"APPLICATIONS, ISSUES & ANSWERS for SNCR"

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Fuel Tech Experience

- **Urea Based SNCR to Reduce NOx**
  - **400 Installations World Wide**
  - **~360 Retrofits**
  - **310 Industrial**
  - **90 Utilities**

GENERAL INDUSTRY EXPERIENCE

- Electric Utilities
- Wood-fired IPPs / CoGen Plants
- TDF Plants
- Pulp & Paper
  - Grate-fired
  - Sludge Combustors
  - Recovery Boilers
  - Wellons Boilers
  - Cyclones
- Refinery Process Furnaces
  - CO Boilers
- Petrochemical Industry
- CoGeneration Package Boilers
- Municipal Solid Waste
- Process Units
- Cement Kilns

NOxOUT® SNCR EXPERIENCE

Boiler Types

- Utility Boilers
  - T-fired, Wet Bottom, Front-wall Fired, Cyclone, Tower, Opposed-wall
- Circulating Fluidized Bed
- Bubbling Fluidized Bed
- Stoker, Grate Fired
- Incinerators
- Industrial

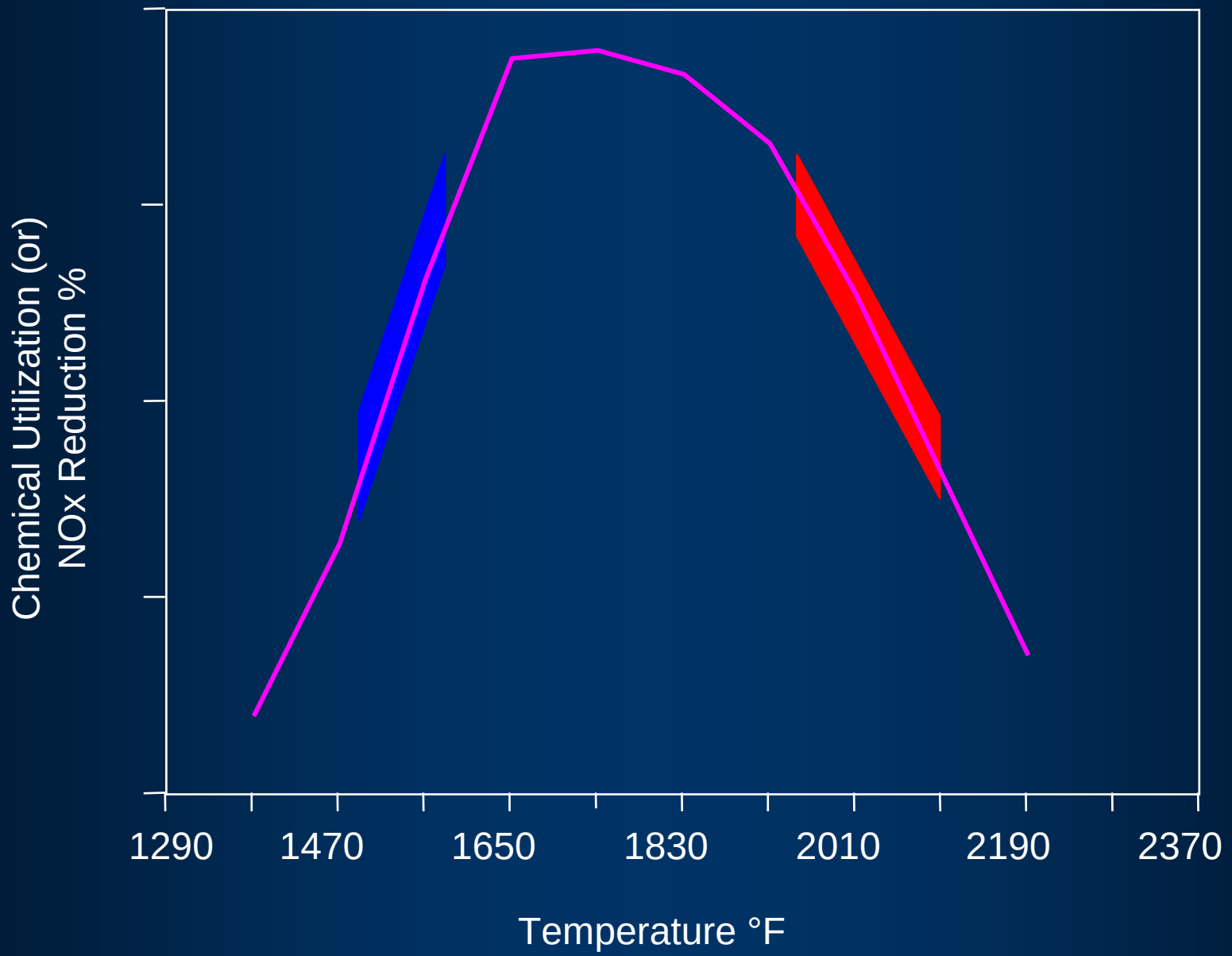
Fuels Used with NOxOUT® SNCR Systems

Fuels

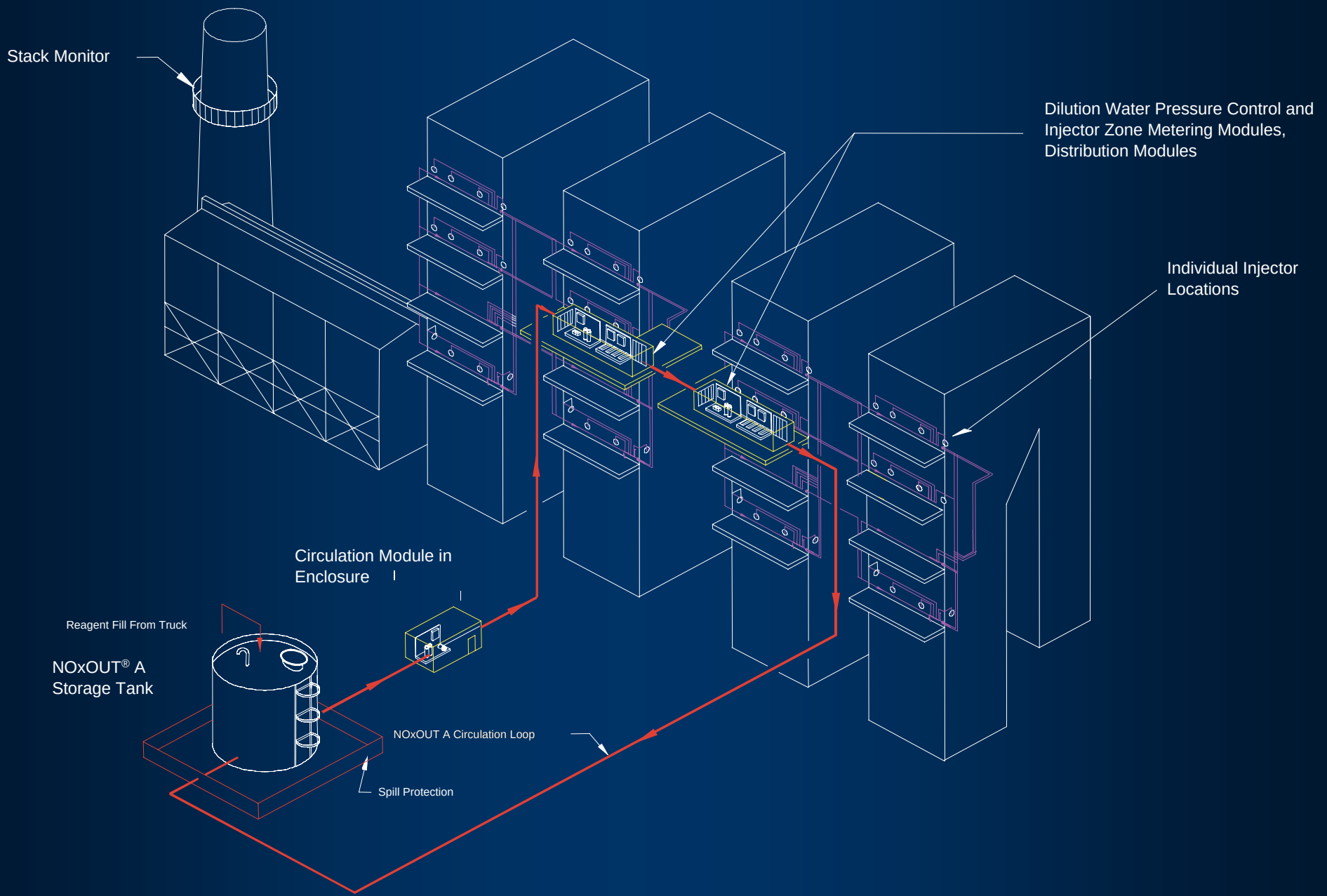
- Bituminous, Sub-bituminous, PRB, Lignite
- Oil - #2 and #6
- Natural Gas
- Refinery Gases (High CO)
- Municipal Solid Waste
- Tire Derived Fuel
- Wood, Bark, Bagasse
- Sludge
- Poultry Waste

EGU Facilities - SNCR

TYPICAL SNCR PROCESS CURVE



NOxOUT® SNCR PROCESS SCHEMATIC



Time to "demythologize"…

- **SNCR is not applicable to multi-fueled units.**
- **SNCR is only applicable to base-loaded boilers or processes.**
- **SNCR produces excessive NH_3 slip.**
- **Ammonia is a dangerous chemical.**

NOxOUT® SNCR on B&W Bubbling Fluidized Bed Boiler 450,000 Lb/hr Design Steam Flow

Fuel Fired	Wood, Sludge, TDF	Wood, Sludge	
Steam Flow (kpph)	**450**	**450**	**375**
Maximum Heat Input (MMBtu/hr)	**748.5**	**710.6**	**624.4**
Uncontrolled NOx (ppm)	**262**	**248.6**	**218.6**
Controlled NOx (ppm)	**111**	**111**	**111**
NOx Removal (%)	**57**	**55**	**50**
NH_3 Slip Limit (ppm)	**15**	**15**	**15**

NOxOUT® SNCR On Hazardous Waste Combustor
225,000 ACFM SCC Off-Gas Flow

Fuels Fired	High NOx	High NOx	High NOx
Maximum Heat Input (mmBtu/hr)	145	145	145
Uncontrolled NOx (ppmvd)	740	730	719
Controlled NOx (ppmvd)	333	365	431
NOx Removal	55%	50%	40%
NH_3 Slip at Stack (ppm)	20	15	10
Expected Temperature (°F)	1800	2000	2200

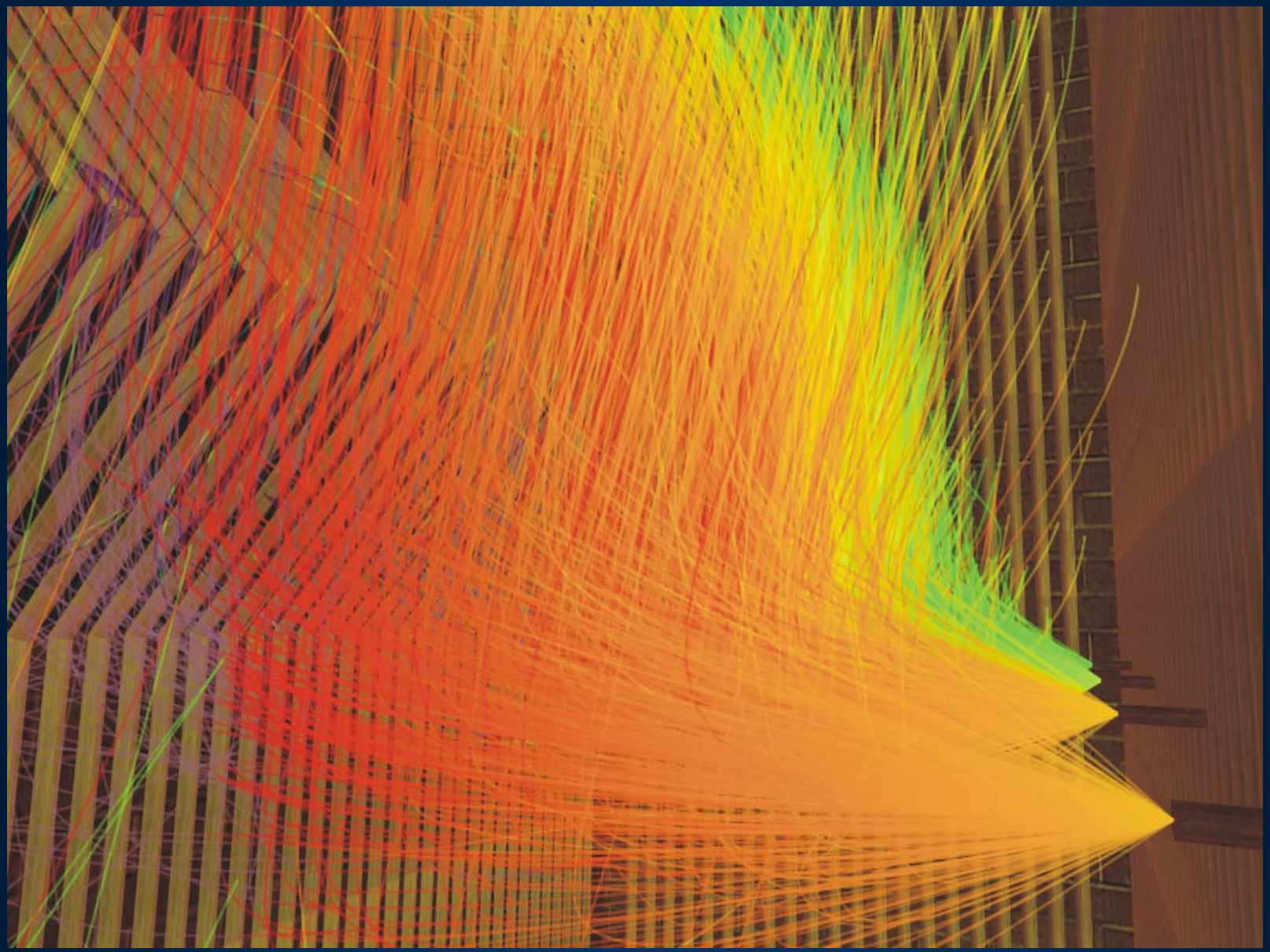
NOxOUT® SNCR on Grate-Fired Boiler
325,000 lb/hr Design Steam Flow

Fuels Fired	Wood	Wood/Oat Hulls	NG
Maximum Heat Input (mmBtu/hr)	516.0	493.0	448.0
Uncontrolled NOx (lb/mmBtu)	0.34	0.34	0.34
NOx Removal	56%	56%	56%
NH_3 Slip from Process (ppm)	30	30	25

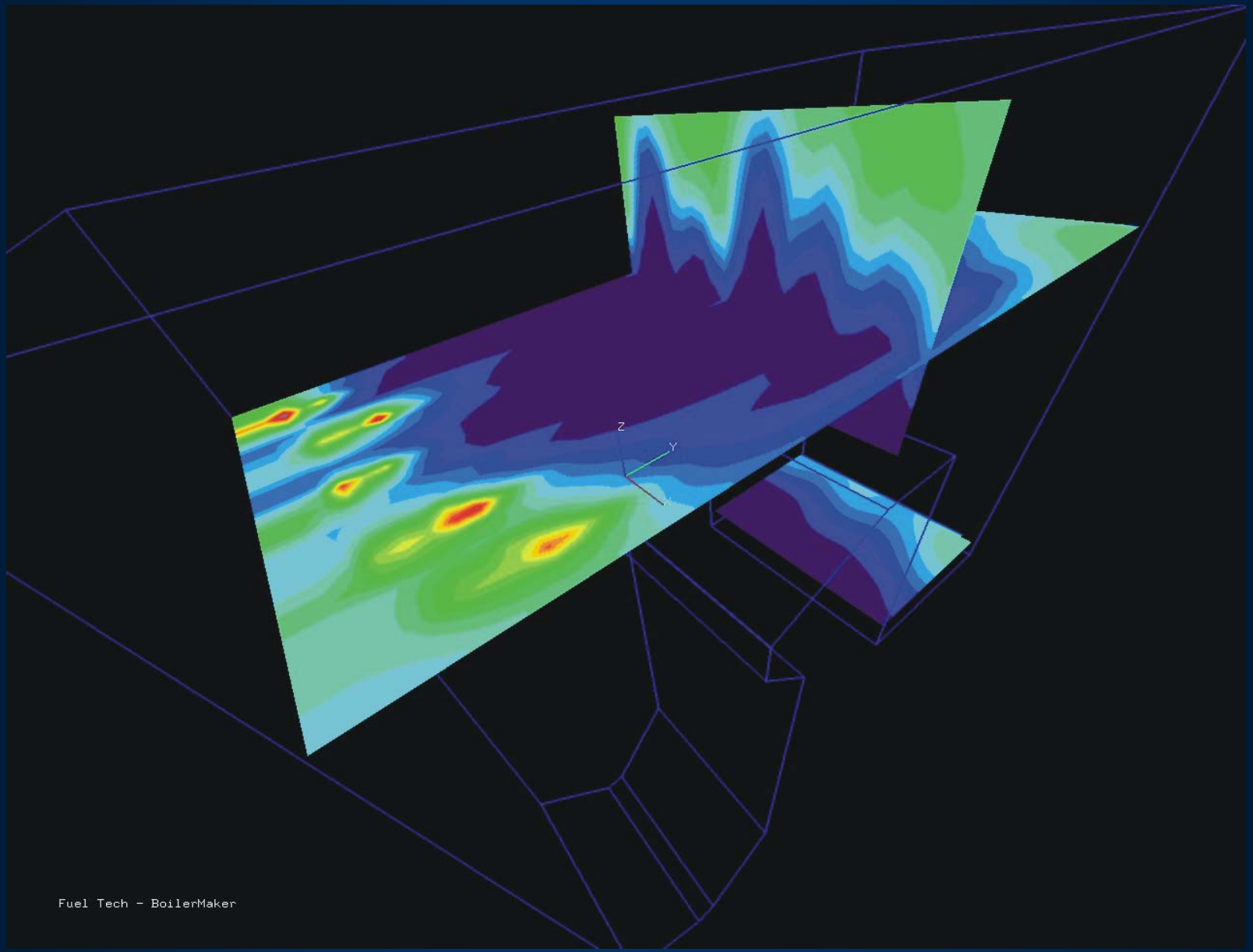
NOxOUT® SNCR on B&W Bark and Ng-Fired Boiler 315,000 lb/hr Design Steam Flow, 0.250 Baseline NOx

Fuel Fired	Bark	Bark	Bark/NG	Bark/NG
Steam Flow (kpph)	315	220.5	315	220.5
Maximum Heat Input (MMBtu/hr)	548	384	548	384
Uncontrolled NOx (lb/MMBtu)	0.250	0.250	0.250	0.200
Controlled NOx (lb/MMBtu)	0.150	0.150	0.188	0.160
NOx Removal (%)	40	40	25	20
NH_3 Slip at Scrubber Inlet (ppm)	30	30	25	20
Expected Temperature (°F)	1850-1950	1700-1800	1950-2050	1950-2050

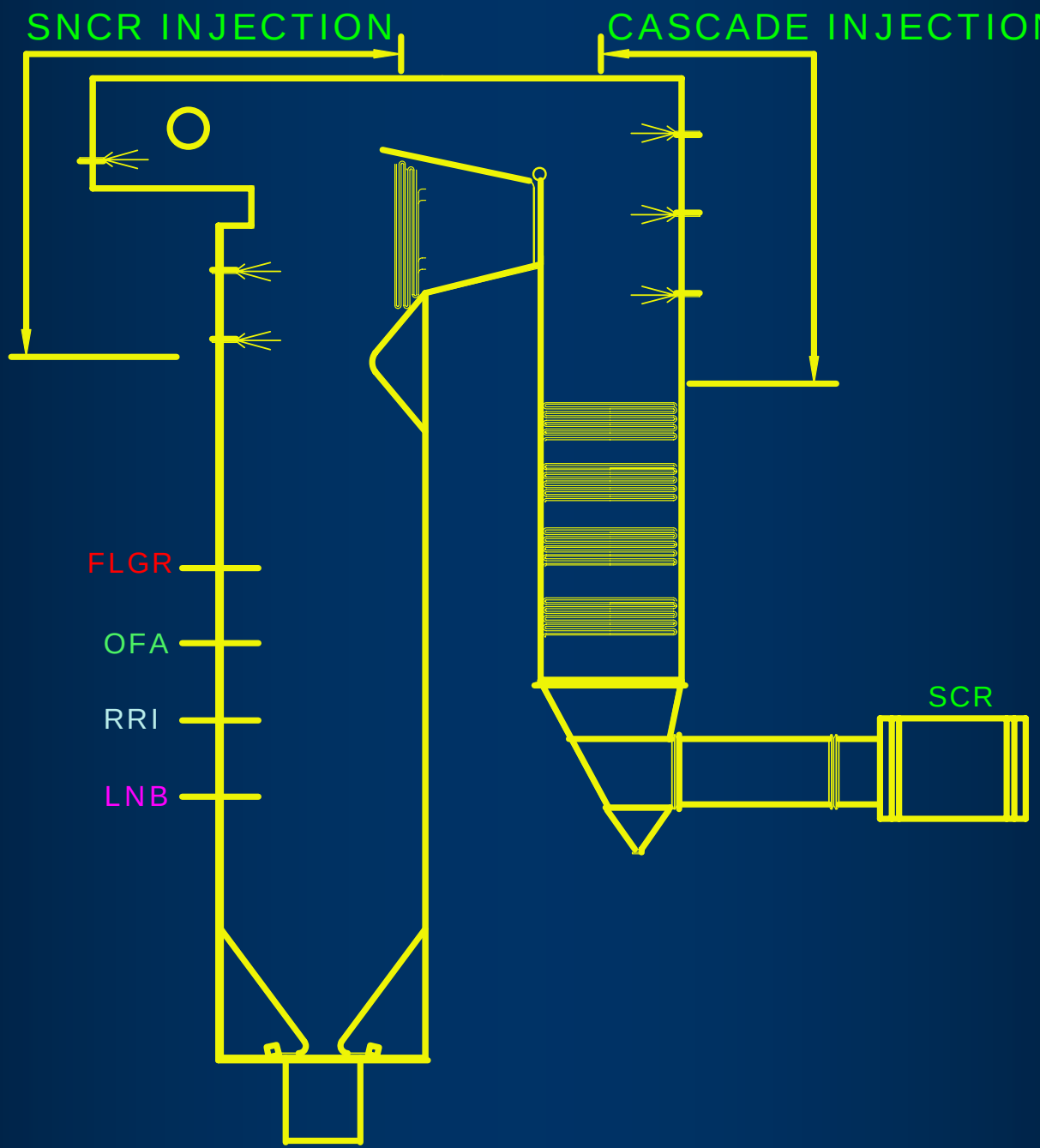
3D VISUALIZATION – Urea Injection Sprays



3D VISUALIZATION – NH_3 Distribution



Combined Technologies



Annual Basis

NOx Control	*NSR*	*Tons Removed*	*Total $/Ton*
SNCR	0.67	680	1,753
SNCR	1.04	1,069	1,502
RRI	2.05	1,117	2,440
RRI	3.05	1,409	2,726
RRI	4.09	1,571	3,186
SNCR/RRI	2.97	2,024	2,507

NOxOUT CASCADE ® – Steel Industry Direct Fired Furnace

- Furnace Heat Input = 48 MMBTU/hr
  - **NOx Baseline = 0.30 lb/MMBtu, 222 ppmd@5.37 % O2**
  - **Controlled NOx = 0.045 lb/MMBtu, 33.3 ppmd@5.37% O2**
  - **SNCR NOx Reduction = 75%**
  - **SCR Reduction = 40%**
  - **Overall Reduction = 85%**

NOxOUT CASCADE ® - Industrial

- Furnace Heat Input = 60 MMBTU/hr
- NOx Baseline = 0.227 lb/MMBtu
- Controlled NOx = 0.054 lb/MMBtu

- SNCR NOx Reduction = 60%
- Incremental SCR Reduction = 40%
- Overall Cascade Reduction = 76%

NOxOUT® SNCR CO Boiler

- Fuel: Natural Gas & Reg. Gas
- Heat Input: 243 MMBtu/hr
- Total Flue Gas Flow = 3,218,729 WSCFH
- NOx Baseline = 169 ppmw @ 4.18% O2
  (65 lb/hr)
- NOx Target = 44 ppmw @ 4.18% O2
  (16.9 lb/hr)
- 74% Reduction, 20 ppm NH3 Slip @ 13 GPH

Future Rules

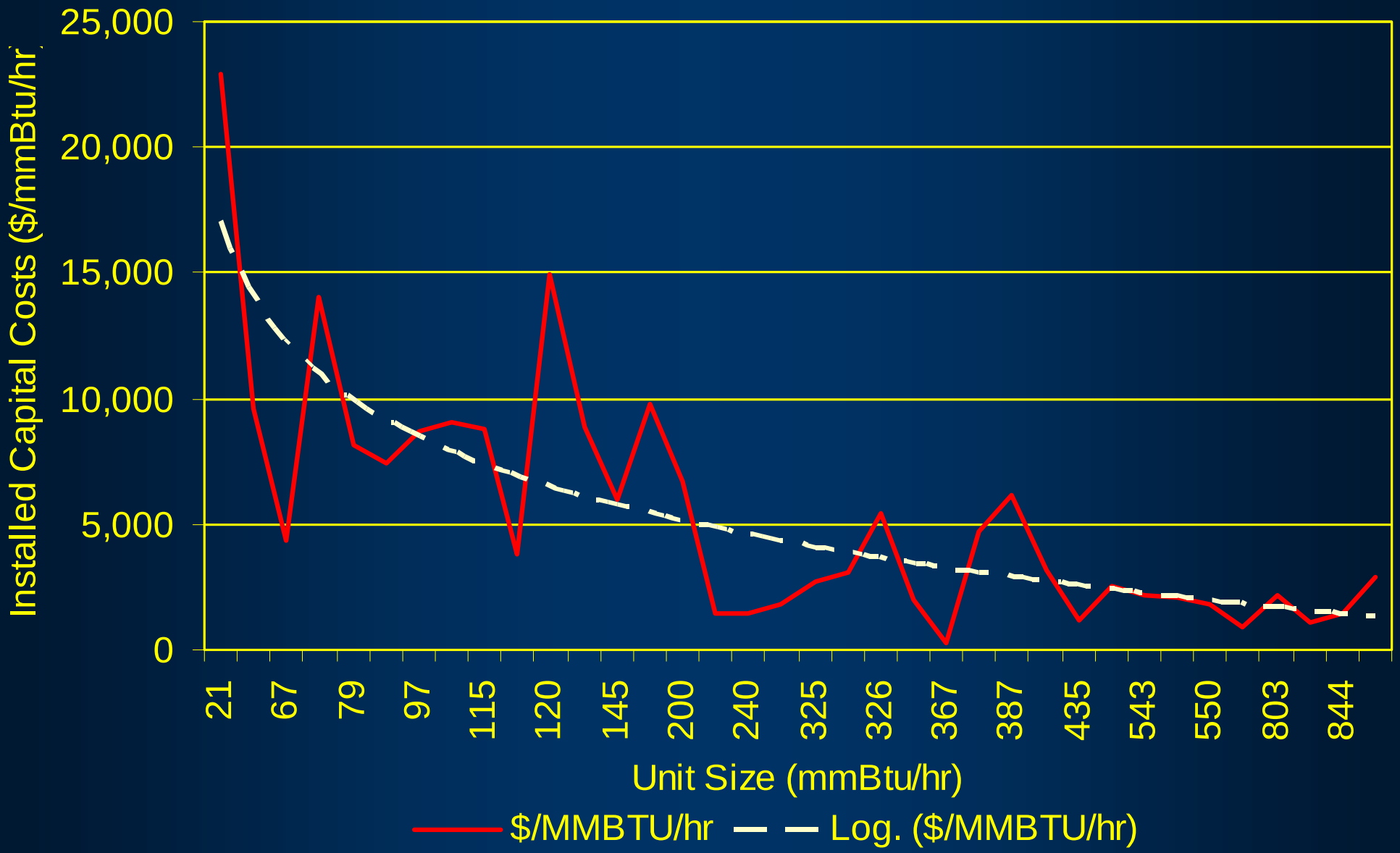
- **Cost effectiveness becomes a defining criterion on a more case-by-case basis.**
- **RACT - for 8 hr. O3 NAAQS**
  - **Technically feasible**
  - **Cost Effective**
- **BART for Regional Haze Rule**
  - **Cost Effectiveness is a Statutory Criterion**

Cost Effectiveness Algorithms

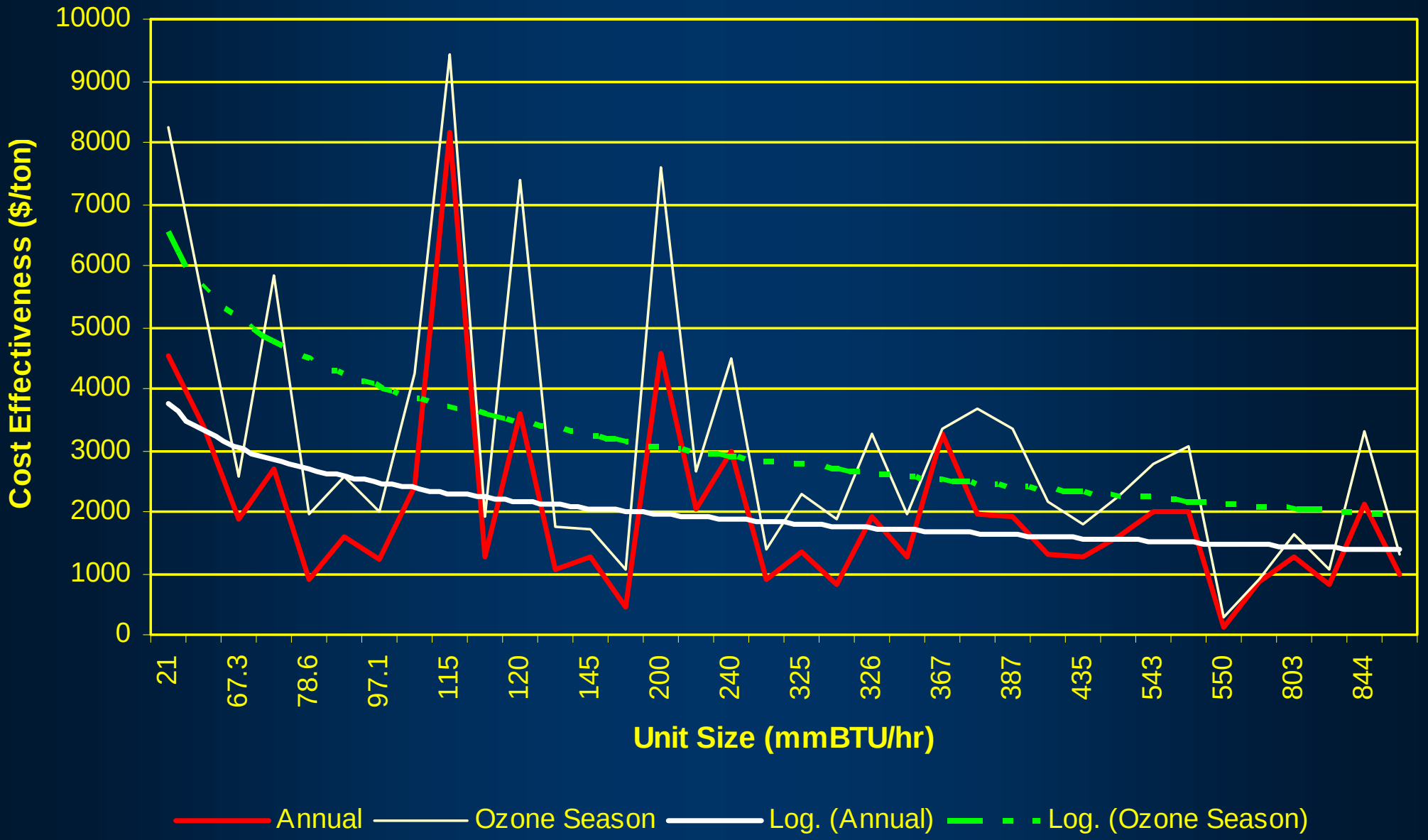
- CUECost * (± 30% by design)
- OAQPS Manual (10/2000 last update)
- EPRI TAG *

* Applicable to EGUs

Actual SNCR Installed Capital Costs on Industrial Sources



Actual SNCR Cost Effectiveness on Industrial Sources



Capital Recovery from Cost Effectiveness Manual

- **20 yr. Recovery Period**
- **7% Rate**

Vague 3

- **"Factored" Installation Costs**
- **Retrofit Difficulty Factor**
- **Project Contingency**

Compliance Cost ≠ Control Cost

- Control Costs
- CEMs
- Permit Costs
- \+ Consultant Costs

- Compliance Costs (are applicable and incurred wo/controls)