EPRI Heat Rate Conference February 2009

The Unintended Consequences of New Source Review (NSR)
Imagine What the Utility Industry Could do without NSR

Dick Storm, Senior Consultant
Storm Technologies, Inc.

Abstract:

This presentation will review some Examples of What America Could Do to Reduce Carbon Dioxide, and Improve Coal Plant Efficiency, if "New Source Review" was not a factor for Major Modifications and Upgrades.

The New Source Review Rule (NSR) has been in effect for over a decade. This presentation will discuss opportunities that could be possible, were it not for the obstruction of progress of NSR. The presentation will cover personal experiences of the author where large coal fueled utility boilers had/and still have significant opportunities for improvement. Performance improvement changes have not been considered at some plants, because of the threat of NSR penalties. Yet, the opportunities for improvement have been documented and proven. [1, 2, 3, 4, 5, 7, 8]

It seems foolish for us as an industry to not actively pursue changing counter-productive environmental rules that actually work against responsible environmental stewardship and the best interests of America?[8]

These archaic rules, as understood by the author actually penalize a large utility boiler owner for doing the right things for efficiency, lower cost power generation, fuels flexibility and reduced carbon dioxide emissions.[6,8]

Because NSR was implemented for environmental protection reasoning, it definitely fits as an example of large unintended consequences from a rule or law that may have had good intentions.

The presentation will review three examples of corrective actions that could cost-effectively be made to save in the magnitude of 500 to 1,000 Btu's per kWh heat rate improvement.

From a reduction in carbon basis, consider this: If the existing fleet of coal plants were upgraded to improve efficiency by 5% for all plants, the CO_2 reduction could be more than 500 million tons per year. [6]

Also, if the entire existing fleet of coal plants was increased in efficiency by 1%, it would generate for no carbon increase about the same amount of electricity as all non-hydro renewable electricity in 2005 (60 billion kWh). [6]

There is 335,830MW's [12] of coal power generation capacity in America. A five percent increase in capacity is enough power to supply a small state and of course a five percent improvement in efficiency would exceed the total installed wind power capacity of 2007. [11] Coal plant capacity is more reliable than wind or solar and can provide power 24/7 when the electric load demands power. Further, coal plants perform at proven high reliability as required by an industrialized economy.

Additional base load generation is necessary to provide reliable baseload generation for a projected increasing demand. Upgrading the existing coal fleet would seem to be picking the low hanging fruit of how to develop 15-17,000 MW of clean coal generation. [9, 10, 12]

From a cost viewpoint, upgrading the existing coal fleet would be some of the least cost base load power generation new capacity that could be selected. [13]

The abolishment of NSR is simply the right thing to do.

1.0 Introduction

The typical pulverized coal power plant in America is about 35 years old. These plants, though old, are expected to be required to generate electricity for decades to come for various reasons of difficulty in siting and permitting new plants and public opposition to smoke stacks. Coal is absolutely necessary as a major energy source as far as we can see into the future. [9, 10, 12, 13]

Since the design and start up of these plants in the 1970's or before there are a number of changes that have taken place. Amongst them:

- The existing equipment has aged and cannot perform as well as a new plant. The NSR rule has provided a disincentive for improvements in efficiency and made the term "upgrade" a dirty word.

- New environmental standards have required extremely expensive and comprehensive back end stack clean up equipment. Essentially, any coal plant with highly efficient fabric filters, highly efficient electrostatic precipitators, an SCR (Selective Catalytic Reactor) and FGD (Flue Gas Desulfurization) should be considered a "Clean Coal Plant" These retrofits are completed on most large coal plants.

- New technologies and designs of steam plant components have become available for retrofitting, that were not available or known in the mid 1970's. Such as advanced steam turbine rotor blade design [2, 3, 4, 5], controls technology [7], improved metallurgical materials, and boiler fire-side cleaning technologies for firing fuels of lower quality. [14]

- Over the life of the existing coal fleet, fuel costs have escalated by a factor of ten in cost per million Btu's, making efficiency improvements more attractive now than in the original design time period. Such as larger and more efficient air heaters for reducing the boiler exit gas temperatures to a lower level and reducing air leakage rates. Easily understood and documented improvements are available for steam cycle upgrades such as, installing more advanced and larger condensers or cooling towers for improved turbine performance. Steam turbine uprate potential is well documented and proven.

Here are some examples of significant improvements that could be implemented for less cost than the equivalent installed new generation capacity. Estimated to be well below $2,000kWh, and well below the installed cost of any renewable power.

The NSR process has created conditions that have rewarded mediocre steam plant performance and provided a disincentive for steam plant efficiency improvements. The overall result of NSR has been that worse plant performance has resulted, rather than improved. [6,8] Stack emissions have been substantially reduced. Worse plant performance is referring to thermal performance.

It is in the best interest of America to abolish NSR. This is for at least six reasons: 1.) Reduce power generation costs for all, 2.) For us to be "Good Steward's" of America's traditional fuel source for over 48% of our nation's electricity generation, 3.) Increase generation from native American fuels by about 5% from existing plants, 4.) Increase the base load generation capability and efficiency to support America's industrial base, 5.) accommodate more renewable power generation from less consistent power sources, such as wind, and 6.) Reduce the CO_2 emissions of America's coal fleet.

2.0 Three Typical Coal Plants to Consider

Plant "A"

600 MW Pulverized Coal 2400 psi/1,000°F./1,000°F corner fired unit firing western PRB fuel

Plant "B"

500 MW Pulverized Coal 2400 psi/1,000°F./1,000°F wall fired unit firing western PRB fuel

Plant "C"

650 MW Pulverized Coal 2400 psi/1,000°F./ 1,000°F wall fired unit firing eastern bituminous coal fuel

Here are some of the changes that could be implemented to these boilers, were they not constrained by NSR:

- Install new regenerative airheaters and replace aging ductwork from the boiler to the I.D. Fans.
- Change the superheater and reheater surfaces to permit the furnace exit gas temperatures to be combustion tuned to be consistent with new fuel source requirements. Some boilers have insufficient superheater or reheater surface to produce design steam temperatures with a furnace side best possible FEGT. The insufficient SH and RH surface then requires that the FEGT (Furnace Exit Gas Temperature) be driven to higher than optimum temperatures. Therefore the higher than optimum FEGT required for best steam-side thermal performance is not compatible for the best fire-side slagging and fouling performance. Storm calls this a "Fire Side/Steam Side" incompatibility. In other words, to achieve design steam temperatures the furnace exit gas temperature must be driven above the ash softening temperature, thus creating excessive slagging and fouling that requires extreme sootblowing of the high temperature superheater and high temperature reheater. The elevated upper furnace temperatures contribute to accelerated slagging and fouling which is mitigated by aggressive sootblowing. The high sootblowing medium consumption wastes high energy steam from the cycle. Further, the reliability of the boiler is affected by sootblower erosion. Cinders removed from the high temperature tube surfaces entrain in the flue gas steam and foul the SCR and airheaters. Also, there is some opportunity to reduce the flue gas temperature before leaving the economizer for reasons of both reliability and efficiency.
- Upgrade the alloy of the existing superheaters and reheaters.
- Replace existing feedwater heaters with upgraded alloy and improved heaters.
- Redesign and upgrade the furnace waterwalls and add water-cooled platens.
- Installing new and larger condensers and/or cooling towers for reduced condenser back pressure.
- Install hybrid air cooled/water-cooled condensers to reduce cooling water usage
- Install new more efficient steam turbine rotors to upgrade and uprate capacity and efficiency.
- Install larger boiler feedpumps to compliment an uprated boiler and turbine and increased steam flows.
- Other changes as required to "de-bottleneck" both the combustion process and the steam cycle.
- Upgrade coal pulverizers for less auxiliary power consumption and larger capacity, better fineness.

3.0 Plant "A" 600 MW Corner Fired Unit - Steam-Side/Fire-Side Incompatibility

This boiler side elevation is shown on Figure 1. The original design was for a higher quality fuel than presently fired. PRB (Powder River Basin) sub bituminous fuel is now attractive to use for reasons of sulfur, price, availability and NO_x. The PRB fuel operates best when the Furnace Exit Gas

Temperature is about 2,150°F. For both reasons of a fuel change over the operating life of the plant and the changing firing conditions of low NO_X operations, the furnace exit gas temperature (FEGT) now tends to operate at about 2,400°F rather than the desired 2,150°F preferred for reduced slagging and fouling. It has been demonstrated that the firing conditions can be tuned for a reduced FEGT, in the range of 2,150°F. The reduced FEGT is desirable for reduced slagging and less aggressive sootblowing. When the FEGT is reduced for more favorable fire-side slagging and fouling conditions, then the superheater and reheater temperatures cannot achieve the design and required 1,005°F. This is an example of what we refer to as “Fire Side/Steam Side Incompatibility”.

In a perfect world with no NSR here are real world practical changes that could be implemented on this 600MW, 30 year old plant. The technology to apply these modifications and upgrades is proven and can be implemented with a high level of confidence in their success.

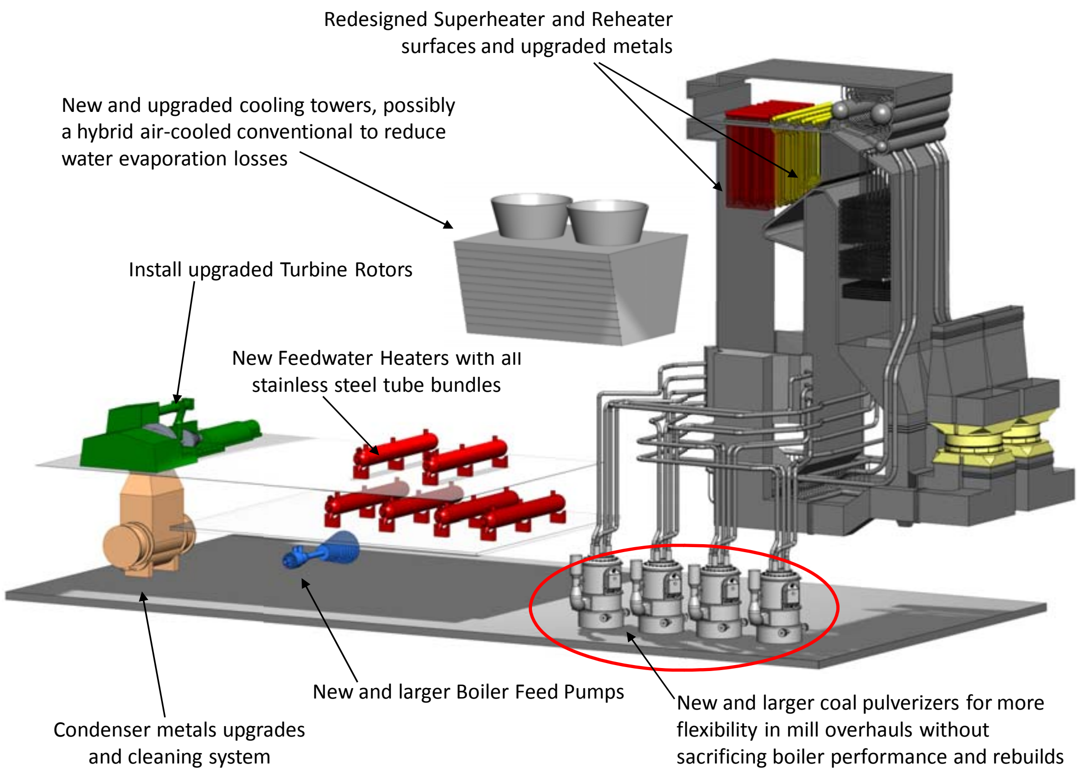

Figure 1

The changes which could be applied to this boiler are: Complete resdesign of the superheater and reheater, to add more surface and upgrade the alloy for increased reliability and life. These boiler upgrades are expected to cost about five million dollars. The turbine rotors and steam path improvements are also feasible and between the combination of steam path improvements and boiler surface changes, it is expected that an additional 50MW in power output could be achieved, and a savings of 300-500 Btu’s/kWh in heat rate.

The balance of plant improvements are suggested for consideration for purposes of reliability, capacity, efficiency and reduction in plant water consumption. The idea of a hybrid air-cooled/evaporative cooling tower is suggested because in many localities water evaporation is a growing concern. By improving heat-rate and reducing the heat rejection to the cooling towers, some evaporation losses could be an additional benefit. When changes to the cooling water cycle are considered then the prospect of using an air-cooled condenser for part of the condenser heat removal reduces plant water consumption.

4.0 Plant "B" 500 MW Wall Fired, 2,400 psi/1,000°F./1,000°F- Another Steam-Side/Fire-Side Incompatibility

This wall fired boiler has a similar steam side, fire side incompatibility. The FEGT (Furnace Exit Gas Temperature) must be increased to over 2,300°F average bulk gas temperature in order to reach the design steam temperature.

Again, the redesign of the superheater and reheater on this boiler to match the heat transfer surfaces with the present day fuels and steam demand will yield significant overall heat rate improvement.

Combining the boiler improvements with uprated and upgraded steam turbine rotors and controls could conceivably increase output 35MW or more and also improve the overall heat rate by 500 Btu's/kWh.

Boiler Upgrades to Consider for Maximum Efficiency, Reliability and Increased Capacity

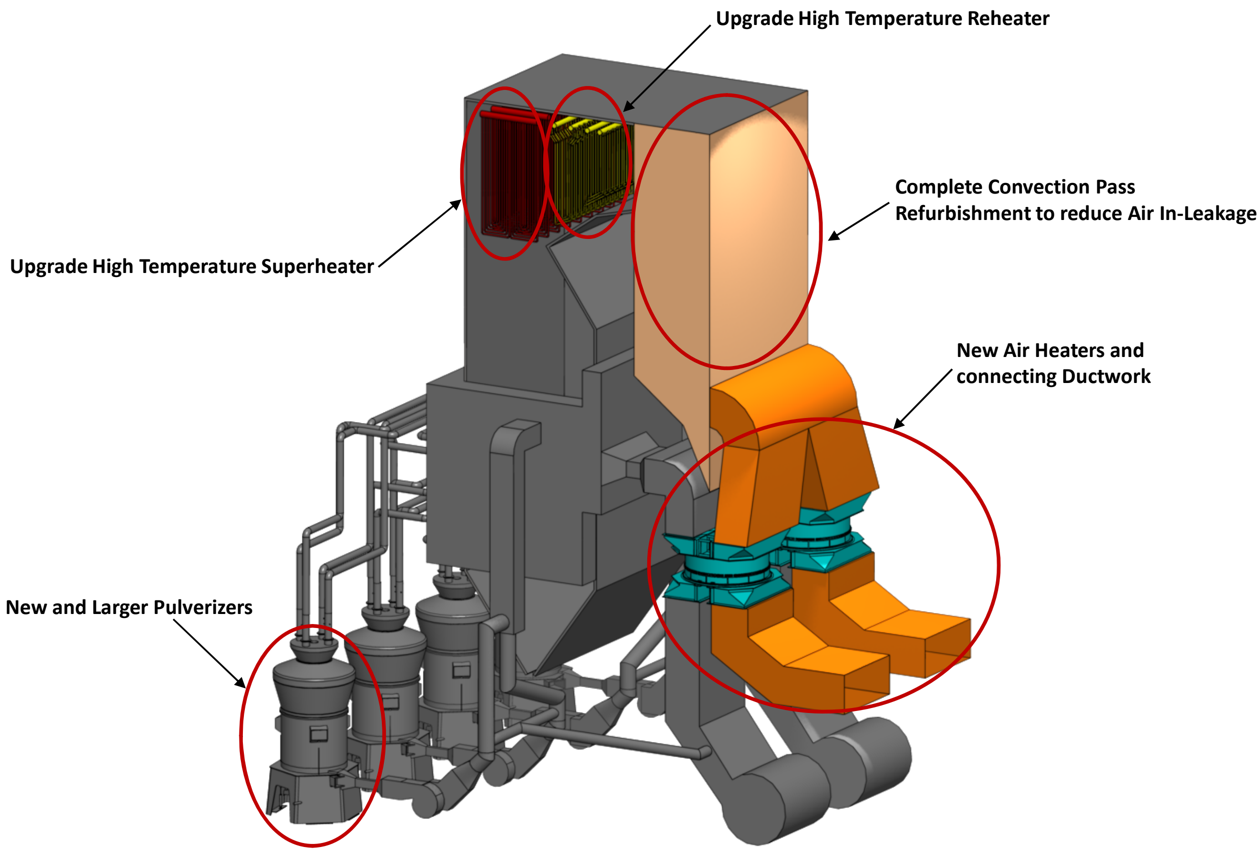

Figure 2

5.0 Plant "C" 650 MW Wall Fired, 2,400 psi/1,000°F./ 1,000°F- Air Heater Replacements

The improvement potential for this boiler is mainly focused on the boiler exit gas ductwork and airheater replacements.

The present airheaters are an unusual design and tend to have leakage rates well over 15% at Best. Also, the exit gas temperature corrected to no leakage have opportunity to be reduced at least 35°F. The combination of replacing the airheaters with the latest and most advanced regenerative airheaters, increasing the heat transfer and reducing the total leakage can improve heat rate by about 200 Btu's/kWh.

Combining the improvements of the combustion process with advanced steam turbine rotors and steam path improvements could result in a 50 MW increase in capacity and an estimated overall heat rate improvement of about 500 Btu's/kWh or better.

Boiler Improvement Potential for Heat Rate, Capacity and Reliability Improvement

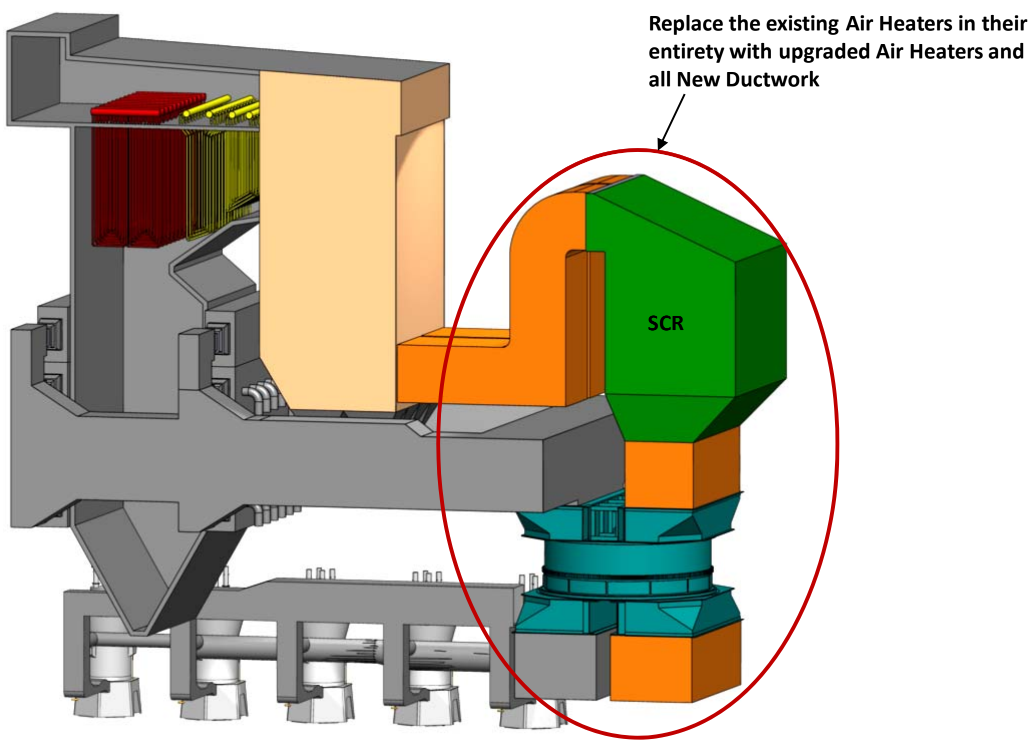

Figure 3

Summary

We cannot name the plants where we have made these observations, for obvious reasons. The examples above present huge incentives in both CO_2 reductions as well as fuel cost savings and capacity increases. These changes if they were permitted could be done for far less cost than equivalent new generation capacity, and even for less cost of carbon capture than installing new renewable power of similar capacity. [1, 6, 8] The costs the author has seen for proposed renewable power range from $3,000/kWh to $10,000/kWh. Although renewable are good to build and also the right thing to do, where practical, upgrading the coal fleet in capacity and efficiency is also the right thing to do for America.

Case Study	Unit Description	Modifications / Factors of poor performance / reduce efficiency	Expected Cost	Expected Efficiency Gain (%)	Expected Savings ($) with Efficiency Gains first year
1	500 MW Tangential Fired Sub-Critical Unit	Addition of SH & RH Surface to lower FEGT in conjunction	$5 million	5 to 7%	$4.6 to 6.4 million based on current fuel cost of $2.50 mmbtu.
2	600 MW Wall Fired Sub-Critical Unit	Replacement of Air Heater	$16 million	5 to 7%	$6.6 to 9.3 million based on current fuel cost of $3 mmbtu.
3	250 MW Wall Fired Super Critical Unit	FW Heater Replacements	$1 million	1 to 2%	$0.33 to 0.67 million based on current fuel cost of $1.82 mmbtu.
4	325 MW Tangential Fired Super Critical Unit	Flue Gas Temperature High LOI's Increased Fan Usage High Spray Flow **Total Cost Per Year**	$2.1 million $0.43 million $0.47 million $1.12 million **$4.1 million**	8%	$4.1 million based on current fuel cost of $2.17 mmbtu.
5	160 MW Wall Fired Sub-Critical Unit	Uprate in Primary Air Fans, Pulverizer Mill Motors & OFA System	4,500,000	Ability to be fuel flexible. Typically the environmental friendly coal (i.e. PRB & Adaro) which has a lower fuel bound nitrogen content will have lower HHV and require more fuel to be burned to maintain same MW output.	1 yr
6*	167 MW Wall Fired Sup-Critical Unit	Pulverizer Rebuilds & OFA System	4,200,000	Ability to be fuel flexible and 40 to 60% reduction in NO_X emissions	1 yr
7*	90 MW Tangential Fired Sub-Critical Unit	Pulverizer Rebuilds & OFA System	2,250,000	Ability to be fuel flexible and 40 to 60% reduction in NO_X emissions	1 yr

*Denotes project that was completed

Figure 4

The rough costs and benefits are provided on Figure 4 of some additional examples of practical improvements that could be implemented were it not for NSR. Some additional projects that have been completed are included just to show that truly, some of these kinds of “major changes” can be accomplished very cost-effectively.

We understand that NSR is a political problem not a technical one that EPRI can solve. But the fact is there is enormous savings in fuel cost and CO_2 emissions if NSR was abolished. Perhaps an even more important benefit in uprating the existing coal fleet capacity is producing the increased electric power that America needs from a proven and reliable fuel source available within our boarders and abundantly available.

References

[1] ***"Reducing CO_2 Emissions by improving the efficiency of the existing Coal-Fired Power Plant Fleet"*** DOE-NETL, July 23, 2008

[2] ***"Steam Turbine Upgrading: Low Hanging Fruit"*** Dr. Robert Peltier, POWER Magazine, April 2006

[3] ***"The Deployment of Clean Power Systems for Coal"*** Nick Otter, Alstom CCT 2007

[4] ***"Steam Turbine Uprates"*** J. F. Lesiuk G-E GER – 4199 GE Power Systems

[5] ***"New Benchmarks for Steam Turbine Efficiency"*** Dr. Alexander S. Leyzerovich, Power Engineering, August 2002

[6] ***"NSR and Greenhouse Gas Emissions"*** American Coalition for Clean Coal Electricity, 2008

[7] ***"Industrial Steam, Turbine Value Packages"*** Mark Scoretz, Raymond Williams, GE Energy, January 2008

[8] ***"Regulating by Vintage: Let's put a cork in it"*** Robert N. Stavins, Professor of Business and Government, Harvard University. The Environmental Forum, The Environmental Law Institute, 2005

[9] ***"The NextGen Energy Council"*** Management Information Services, Inc. September 2008

[10] ***"America Needs New Power Plants"*** Eugene M. Trisko, January 2006

[11] ***"American Wind Energy Association Press Release"*** January 17, 2008

[12] ***"EIA (Energy Information Administration) Official Energy Statistics from the US Government"*** 2006

[13] ***"Busbar Estimates, $/MWh, page 3 of SCANA Corporation Mid-Year Report July 2008, showing the justification of new nuclear and comparisons of production costs of ten sources of new power generation seven of the 10 being renewable"***

[14] Clyde Bergmann's Boiler Cleaning Symposium, 2008