

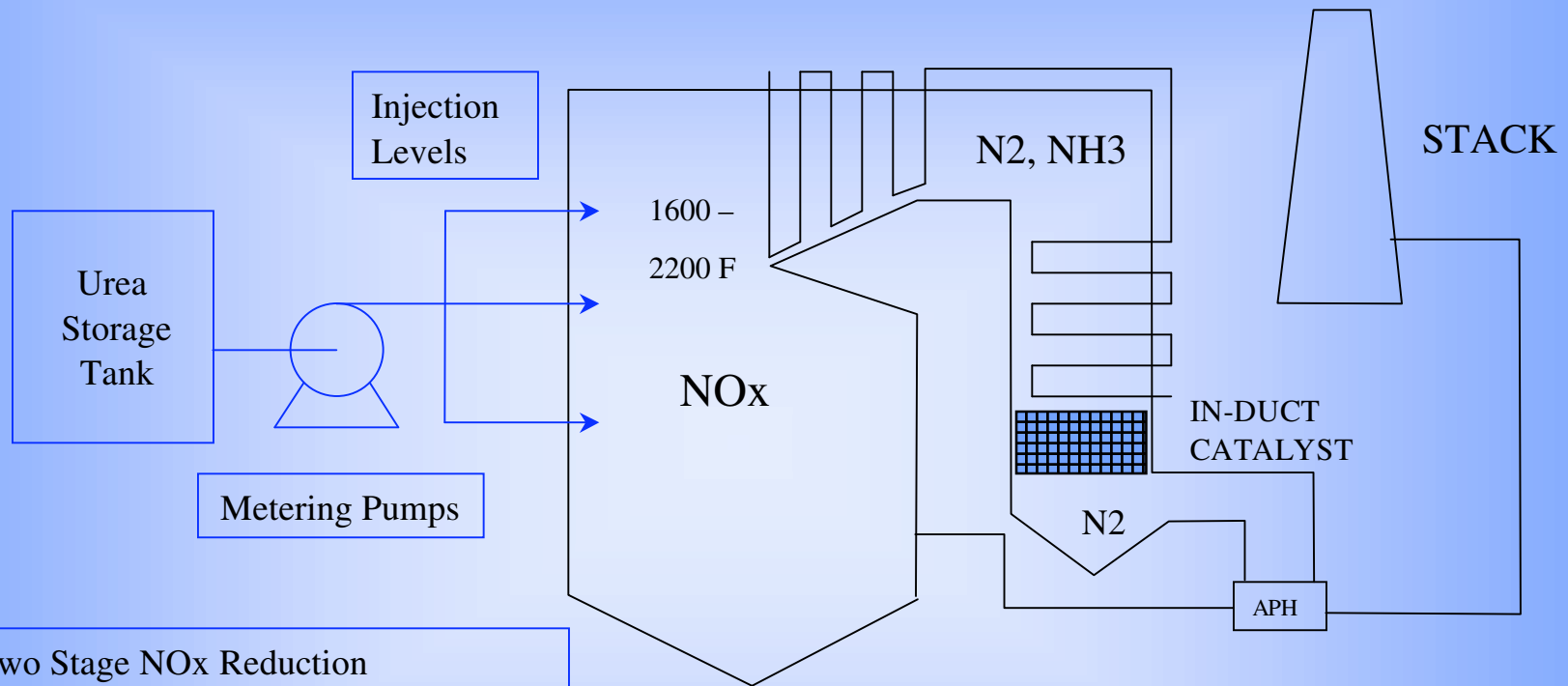
# Hybridized SNCR / SCR

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**4th Annual Reinhold Environmental  
NOx Round Table and Expo 2005**

# *SNCR/SCR Hybrid Process*



- Two Stage NO<sub>x</sub> Reduction
- SNCR NH<sub>3</sub> Slip feeds Catalyst
- High NO<sub>x</sub> Reduction
- Low Ammonia Slip
- Lower Installation Cost than SCR
- Lower Capital Cost than SCR

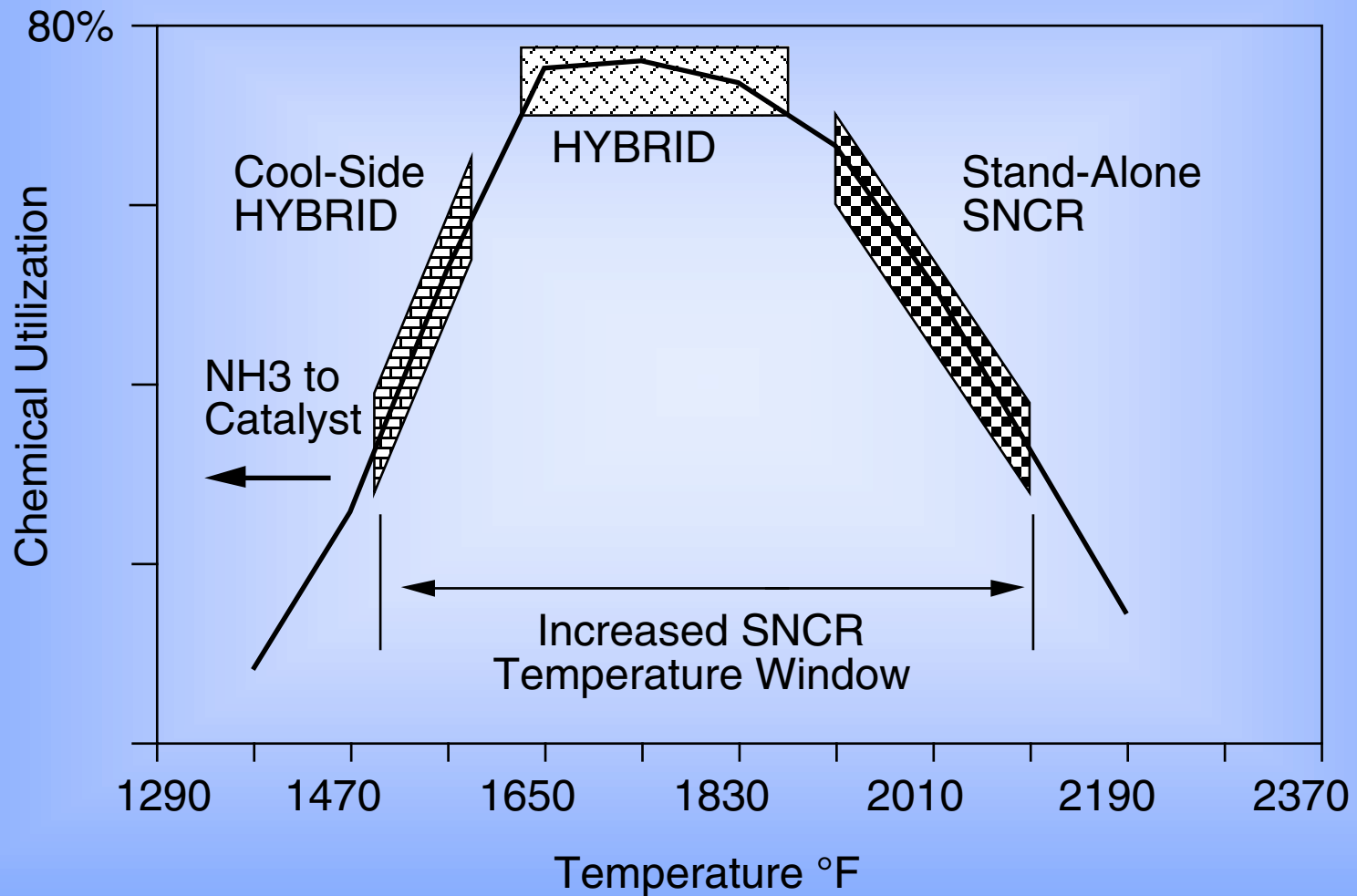
## *Hybrid SNCR /SCR*

- A **Redesigned** SNCR System with SCR
- Higher NO<sub>x</sub> Reduction and Utilization than SNCR
- Lower Capital Costs than Full-scale SCR
- Greater Operational Flexibility
  - Seasonal NO<sub>x</sub> Emission Limits
  - Seasonal and Daily Load Variations
  - Marketplace Variations ( Fuel Supply, NO<sub>x</sub> Credits )

# *Selective Non-Catalytic Reduction*

- High temperature urea injection
- $2(\text{NH}_2)\text{CO} + 2 \text{NO} + 1/2 \text{O}_2 \Rightarrow 2 \text{N}_2 + 2\text{H}_2\text{O} + \text{CO}_2$
- Performance dependent on:
  - Chemical release temperature
  - Effective residence time
  - Chemical coverage and mixing
  - CO, fuel sulfur, and ammonia slip constraints

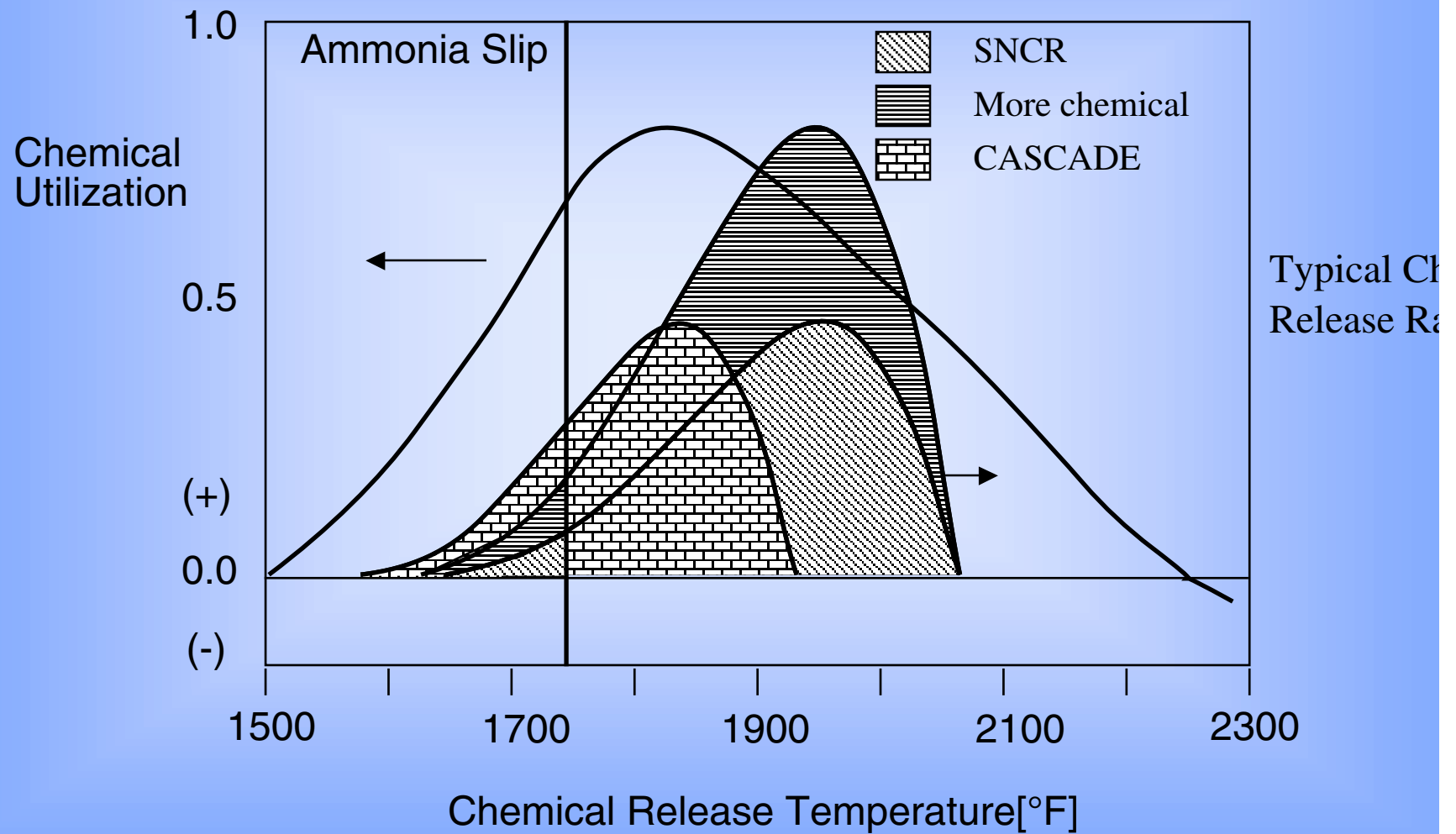
# Hybrid Improves Chemical Utilization



## *Hybrid Makes Sense When You Have...*

- Improved SNCR Chemical Utilization
  - Decreased operating cost vs. traditional SNCR
- Reduced capital commitment (\$)
  - Compact catalyst reactor
  - No fan upgrades
- Proper temperature, face velocity and ash loading
- Ammonia / NO<sub>x</sub> Distribution at the Catalyst

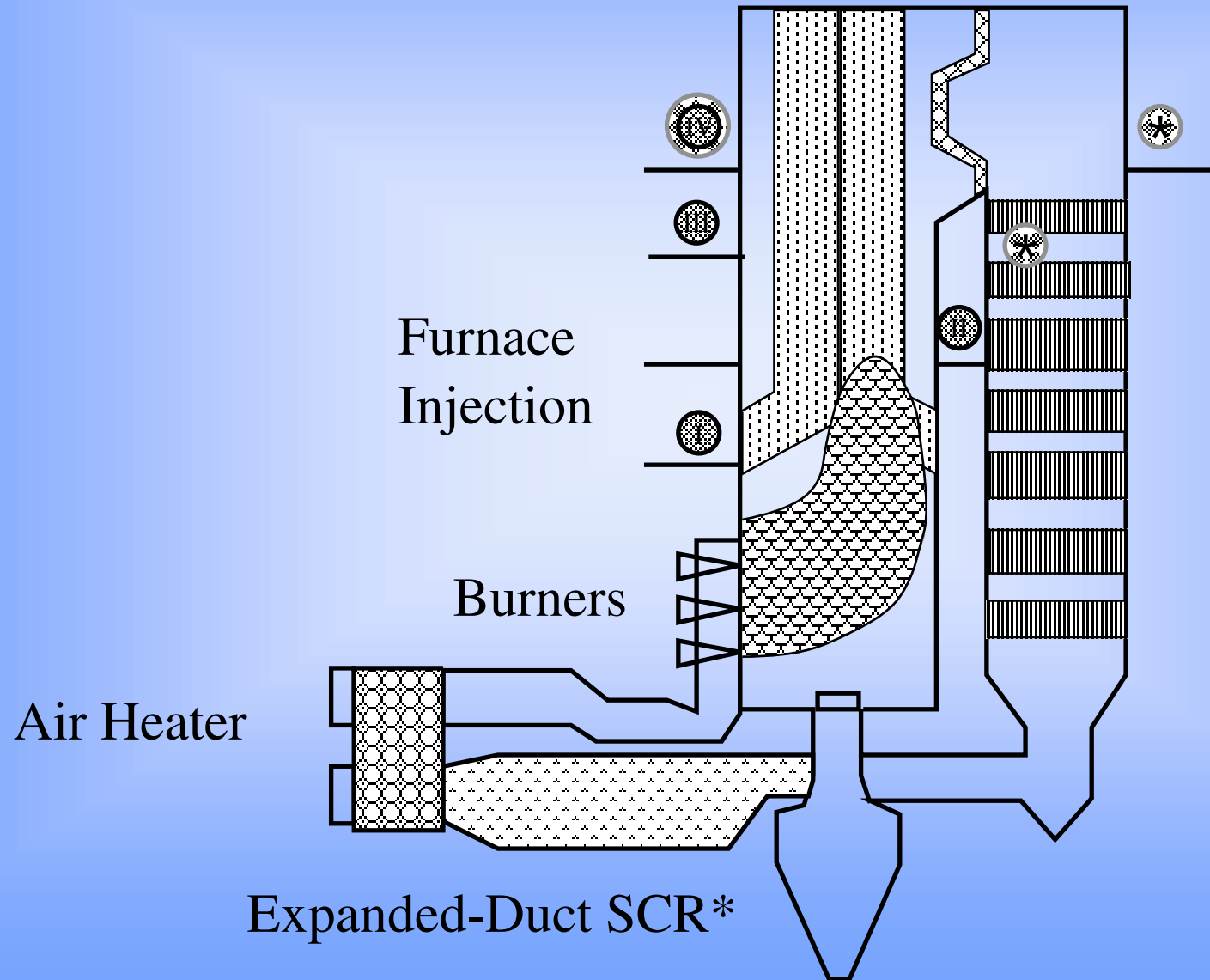
# Lower Temperature Injection Not More Chemical!



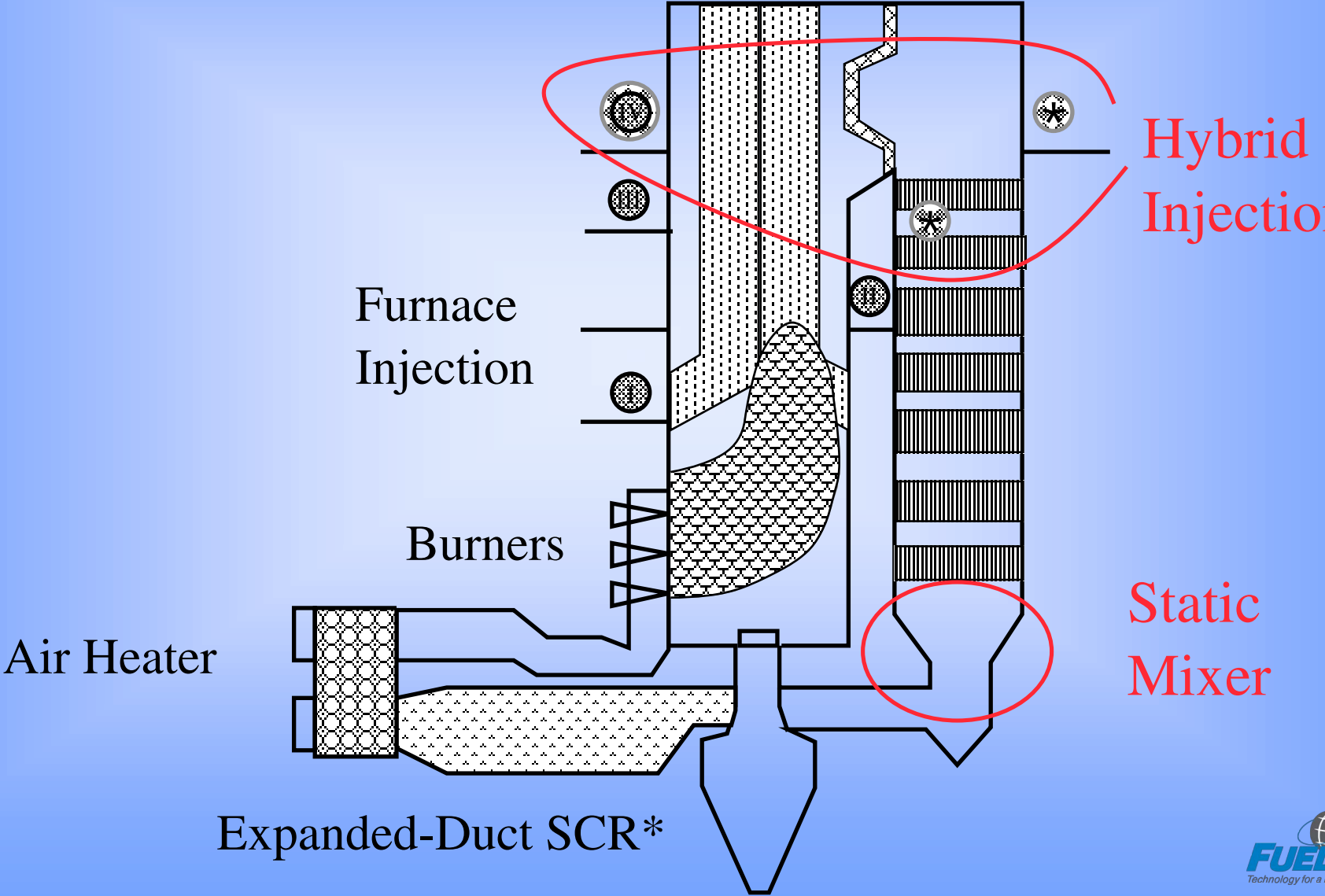
## *Process Experience - PSE&G Mercer Generating Station*

- 320 MWe Utility Boilers firing Coal and Natural Gas
- F-W wet bottom, continuous slagging, twin-furnace
- Installed NO<sub>x</sub>OUT SNCR system
  - 37% reduction, 31% utilization, 4 ppm NH<sub>3</sub> slip
- Installed full-scale 90-95% SCR system
  - Ammonia injection grid
  - Static mixing vanes before AIG

# *PSE&G Mercer Unit #2*



# PSE&G Mercer Unit #2



## *High Load (320MWe) Hybrid Results*

Fuel	NOx Control System	NSR	SNCR Reduction	SNCR Utilization	SCR Reduction	Total Reduction	Overall Utilization
Coal	Standard SNCR	1.19	37.0%	31.1%	-	37.0%	31.1%
Coal	Hybrid	0.79	41.1%	52.0%	16.3%	50.7%	64.2%
Coal	Hybrid	1.15	36.9%	32.1%	54.2%	71.1%	61.8%
Gas	Hybrid	1.44	36.1%	25.1%	78.9%	86.5%	60.1%
Gas	Hybrid	1.56	39.0%	25.0%	83.6%	90.0%	57.7%

- Ammonia Slip at 10 ppm or less

## *Hybrid Makes Sense When You Have...*

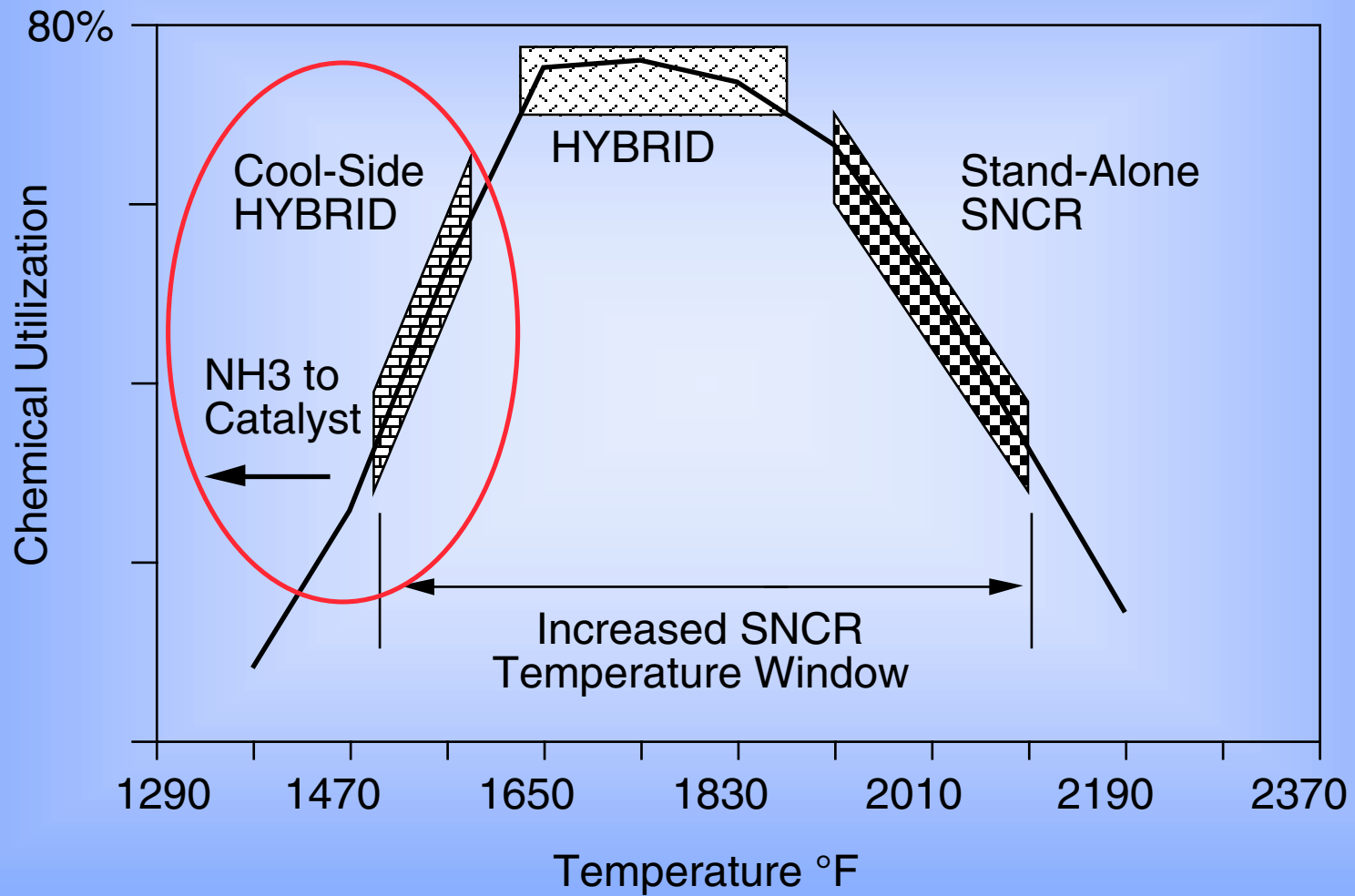
- **Improved SNCR Chemical Utilization**
  - Decreased operating cost vs. traditional SNCR
- **Reduced capital commitment (\$)**
  - Compact catalyst reactor (16 - 54% SCR Reduction)
  - No fan upgrades (one catalyst module)
- *Proper temperature, face velocity and ash loading*
- *Ammonia / NO<sub>x</sub> Distribution at the Catalyst*

## *Low Load (80 MWe) Hybrid Results*

Fuel	NOx Control System	NSR	SNCR Reduction	SCR Reduction	Total Reduction	Overall Utilization	Ammor Slip
Coal	Standard SNCR	1.28	61.0%	-	61.0%	48.8%	7 ppm
Coal	Hybrid	1.22	10.5%	91.5%	92.4%	75.7%	1 ppm
Gas	Standard SNCR	1.07	40.0%	-	40.0%	37.4%	7 ppm
Gas	Hybrid	1.3	11.5%	94.6%	95.3%	73.0%	3 ppm

- 90% - 95% SCR Reduction
- Cold-side SNCR chemical release

# Hybrid Improves Chemical Utilization



## *Hybrid Makes Sense When You Have...*

- **Improved SNCR Chemical Utilization**
  - Decreased operating cost vs. traditional SNCR
- **Reduced capital commitment (\$)**
  - Compact catalyst reactor (16 - 54% SCR Reduction)
- **Proper temperature, face velocity and ash loading**
- **Ammonia / NO<sub>x</sub> Distribution at the Catalyst**
  - Greater than 90% NO<sub>x</sub> reduction

## *Seward Station - Boiler # 15 (Unit #5)*

- 147 MW gross generating capacity
- CE - tangentially fired - coal
- 0.8 - 1.5 percent sulfur
- 1990 NO<sub>x</sub> baseline of 0.78 pounds per million Btu
- Phase I control (CAAA)
  - RACT - NO<sub>x</sub>OUT<sup>®</sup> SNCR system
- Phase II control (May, 1999)
  - 55% reduction from 1990 baseline (0.35 lb)

## *SNCR to Hybrid SNCR/SCR*

- Changes to Optimize the SNCR system
  - Lower effective chemical release temperature
  - Maximize NO<sub>x</sub> reduction
  - Increase in allowable ammonia slip
- Optimize chemical utilization

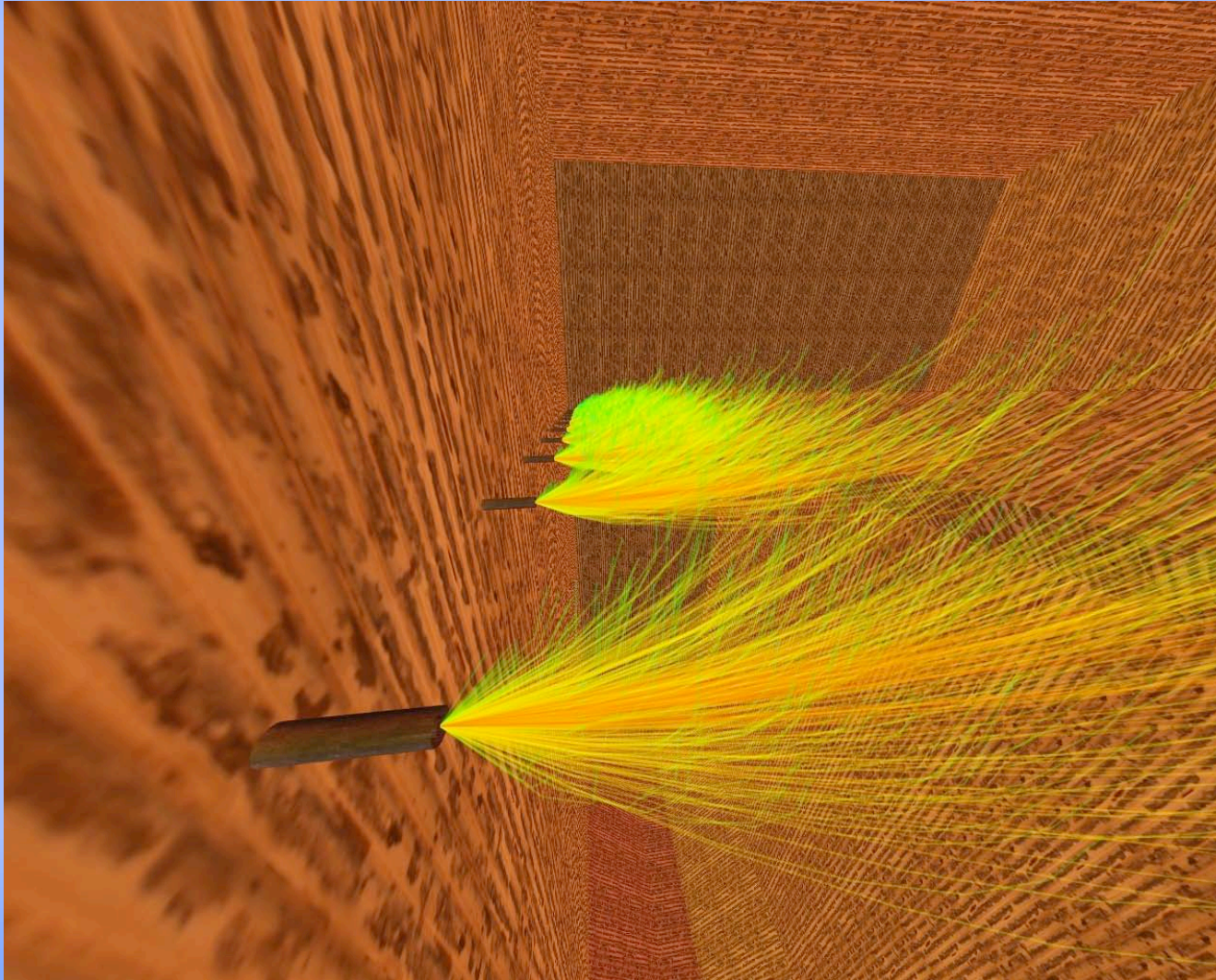
## *SNCR to Hybrid SNCR/SCR*

- Install catalytic reactor (SCR) to reduce ammonia slip
  - Minimize capital expenditure
  - Provide ammonia / NO<sub>x</sub> ratio at catalyst face
  - Equalize velocity distribution
  - Equalize temperature distribution
  - Equalize ash distribution (erosion)
  - Minimize SO<sub>2</sub> oxidation to SO<sub>3</sub>

# *NO<sub>x</sub>OUT<sup>®</sup> SNCR*

- Installed NO<sub>x</sub>OUT SNCR system in 1996
  - Three injection zones
  - 50% to 100% load following
  - Zone #3 consists of Multi-Nozzle Lances
- Multi-Nozzle Lances (MNL's)
  - Permit chemical injection in convective pass
  - Provide nearly complete coverage

# *Fuel Tech Urea Injection Modeling*



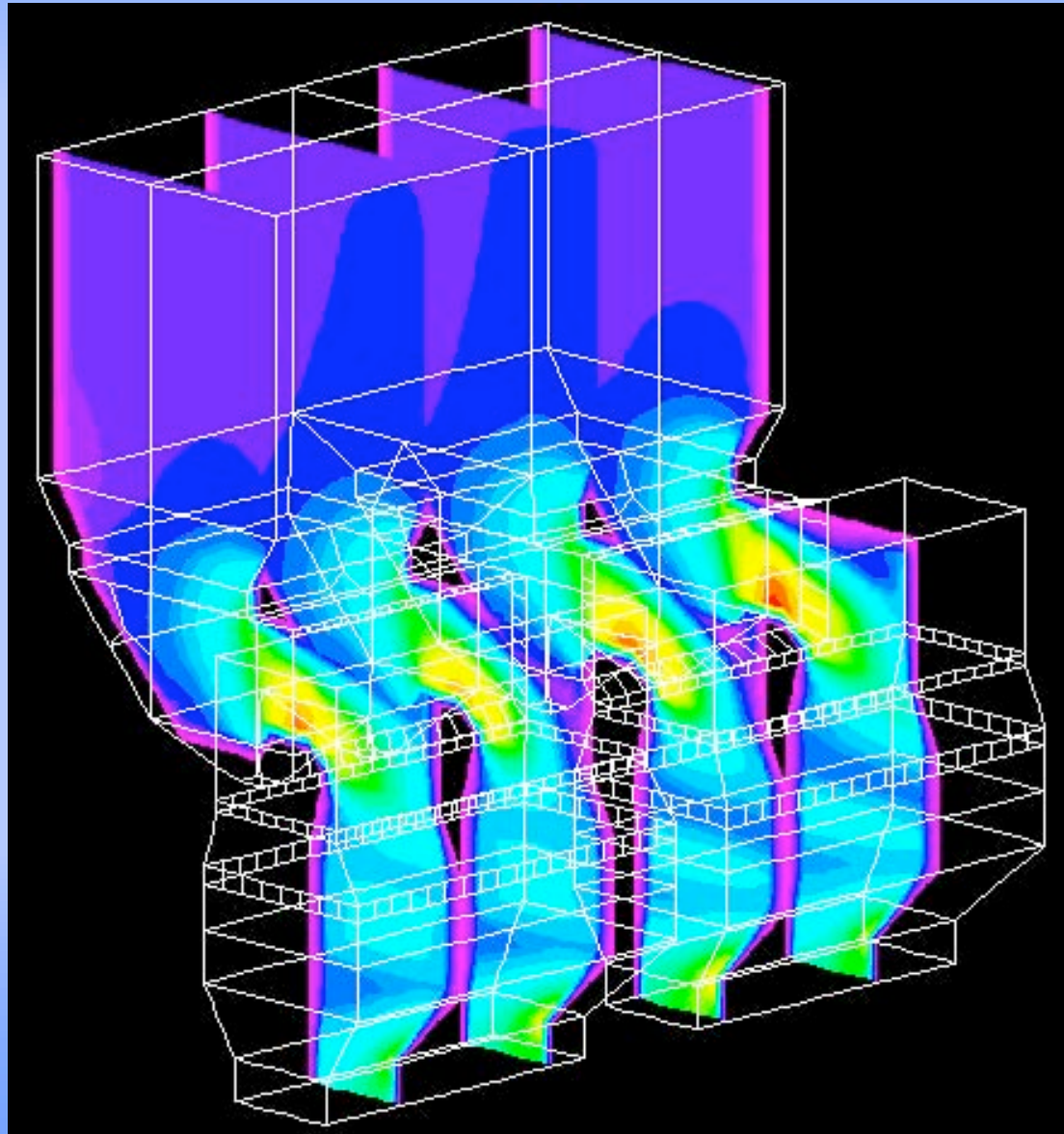
## ***NO<sub>x</sub>OUT<sup>®</sup> Performance - 147 MWg***

- Moving from furnace to convective pass injection
  - 42% reduction, 0.45 #/MMBtu, <5 ppm NH<sub>3</sub> slip
  - 35% reduction, 0.5 #/MMBtu, <2 ppm NH<sub>3</sub> slip
    - Less than 10 % in convective pass
  - 54% reduction, 0.36 #/MMBtu, <10 ppm NH<sub>3</sub> slip
    - Short-term testing

## *Demonstration Catalyst Selection*

- Two catalysts were selected for the parallel ducts
  - Honeycomb
  - Plate-Type
- Required Ammonia Reduction from 20 ppm to 2 ppm
- Minimum SO<sub>3</sub> production (Ammonium Salts)
- Minimum pressure drop
- Withstand coal fired gas stream

# *CFD Reactor Modeling*



# *Cold Flow Modeling*



## *Hybrid SNCR/SCR Performance*

- Single Layer of SCR Catalyst
- Maximum Reduction Achieved (>50%)
- Variable NH<sub>3</sub> slip dependent on Load: 2 - 20 ppm
- Increased Chemical Utilization
- Less than 2 ppm ammonia slip at SCR Outlet

## *Conclusions*

- Hybrid combines **redesigned** SNCR with SCR
- Hybrid can be used to control slip and improve utilization
- Hybrid design significantly reduces SCR retrofit capital
- Increased Control Flexibility: Operating vs. Capital Costs
- Each Unit Must Be Evaluated to Determine Feasibility for placement of an IN-DUCT or COMPACT SCR.