An EPA Perspective on Reburn Technology for NO_X Control

by

Robert E. Hall

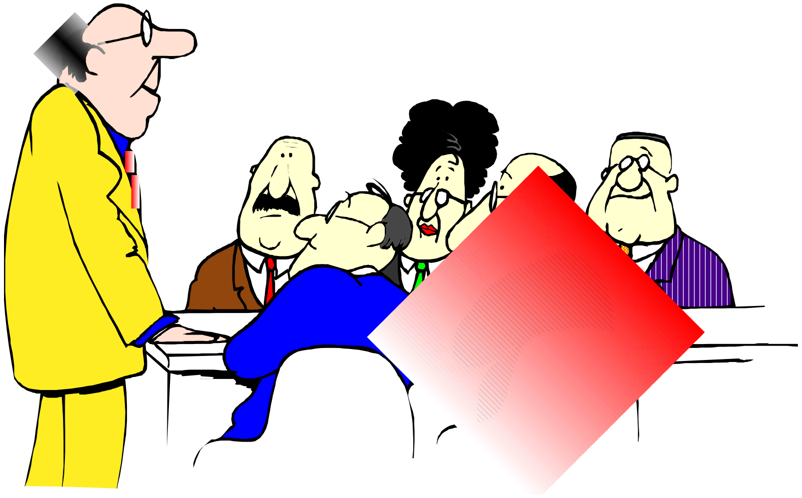
And

Ravi K. Srivastava

2004 Conference on Reburning for NO_X Control

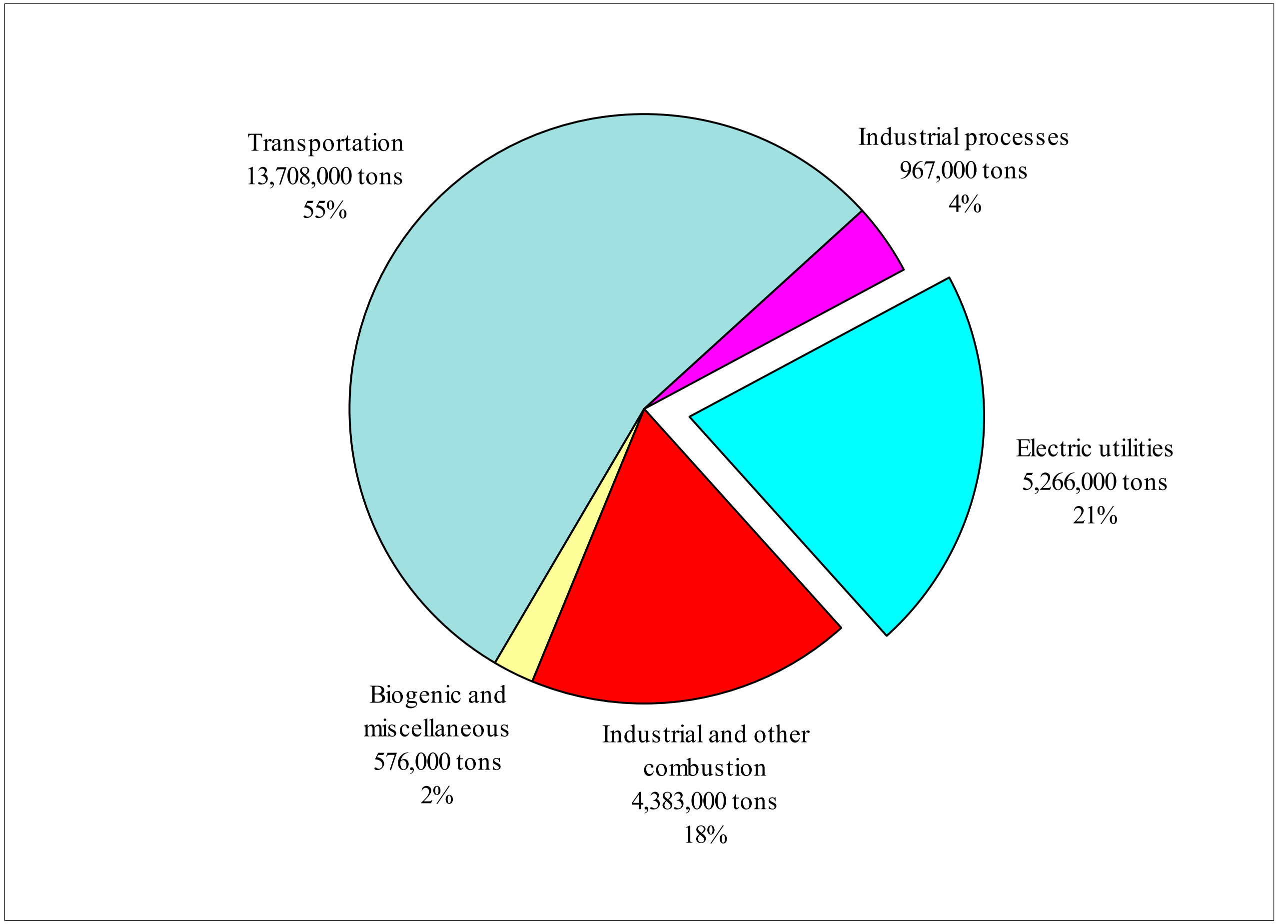
What We'll Cover Today . . .

- Sources of NO_X emissions
- Regulatory overview
- NO_X formation
- Reburn control technology

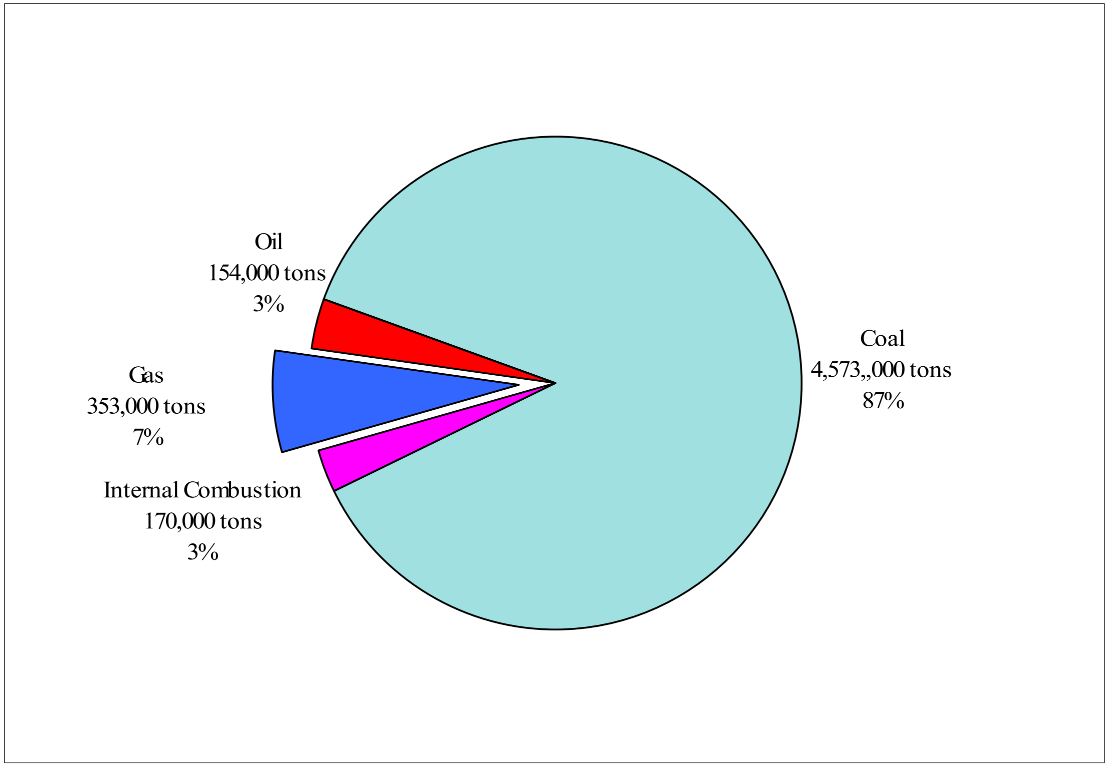


UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

So, Where Does NO_X Come From?



Utility Sources of NO_X



Title IV NO_X Program, Phase I

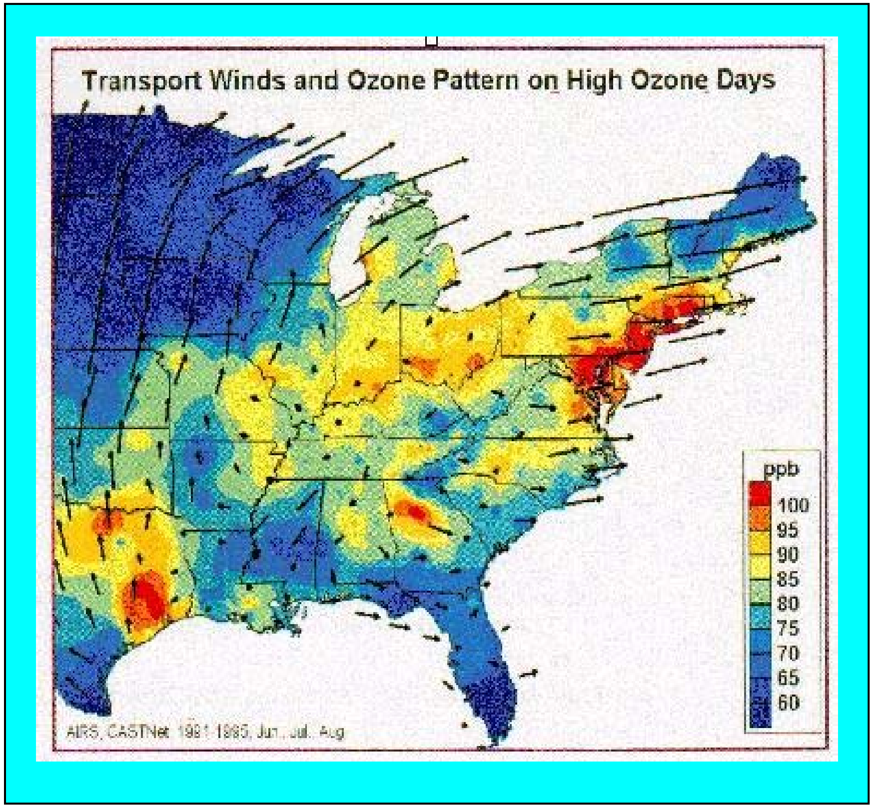
- Affected sources nationwide, starting January 1, 1996
- Emission limits for Group 1 boilers
  - Dry bottom, wall-fired: 0.50 lb/10^6 Btu
  - Tangentially fired: 0.45 lb/10^6 Btu
  - Basis: low NO_X burners
- NO_X reduction: 340,000 tons/yr

Title IV NO_X Program, Phase II

- Affected sources nationwide, starting January 1, 2000
- Revised limits for Group 1 boilers
  - Dry bottom, wall-fired: 0.46 lb/10^6 Btu
  - Tangentially fired: 0.40 lb/10^6 Btu
  - Basis: low NO_X burners
- Emission limits for Group 2 boilers
  - Cyclone (>155 MWe): 0.86 lb/10^6 Btu
  - Cell burner: 0.68 lb/10^6 Btu
  - Wet bottom (>65 MWe): 0.84 lb/10^6 Btu
  - Vertically fired: 0.80 lb/10^6 Btu
  - Basis: Comb. Controls, SCR, NGR
- NO_X reduction: about 2 million tons/yr

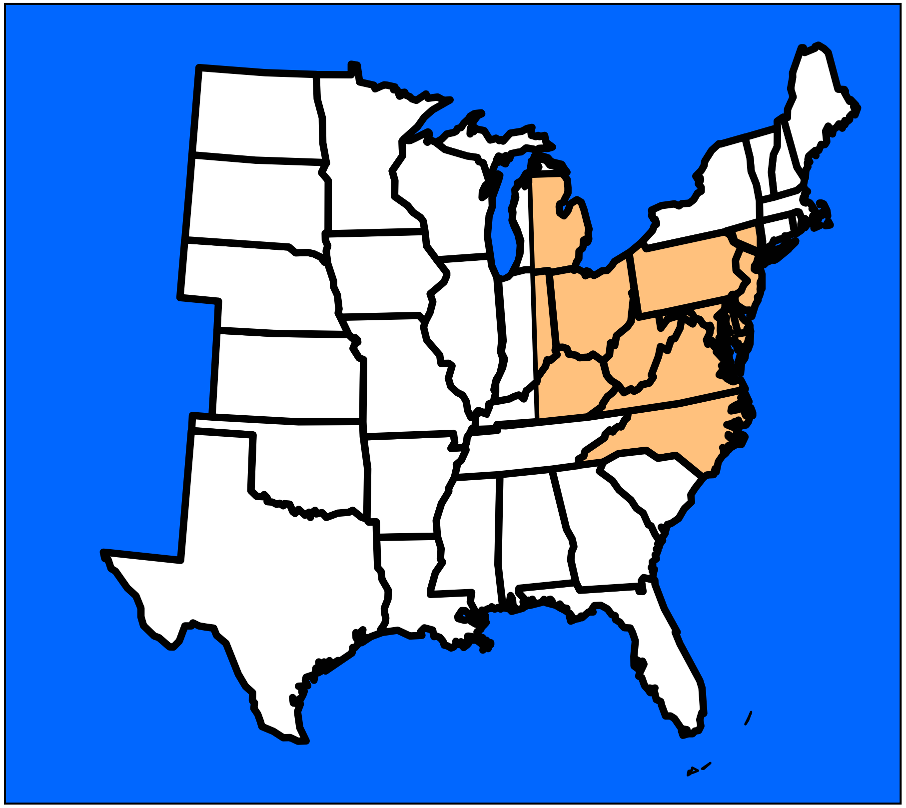
NO_X SIP Call

- NO_X budgets for 19 States & DC, starting May 2004
- Assumes reductions primarily from large sources in a cap and trade program
  - EGUs (average rate): 0.15 lb/10^6 Btu
  - Non-EGU: 60% control level
- Basis: a variety of NO_X controls
- NO_X reduction: 1 million tons by 2007



Section 126 Rules

- NO_X budgets for 12 States & DC, starting May 31, 2004
- Assumes reductions from large boilers/turbines in a cap and trade program
  - EGUs (average rate): 0.15 lb/10^6 Btu
  - Non-EGU: 60% decrease
- Basis: a variety of NO_X controls
- Requirements do not apply if area has approved NO_X SIP Call rules in place



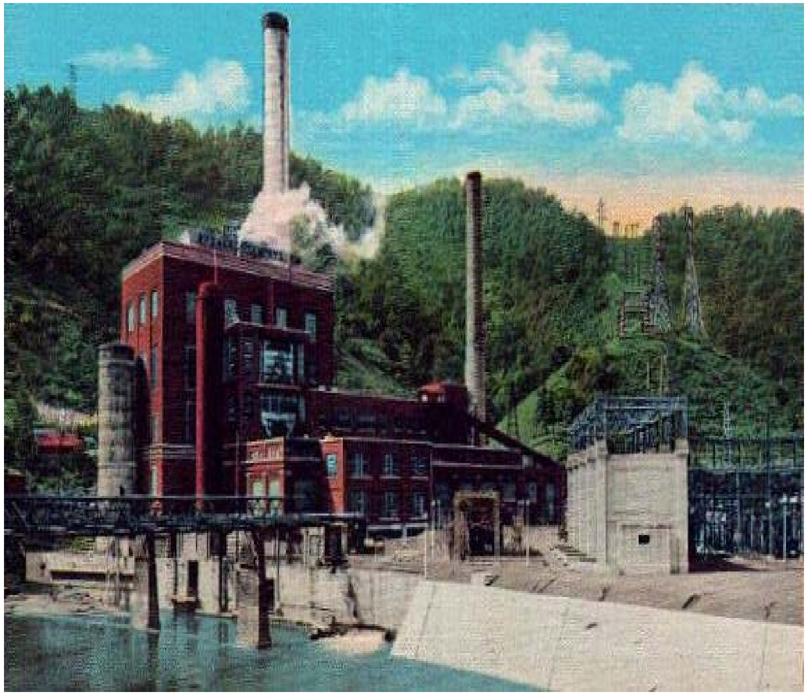
Clear Skies Initiative

- Reduce air pollution from electricity generators and, thereby, improve air quality throughout the country
- Emissions Reductions: NO_X by 67 percent, SO_2 by 73 percent, and mercury by 69 percent
- Timing: Emission reductions phased-in from 2008-2018.
- Regulatory approach: phase-in of Cap and trade program

NO_X Formation

- Thermal NO_X C oxidation of molecular nitrogen in the combustion air
- Fuel NO_X C oxidation of chemically bound nitrogen in the fuel
- Prompt NO_X C resulting from reaction between molecular nitrogen and hydrocarbon radicals (relatively minor fraction)

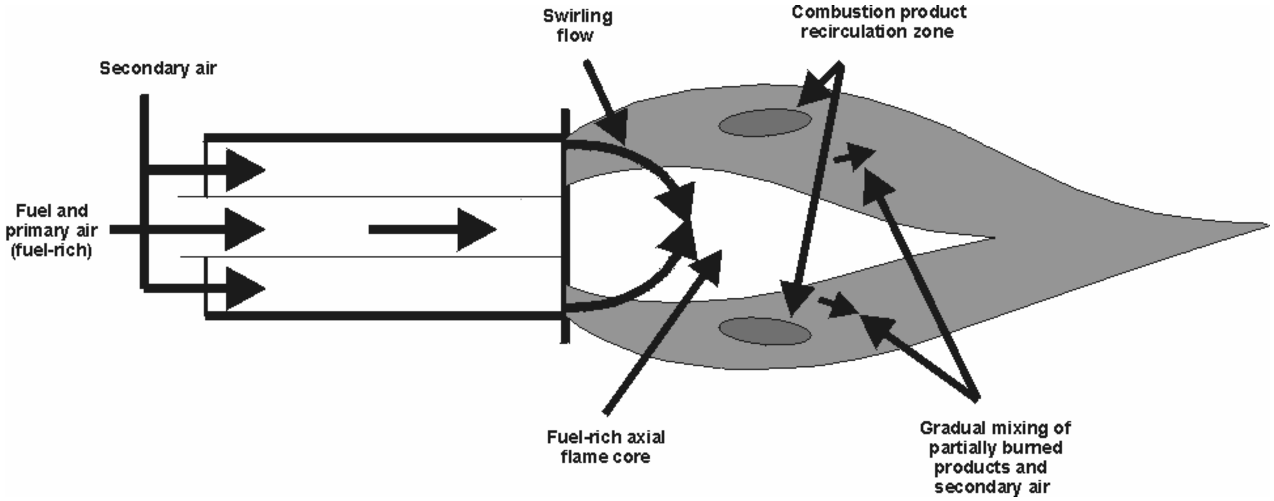
Control Technologies



- Primary – decrease the production of NO_X in the primary combustion zone
  - Widely used – low NO_X burners (LNBs) and overfire air (OFA)
- Secondary – reduce the NO_X already present in the flue gas
  - Widely used – reburning, selective non-catalytic reduction (SNCR), and selective catalytic reduction (SCR)

LNB

- Limits NO_X formation by delaying complete mixing of fuel and air
- Can provide reductions in excess of 50%



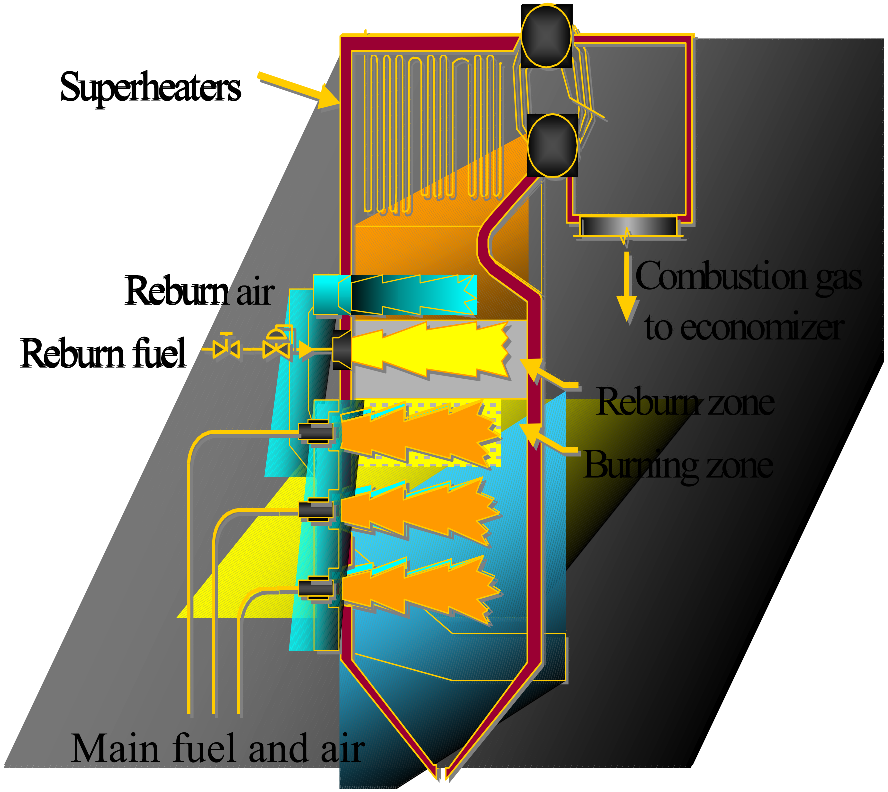
OFA

- 5% to 20% of the total combustion air is injected through ports located downstream of the top burner level
  - Burners operate at lower than normal air-to-fuel ratio resulting in NO_X control; OFA added to achieve complete combustion
  - Can be used with LNB to increase NO_X reduction by 10% to 25%

Primary Controls – Performance

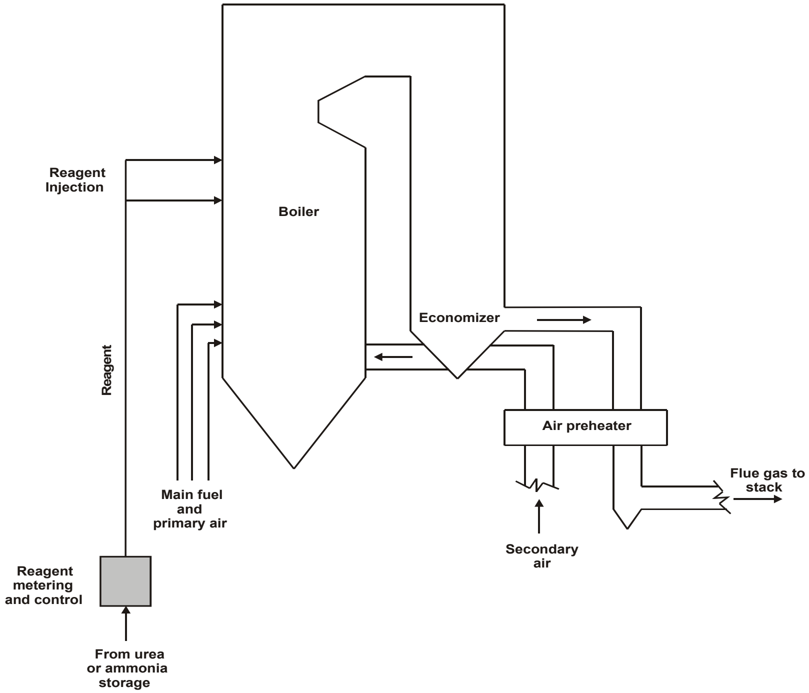
Boiler Type	Control	# of boilers	Reduction (%)
Dry-bottom, wall	LNB	66	44
Dry-bottom, wall	LNB+OFA	21	48
Tangential	LNB	44	43
Tangential	SOFA	23	33
Tangential	LNB+SOFA	23	45

Reburning



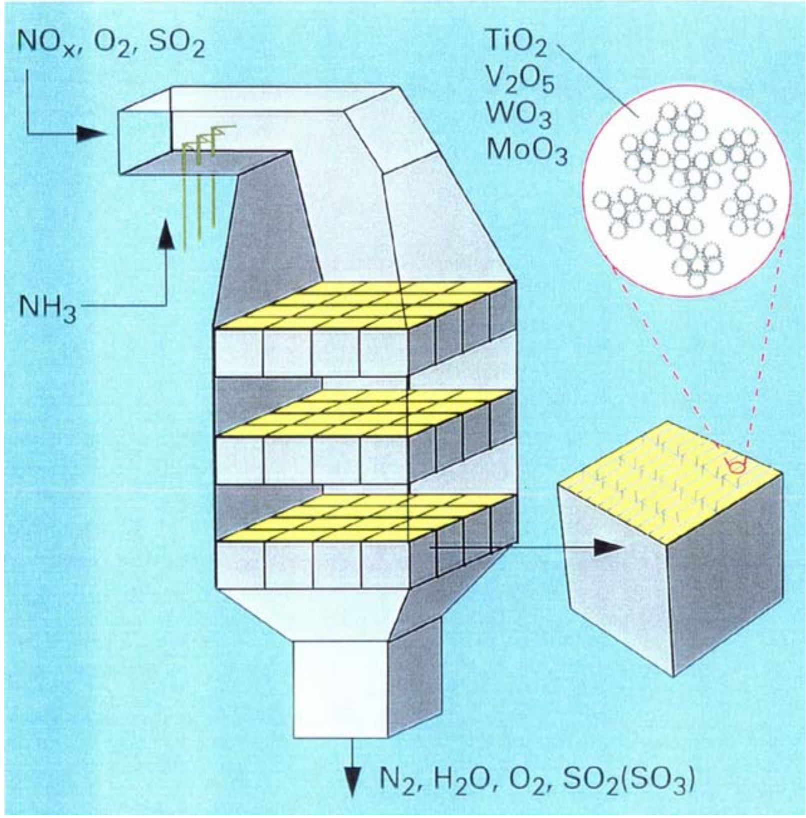
- Reburn fuel (natural gas, coal, other fuels) is injected to provide 15-25% of total heat input
- $\geq$50% NO_X reduction, mercury and SO_2 reduction
- Low capital costs
- Fuels costs, availability of adequate residence time
- Applications: cyclone, wall, tangential; 33-800 MWe

SNCR



- Urea or NH_3 injection, generally between 980 to 1150 ^oC
- 30% to 60% NO_X reduction
- Low capital costs
- Load following, NH_3 slip, performance on larger boilers
- Applications: cyclone, wall, tangential; 50-620 MW

SCR



- NH_3 injection, generally between 350 and 400 ^oC
- More than 90% reduction is possible
- Capital intensive, space requirements, NH_3 slip, SO_3 emissions, catalyst deactivation
- Applications:
  - More than 75 boilers; cyclone, wall, tangential; 122 - 1300 MW

REBURN BACKGROUND

- Reburn was conceived by Dr. Jost Wendt in the late 1960s
- Dr. Wendt gave a paper at the Combustion Institute Meeting in 1973
- In 1980 Japanese researchers reported on pilot-scale results at an Information Exchange in Tokyo

REBURN BACKGROUND

- Bench- and pilot-scale tests showed >50% NO_X reduction
- Reburn was effective for all fossil fuels
- Reburn was cost effective
- Reburn could be combined with other technologies (e.g. LNB) to achieve greater NOx reduction

REBURN BACKGROUND

- In 1980 EPA began in-house and contract research on reburn
- In 1988 EPA, GRI, EPRI, and DOE co-sponsored the first full-scale demonstration of reburn in the U.S. on a 108 MW cyclone coal-fired boiler at the Niles Station of Ohio Edison and achieved a 50% NO_X reduction

REBURN BACKGROUND

- The Niles demonstration was followed by three DOE Clean Coal Demonstrations on smaller boilers
- From 1989 to 1992, EPA co-sponsored a gas reburn demonstration with the Soviet Union on a 300 MW wet-bottom boiler at the Ladyzhin Power Station that achieved a 52% NO_X reduction

REBURN BACKGROUND

- The Ladyzhin data was used by EPA as a factor for NO_X regulations on wet-bottom boilers
- In 2002 EPA and Taiwan EPA completed a demonstration of coal-reburn on a 20 MW coal-fired industrial boiler in Taiwan that achieved a 50% NO_X reduction

CURRENT REBURN USAGE

- To date, reburn has been installed on over 5000 MW of boiler capacity in the United States
- Reburn is used in many countries, including the United States, Russia, Ukraine, Italy, Sweden, Scotland, Japan, and Taiwan
- Bench-scale tests performed by GE EER have shown the potential for 80% to 90% mercury capture in the ash when coal-reburn is used

PLANNED Hg CONTROL TESTS

- Full-scale tests to evaluate mercury control via reburn technology are planned in 2004 in Taiwan on a 20 MW industrial boiler and in Kentucky on a 220 MW utility boiler
- Reburn has the potential to be used as a multipollutant control technology

Further Reburn Developments

- Reduce costs
- Increase performance
- Increase flexibility

Fuel-Lean Gas Reburning

- Careful injection and controlled mixing of natural gas into the furnace exit region
- Less than 10% gas heat input and no burnout air
- Applications:
  - 4 boilers; cyclone, roof, tangential; 30-40% reduction

Advanced Gas Reburning

- Free radicals from reburning enhance SNCR NO_X reduction
- Potential for 70-80% reduction
- SNCR reagent injected
  - After burnout air (non-synergistic AGR)
  - Into or before burnout air (synergistic AGR)
- Application:
  - 104 MW; T-fired; 68-76% reduction

Amine Enhanced Gas Injection

- Synergistic use of reburning and SNCR without using burnout air
- Reagents injected to create local, fuel-rich NO_X reduction zones
- 50-70% NO_X reduction
- Applications:
  - 4 boilers; wall, turbo; 207-660 MW