PERFORMANCE IMPROVEMENT IN COAL-FIRED POWER STATIONS --THE SOUTHERN COMPANY EXPERIENCE—

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SYNOPSIS

In the early 1970's Southern Company's 20,000+ MW of coal-fired generating plants experienced severe declines in performance with their Equivalent Availability Factor (EAF) reaching a low of only 69% in 1976. Over the next decade numerous programs were implemented in an attempt to reverse that trend with the result that by the early 1990's the EAF had reached over 91%, one of the highest levels in the United States at that time. In addition a heat rate improvement of over 450 BTU/KWHR was achieved during the same period. Although many equipment refurbishment projects were implemented as part of this improvement program, the majority of the improvement can be attributed to improvements in management, both at the local plant level as well as the corporate level.

This month's case study will summarize the reasons for the performance degradation during the early 1970's and detail the actions undertaken that resulted in the 22 percentage point increase in availability and the 4.5% improvement in heat rate. Also, the cost and benefits of the improvements will be quantified and the environmental impact estimated.

AVAILABILITY TREND - 1970-1976

In the early 1970's, there was a significant downward trend in the availability of Southern Company's 20,000+ MW coal-fired units (88% in 1970; 69% in 1976) as well as the U.S. industry average as a whole. This downward trend was triggered by the inability of the company to provide sufficient resources to adequately address the unprecedented financial requirements brought about by high load growth (7-9% per year) as well as increased particulate emissions reduction requirements. This lack of funding led to several management decisions being implemented that emphasized short-term cash-flow interests, in the hope that long-term plant performance would not be severely degraded. These decisions included:

1) New technology plants (i.e. supercritical) were being designed and built without thoroughly appreciating the "Learning Curve" requirements of those technologies.
2) A design philosophy of "Low Initial Cost" was used instead of "Lowest Life-Cycle Cost" criteria for new generation.
3) Lower quality coal was purchased based on a "Lowest Delivered Cost" criteria rather than "Lowest Total Cost" (Delivered plus Operational Cost).
4) A reactive style of maintenance (fix it when it breaks) was being used instead of a proactive or anticipatory style.
5) Plant staffs were too small and not adequately trained (new plants siphoned off experienced operators and maintenance personnel).
6) There was a lack of management decision tools to determine which spending options would give the highest returns on the limited resources (manpower, time and money) available.

Although possible negative impacts of these policies were acknowledged, the degree to which they actually affected plant performance was much greater than expected. However, given the extreme constraints on available resources at the time, these decisions were virtually the only options available.

AVAILABILITY TREND - 1976-1991

The dramatic turnaround in coal-fired plant availability began in 1976 (69% in 1976; 91% in 1988) and was due primarily to the increased awareness and commitment of senior management to provide the resources necessary to achieve availability improvement. Among the programs successfully implemented as a result of that commitment were the following:

1) The creation of a generating plant examining board (GPEB) (Ref. 1). The GPEB Program selected as its members the best-qualified and most respected individuals in their respective fields (plant management, operations, maintenance, engineering, etc.) from among all of the operating power plants in the company. This group reviewed annually the condition of each power plant and made recommendations to executive management concerning actions and expenditures required to achieve performance improvement. The GPEB soon gained the trust of the plant's staff when they realized that a) The knowledge shared by the best personnel in Southern Company was of great value to the local plant and b) The GPEB's recommendations were given great weight by the central office executives when it came time to allocate available resources.
2) Monthly meeting of all plant managers and senior executives were held to review previous outages. Each month each manager was required to explain each outage event and to state a) the root cause of the problem, b) the immediate solution applied and its results and c) the long term solution that would eliminate or minimize the problem. Each of the other managers and executives in attendance would be able to offer their insights and perspectives to help find the best solution.
3) A methodology was developed that estimated the effect on operational cost of the unit resulting from the burning of different quality coals (Ref 2). This allowed fuel procurement decisions to be made on the basis of total cost instead of only delivered cost, often resulting in the use of higher quality and/or washed coal.
4) Greatly enhanced unit specific Operations and Maintenance (O & M) procedures and training programs were developed.
5) A system of reporting and analysis of failures was created (Ref 11).
6) Improved repair shop facilities and warehouses were built and a sophisticated spare part management program was implemented.
7) A program for increasing the effectiveness of maintenance and more effectively directing maintenance efforts toward problem areas was adopted, which included the implementation of pro-active maintenance practices such as preventative maintenance and condition monitoring.
8) Southern Company's in-house plant design organization provided increased engineering support to the operating plants during design upgrade projects. Some of those projects included:
    a) Precipitator upgrades to meet new particulate emissions requirements.
    b) Conversion of pressurized fired boilers to balanced draft
    c) Control system upgrades
9) As a result of the designers' ongoing interaction with the operating plants in solving problems at those plants, the next generation of designs incorporated those lessons learned so that they had higher inherent levels of performance.
10) A "best practices" computer database was developed for use by all Southern Company plant's staff.
11) New decision support tools were developed that greatly enhanced the ability of decision makers throughout the company to economically justify and prioritize performance improvement projects as well as make better day-to-day O & M decisions, helping to ensure that optimum use was made of the resources that were available. Key to these tools was the development of a methodology to accurately estimate the value the company would receive resulting from an improvement in performance (availability, heat rate, etc.) of each power plant (Ref 3, 4, 5) and the wide dissemination of these projections throughout the generation organization.

Although it is impossible to allocate what percent of the total availability improvement was due to any one of the above programs (in part because the total improvement was greater than the sum of the individual parts), what should be obvious is that most of these programs were aimed at improving management practices and other human factor issues, with only a minority focusing on new equipment/technology. This is not to belittle the necessity of replacing old worn out equipment or upgrading the plants with advanced technologies, but rather to emphasize the complementary role that enhanced management practices plays in cost-effective improvement.

3.0 HEAT RATE TREND

After the negative availability trend had been reversed the focus shifted to improving the efficiencies of the units. (In the United States the most common measure of efficiency is the term "Heat Rate", in British Thermal Units (BTU) per kilowatt-hour (kWh)). Beginning in the early 1980''s the Southern Company's heat rate began decreasing (improving) due to a similar combination of factors that were responsible for the availability improvement.

Again the increased commitment by executive management to heat rate improvement provided the foundation and environment necessary for the resulting substantial improvement in heat rate of 4.5% over the next several years. The specific programs that were implemented included:

1) Establishing clear, measurable goals for improved heat rate.
2) Developing heat rate improvement training programs for plant staffs.
3) Creating a plant heat rate review board based on the same principles as the generating plant examining board (Ref. 1).
4) Assignment of a heat rate engineer at each plant.
5) Establishing a centralized heat rate-testing group.
6) Installation of cost-effective design upgrades including heat rate monitoring systems.
7) Creation of a system-wide heat rate technical network of experts.

As in the case of the availability improvement, the majority of the heat rate improvement can be attributed to improved management practices (Ref. 6, 7, 8).

4.0 COST AND BENEFITS

The improvement in availability and heat rate was not achieved without a substantial cost, both for equipment upgrades and improved management practices. In terms of 1990 dollars per Kilowatt of installed capacity, Southern Company averaged spending twice as much per year from 1976 to 1990 as had been spent in the early 1970's. This was equivalent to an increase of $325,000,000 per year for production support of its coal-fired units.

The value of this performance improvement to Southern Company, however, was far in excess of these costs and came from four primary areas: 1) replacement energy savings, 2) deferred construction savings, 3) reduced reserve margin requirements savings, and 4) fuel savings. Replacement energy savings relates to the fact that if the more efficient Southern Company units have higher availability, less efficient units will not have to generate power as often and/or the Southern Company will not have to purchase as much higher cost energy from other sources. In addition the increase in energy-producing capability represented by this availability improvement was the equivalent of over 6,000 MW of capacity that could be deferred without adversely affecting the system's customer service reliability. Added to that was a long-term reduction in reserve margin requirements. Finally the improvement in heat rate reduced the amount of coal that was required to be purchased. Taken together the value resulting from the performance improvement of these coal-fired plants was calculated to be $1,343,000,000 per year. Therefore the benefit to cost ratio was 4.13 ($1,343,000,000 / $325,000,000). To put this in perspective the net savings of $1,018,000,000 per year ($1,343,000,000 – $325,000,000) resulting from performance improvement of its coal-fired power plants was over 12% of Southern Company's total annual revenues in 1990 and over 100% of its net income (profit). Therefore, without this performance improvement, Southern Company would have had to raise its rates by over 12% or reduce its profit margin (probably some combination of the two). . Since neither increased rates nor reduced profit margins are desirable, especially in the increasingly competitive business environment facing US utilities today, the crucial importance of the performance improvement achieved by Southern Company's power plants can be readily appreciated.

In addition to these dramatic economic results there was also a positive environmental impact due to a substantial decrease in the plant's emission rates as a result of their performance improvement. As an example, CO2 emissions were reduced by 7,000,000 tons per year, while other types of emissions had similar reductions. In effect, these emissions reductions were realized at zero cost since they were a by-product of the plants' overall performance improvement.

8.0 CONCULSIONS

Several important conclusions can be reached based on the experience of Southern Company, as well as other utilities worldwide which have improved their power plant performance:

1) Performance improvement can be achieved.

2) Performance improvement requires a systematic, comprehensive and continuous program with strong commitment from executive management.

3) Some equipment replacement, refurbishment or upgrades will be required.

4) The majority of the focus should be on improving management practices.

5) The addition of advanced technology power plants combined with improvement in management practices are complementary pieces of the total improvement puzzle.

6) New advanced technology plants will only reach their full inherent design potential if the most effective management practices are applied.

7) Performance improvement of existing power plants is a proven, cost-effective way to increase the energy producing capabilities of a utility while producing substantial environmental benefits.

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