Zonal* Combustion Optimization for Coal-Fired Boilers

McIlvaine Hot Topic Hour

Neil Widmer and Antonio Marquez
Boiler Optimization Services
September 27, 2012

imagination at work

* Trademark of General Electric Company

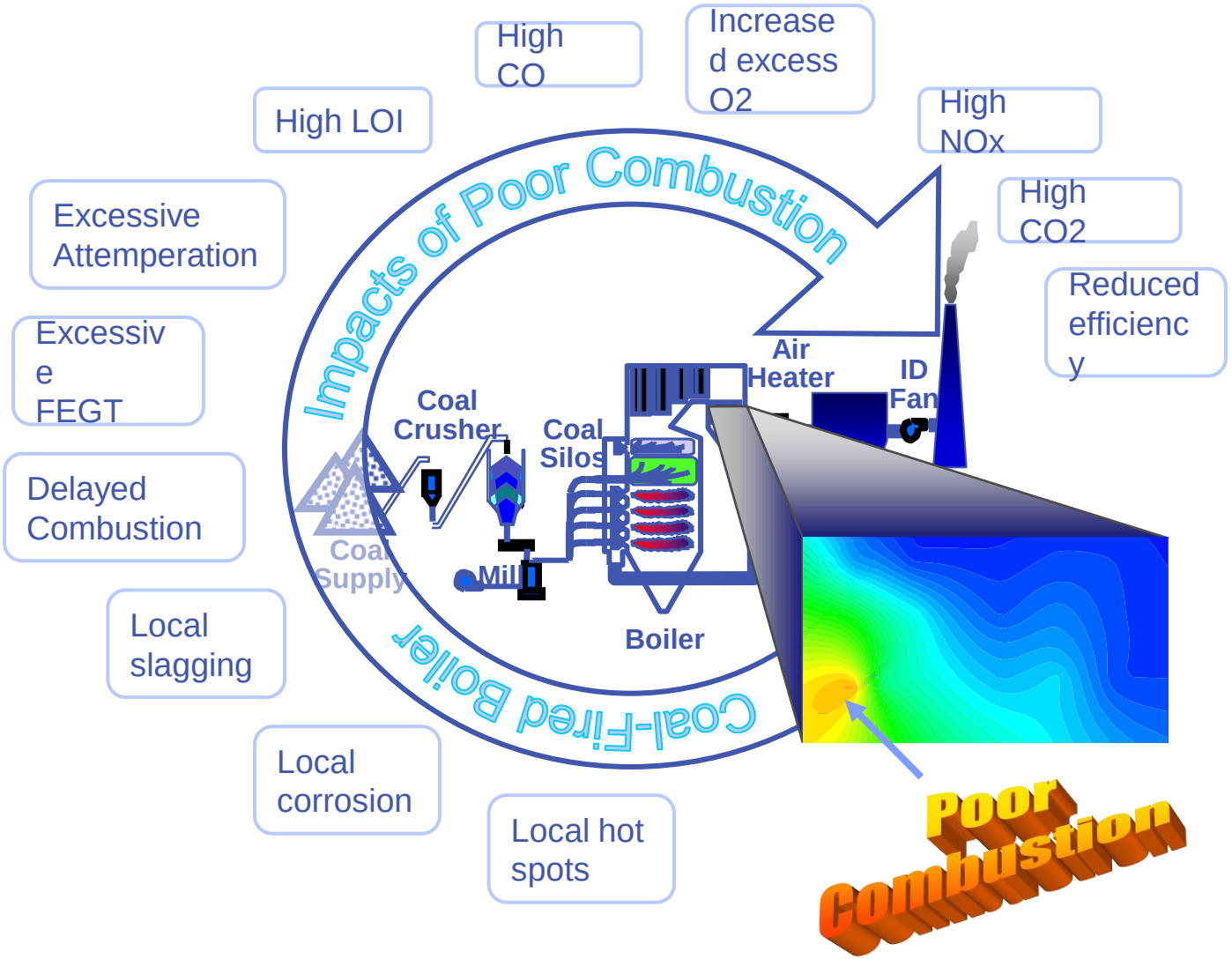
a product of ecomagination℠

Outline

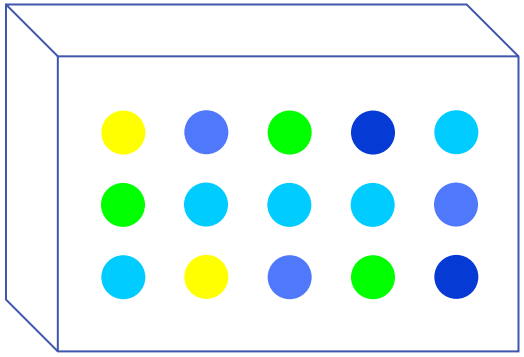
- Principles of combustion optimization … how to obtain the optimum efficiency, availability and performance
- Available approaches
- GE's Zonal combustion approach
  - Overview
  - Applicability
  - Capabilities
  - Limitations
  - Cost/Benefit
- Real world experience

Principles of Optimization

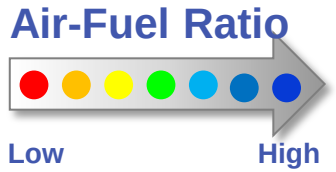
Combustion is a major contributor to coal-fired boiler performance losses

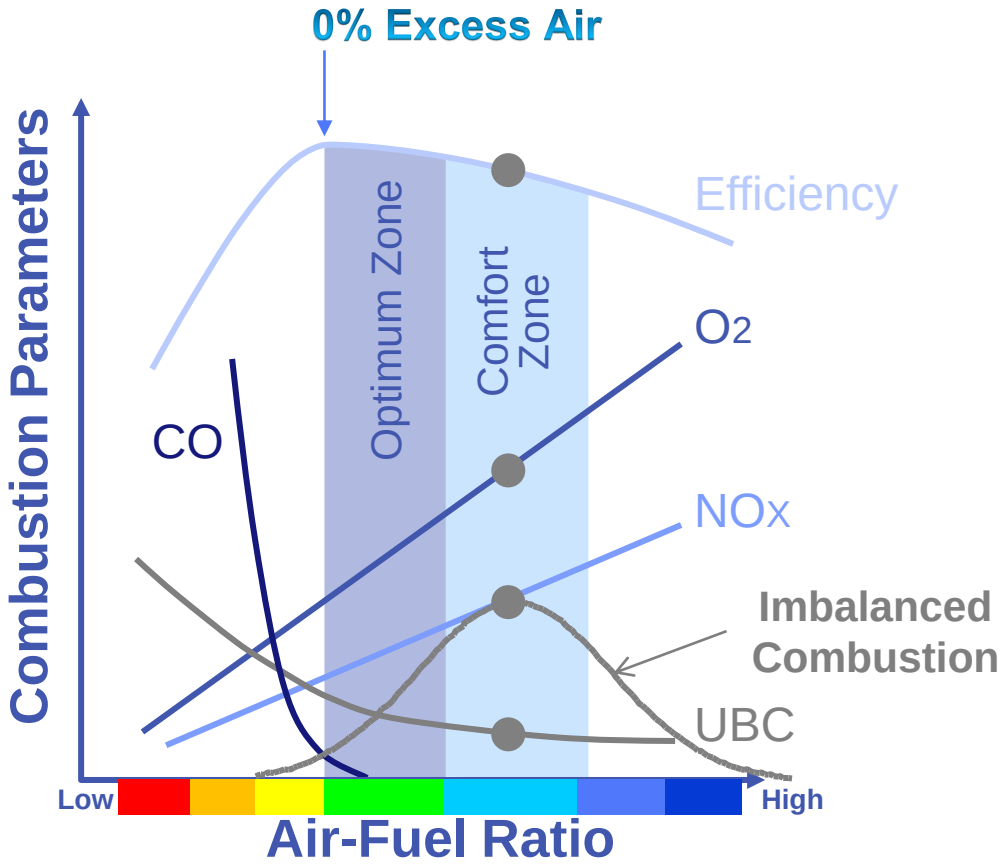


Typical burner-to-burner imbalance forces operation at high excess air levels



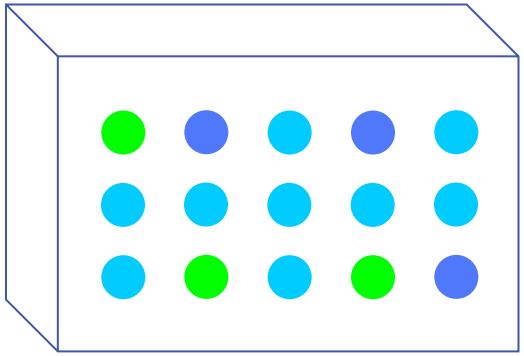
Example Burner Array



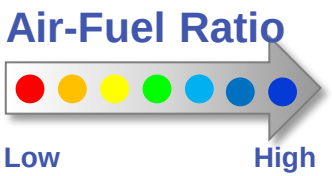


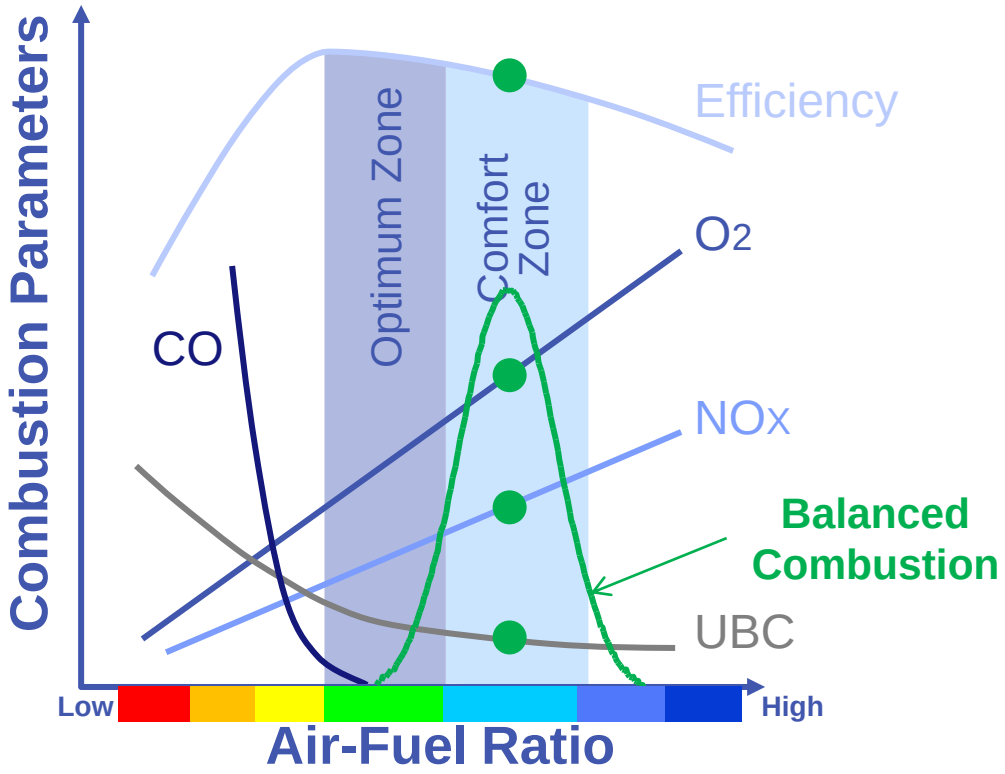
Unique ability to detect combustion imbalance

First step in improving combustion is to balance fuel-air distribution



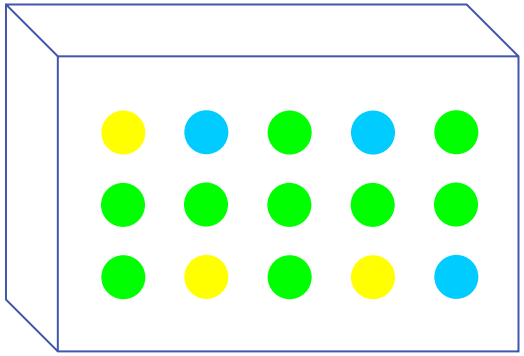
Example Burner Array



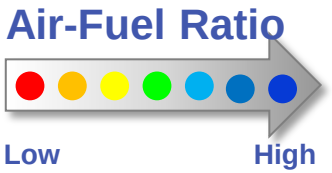


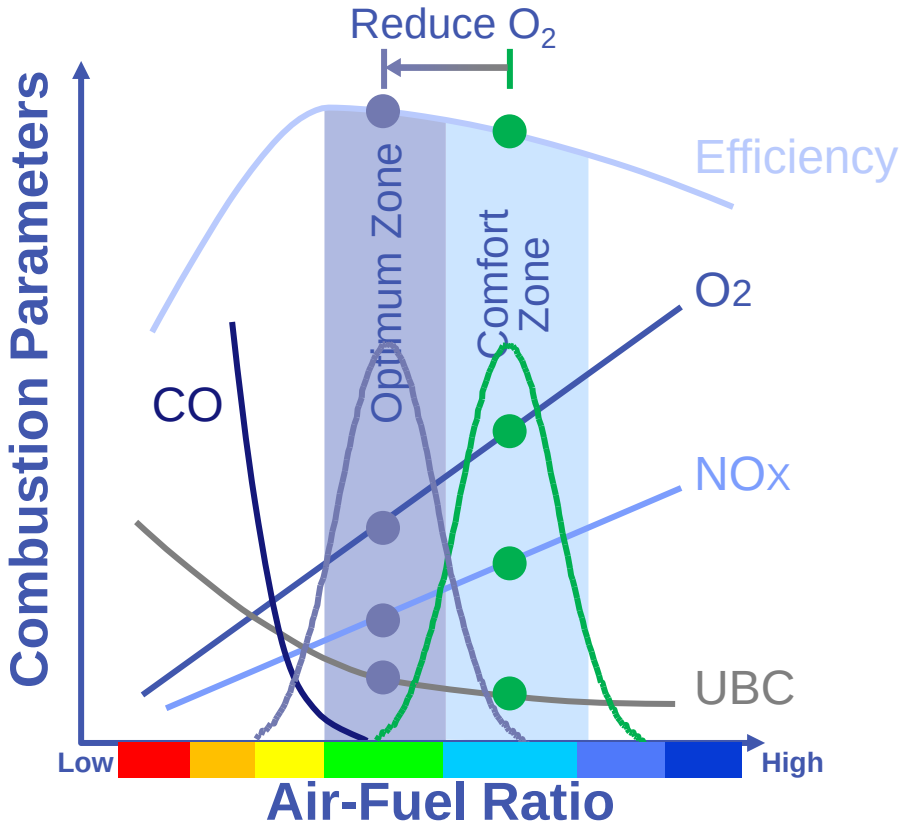
Tools and know-how to balance combustion

Balanced combustion avoids operating issues and allows operators to reduce excess air



Example Burner Array





Confidence to operate at optimum

Available Approaches

Available combustion optimization approaches

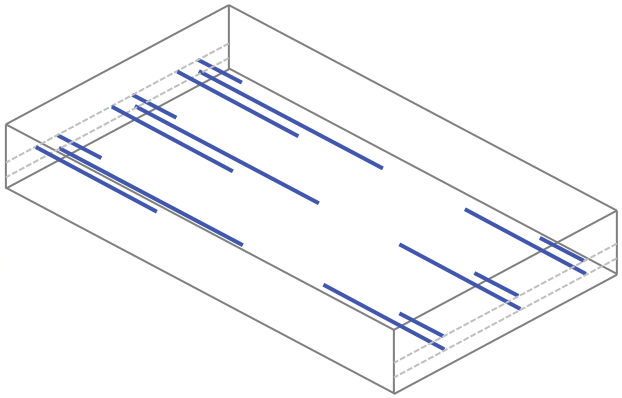
Approaches	Pros	Cons
Burner Coal Flow Balance	• Good practice • Reduces air adjustments	• Does not ensure uniform combustion
Burner Air-Fuel Ratio Control	• Reasonably balances Burner A/F	• May not balance furnace A/F • Limited accuracy • Expensive per burner system
Manual Economizer Gas Mapping	• Improves combustion when tuned	• Slow and imprecise mapping • Operate blind between tunings
Furnace TDL Measurements	• Fast, path average conditions	• Lack spatial detail • Poor CO detection • Data difficult to interpret
Optimizations (AI) Software	• Fast response • Can handle complex operation	• Can drive unit into poor combustion zone
Zonal Combustion	• True combustion optimization • Online operation benefits • Synergies with coal balance and AI software	• Need operator and maintenance engagement

GE’s Zonal Combustion Approach

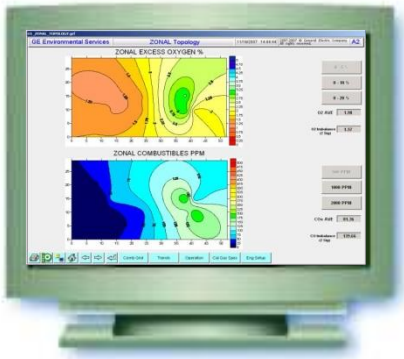
Zonal – foundation for success

Reliable sensors and equipment

Expert designs and implementation



a product of ecomagination



Intuitive combustion information

Simplified operation & maintenance

Standalone tool for operator, I&C and engineers access

Operator Information

> Real-time O_2 & CO profiles

> Measurement trends

Maintenance Support

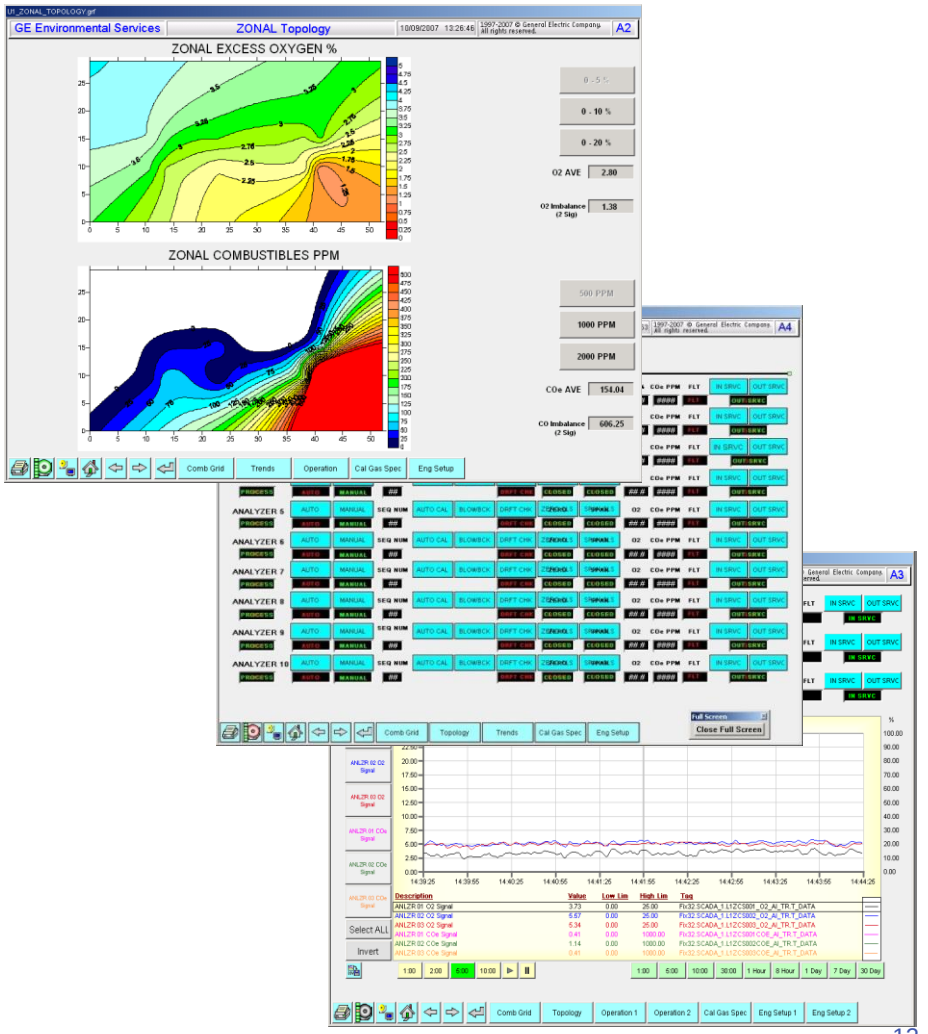
> Analyzer calibrations & drift checks

> Probe Blowback

Engineer Analytics

> Combustion average & imbalance

> Data historian

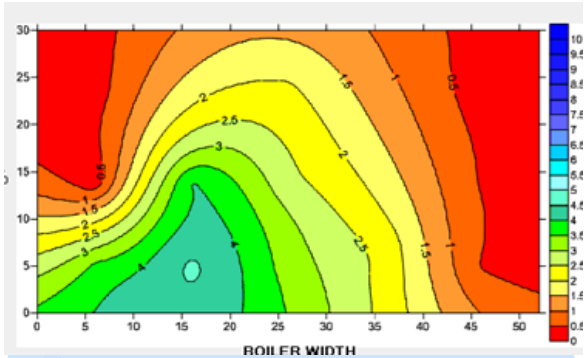


Zonal intuitive display

- > Spatial information
- > Intuitive color scheme
- > Minimizes operator data overload

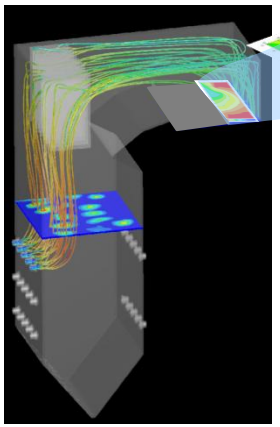
Exterior Backpass Wall

Left Side of Boiler



Right Side of Boiler

Top view

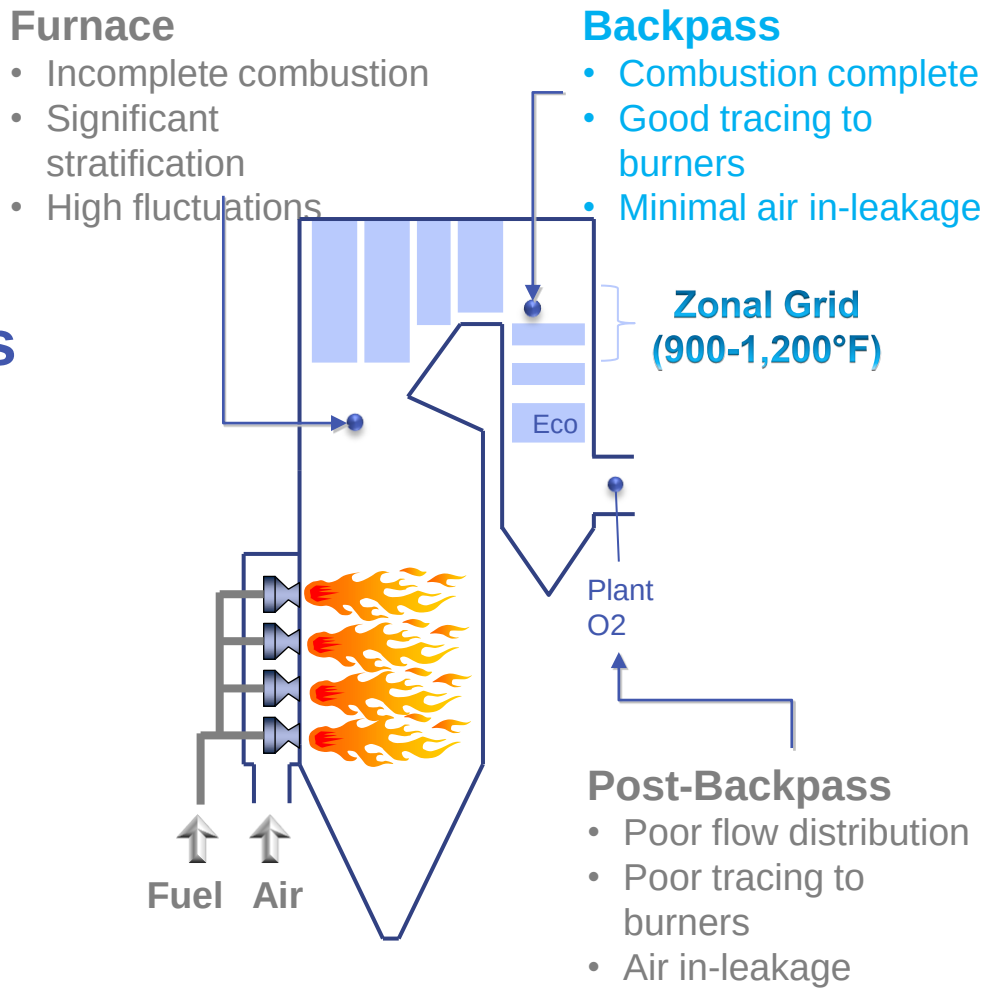


Color schemes:

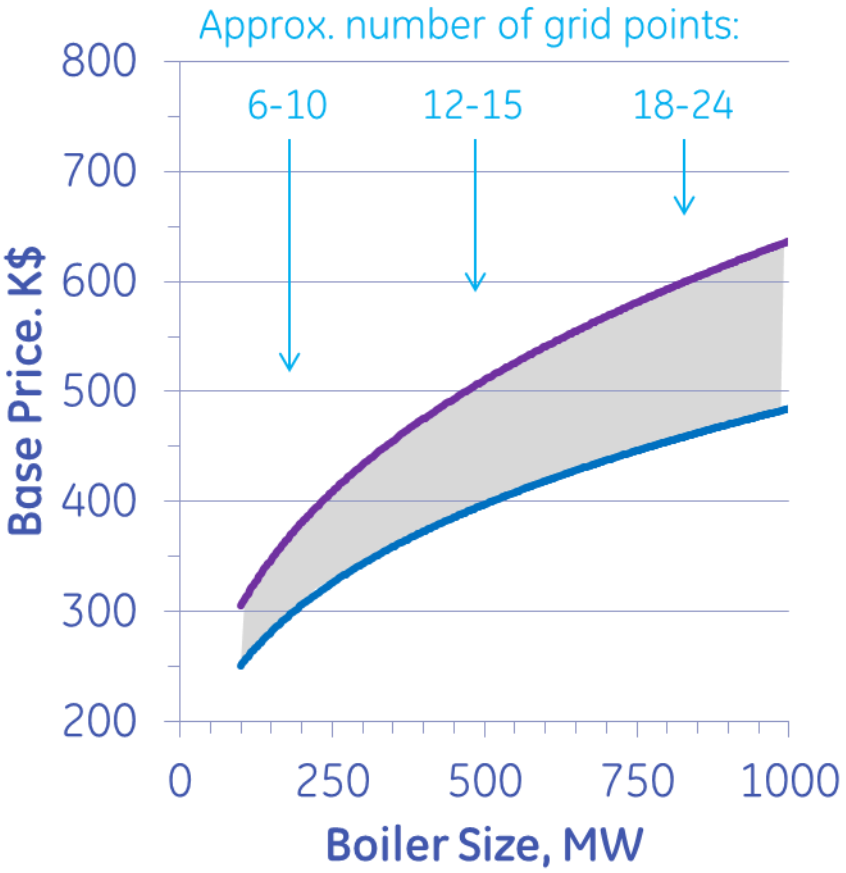
- ❑ **Red is bad** (Low O_2, High CO)
- ❑ **Green is good**
- ❑ **Blue is excessive** (High O_2, no CO)

Zonal Combustion Monitoring System Application targets:

- **Fired boilers**
  - Small to large size
  - Coal and natural gas
- **All firing configurations**
  - Wall, Tangential, Riley, & Cyclone
  - With or without LNB/OFA
- **Wide range of coals**
  - Ash up to 30%
  - Moisture up to 40%
  - Sulfur up to 4.0%



Zonal Combustion System Costs and Benefits



Benefits

- Increase boiler performance and availability
- Improve fuel flexibility and emissions compliance
- Simplify and enhance boiler operation

Avoiding one forced outage can justify investment

Zonal Real World Experience

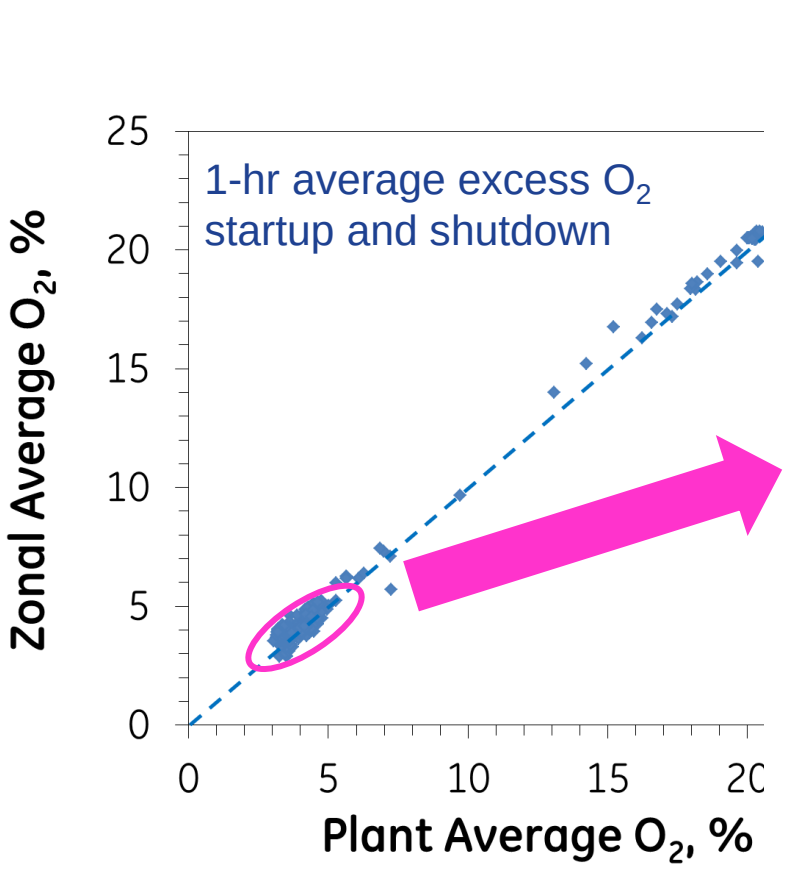
Zonal hardware installation

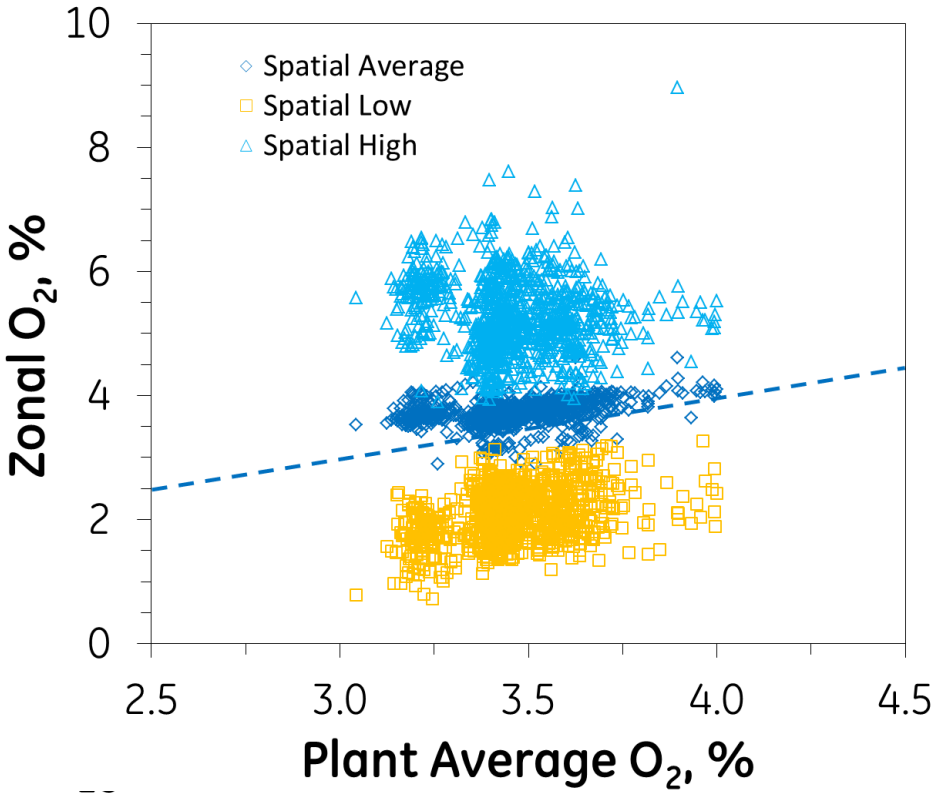
Analyzer Heads

Probe Support Sleeves

Electronic Assemblies

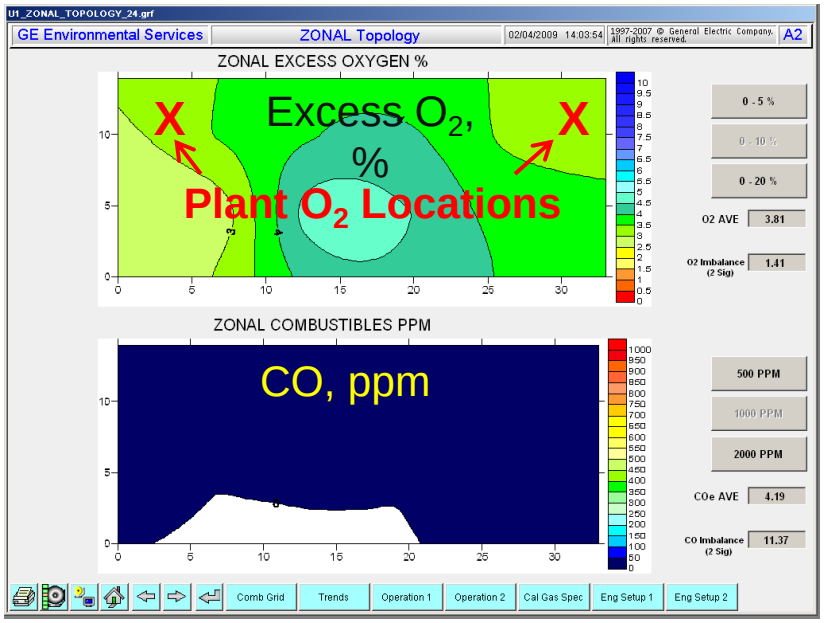
Zonal is in excellent agreement with traditional O_2 … higher resolution improves accuracy

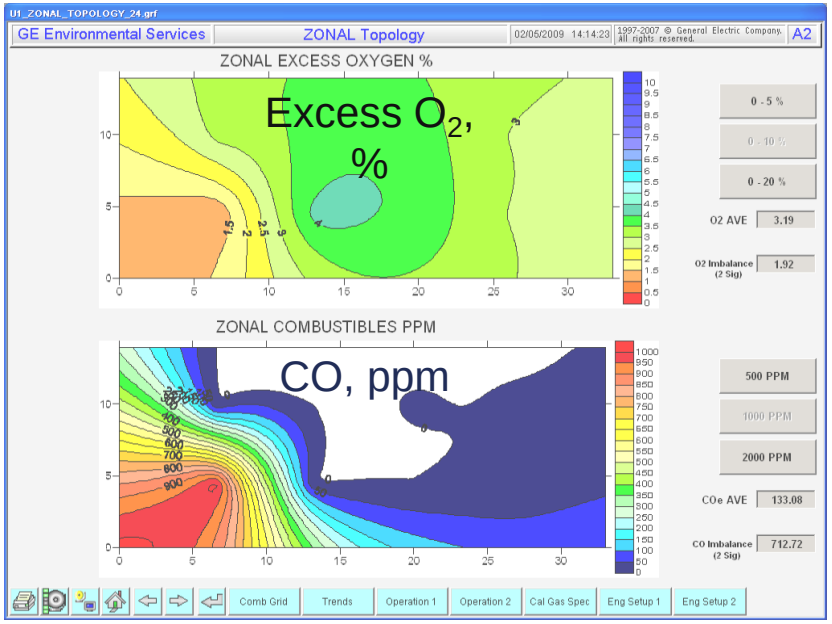




Zonal is being used for air regulation control

Zonal: Mid-Western US front wall-fired boiler As-Found Zonal Combustion Conditions





Normal O_2 Operation

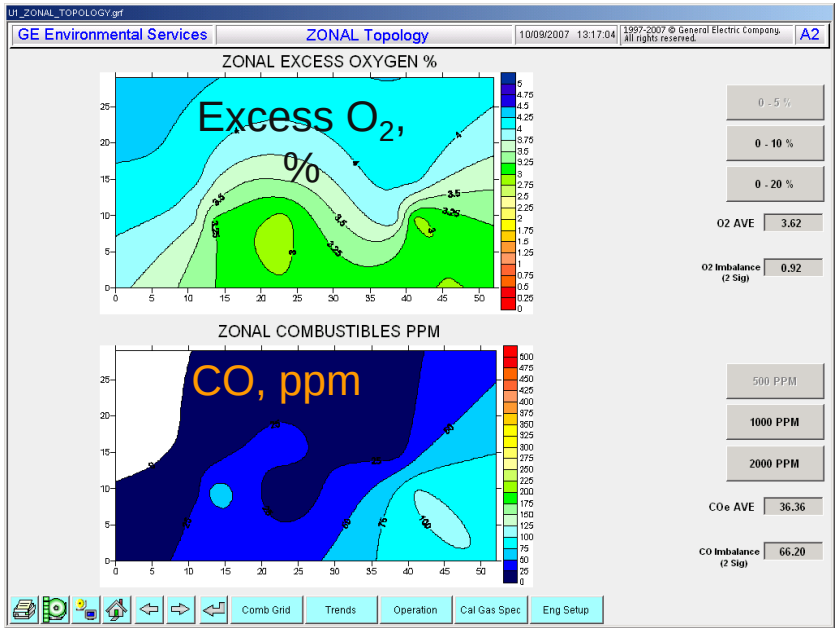
- Plant O_2 average = 3.0%
- Zonal O_2 average = 3.8%
- Zonal O_2 variance +/- 1.4%

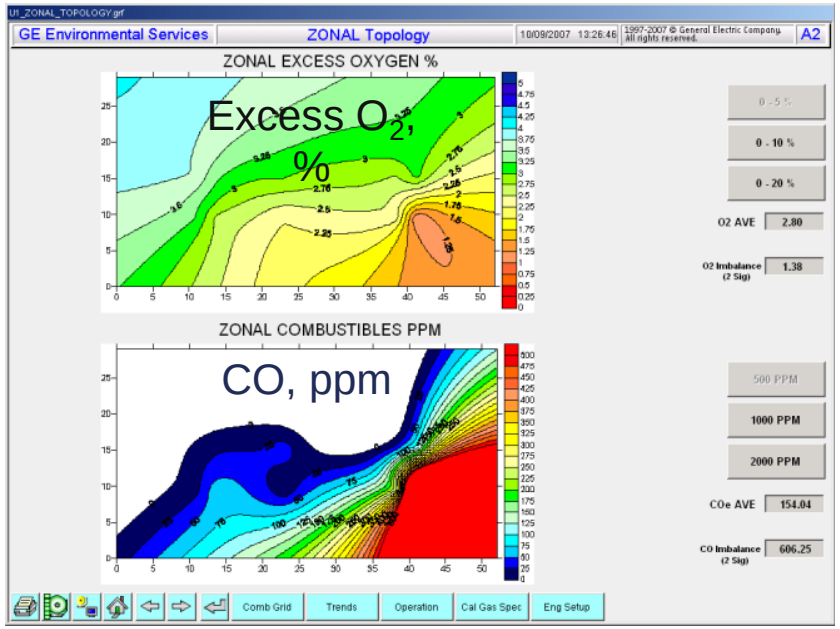
Reduced O_2 Operation

- Plant O_2 average = 2.5%
- Zonal O_2 average = 3.2%
- Zonal O_2 variance +/- 1.9%

Unknowingly operated at high excess O_2

Zonal: Western US tangential-fired boiler As-Found Zonal Combustion Conditions





Normal O_2 Operation

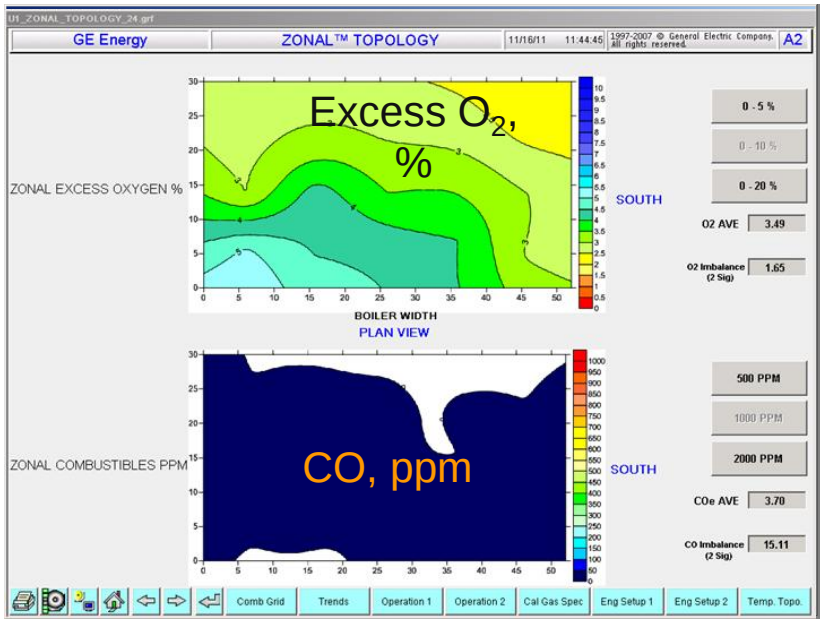
- Zonal O_2 average = 3.6%
- O_2 Imbalance = +/- 0.9%
- CO average = 37 ppm

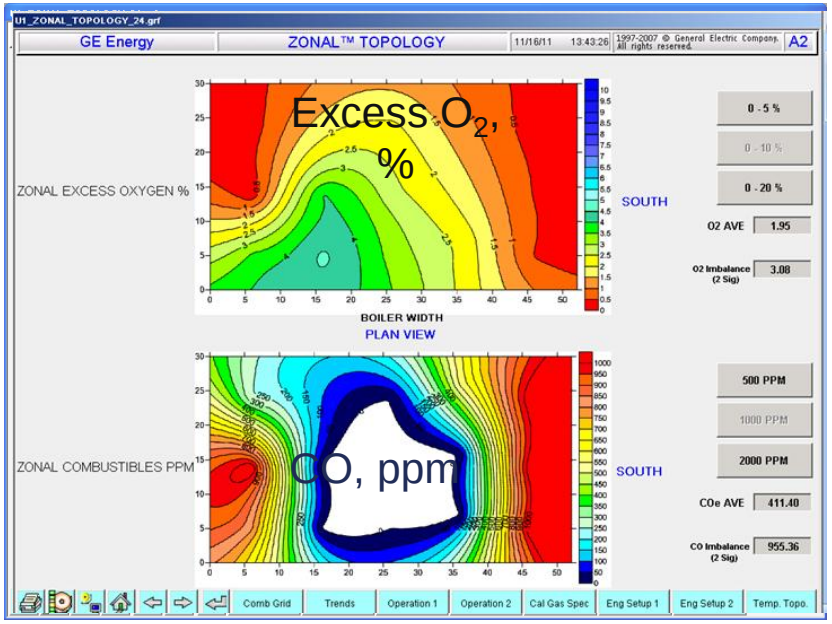
Reduced O_2 Operation

- Zonal O_2 average = 2.8%
- O_2 Imbalance = +/- 1.4%
- CO average = 150 ppm

Severe slagging at reduced excess O_2 operation

Zonal: Northern US opposed wall-fired boiler As-Found Zonal Combustion Conditions





Normal O_2 Operation

- Zonal O_2 average = 3.5%
- Zonal O_2 variance +/- 1.7%
- CO average = <25 ppm

Reduced O_2 Operation

- Zonal O_2 average = 2.0%
- Zonal O_2 variance +/- 3.1%
- CO average = 400 ppm

Furnace wall corrosion drove need for high O_2 imbalance

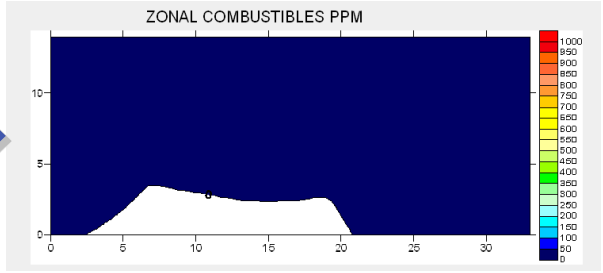
Zonal: Mid-Western US front wall-fired boiler

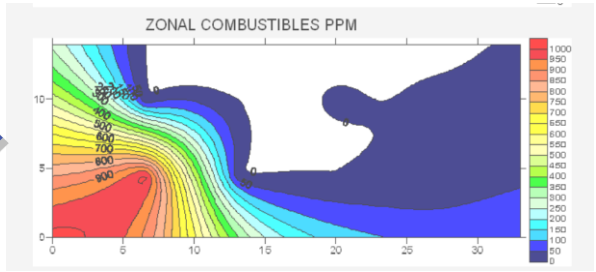
Zonal CO Profiles

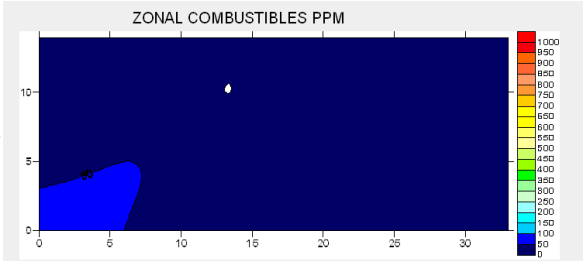
As Found Normal O_2

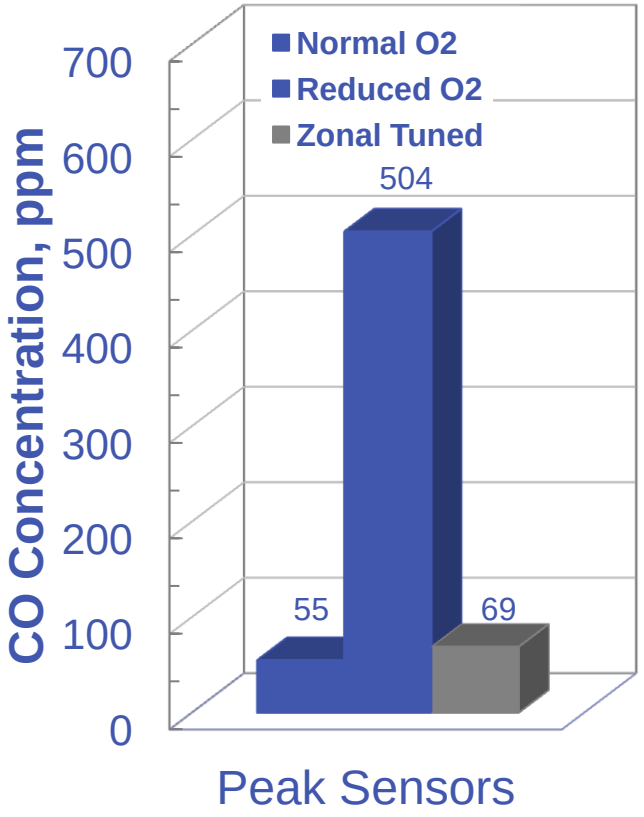
As Found @ Reduced O_2

Zonal Tuned @ Reduced O_2





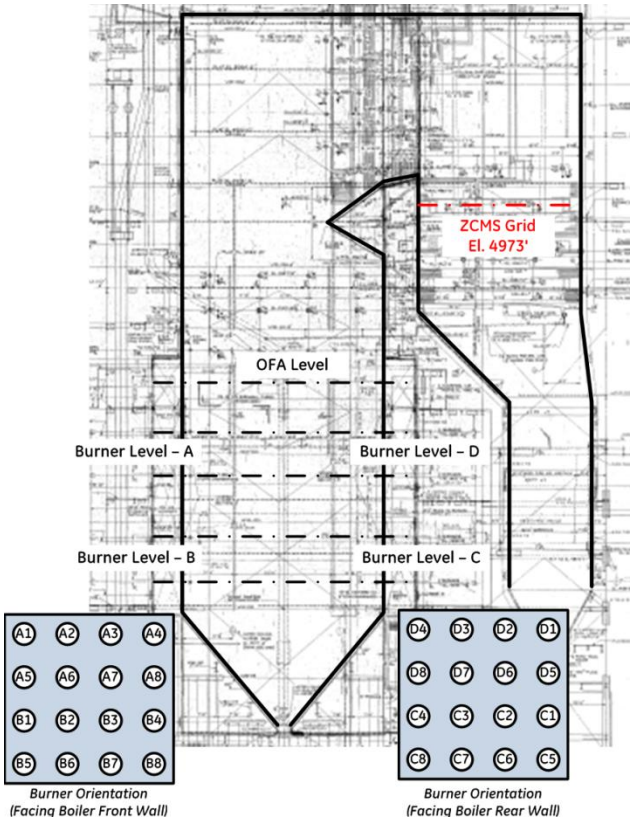




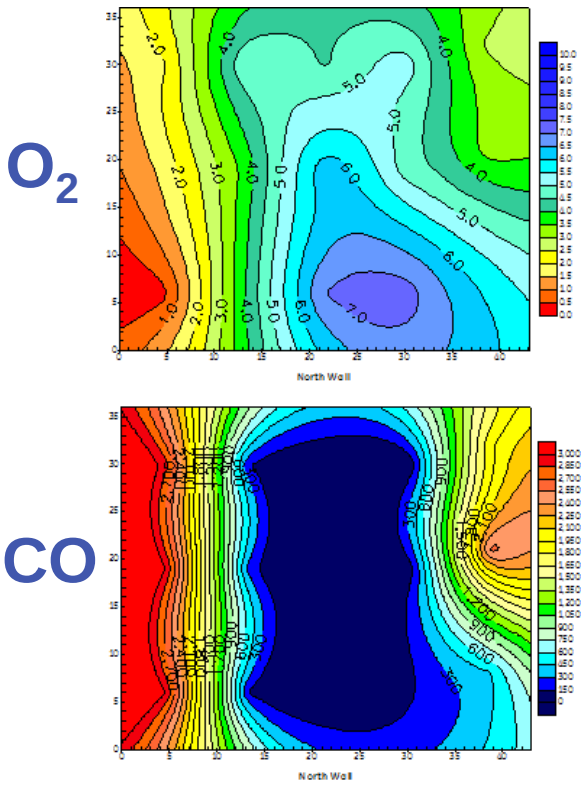
Zonal provides ability to tune out poor combustion

Zonal: Western US opposed wall-fired Boiler Combustion tuning

Opposed Fired Boiler

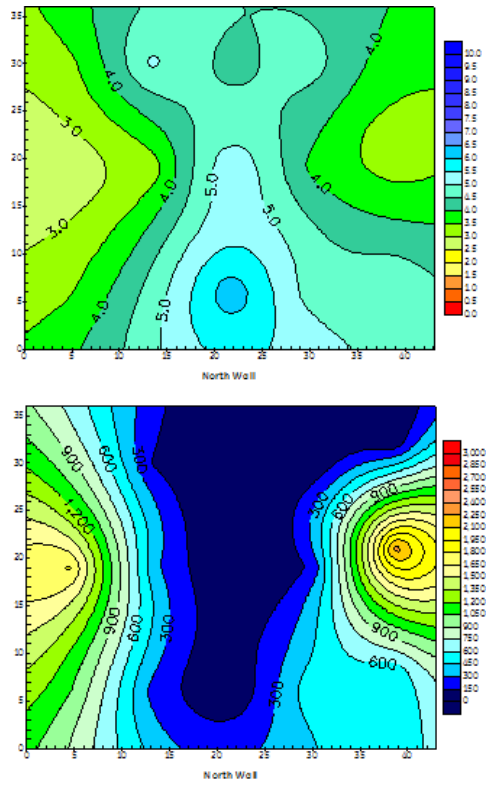


As Found



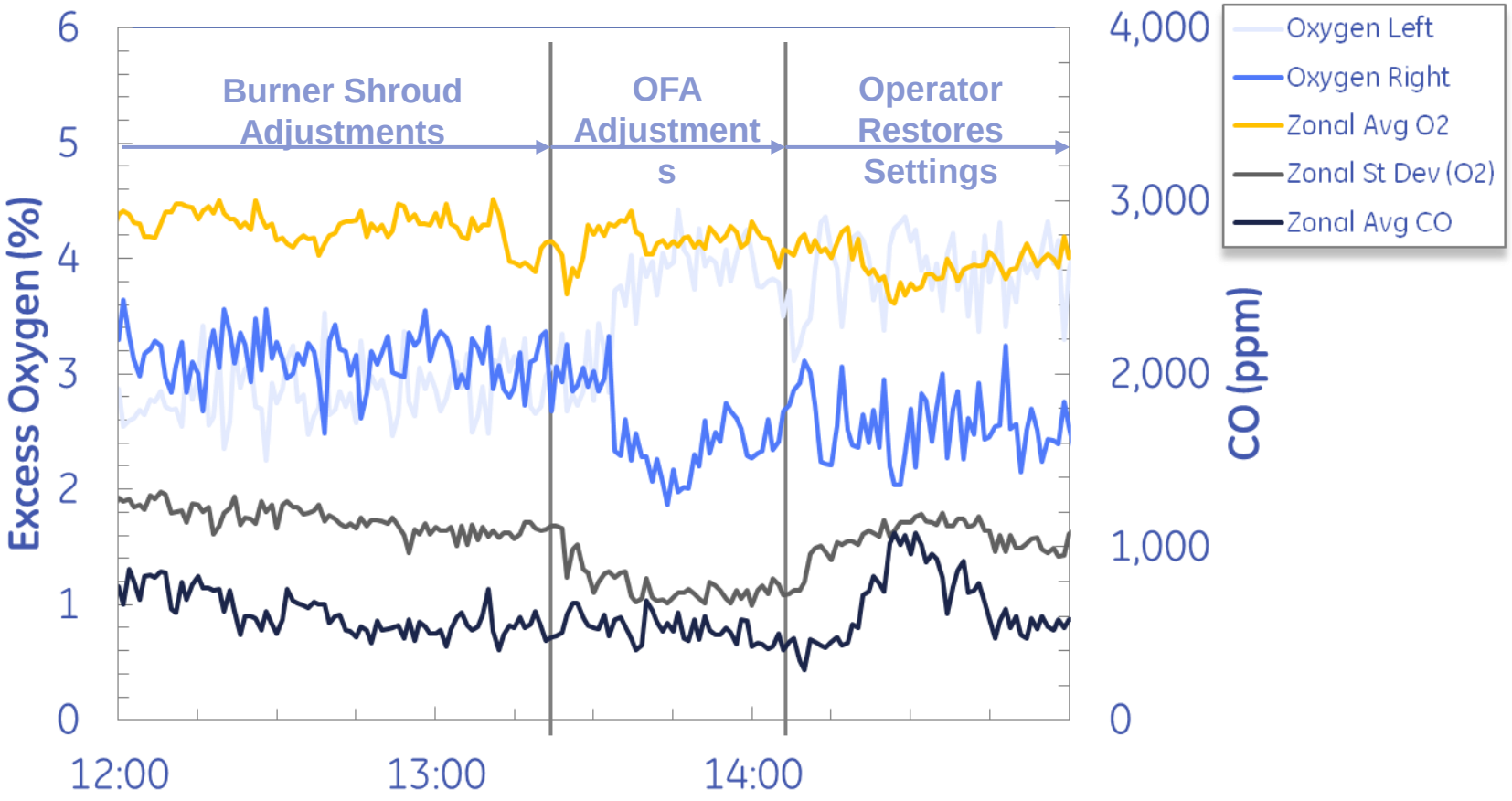
O_2: 4.24 %
O_2 Dev.: 2.0
CO: 975 ppm

Tuned



O_2 : 4.23 %
O_2 Dev.: 0.99
CO: 548 ppm

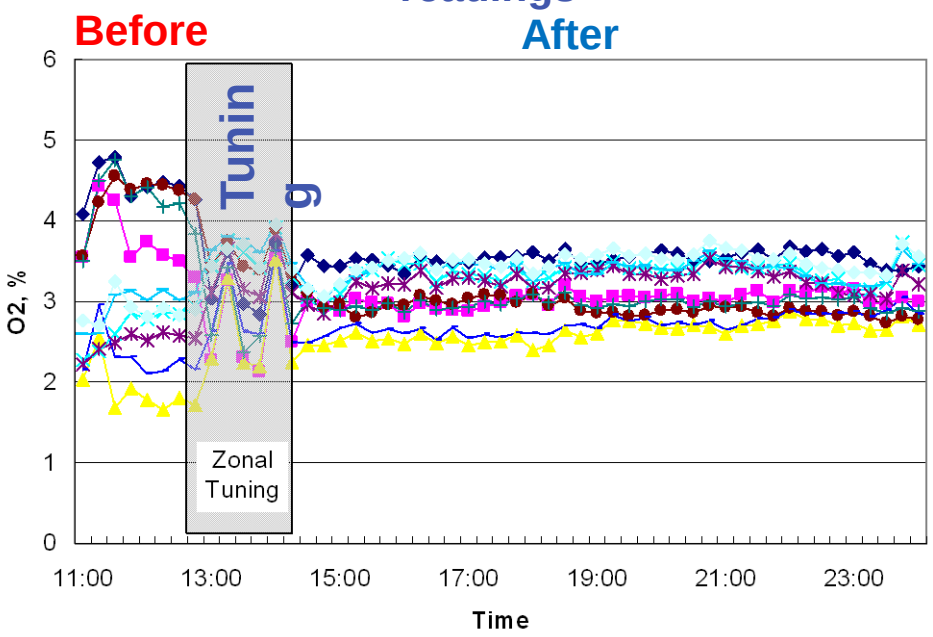
Zonal: Western US opposed wall-fired boiler Combustion tuning



Zonal improves understanding and operating behaviors

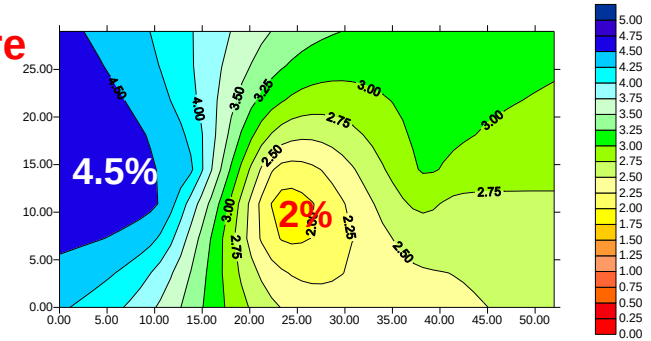
Western US tangential-fired boiler Zonal Tuning Advisor results

Time series of Zonal sensor oxygen readings



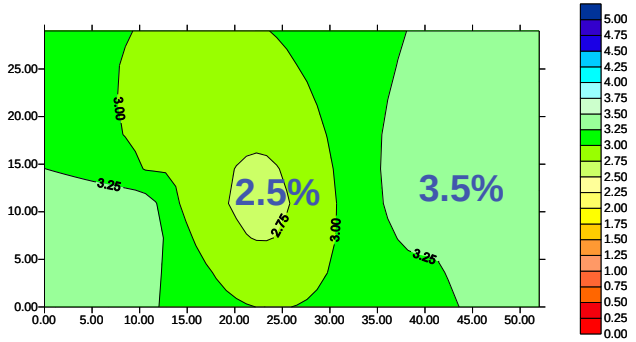
Zonal O_2 Profile

Before



- O_2 average: 3.3%
- O_2 imbalance: +/- 1.0%
- CO: 34 ppm

After

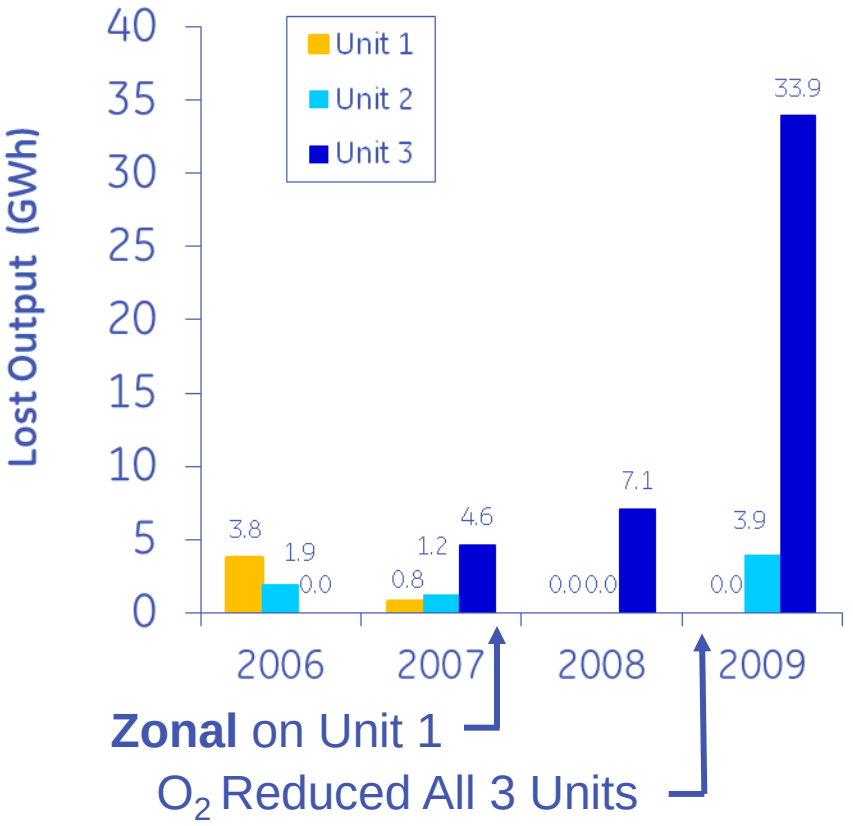


- O_2 average: 3.1%
- O_2 imbalance: +/- 0.3%
- CO: <25 ppm

Tuning Advisor balanced boiler excess O_2

Western US tangential-fired boiler Zonal improved unit availability

- Zero slagging outages on Unit 1 after Zonal installed in August 2007
- In January 2009 O_2 was reduced on all 3 units to reduce NOx
  - Zero lost output on Zonal unit (Unit 1)
  - Lost output on other units increased



Unit 1 burns severe slagging western US coals

GE Zonal System Installations

No.	Site	Location	Boiler	MW	Grid	Service	Benefits
1	A-1	Utah, US	T-Fired	460	2x5	10/2007	Slagging, NOx, Efficiency
2	B-1	Denmark	Wall-Fired	380	2x6	6/2008	Excess O_2, NOx
3	C-1	UK	Wall-Fired	180	2x4	7/2008	NOx
4	C-2	UK	Wall-Fired	180	2x4	7/2008	NOx
5	D-1	Minnesota, US	Wall-Fired	80	2x4	1/2009	NOx, Slagging
6	E-3	Florida, US	Wall-Fired	380	3x4	12/2009	Excess O_2, Coal Flexibility
7	F-7	Michigan, US	Wall-Fired	35	2x3	5/2010	NOx
8	G-2	Colorado, US	Wall-Fired	350	3x5	1/2011	CO, NOx, Slagging
9	G-1	Colorado, US	T-Fired	350	3x5	5/2012	NOx, Slagging
10	H-1	Kentucky, US	Wall-Fired	425	3x5	8/2011	Coal Flexibility, NOx, Corrosion, Slagging


imagination at work