

**A CASE
HISTORY**

FUEL-COST ADVANTAGE ONLY ONE KEY REASON
MAJOR WISCONSIN UTILITY EXPANDS CAPACITY WITH
FOSTER WHEELER CFB STEAM GENERATOR

MANITOWOC PUBLIC UTILITIES

Manitowoc Public Utilities chose a Foster Wheeler CFB steam generator for added power-generating capacity. A CFB burns fuel with limestone in a mixture which is "fluidized" in a suspended "bed" by blowing air in from the bottom of the combustion chamber. Air pollutants are greatly reduced because the calcium from the limestone captures most of the sulfur, which is easily and efficiently filtered from the flue gasses. Maximum fuel efficiency is also achieved by re-"circulating" combustion gasses through the combustion chamber several times until all of the fuel is completely burned.



In 1986, recognizing its growing need for added power-generating capacity, Manitowoc Public Utilities (MPU) commissioned a firm of consulting engineers to determine the best course of action. MPU's final decision: purchase of a 200,000 lb/hr 20-MW circulating fluidized-bed (CFB) boiler from Foster Wheeler Energy Corporation. MPU's reason for the decision: hard economics, particularly as related to fuel costs.

Located on the shore of Lake Michigan about 75 miles north of Milwaukee, the City of Manitowoc, Wisconsin, is provided with its water, steam and electricity by MPU, a municipally owned utility. With five stoker-fired coal-burning units, two diesel-engine generators and five steam-turbine generators, the power plant was theoretically capable of generating 86 MW. However, the plant could only produce

enough steam to utilize 64 MW of its total capacity.

In 1986, MPU commissioned the engineering consulting firm of Lutz Daily and Brain (LD&B) to conduct an electric-supply study to determine the optimum source of additional electric capacity for MPU. (The study was submitted to the Wisconsin Public Service Commission for its authorization.) LD&B originally considered three alternatives: the addition of a 200,000 lb/hr stoker-fired boiler; the addition of a 200,000 lb/hr atmospheric circulating fluidized-bed boiler; and the purchase of power from an outside source.

SCRUBBERS MANDATED

Critically affecting the study, which projected costs over a 17-year period, was the fact that the U.S. Environmental Protection Agency (EPA) had just proposed new emissions regulations. These would force utility-sized coal-fired boilers to use expensive flue-gas



MANITOWOC PUBLIC UTILITIES
FLUIDIZED BED BOILER ADDITION
 \$21,611,000 PROJECT
BUILDING NOW FOR MANITOWOC'S FUTURE

ENGINEER: BURT, DACEY & BRAIN	SUBSTRUCTURE: HAMANN CONST.
BOILER, BAGHOUSE: ROYER WHEELER ENGINE CONP.	STRUCTURAL STEEL: ZALK, JOSEPH
DISTRIBUTED CONTROLS: BAILEY CONTROLS CO.	SUPERSTRUCTURE: HAMANN CONST.
SITE PREPARATION: VAN MULLEN/KAPITZ CONST. CO.	COAL HANDLING EQUIP.: FUEL ECON. CONTRACTING CO.
ASH HANDLING SYSTEM: DETROIT STOKER CO.	LIMESTONE HANDLING EQUIP.
MECHANICAL AUXILIARIES: CRANE, YUBA, IRB/MIPPOWER	PIPEWORK: THE POWER CONTRACTING CO.
CONT. EMISSIONS MONITOR: LEAR SIEGLER	POWER WIRING: THE POWER CONTRACTING CO.
ELECTRICAL EQUIPMENT: LINE POWER METHOD	

ONE WAY

A CASE HISTORY

scrubbers to meet more-stringent sulfur-emissions limitations. Not unexpectedly, the proposed regulations had a detrimental impact on the cost effectiveness of the stoker-fired boiler. In 1986 dollars, the CFB boiler option was found to be \$2.106 million less than the stoker-fired boiler option, and \$8.698 million less than the purchase-power option over the 17-year study period.

In 1987, a new study by LD&B compared the CFB boiler to the purchase-power option. The results of the study convinced the utility to purchase a 20-MWe CFB boiler, a project awarded to Foster Wheeler early in 1989 on the basis of sealed competitive bids.

The Foster Wheeler CFB at MPU was started up in March 1991 and achieved full load eleven hours after coal was first introduced. It successfully completed performance testing for coal several months later and switched to 100% petroleum-coke firing. MPU and Foster Wheeler plan to test the use of shredded tires as a fuel "supplement" for the CFB in the future. (Tests conducted by Foster Wheeler's R&D group before the project

was completed have confirmed the feasibility of shredded tires as a fuel supplement for the unit.)

The CFB steam generator, which includes a baghouse filter system, produces 200,000 lb/hr of superheated steam at 975 psig and 905°F. It is designed to burn either high-sulfur bituminous coal or petroleum coke, with the possible introduction of shredded tires (because of the cost advantage). An additional advantage of the CFB is its ability to fire coals with a greater percentage of fines—less expensive coals—than the stoker units.

NEED FOR FLEXIBILITY

A number of factors necessitated the need for a high degree of engineering flexibility on the Manitowoc project. First, site and layout constraints required that the heat-recovery area (HRA) be positioned at a right angle to the furnace rather than the more typical in-line configuration.

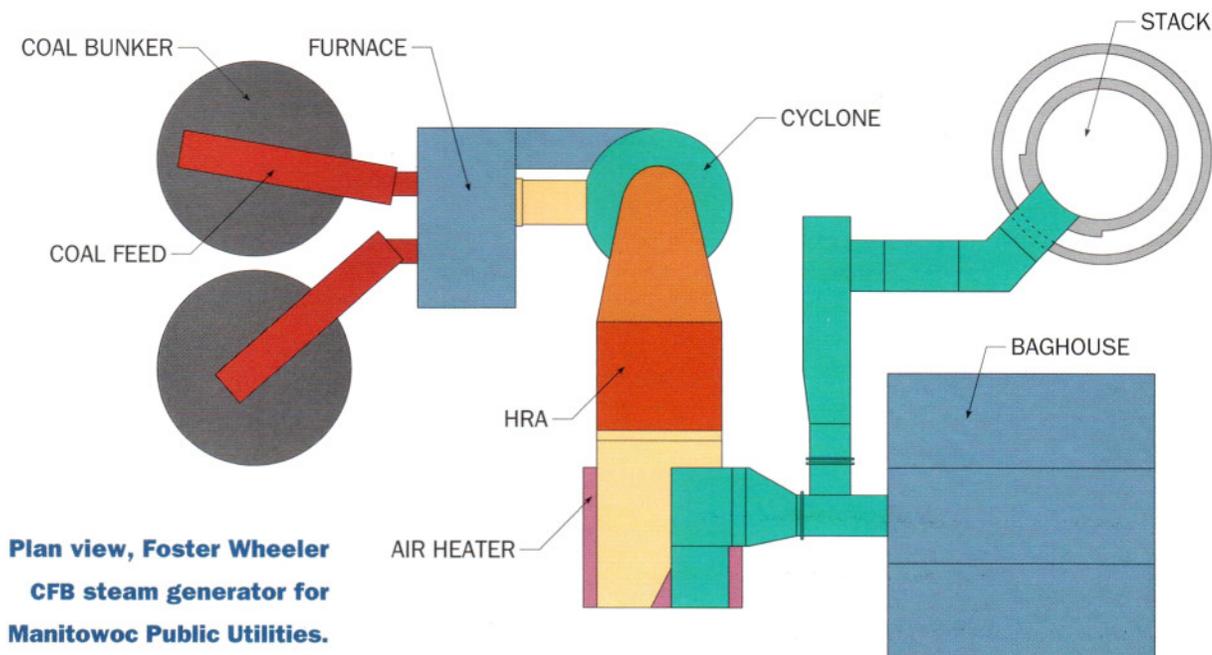
In order to enable MPU to take full advantage of other power generated within the system, the Foster Wheeler

CFB was designed to provide a high degree of start-up flexibility, allowing overnight shutdown and quick restart when necessary.

In addition to the usual concern for regulated emissions, Foster Wheeler engineers took steps to minimize noise emissions to ensure quiet operation of the CFB because a high school is located in close proximity to the plant. (Water from Lake Michigan is used for cooling in the plant, and the section of lake shore by the plant is a popular bathing area, thanks to the warming effect of the cooling-water discharge.)

The wide range of fuels that could be burned efficiently in the Foster Wheeler CFB was a key reason the unit was selected by MPU. A fuel-cost analysis, part of the consulting-engineers' study, clearly highlighted the CFB's advantage. The plant's stoker-fired boilers require coal with limited fines to fire the fuel properly. The cost of coal for the CFB was conservatively estimated to be approximately 4% less than the stoker-quality coal.

The study, however, did not take into account all the potential savings avail-



Plan view, Foster Wheeler CFB steam generator for Manitowoc Public Utilities.

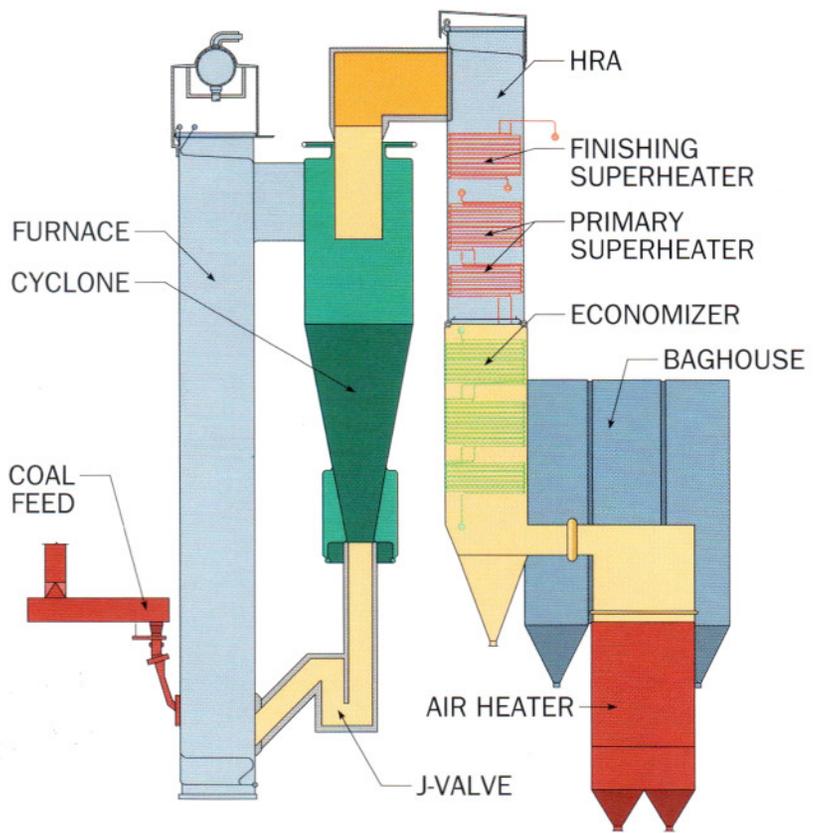
able to a CFB through the use of a wider range of coals. For the 17-year projection, assuming the stoker-fired coal as the standard, the savings in fuel costs for the CFB over the stoker-fired units was put at \$2.337 million. But if lower-grade fuels are substituted, and these are assumed to be 10% lower in cost than the stoker-quality coal used in the analysis, the additional savings in 1986 dollars for the 17 years was estimated to be \$2.9 million. This put the cost of fueling the CFB (with lower-cost coal) at some \$5.23 million less than the stoker-fired unit over the study period.

ALTERNATE FUELS OPTION

Burning fuels other than coal was another option not factored into the fuel-cost study. When the specification for the CFB boiler was issued, it required the unit to reach maximum continuous load on either coal or petroleum coke. The price for the coke is expected to be about 55% that of coal for the stoker-fired units.

Additionally, even before the fuel-cost study was conducted, MPU had completed a technical analysis of the sludge from the city's waste-water treatment plant. Burning that sludge (feasible in the CFB) would provide a cheap fuel for the utility and a community service to the city.

Finally, shredded tires are another "community-service" fuel being considered by MPU. The utility would, in fact, be paid for removing the tires from landfills and storage sites. The practicality of using shredded tires as a fuel—and an assessment of the potential risks involved—in a commercially sized CFB was thoroughly tested in a hot CFB pilot plant at Foster Wheeler Development Corporation (FWDC).



Side view, Foster Wheeler CFB steam generator for MPU.

TIRES CAN BE BURNED

Results of the test burn show that relatively good combustion can be expected while burning tires, with no unusual fire-side problems or gaseous emissions.

In addition, the research program found that wire removal did not appear to be a problem at the fuel size tested. The study's conclusion was that continuous commercial operation on a blend of shredded tires and coal should be practical and economical.

A brief summary of fuel prices included in the FWDC research report also underlines the fuel-cost advantage of a well-designed CFB over a stoker-fired unit. The report put stoker coal at approximately \$48/ton. CFB coal would cost \$35/ton, and coke \$26/ton. The utility, however, would be paid \$3 per ton net, after shred-

ding, by the City of Manitowoc for disposing of the tires by burning.

Operator friendly, environment friendly and cost efficient, the Foster Wheeler CFB at Manitowoc is an outstanding example of how a tested technology, a focused R&D program and creative engineering design can be blended to meet the specific requirements—both physical and economic—of a client. ■

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