# Choosing the Right Boiler Air Fans at Weston 4

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## By Nancy Spring, Senior Editor

Proper air and gas flow are necessary for optimum combustion in the boiler of a modern steam generating system. How the dampers, stack design and fans interplay determines system operations efficiency. As one critical element in that mix—and as one of a power plant's largest electricity consumers—the choice of boiler air fans is one to be made carefully.

The fan industry is a mature one, said John Gray, manager of sales for TLT-Babcock Inc., a New York Blower company. In terms of advancements and new technology, there isn't much change in fan design from year to year. So when it comes to the three "big" boiler air fans—forced draft (FD) fans, induced draft (ID) fans and primary air (PA) fans—the decision revolves around efficiency.

"Efficiency is very important for the big coal-fired power plants," said Gray. "These fans are the biggest consumers of power usually in the whole plant so they're always in the spotlight. The fan has to be as efficient as it can because there are dollars in savings every minute that fan operates."

## Conceptual Design

For the Weston 4 supercritical coal-fired plant, the fan decision-making process began with an overall conceptual design for fan selection. At Weston 4, that work was done by Black & Veatch, said Philip Hayes, Wisconsin Public Service Corp. (WPS) Weston 4 project manager.

Weston 4 was awarded Power Engineering magazine's 2008 Project of the Year award in the coal-fired category. The 530 MW supercritical coal plant was built with some of the most advanced coal-fired technology available and is one of the cleanest coal-fired power plants in the U.S. The plant is co-owned by Wisconsin Public Service Corp. and Dairyland Power Cooperative and went online on June 30, 2008.

*Induced draft fans being erected at the south unit of Weston 4. Photo courtesy Wisconson Public Service.*

"On a project Weston 4's size, the combustion air and flue gas flow needs can be defined fairly easily with combustion analysis computer programs, which define the required air flow and resulting flue gas flow for the plan," said Tom O'Brien, Black & Veatch (B&V) associate vice president and Weston 4 project manager. Communication with the WPS operations people also helped streamline B&V's decision-making on the number and type of fans.

"At the kickoff meeting in December 2002, we walked through major features of the plant and talked about WPS preferences," said O'Brien. "Some things we could decide right then and other things we said we would determine based on subsequent studies."

One item B&V studied was the ID fans. The flue gas flow of ID fans is equal to the sum of the other two fans plus the fuel combustion products and their horsepower requirements are greater.

"We looked at single-speed ID fans, two-speed ID fans and variable frequency drives (VFDs) We also considered whether or not we would design for full load at the low speed or at the high speed," said O'Brien.

Study results were analyzed with WPS's projected load model in mind. Because Weston 4 would be the WPS fleet's biggest and most efficient plant, it would run as base load. "Based on the load model they gave us, we decided against the variable frequency

drives for ID fans and decided we wanted to go with two-speed to optimize the total life cycle (capital plus operating) cost over the life of the facility," said O'Brien.
Weston 4 uses a balanced-draft system as opposed to a forced-draft approach. "In the balanced-draft approach, the boiler operates at a slightly negative pressure so as to draw any potential leaking air in instead of leaking hot gas out,"said O'Brien.
The PA fans supply pulverizers with the air needed to dry the coal and transport it from the pulverizers to the boiler. Because of the pressure drop associated with this transport process, the PA fans require significant static pressure, more so than their air supply counterparts, the FD fans. The FD fans supply the balance of the required combustion air to the boiler and typically have a capacity two to two-and-a-half times that of the PA fans. With the use of the air quality equipment at the back of the boiler, maintaining the furnace pressure slightly negative requires using the ID fans to pull the gas out and send it toward the stack. ID fans are sized based on a combination of the air flow of the other two sets of fans, and combustion products, plus any leakage in the air heater or flue gas handling components.
Two of each of these fans were specified to improve system reliability. Equally important was the fact that the technology is not available to provide centrifugal fans large enough to handle the entire flue gas flow stream with only one 100 percent fan. On Weston 4, there are two 50 percent PA fans, two 50 percent ID fans and two 50 percent FD fans.
Some options exist when it comes to choosing the type of fan, although O'Brien said centrifugal fans are generally used where a higher static head is needed. For example, the PA fan has to supply more static pressure so a centrifugal fan typically is chosen. The ID fans have a fairly high static head so those, too, are centrifugal. The FD fans are axial flow models.

*Induced draft fan foundations. Photo courtesy WPS.*

The actual Weston 4 fan size—in terms of horsepower, inches of static pressure, total volumetric flow—was decided by Babcock & Wilcox (B&W), under the boiler contract.
"It's their duct work, their burner, their boiler and in this case, their AQCS (air quality control system) equipment, so it makes sense to have them do it," said O'Brien, referring to the boiler maker. "I imagine our criteria and B&W's are probably very similar. What we do is more about how much redundancy we want, because B&W certainly knows how to size fans as well as we do."

## Other Design Elements

O'Brien said the ID, PA and FD fans are run by large, high-voltage motors and draw a lot of power through them, facts that are taken into consideration from the start.
"When we design, we supply separate trains of redundant equipment from separate power sources, so if we lose one power source, we won't lose the entire plant," he said.
To reduce the corrosion potential of cold combustion air coming in contact with flue gas handling equipment, as well as the energy to dry the coal in the pulverizers, the air is preheated in two stages, said O'Brien.
The PA and FD fans are in a room where coils and louvers are in the wall. The air is drawn across the coils and heated to 55 degrees. The combustion air is then heated by second stage air preheating coils in the fan discharge ducts to provide protection in the boiler against cold-end corrosion.
In the second stage, air is heated by energy captured off the flue gas by the air heaters. "We preheat the air with energy that would be going out the stack anyway," O'Brien said. "This design is common to the power industry in general and is not a feature unique to the Weston plant." Both primary air and forced draft air are heated by the air heaters. The primary air is then

routed to the pulverizers for transporting the coal from the pulverizers to the coal burners and subsequently to the furnace. The forced draft air is routed to the furnace.

## Fan Selection

For Weston 4, the forced draft fans are single-speed axial flow with adjustable pitched blades, while the primary air fans are single-speed centrifugal with inlet guide vanes, said WPS' Hayes. The Weston 4 induced draft fans are centrifugal with variable inlet vanes and two-speed motors.

As Matt Kurian, B&W project manager on Weston 4, described it, B&W's scope ranged from the boiler to the stack. When it came to the FD fans, the choice was axial. "They are more efficient," he said.

"It's fairly common for FD fans to be axial because axial fans' blade pitch can be adjusted," said Charlie Waugh, project engineer, B&W Power Generation Group.

*Primary air fan at Weston 4. Photo courtesy WPS.*

Erick Hengy, project manager, Fläkt Woods Americas, the company that supplied the PA and FD fans, said one of the few changes made in fan selection over the years has been to introduce axial fans for FD service. "The relatively high flow and low pressure requirements of FD service make axial fans a good choice for this application," he said.

The Weston 4 FD fans are single-stage axial fans with aluminum blades operating at 1,200 RPM, said Hengy. By contrast, the PA fans are centrifugal. "The Weston 4 PA fans are double width, double inlet centrifugal airfoil bladed fans operating at 1,800 RPM," he said. Both types of fans were provided with inlet silencers and circulating oil lubrication systems.

## The Supercritical Difference

Coal-fired power plants operating at supercritical pressures and high temperatures were built in the U.S. in the late 1950s and throughout the 1960s—B&W supplied one of the first supercritical boilers in 1957. By the mid-1970s, however, demand for large supercritical units began to wane as U.S. utilities turned their attention to smaller coal and natural gas-fired plants and peaking units.

Supercritical boilers operate at higher temperatures and pressures than subcritical boilers, using less fuel and emitting less $CO_2$ per MW of electricity generated. A cycle efficiency improvement of approximately 2.5 percent is associated with a pressure increase from the typical subcritical 2,400 psi throttle to the typical supercritical throttle pressure of 3,600 psi. Other efficiency improvements include overall cost reductions in fuel handling and usage, flue gas treatment and ash disposal.

In 2004, B&V's O'Brien said a group of 10 people working on the Weston 4 project visited a supercritical unit in Australia to learn what was different about a supercritical plant.

"On the flue gas side there's not much difference between a subcritical and supercritical," said O'Brien. "The steam temperature and pressures are higher with a supercritical but you could run a subcritical plant up to the same temperatures. On a supercritical, the boiler doesn't have a drum, it's all once through."

Weston 4 features superheated steam temperatures of approximately 1080 F and operates at a supercritical pressure of 3,790 psi.

"Everyone's interested in maximum efficiency," said B&W's Charlie Waugh. "For coal-fired plants, supercritical boilers will stay around."