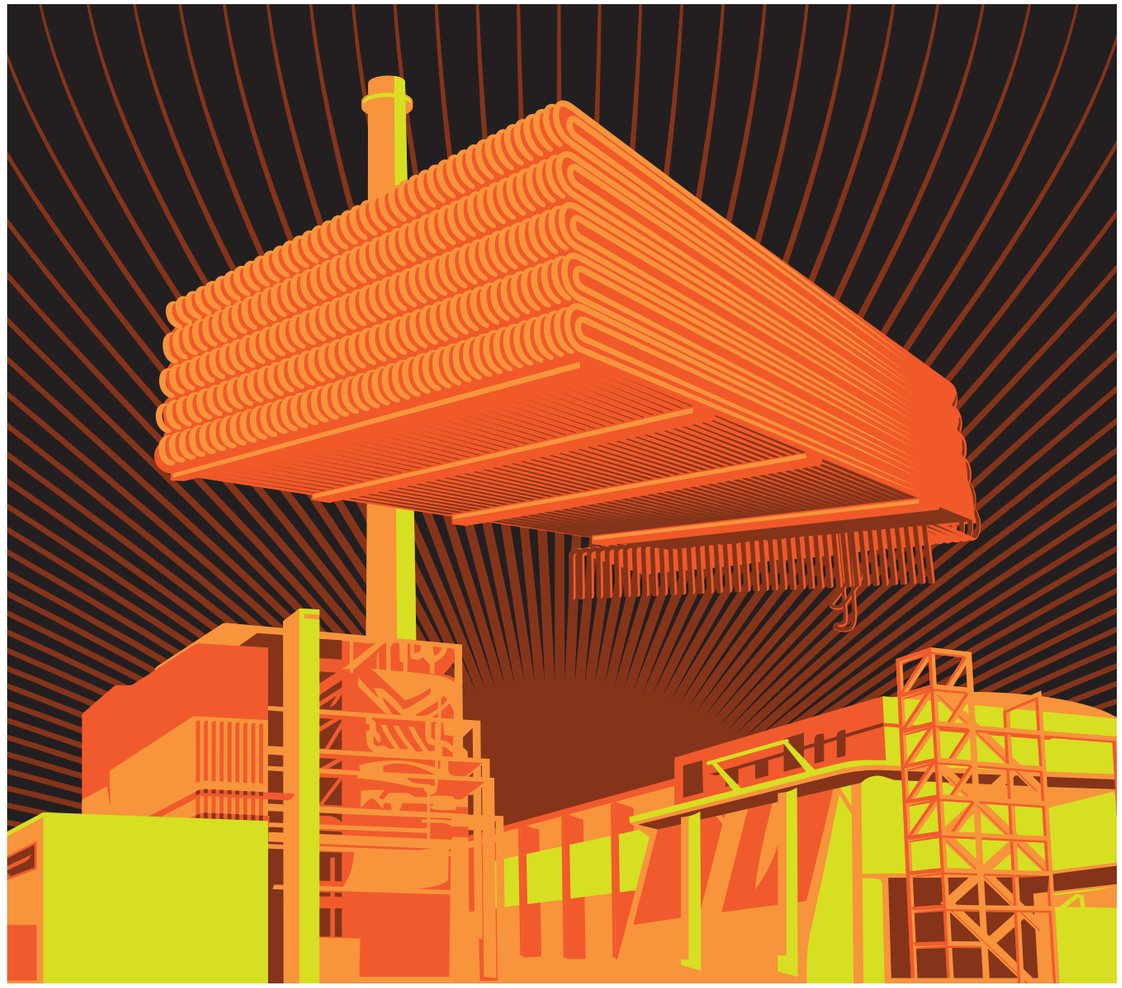
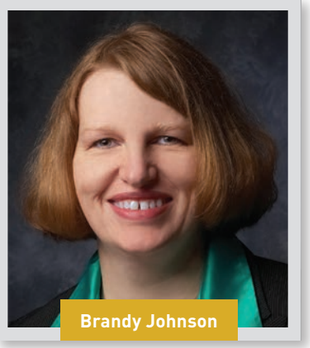


ULTRA-SUPERCRITICAL BOILER

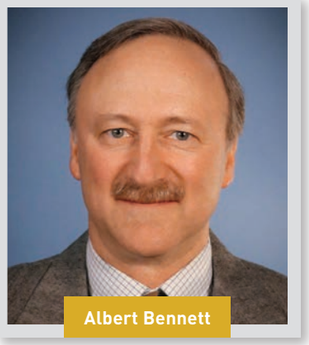
INNOVATORS Babcock & Wilcox. Brandy Johnson, vice president, new build utility and environmental; Albert Bennett, technical consultant.

INNOVATION Ultra-supercritical boiler at John W. Turk Jr. Power Plant withstands very high pressure and temperatures, enabling the plant to operate at a net efficiency of better than 39 percent.

IMPACT Plant uses less fuel than standard coal-fired boilers and releases 17 percent fewer CO_2 emissions.



Brandy Johnson



Albert Bennett

PRESSURE TECHNOLOGY

INCREASING EFFICIENCY

Advanced Babcock & Wilcox boiler takes the heat.

STORY BY MARK C. CRAWFORD • ILLUSTRATION BY THOMAS ROMER

When engineers are challenged to extract more power from the fuel entering a Rankine cycle thermal plant, they have a few options. Among the most challenging are raising the steam temperature and increasing the pressure.

The technology demonstrated at the John W. Turk Jr. Power Plant in Fulton, Ark., tackles both challenges, raising the pressure and temperature of the steam to new heights. While other plants in the United States operate at supercritical pressure, the Turk plant is the first where the final steam conditions exceed both the critical pressure and a temperature of 1,100 °F. Operating as an ultrasupercritical boiler, the Turk Plant has the highest net plant efficiency of any solid fuel power plant in the U.S.

Plant owner Southwestern Electric Power Company tapped Babcock & Wilcox to design, supply, and erect the 600-MW advanced supercritical steam generator.

"B&W's full project scope included the engineering, design, supply, and installation of a 600 MW-net pulverized coal-fired spiral-wound universal pressure steam generator, a selective catalytic reduction system, a dry flue gas desulfurization system, pulse jet fabric filter, and associated auxiliary equipment," said Brandy Johnson, vice president, new build utility and environmental, for Babcock & Wilcox.

To best optimize efficiency, the design team selected a single reheat cycle with elevated steam pressure and temperature.

In designing high-temperature steam cycles, designing the interface between the stainless steel tubing (in the area exposed to hot flue gas) and the high-strength ferritic collection headers outside of the hot

gas is especially important. As the average design steam temperature increases, the temperatures of the individual superheater tubes can vary widely. Material fatigue places an upper practical limit on the steam temperature.

According to Albert Bennett, a technical consultant for Babcock & Wilcox who was significantly involved on the project, "Special attention was made to ensure that the steam temperatures were controlled such that early fatigue failure would not be an issue."

The team found new chrome- and nickel-based superalloys that could be used in the steam generator, piping, and other system. Those alloys should hold up for three decades or more.

With a superheater outlet pressure of 3,789 psig—well above the critical pressure of 3,206 psig—an outlet temperature of 1,126 °F, and a steam flow of 4,419,400 lbs. per hour, the Turk plant has been able to produce a net plant heat rate of 8,730 Btu/kWh—equivalent to a net plant efficiency of 39.1 percent since it entered commercial operation in 2012.

By comparison, the fleetwide average for coal-fired boilers is 32.5 percent. That difference makes a substantial impact on emissions per megawatt-hour of power generated. The higher efficiency results in less overall coal consumption and fewer emissions, including carbon dioxide, per megawatt output.

Babcock & Wilcox engineers also employed computational fluid dynamics modeling to place burners and overfire air ports to make the best use of low-sulfur coal. ME

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