Site Considerations for Repowering with Advanced Circulating Pressurized Fluidized Bed Combustion (APFBC) from the L.V. Sutton Station Concept Assessment

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ABSTRACT

This paper reports on the results of a U.S. Department of Energy (DOE) conceptual design evaluation of an early commercial repowering application of advanced circulating pressurized fluidized bed combustion combined cycle technology (APFBC). Here, APFBC would repower an existing generation station, the Carolina Power & Light Company's (CP&L) L.V. Sutton steam station. Concepts are presented for APFBC repowering of Unit 2 (226 MWe) and of both Units 1 and 2 in combination (340 MWe total). This evaluation found that it is more economical to repower the existing coal-fired generation unit with APFBC than to build new pulverized coal capacity of equivalent output. The paper provides a review of the DOE study and summarizes the design and costs associated with the APFBC concept.

APFBC technology is under development and will be ready for commercial application soon. A DOE-sponsored Clean Coal Technology (CCT) demonstration project is being developed to pioneer the first commercial APFBC demonstration, scheduled in year 2002. That 170 MWe APFBC CCT demonstration will use all new equipment, and become the City of Lakeland's C.D. McIntosh, Jr. steam plant Unit 4.

This paper's concept evaluation is for a larger implementation than the Lakeland McIntosh CCT project. The repowering of L.V. Sutton Unit 2 is projected to boost the energy efficiency of the existing unit from its present 32.0 percent HHV level to an APFBC-repowered energy efficiency of 42.4 percent HHV (44.1 percent LHV). An APFBC system with a single large-frame Westinghouse W501F combustion turbine modified for APFBC use are added. The APFBC-modified W501F is rated at 138 MWe output. The combination of this combustion turbine with the APFBC system and the existing steam turbine/generator produces a 225 MWe class repowered APFBC combined cycle. At this size, APFBC has a wide application for repowering many existing units in America.

The DOE team of Parsons Power Group Inc., Foster Wheeler Development Corporation, and the Westinghouse Electric Corporation developed the concept. This team worked with CP&L’s engineering and production costing departments to assess the implementation of the design at the site, and estimate unit dispatch characteristics over the plant life. This information, along with the costs, establishes utility industry-based life-cycle economics of the repowering expected in actual operation.

The paper focuses on the design issues, shows how the APFBC power block integrates with the existing site, and gives a brief summary of the resulting system performance and costs.

APFBC DESCRIPTION

An advanced circulating pressurized fluidized bed combustion combined cycle (APFBC) power plant is a new type of gas turbine combined cycle that is fueled entirely on coal. It provides environmental performance superior to new source performance standards (NSPS) requirements, and DOE *[DOE, 1993]* estimates it is capable of producing electricity at 42 to greater than 50 percent net plant efficiency (HHV). APFBC is projected to have attractive low production costs (fuel cost plus fixed and variable operating and maintenance costs are low). Based on earlier DOE evaluations*[De Lallo et al., 1997]*, DOE found that plant repowering is an attractive way to demonstrate the technology in early commercial applications, add to the base of information on APFBC operability, firmly establish a base of capital and operating costs, and prove APFBC economy, reliability, and availability. There are potentially a large number of plants of similar size to the L.V. Sutton units that could benefit from APFBC repowering.

The APFBC system uses technologies developed by DOE and industry partners. Exhibit 1 shows the major components of an APFBC power plant. APFBC uses a circulating pressurized fluidized bed (PFB) combustor with fluid bed heat exchanger to develop hot air for the gas turbine and steam for the steam bottoming cycle. In addition APFBC has a carbonizer (a fluidized jetting-bed device) to produce fuel gas from coal for the gas turbine topping combustor. The provide high combined cycle energy efficiency levels on coal.

Exhibit 1. Advanced Circulating Pressurized Fluidized Bed (APFBC) Power System Sketch

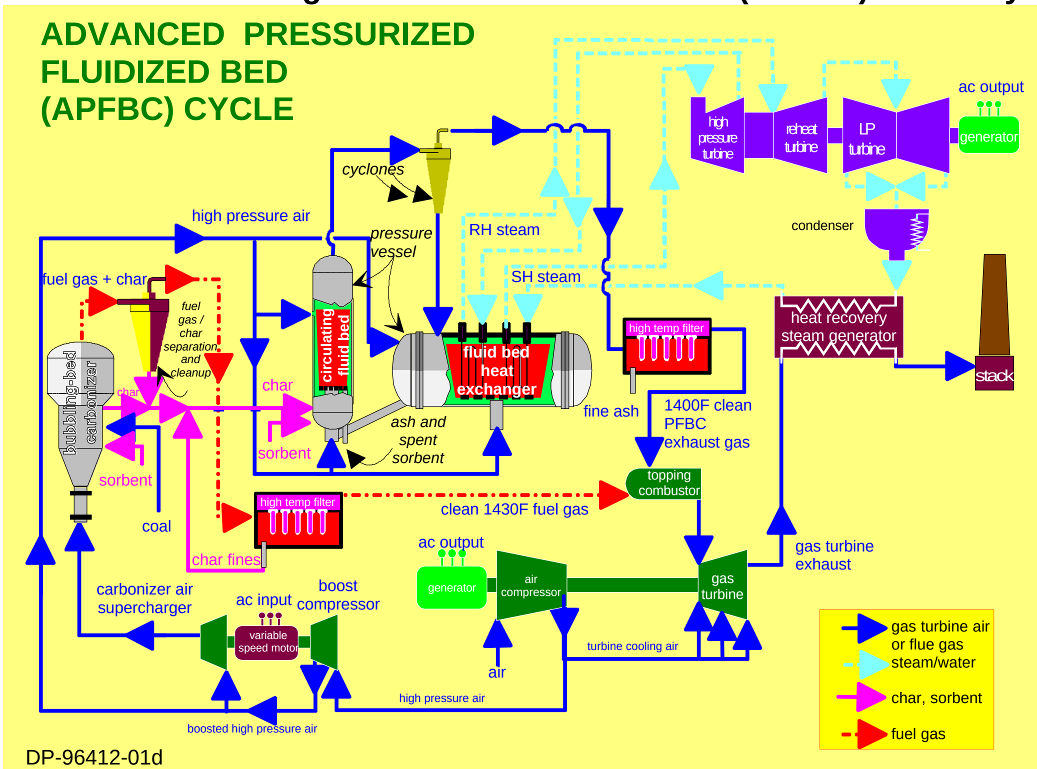

Exhibit 1 illustrates the APFBC system. Some of the major equipment in this system includes the following:

- A boost compressor system is employed after the gas turbine compressor to overcome the pressure drop of the APFBC equipment, so that an aerodynamic match is made that preserves the use of gas turbine expansion sections designed for natural gas service. The boost system also assists start-up and improves operational flexibility.
- The carbonizer, a pressurized jetting-bed, operates at 1700 °F, and converts part of the coal into synthetic fuel gas. This syngas is a low Btu gas, with an HHV heating value of about 136 Btu/scf. The remainder of the coal energy is in the form of char, which is sent to the PFB combustor. Limestone is added in the bed to absorb sulfur.
- This hot 1430 °F syngas passes through ceramic candle filters to remove dust.
- The circulating PFB combustor operates at 1550 °F and burns the char to produce steam and to heat combustion air for the gas turbine. The PFB combustor completes the combustion, but has sufficient excess air (about 16 percent oxygen) that this vitiated (partly used) air can be used in the gas turbine topping combustor. Coal can be added in addition to the char, if more steam generation is needed. Limestone is added in the bed to absorb sulfur.
- Hot cyclones separate out the solids from the vitiated air, and send the solids to the fluid bed heat exchanger to raise some of the steam for the steam turbine.
- Additional ceramic candle filters clean the hot 1400 °F vitiated air to remove dust.
- The gas turbine is modified to export high pressure air, accept high temperature air to combustor, and accept low Btu fuel gas. In this application, the Westinghouse W501F used is modified for APFBC operations. These modifications cause a slight derate in output compared to the unmodified natural-gas-

fueled production version. A W501F modified for APFBC operations has a rating of 138 MWe output whether running on syngas for APFBC operations, or on natural gas during start-up periods.

- The clean synfuel gas and vitiated air burn in the special gas turbine topping combustor, heating the gases to the combustion turbine's rated firing temperature. The gas turbine produces about half of the station output. In this application, internally mounted multi-annular swirl burners (MASB) are used in the APFBC-modified W501F topping combustor.
- The gas turbine heat recovery steam generator (HRSG) produces more steam. The steam conditions developed in the HRSG and the fluid bed heat exchanger match the existing steam turbine's needs, so the added steam-generated output results in high combined cycle efficiency levels.
- An APFBC system has combined cycle efficiency levels, 42.4 percent HHV (44.1 percent LHV), but operates on low-cost low rank coal or opportunity fuels.

Repowering Considerations. In the repowering concept, the steam conditions developed in the HRSG and the fluid bed heat exchanger would be matched to the demands of the existing turbine generator, whose added output results in high combined cycle efficiency levels. The repowering system described here is located adjacent to existing structures, and replaces the existing boiler, which at this site would be abandoned in place. In other locations, the APFBC equipment could use the space formerly occupied by the existing boiler as well as added space close by. Since the existing boiler is not used in APFBC repowering, owners can choose to:

- Demolish the existing boiler, or
- Retire the existing boiler in place, or
- Retain the existing boiler in standby for increased reliability states.

<u>APFBC Implications</u>. The high efficiency of APFBC is a direct consequence of combined cycle operation. Some of the output comes from a gas turbine, with the balance from the steam cycle. The unique arrangement of APFBC components allows all of this to occur using coal as the only fuel for all parts of the process. With APFBC, coal consumption is 30 percent less per kilowatt than the existing unit, and the coal consumption would be significantly lower per kilowatt output than for a new pulverized coal or atmospheric fluidized bed plant, the current commercial standards for coal-fueled generation. With its high efficiency, the APFBC will have 1/3 lower emissions of CO_2 per kilowatt than the existing unit, and lower emission of pollutants. The limestone in the fluidized bed has been tested and shown effective for sulfur capture, so 95 percent of the sulfur is removed at a calcium-to-sulfur molar ratio less than 2-to-1. This level of capture exceeds the 90 percent sulfur removal criterion in the NSPS, and only 70 percent reduction is needed at the site. Fluid bed temperatures are uniform and low, so NOx emissions are estimated below 0.3 lb/10^6 Btu, which are below those required by the Title IV NSPS at the site (carbonizer/PFB combustor tests have demonstrated NOx emissions at 0.1 lb/10^6 Btu *[Robertson, 1996]* below Title I requirements). In pilot plant tests, particulate emissions have consistently measured below 3 ppm (0.003 lb/10^6 Btu), which is an order of magnitude lower than NSPS requirements. Exhibit 5 (shown later on page 15 along with a discussion on the environmental characteristics) shows how the environmental emissions compare to both present and possible future environmental emission requirements.

A successful repowering in the size evaluated in this paper would improve the prospects for earlier commercialization of APFBC, and pave the way for the introduction of similarly sized replicate repowering units and all-new stand-alone "greenfield" installations.

LOCATING THE APFBC SYSTEM AT THE L.V. SUTTON STATION

This paper summarizes results from detailed DOE for repowering the Carolina Power & Light (CP&L) L.V. Sutton steam station evaluations *[Weinstein 1997b, 1997c, Weinstein et al. 1997i]*. The power block for an APFBC system consists of the solids handling equipment, the carbonizer and its filters, the circulating PFBC combustor/heat exchanger, combustion turbine, and heat recovery steam generator (HRSG).

Exhibit 2 provides an illustration of the APFBC power block for the L.V. Sutton station. Exhibit 3 gives an elevation view of these items. Moving from back to front in the Exhibit 2 sketch are the following equipment:

- Coal handling silos, furthest back, rendered in violet,
- Limestone feed silos rendered in gray,
- Carbonizer (partly obscured by candle filters),
- Two carbonizer fuel gas ceramic candle filters rendered in green,
- Fluidized bed combustor (the single tall vertical vessel rendered in red),
- Fluid bed heat exchangers (largest vessel, the only one horizontal, rendered in orange),
- Four PFBC hot cyclones rendered in steel blue,
- Six vitiated air ceramic candle filters rendered in green,
- Boost compressor and driver (partly obscured by pipes),
- Combustion turbine (yellow)/generator (green),
- Bypass stack for temporary operations on natural gas as a simple cycle gas turbine,
- Heat recovery steam generator, and
- Primary stack, in the sketch foreground.

Exhibit 2. Isometric Sketch of APFBC Power Block

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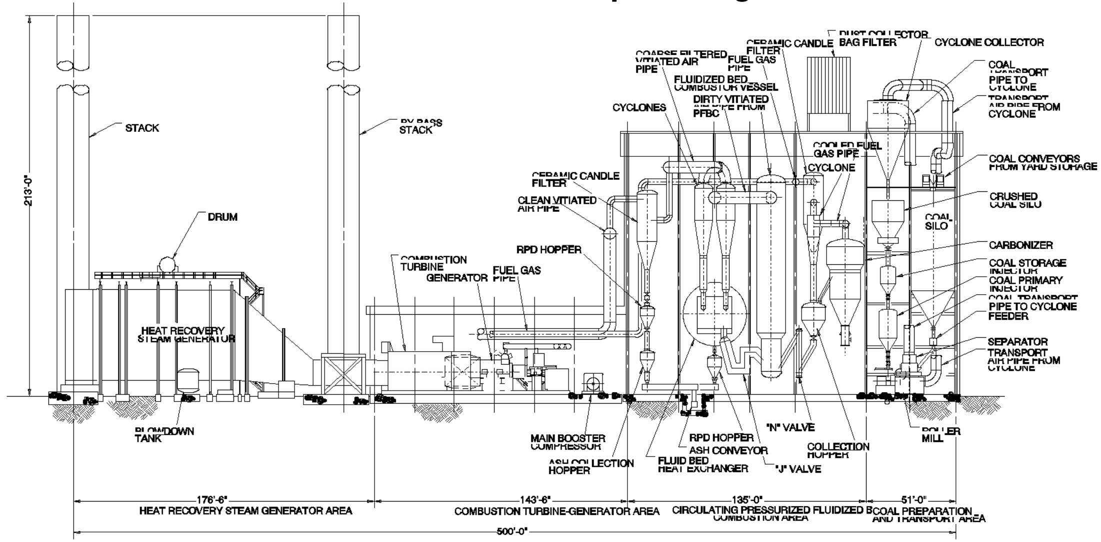
Exhibit 3 Elevation View of L.V. Sutton Repowering APFBC Power Block



PARSONS

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ENVIRONMENTAL & LICENSING

Exhibit 4 shows the gaseous emissions comparison for APFBC repowering, and Exhibit 5 compares the expected APFBC emissions to today's requirements for the site, and possible future emissions limits that might arise. Exhibit 6 gives comparisons of the solid waste produced.

Exhibit 4. Emissions Comparison

SO_2	Unmodified Unit 2	1.83 lb/10^6 Btu	6,340 tons/yr†	19.50 lb/MWh
	Unit 2 upgraded with wet FGD	0.15 lb/10^6 Btu	480 tons/yr†	1.50 lb/MWh
	Repowered with APFBC	0.09 lb/10^6 Btu	516 tons/yr†	0.67 lb/MWh
NOx	Unmodified Unit 2	0.62 lb/10^6 Btu	2,150 tons/yr†	6.6 lb/MWh
	Unit 2 upgraded with low NOx burners and SNCR	0.45 lb/10^6 Btu	1,440 tons/yr†	4.8 lb/MWh
	Repowered with APFBC	0.30 lb/10^6 Btu	1,720 tons/yr†	2.2 lb/MWh
Particulate	Unmodified Unit 2	0.040 lb/10^6 Btu	56.0 tons/yr†	0.430 lb/MWh
	Unit 2 upgraded with fabric filters	0.016 lb/10^6 Btu	7.0 tons/yr†	0.172 lb/MWh
	Repowered with APFBC	0.002 lb/10^6 Btu	11.5 tons/yr†	0.015 lb/MWh
CO_2	Unmodified Unit 2	219 lb/10^6 Btu	759,000 tons/yr†	2335 lb/MWh
	Environmentally upgraded	219 lb/10^6 Btu	721,000 tons/yr†	2250 lb/MWh
	Repowered with APFBC	219 lb/10^6 Btu	1,257,000 tons/yr†	1630 lb/MWh

† annual emissions are based on an assumed 70 percent capacity factor, Case B17A

Exhibit 5. APFBC Repowering Emissions Compared to Present, Future and Possible Future Emissions Limits

	Today's Regulatory Limits	Future or Proposed Future Limits	Repowered with APFBC
SO_2	1.730 lb/10^6 Btu	1.200 lb/10^6 Btu required Jan. 1, 2000[a]	0.090 lb/10^6 Btu
NOx	0.450 lb/10^6 Btu	0.150 lb/10^6 Btu being proposed[b]	below 0.300 lb/10^6 Btu[†]
Particulate	0.110 lb/10^6 Btu	??? being proposed[c]	0.015 lb/10^6 Btu

notes:

† APFBC would meet current NOx standards. The future more stringent NOx standards listed in the second column are proposals, not requirements (see note [b] below). Tests have shown NOx emissions as low as 0.100 lb/10^6 Btu. The Wilsonville integrated APFBC testing, expected in 1998, will verify if levels below 0.150 lb/10^6 Btu are attained in long-term APFBC operations (expected); if not a device such as SCR might be required should the more stringent standards be implemented.

a Future requirement mandated by the Clean Air Act Amendments 1990, Title IV, Acid Deposition; takes effect January 1, year 2000.

b Proposed, not yet enacted; level listed is from the Memorandum of Understanding of the Northeast Ozone Transport Region.

c Proposed levels not yet established when this was written (October 1997). Recently revised National Ambient Air Quality Standards for PM-2.5 is in the process of designating areas that are not meeting air quality standards. These designations will result in an as-yet undefined but more stringent emission limit.

Exhibit 6. Solid Waste Comparison

	Existing Unit 2 Without FGD *has no sulfur emission control*	**Upgraded Unit 2 with FGD** *Sorbent: Limestone*	**Repowered with APFBC** ***Sorbent: Limestone***
Unit Output, kW	106,000	104,640	226,491
lb/h	7,200	13,850	24,000
t/d	86	166	288
Number rail cars per week	None*	18	32
10^3 t/yr†	31	61	1,058
10^3 t/yr§	22	42	74
t/kW-yr†	0.30	0.58	0.46
t/kW-yr§	0.21	0.41	0.32

* Disposal is at on-site dedicated sludge pond
† 100 percent capacity factor
§ 70 percent capacity factor

Solid Waste Production Comparison

- The two major solid waste streams from the APFBC combustion plant are the PFB combustor spent bed material, and the particulates captured by the fuel gas and vitiated air ceramic candle filters. Coal ash and $CaSO_4$ make up over 77 percent of the solid waste production.

- APFBC ash is an undifferentiated alkaline mixture.

- The amount of waste generated is a function of coal ash and limestone sorbent characteristics as well as the level of SO_2 capture needed.

- APFBC ash is a dry product that is hydrophillic. It sets-up on contact with water, and thus either needs to be transported in dry covered containers, or hydrated before loading for transport.

- APFBC ash is benign product that is suited for landfill. It has been tested as an agricultural substitute for lime, with positive results, and has good characteristics as a base construction for roadways, and as a portion of conventional concrete/standard concrete masonry construction.

- There may be a market for APFBC ash, if a local market has need for the possible products.

- If local markets for this ash as a byproduct can be found, the owner can realize both financial and non-financial benefits. These uses make economic sense if transportation distances are modest; otherwise, it might prove more economical to dispose of the benign waste.

Water Quality Regulations

- Even though plant output increases by 125 MW, this is mostly combustion turbine addition. APFBC causes only a modest increase of steam turbine exhaust flow. Therefore, increase in the flow or temperature of discharge water is minor, so APFBC repowering is not expected to exceed the existing water temperature limits provided by the National Pollutant Discharge Elimination System (NPDES) permit.

- Water allocations are not expected to change, even though plant output increases by 125 MW.

- There may be minor changes to other wastewater streams internal to the plant, such as those associated with runoff from the ash and sorbent storage/handling systems.
  - Wastewater characteristics of the effluent from the repowered unit will need to be investigated for any significant changes in quantity or quality.
  - Effluent limitations applicable to the repowered or upgraded unit are expected to be similar to those that currently apply to the L.V. Sutton Station.
  - It is not expected that any repowering concept will result in significant water impacts that would require the use of different wastewater treatment systems or cooling towers.

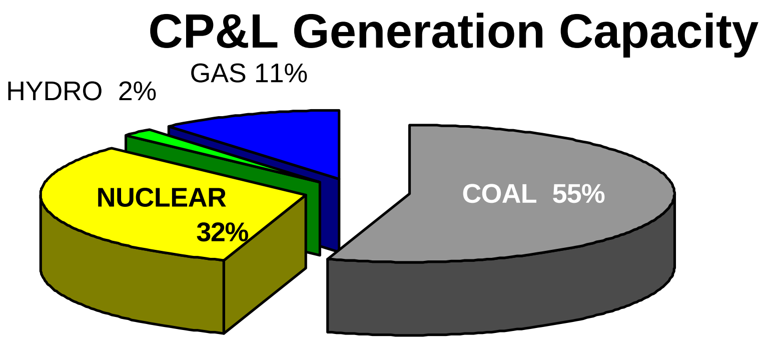
REPOWERING SUTTON UNIT 2

Carolina Power & Light is interested in APFBC repowering for the following reasons:

- The opportunity to increase generation capacity and improve heat rate on a unit with a low capacity factor through new technology that affords potential competitive economic advantage.
- In a competitive environment, low price wins.
- Coal remains an important fuel to CP&L.
- APFBC is a clean technology, has good cycle efficiency, and has the technology test programs in place to prove its feasibility.
- Should gas prices increase above projections, coal projects could become more favorable.

Basically, CP&L wants to understand this technology better to determine the feasibility of APFBC as a possible next coal-fired unit option.

CP&L System Overview

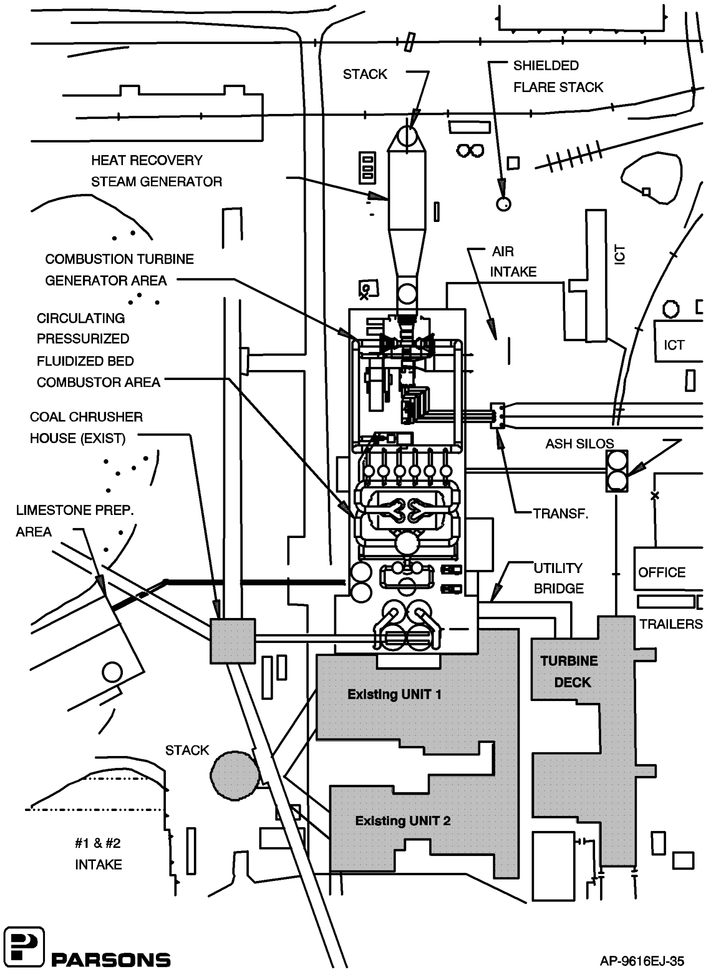


- Total System Capacity....................................9,613 MW
- System Load Growth ....2.4 percent each year
- Fossil Generation Costs..............Less than $ 0.020/kWh

Carolina Power & Light's L.V. Sutton Units 1 and 2

- This work is complete.
- Plant layouts, power block plan and elevations, 3-D CADD, coal and limestone handling, and electrical one-line diagrams prepared.
- Preliminary APFBC performance estimated, evaluated by the manufacturers, and revised estimates prepared.
- Unit 1 is 97 MW non-reheat unit, Unit 2 is a 106 MW reheat unit. We considered repowering either Unit 2, or Units 1 and 2 in combination.
- These are 1955 vintage units.
- Non-reheat Unit 1 steam flow is about 950,000 pph, at 1450 psig / 1000 ºF. Reheat Unit 2 steam flow is 775,000 pph at 1450 psig / 1000 ºF / 1000 ºF.
- Unit 1 heat rate is 11,608 Btu/kWh (29.4 %). Unit 2 is 10,660 Btu/kWh (32.0 %).
- Both units have been operating at about low capacity factor.

PT-96603-02b photo courtesy of Carolina Power & Light



L.V. Sutton Plot Plan Arrangement

- The APFBC equipment could be placed either at the north of the existing equipment, adjacent to Unit 1, or south adjacent to Unit 3.
- Either arrangement requires some compromise.
- Both arrangements require long steam pipe runs.
- The south arrangement has more complex coal delivery consequences.
- The north arrangement requires a longer length of transmission wire to get to the switchyard.
- The north end has coal and limestone delivery and operations advantages.

✔ *North-end arrangement chosen.*

Operating Conditions for APFBC Repowering L.V. Sutton Unit 2

- Carbonizer temperature: 1700 ºF.
- Fuel gas temperature to filters: 1430 ºF.
- Circulating PFBC bed temperature: 1550 ºF.
- Vitiated air temperature to filters: 1400 ºF.
- Heat recovery steam generator stack temp.: 280 ºF.

Expected Performance and Cost

Exhibit 7 lists the expected performance of the APFBC repowering, compared to the unit if no modifications were made, and to the unit if conventional environmental upgrades were incorporated.

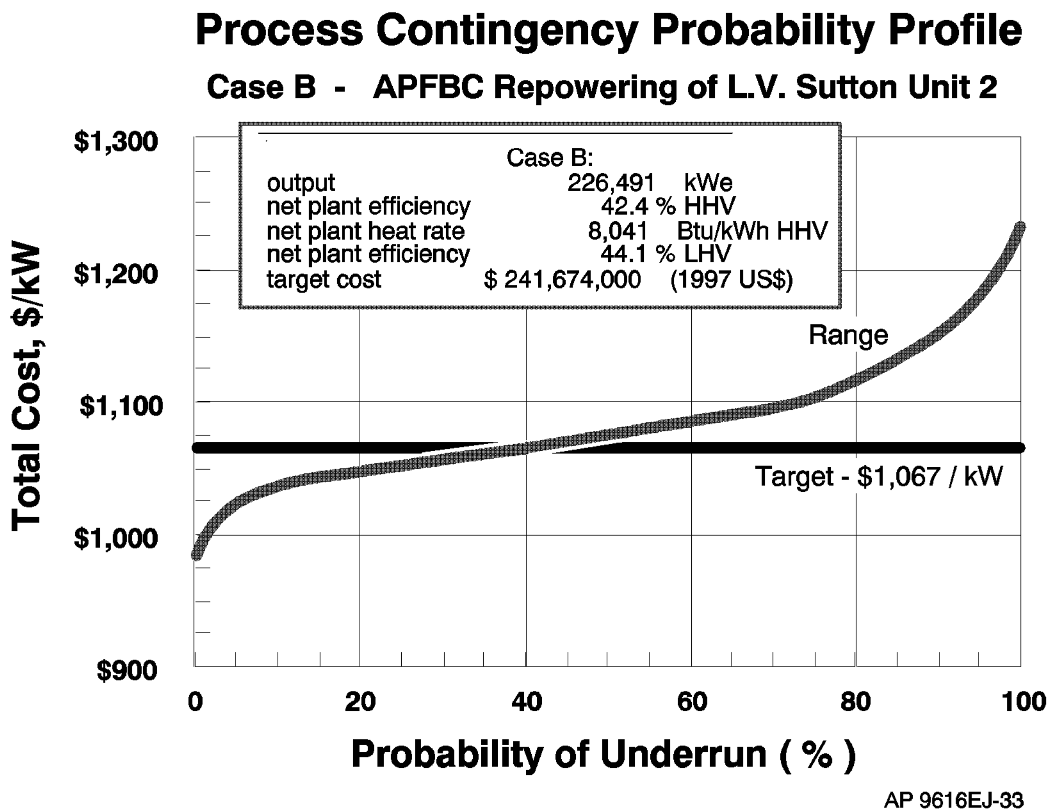
Exhibit 8 shows the expected total plant cost for this repowering. These are shown as a range estimate, that reflects the expected range of risk exposure to decision-makers. The curve displays the evaluation team's degree of confidence about the lowest and the highest costs that could occur for each piece of equipment in the plant, based around a target cost from a Parsons Power cost model estimate. That range can be used to infer an appropriate process contingency for the degree of risk exposure a decision-maker is willing to accept. The curve gives the estimated total plant cost in January 1997 dollars, which includes the overnight construction cost of the equipment, material, installation labor, engineering, and an allowance for project contingency.

Exhibit 7. Expected Performance

case ID:	Existing Existing reheat Unit 2	Case EU-2 Environmental Upgrade Unit 2 low NOx + FGD	APFBC Repowered Unit 2 Case B APFBC + W501F with MASB
Steam turbine repowered	as is	as is	existing reheat Unit 2
G/t gross kWe Unit 2 gross kWe Auxiliary load, kWe	-- *112,500 kWe* *-6,500 kWe*	-- *112,500 kWe* *-7,860 kWe*	*138,400 kWe* *105,111 kWe* *- 17,020 kWe*
Net plant output, kWe	106,000 kWe	104,640 kWe	226,491 kWe
Net plant HHV efficiency	32.0 %	31.6 %	42.4 %
Net plant HHV heat rate	10,660 Btu/kWh	10,800 Btu/kWh	8,041 Btu/kWh
Net plant LHV efficiency	33.3 %	32.9 %	44.1 %

If *both* Units 1 and 2 are repowered instead, then the net plant efficiency drops about 2 points, but output increases to 360 MW; this would add an all-coal-fired increment of 108 MW more output for only modest additional capital cost.

Exhibit 8. L.V. Sutton APFBC Repowering Estimated Total Plant Cost



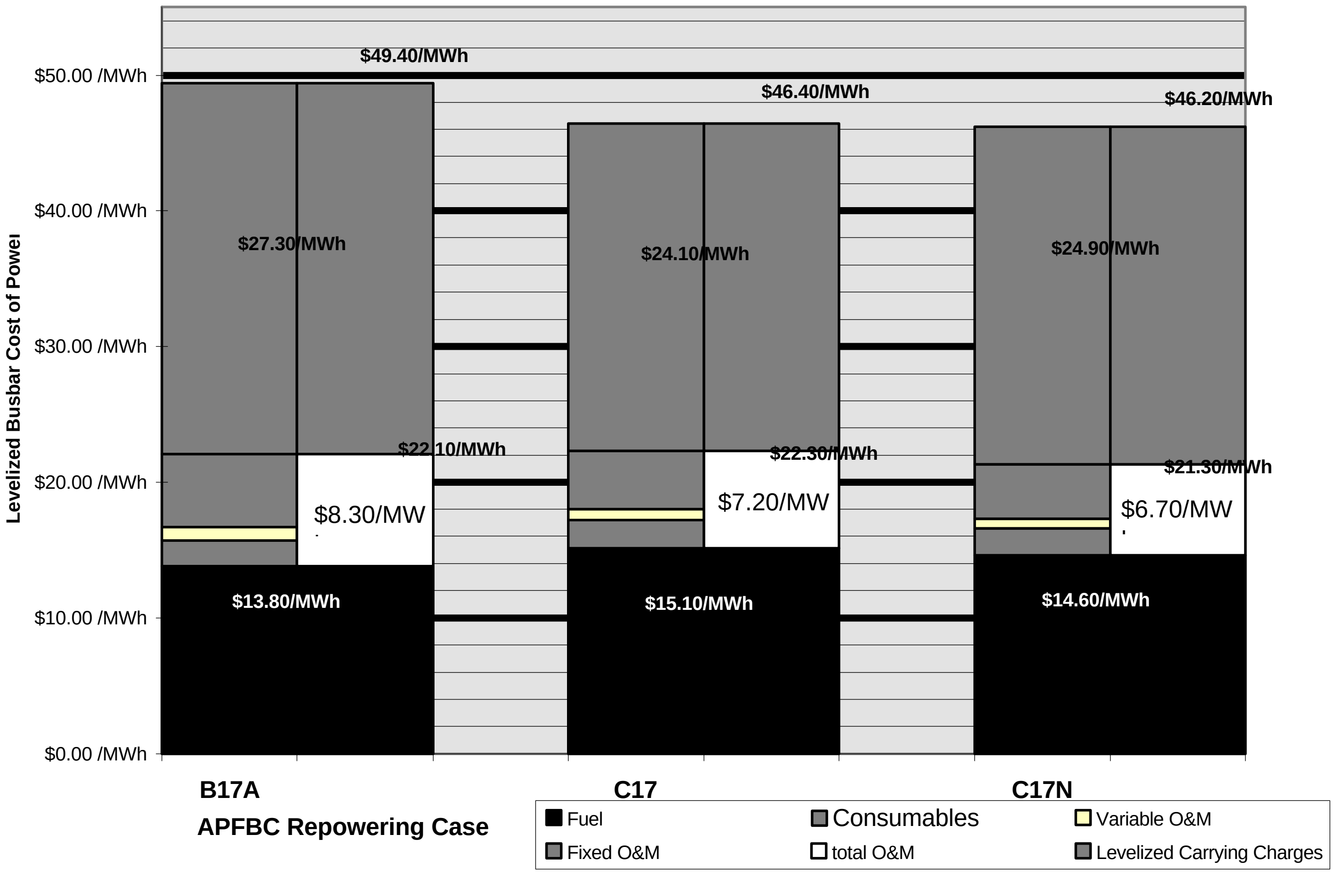
CP&L's Production Costing Analysis

CP&L evaluated how the APFBC system would dispatch on their electric grid, and concluded:

- APFBC would become the most efficient coal-fired unit, first dispatched as baseload.
- L.V. Sutton Unit 2, which now dispatches at low capacity factor, would move to over 80 percent capacity factor with APFBC.
- In the near term, there is sufficient baseload reserve at CP&L, so investment is only needed in natural-gas-fired combustion turbine peakers.
- APFBC repowering appears to have superior economics over a new conventional pulverized coal unit with FGD.
- When new coal-fired generation is needed, APFBC will be given serious consideration.

Exhibit 9 shows the expected economics of some of the preliminary study cases. Case B17A is an APFBC repowering of only Unit 2, while Cases C17 and C17N are two variations repowering both Units 1 and 2.

Exhibit 9. Comparison of Economics of the L.V. Sutton Study Cases



The economic assessment in the DOE study *[Weinstein, 1997c]* drew the following conclusions:

- The estimated lifecycle total levelized busbar cost for electricity is shown in Exhibit 9, as dollars per megawatt-hour of generation, for the 20-year operation period from year 2002 through 2021.
- The production costs for an APFBC repowered plant are shown in the middle-right of the shaded bars (excluding the carrying charges), and are around $22 /MWh. The white bar represents the sum of the consumables and O&M.
- IF new baseload capacity is NOT needed, it is best to retain the unit in good operating condition. The unit would dispatch at a low capacity factor. The unit would be in economic dispatch mode, cycling frequently, with frequent stop-start cycling damage, and long periods of idle time when repairs could be made to retain high start up availability. Because of the low capacity factor, few betterment projects are justified.
- *IF* environmental restrictions are not stringent, simple upgrades might make sense. Putting an FGD on the L.V. Sutton unit would be costly.
- *IF* load growth in peaking is growing faster than baseload, simple cycle combustion turbines operating on natural gas make the most sense.
- *IF* new baseload capacity is needed, coal-fueled APFBC has superior economics. An APFBC-repowered unit would dispatch at over 80 percent capacity factor, and would be in steady use for all the time it is available for service. Because of high capacity factor, a larger number of betterment projects are economically attractive.

Some observations about the characteristics of an APFBC repowering:

- Life cycle economics must compete with other alternatives.
- The capital burden is important.
- Differences in fuel price can affect the technology selection.
- There will be increased pressure for ever lower environmental emissions.
- Increased demand for gas generation in the future means gas prices may eventually rise.
- Early retirement of nuclear units might accelerate the need for new large blocks of capacity.
- Coal could emerge again to dominate the larger projects.
- There is a large potential market for replication of a repowering similar to the L.V. Sutton, Dan River, and Greenidge station concepts.
- Single combustion turbine repowering replicates would suit the characteristic of hundreds of existing coal-fired units.
- Multiple combustion turbine APFBC installations could accommodate larger units. Many APFBC components are amenable to multi-modular implementation.
- APFBC repowering could be accomplished in a phased approach: add a combustion turbine modified with MASB burners and topping combustor, but operating on natural gas as a peaker. As baseload demand develops, add the PFB combustor and heat exchanger, reducing the need for natural gas, operating as a 1-½ generation PFBC. When price proves favorable, add the carbonizer, and become a complete 2nd generation APFBC system.

APFBC Repowering Can Create Competitive Advantage

- Lower cost opportunity fuels can be used.

- Coal-fired repowering is likely better suited in areas where economical gas delivery might be subject to curtailment or significant price fluctuation during seasonal gas demand peaks; these gas-use peaks are likely to be coincident with periods of higher electricity demand, when the competitive spot market price of electricity will command premium electricity rates. Being able to generate during the most profitable operating periods is important to good financial return.

- The superior environmental performance of APFBC means more megawatts can be squeezed out of an existing site. The high efficiency means less CO_2 per MW output, should CO_2 reductions be mandated.

- Water rights permits are likely avoided even though output increases; the APFBC repowering does not significantly change water use.

- Transmission access exists already; the transmission and switchyards are already strategically near the load centers. However, the increased capacity from APFBC repowering needs to be within the capability of the existing network.

- Using an existing site at higher capacity factor reduces the maintenance and life-reduction costs from damaging start-stop operations.

- Upgrades keep existing plants competitive, retaining the value of an asset.

CP&L's Perspective on APFBC Technology

APFBC Benefits

- Uses coal as a fuel, has flexibility to use a range of low rank coals and opportunity fuels if price is favorable.
- Good cycle efficiency.
- Available soon.
- Lower installed cost and O&M cost.
- Test programs are in place to address all significant issues.

Risks Affecting APFBC

- Stricter future environmental requirements such as OTAG, PM-2.5, etc. could affect APFBC economics compared to those of alternatives, some favoring APFBC, some not.
- Natural gas price increases would favor APFBC.
- Ceramic candle filters need more testing time.
- Gas turbine MASB burners need more testing time.
- Long-term large-scale integrated testing is needed.

CP&L's Assessment

Does the Power Industry Need to Pay Attention to APFBC Repowering?

- Repowering with APFBC provides real benefit. With installed capital costs and lower O&M costs than a new pulverized coal plant with an FGD, a generating company can increase energy efficiency and reduce production costs from an existing unit.
- The power industry is undergoing dramatic changes as it moves toward increased competition.
- A unit in start-stop duty at low capacity factor becomes a baseload coal unit with APFBC repowering.
- APFBC economics seem to be there.
- There are many existing units that could benefit: in America, and exported to the world.

…YES!

ACKNOWLEDGMENT

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