NATIONAL ENERGY TECHNOLOGY LABORATORY

Potential Impact of Improved Sensors, Controls on Coal-Fired Power Plant Forced Outages

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Introduction

DOE's National Energy Technology Laboratory (NETL) is funding advanced research into sensors and control technologies that have the potential for operational improvements that could decrease the annual number of forced outage hours experienced by a Coal-Fired Power Plant (CFPP). This paper examines the potential economic impact of improvements in unit availability due to advances in sensors and controls technology.

Historically a CFPP unit is forced to shut down between 200 and 600 hours per year due to unexpected component failures or human error as shown in Exhibit 1[1]. These forced outages represent a significant loss of revenue to the utility.

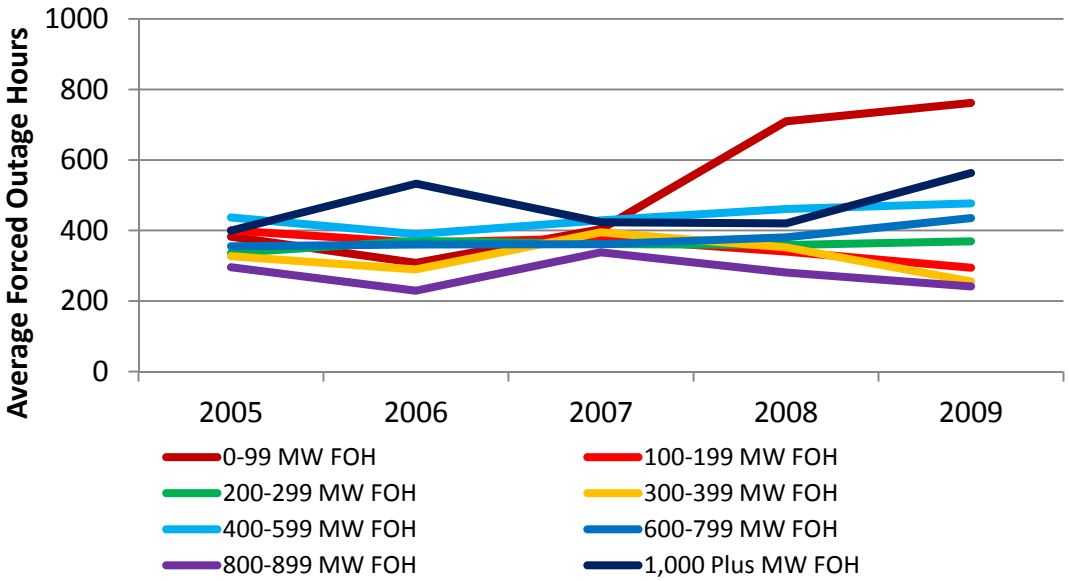

Exhibit 1 Average Forced Outage by Unit Size[1]

The vast majority of forced outages are attributed to failures of boiler components (see Exhibit 2). Balance of plant components (fans, pumps, compressors, etc.) are the next leading cause followed by steam turbine issues.

[1] The outage data was obtained from the North American Electric Reliability Corporation (NERC) Generating Availability Data System (GADS) for coal-fired units from 2005 through 2009.

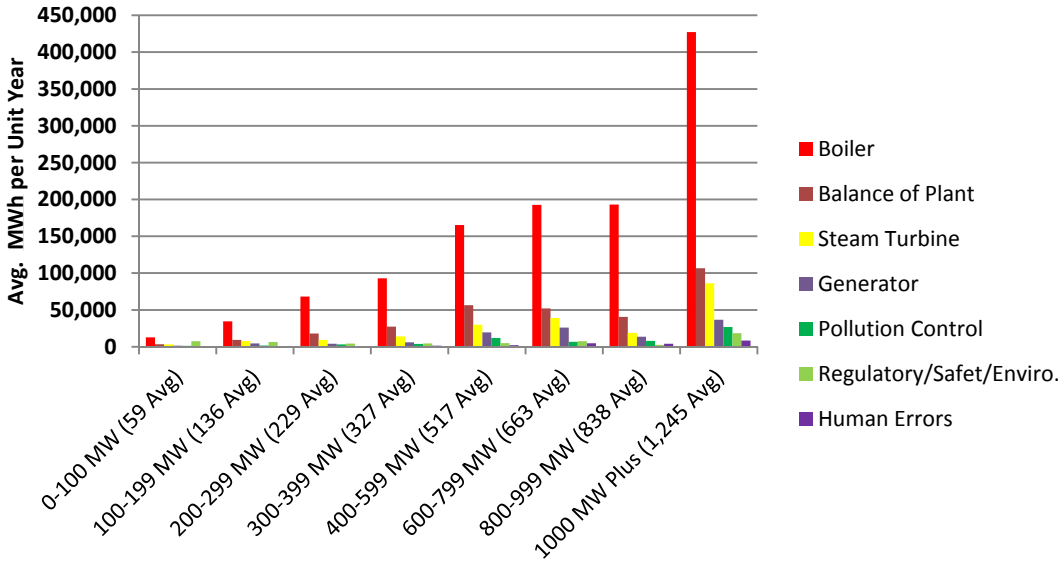

Exhibit 2 2005-2009 Average Forced Outages and Derates[1]

Potential Improvements

Advanced sensors and controls have the potential to significantly decrease the number of forced outage hours experienced by a coal fired unit. Boiler operations could be improved by providing the operator with better information about the local temperature profiles, combustion properties, tube conditions, etc. Turbine operation could be extended through better monitoring of blade and bearing temperatures and vibration. Balance of plant equipment life could be extended though controls that can be tuned to optimize the operation of each component. Advanced controls on pollution control equipment could significantly reduce maintenance requirement through better flow control and system optimization. Although human errors account for only a small percentage of the forced outage hours (approximately 8,000 MWh for 1,000 MW plus units) there is potential for advanced controls to significantly reduce this number through the use of automated systems that prevent errors that cause equipment damage.

Based on discussions with experts on CFPP operations and maintenance, improvement potential factors were developed (see Table below). Given that many of the advanced sensors and controls being researched and developed under the NETL program are in the early stage of development, the estimated percentage improvement of each component represents an "an approximate improvement potential," and may in fact turn out to be a conservative estimate when actual advanced sensors and controls data become available. As these technologies are further developed and tested in the plant environment, better estimates of improvement potential will be developed.

The improvement potential estimates listed below are the expected percentage decrease in the number of forced outage hours attributed to each component.

Advanced Sensor and Controls Improvement Potential Estimates

Component	Estimated % Improvement
Boiler	10%
Turbine	30%
Balance of Plant	30%
Pollution Control	50%
Human Errors	90%
Regulatory/Safety/Environment	5%

Potential Economic Impact

There is a significant positive impact on a unit's operating revenues by decreasing the annual number of forced outage hours. This impact becomes more pronounced as the unit size increases.

For this analysis, the revenue loss calculated per unit is equal to the forced outage hours multiplied by the amount of power generated and the wholesale price of the power. The total revenue loss is the incremental sum from each component. A power price of $55.07/MWh was used which was the average of weighted prices in the PJM, NEPOOL, and ERCOT markets from January through March 2011.

Exhibit 3 illustrates the revenue loss due to forced outages and derates. An average 1,245 MW unit has historically lost approximately 570 operation hours per year, which translates to 710,000 MWh of lost generation – costing the unit's operator almost $40 million. Conversely, revenue loss is significantly less at small units due to reduced generating capacity.

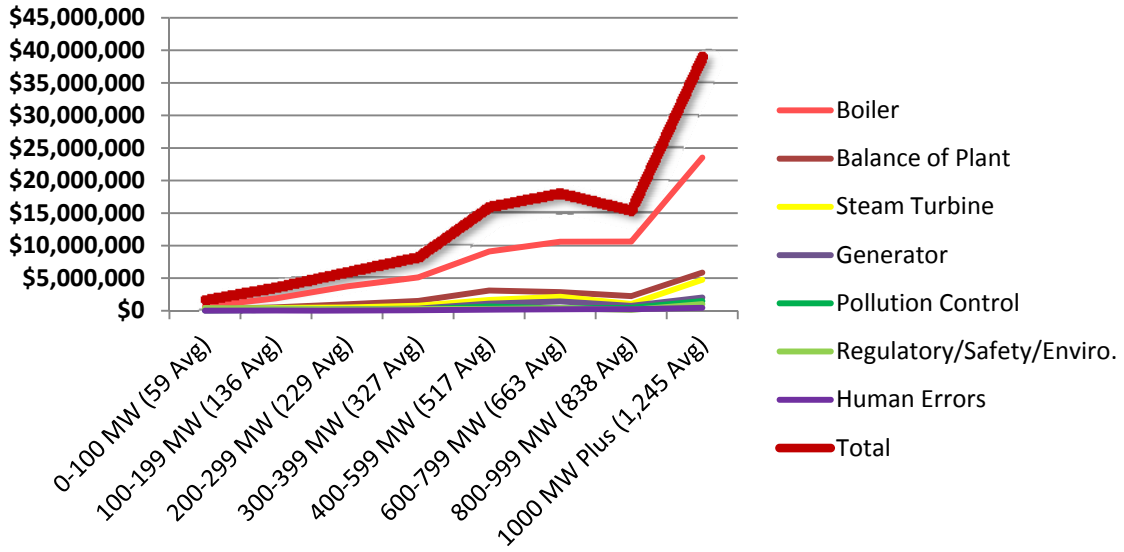

Exhibit 3 2005-2009 Average Annual Unit Revenue Loss due to Forced Outages and Derates

When the advanced sensors and controls improvement factors listed above are applied, the potential increase in revenue due to additional unit operational hours can be significant. For instance, an average 1,245 MW unit could experience an increase of approximately 100 operational hours resulting in increased revenue of nearly $7 million per year as shown in Exhibit 4.

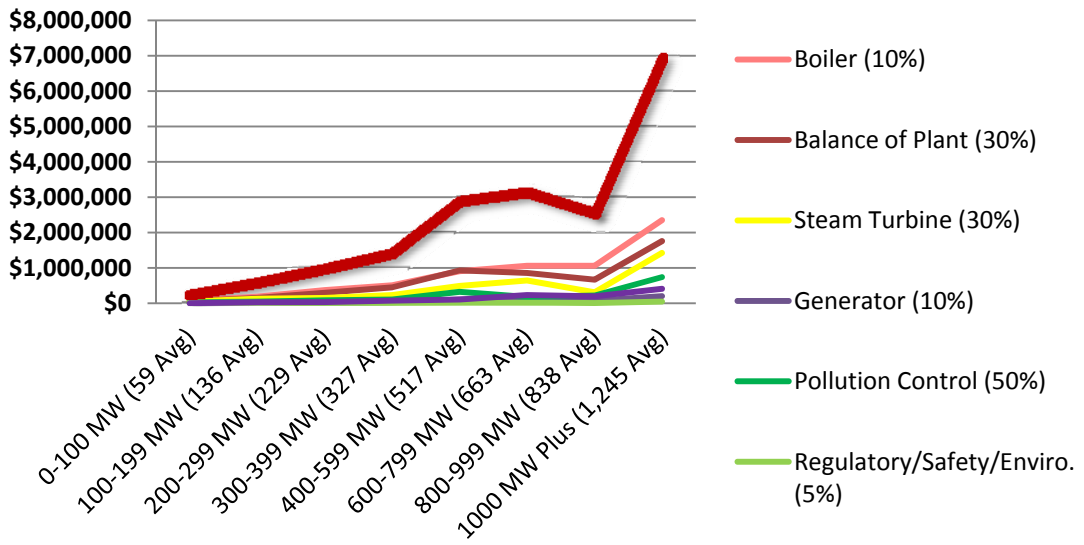

Exhibit 4 2005-2009 Average Potential Annual Plant Revenue Increase Due Decreased Forced Outages and Derates

In addition to increasing revenue, decreased forced outage hours will reduce contract maintenance costs. Typically when a unit is forced offline, contract trades (boilermakers, pipefitters, sheetmetal workers, etc.) are brought in to complete the repairs. These repairs can often last 21 – 28 days and cost between $1.5 and $3.0 million.[2] An hourly "high" cost of repairs was developed by assuming 21 days at $3.0 million or $5,952 per hour. When this cost is applied to the potential decreased outage hours it works out to be an additional savings of $250k to $500k as shown in Exhibit 5

[2] Communication with WorleyParsons' Group Inc.

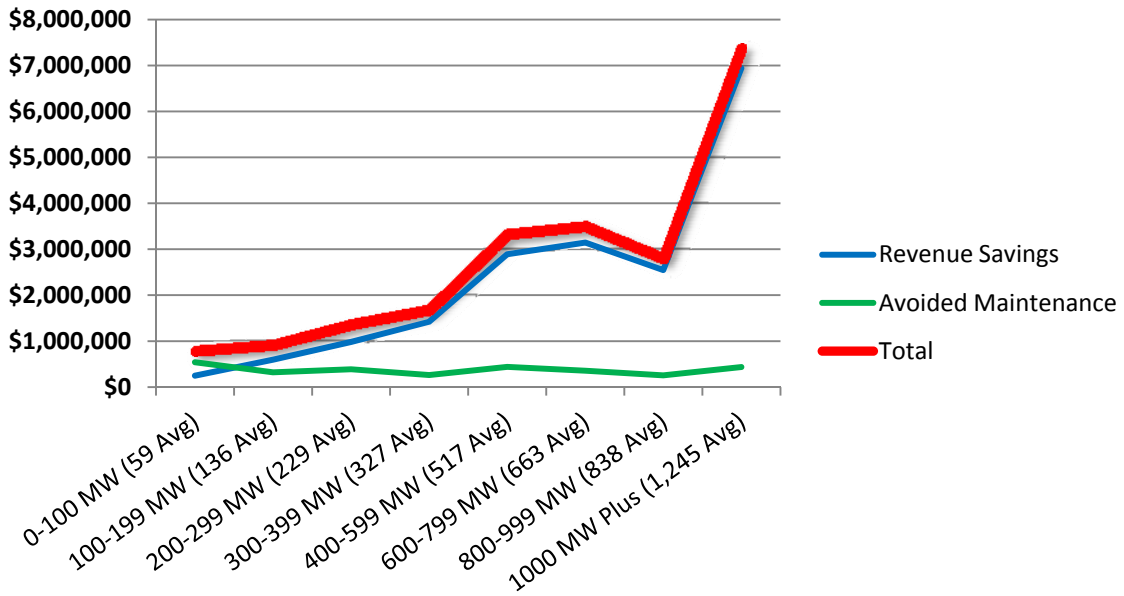

Exhibit 5 2005-2009 Average Potential Annual Plant Savings due to Revenue Increase and Avoided Maintenance

Conclusions

While advanced sensor and control technologies may allow a CFPP to run more efficiently, they also have the potential to reduce the number of unit forced outages. Because of the significant economic impact, utilities will be more interested in investing/implementing advanced technologies that reduce forced outages, especially at their large base loaded units. Operators will be more likely to invest in sensor and control upgrades at their larger units because the revenue impact is significantly more and the payback on the investment is shorter.

If sensor and control upgrades can provide the plant-wide improvements assumed in this analysis, than the simple payback of a $1 million upgrade would be a year or less for most units. There appears to be a break in the revenue savings curve around the 300 - 400 MW unit size indicating that major upgrades costing more than $1 million may be more economically viable for units above this size.

Recommendations

The potential capabilities and costs of the sensors and controls under development should be better understood. The advanced technologies should also be evaluated not only on their operational/efficiency potential, but also their effect on forced outages. This better economic understanding should lead to earlier industry interest and faster development and introduction.