoisted into position by a large crane.

large diversified companies like Hitachi that can design and install all the components of the plant — boilers, equipment, structural steel, etc. — and can execute EPC contracts.

The primary advantages of simultaneous construction are that:

(1) Temporary scaffolding and temporary equipment can be simplified and reduced thus reducing the amount of work in high places and improving safety.

(2) Installation can proceed in parallel with excavation and earth work, and congested work is reduced. This not only improves work efficiency but also reduces the overall construction process by reducing the number of times that a crane has to be brought in.

Let us briefly consider the floor unit construction, which is relatively important in simultaneous construction. Lugs to accommodate different equipment in the plant are welded to steel beams in advance and the beams are assembled into flat assembled floor units. Handrails, gratings, ducts, piping are all laid out on the floor units and then hoisted into position as a single piece. This enables most of the work to be done at ground level, and also permits 20 to 30 pieces — a combination of beams and equipment — to be lifted into place all at the same time.

CONCLUSIONS

Based on extensive experience with supercritical-pressure pulverized coal combustion technology, Hitachi, Ltd. and Babcock-Hitachi K.K. were awarded an EPC contract to build Genesee Phase 3, a 495-MW-capacity coal-fired power plant in Edmonton, Canada. This is the first supercritical-pressure power station to be built in Canada. Adhering closely to the planned construction timeframe and featuring high efficiency and low emission technologies, the major installation work is now completed. Working in close cooperation with EPCOR Power Development Corporation, the commissioning phase is now in progress, and the plant will be substantially completed in the first quarter of 2005.

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