Advancing CFB technology

The power of sustainable energy solutions
Korean Southern Power Company's Green Power Plant in Samcheok, South Korea features four Sumitomo SHI FW advanced 550 MWe ultra supercritical CFBs
We have steadily increased unit size and integrated advanced field-proven design features into our CFB technology. Our CFBs first reached small-scale utility application in 1987 on the 110 MWe Tri-State Nucla power project in the U.S., then went on to the medium utility scale in 2001 with the 2 x 300 MWe units for the Jacksonville Energy Authority. Over the 1998-2004 period we delivered six CFB units totaling nearly 1500 MWe for the largest CFB repowering project ever in history—the Turów project in Poland.

Our success has come from a track record of satisfying clients’ reliability, environmental, and efficiency goals with innovative technology for converting economical solid fuels into valuable steam and power. Through our experience of supplying over 625 fluidized bed units to industrial and utility customers worldwide, we have steadily scaled-up and improved our technology. Over 475 of these fluidized bed steam generators have been CFB designs.

Our latest pioneering can be seen in Korean Southern Power Company’s (KOSPO) selection of our most advanced supercritical CFBs to power its Green Power Project in Samcheok, Korea. Phase I of this impressive greenfield power facility features four 550 MWe ultra supercritical CFBs at its center.
Think green

Low emissions are a key benefit of our CFB technology allowing them to meet the strictest environmental standards. Our CFBs stage the combustion process and operate at low combustion temperatures while giving the fuel long burning times, resulting in naturally low nitrogen oxide (NOx) formation and high combustion efficiency. They can also capture the fuel’s sulfur as the fuel burns by using low-cost limestone and employing selective-non-catalytic-reduction (SNCR) to achieve very low NOx and sulfur oxide (SOx) emissions in the most economical way, and in most cases, avoiding add-on pollution control equipment.

The CFB advantage is particularly highlighted in repowering projects. SOx and particulate emissions can often be cut by over 90% and NOx emissions by over 50%. Carbon dioxide emissions are often cut by 25% or more due to the dramatic improvement in boiler and plant efficiency when older equipment is replaced. For the lowest emissions, our supercritical, once-through-unit (OTU) CFB technology can reduce all these emissions another 5-10%, due to its ability to further increase overall plant efficiency.

For climate change concerns, we offer Flexi-Burn® carbon capture technology for our utility CFBs. Flexi-Burn® allows the CFB to operate in either an economical air fired mode, as all plants do today, or in a carbon capture mode without requiring significant plant modifications. In the carbon capture mode, the CFB produces a carbon dioxide rich flue gas that can be stored underground. The technology will give power producers the flexibility to operate in either mode depending on regulation and market conditions.
Fuel flexibility
Our CFB units are capable of firing nearly all solid fuels—including waste products that otherwise would have been land-filled—while maintaining the lowest levels of emissions, and the highest equipment reliability and efficiency. Our fuel experience is unmatched as proven by our capability to design units for even the lowest-quality fuels. Our CFBs give plant owners the flexibility to source fuel from the widest base of suppliers and industries, improving their fuel supply security while taking advantage of fuels pricing and market conditions.

![Fuel Types Chart]

 OUR CFB FUEL EXPERIENCE
% of operating SHI FW CFB capacity by primary fuel type

- Coals: 28%
- Others: 61%
- Lignite: 1%
- Biomass: 7%
- Petcoke: 1%

Reliability
Our simple yet advanced CFB designs can achieve the highest plant availability, proven by over 30 million hours of operational experience, even after years of operation. Preventative conditions monitoring, expert maintenance, and rapid-response repair work—all supplied by our service teams—help ensure maximum reliability—year after year.

AVERAGE ANNUAL PLANT AVAILABILITY*
% of 8760 hours

- Plants with Sumitomo SHI FW CFB boilers
  - NERC - All boilers
  - NVGB - All boilers
  - WEC - All boilers

*Note: Availability means total time plant is available to run accounting for both planned and unplanned downtime. Sumitomo SHI FW CFB values based on client supplied data reported over 2000-2008 period for units mainly located in Europe. PC values based on client supplied data over 2002-2011 period for units mainly located in Europe and reported in VGB PowerTech Report, TW103Ve, published in 2012.
The Lagisza Power Plant in Poland features a 460 MWe Sumitomo SHI FW vertical tube supercritical CFB—state-of-the-art CFB technology successfully operating since 2009.
Utility CFBs

What started off as a solution for hard-to-burn fuels has become a mainstream boiler technology for utility power generation.

Going supercritical
We have taken the next major step forward in advancing our CFB technology by offering our latest generation of supercritical once-through steam generation technology, which incorporates Siemens’ BENSON vertical-tube evaporator technology for units above 300 MWe. This allows us to offer our utility clients all of the benefits of CFB combustion technology, together with the high efficiency of supercritical steam technology.

Supercritical technology improves overall plant efficiency by 5-10% compared to conventional natural circulation steam technology, which translates directly into a 5-10% reduction in the plant’s air and ash emissions as well as its fuel and water needs for each megawatt generated. When we say a reduction in air emissions, we mean all air emissions like SOx, NOx, mercury and particulates as well as greenhouse gases, like carbon dioxide.

As with our conventional natural circulation CFBs, these highly efficient supercritical units will be equally at home with hard-to-burn fuels, as well as common utility coals. We have developed a modular design approach allowing us to offer units up to 800 MWe in steam capacity.

CFB value for utilities
Our utility customers have turned to CFBs due to the value they see in our technology: fuel flexibility, low emissions, and reliability. Many are seeing value in petroleum coke, lignite, waste coal and biomass from both an economic and environmental aspect. Our technology can reliably and cleanly burn these fuels as primary fuels or in combination with other fuels over the life of the plant, giving power generators the flexibility to alter their fuel strategies and to take advantage of fuel market opportunities and changes in environmental regulation.

Our Utility CFB Fuel Experience

<table>
<thead>
<tr>
<th>Primary Fuel Type</th>
<th>% of Operating SHI FW CFB Capacity</th>
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</thead>
<tbody>
<tr>
<td>Coals</td>
<td>1%</td>
</tr>
<tr>
<td>Oil shale</td>
<td>4%</td>
</tr>
<tr>
<td>Lignite</td>
<td>10%</td>
</tr>
<tr>
<td>Biomass</td>
<td>5%</td>
</tr>
<tr>
<td>Petcoke</td>
<td>5%</td>
</tr>
<tr>
<td>Peat</td>
<td>1%</td>
</tr>
<tr>
<td>Waste</td>
<td>74%</td>
</tr>
</tbody>
</table>

Recent Utility CFB Projects

Soma Kolin Thermal Power Plant
Location: Soma, Turkey
Customer: Harbin Electric International Co. Ltd.
Start-Up Year: 2018
Capacity: 2 x 255 MWe
Fuel: Lignite

Samcheok Green Power Plant
Location: Samcheok City, Gang Won Do, Korea
Customer: Korean Southern Power Co., Ltd
Start-Up Year: 2017
Capacity: 4 x 550 MWe
Fuel: Coal, Biomass

Mao Khe Thermal Power Plant
Location: Quang Ninh Province, Vietnam
Customer: Wuhan Kaidi Electric Power Co.
Start-Up Year: 2012
Capacity: 2 x 220 MWe
Fuel: Anthracite Coal
A leader in industrial CFBs

Our industrial Circulating Fluidized Bed (CFB) steam generators are well known in the industry for their low emissions, reliability and long life

Our history of developing innovative combustion technologies for industry began with our bubbling fluidized (BFB) steam generators, from which we developed our robust CFB technology for a diverse range of industrial fuels and energy needs. We are now a leading supplier of industrial CFB technology, supplying over 175 units with sizes approaching 200 MWe for industrial applications.

**Proven experience**
The solutions we have provided have been as diverse as our clients’ needs. The CFB we supplied to a Swedish paper mill to convert their waste bark and sludge into useful steam needed by the mill, as well as the 26 petcoke-fired steam generators we delivered to Sinopec in China, demonstrate our ability to customize units to meet clients’ needs. Our industrial boiler designs have been proven and advanced based on 40 years of operating experience.

**Widest fuel experience**
Multi-fuel firing is particularly important in industrial applications where utilizing on-site waste has a high value. Fuel flexibility is a key factor in unlocking the value of these waste streams since both their quality and volumes can vary on a daily basis. Our CFB technology has proven itself over the widest range of industrial fuels.

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**OUR INDUSTRIAL CFB FUEL EXPERIENCE**

<table>
<thead>
<tr>
<th>% of operating SHI FW CFB capacity by primary fuel type</th>
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<tbody>
<tr>
<td>Coals</td>
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<tr>
<td>Petcoke</td>
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<tr>
<td>Waste</td>
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Highly reliable
Industry relies on high availability: day in, day out, year round. Our CFBs have a proven track record of being highly reliable.

Our CFBs have excellent load-following capabilities, enabling them to accommodate rapid swings in process steam requirements. Their wide turn-down range means that our units can adapt to temporary or seasonal changes in steam or district heat needs, operating at very low loads of nameplate capacity.

To achieve the highest reliability, we offer SmartBoiler™ to all CFB plant owners and operators. SmartBoiler™ is an intelligent operation and service support tool for monitoring, diagnosing, analyzing and optimizing steam generation and power plant operation. SmartBoiler™combines our experience and expertise in fluidized bed combustion with advanced information technology.

RECENT INDUSTRIAL CFB PROJECTS

Seagull Cogeneration Power Plant
Location: Gunsan City, South Korea
Customer: eTEC E&C Limited
Start-Up Year: 2016
Capacity: 250 MWe
Fuel: Indonesian Coal

Yuen Foong Yu Paper
Location: Yangzhou Jiangsu Province
Start-Up Year: 2013
Capacity: 50 MWe
Fuel: Coal & Paper Sludge

Rio Turbio
Location: Santa Cruz, Argentina
Customer: Isolux Ingenieria S.A. y Tecna Proyectos y Operaciones, S.A. (UTE)
Start-Up Year: 2012
Capacity: 2 x 120 MWe
Fuel: Bituminous Coal
Renewable energy CFBs

Biofuels and waste are two of the fuel groups ideally suited for our CFB technology.

A green technology
Concern about climate change is a key factor for developing and implementing renewable energy solutions today.

Use of biomass in power generation can contribute significantly to reducing emissions of carbon dioxide—a greenhouse gas. The fuel flexibility of our CFB technology allows them to utilize a wide range of renewable and waste fuels and fuel mixes, helping our world reach a goal of reduced greenhouse gas emissions.

Our CFBs can also divert waste headed for land-fills and instead convert this waste into valuable steam and electricity to support our growing energy needs.

Our state-of-the-art "Advanced Bio CFB" can co-fire high alkaline, quick-growing agro biomass in utility CFBs.

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**OUR RENEWABLE CFB FUEL EXPERIENCE**

% of operating SHI FW CFB capacity by primary fuel type

- Forestry and pulp and papermaking waste: 79%
- Wood processing waste: 11%
- Industrial waste and municipal refuse-derived fuel: 6%
- Agricultural waste: 4%

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9 Circulating Fluidized Bed Technology
Becoming more green
Co-firing renewable fuels in a CFB plant originally designed for coal is an excellent, cost-effective option for helping our environment. In most cases, our operating coal-fired CFBs can co-fire biomass or waste fuels by simply adding a biomass fuel handling and feeding system, and modifying boiler operating procedures.

Green fuels
Biofuels include natural materials and waste produced by various industrial or other processes.

- Forestry operations
  - thinnings
  - harvesting waste
  - bark
  - stumps
- Wood processing waste
  - offcuts
  - sawdust
  - demolition wood
- Pulp & papermaking waste
- Fast-growing energy crops
- Agricultural waste
- Industrial waste
- Municipal Refuse-Derived Fuel (RDF)

Avoided CO2 Emissions*

*(Ktonnes/yr)*

<table>
<thead>
<tr>
<th>% Biomass Fired</th>
<th>100%</th>
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<tbody>
<tr>
<td>25%</td>
<td>218</td>
</tr>
<tr>
<td>10%</td>
<td>87</td>
</tr>
</tbody>
</table>

*Based on a 150 MWe coal plant with balance fuel being biomass

RECENT RENEWABLE CFB PROJECTS

- **Polaniec Power Station**
  - Location: Polaniec, Poland
  - Customer: GDF Suez Energia
  - Start-Up Year: 2012
  - Capacity: 190 MWe
  - Fuel: Biomass (Wood/20% Agro Waste)

- **Green Energy Centre**
  - Location: Daegu, South Korea
  - Customer: GS Engineering and Construction
  - Start-Up Year: 2016
  - Capacity: 23 MWe
  - Fuel: Waste - RDF

- **Dangjin 4 Biomass Power Plant**
  - Location: Dangjin, South Korea
  - Customer: GS Engineering and Construction
  - Start-Up Year: 2015
  - Capacity: 105 MWe
  - Fuel: Biomass
We are the premier global supplier of innovative circulating fluidized bed (CFB) technologies, providing sustainable value to our customers through our relentless drive for environmentally sound and reliable power solutions while we grow.