Coal-fired Power Generation:

The Need to be Nimble

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U.S. COAL PLANTS CONTINUE TO PROVIDE MORE THAN HALF OF THE NATION'S ELECTRICITY, REPRESENTING A DEPENDABLE SOURCE OF BASELOAD POWER FROM A PRICE-STABLE FUEL. YET TO AN INCREASING DEGREE, A COAL PLANT'S VALUE MIGHT BE TIED TO NEWLY-ACQUIRED FLEXIBILITY IT DIDN'T HAVE WHEN ORIGINALLY COMMISSIONED.

Upgraded coal-fired power plants provide leverage against unstable natural gas prices and in some instances, are even serving burgeoning wholesale power markets, historically the nearly exclusive turf for gas fired combined-cycle and peaking units built during the past 15 years. New opportunities abound for the more versatile and flexible units in the U.S. coal fleet.

Historically, power providers who built coal plants focused on base-load reliability, not operational flexibility. But basic improvements, such as modifying tuning or control design to match new operational profiles, can often provide large financial returns from minimal investment. "Aging coal-fired plants have extensive opportunities for improved performance because of the new economic benefits of operational flexibility," says Joyce Dasch, power marketing manager for Emerson Process Management's Power & Water Solutions industry center. "Power producers must identify opportunities to improve coal-fired units and prioritize these opportunities based on expected return and impact on their business objectives."

Carolina Power & Light believes even costly enhancements can be worthwhile, if they allow an owner to run coal-fired units more hours a year. The company has committed to spending $800 million by 2013 to install scrubbers and selective catalytic reduction on eleven coal-fired units. The company's parent, Progress Energy, derives its power from an even mix of coal, nuclear and natural gas.

"Eight hundred million dollars could buy us a lot of new gas-fired generation," says Mark Mulhern, who heads Progress Energy's competitive generation business unit. "But gas prices have put a damper on the gas-fired generation market. That in turn has made for a pretty decent first quarter for the companies with lots of coal capacity. That has even extended into the wholesale competitive market."

There are times when Progress Energy's coal plants are producing, or can produce, more highly dispatchable energy than needed to serve the company's retail customers in North Carolina and Florida, says Mulhern. "That excess power can be sold into the wholesale market when economical. We call it real time trading or physical optimization. Customers on both the regulated and non-regulated side are starting to figure out that coal is a great benefit to them."

Writing in *Fortune* in January, Peter Huber and Mark Mills agree that coal-oriented utilities are among those best positioned to weather the current shakeout in the electric power business. The way to capitalize on the country's appetite for electricity, they say, is to

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identify producers that don't burn lots of expensive gas. They say now is the time to buy utilities, but only those that have steered clear of speculative foreign investments, trading debacles and natural gas.

Their conclusion: "There's now a huge opportunity to generate power under the sky-high umbrella set by gas. Old plants can be juiced up like hot rods, and that's now happening. Some 80 GW — about 10 percent of current total U.S. capacity — will be squeezed out of existing coal and nuclear plants in coming years."

The question is: What coal plant improvements make them even more competitive in today's energy markets in terms of dispatch, capacity, availability and emissions?

Milwaukee-based turbine/generator service provider ReGenCo identifies several areas on the steam turbine side, such as diaphragm changeout combined with rotating brush seals; new blades and tipseals; new rotors; one row of new blades with conversion to full arc; or all the above with new inner casing and several additional rows of blading. Another option identified by ReGenCo is conducting a thorough materials analysis and possible removal of operational restrictions imposed by OEMs such as prewarming criteria.

On the boiler side, Babcock & Wilcox identifies dozens of potential improvements including economizer upgrades, furnace wall corrosion reduction, and superheater upgrades to improve fuel ash corrosion resistance, restore full load capability and improve availability. B&W also recommends strategies for fuel switching.

PROCESS OPTIMIZATION

One of the most cost-effective means of improving the performance of the existing coal fleet is by employing advanced computer technology unavailable when the units were commissioned two or three decades ago. Emerson says the typical coal-fired generating unit can achieve significant performance improvements through solutions that are easily implemented in a few months with no outage required, and provide quick payback within six to 12 months. Typical examples are tuning, minor control changes, and advanced control and optimization software.

"Power producers need to be able to see the whole operational picture at every level of the company enterprise," says Dasch. "They need to see how they are meeting their unit commitments, their current plant efficiencies, their fleet emissions compliance, and their market competitiveness."

She cites an instance at a Midwestern utility where minor control design changes to the plant's information and control system along with unit tuning on a 220 MW coal-fired unit resulted in more than a 300 percent improvement in ramp rate (from 1.5 percent/min to 5 percent/min), providing greater operational flexibility and market bidding opportunities. At another Midwestern utility, Emerson's SmartProcess Optimization Software combustion and sootblower modules implemented on a 600 MW coal-fired unit provided NO_x emission reductions of up to 25 percent, heat rate reductions of up to 1.11 percent and CO reductions of up to 100 ppm. And at a 550 MW coal-fired unit, Emerson's steam temperature optimizer reduced steam temperature swings from +/-40 F to +/-5 F, resulting in a major reduction in boiler tube leaks and a resultant step change in availability.

Curt Lefebvre, CEO of Boston-based NeuCo, says optimization is a top-down process to determine what the set points should be on various systems to achieve business goals. "It's the opposite of how the original plants were often designed from the bottom up. Certainly we also look at engineering improvements that will better match the business plan, but implementing those changes require big lead times and outages. Everyone has accepted the fact that if we could have better automation and control on how these processes are working, it will lead to all kinds of capabilities to get more out of these assets."

Although engineering optimization methods have been around for a long time, it has been inexpensive Pentium-based computers and their mind-boggling ability to crunch large amounts of numbers that have brought optimization to full fruition. In addition, algorithms for addressing previously daunting challenges have emerged, mostly from what is loosely termed the artificial intelligence community.

"That's the only way we can manage the huge number of variables that must be considered," says Lefebvre. NeuCo personnel go into a plant with a PC and software that tell the distributed control system (DCS) where the control points should be rather than the operators and engineers deciding where they should be. "We end up with the best combination of those points for the asset. Rather than changing every system, we fine tune the performance of existing systems and coordinate them toward the achievement of an established business goal."

NeuCo has more than 50 real time combustion optimization systems operating in closed-loop at U.S. power plants. "Typically it takes a week to install the software and three weeks to get it wired to all actuators and sensors.

Coal blending is an effective means of achieving greater operational flexibility for the existing coal fleet. Detroit Edison's 3,000 MW Monroe plant blends three coal types in an almost infinite number of recipes to fit specific market conditions. Photo courtesy of Detroit Edison.

Six weeks after that, we will have fully explored the operating regime, and within 10-12 weeks we are in full fledged closed-loop control demonstrating benefits for that unit."

Lefebvre says the average return on investment across 50 installations is less than eight months. And most of these benefits are derived from just managing the distribution of fuel and air in the furnace, he says. "There is a reduction in NO_x emissions, improved fuel efficiency, and much less variance and swinging of the unit." Other NeuCo products can integrate and optimize critical plant sub-systems in the context of a unit's performance goals, and optimize multiple units in the context of a plant's financial objectives.

NeuCo's alliance with Kansas City-based power industry engineering and consulting firm Black & Veatch expands the ability of both firms to bring a strategic approach to plant optimization. "The addition of market forces created through quasi-deregulation essentially creates two sources

of profit — the traditional generation revenue stream plus new opportunities introduced by market dynamics," says Scott Stallard vice president of B&V's energy service division. "That's what's new to the industry and what's really driving the need for larger optimization solutions."

Stallard identifies three things that had to come together to create the current market opportunity for today's coal fleet:

1. *Significant deregulation had to occur.*
2. *Information technology tool sets had to become powerful enough to handle problems more globally.*
3. *Markets had to realize that trading must occur around generation assets rather than financial assets.*

"Three or four years ago, the computer systems were powerful enough but the traders believed they didn't need any assets in their portfolio. Six years ago, the markets didn't exist because deregulation wasn't as far along as it is now. Now all three elements are in place creating some real opportunities," says Stallard.

Optimization software from Emerson Process Management provided WE Energies with a cost-effective method of reducing NO_x at its Valley Power Plant in Milwaukee. Photo courtesy of Emerson Process Management.

TURNDOWNS BELOW DESIGN LEVELS

Some coal plant operators are endowing units with the ability to operate at much lower output than ever considered by designers.

"The entire class of coal-fired once-through boilers are the ideal candidates," says Bill Burke, Foxboro's director of power industry solutions. "That probably represents 30 percent of the installed base. And many of those units exist in areas where there have been major investments in combined-cycle plants. When the new combined-cycle plants come on, the tendency is for them to start displacing other units in the merit order of dispatch, which puts some of the central station baseload units into operating regimes they are not accustomed to historically. Owners need to learn how to modify operational expectations of these units and investigate low-capital options to increase the value of the asset in that competitive market."

Foxboro's Terry Greenlee, vice president of business development, describes the dilemma. "Coal plant operators get into an economic bind that says they are trapped at 250 MW and if they can't run below 250 overnight, they may be faced with either wasting 200 MW for 10 hours or shutting it down, especially with supercritical boilers. Then they have unreliability in the mornings because a lot of times the once-throughs look like they're ready to go up the ramp and move but they're being launched without enough powder in the engine. Temperature sensors can give you miscues about energy stored in the system that make you feel like you're ready to launch and you aren't. The readings are correct but that's not a reliable indicator of readiness. The calculation needs to be based on stored energy results from temperature, mass and flow calculations."

Foxboro has merged plant simulators into its optimization process. "There is a real renaissance of scientific method going on and a lot of customers don't even know it's possible to do some of the things that can be achieved," says Greenlee. During the past three years, Foxboro has been applying highly detailed simulators, originally developed for operator training, to its plant optimization process for achieving turndown and other plant characteristic alterations.

In one case, Foxboro looked at Babcock & Wilcox supercritical once-through boilers that can be fired by either coal or gas. "We looked at getting way below the minimum design points placed on those plants over their history," says Greenlee. "When they were first built, the minimum design on a 600 MW unit might have been 250. Conventional wisdom was that can't be done without a low-load modification that could cost $6 million and require a 90-day outage."

Foxboro looked at a generic set of gas units and found a 250 MW unit for which the low load specified by the manufacturer was 125 MW. "Our analysis indicated that a new control structure would allow it to run at 50 MW. When you go to these low loads, you tend to starve out your boiler feed pumps if they're steam driven. But we determined a way to rework the main steam header routing to the boiler feed pump and still maintain enough energy in the steam flow at the lower load to allow that feed pump to function. In addition, we were able to maintain the correct pressure and temperature in the first stage of the turbine so that in the morning the unit could come back quickly."

Greenlee estimates that for less than $70,000, an operating strategy was identified to achieve more than $50 million in improvement. The strategy identified required a new control system, which would cost about $2 million, and a new 201 valve, which is the main breakdown valve for the B&W once-through series. Although the work was done on a gas unit, there is full application on coal units as well since the operating analysis was made using a coal-fired simulator.

"That same client has come back asking us to convert all of its gas units into pseudo-peakers," says Greenlee. "They wanted us to find all the constraints in those units that keep them from moving as fast as they can possibly move. The point is that once companies become aware of this approach, they embrace it."

John Koslosky, proposal group manager at The Babcock & Wilcox Company, says his firm is seeing its customers beginning to ask about a more integrated approach to servicing their boilers. "Our service business for years has been NO_x control

and component replacement projects, but now our customers are starting to talk about optimization issues, cycling strategies, fuel flexibility, constructability, minimizing outages and outage duration, and system wide emissions compliance. The priority of these issues is unique to each customer and requires a much more integrated approach to field service, replacement parts inventory, design engineering and construction, and that is obviously something we can provide."

B&W has received inquiries on 500 MW units that customers want to run as low as 50 MW. "We are currently evaluating the consequences of an owner taking a unit designed for baseloaded operation and making it a cycling unit," says Rob Tedrow, project manager. "If they are considering cycling, as a minimum, they should review their pre-boiler cycle equipment and water chemistry, the boiler arrangement with regard to the hardware setting and its ability to take thermal cycles, low load impact on emissions strategies, their dispatch costs and in-house power costs, as well as seeing if it makes sense to keep the unit hot when not in use to prevent putting the unit through increased thermal cycles. This may require use of either boiler or turbine bypass systems where additional plumbing and valving will be needed to redistribute the thermal energy."

ESTIMATED SAVINGS FROM CONTROL MODERNIZATION

Summary of Savings Expected	Estimated Improvements Per Unit Per Year	Estimated Savings Per Unit Per Year
Improved Heat Rate	+1.25%	$273,750
Improved Availability	-2 Forced Outages	$436,800
Improved Maneuverability	+40MW for 4 Hrs/Day	$302,400
Reduced Maintenance	-30% Labor Hrs	$43,785
Reduced Start-Up Fuel Cost	-10% Fuel Used	$5,400
Total		**$1,062,135**

Source: The Power & Water Solutions Division of Emerson Process Management

Fuel Blending

A coal plant's flexibility can be immensely impacted by its ability to blend coals of various ash, heat, and emission characteristics in order to meet optimum market opportunities as they arise. "Fuel is one of the key opportunities, there's no doubt about it," says Stallard. "It's one of the untapped resources in the whole value chain. Because with fuel, you are in a world that in the past has been dominated by pass-through economics. But now you're in a world where optimizing coal quality in concert with power demands can lower costs or lower emissions and generate higher margins"

Perhaps no plant in the U.S. has been aggressively engaged in fuel blending longer and on such a massive scale as Detroit Edison's 3,000 MW Monroe plant located south of Detroit. The plant's four 750 MW units can consume up to 9 million tons of coal per year. Blending capability was added to Monroe as a result as changing state regulations regarding the sulfur limits that went into effect in 1980 and 1985. The plant takes delivery of three kinds of coal: Powder River Basin, low sulfur Central Appalachian, and mid-sulfur eastern.

> SOME COAL PLANT OPERATORS ARE ENDOWING UNITS WITH THE ABILITY TO OPERATE AT MUCH LOWER OUTPUT THAN EVER CONSIDERED BY DESIGNERS.

Although initially adopted to meet tighter emission restrictions, the flexibility provided by the almost infinite fuel recipes that can be blended from the combination of coals has also made Monroe one of the nation's most efficient and competitive generating stations.

"The generation optimization group monitors the market for purchase power costs and monitors the fuel blend at Monroe," says Gary Lappander, director of fuel supply for Detroit Edison. "There will be times when it is economic to go to 100 percent western (only 8,800 Btu/lb). In that case, we take a derate on a Saturday or Sunday and then the plant will change the blend back on the second or third shift on Sunday to get us back to our full capability that can only be achieved with the higher Btu fuel.

The plant routinely blends fuel for the market, allowing it to minimize fuel costs for Detroit Edison's native load customers and maximize the fuel price gap between its costs and the price the plant can get on the wholesale market in those cases where it can dispatch economically to the deregulated segment.

Asset Valuation Part of the Asset Value

The value of a flexible, decades-old coal plant may not be as obvious in today's market as it would have been had the utility rate-base paradigm envisioned at the time of construction continued to the present. That's where the ability to know a plant's current value becomes a critical element of the value itself. That knowledge allows an owner to know if the asset fits his current business plan, and perhaps more importantly, lets potential buyers know if it fits theirs.

"I don't think anyone is doing enough on asset evaluation to truly understand how plants are capable of performing," says Lefebvre. "Optimization technology can help people on both sides of an acquisition; those looking for under-valued assets to acquire, and those looking to identify which assets should be sold because they will not be able to perform as required. If you discover that a plant is capable of a different performance characteristic in terms of heat rate, emissions or availability than historically demonstrated, its value changes radically. And there's certainly a lot of money to be made out there based on this knowledge." PE