# JEA Large-Scale CFB Combustion Demonstration Project

***Demonstration Operations Complete***

## Participant

JEA (formerly Jacksonville Electric Authority)

## Additional Team Members

Foster Wheeler Energy Corporation — technology supplier

## Location

Jacksonville, Duval County, FL (JEA's Northside Station, Unit No. 2)

## Technology

Foster Wheeler's atmospheric circulating fluidized-bed (ACFB) combustor

## Plant Capacity/ Production

297.5 MWe (gross), 265 MWe (net)

## Coal

Eastern bituminous and Petroleum coke (petcoke)

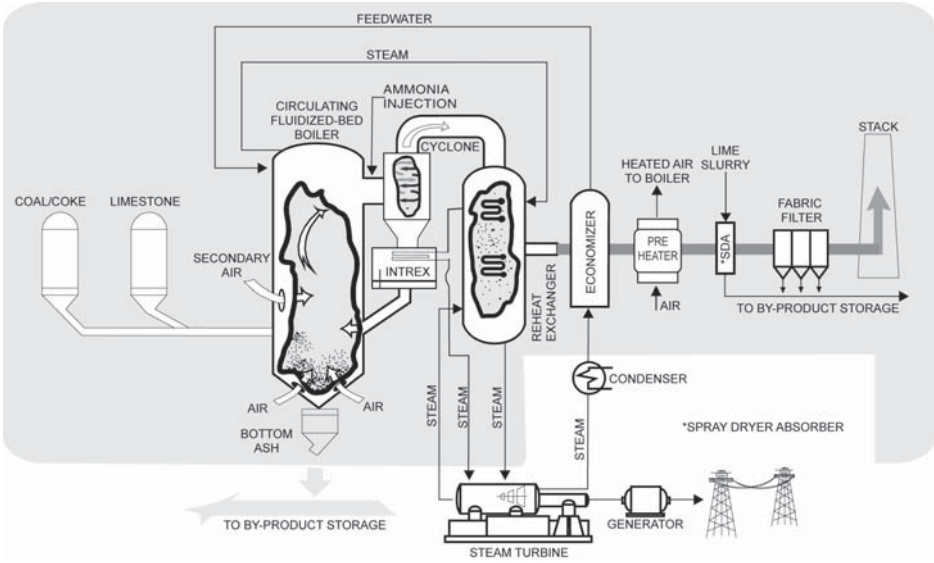
## Project Funding

| | | |
|---|---|---|
| Total | $321,392,624 | 100% |
| DOE | 74,723,785 | 23 |
| Participant | 246,668,839 | 77 |

**CCTDP**

**Advanced Power Systems**

| | | | |
|---|---|---|---|
| IGCC | ☐ | CFB | ■ |
| Hybrid | ☐ | Adv Comb | ☐ |




## Objectives

To demonstrate scale-up of atmospheric circulating fluidized-bed combustion (ACFB) to 297.5 MWe (gross); to verify ACFB technology cost and performance expectations; to provide potential users with data requisite to assessing ACFB as an option for large-scale commercial capacity additions or retrofits; to achieve greater than 90 percent sulfur dioxide ($SO_2$) removal; and to reduce nitrogen oxide ($NO_x$) emissions below New Source Performance Standards (NSPS).

## Technology/Project Description

The project demonstrates replacement of an inoperable oil/natural gas-fired Unit 2 boiler rated at 275 MWe with a 297.5-MWe (gross) ACFB. In the ACFB system, coal or coal fuel blends are crushed to minus 1/4 inch, mixed with crushed limestone (sand size), and pneumatically injected into the base of the ACFB. The mixing action of the ACFB enables efficient combustion at temperatures below 1,600 ºF (well below thermal $NO_x$ formation temperatures), and provides greater than 90 percent sulfur capture through good sorbent contact with $SO_2$ released during combustion. Secondary air assists mixing and combustion and helps move the lighter combusted materials out of the combustor. Aqueous ammonia is injected prior to the entrained materials entering a cyclone separator. The cyclone separator mixes the ammonia, which reduces $NO_x$ to nitrogen and water; separated solids pass over an INTREX™ steam superheater; and the solids return to the combustor. A portion of the solids leave the combustor as ash and calcium sulfate. Gas from the cyclone heats steam in reheater/superheater tube bundles located in a relatively soot-free chamber; further heat is recovered in an economizer that heats feed water and in a combustion air preheater. High-pressure steam from the INTREX™ (2.0 x $10^6$ lb/hr, 2,500 psig, 1,000 ºF) and low-pressure steam from the reheater (1.78 x $10^6$ lb/hr, 548 psig, 1,000 ºF) drive a steam turbine-generator unit. Flue gas from the air preheater passes through a polishing spray dryer absorber (SDA) using a lime slurry to further reduce $SO_2$ emissions, and through a baghouse to remove particulates.

| Project Duration<br>169 Months | Period of Operation<br>24 Months | Status/Schedule<br><br>*Estimated date |
|---|---|---|

## Benefits

ACFB offers superior cost and performance compared to conventional pulverized coal-fired (PC) plants in highly competitive power markets requiring superior environmental performance to ensure plant acceptance. In either greenfield or repowering applications, ACFBs outperform PC plants by meeting stringent environmental requirements without having to install expensive and energy-robbing post-combustion controls, such as selective catalytic reduction and large wet flue gas desulfurization units. This capability affords an efficiency gain and reduces the significant capital costs associated with large post-combustion controls. Also, ACFBs provide a high degree of fuel flexibility that extends beyond all types of coal to renewables and wastes, such as petroleum coke (petcoke). Petcoke is a refinery waste in plentiful supply that represents a solid waste management problem to refineries, but a low-cost, high-energy fuel to ACFBs. This fuel flexibility equates to low operating costs relative to PC plants. This project moves ACFB technology into the large utility boiler arena, an important market sector.

## Status/Accomplishments

The Final Technical Report was issued in June 2005, completing this project.

## Results Summary

### Operational

- Over a 24-month operating period, the demonstration unit was on-line for 12,293 hours producing 3,031,408 MWh (net) of electricity.
- During 2003 and 2004, the unit operated at an average heat rate of 9,516 Btu/kWh (35.9 percent efficiency).
- The performance test results confirm that the full load boiler efficiencies for three of the four fuels exceeded 90 percent (the boiler efficiency on Illinois 6 was 88 percent).
- The design basis for $SO_2$ removal efficiency was 85 percent (typical) in the boiler and 12.1 percent (typical) in the polishing scrubber. The as-tested efficiencies ranged between 95 percent and 98 percent in the boiler and between 1 percent and 4 percent in the scrubber.

STATUS

| | | |
|---|---|---|
| Report | *Final Report Issued* | *6/05* |
| Operation | *Operation Completed* | *12/04* |
| Construction | *Operation* | *1/03* |
| Design | *Construction* | *12/00* |
| | *NEPA Completed (EIS)* | *12/00* |
| PreAward | *Award* | *11/90* |
| | *Selection* | *6/89* |

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- The average Equivalent Availability Factor (EAF) for the demonstration project was approximately 66 percent. For comparison purposes, the North American Electric Reliability Council (NERC) Generating Availability Data System indicates EAF to be approximately 84 percent for similar sized units (mostly pulverized coal).

#### Environmental

- As shown in Exhibit 3-5, stack emissions were well below permit limits.
- During the 100 percent load test on 80/20 (petcoke/Pitt 8 coal) blended fuel, the spray dryer absorber removed 98 percent of the incoming mercury.
- Ash in the By-Product Storage Area (BSA) sets up to form a low strength aggregate type material, with essentially the only water run-off being precipitation.
- The Florida Department of Environmental Protection has classified Unit 2's ACFB blended ash by-product (bed ash and fly ash) as an "industrial by-product" allowing it to be used for beneficial purposes.

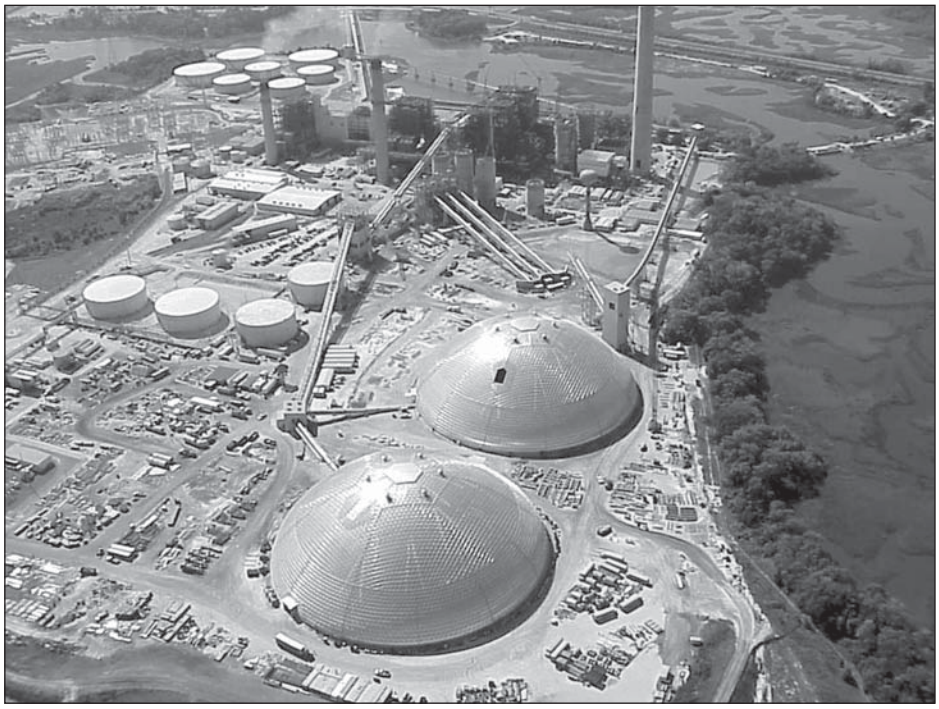
#### Economic

- At project completion, the actual capital cost was $321,392,624 for Unit 2 and one-half of the shared facilities or $1,080/kW at the gross output rating of the unit.

## Project Summary

JEA Northside Unit 2 has demonstrated the successful, commercial operation of a 300-MW class ACFB boiler. As tested, boiler efficiencies on various fuels met or exceeded the design values and proved competitive with PC boilers of the same size.

During testing on each of four different fuels, the project operated steadily at each of four different loads (100



*JEA's Northside Station with Fuel yard in foreground and Foster Wheeler's ACFB in background.*

percent, 80 percent, 60 percent, and 40 percent) without any deviation in unit output, proving fuel flexibility. The 40 percent load test on the 80/20 blended fuel was not conducted due to Hurricane Charlie. Some blending of petcoke and coal was required, however, to prevent ash agglomeration experienced when firing 100 percent petcoke.

As shown in Exhibit 3-5, Unit 2 reduced stack emissions well below permit limits. The overall $SO_2$ removal rate exceeded 98 percent. Design flexibility allowed JEA to operate Unit 2 at a much higher boiler $SO_2$ removal rate than originally specified to offset problems experienced with the polishing scrubber limestone feed system. Modifications to the limestone system were planned following the demonstration period to allow a change back to the original design basis.

During the 2-year demonstration period, the EAF was significantly lower than industry average values. The project successfully identified a number of recommended changes to improve unit reliability and availability for future commercial service. These include modifications to the following systems/equipment:

- INTREX system,
- Expansion joints,
- Stripper cooler, and
- Limestone system.

FW has concluded that the INTREX design is not viable, and is no longer offering this design feature on new ACFB boilers.

The project has received *Power* magazine's 2002 Power Plant Award, and was nominated for *Power Engineering* magazine's 2003 Power Plant of the Year Award. JEA's project manager was awarded the Florida Engineering Society's Technical Achievement Award 2002 for his work on the project.

**Exhibit 3-5**
**Stack Emissions Data**

| Parameter | CY 2003 | CY 2004 | Permit Limit |
|---|---|---|---|
| $SO_2$, lb/MMBtu, 24-hr avg. | 0.14 | 0.17 | 0.20 |
| $NO_x$, lb/MMBtu, 30-day avg. | 0.07 | 0.08 | 0.09 |
| CO, lb/hr, 24-hr avg. | 84 | 100 | 350 |
| PM, lb/MMBtu | 0.005 | 0.005 | N/A |