

**A new generation of
pulverized coal technology**

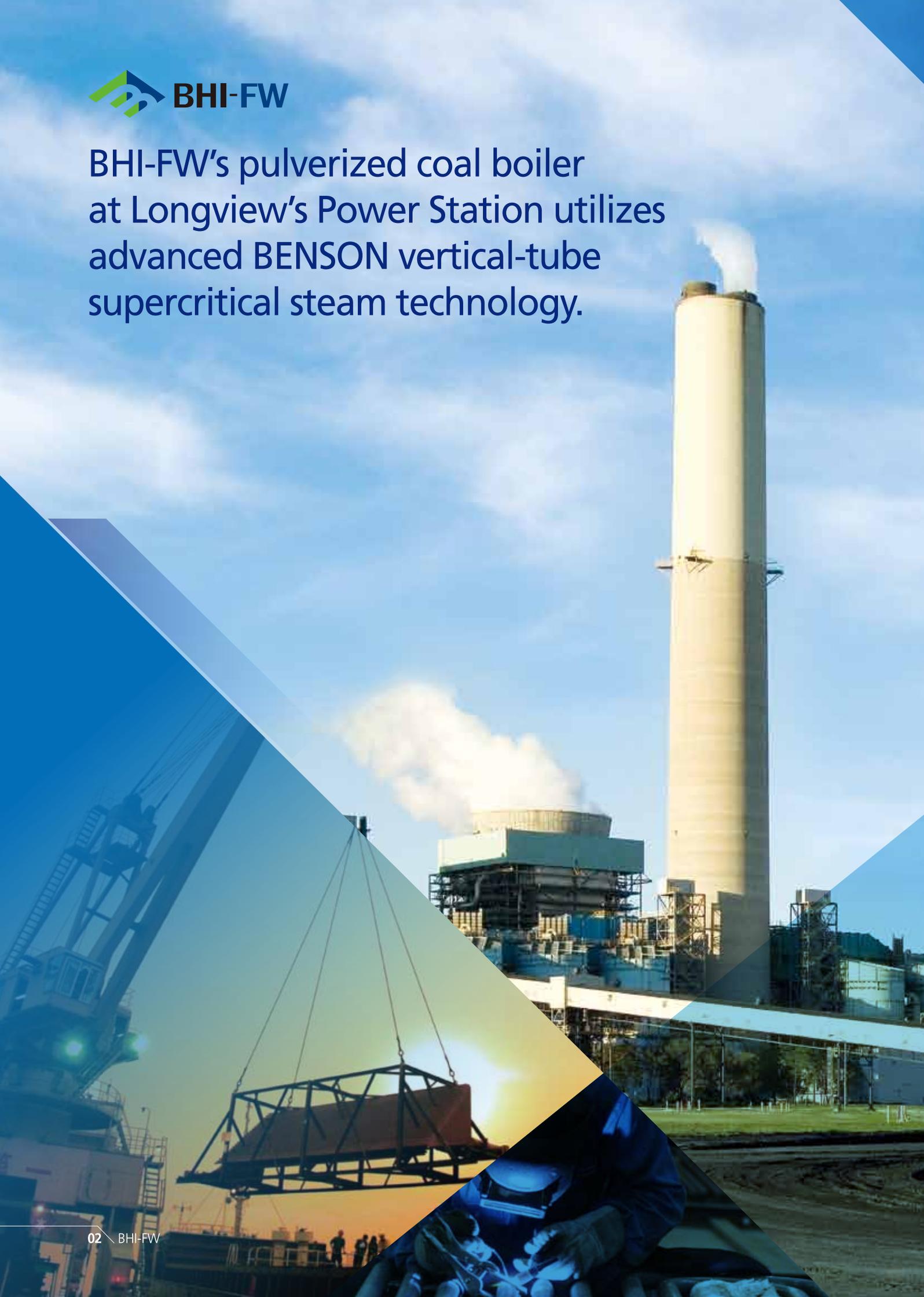
PC Boiler

2 x 600 MWe advanced
ultra-supercritical PC units
at the Buk-Pyeong plant
in South Korea





BHI-FW's pulverized coal boiler at Longview's Power Station utilizes advanced BENSON vertical-tube supercritical steam technology.



A long history with pulverized coal steam generators

For over half a century, BHI-FW has been designing and manufacturing utility pulverized coal (PC) steam generators. Our utility steam generators have proven themselves with over 50 million hours of operation, up to 1,100 MWe in size, and have the capability of burning a wide range of coals from anthracite to sub-bituminous fuels as well as petroleum coke.

Our natural circulation boilers are designed to be inherently safe by naturally increasing water flow as tube heat flow increases, under normal or upset scenarios, without relying on pumps, back-up systems or mechanical equipment.

The natural circulation characteristic is also included in our supercritical once-through BENSON Vertical Tube (BVT) technology, offered as a design option on all our utility PC steam generators.

Our units feature many other time tested advanced design features like low NOx firing systems, MBF and ball mills, SCR systems, split and series back pass resulting in improved reliability, low emissions and peak plant performance.



BHI-FW PCs stand out because of their time-tested design features

Our state-of-the-art low NOx combustion systems deliver high combustion efficiency and the lowest emissions



Dependable Performance

- ▶ Six-lobe opti-flow nozzle has over 50% more peripheral exposure for devolatilization compared to round nozzles
- ▶ Improves emissions, erosion, slagging, turndown, and boiler performance
- ▶ Reliable online tuning

Repeatable Controllability

- ▶ Two air zones, three linear drives, for independent swirl and airflow control
- ▶ Fixed vane swirlers minimize binding
- ▶ Non-pitot air flow measurement – strong DP signature, low clogging



Advanced arch-fired low NOx preheat burners

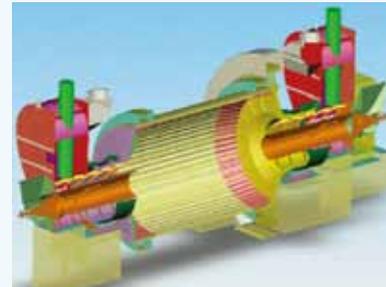
- ▶ Multi-level air staging for the lowest NOx emissions
- ▶ Fuel preheating for improved combustion efficiency
- ▶ Air separating cyclone burners for easy ignition
- ▶ Natural hot gas recirculation for flame stability
- ▶ Unit turndown to 40% load without support oil

BHI-FW MBF coal pulverizers are designed and built to handle the widest range of coals



- ▶ Ceramic or high chrome composite grinding rollers and table segments
- ▶ Refractory lined classifier housing and mill discharge assembly
- ▶ Refractory lined roller coal shields
- ▶ Individually tensioned, fixed rollers
- ▶ Three point maintenance access
- ▶ Low internal fuel air velocities

BHI-FW ball mills are rugged and highly reliable

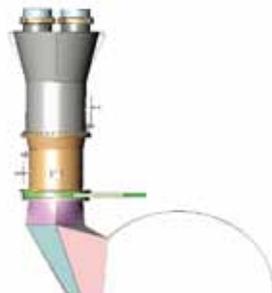


- ▶ High chrome abrasion resistance and long life grinding liners
- ▶ High-efficiency static M-style classifier
- ▶ Reliable direct measure level control
- ▶ Positive conveyor coal feed
- ▶ Coal distribution control to burners

Coal flow balance valve



- ▶ Controls coal distribution exiting a pipe going into a split
- ▶ Aggressively mixes two-phase flow
- ▶ Creates homogenous plug flow
- ▶ Capable of on-line adjustment
- ▶ No required equipment



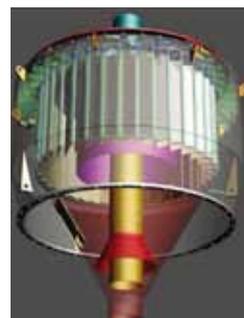
- ▶ Breaks heavy coal rope imbalance upstream of pipe split
- ▶ Ideal for exhauster fan mills
- ▶ Tuning vanes with on-line adjustability
- ▶ No special adjustment tools required
- ▶ Ceramic-lined ID for maximum erosion protection



- ▶ Controls both coal and air flow
- ▶ Acts as a mild restriction on individual coal pipes
- ▶ Maximum restriction : 50%
- ▶ Dual blade design maintains annular flow profile
- ▶ On-line adjustment capability
- ▶ Simple adjustment : standard ratchet tool



- ▶ Pulverizer capacity
- ▶ Coal particle fineness distribution
- ▶ Higher separation efficiency with "steeper" particle fineness distribution
- ▶ Overall combustion efficiency

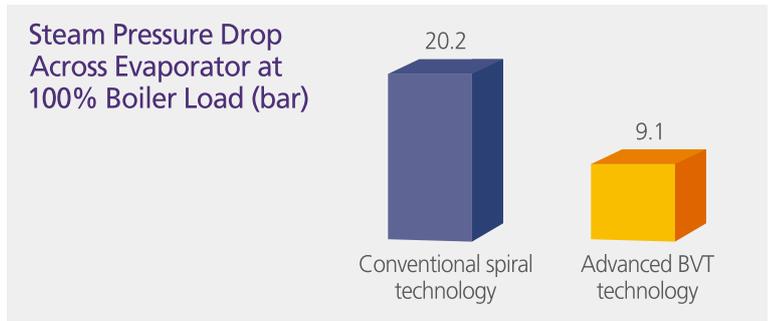


- ▶ Reduced NOx and unburned carbon
- ▶ Increased mill capacity
- ▶ Reduced grinding power
- ▶ Improved mill response

Not all supercritical technologies are the same

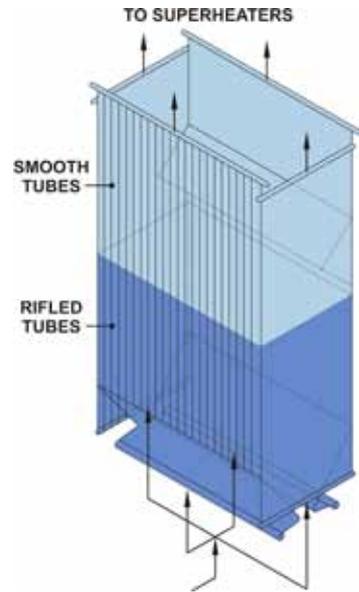
BHI-FW's BENSON Vertical Tube (BVT) supercritical steam technology has significant advantages over conventional spiral technology. Since the evaporator tubes are vertical along the entire furnace height, the furnace walls are easier to fabricate, erect and repair.

In addition, the steam flow of BVT technology is much lower in each tube than spiral technology, resulting in a lower steam pressure loss which further improves plant efficiency. BVT technology also features a passive self cooling characteristic which can limit the temperature rise of tubes receiving higher heat flow, extending furnace life, reducing maintenance and improving plant reliability.

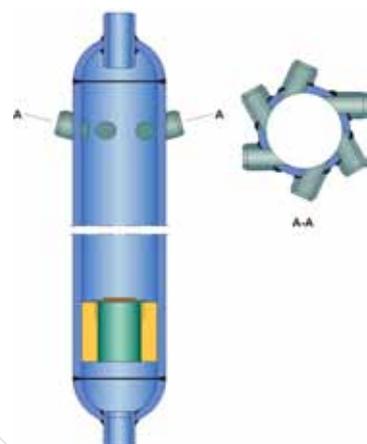


To further reduce maintenance and improve plant reliability, evaporator tubes which receive high heat are rifled resulting in a spiral ridge along the inside length of the tube. After years of research, the ridge geometry has been perfected so that a film of liquid water will coat the tube wall to provide effective cooling at much higher steam qualities and tube metal temperatures than conventional smooth tube technology.

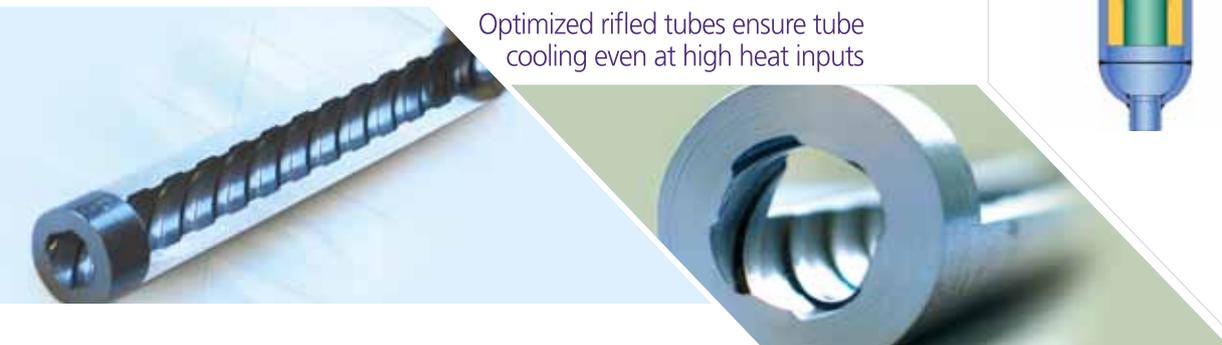
For ease of operation, BVT supercritical technology utilizes in-line tangential steam/water separators which allow the steam generator's evaporator to automatically transition from circulating to once-through steam mode during unit start-up and shut-down, while providing a wide range of operation in the once-through mode.



- ▶ Small tubes for self cooling effect
- ▶ Simple support system
- ▶ Low pressure drop
- ▶ Easy to maintain
- ▶ Lower cost to build
- ▶ Eliminates slag ledge used in conventional spiral designs

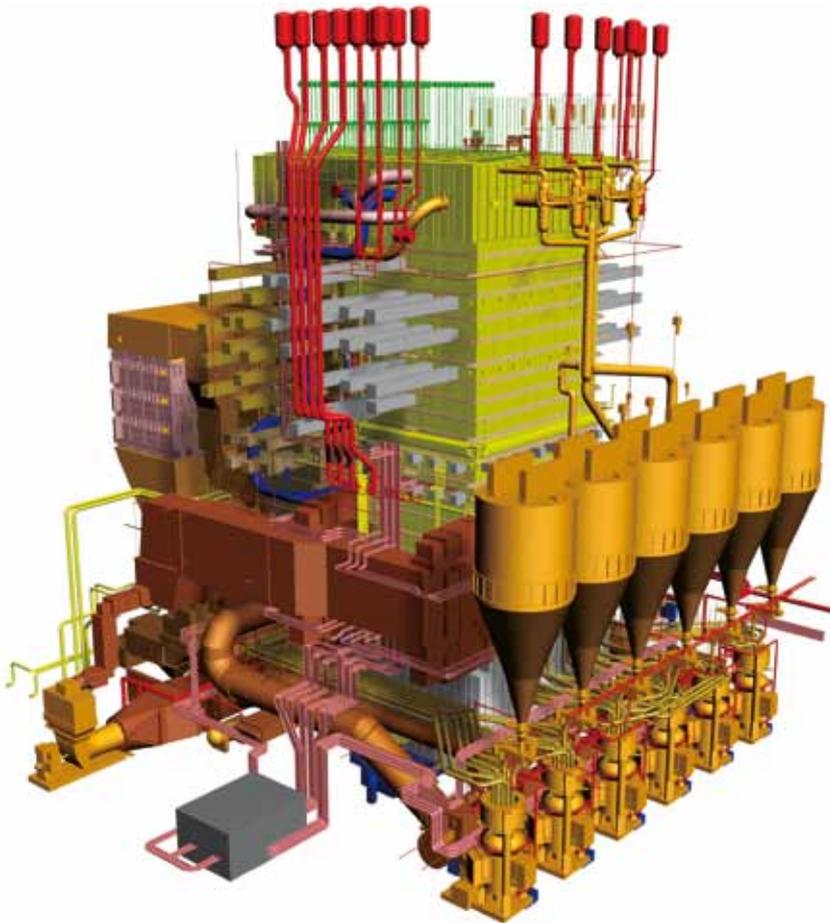


Optimized rifled tubes ensure tube cooling even at high heat inputs



The Longview Power project

Advancing utility PC technology



We have coupled our proven wall-fired pulverized coal (PC) steam generators with advanced BENSON vertical-tube (BVT) supercritical steam technology.

Supercritical steam technology can achieve plant efficiencies well beyond conventional subcritical drum-type units, thereby producing more electricity and less emissions from a steam power plant. By coupling these technologies together, we offer a steam generator design balanced with both proven and advanced design features, such as:

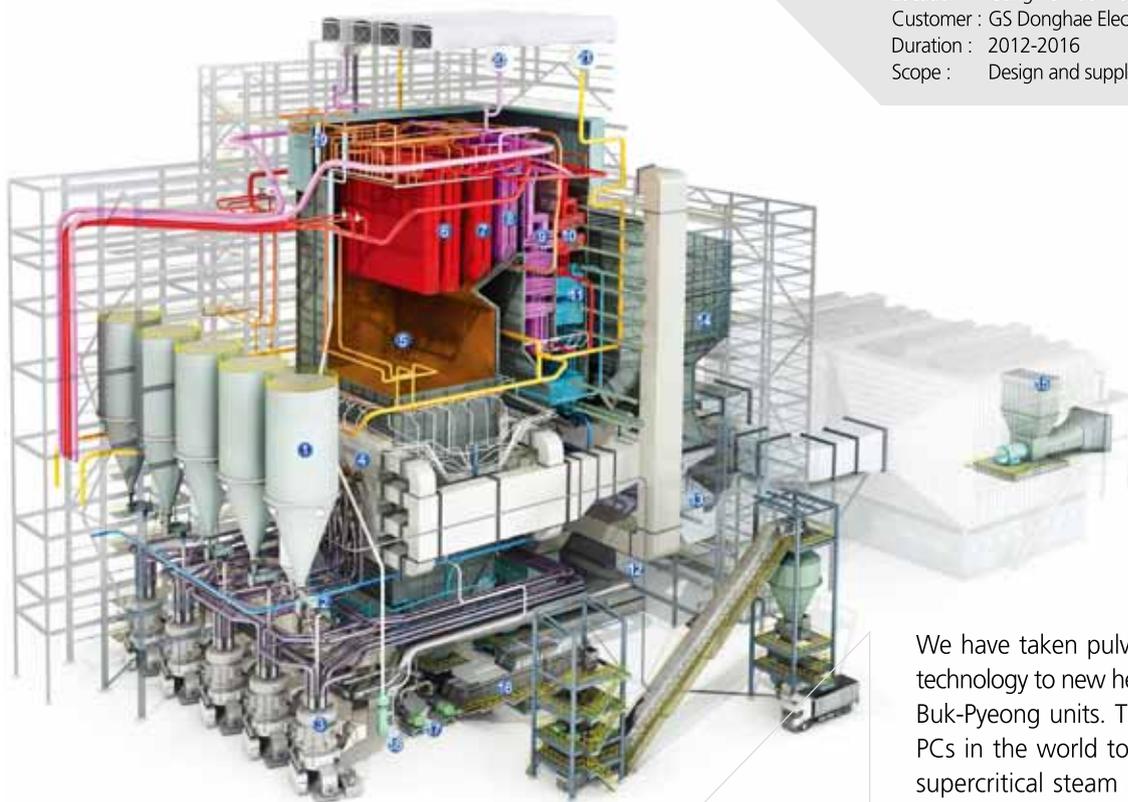
- ▶ Simple vertical tube furnace design, which is easier to fabricate, build and repair
- ▶ Built-in self cooling characteristic for high reliability and maximum furnace life
- ▶ Generous furnace volumes for complete combustion of the fuel
- ▶ MBF and ball mill pulverizers for the widest solid fuel range
- ▶ Staged low NOx combustion systems
- ▶ SCR for the lowest NOx emissions

Project summary

Location : Madsville, WV, USA
Customer : Longview Power, LLC
Duration : 2007-2011
Scope : Design and supply of PC boiler

Plant Electrical Output (Gross/Net)	770 MWe/695 MWe	
Net Plant Efficiency (LHV/HHV)	40.8%/39.1%	
Net Plant Heat Rate (LHV/HHV)	8831/9214 kJ/kWh	8370/8733 Btu/kWh
Steam Flow (SH/RH)	2218/1825 tph	4876/4012 kpph
Steam Pressure (SH/RH)	258/55 barg	3720/773 psig
Steam Temperature (SH/RH)	569/567 °C	1056/1052 °F
Feedwater Temperature	298 °C	568 °F
Fuel	West Virginia bituminous coal	

The Buk-Pyeong Power project



Project summary

Location : Gangwon-do Province, South Korea

Customer : GS Donghae Electric Power Co., Ltd.

Duration : 2012-2016

Scope : Design and supply of PC boiler

Wall-Fired supercritical BENSON vertical tube steam generator

We have taken pulverized coal (PC) technology to new heights with these Buk-Pyeong units. They are the first PCs in the world to combine ultra-supercritical steam conditions with BENSON vertical-tube, low-mass-flux, once-through technology to achieve high efficiency.

The plant's high efficiency significantly reduces the plant emissions and operating cost providing a benefit to both the environment and Korea's electricity rates.

We have teamed with our licensee in South Korea, BHI, to successfully deliver and commission these two cutting edge PC units to GS Donghae Electric Power Co. for the Buk-Pyeong Power Plant project located in the province of Gangwon-do, South Korea.

Our role in this project included working closely with BHI in the design of the units, as well as, overseeing their construction and commissioning of the units.

Plant Electrical Output (Gross/Net)	2 x 605 MWe/2 x 595 MWe	
Steam Flow (SH/RH)	1760/1414 tph	3873/3111 kpph
Steam Pressure (SH/RH)	253/49 barg	3669/711 psig
Steam Temperature (SH/RH)	603/613 °C	1117/1135 °F
Feedwater Temperature	290 °C	555 °F
Fuel	Bituminous coal, oil	

BHI-FW's subcritical natural circulation wall-fired PCs

Designed and built for long life and high reliability



- ▶ Natural circulation furnace circuitry "self compensates" for heat flux unbalances
- ▶ Optimized furnace size yields high combustion efficiency and minimizes flame impingement on furnace walls
- ▶ Low NOx opti-flow burners maximize carbon burnout, with minimal NOx production
- ▶ Wide tube spacing and in-line tubes to prevent ash bridging
- ▶ Low gas velocities for low erosion
- ▶ Refractory and erosion shield protection in high wear areas
- ▶ Patented induct heater for economical SCR ammonia vaporization
- ▶ Flue gas or steam bypass for efficient reheat temperature control
- ▶ Robust MBF coal mills to handle abrasive high ash coals

Wall-Fired subcritical natural circulation steam generator



OPG Power, Unit IV

Location : Chennai, India
 Customer : OPG Power Generation Pvt. Ltd.
 Start-Up Year : 2015
 Capacity : 1 x 180 MWe
 Fuel : Indonesian Coal/Indian Coal



Springerville Generating Station Units 3 & 4

Location : Springerville, AZ, USA
 Customer : Bechtel Power Corp./ Salt River Project (SRP)
 Start-Up Year : 2006, 2009
 Capacity : 2 x 400 MWe
 Fuel : PRB Coal

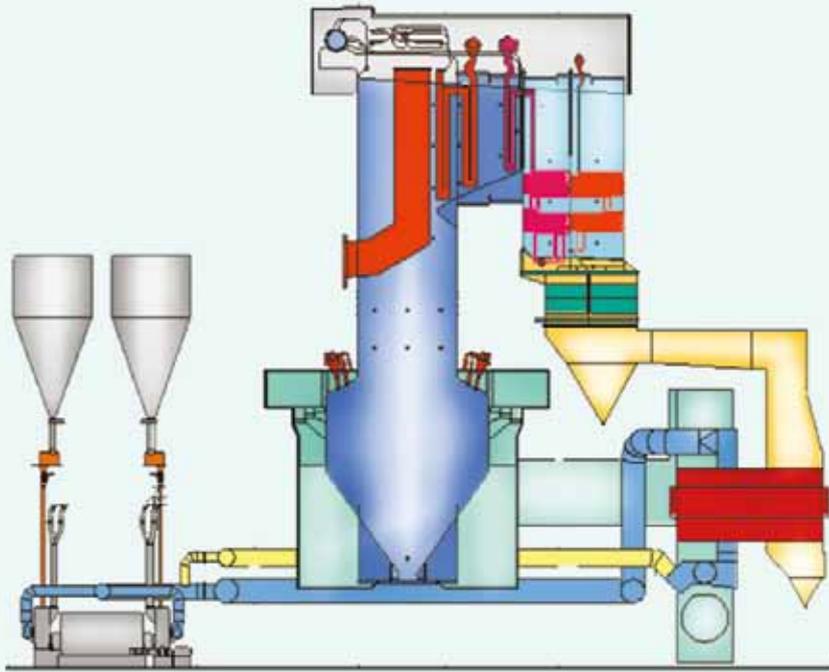


Quezon Power Plant

Location : Quezon, Philippines
 Customer : Quezon Power Limited Co.
 Start-Up Year : 2000
 Capacity : 1 x 486 MWe
 Fuel : Coal, Oil

BHI-FW's advanced pulverized coal technology for low volatile fuels

Natural circulation units for subcritical steam conditions



- ▶ Double cyclone burners creates a “W” flame shape for high carbon burnout of low volatile fuels
- ▶ Burner vent-to-overfire air system aids ignition and minimizes NOx formation
- ▶ Selective refractory covering in lower furnace enhances ignition and promotes complete combustion
- ▶ Self compensating “natural circulation characteristic” to minimize temperature unbalances
- ▶ Vertical tube wall construction simplifies erection, maintenance, and repair
- ▶ Low minimum load which reduces start-up time, auxiliary fuel and start-up pump power consumption

Arch-fired Subcritical Natural Circulation Steam Generator



Thai Binh Thermal Power Station

Location : Thai Binh, Vietnam
 Customer : Marubeni Corporation
 Start-Up Year : 2017
 Capacity : 1 x 300 MWe
 Fuel : Anthracite Coal



Vinh Tan Arch-Fired Units I & II

Location : Binh Thuan Province, South Vietnam
 Customer : Vietnam Electricity (EVN)
 Start-Up Year : 2013 - 2014
 Capacity : 2 x 622 MWe
 Fuel : Anthracite



Nghi Son 1 Arch-Fired Project

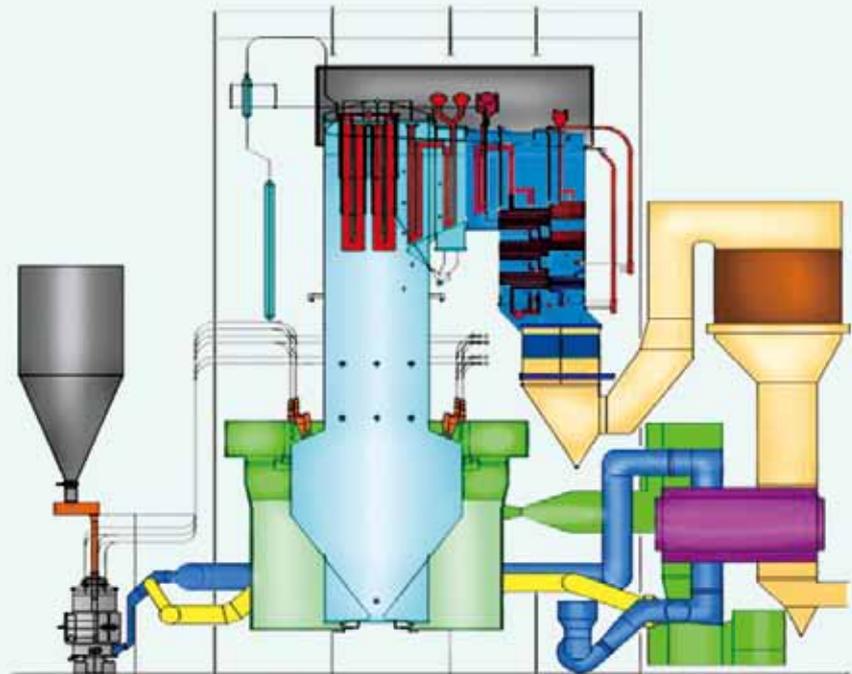
Location : Thanh Hoa Province, Vietnam
 Customer : Vietnam Electricity (EVN)
 Start-Up Year : 2013 - 2014
 Capacity : 2 x 300 MWe
 Fuel : Pulverized Anthracite Coal

Once-through vertical tube units for supercritical steam conditions

Arch-Fired Once-Through Supercritical Steam Generator

Provides all of the beneficial design features of our natural circulation units plus more

- ▶ Higher plant efficiency for lower emissions and plant operating cost
- ▶ Optimized rifled furnace tubes to ensure tube cooling even for highly heated tubes
- ▶ Eliminates slag ledge between spiral and vertical-tube sections in conventional spiral wound designs
- ▶ Lowest steam/water pressure loss maximizes plant efficiency
- ▶ Simple vertical-tube furnace design is easier to fabricate, build and repair
- ▶ Low mass-flux BENSON vertical-tube evaporator technology provides safe self-cooling protection



RECENT PROJECTS



Datang Supercritical Arch-Fired PC Power Plant

The Datang power plant in Heshan City located in China's Guangxi province is one of the most advanced coal power plants in China. The plant utilizes one very advanced 675 MWe arched-fired PC steam generators supplied by SBW, the licensee of BHI-FW.

The steam generators incorporate BENSON vertical-tube, low-mass-flux, once-through technology to produce steam at supercritical conditions allowing the plant to achieve high efficiency. The plant's high efficiency significantly reduces the plant emissions and operating cost providing a benefit to both the environment and Guangxi's electricity rates.

Location : Heshan City, Guangxi Province, China
Customer : Datang Guiguan Heshan Power Gen Co, Ltd.
Start-Up Year : 2012
Capacity : 2 x 670 MWe
Fuel : Anthracite Coal



Challenge of Future
BHI



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