White paper

Keeping Your Coal Asset in the Game:

Essential Must Dos and Investment Options

Shareables

- Decades of focus on reducing emissions has left many coal assets overlooking fruitful efficiency improvements.
- Continued market pressures are driving coal assets into new efficiency and investment option/mothballing considerations.
- There are a few key investment options for coal assets to enhance competitiveness if efficiency and maintenance improvements aren't enough.

Executive Summary

Due to the continued view of low natural gas prices and static coal prices, coal asset owners face significant pressure to improve, modify, upgrade or mothball and/or replace existing coal-fired assets. Renewable portfolio standards, renewable energy prices, and their associated economic incentives have served to increase this pressure. Although decisions on how best to move forward will involve risk and uncertainty, there are opportunities. There are options available to asset managers and potential investors to improve coal power asset economics that can be economically justifiable in today's marketplace if the proper strategy is implemented.

"Must-Dos" to Stay Competitive

Efficiency Improvements

Based on ICF's collective power plant experience, we are convinced that coal plants can improve efficiency in light of ever increasing demands on emission control in an economically viable manner. Decades of focus on reducing emissions has resulted in heat rate and maintenance being largely overlooked. However, it is possible that a 10 percent heat rate improvement can be achieved without considerable investment. Ultimately, to be successful, this endeavor will have to be driven from the top down, a market justified amount of capital allocated and staff training with refresher courses mandated to maximize success potential.

Increasing boiler efficiency, improving turbine train efficiency and increasing net electrical output should be the focus of any heat rate or efficiency improvement program. This starts with a reasonably accurate means to monitor heat rate and component efficiency. Once an appropriate heat rate monitoring program is implemented, many potential improvement areas for consideration will arise. Each will need to be vetted and the cost/benefit analyzed specific to the asset, its cost of service, and market in which it operates. The actual list for justifiable improvements and their payback periods will vary from plant to plant, but there are a few areas that tend to provide quicker returns.

EXHIBIT 1. HEAT RATE IMPROVEMENTS

Heat Rate Improvement	Efficiency Benefit	Typical Payback
Cycle Isolation	0.25% to 3.0%	<1 Year
Control Upgrades	0.25% to 1.0%	<1 Year
Condenser Performance	0.25% to 2.0%	<1Year
Turbine Seals	0.5% to 4.0%	2 to 3 Years
LP Turbine Blade Upgrade	1.0% to 2.0%	2 to 5 Years
Feedwater Heater Performance	0.25% to 1.0%	1 to 3 Years
Combustion Air Modifications	0.25% to 1.0%	3 to 4 Years

Source: ICF

Given the relationship between heat rate and power plant thermodynamic efficiency a collective 10 percent heat rate improvement for a plant operating at 10,000 British thermal units per kilowatt-hour ("Btu/kWh") would equate to approximately a 3.8 percent thermodynamic efficiency improvement.

Reducing Costs

Coal plants can strategically reduce costs primarily oriented around operations, maintenance and fuel to improve competitiveness.

Fixed and variable operation and maintenance costs, and capital expenditures are often targeted because they are apparent and easy. Such costs certainly need to be optimized and treated like any other precious resource, but cost cutting with no strategy should be avoided. Staff that understand the impact of the reduction, cancellation or deferment of a given line item should be involved so that decisions are made from a technically savvy, asset management driven and market-wise position. If costs are cut too deep, life degradation, decreased reliability/availability and a build-up of required capital and O&M expenditures can result.

Minimizing fuel costs, the lion's share of operating costs, to the greatest extent possible is always prudent. Lower cost, out of specification fuel, can easily cost you more in maintenance and operational performance impacts than saved on fuel. Long and short term fuel positions can be both positive and/or negative. For instance, if you don't have a coal contract and are buying on the spot market, coal prices could correlate with natural gas prices. Thus, if natural gas prices increase and you have a hedge in place, you may want to take advantage of cheap coal pricing.

In the end, cost-cutting can only go so far and then investment options will need to be considered.

Investment Options

Based on ICF's review and the assumptions made herein, Exhibit 2 illustrates which option(s) is/are most likely to be economically viable for the indicated service life range with corresponding capacity factor ("CF") and relative natural gas price environment.

EXHIBIT 2. SHORT- AND LONG-TERM TRAJECTORIES

Service Life	Low Natural Gas	High Natural Gas
Up to 10 Years	Low CF 1) Convert to Natural Gas 2) Continue to operate on coal[1] 3) Mothball[3] High CF 1) Not feasible [2] 2) Continue to operate on coal[1] 3) Mothball[3]	Low CF 1) Continue to operate on coal 2) Mothball[3] High CF 1) Continue to Operate on Coal
30 years Plus	Low CF 1) Not feasible[2] 2) Continue to operate on coal[4] 3) Mothball[3] High CF 4) Repower 5) New Combined Cycle	Low CF 1) Continue to operate on coal 2) Mothball[3] High CF 1) Repower 2) New Combined Cycle 3) Continue to Operate on Coal[4]

Source: ICF

1) Only if capacity pricing justifies and you are not operating at a loss where mothballing may make more sense.
2) No investment option appears to make sense.

3) If operating at a loss on coal.
4) If natural gas prices are high enough.

Retrofits/Modifications

ICF assumes that all coal plants that were a likely target for any significant capital investment had already met the Mercury and Air Toxics Standards. There is the possibility of activity around a relaxing of the reentry ban where coal plants could exit and enter the market more freely. This change could result in a change in capacity and energy pricing which in turn could improve the marketability of certain coal assets.

Full Natural Gas Conversion

A full fuel switch to natural gas has a more probable chance of being economically justifiable if natural gas prices remain low in the short term, and interconnection and availability is readily available. Counter to this, given the unlikelihood of a carbon tax this option seems less justifiable in the long term. If some sort of coal phase out plan is adopted in lieu of CPP, fuel switch may be viable for coal plants on the margin to extend economic life. Added benefits may include decreased maintenance costs and increased availability.

A complete fuel switch to natural gas could also result in negative impacts to capacity (decrease) and heat rate (increase) requiring modifications/replacement of the air handling equipment and boiler heat transfer surfaces to maintain steam conditions. The cost of delivering natural gas to the facility would have to be considered, it can be very costly and in certain cases not even possible.[1] Natural gas typically has a much higher hydrogen content than coal so the increase in combustion hydrogen losses would typically result in a decrease in boiler efficiency. The coal handling system and equipment would no longer be required which would reduce operating costs, auxiliary power consumption, and reduce personnel. Also, there may be other ancillary benefits such as the elimination of soot-blowers and reduction of spray flow to control superheat and reheat temperatures. Burner system modification requirements could vary widely and control system modifications would be required.

Repowering

This option has a more probable chance of being economically justifiable for anticipated high capacity factors when the investment horizon is longer term. This option could result in a lower capital investment than a new combined cycle. Despite the heat rate penalty compared to a new combined cycle, there could be economic plays in the mid-term due to the lower capital costs depending on the repowering requirements and the markets in which the plant generates.

Repowering would typically utilize the existing steam turbine in a 2 on 1 combined cycle scheme. Hopefully the existing substation/switchgear and transmission capacity could accommodate the

[1] ICF has performed analysis on what it would cost to connect all various coal plants in the coal fleet to the nearest viable natural gas pipeline.

repower generation. However, transmission curtailment and line congestions are of increasing concern and would also need to be considered. Conversely, if the substation and transmission capacity is available it could represent significant cost savings. Also, the heat rate would be greatly reduced (perhaps improved on the order of 35 percent) relative to the existing coal plant.

There would likely be some economies realized due to the ability to utilize the existing steam turbine and some of the balance of plant systems (e.g. the condenser, heat rejection system, administration buildings, control room, laboratories, etc.). However, these advantages are slightly offset due to potential reliability issues of the older equipment and the overall risk this option presents compared to a new combined cycle. The overall economic viability of this option will depend on the balance of plant systems to be used and the off-site requirements to operate and deliver its power to market. Space available for the gas turbines and heat recovery steam generators will need to be factored. Hopefully, these can be placed on the abandoned coal yard if the site space constraints are tight.

Abandonment of the unit, but left in place, will come with certain ongoing liabilities and future cost of the asset. Demolition will certainly come with costs, and ideally, the salvage cost would cover the cost of demolition, but the economics can vary widely.

New Combined Cycle

This option requires the greatest level of investment, but is also the most efficient. Here there is an investment with a more probable chance of being economically justifiable for anticipated high capacity factors and when the investment horizon is longer term. Long term plays with this option in an environment of rising gas prices may be offset with improving coal plant economics.

The coal plant would be completely abandoned to install a new 2 on 1 combined cycle scheme. The most economic decision would be to size the new combined cycle plant to the existing substation/switchgear and transmission capacity. However, if the output is increased, it could necessitate substation/switchgear and even perhaps transmission upgrades and the potential for curtailment and line congestion should also be reviewed. Conversely, if the capacity is available it could represent significant cost savings. Also, the heat rate would be greatly reduced (perhaps improved on the order of 40 percent) relative to the existing coal plant. There would likely be a use for existing infrastructure and the repowering reliability issues and the risks associated with utilizing aged equipment not strictly consistent with their original design is eliminated.

Also, this option offers the most operational flexibility. Due to the high capital cost, the economic viability of this option depends primarily on the length of service or marketability assumed and less on gas prices. Space available for the combined cycle plant will need to be factored, but presumably, could fit within the abandoned coal yard if the site is tight. Also, the fact that if the decision to mothball a unit is made the two-year moratorium on that unit returning to the market, or perhaps not, needs to be factored. The same scenario plays out for an abandoned asset as described earlier in the repowering section.

About the Authors

Pete Ruestman has over 32 years of experience in power generation including Testing and Troubleshooting, Operations & Maintenance, Rate Cases, Construction, Commissioning, Research & Development, Product Development, Performance Improvement, and Independent Engineering. Given his diverse background, Pete supports projects in all phases of due diligence from the pre-financing support to financial close, construction monitoring, commissioning and annual budget/performance monitoring over the term of debt. He has spent a good portion of his career pursuing and developing international markets. He holds a Bachelor of Science in Mechanical Engineering received from the University of Missouri - Rolla and a Master in Business Administration from Southern Methodist University. He is a registered Professional Engineer in the states of Texas and Missouri.

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