# Bundling Technologies for Cost-effective $NO_x$ Control

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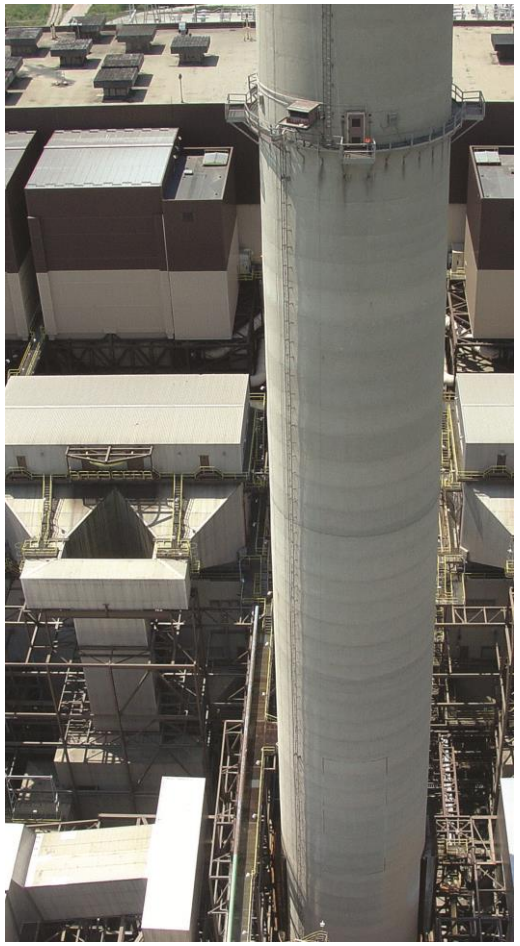
# Changing $NO_x$ Control Market

- New limits may involve installation of advanced combustion controls and/or SNCR, *but*
- Some units being forced as low as 0.05 lb/MMBtu $NO_x$, often leaving choice between SCR and retirement
- SCR is less desirable because marketplace has changed
  - Lower baseline $NO_x$ and lower capacity factors make SCR less cost-effective
  - Large capital investments are no longer desirable due to market uncertainties
- Life extension need of existing fleet requires cost-effective alternatives to SCR

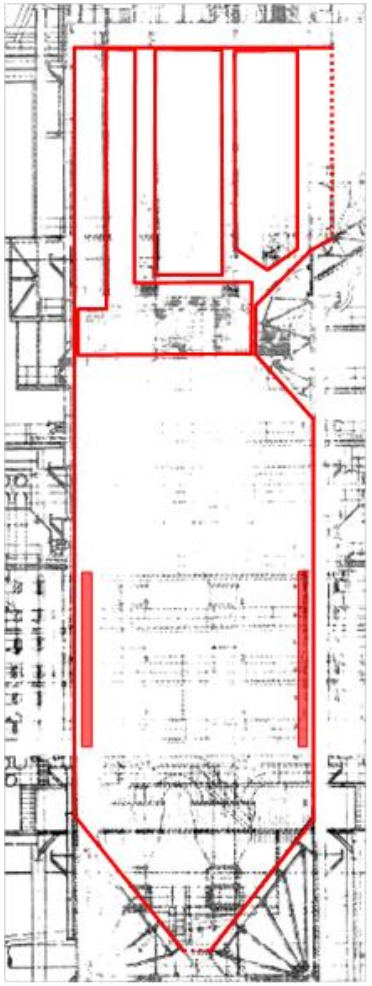
# Non-SCR $NO_x$ Reduction Strategy

- Minimize baseline emissions by applying advanced combustion controls, as ROFA® and Rotamix® at Fiddler's Ferry
- Implement LoTOx™ (low-temperature ozone injection) to achieve cost-effective "SCR-like" $NO_x$ emissions



# Unit Description

- SSE's Fiddlers Ferry Unit 2 in UK
- 500 MWe supercritical unit
- Twin tangential furnace
- Equipped with CCOFA and SOFA
- Burning blends of Columbian, Russian, and U.S. coal
- Baseline Avg. NOx: 0.44 lb/mmBtu

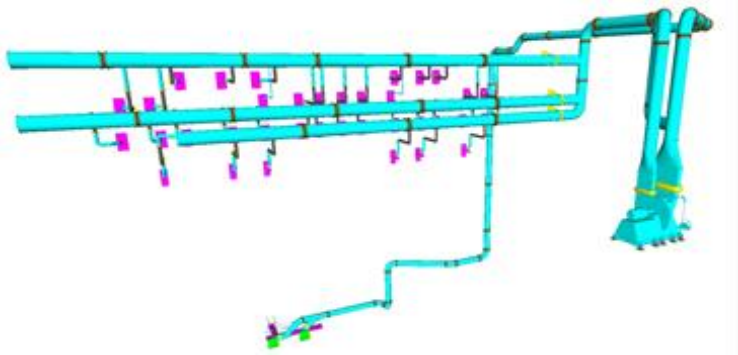


# Operating Conditions and Fuel Analysis

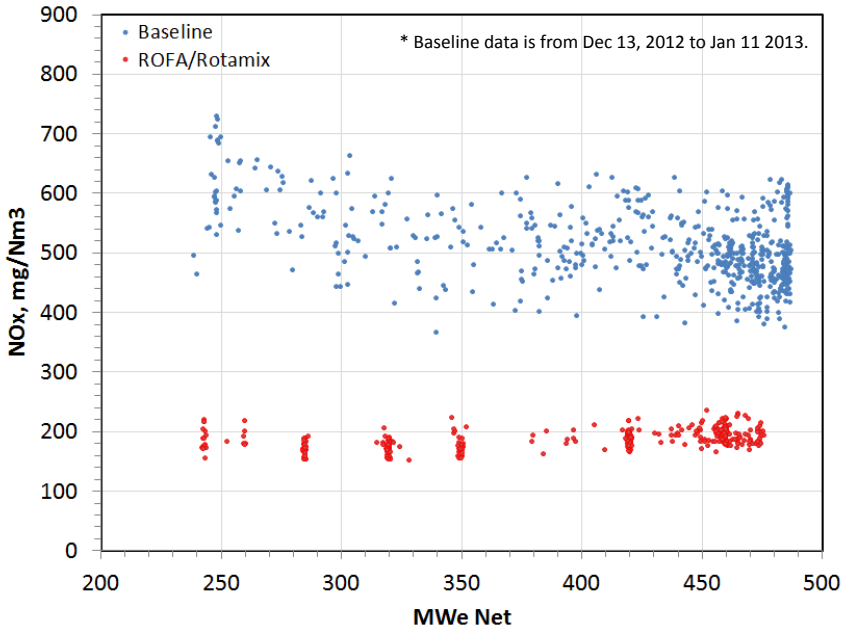
| | Unit | Value |
|---|---|---|
| System Firing Rate (based on NCV) | [$MW_{th}$] | 1245 |
| System Load | [$MW_e$ gross] | 511 |
| System Excess Air | [%] | 14.4 |
| System Excess $O_2$ | [% dry] | 2.70 |
| System Excess $O_2$ | [% wet] | 2.45 |
| System Fuel Flow | [kg/s] | 50.0 |
| System Air Flow | [kg/s] | 497.8 |
| | **Unit** | **Value** |
| Moisture | [%wt] | 12.30 |
| Ash | [%wt] | 9.05 |
| Volatile Matter | [%wt] | 31.05 |
| Fixed Carbon | [%wt] | 47.60 |
| | | |
| Carbon | [%wt] | 66.25 |
| Hydrogen | [%wt] | 4.07 |
| Oxygen | [%wt] | 5.95 |
| Nitrogen | [%wt] | 1.43 |
| Sulphur | [%wt] | 0.95 |
| Chlorine | [%wt] | 0.02 |
| GCV | [kJ/kg] | 26068 |
| NCV | [kJ/kg] | 24898 |

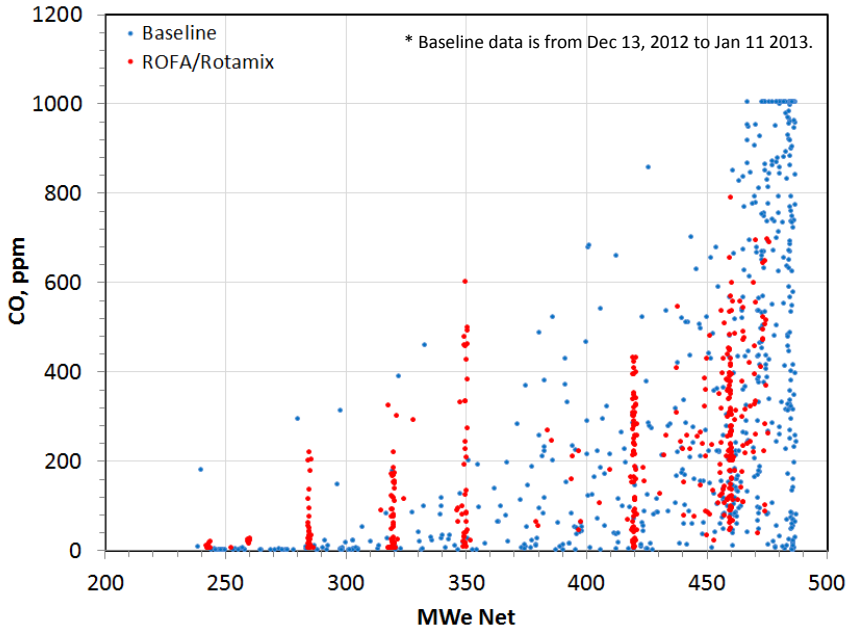
# Integrated NOx Reduction System

- Rotating Opposed Fire Air (ROFA)
  - Two ROFA fans
  - 12 ROFA boxes
  - Modulated dampers
  - Ductwork
- Rotamix SNCR
  - Rotamix fan
  - Rotamix boxes
  - Urea solution handling and dilution
  - Injection lances and devices
- Burner modifications
- Keep existing SOFA/CCOFA



# 17-Days Trial Test Results




- NOx reduced from around 0.44 lb/mmBtu to below 0.16 lb/mmBtu. Averaged NOx after modifications is 0.153 lb/mmBtu.
- CO reduced from up to 1000 ppm to below 400 ppm.

# LoTOx® $NO_x$ Control Technology

- Low-temperature oxidation
- Offered by Linde Group
- $NO_x$ scrubbing
- Widely used in refining industry with ~30 FCCU installations
- 25 MW coal-fired institutional boiler installation
- EPRI pilot demonstration at Coal Creek
- 90% $NO_x$ removal

# Reaction Kinetics

- $NO_x$ scrubbing
  - Inject ozone downstream of air heater
  - Convert insoluble $NO_x$ to highly-soluble $N_2O_5$
  - Requires ½ second residence time at 300ºF
  - Capture in scrubber
- No $SO_2$ oxidation to $SO_3$

| Reaction | Rate constants @ 25ºC |
|---|---|
| $NO + O_3 \rightarrow NO_2 + O_2$ | 62,500 |
| $2\,NO_2 + O_3 \rightarrow N_2O_5 + O_2$ | 125 |
| $CO + O_3 \rightarrow CO_2 + O_2$ | 1 |
| $SO_2 + O_3 \rightarrow SO_3 + O_2$ | 5 |

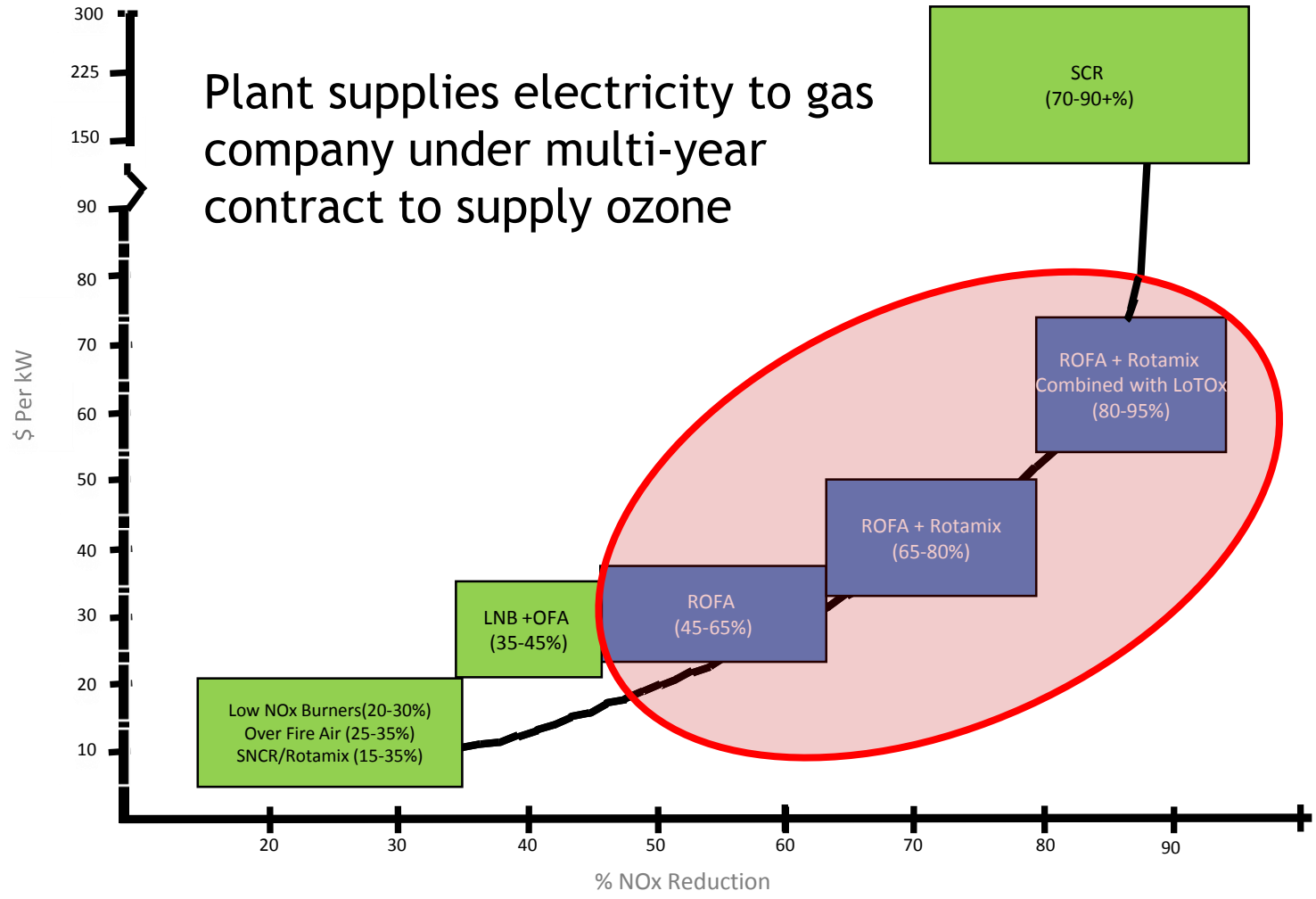
# Performance and Operational Advantages

- $NO_x$ Performance
  - Capable of 90% removal
  - Select % removal by treating fraction of gas flow
- Multi-pollutant control
  - 50-70% Hg oxidation
  - Offset $CaBr_2$ addition rate
- Ozone supply flexibility
- Advantage over SCR
  - No MOT constraints
  - No AH fouling
  - No catalyst deactivation

# Utility Boiler Applications – What's Changed?

- Lower $NO_x$ baselines
- Smaller units
- Reduced capacity factors
- Improved utilization of oxygen in ozone production
- More flexible ozone delivery options
- Effluent regulations driving more plants to ZLD
- FCCU long-term operation

# ‘Over the Fence’ Ozone Supply Cost Model



# Summary and Conclusions

- Non-SCR boilers are being pushed to further reduce $NO_x$ emissions
- ROFA and Rotamix are cost-effective, but cannot achieve SCR-like emissions reductions
- LoTOx is best-suited to applications with low baseline $NO_x$ emissions
- The combination of ROFA and LoTOx provides a cost-effective alternative to SCR, with fewer operational constraints