*Foster Wheeler has been contracted to supply the world's first supercritical CFB boiler. The 460 MWe unit for Poland's PKE will also be the largest CFB of any type to be supplied to date.*

## The world's first supercritical CFB

Drawing on the work carried out under the umbrella of the HIPE project, Foster Wheeler has now taken the next major step forward in the development of fluidized bed combustion – and launched supercritical once-through CFB technology at full utility size, in the 500 MWe range and above.

This combines all the benefits of Foster Wheeler's second-generation CFB product line with the latest generation of Siemens' BENSON Vertical Low Mass Flux Once Through technology, offering world-leading levels of overall operating and fuel efficiency, together with very low emissions, without either flue gas desulfurization (FGD) or selective catalytic reduction (SCR) systems.

The first plant to employ this technology, a 460 MWe unit contracted by Poludniwy Koncern Energetyczny (PKE) in Poland, will use some 5% less fuel for every GWh of electricity that it generates than a conventional drum-based CFB design. Typical of Foster Wheeler's subcritical CFB designs, the plant will be equally at home with lower-grade coal slurry as with normal bituminous coal.

A modular approach has been adopted to enable even larger sizes to be offered in the future, together with higher steam parameters, while still using conventional materials.

Overall, supercritical CFB technology offers a valuable edge in terms of total capital costs, plant performance, and flexibility compared, for example, to supercritical PC technology. The ability of high-efficiency, supercritical CFB to use low-quality, low-priced fuels, including renewables, opens up a number of opportunities for reducing $CO_2$ emissions.

Efficiencies in the 43-45% range can increase power generation efficiency by 10-15% compared to subcritical CFB technology, and reduce $CO_2$ emissions by 15% to 20% compared to conventional solutions.

*Customer: PKE/Lagisza, Poland*

| | |
|---|---|
| Contract award | February 2003, notice to proceed projected for 3Q, 2004 |
| Configuration | 460 MWe supercritical boiler island |
| Fuel | Coal; coal slurry, biomass (options) |
| Total heat output | 966 MWth |
| Steam flow | 370/307 kg/s |
| Steam pressure | 27.5/5.5 MPa |
| Steam temperature | 565/580 °C |
| Feedwater temperature | 290 °C |

Employing over 200 engineers and technicians, EPK has extensive experience in designing power plants and CHP facilities, with references totaling over 11,000 MW of installed capacity in Poland, central and southern Europe, and the Middle East. EPK works closely with a number of scientific institutes, equipment suppliers, and other consultant engineers.

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Foster Wheeler Power Group Europe is a specialist in turnkey power projects, advanced boiler technology, and associated service. Fluidized bed boilers – and circulating fluidized bed (CFB) boilers in particular – lie at the heart of the company's know-how and product offering. With more than 215 CFB deliveries worldwide, Foster Wheeler is the market leader in the field.

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As one of the world's premier vendors in the power sector, Siemens Power Generation supplies products, plants, and services for generating power and district heat, as well as drives and compressor systems. By leveraging its experience and knowledge, Siemens delivers proven technology and services to meet a range of customer needs.

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VTT Processes is one of the six research institutes within VTT Technical Research Centre of Finland, the largest center of its type in the Nordic countries. VTT Processes focuses on research, development, and demonstration services for the energy and forest products sectors, and acts as a technology partner for industry and a consultancy resource for public sector decision-makers.

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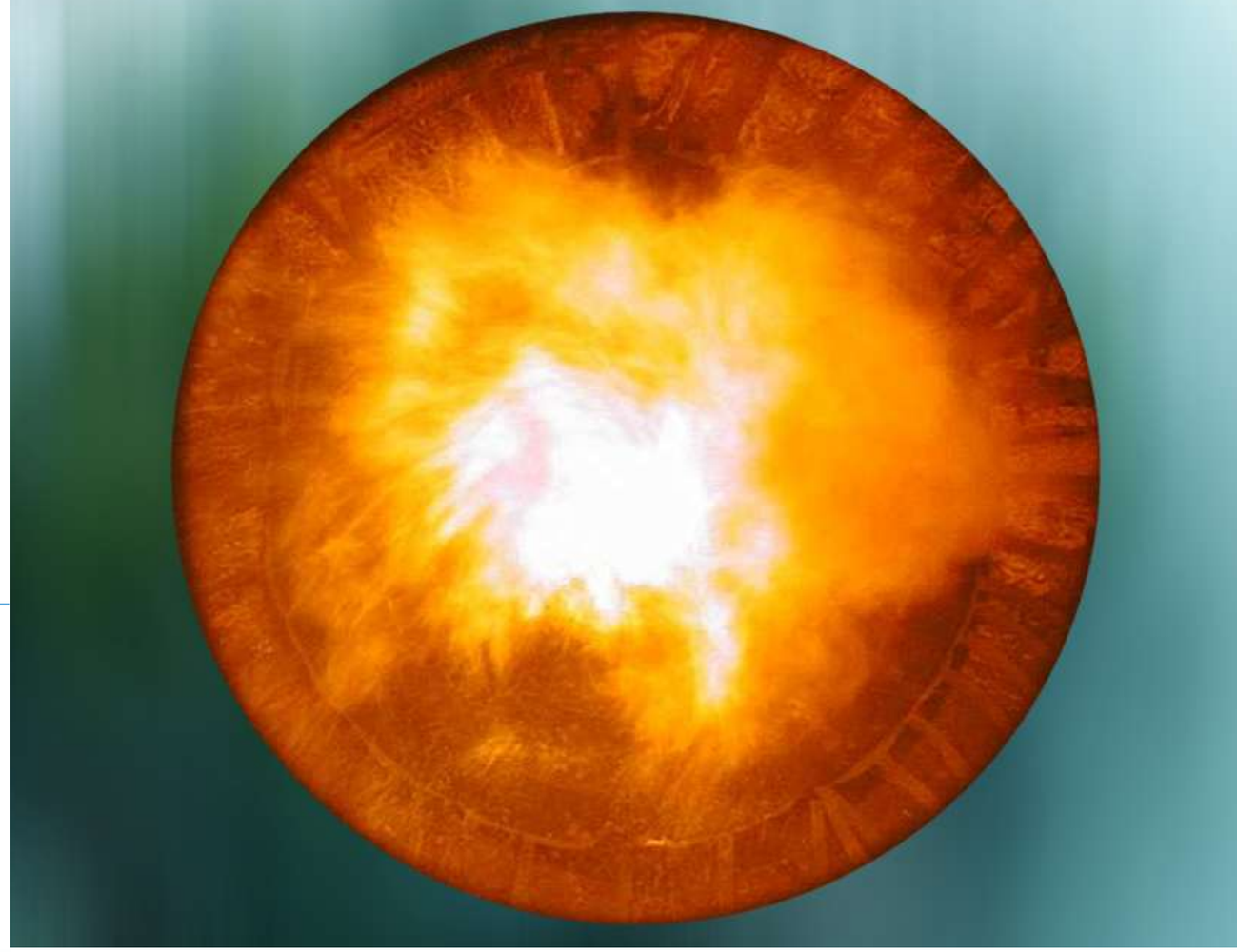
# Supercritical CFB
# A New Generation of Technology

## HIPE
## High Performance Multifuel CFB with Advanced Steam Cycle

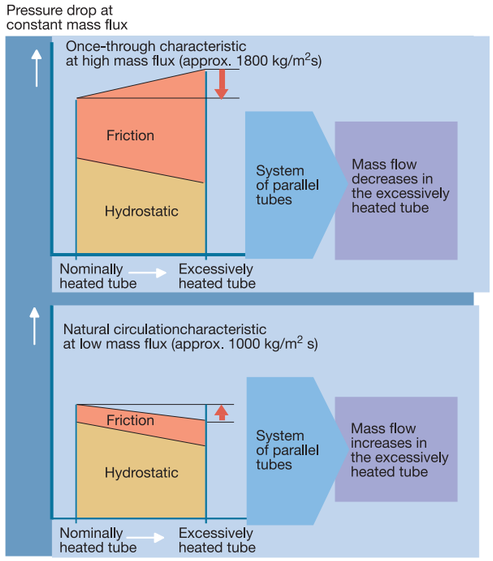


## Pushing forward the CFB frontier

*Circulating fluidized bed (CFB) technology has come a long way over the last 20 years. What started off as a solution mainly for hard-to-burn fuels, particularly in the forest products industry, has become a mainstream combustion technology available in ever-larger boiler sizes.*

*The benefits of CFB technology – such as its multifuel capability and low-emission performance without the need for secondary systems – have made it an increasingly attractive alternative for many users. The reliance on subcritical steam parameters, however, has limited CFB's potential in true utility-scale applications, with the largest current designs in the order of 300 MWe, and means that efficiencies above 38-40% are not possible.*

*To overcome these limitations, a project consortium consisting of VTT Processes, Foster Wheeler Energia Oy, Siemens Power Generation, and EnergoProjekt Katowice (EPK) was formed in 2000 to develop a breakthrough in utility-scale solid fuel power generation, by combining high-efficiency CFB technology with supercritical steam parameters.*




*Advantages of BENSON boilers with vertically tubed water walls.*

*This saw the creation of the HIPE – High Performance Multifuel CFB with Advanced Steam Cycle project. With the backing of the EU, and coordinated by VTT Processes, the project ran between 2001 and 2004, and led to the launch by Foster Wheeler of the world's first commercial supercritical CFB solution.*

*Foster Wheeler brought its market-leading CFB expertise to the project, Siemens its latest BENSON low mass flux once-through technology, and EPK its knowledge of the needs of utilities and the Polish market in particular – while VTT contributed its research capabilities and extensive experience in coordinating multipartner, multinational research projects.*

## The challenge

Many countries, including both old and new members of the European Union, are heavily dependent on coal for electricity generation. Coal can be expected to play a key role in the future as well. Not only in Europe, but also in countries such as the US, China, and India.

Ageing capacity is a particular problem. Over 60% of capacity in the EU is more than 20 years old, and in some countries even higher. Only 8% of existing plants in the EU have an efficiency of 40% or greater. This will require large numbers of replacement facilities to be built over the next few years.

CFB combustion, and above all supercritical CFB combustion, has a lot to offer in helping ensure that coal can be used more cleanly, efficiently, and more sustainably to meet these challenges and enable generators to benefit from:

- higher efficiency
- improved fuel flexibility, including the ability to fire low-cost, difficult-to-burn coal, coal waste, and other fuels
- better operational flexibility, with wider load swing potential, and
- enhanced cost-effective emissions performance.

The challenge facing the HIPE project was to integrate the once-through sliding pressure steam cycle with large-scale CFB combustion, and address issues related to the design, management, and operational safety of such a boiler. This involved

- understanding new furnace process issues
  - combustion profile
  - fuel and char reactivity
  - material behavior processes
  - boiler dynamics
  - boiler response times
  - fuel/combustion air mixing processes
  - heat transfer
- characterizing boiler dynamics to develop new control algorithms, and
- measuring process parameters for design and dimensioning needs.

## Integrating two technologies

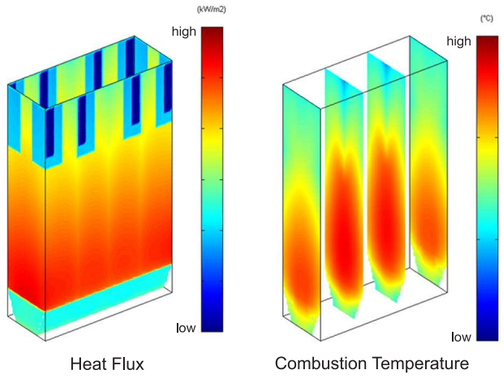
When configuring the evaporative circuit in a once-through boiler, it is important to consider:

- how to minimize peak tube-metal temperatures
- how to minimize the temperature differential between adjacent enclosure tubes, and
- how to control dryout conditions.

The self-regulating behavior of the natural circulating BENSON low mass flux design limits temperature fluctuations caused by imbalances in heat absorption and differences in geometry.

CFB furnace heat fluxes are less than half those of the peak heat fluxes in pulverized coal (PC) furnaces, which means that low mass-flow rates can be used in the furnace tubes without the risk of tube overheating. The flywheel of circulating solids in a CFB furnace also provides relatively uniform heat-absorption rates, which minimize concerns for heat-absorption imbalances.

The less severe environment of a CFB furnace compared to a PC environment also means that smooth water wall tubes are sufficient for heat flux surfaces that are heated on one side. Heat flux surfaces heated on both sides can be fabricated from standard rifled tubes.




*Heat flux and combustion temperature profiles in a 460 MW CFB boiler.*

## A joint effort

The partners in the project focused on:

- developing a viable large-scale CFB boiler, including furnace design, the design and location of superheaters, the design and dimensioning of CFB process components, and material and construction issues
- assessing the effect of increased lateral dimensions on mixing, combustion performance, temperature profiles, and heat transfer
- optimizing the inherent benefits of CFB combustion, such as high combustion efficiency and low emissions, at the larger size envisioned, and
- improving boiler performance analysis capabilities to take account of larger-scale CFB combustion.

VTT Processes coordinated the project, and focused on enhancing the partners' understanding of how fuels and materials behave in CFB systems. Using its CFB pilot-scale test environment, VTT carried out a number of fuel reactivity tests, and developed and verified analysis tools using dynamic and static modeling techniques.

Foster Wheeler drew on its in-house work in the field begun in the early 1990s, which included a dynamic simulator used on earlier supercritical designs, to develop an appropriate boiler configuration, together with the best components, for meeting the requirements of the once through cycle. Developing a capability for analyzing boiler dynamics and controls, including detailed heat transfer and combustion profiles, at larger furnaces sizes and with greater accuracy was a particular priority.

Siemens tested a number of potential furnace configurations under CFB process conditions, evaluated various CFB designs to help identify the best 'fit' for the requirements of BENSON technology, and analyzed furnace dynamics and controls for superheating. Siemens provided the thermohydraulic design of the BENSON furnace used, and the company's BENSON test rig in Germany was employed for heat transfer and pressure drop tests on evaporator tubes.

Leveraging the results generated by the research teams, EPK was responsible for carrying out a series of market and feasibility studies on supercritical CFB technology in Eastern Central European markets where there is a clear opportunity for the technology, particularly Poland.

The outcome of this work by the HIPE partners confirmed that CFB combustion is an ideal match for BENSON technology. It also led to the commercialization of the technology by Foster Wheeler, and the winning of the world's first contract for a supercritical CFB boiler.