



Challenge of Future  
BHI

A new generation of  
pulverized coal technology

# PC Boiler



#### **BHI-FW**

53 Frontage Road, Suite 225 Hampton, NJ 08827, USA  
E-Mail. sales@bhifw.com

#### **BHI Indonesia**

Gedung Berca Indonesia 5th Floor Room 502 Jln.  
Palmerah Utara No.14 Jakarta Barat 11480, Indonesia  
E-mail. bhi\_indonesia@bhi.co.kr

#### **BHI (THAI) CO., LTD. (HEAD OFFICE)**

5/5, Srinakarin Soi 46/1 (Soi Pramote), Srinakarin Road,  
Nong Bon, Prawet, Bangkok 10250 Thailand  
E-mail albert@bhi.co.kr

#### **BHI CO., LTD (BRANCH)**

Dubai Silicon Oasis, DDP, Building A1, Dubai, United Arab Emirates  
E-mail happyman@bhi.co.kr

#### **BHI Haman Shop**

122, Jangbaek-ro, Gunbuk-myeon, Haman-gun,  
Gyeongsangnam-do, 637-824 Korea  
E-mail. sales@bhi.co.kr

#### **BHI Moro Shop**

309, Yeomyeong-ro, Gunbuk-myeon, Haman-gun,  
Gyeongsangnam-do, 637-823 Korea

#### **BHI Sacheon Shop**

116, Gongdan 1-ro, Sanam-myeon, Sacheon-si,  
Gyeongsangnam-do, 664-942 Korea



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



## Highly reliable wall-fired low NOx burners

### 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

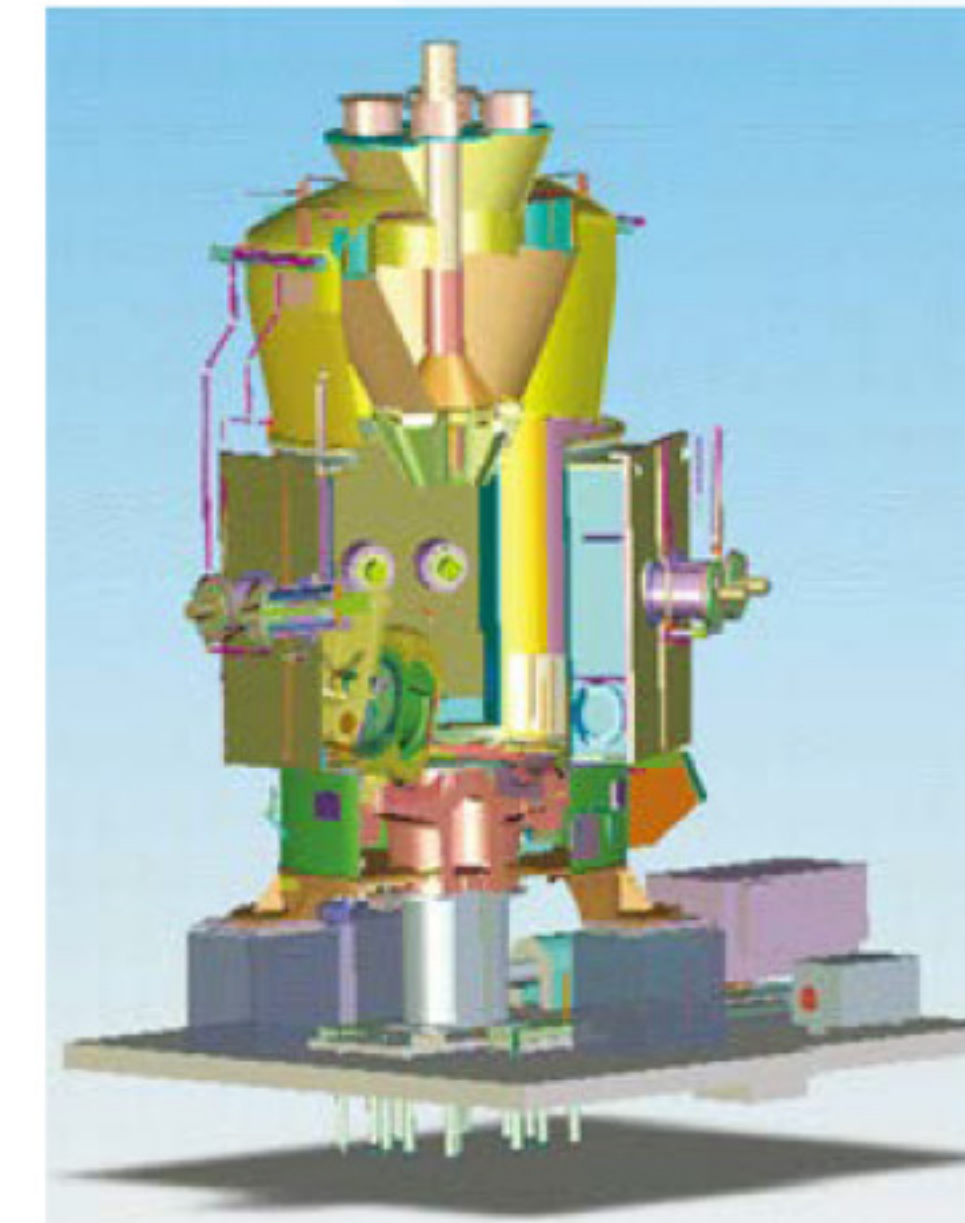
- ▶ Two air zones, three linear drives, for independent swirl and airflow control
- ▶ Fixed vane swirlers minimize binding
- ▶ Non-pitot air flow measurement – strong DP signature, low clogging



## Advanced arch-fired low NOx preheat burners

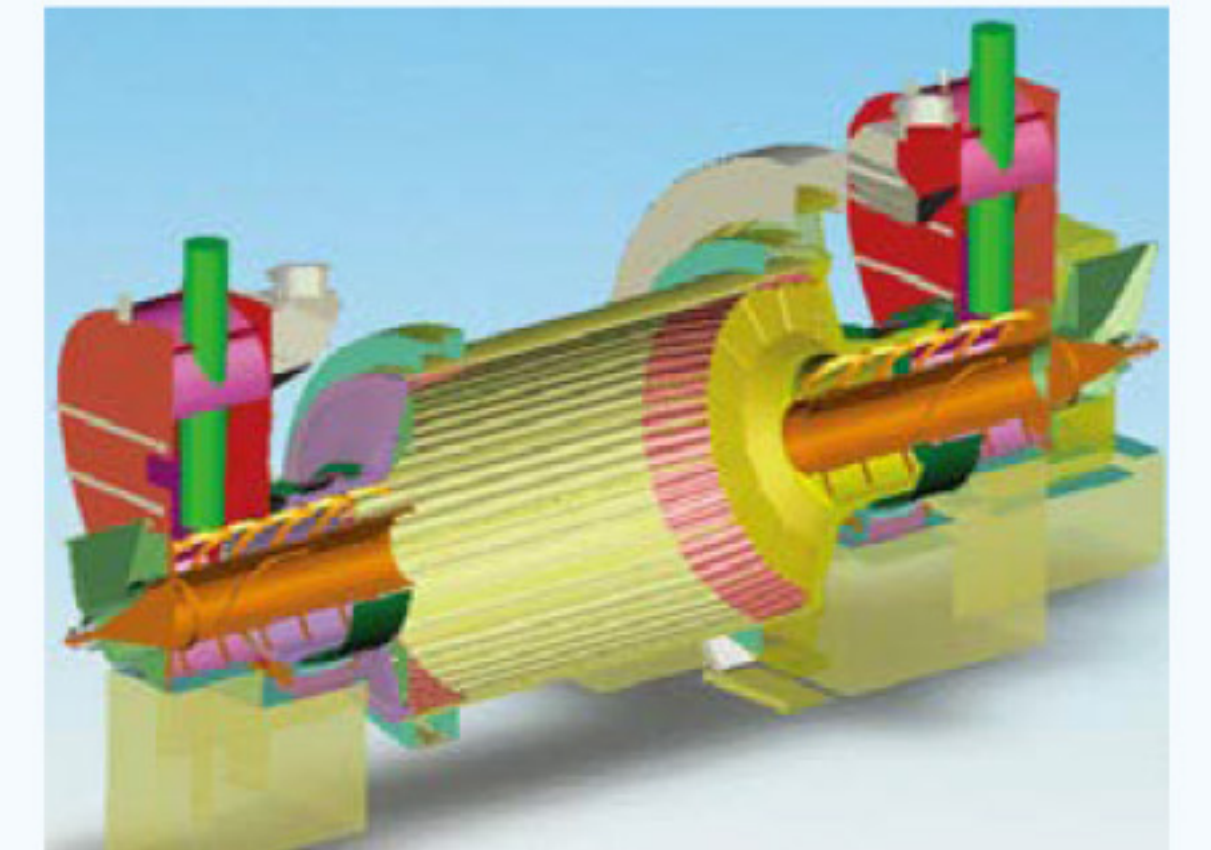
- ▶ Multi-level air staging for the lowest NOx emissions
- ▶ Fuel preheating for improved combustion efficiency
- ▶ Air separating cyclone burners for easy ignition
- ▶ Natural hot gas recirculation for flame stability
- ▶ Unit turndown to 40% load without support oil

## 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



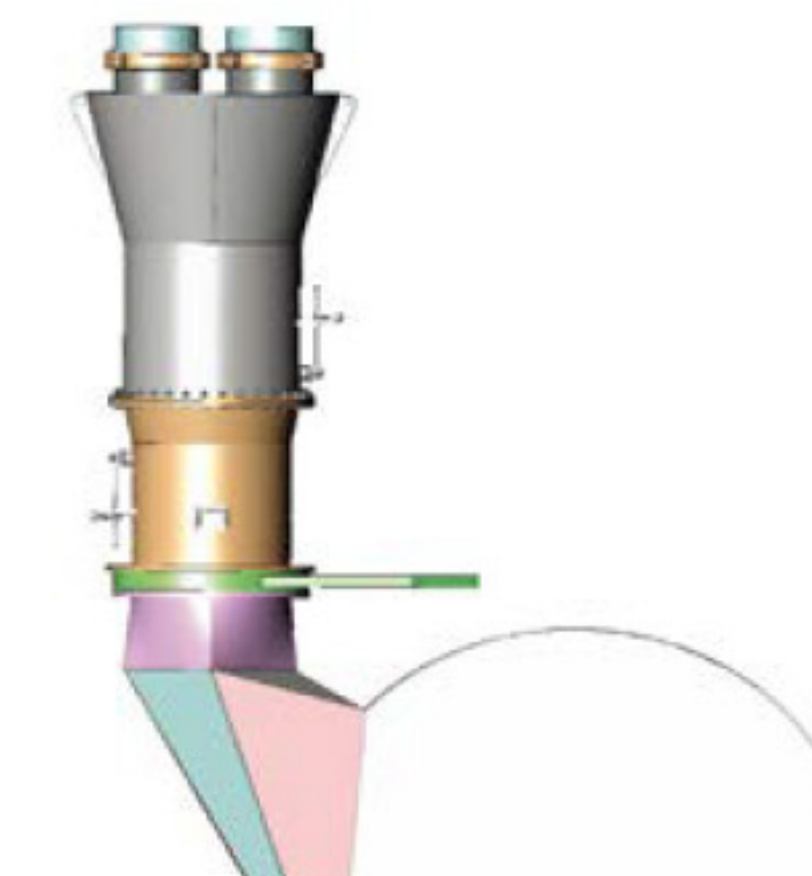
- ▶ High chrome abrasion resistance and long life grinding liners
- ▶ High-efficiency static M-style classifier
- ▶ Reliable direct measure level control
- ▶ Positive conveyor coal feed
- ▶ Coal distribution control to burners

## Riffle box technology



- ▶ 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

## Tower distributors



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

## Coal flow balance valve



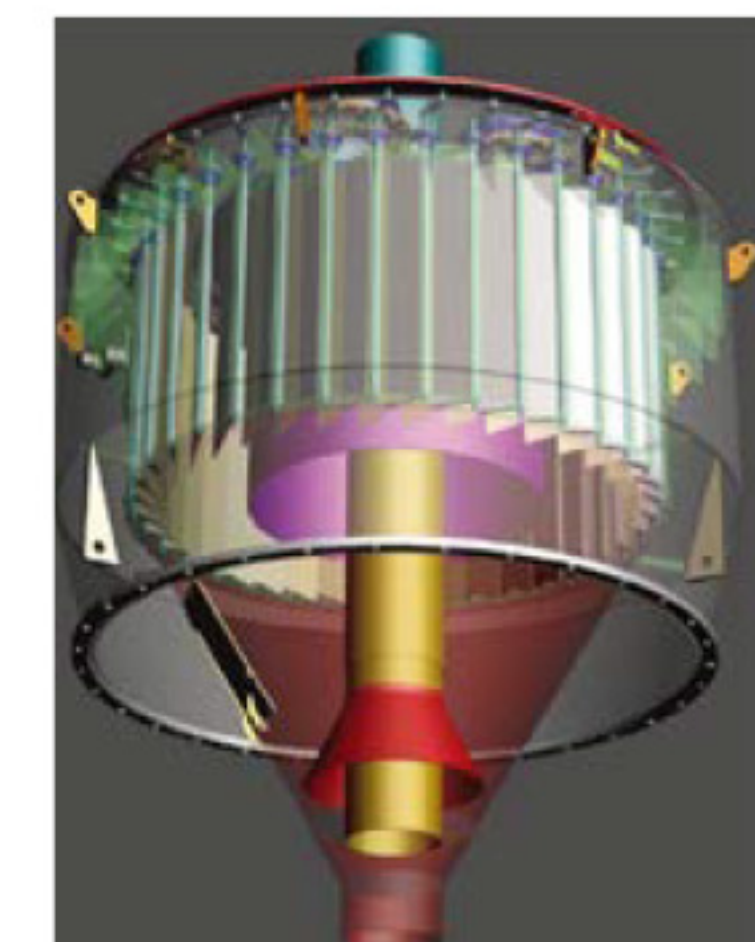
- ▶ Controls both coal and air flow
- ▶ Acts as a mild restriction on individual coal pipes
- ▶ Maximum restriction : 50%
- ▶ Dual blade design maintains annular flow profile
- ▶ On-line adjustment capability
- ▶ Simple adjustment : standard ratchet tool

## Dynamic classifier



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

## M classifier



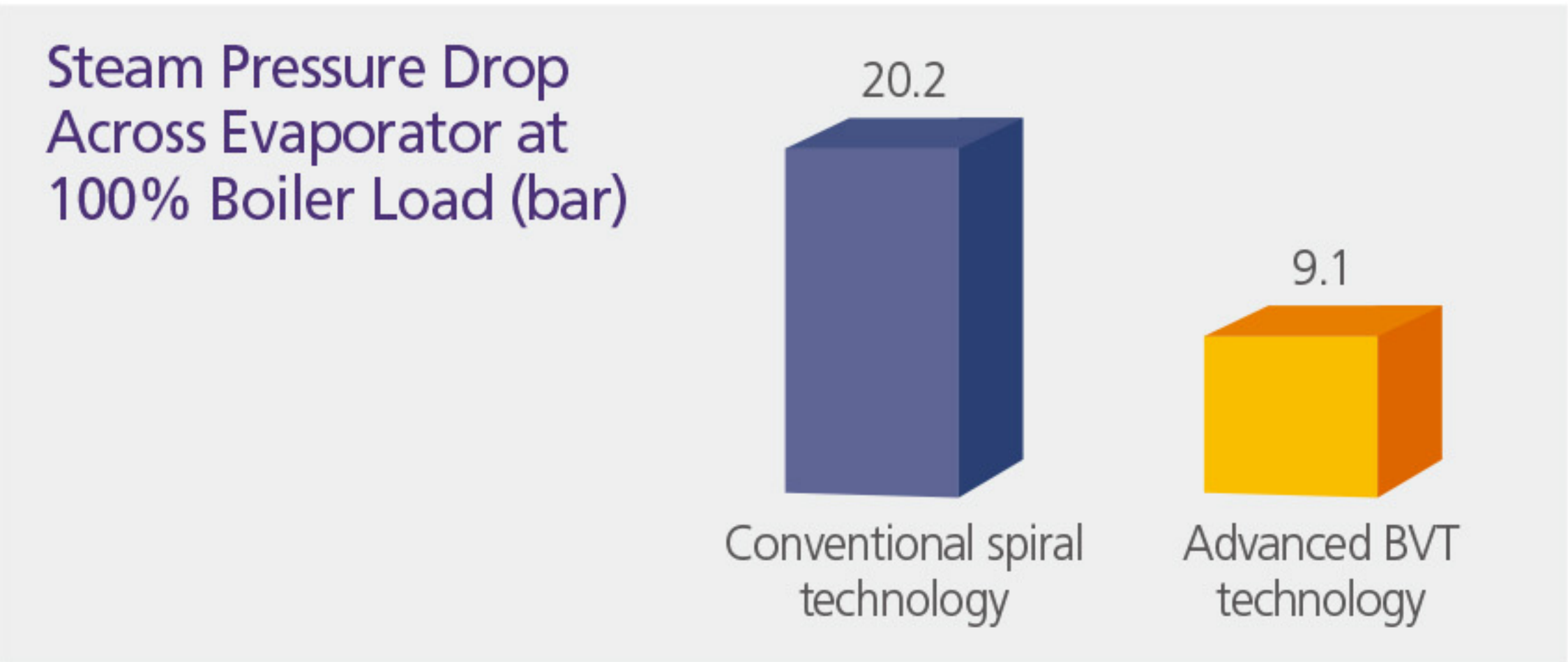
- ▶ Reduced NOx and unburned carbon
- ▶ Increased mill capacity
- ▶ Reduced grinding power
- ▶ Improved mill response



# Not all supercritical technologies are the same

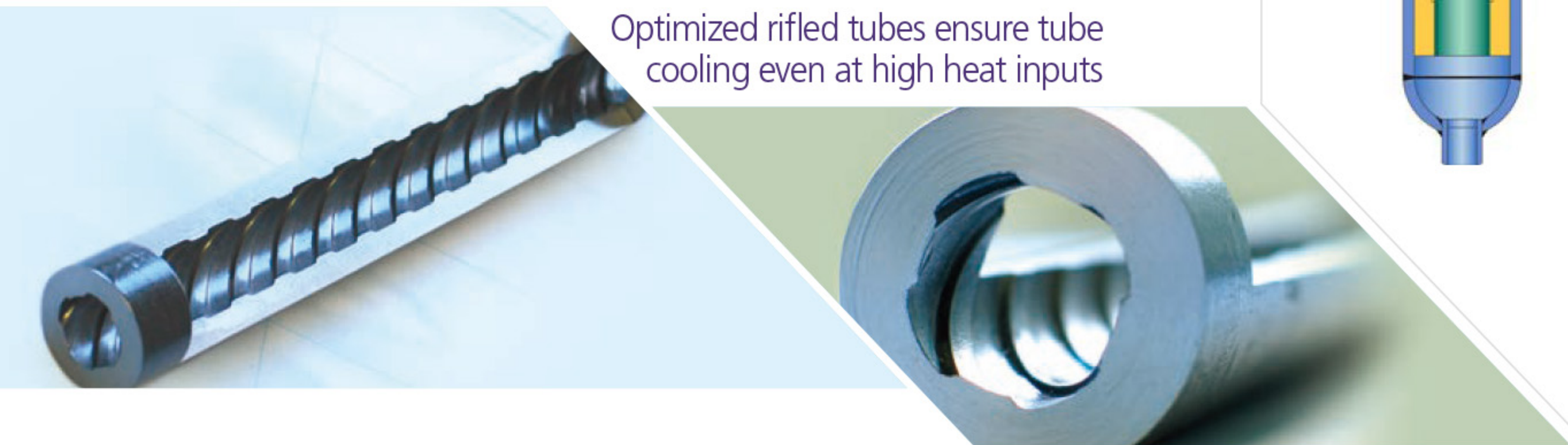
BHI-FW's BENSON Vertical Tube (BVT) supercritical steam technology has significant advantages over conventional spiral technology. Since the evaporator tubes are vertical along the entire furnace height, the furnace walls are easier to fabricate, erect and repair.

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.



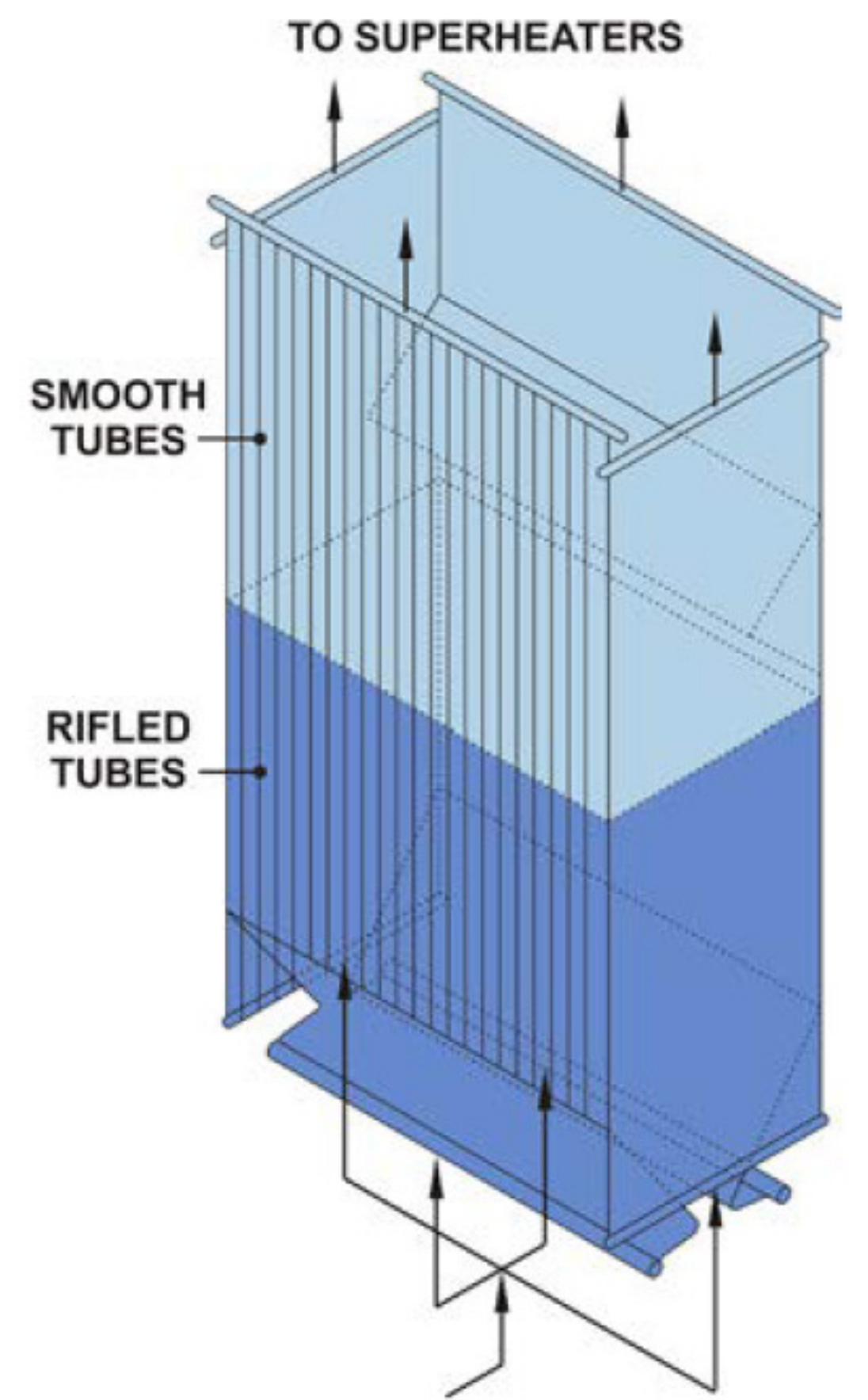
To further reduce maintenance and improve plant reliability, evaporator tubes which receive high heat are rifled resulting in a spiral ridge along the inside length of the tube. After years of research, the ridge geometry has been perfected so that a film of liquid water will coat the tube wall to provide 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.



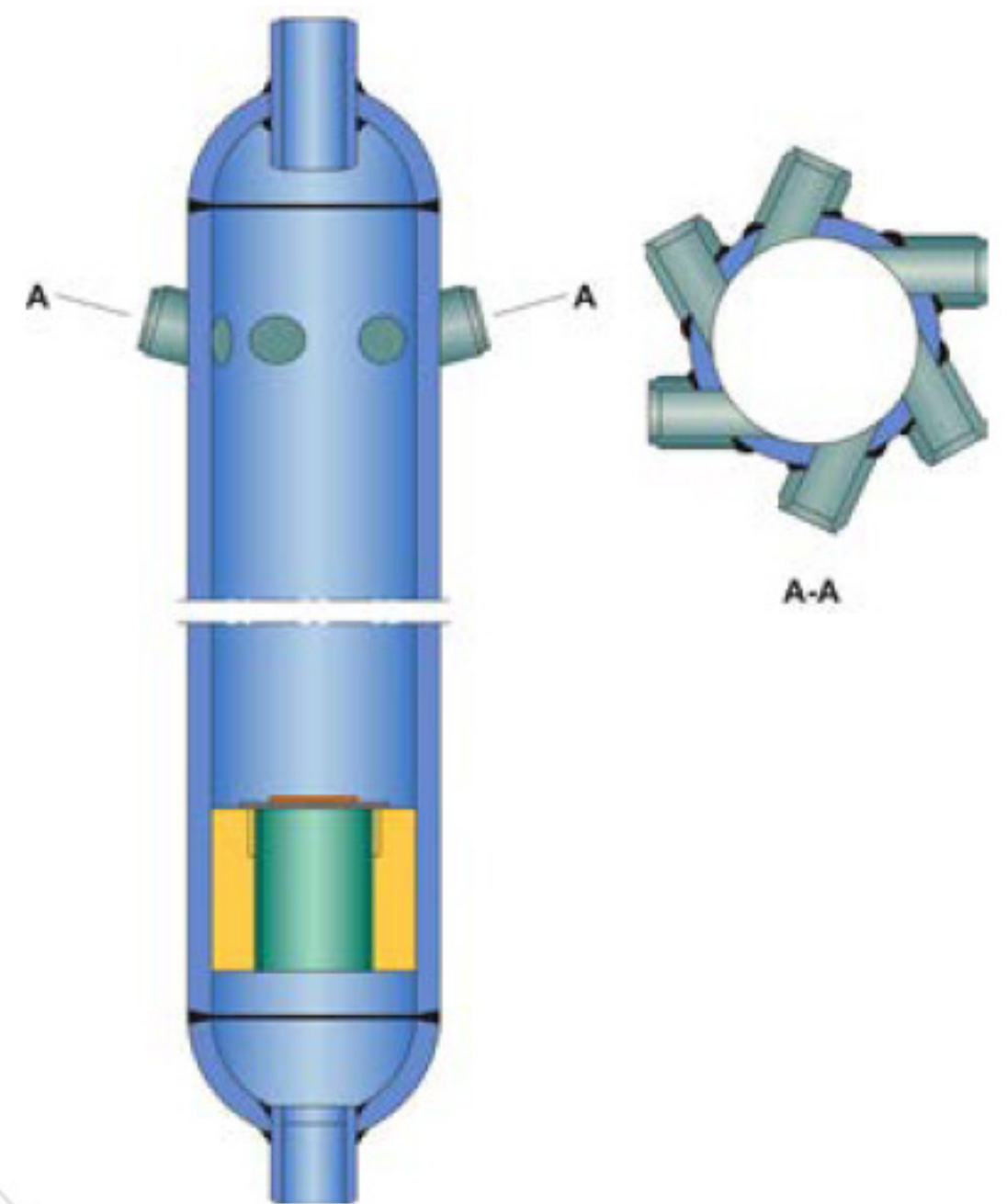
Optimized rifled tubes ensure tube cooling even at high heat inputs

## BHI-FW's advanced BVT steam generator technology

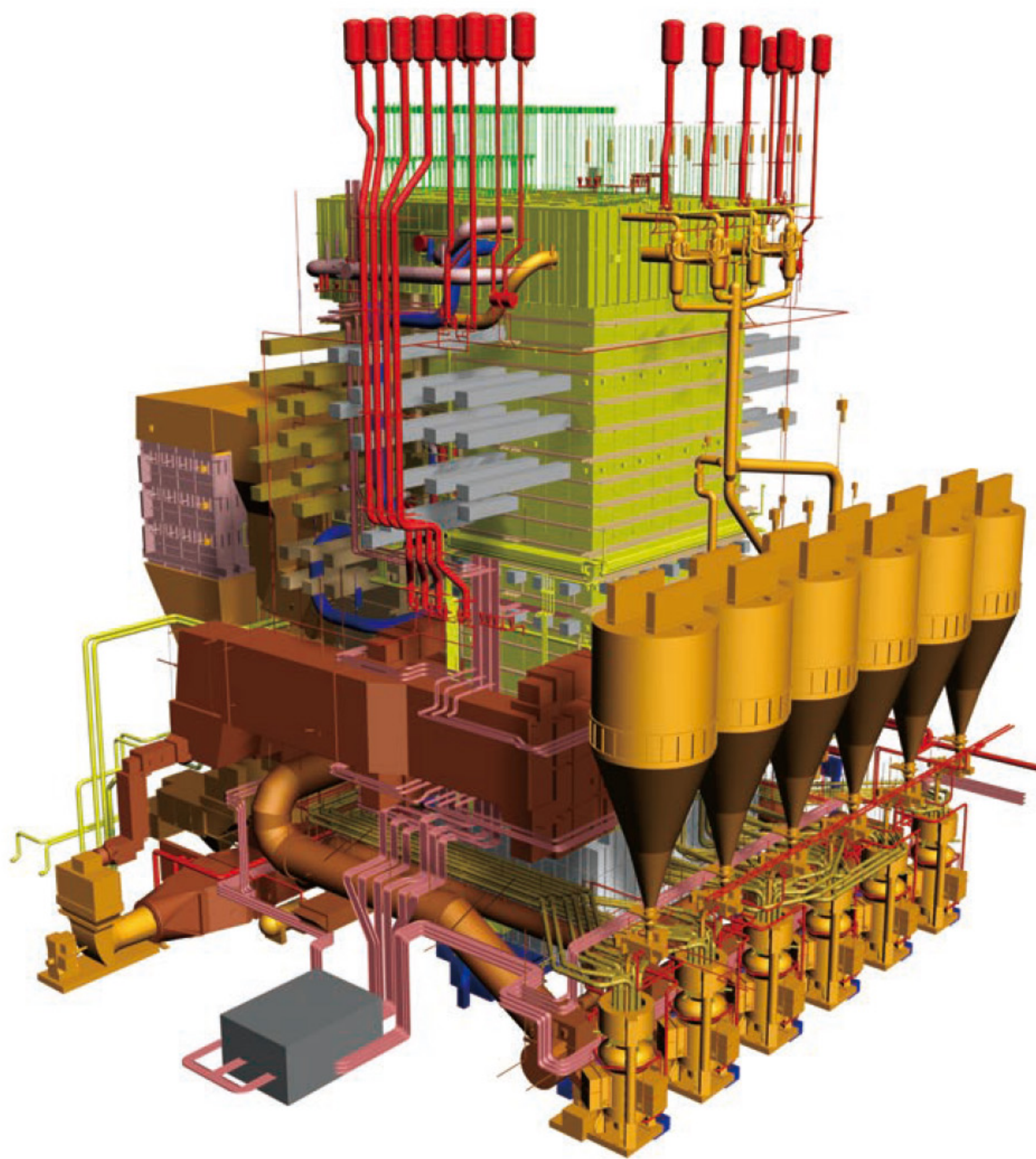


- ▶ Small tubes for self cooling effect
- ▶ Simple support system
- ▶ Low pressure drop
- ▶ Easy to maintain
- ▶ Lower cost to build
- ▶ Eliminates slag ledge used in conventional spiral designs

## Inline tangential steamwater separator



# The Longview Power project Advancing utility PC technology



## Going supercritical

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:

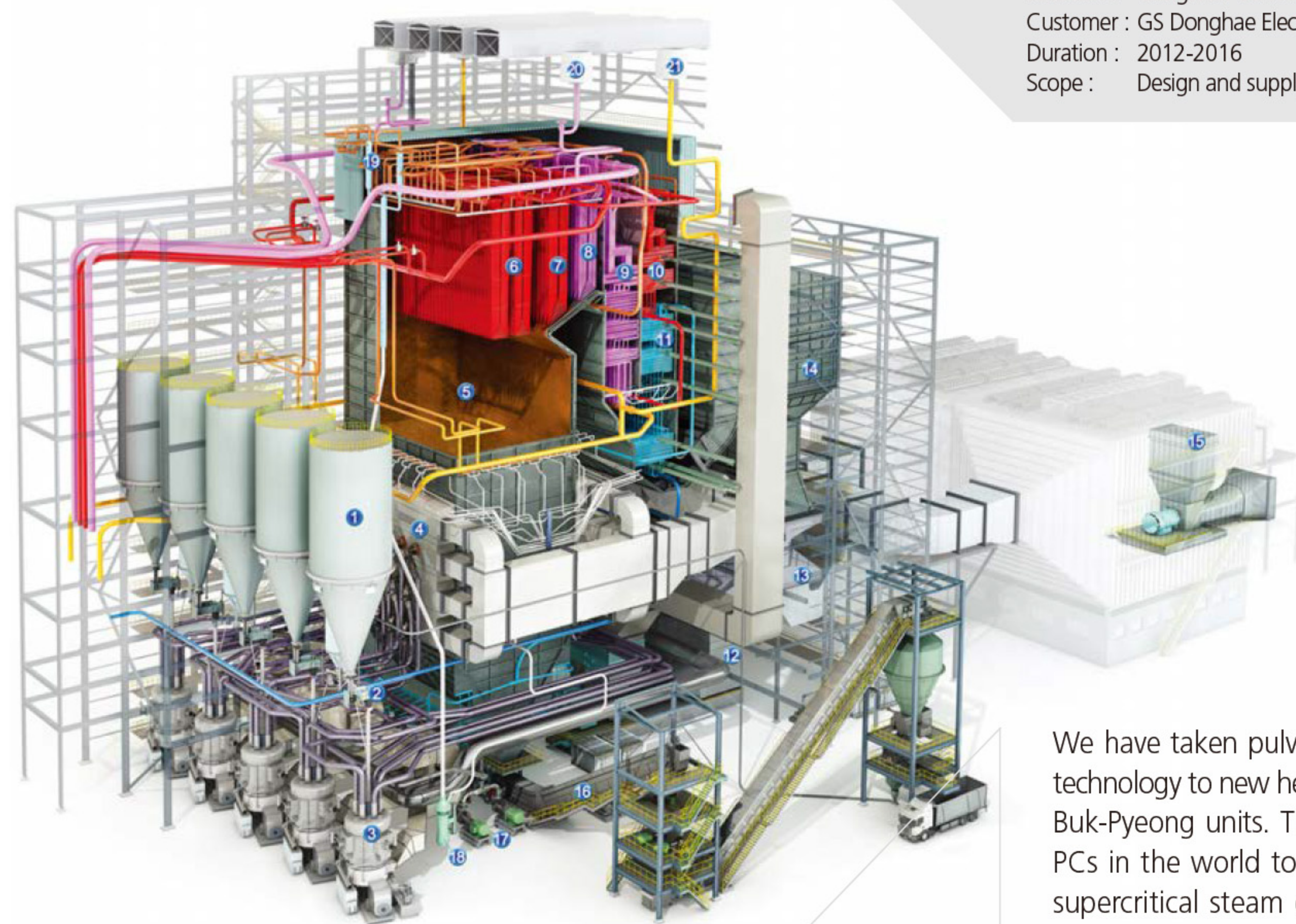
- ▶ Simple vertical tube furnace design, which is easier to fabricate, build and repair
- ▶ Built-in self cooling characteristic for high reliability and maximum furnace life
- ▶ Generous furnace volumes for complete combustion of the fuel
- ▶ MBF and ball mill pulverizers for the widest solid fuel range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

**Project summary**  
Location : Maidsville, 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

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.

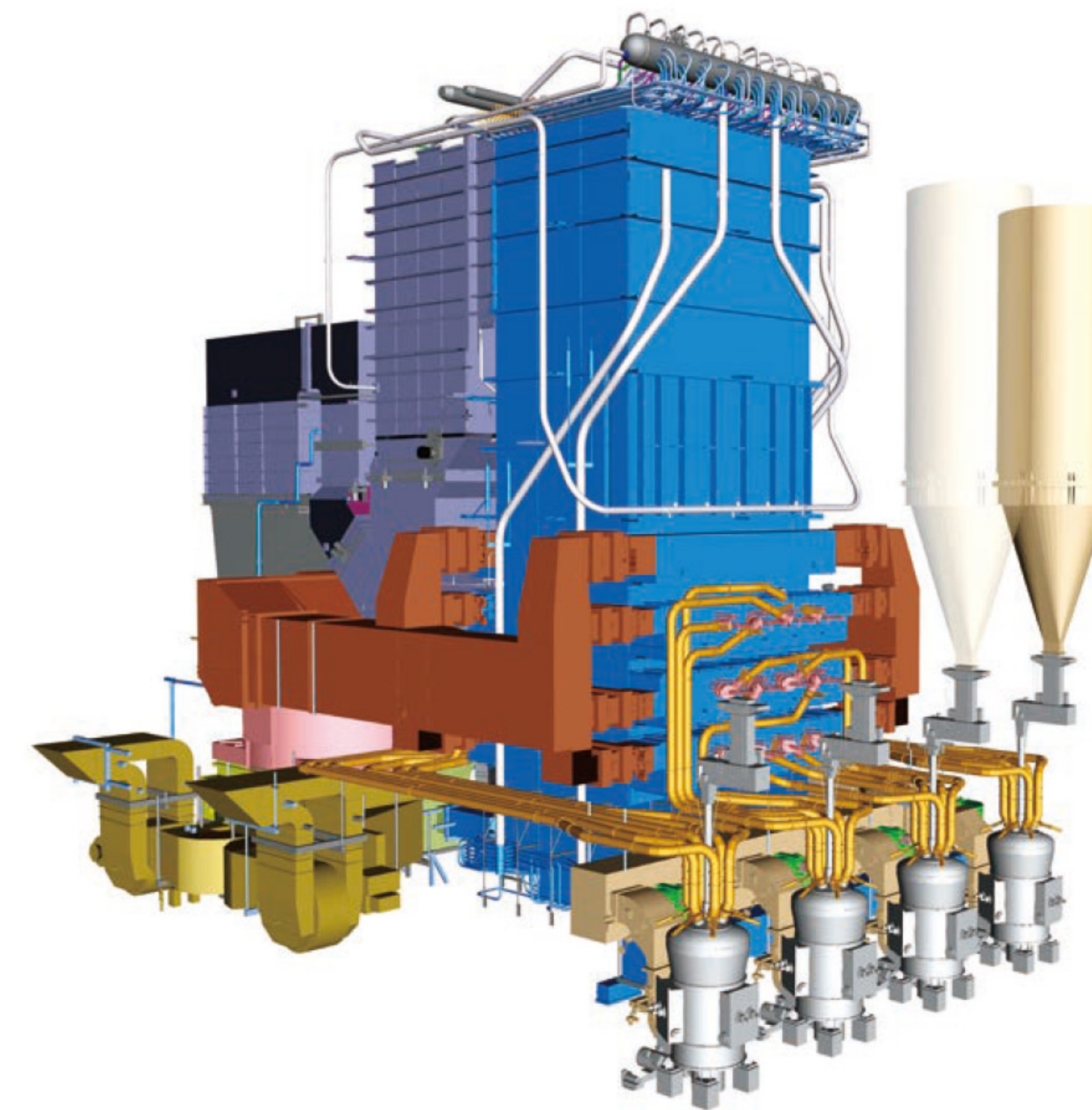
Our role in this project included working closely with BHI in the design of the units, as well as, overseeing their construction and commissioning of the units.

### Wall-Fired supercritical BENSON vertical tube steam generator

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

### RECENT PROJECTS



#### 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



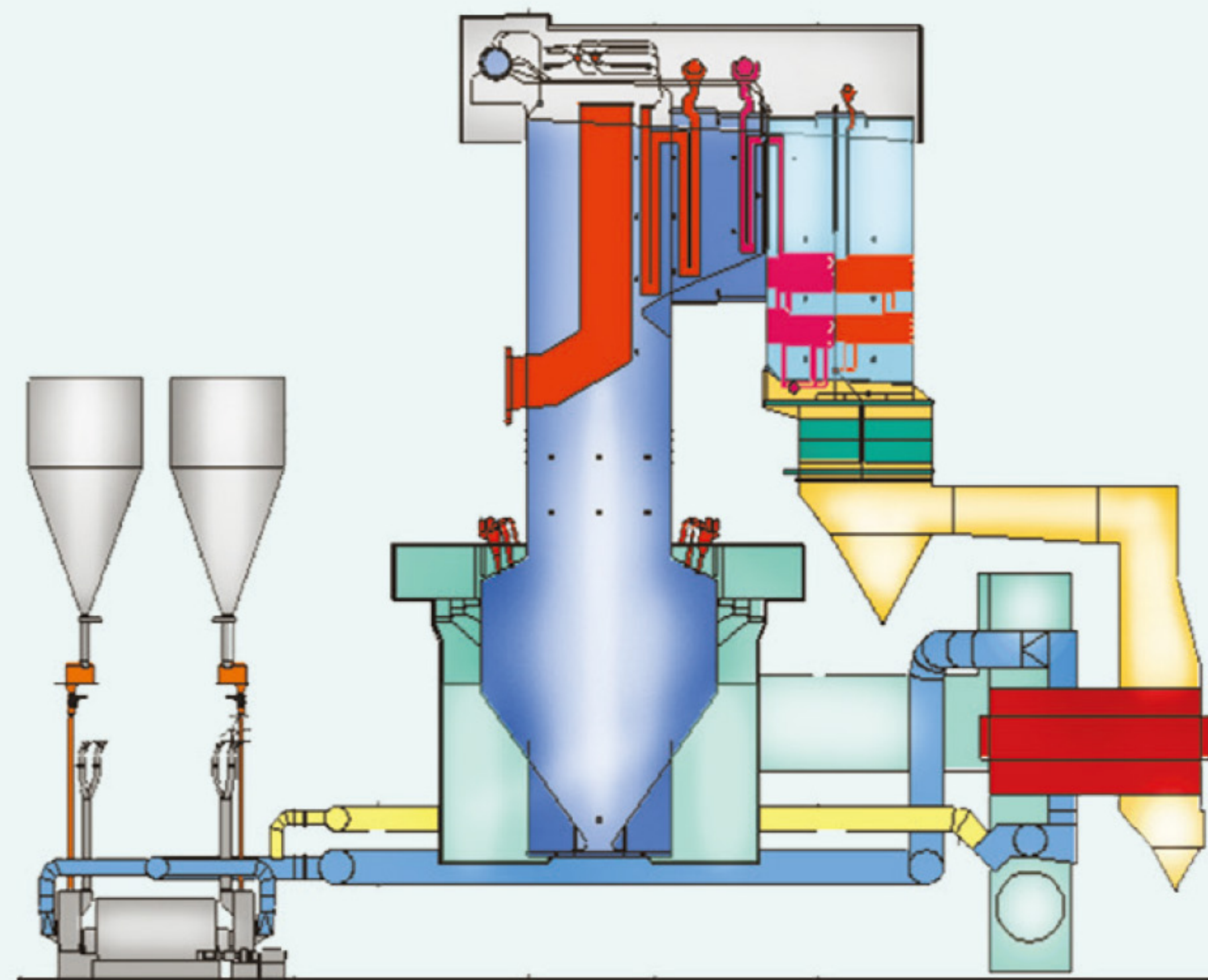
#### Quezon Power Plant

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

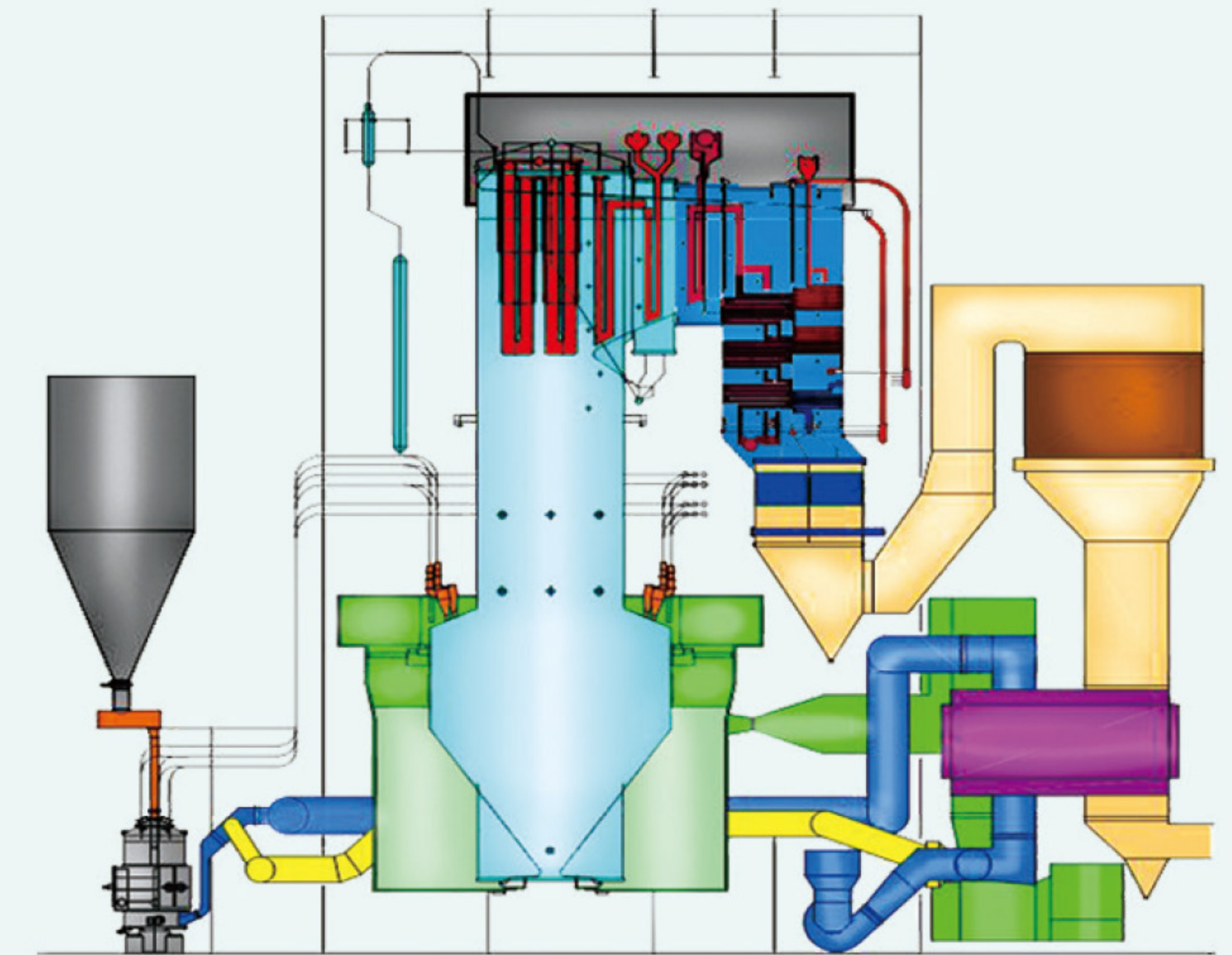


- ▶ Double cyclone burners creates a "W" flame shape for high carbon burnout of low volatile fuels
- ▶ Burner vent-to-overfire air system aids ignition and minimizes NOx formation
- ▶ Selective refractory covering in lower furnace enhances ignition and promotes complete combustion
- ▶ Self compensating "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

# Once-through vertical tube units for supercritical steam conditions

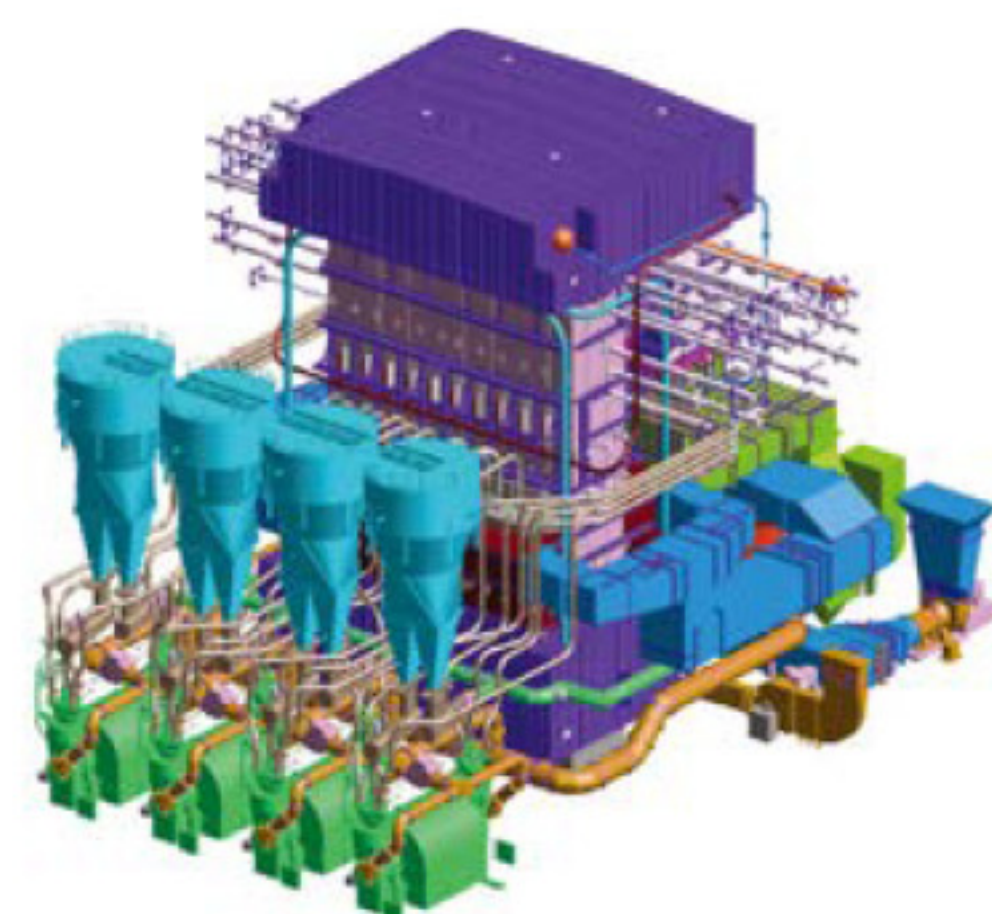
Arch-Fired Once-Through  
Supercritical Steam Generator



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



**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

## 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 arch-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.

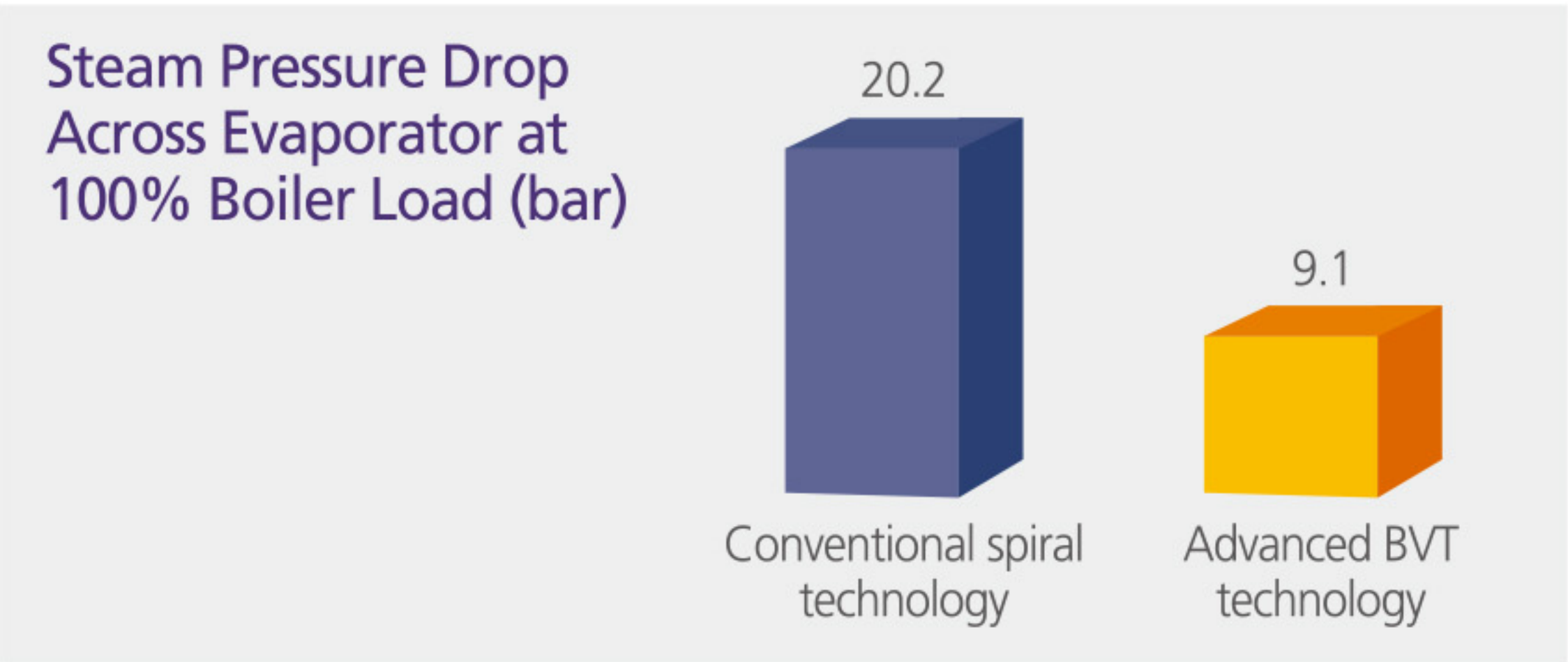
Location : Heshan City, Guangxi Province, China  
Customer : Datang Guiguan Heshan Power Gen Co, Ltd.  
Start-Up Year : 2012  
Capacity : 2 x 670 MWe  
Fuel : Anthracite Coal



# Not all supercritical technologies are the same

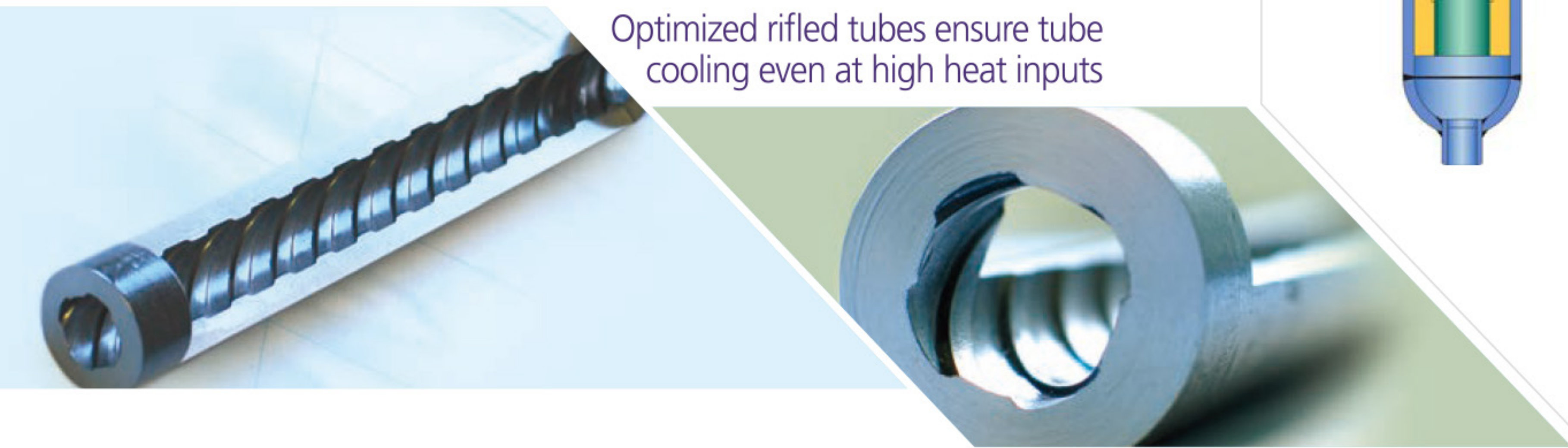
BHI-FW's BENSON Vertical Tube (BVT) supercritical steam technology has significant advantages over conventional spiral technology. Since the evaporator tubes are vertical along the entire furnace height, the furnace walls are easier to fabricate, erect and repair.

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.



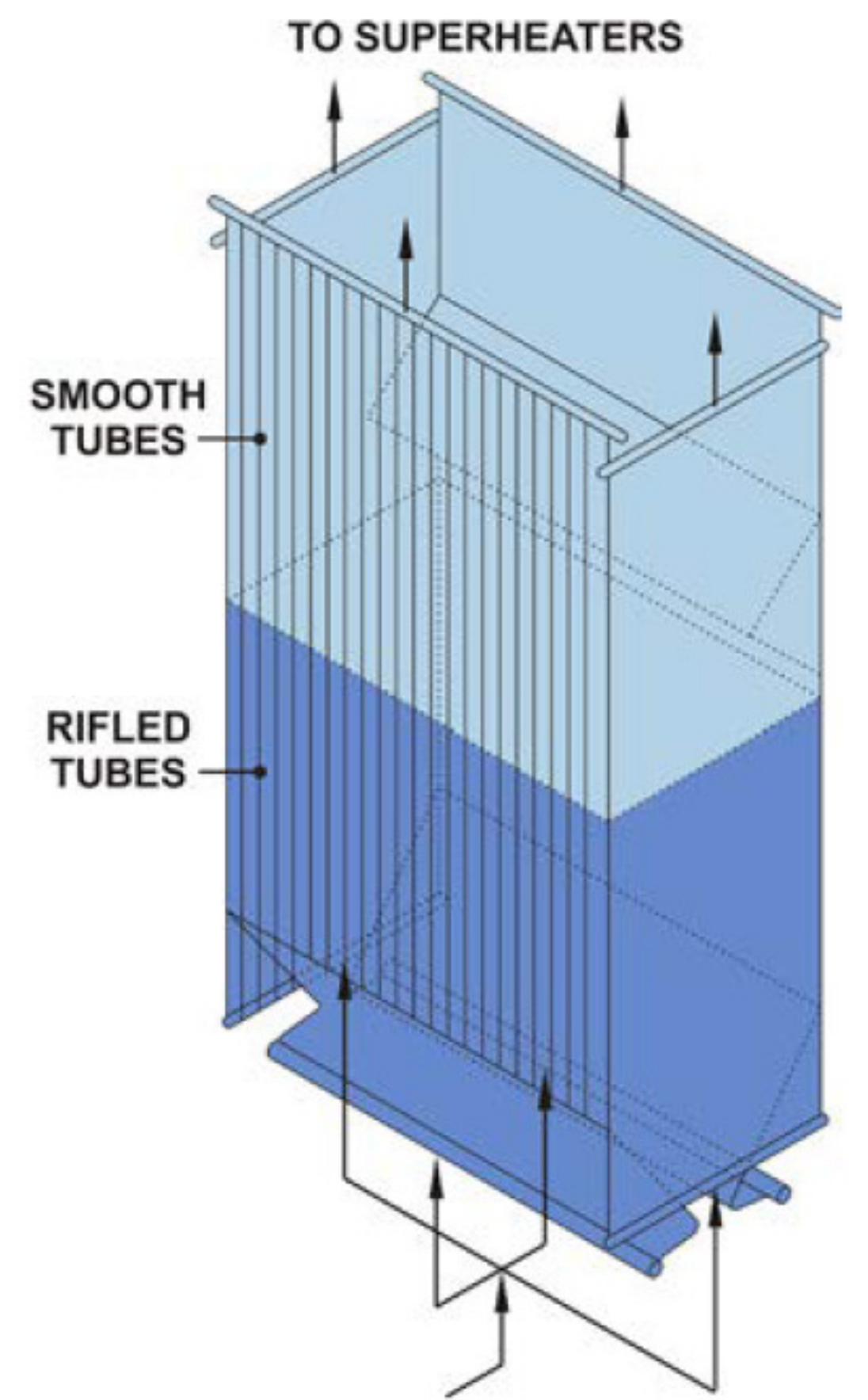
To further reduce maintenance and improve plant reliability, evaporator tubes which receive high heat are rifled resulting in a spiral ridge along the inside length of the tube. After years of research, the ridge geometry has been perfected so that a film of liquid water will coat the tube wall to provide 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.



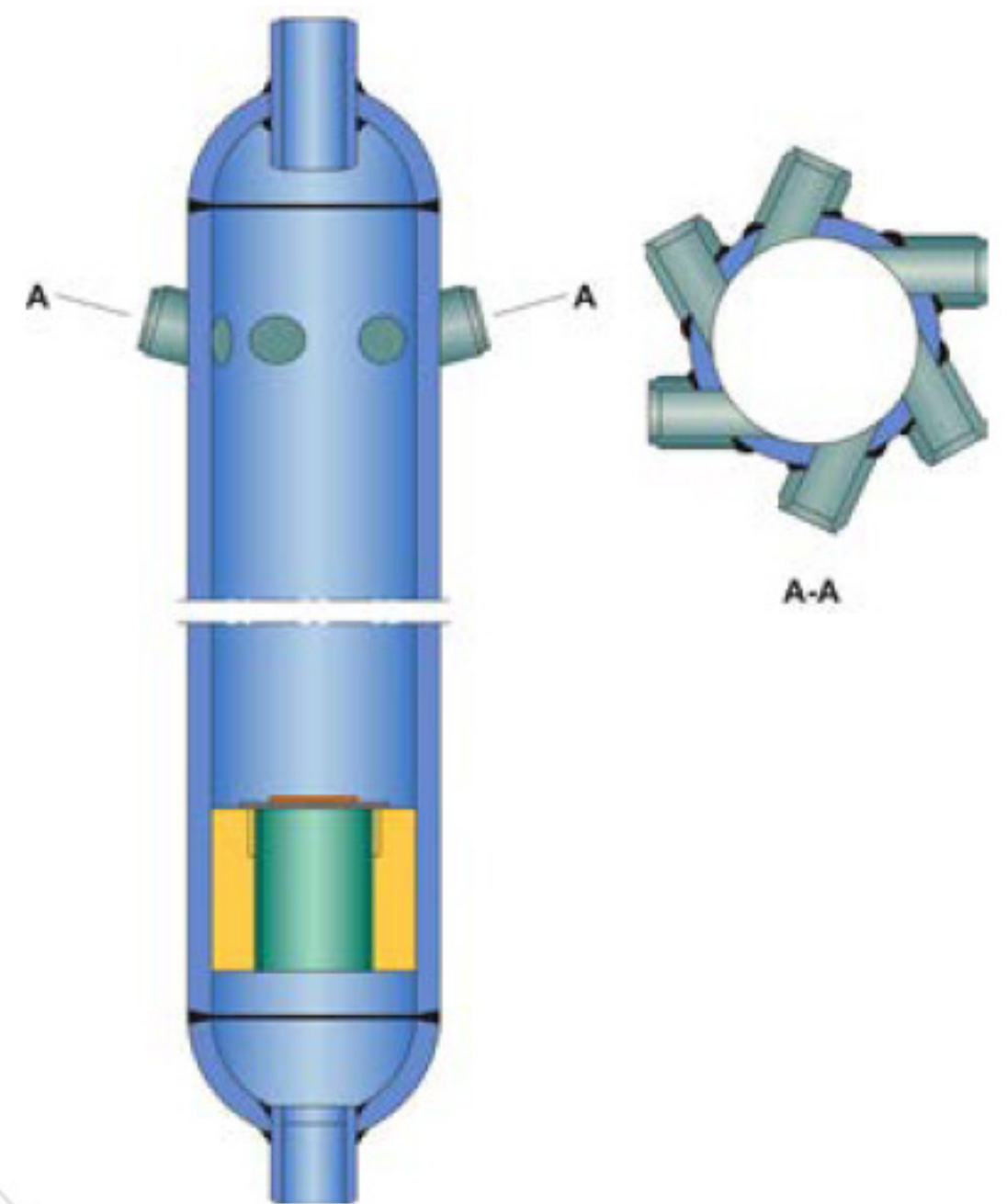
Optimized rifled tubes ensure tube cooling even at high heat inputs

## BHI-FW's advanced BVT steam generator technology

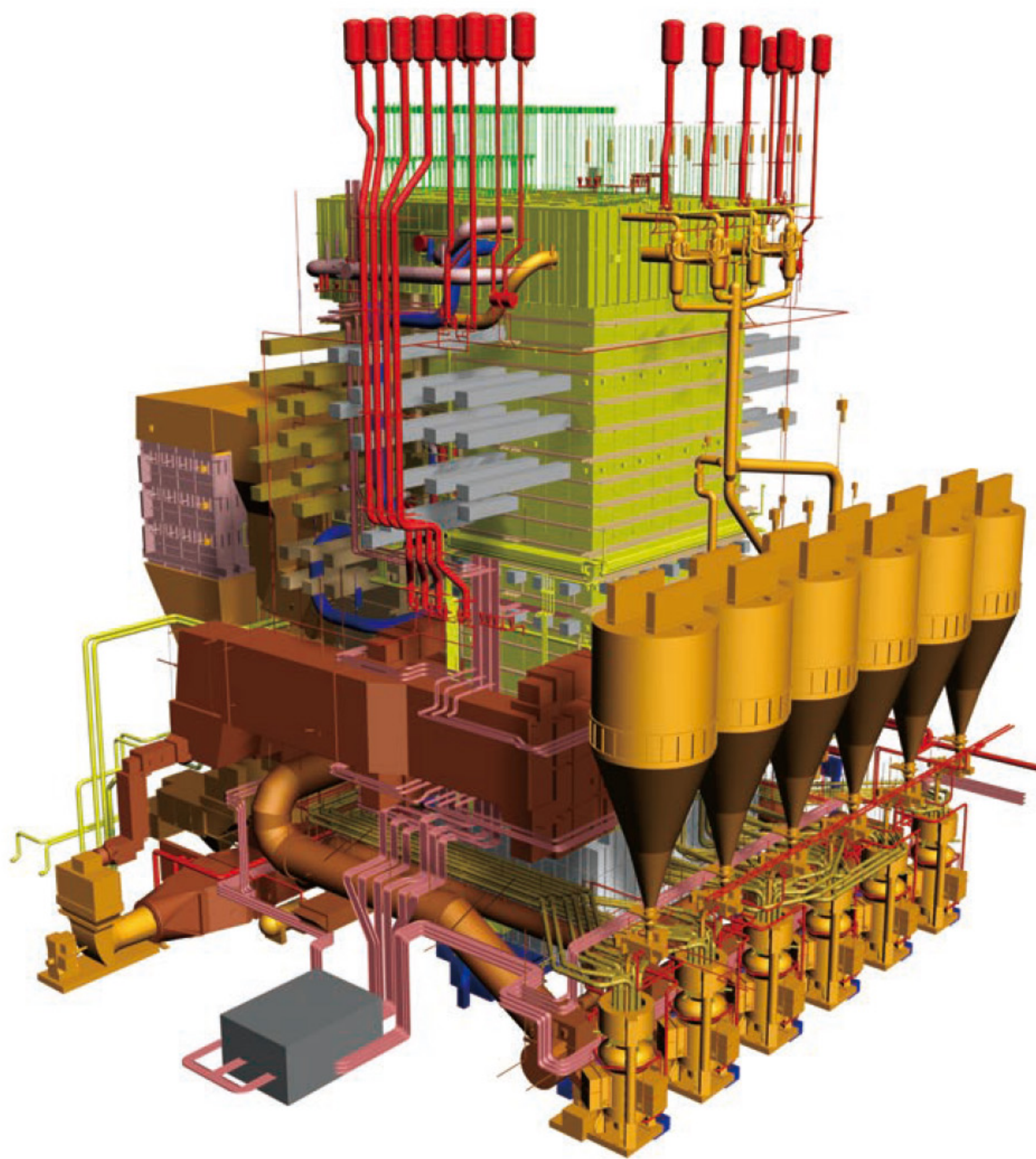


- ▶ Small tubes for self cooling effect
- ▶ Simple support system
- ▶ Low pressure drop
- ▶ Easy to maintain
- ▶ Lower cost to build
- ▶ Eliminates slag ledge used in conventional spiral designs

## Inline tangential steamwater separator



# The Longview Power project Advancing utility PC technology



## Going supercritical

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:

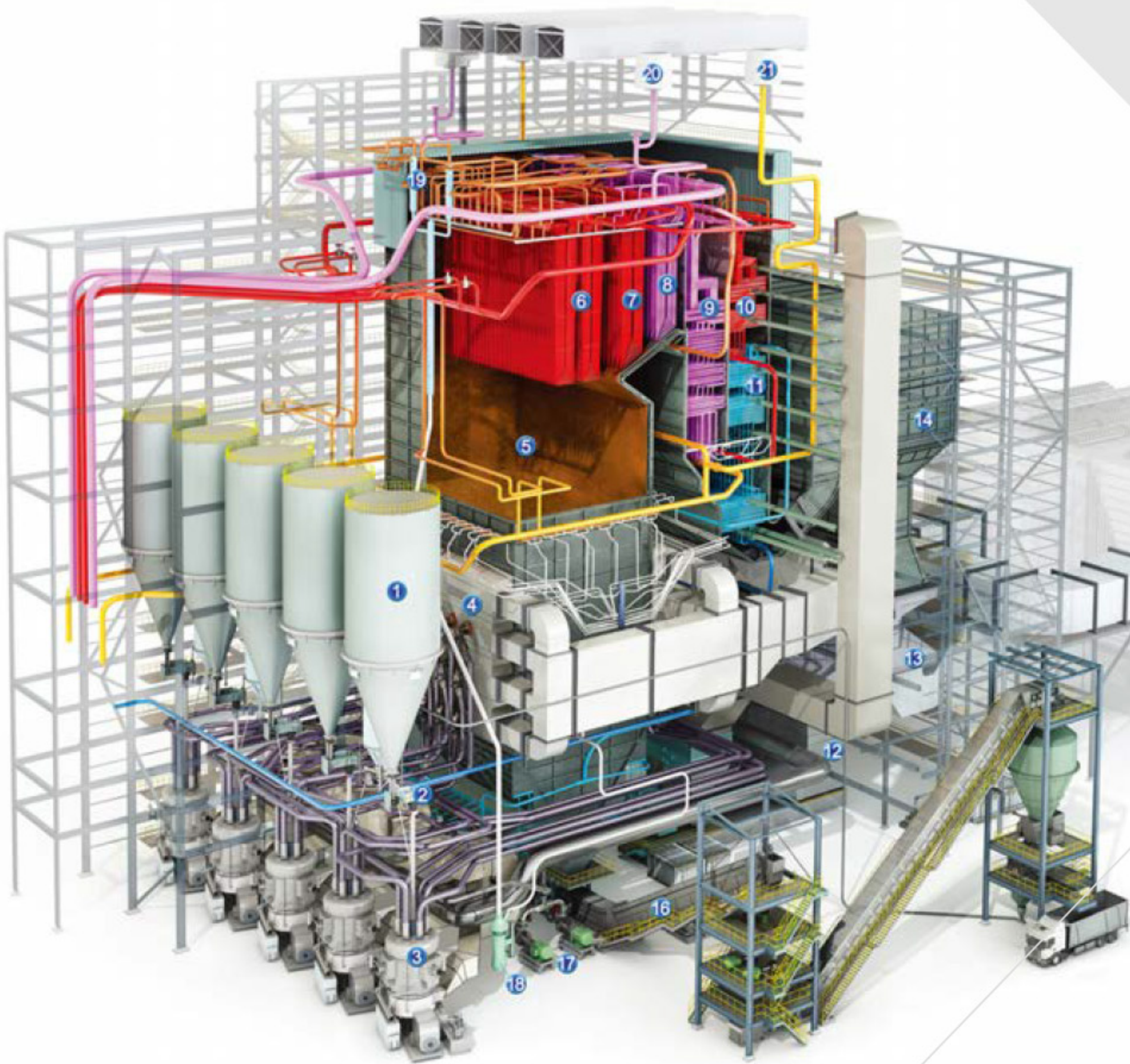
- ▶ Simple vertical tube furnace design, which is easier to fabricate, build and repair
- ▶ Built-in self cooling characteristic for high reliability and maximum furnace life
- ▶ Generous furnace volumes for complete combustion of the fuel
- ▶ MBF and ball mill pulverizers for the widest solid fuel range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

**Project summary**  
Location : Maidsville, 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

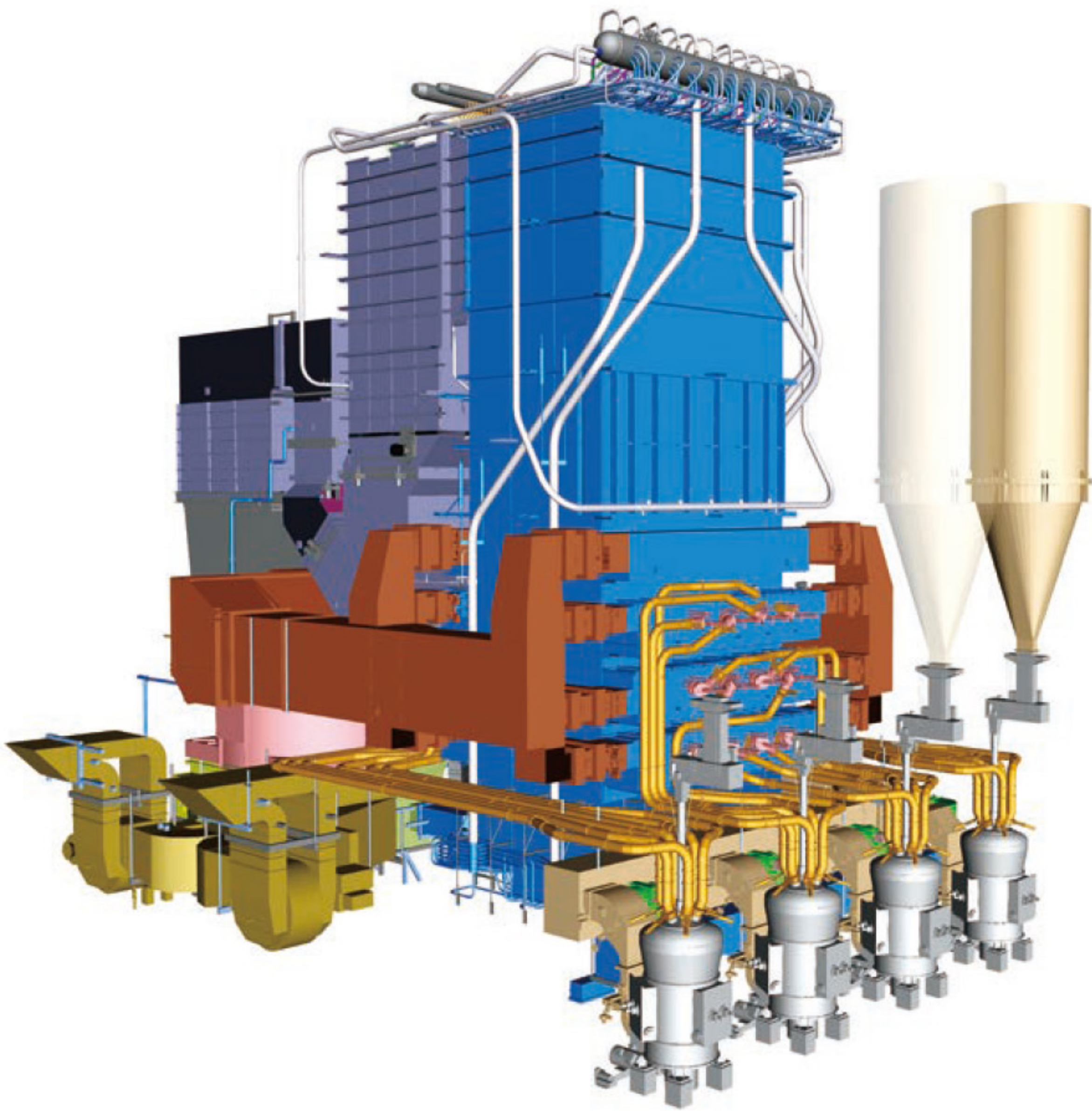
We have taken pulverized coal (PC) technology to new heights with these Buk-Pyeong units. They are the first PCs in the world to combine ultra-supercritical steam conditions with BENSON vertical-tube, low-mass-flux, once-through technology to achieve high efficiency. The plant's high efficiency significantly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

### RECENT PROJECTS



**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

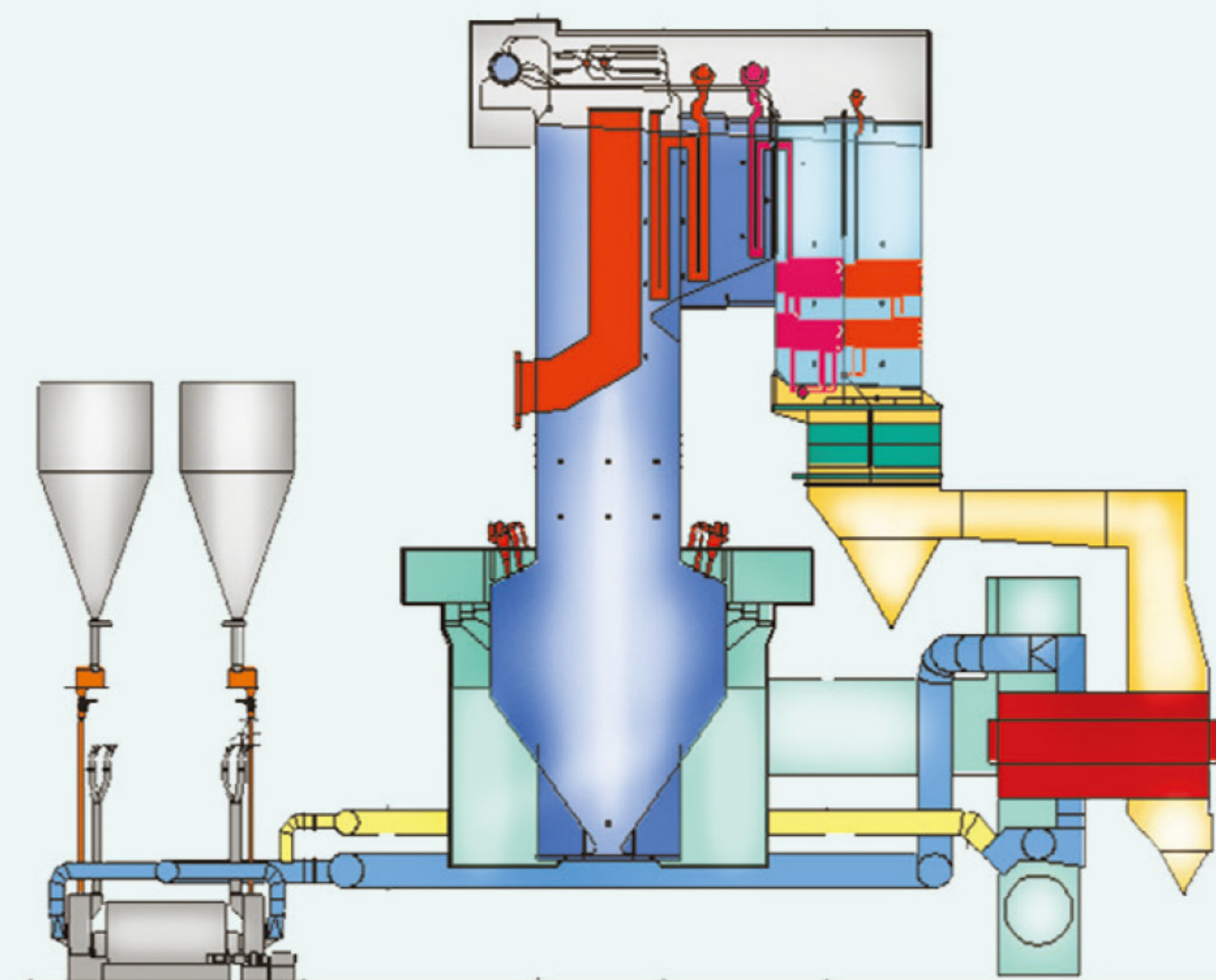


**Quezon Power Plant**  
Location : Quezon, Philippines  
Customer : Quezon Power Limited Co.  
Start-Up Year : 2000  
Capacity : 1 x 486 MWe  
Fuel : Coal, Oil



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

Natural circulation units for subcritical steam conditions



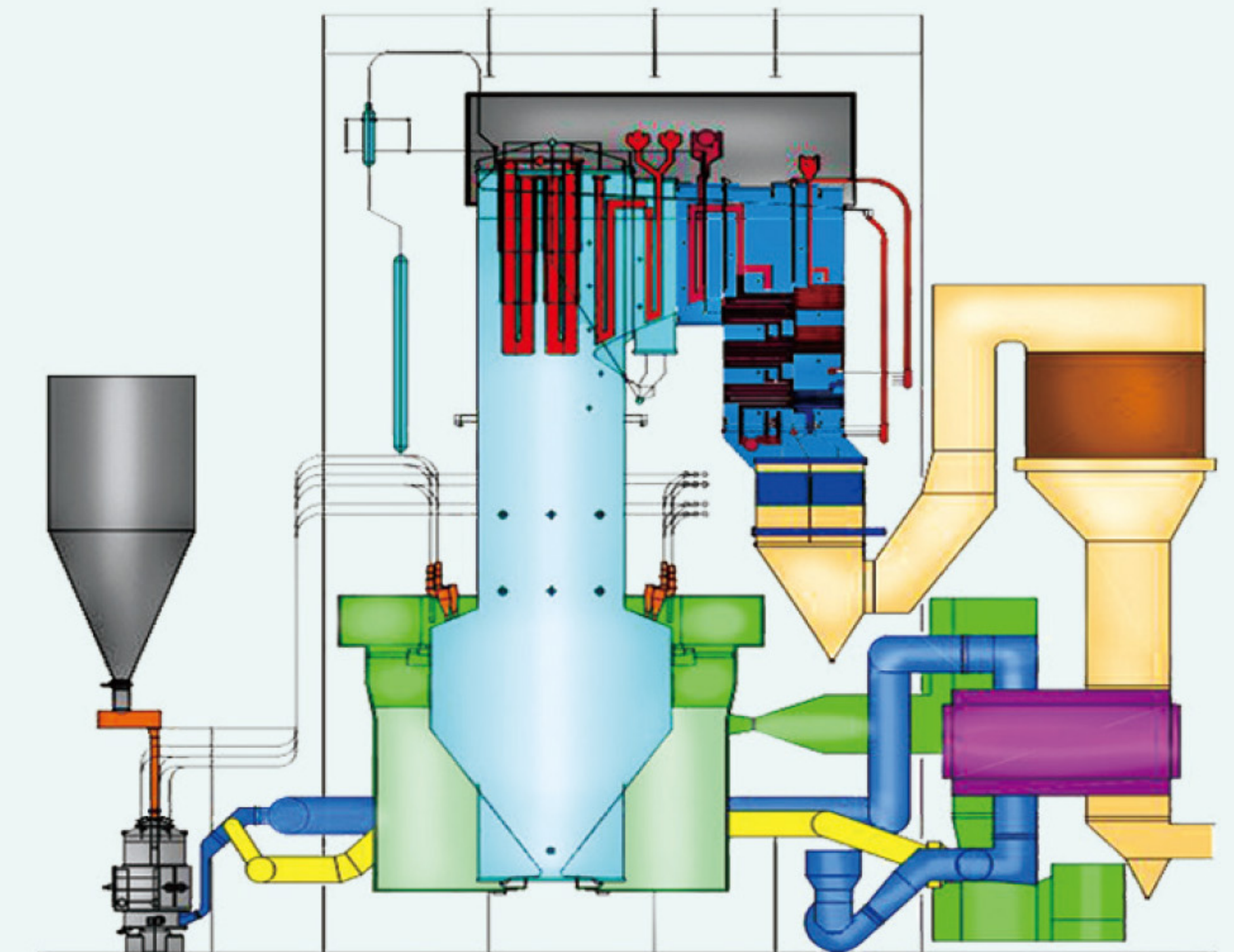
- ▶ Double cyclone burners creates a "W" flame shape for high carbon burnout of low volatile fuels
- ▶ Burner vent-to-overfire air system aids ignition and minimizes NOx formation
- ▶ Selective refractory covering in lower furnace enhances ignition and promotes complete combustion
- ▶ Self compensating "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

# Once-through vertical tube units for supercritical steam conditions

Arch-Fired Once-Through Supercritical Steam Generator

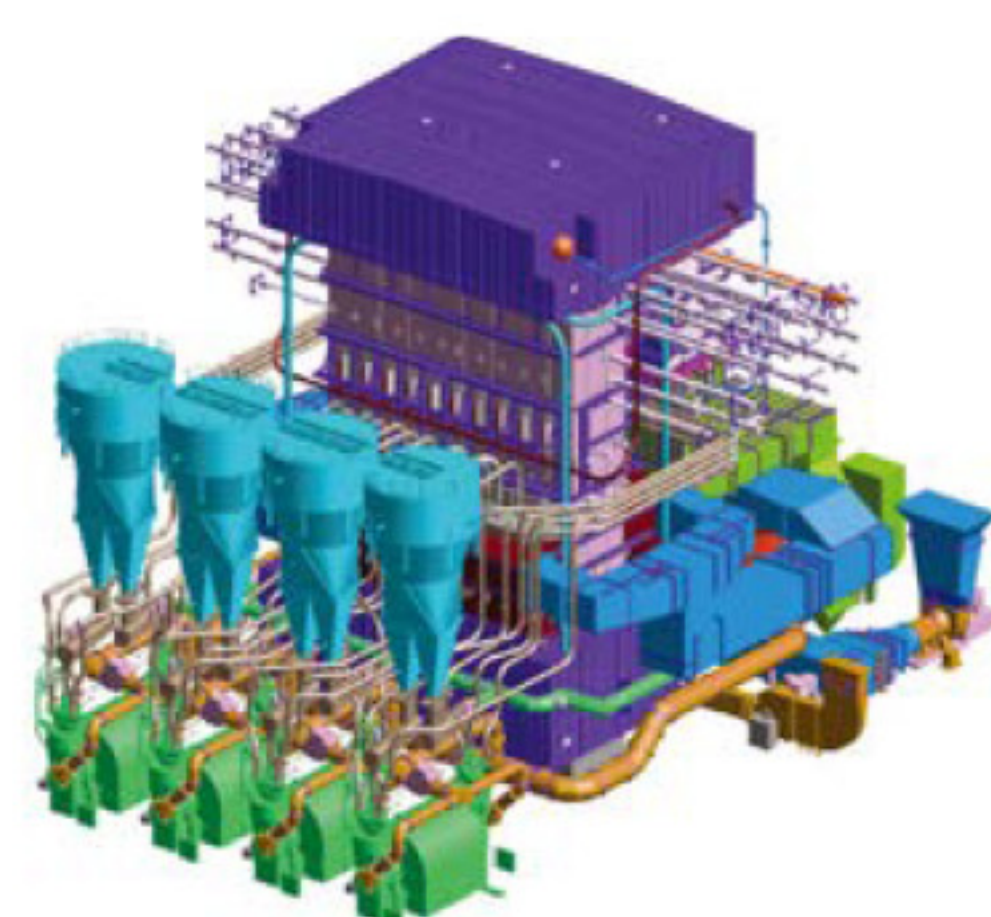
Provides all of the beneficial design features of our natural circulation units plus more

- ▶ 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



Arch-fired Subcritical Natural Circulation Steam Generator

## RECENT PROJECTS



**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

## 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 arch-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