Optimization of Air Pollution Control Equipment

Presented by: Bill Poe
Invensys Operations Management
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Optimization Opportunities

1. Emissions reduction (NOx, SOx, Hg, Opacity)
   - CSAPR raises need for NOx and Sox reduction
   - Low NOx burners and overfire air systems optimization
2. Heat Rate Reduction
3. Faster and More Efficient Ramping
4. Reduced EFOR
5. Improved Coal Mill Operations
6. Improved Post-Combustion Operations

Optimization Opportunities and Benefits

Pre-Combustion

- Coal/Fuel Blending Optimization – 1-2% production increase
- Mill Optimization – lower LOI, heat rate improvement, pluggage detection

Combustion

- NOx Reduction – 10-30%
- Heat Rate Improvement – 0.25-1.5%
- Dynamic Steam Temperature Control – +/- 1%, reduce steam turbine cyclic life expenditure
- Ramp Rate Improvement – up to 100%
- Intelligent Soot-blowing – up to 0.25% heat rate improvement, lower EFOR
- LOI Reduction – 10-30%

Post-Combustion

- SCR's – Reduce NH_3 slip; Lower capital equipment costs;
  - 2% additional reduction in NOx
- FGD's – Increase SO_2 removal efficiency with less limestone consumption

Typical Results

Site	NOx Reduction	Heat Rate Improvement	Annual Benefit
A (340 MW CE Gas)	12.3%	0.65%	$950,000
B (195 MW CE Twin Furnace)	>10%	>0.5%	$325,000
C (600 MW B&W Supercritical)	15-20%	0.5%	$1,200,000
D (850 MW CE Split Furnace)	24%	0.68%	$1,418,000
E (850 MW CE Split Furnace)	18%	0.98%	$2,043,000

Ramp Rate Enhancements

- Steam Temperature Control Impact
- Sliding Throttle Pressure Optimization

Relative Ramp Rate Improvement – 2% - 4%

Coal Price - $2.00 per MMBTU

Fuel Displaced Price - $5.00 per MMBTU

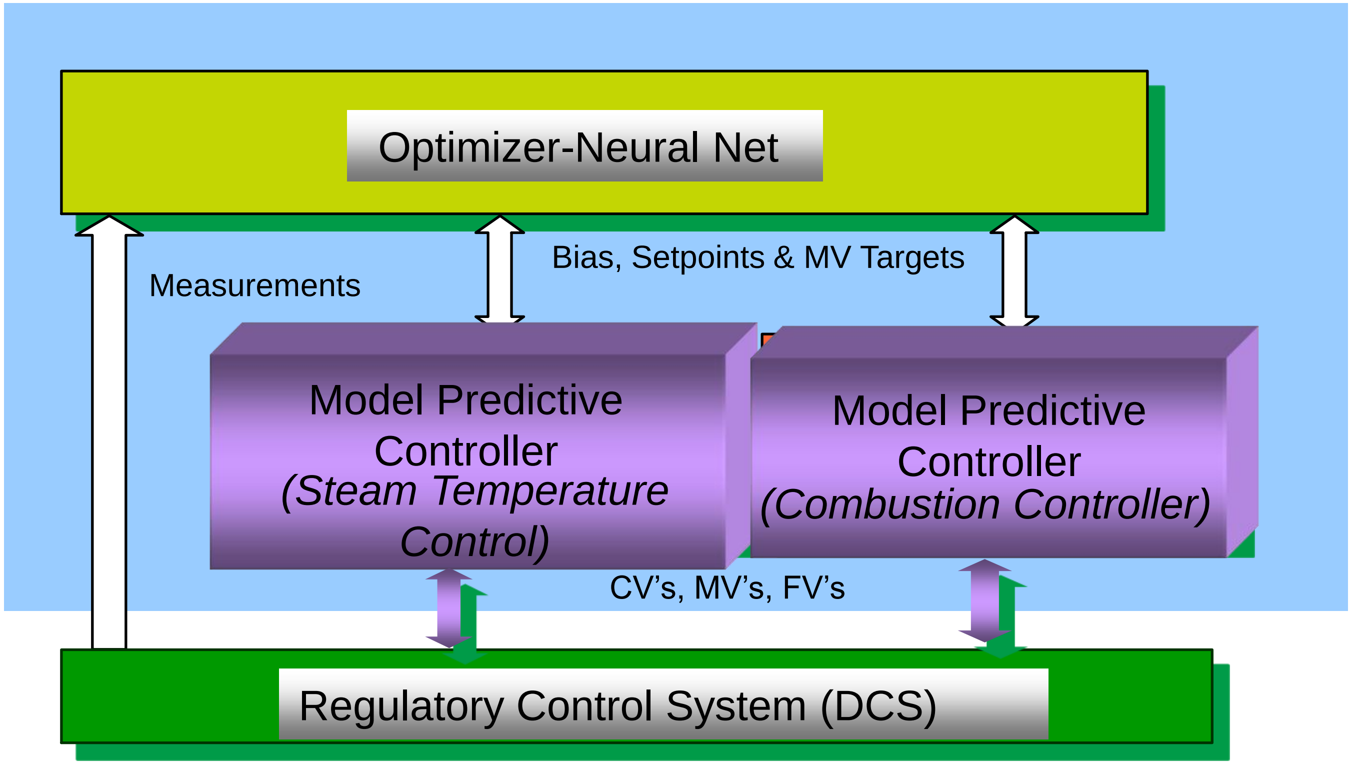
Ramp up and down to 50% load once per day

$250,000 per year for 250 MW plant

Soot Blowing Optimization Benefits

- Improve Heat Rate by up to 0.25% by improving heat transfer ($185,000 per year for 250 MW plant)
- Reduce NOx 5-10%
- Reduce or eliminate the need for units to drop load for a de-slag
- ***Significantly reduce tube erosion***
- Automatically operate the current systems, in closed loop mode, on all units with very little operator intervention.
- Ties together or coordinates the various Water Cannons and Steam Soot Blowers

New Approach to Nonlinear Control



Combination Neural Net / Model Predictive Control

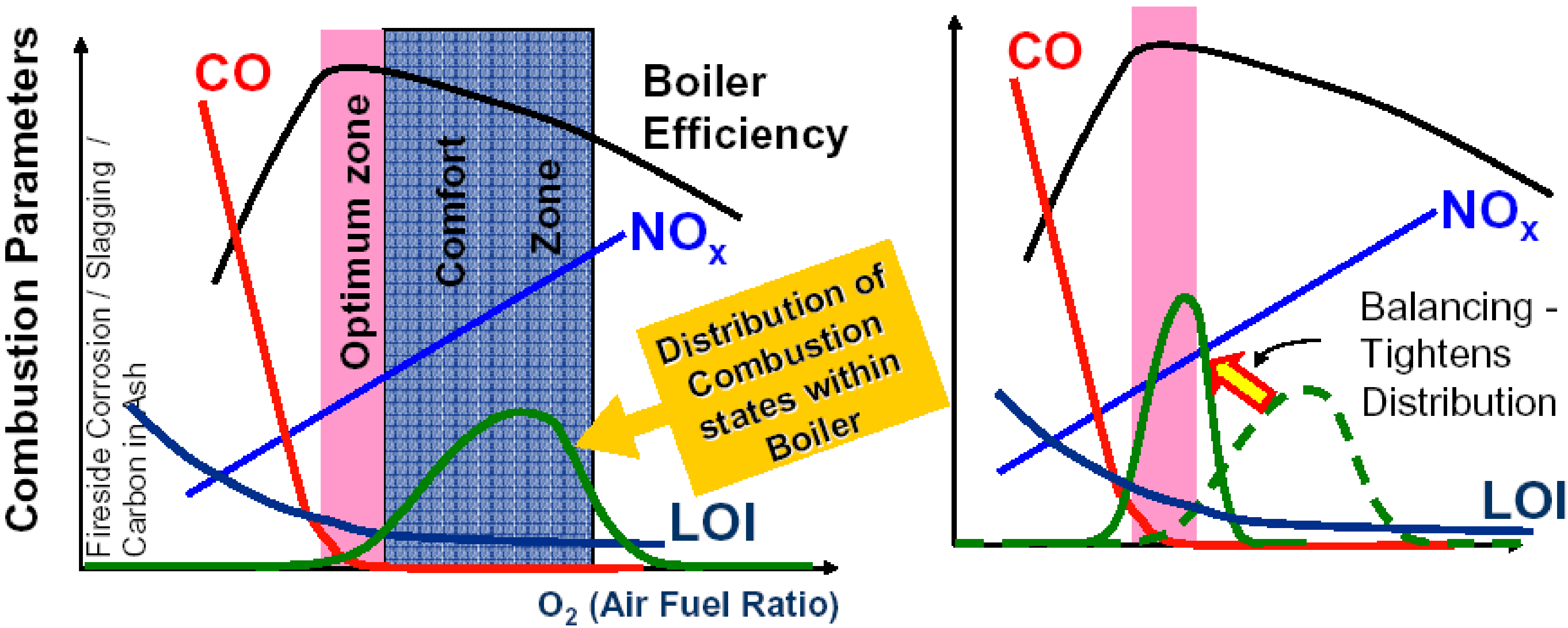
Model Predictive Control Algorithms

- In Use since the 1970s
- Superior Dynamic Response
- Ideal for Constraint Control
- Inherently Linear

Radial Basis Function Neural Nets

- Developed For Identifying Dynamic Data
- Allows Nonlinear Modelling

Combustion Optimization



Initial distribution of boiler combustion– poor performance on both tails

Optimize – tighten and shift distribution

Combustion Optimization Case Study

Heat Rate Improvement: 0.68%

NOx Reduction: 24% Average

- **30% Maximum reduction; 22% Minimum reduction**

On-line time 97.6%

- **High Operator Acceptance**

Improved Steam Temperature Control:

- **Superheater Steam T exceeded 1010°F < 1%**

More effective Soot Blowing Strategy

- **Reduced Maintenance on the ash hopper**
- **Less tube erosion ($100K per yeat)**

More effective control strategies/limits defined…

Estimated Fuel Cost Savings - $709,000/yr /unit
(cap. factor 0.7 at fuel cost of $2/MMBTU)

Summary

- Model Predictive, Multivariable Control complemented by Neural Networks is effective for reducing emissions and optimizing air pollution control systems while achieving fast and accurate dynamic response
- Improved load response, better steam temperature control and more effective soot blowing can be achieved while reducing emissions
- Proven results