Clean Energy Production with Biomass

Proven technologies to utilize biomass as a renewable energy source

B&W BABCOCK & WILCOX

RENEWABLE | ENVIRONMENTAL | THERMAL

Renewable energy has become a beneficial component of a diverse portfolio of energy sources. And one of those sources is biomass.

Babcock & Wilcox (B&W) has been a trusted supplier of biomass combustion equipment for many years. Our extensive list of commercially demonstrated and industry-accepted products are providing reliable steam generation for both process and electric power applications.

While offering a highly available and readily dispatchable renewable energy source, the combustion of biomass also provides environmental benefits such as reduced emissions of nitrogen oxides (NO_X), sulfur oxides (SO_X) and mercury, when compared with other fossil fuels.

Biomass is also a carbon dioxide (CO_2)-neutral renewable energy source. (See lower-right on how we can move from carbon neutral to carbon negative.)

A wide variety of technologies for biomass combustion

B&W has demonstrated experience with a wide range of fuels and technologies for utilizing biomass to produce steam for both process and power generation applications. These include:

- Bubbling fluidized-bed (BFB) boilers
- Circulating fluidized-bed (CFB) boilers
- Stoker-fired boilers
- Black liquor recovery boilers (process recovery)

BFB features and benefits

- Fuel flexibility – wood, bark, tires, sludges, residues
- Open bottom bed for effective debris removal
- Low emissions
- Suitable for new or retrofit applications
- Low maintenance and high availability
- Modular or bottom supported designs reduce cost

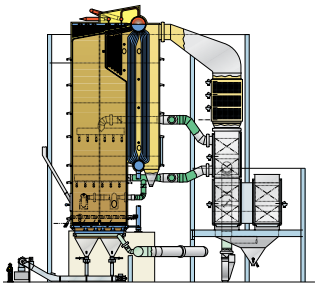
CFB features and benefits

- Ideal for firing with coal, biomass, or a combination of both
- Low maintenance
- High availability
- Compact size and arrangement is ideal for repowering projects
- Low emissions

Bubbling fluidized bed

B&W's BFB technology has been successfully applied to a wide range of wood, wood waste, sludges and residues. Our open-bottom design feature is particularly well suited for biomass fuel applications that contain non-combustible debris. With the capability to tightly control bed temperature, a BFB offers greater combustion efficiency and reduced emissions.

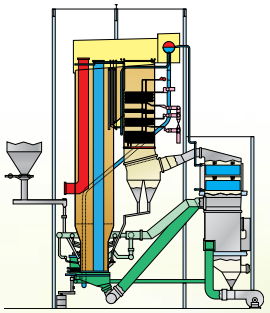
Our ability to successfully retrofit fossil fuel-fired power boilers and convert existing black liquor recovery boilers to fire solid fuel biomass using BFB technology has been repeatedly demonstrated. Our commercial experience with a wide range of unit sizes and fuels makes the BFB boiler a viable option in many situations for efficient and dependable steam generation from biomass.



Bubbling fluidized bed

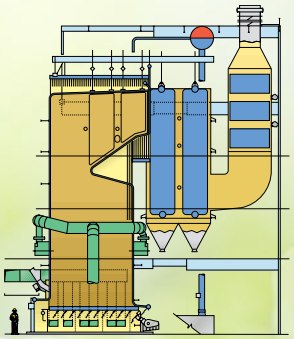
Circulating fluidized bed

B&W's internal recirculation circulating fluidized-bed (IR-CFB) boiler offers economy, reliability and flexibility. One of the main advantages of our CFB technology is that it provides fuel flexibility. It is particularly attractive when co-firing coal with a biomass fuel.



Circulating fluidized bed

The compact arrangement of our CFB design makes it ideal for both repowering and new installations. A unique U-beam particle separator reduces the refractory required and operates at low flue gas velocities which result in significantly lower maintenance than other CFB designs. Additional benefits include operating flexibility and low emissions.



Stoker fired

Stokers

In addition to fluidized beds, vibrating or reciprocating grate stoker-fired units may be the technology of choice in certain applications, particularly for wood, agricultural crops and residues. Our proven Stirling® and Towerpak® boilers are customized to meet specific steam and fuel conditions, but designed within a framework of pre-engineered components to minimize engineering costs and delivery time.

Fuel Technology Matrix

Fuel	Boiler	Environmental Equipment
• Wood/Wood Waste or • Wood/Wood Waste, Sludge, Tires	BFB	• Selective Non-Catalytic Reduction or • Selective Catalytic Reduction
• Coal or • Coal and Wood/Wood Waste, Petroleum Coke, Tires	CFB	• Selective Non-Catalytic Reduction • Dry Flue Gas Desulfurization (in certain applications)
• Wood/Wood Waste • Straw • Stover • Animal Waste • Coal	Stoker	• Selective Non-Catalytic Reduction or • Selective Catalytic Reduction • Wet Flue Gas Desulfurization

New or retrofit

Depending on the application, it may be advantageous to consider installing new steam generating equipment or retrofitting existing equipment with modern combustion technology. B&W combines the engineering know-how and practical experience needed to completely analyze the available options and recommend the most cost-effective course of action.

Emissions control equipment

Today's environmental requirements mean a supplier should not only have the capability to provide the steam generating equipment, but also the environmental equipment necessary to meet mandated air quality standards. B&W's line of environmental products includes technologies for NO_x, SO_2, particulates, and other air emissions:

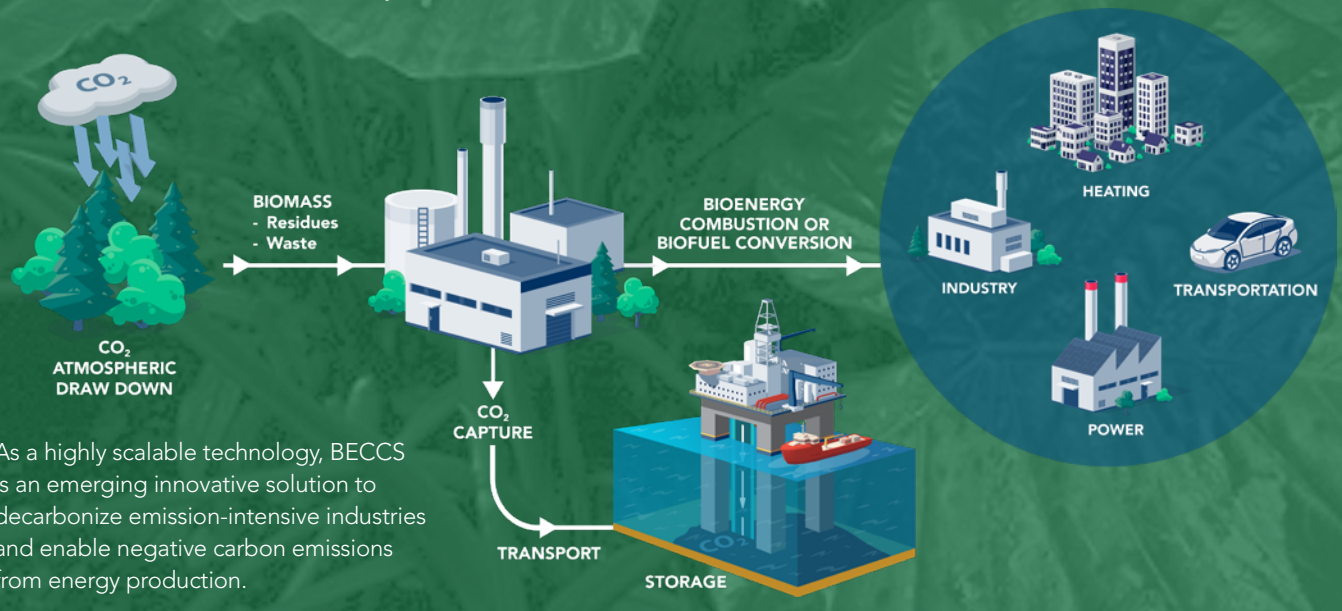
- Selective catalytic reduction (SCR) and non-catalytic reduction (SNCR) systems
- Electrostatic precipitators (ESP)
- Fabric filter baghouses
- Flue gas desulfurization (FGD) systems

Bioenergy with Carbon Capture and Sequestration (BECCS)

By combining traditional bioenergy production with carbon capture and sequestration technologies (known as BECCS), energy can be produced with a **net-negative carbon intensity (CI)** output. Since living matter absorbs atmospheric carbon dioxide (CO_2) during its lifetime, its combustion for energy production results in a neutral or net-zero carbon intensity. By adding technologies which capture and sequester carbon, the process provides a net result of less than zero carbon intensity.

BECCS technology for power and steam – In this application, B&W's biomass-fired BFB boiler technology is combined with our OxyBright™ oxygen combustion technology. Waste biomass is used as the fuel in our BFB boiler. Combustion air is replaced with nearly pure oxygen that results in a flue gas of primarily CO_2 which is suitable for sequestration.

BECCS technology for hydrogen – a unique advantage of B&W's BrightLoop™ chemical looping technology is its ability to use solid fuels, including biomass, to produce outputs such as hydrogen or steam. Our technology is capable of producing a stream of nearly pure hydrogen in addition to a stream of nearly pure CO_2.



As a highly scalable technology, BECCS is an emerging innovative solution to decarbonize emission-intensive industries and enable negative carbon emissions from energy production.

B&W puts it all together

As a single-source supplier, our capabilities extend well beyond steam generating equipment supply. Our core competencies include:

- Engineering
- Project management
- Construction
- Startup and commissioning
- Training programs
- Field engineering services
- Replacement parts
- Condition assessment
- Engineered improvements

From engineering, manufacturing and construction, to startup and field service, B&W knows how to make it all work together for maximum operating efficiency and dependability.

As utilities and industrial firms alike consider future strategies to utilize renewable energy, B&W can provide viable options for the combustion of biomass fuels. We have commercially demonstrated technologies and experience with firing a wide variety of biomass fuels. Contact us today to learn how biomass can be a part of your power and steam generation portfolio.

The Babcock & Wilcox Company
1200 E Market Street, Suite 650
Akron, Ohio, U.S.A. 44305
Phone: +1 330.753.4511

www.babcock.com

BABCOCK & WILCOX

RENEWABLE | ENVIRONMENTAL | THERMAL

Established in 1867, Babcock & Wilcox is a global leader in advanced energy and environmental technologies and services for the power, industrial and renewable markets.

For more information or to contact us, visit our website at www.babcock.com.

E101-3190 500U3E