

***DEMONSTRATED PERFORMANCE  
IMPROVEMENTS ON LARGE LIGNITE-  
FIRED BOILER WITH TARGETED IN-  
FURNACE INJECTION TECHNOLOGY™***

**Les Allery; Josh Rossow; Albert Weisbeck**

**Basin Electric Power Cooperative, Leland Olds Generating Station**

**Gerry Snow, PE; Tim McMahon; Marc Sylvester**

**Fuel Tech, Inc.**

**COAL-GEN 2010**

**August 10 - 12, Pittsburgh**

# *TIFI Introduction & Program Overview*

*Marc Sylvester*

- **Targeted In-Furnace Injection (TIFI)**
- **Mitigating Slag Challenges**
- **Fuel Flexibility**

# *BEPC Leland Olds Station*

*Josh Rossow*



# *Leland Olds Station Perspectives*

*Josh Rossow*

- **Plant Description**
  - ◆ **Unit 2**
- **Fuels**
  - ◆ **North Dakota Lignite & PRB**
  - ◆ **Blend to Control Sulfur, Ash, Sodium**
- **Key Objectives & Goals**
  - ◆ **High Availability Base Load Power**
  - ◆ **Low Cost Power**
  - ◆ **Eliminate Vermiculite Injection**

# *Specific Success Criteria*

*Josh Rossow*

- **Annual Generation Gains (net MWh)**
- **Net Unit Heat Rate Improvement**
- **Reduced Slagging & Fouling**
- **Ability to Recover from Poor Coal Quality**
- **Increased Operator Safety**
- **Reduction in Cleaning Outages**
- **Contribute to NO<sub>x</sub> Reduction Efforts**
- **Reduce/Eliminate Vermiculite System Maintenance, Reliability, & Safety Issues**

# *Slag Management Program at Leland Olds Station*

*Gerry Snow*

- **Lignite/PRB Blend Adjusted Based on Incoming Coal Report**
- **TIFI Program On-Going on Unit 2 Since January 2009**
- **TIFI Injection Rate Adjusted Based on Incoming Coal Properties**
- **Soot Blower Optimization Team**
- **10-Point Boiler Grading Scale Based on Slag Surveys**

# *TIFI Program Results at Leland Olds Station*

- **Eliminated One Annual Cleaning Outages**
- **Remaining Annual Outage Shortened by 4 Days**
- **Reduced Sootblowing, Rodding, Shot Gun Cleaning, & Blasting**
- **Over 45% of Run Time Greater Than 400 MW vs 29% Pre-TIFI**
- **40 - 60°F Reduction in Economizer Exit Gas Temp**
- **5% Decrease in ID Fan Amps**
- **120 - 180 Btu/kWh Decrease in Heat Rate**
- **15 - 16% Decrease in NO<sub>x</sub> Emissions with Cleaner Furnace & O<sub>2</sub> Trim**
- **Additional 30 - 40% NO<sub>x</sub> Reduction with OFA**

# LOS Unit 2 Coal Options

## Proximate Analysis (As Received)

			Lignite	PRB
Moisture	H <sub>2</sub> O	(%)	35.36	33.71
Ash	Ash	(%)	8.01	4.74
Volatile Matter	VM	(%)	28.16	30.32
Fixed Carbon	FC	(%)	28.47	31.23
	Total	(%)	100.00	100.00

## Ultimate Analysis (As Received)

			Lignite	PRB
Moisture	H <sub>2</sub> O	(%)	35.36	33.71
Carbon	C	(%)	42.40	46.05
Hydrogen	H	(%)	1.92	2.55
Nitrogen	N	(%)	0.76	0.68
Sulfur	S	(%)	0.81	0.37
Ash	Ash	(%)	8.01	4.74
Oxygen	O	(%)	10.74	11.90
	Total	(%)	100.00	100.00
Higher Heating Value	HHV	(Btu/lb)	6,905	7,706
Higher Heating Value (MAF)		(Btu/lb)	12,194	12,520

## Mineral Analysis of Ash

			Lignite	PRB
Silicon Dioxide	SiO <sub>2</sub>	(%)	25.66	27.9
Aluminum Oxide	Al <sub>2</sub> O <sub>3</sub>	(%)	11.64	13.49
Titanium Dioxide	TiO <sub>2</sub>	(%)	0.45	0.98
Iron Oxide	Fe <sub>2</sub> O <sub>3</sub>	(%)	8.53	6.49
Calcium Oxide	CaO	(%)	22.95	25.94
Magnesium Oxide	MgO	(%)	6.77	6.65
Potassium Oxide	K <sub>2</sub> O	(%)	0.73	0.28
Sodium Oxide	Na <sub>2</sub> O	(%)	2.94	1.65
Sulfur Trioxide	SO <sub>3</sub>	(%)	18.68	14.6
Phosphorus Pentoxide	P <sub>2</sub> O <sub>5</sub>	(%)	0.18	0.74
Strontium Oxide	SrO	(%)	0.53	0.52
Barium Oxide	BaO	(%)	0.86	0.73
Manganese Dioxide	MnO <sub>2</sub>	(%)	0.08	0.03

Alkalies as N <sub>2</sub> O	(%)	3.42	1.83
Base to Acid Ratio		1.11	0.97
Silica Ratio		0.4	0.42
T250	(°F)	2274	2306

## Ash Fusion Temperatures - Oxidizing

Initial Deformation	IT	(°F)	2218	2142
Softening	ST	(°F)	2224	2165
Hemispherical	HT	(°F)	2235	2206
Fluid	FT	(°F)	2259	2217

## Ash Fusion Temperatures - Reducing

Initial Deformation	IT	(°F)	2140	2106
Softening	ST	(°F)	2207	2152
Hemispherical	HT	(°F)	2238	2200
Fluid	FT	(°F)	2330	2206

# Coal Slagging Indices

## ● Lignite

$$◆ \frac{\text{Fe}_2\text{O}_3}{(\text{CaO} + \text{MgO})} = 0.29 \rightarrow \text{Lignitic Ash}$$

$$◆ R_s = \frac{(\text{Max HT}) + 4(\text{Min IT})}{5} = 2160 \rightarrow \text{High Slag}$$

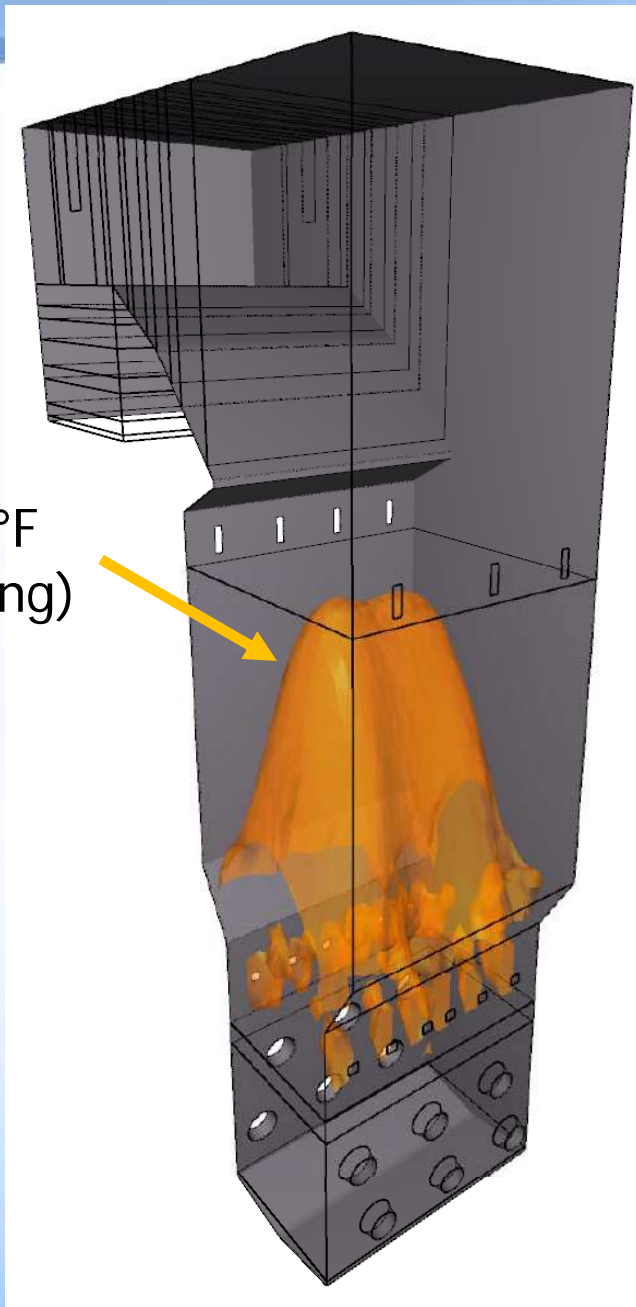
## ● PRB

$$◆ \frac{\text{Fe}_2\text{O}_3}{(\text{CaO} + \text{MgO})} = 0.20 \rightarrow \text{Lignitic Ash}$$

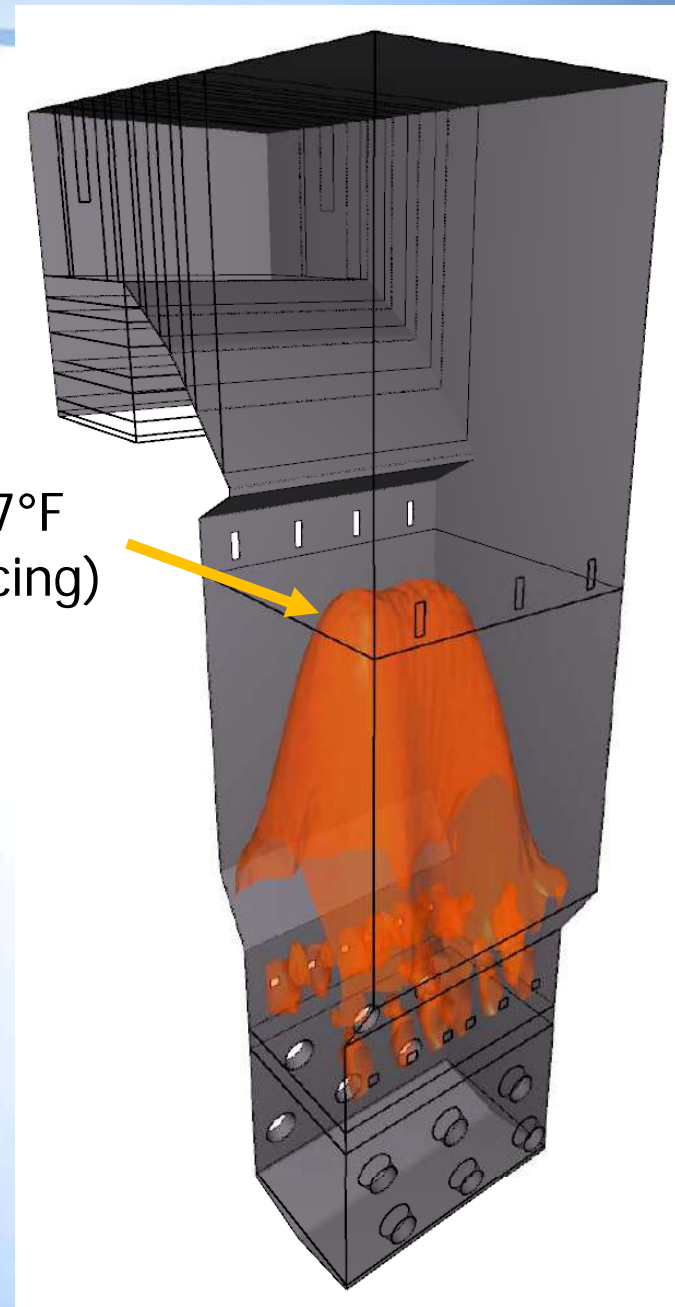
$$◆ R_s = \frac{(\text{Max HT}) + 4(\text{Min IT})}{5} = 2126 \rightarrow \text{High Slag}$$

# Lignite Coal Ash Softening Isotherms

2,224°F  
(Oxidizing)



2,207°F  
(Reducing)



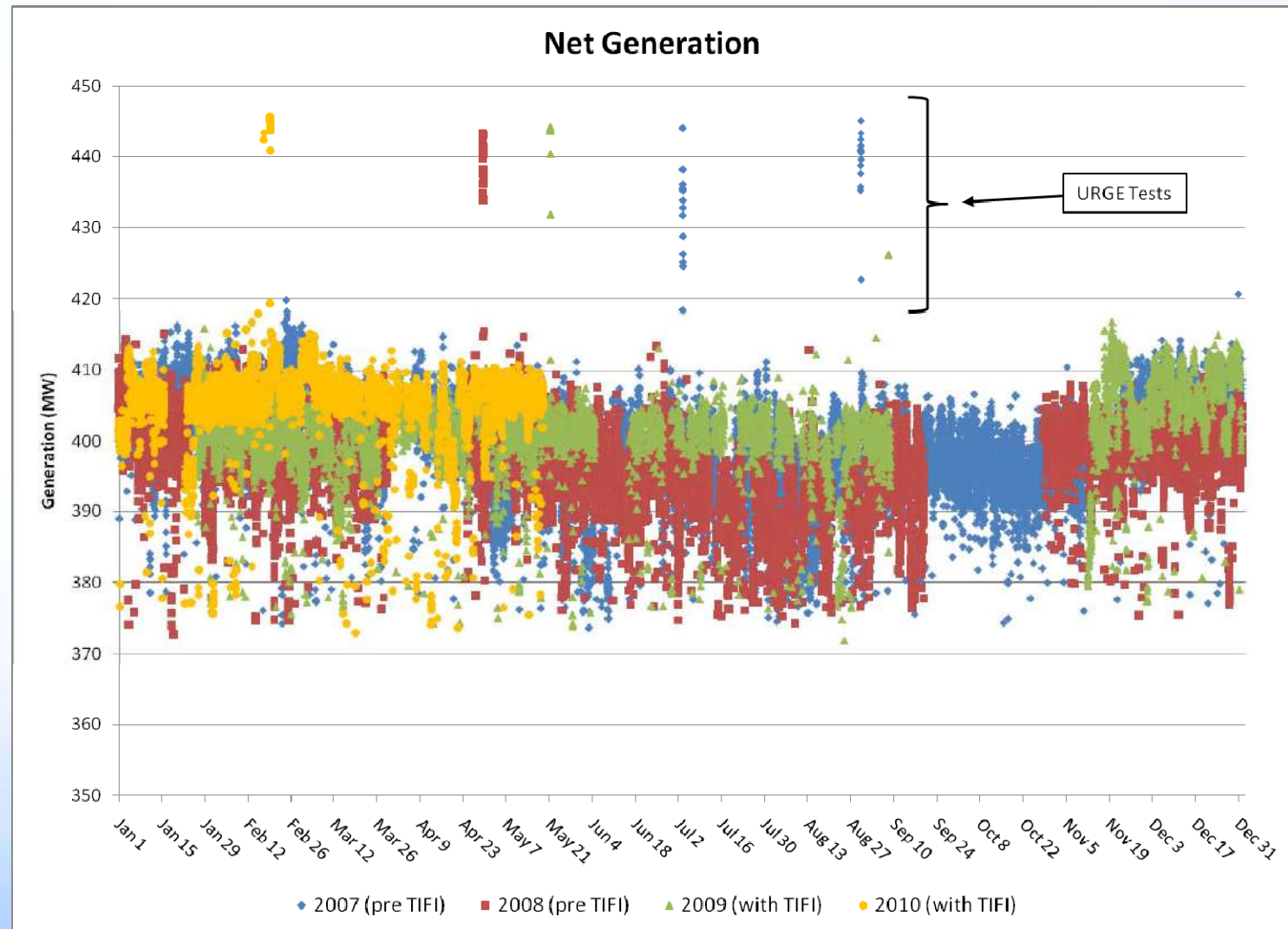
# *CFD Modeling*

**Show CFD Movie  
(Approx. 3 Min.)**

# LOS Unit 2 Net Generation

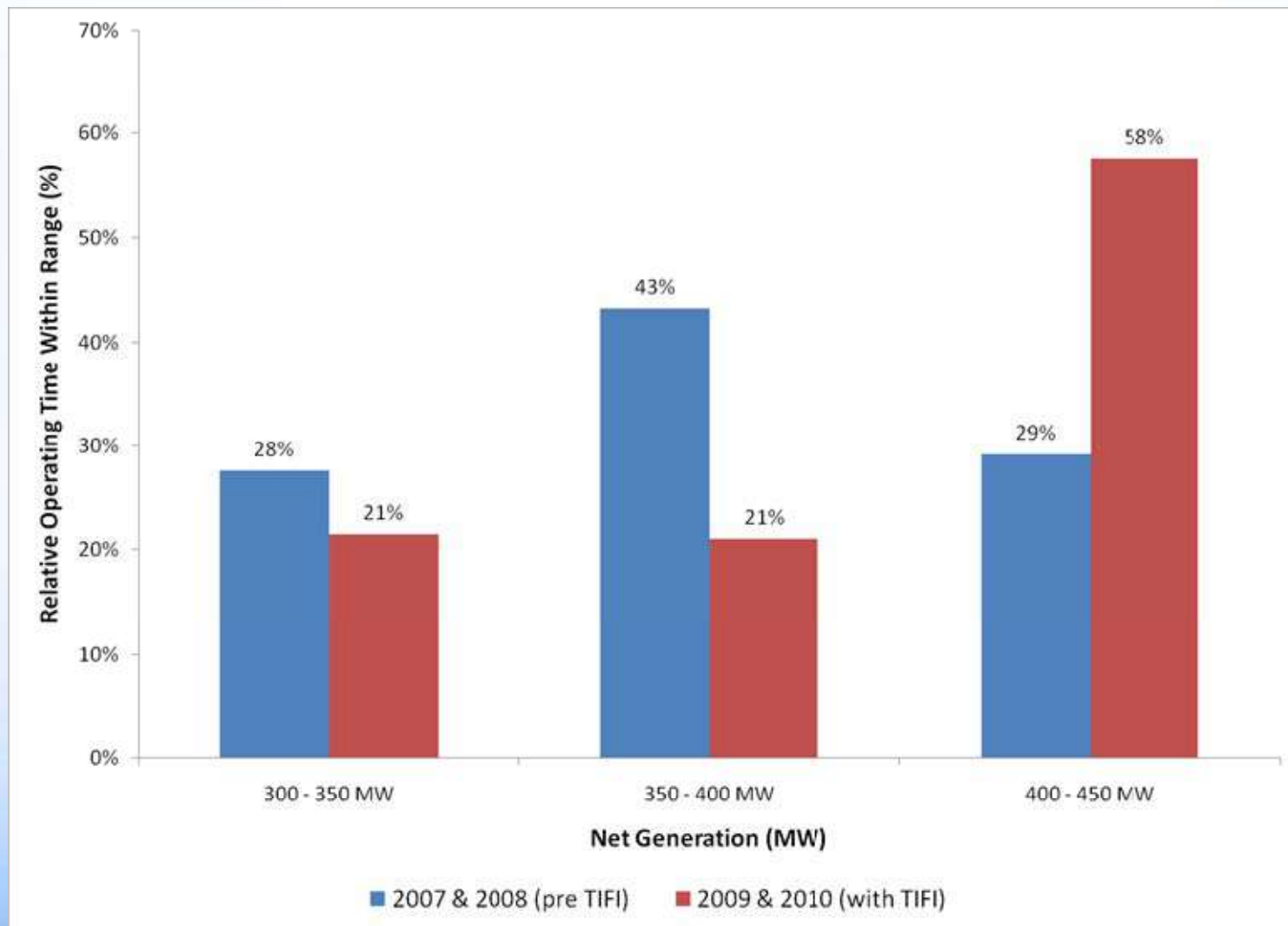
## Year Over Year Comparisons

- Reduced Cleaning Outages in 2009 & 2010
- Unit Output Maintained in 2009 & 2010



# Generation Histogram

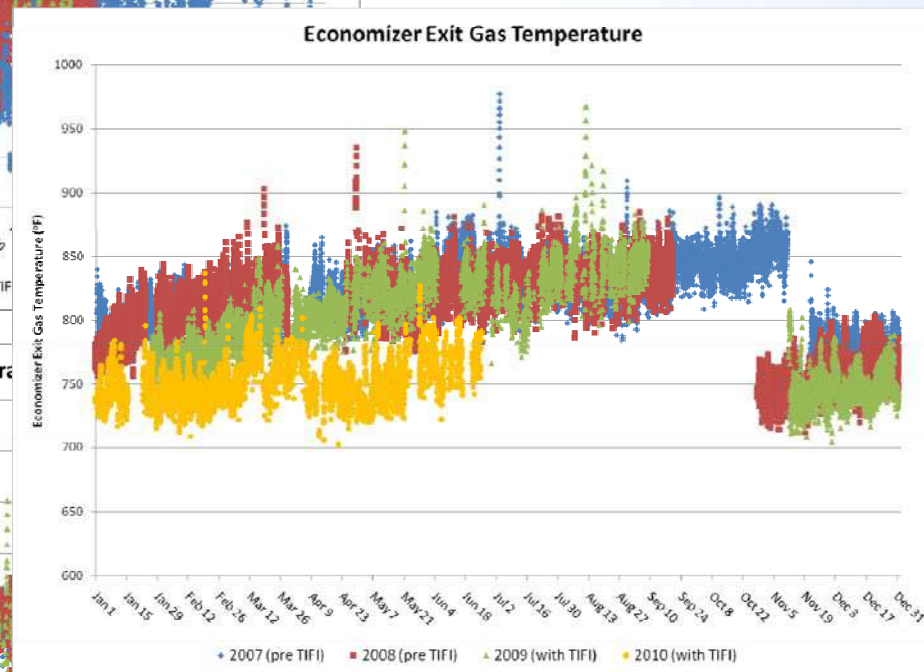
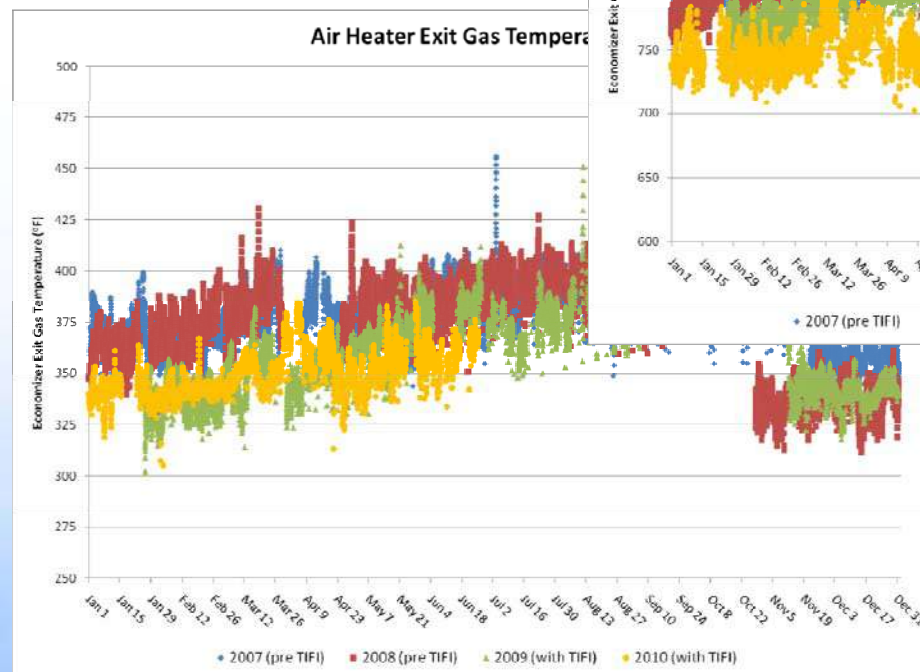
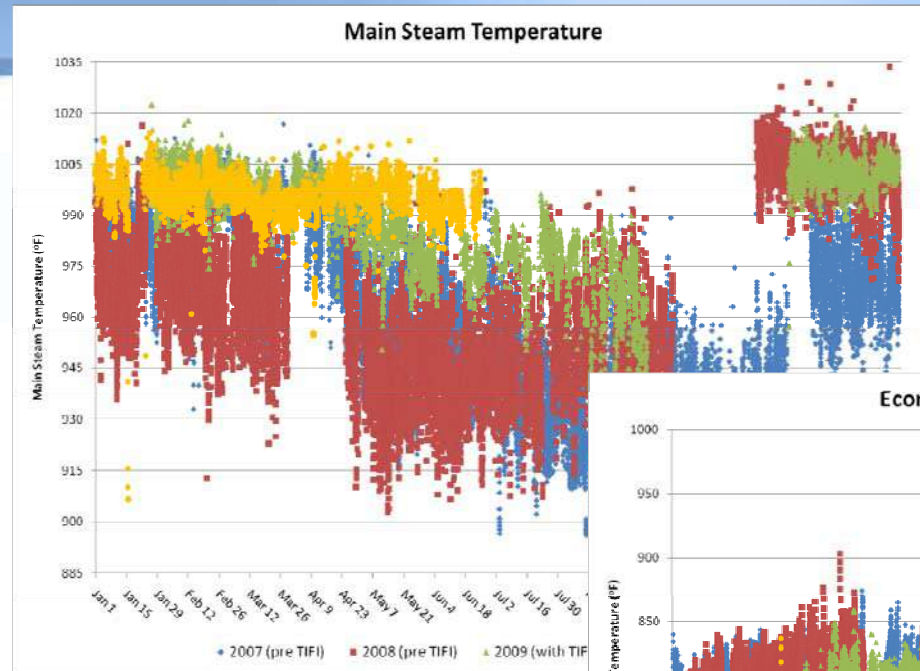
## Increased Operating Time Above 400 MW



# Heat Rate Controllable Parameters

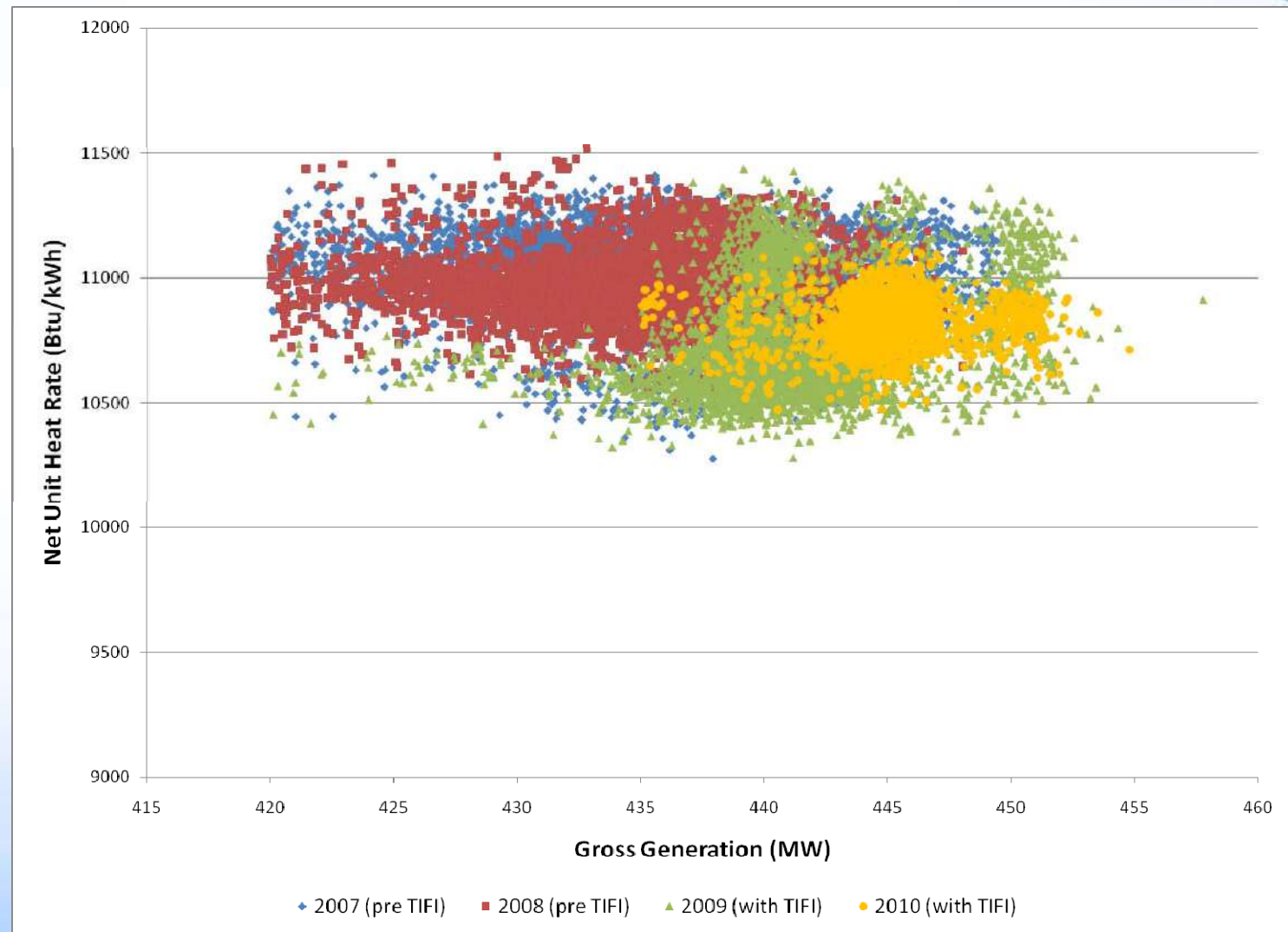
- Improvements in Key Parameters w/TIFI

- ◆ Main Steam Temp
- ◆ Economizer Exit Gas Temp
- ◆ APH Exit Gas Temp



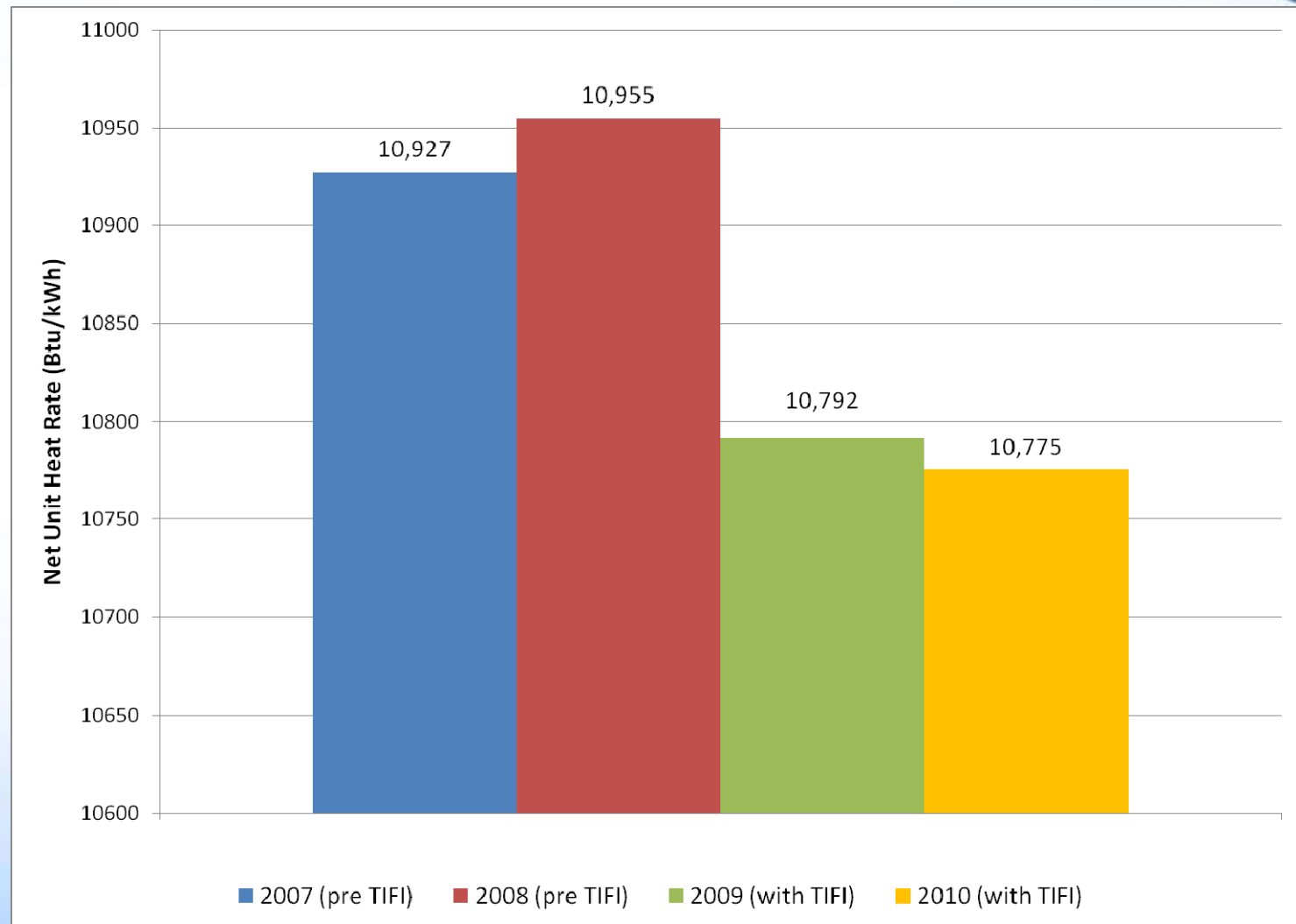
# NUHR versus Generation

- Improvements in Key Parameters Reduce Heat Rate in 2009 w/TIFI
- Heat Rate Efficiencies Maintained in 2010



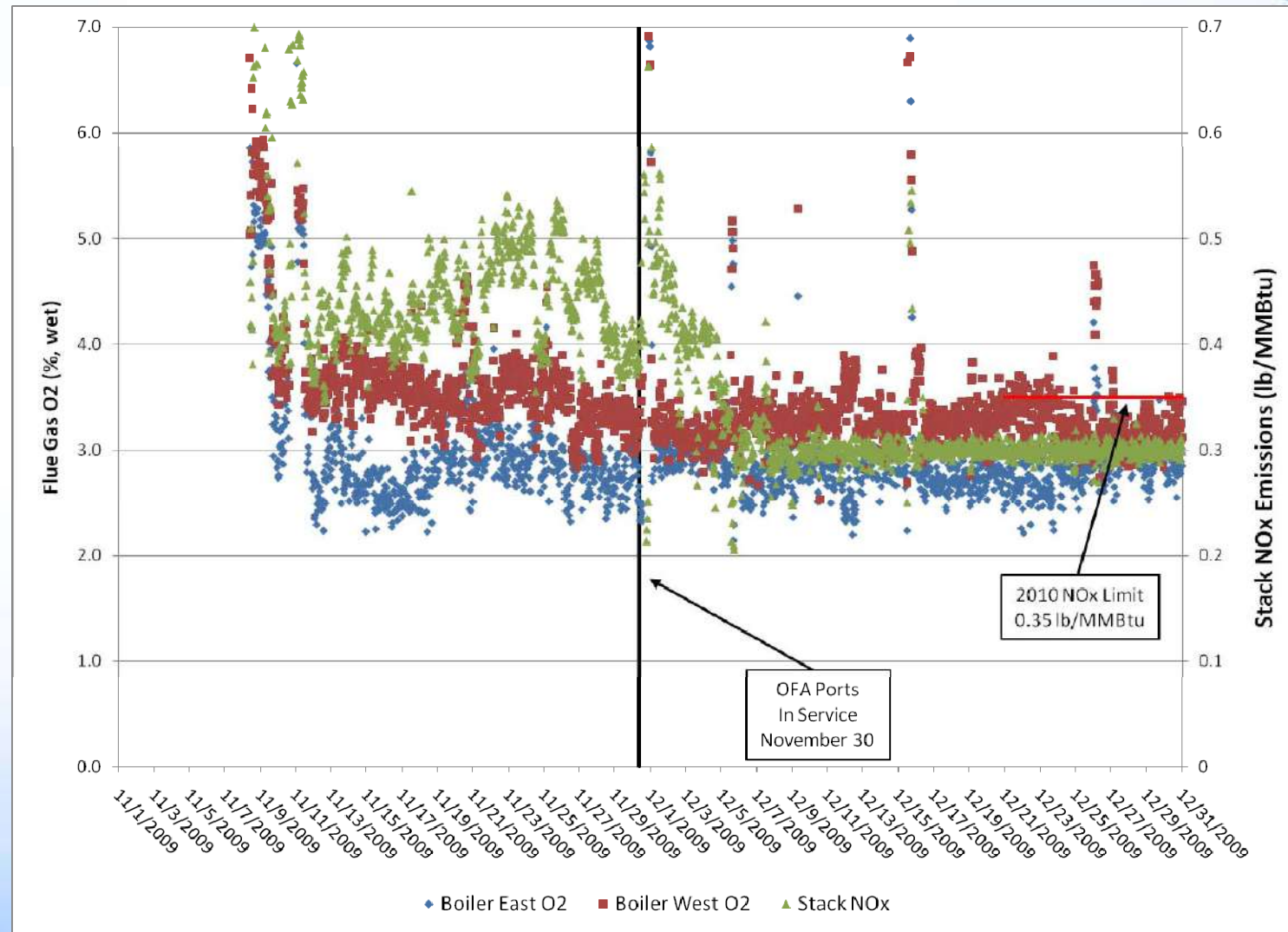
# NUHR Comparisons

- Averages at 440 MW for each run
- 2009 NUHR Reduction w/TIFI Prior To Fall Outage
- 2010 NUHR Shows Continued Improvement



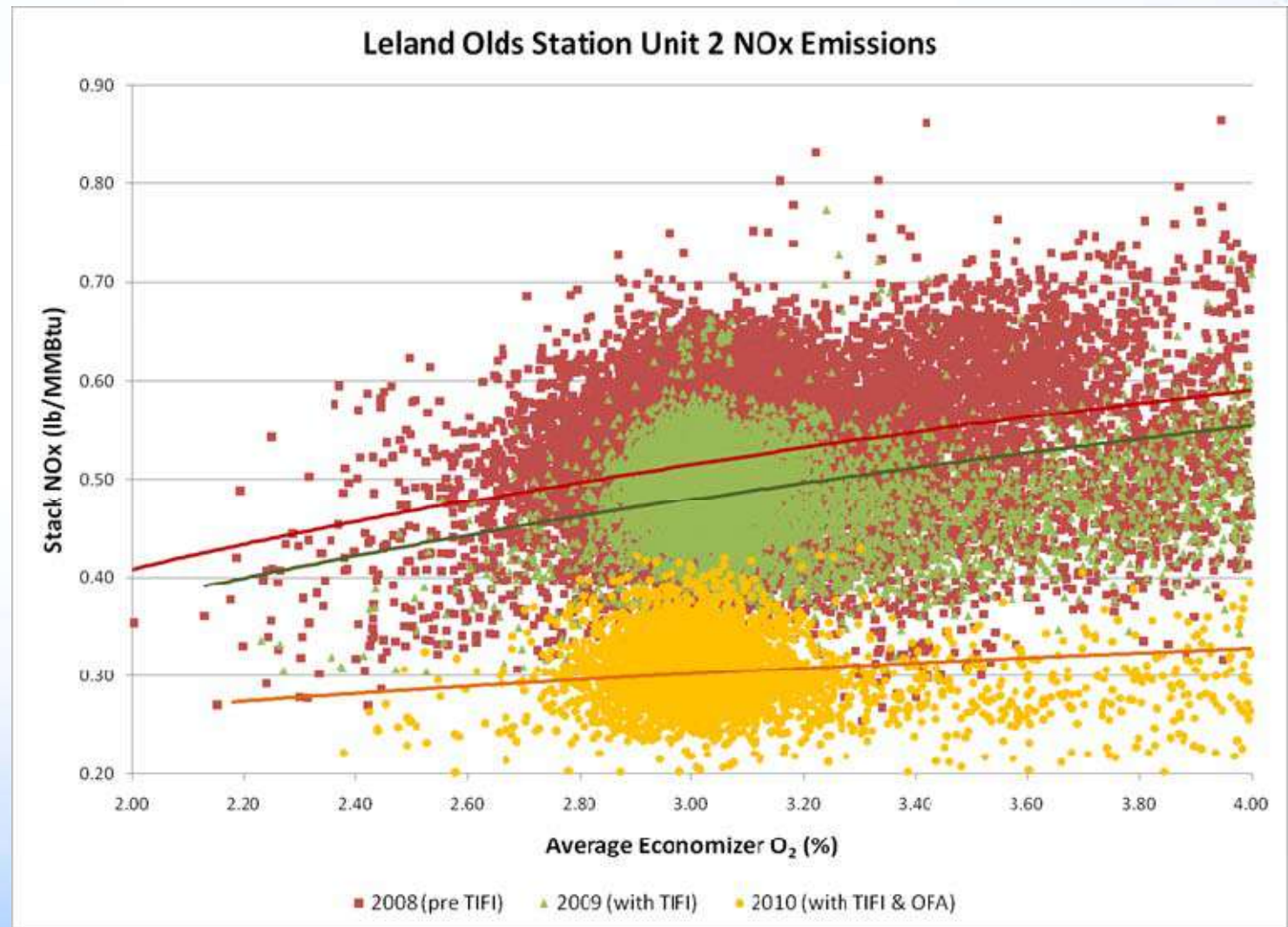
# NO<sub>x</sub> Emissions with OFA

- Improved O<sub>2</sub> Balance With OFA
- 30 - 40% NO<sub>x</sub> Reduction With OFA



# LOS Unit 2 NO<sub>x</sub> versus O<sub>2</sub>

- Compare 3 Operating Periods
- 15 - 18% NO<sub>x</sub> Reduction With TIFI Slag Management
- 30 - 40% NO<sub>x</sub> Reduction With OFA



# Questions?

