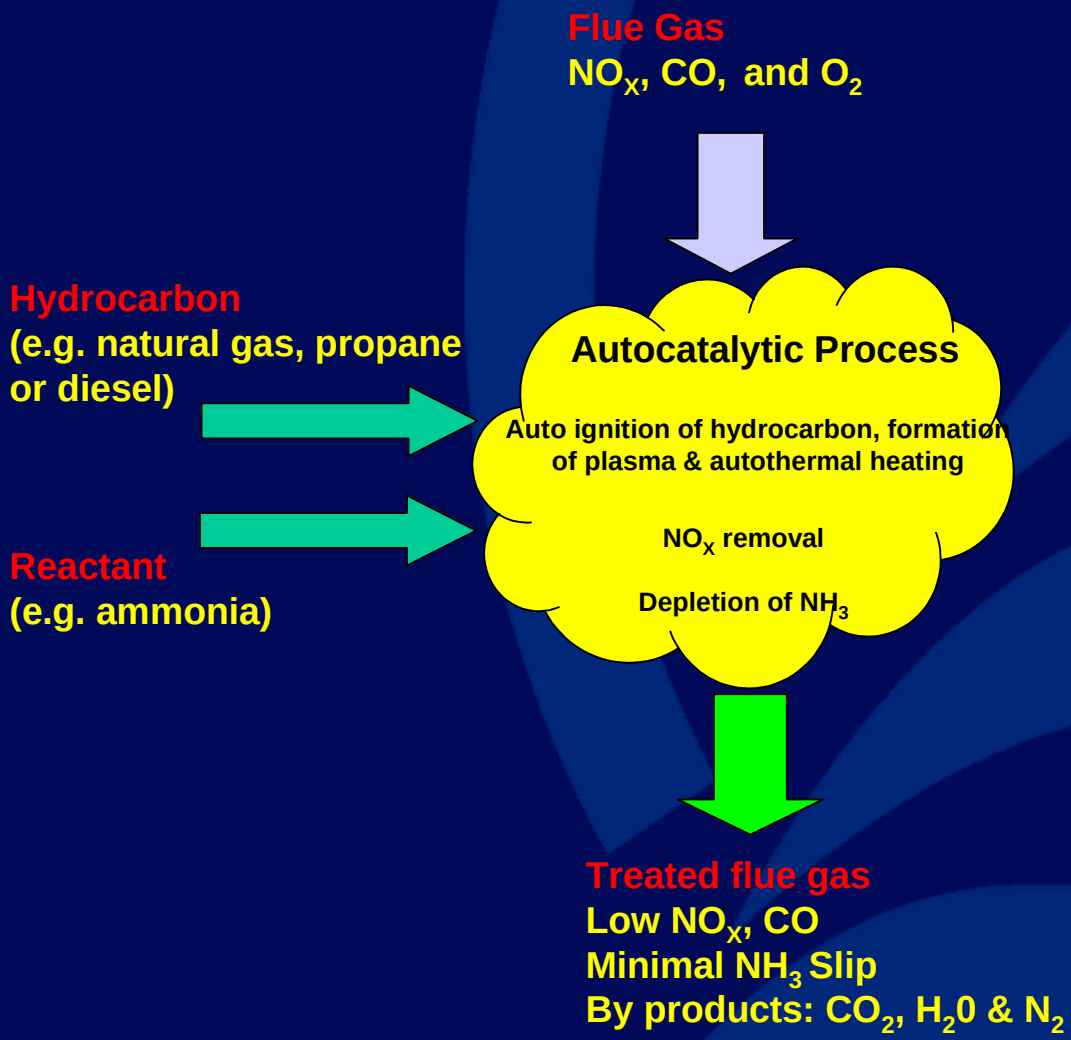
# Selective Autocatalytic $NO_x$ Reduction (SACR)

G Hesselmann & D Hough
Mitsui Babcock

Mitsui Babcock

# SACR Process Description




Mitsui Babcock

# SACR Development

- Demonstrate process for pulverised coal firing at conditions pertinent to large utility boilers
  - Small scale – 0.55 MBtu/h (160 kWt)
  - Large scale – 135 MBtu/h (40 MWt)
  - Plant scale – 200 MWe

Mitsui Babcock

# SACR Development – Small Scale

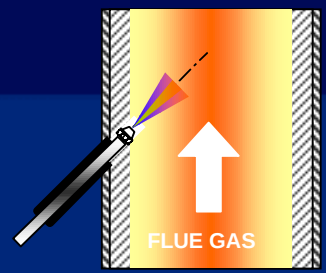
- Small scale – 0.55 MBtu/h (160 kWt)
- Aims
  - Demonstrate process for coal firing
  - Demonstrate process for conditions appropriate to large boiler plant
  - Acquisition of parametric data for process design
- Initial testing completed July 2001

Mitsui Babcock

# SACR Development – Small Scale

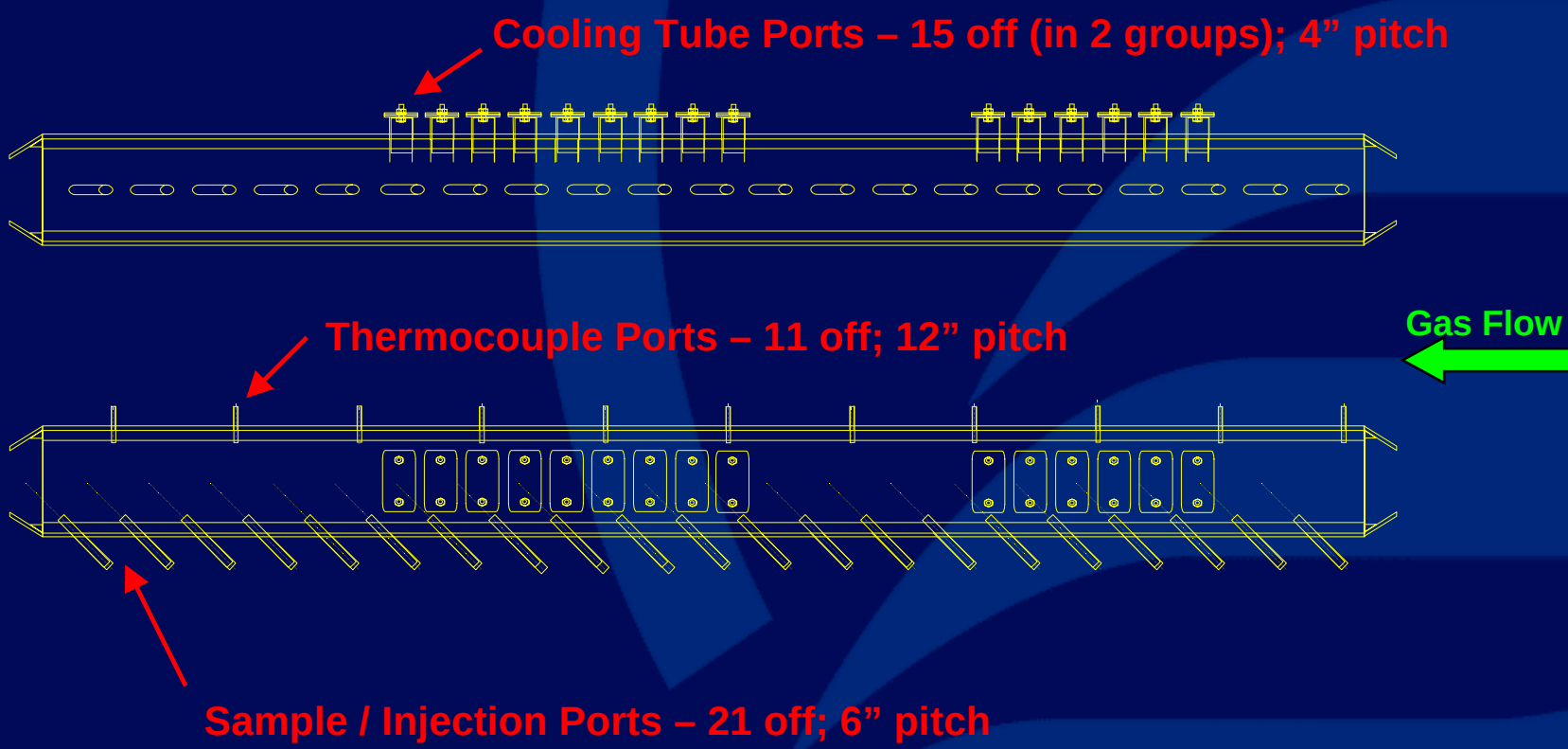
Test Facility

Reactor




Mitsui Babcock

# SACR Development – Small Scale



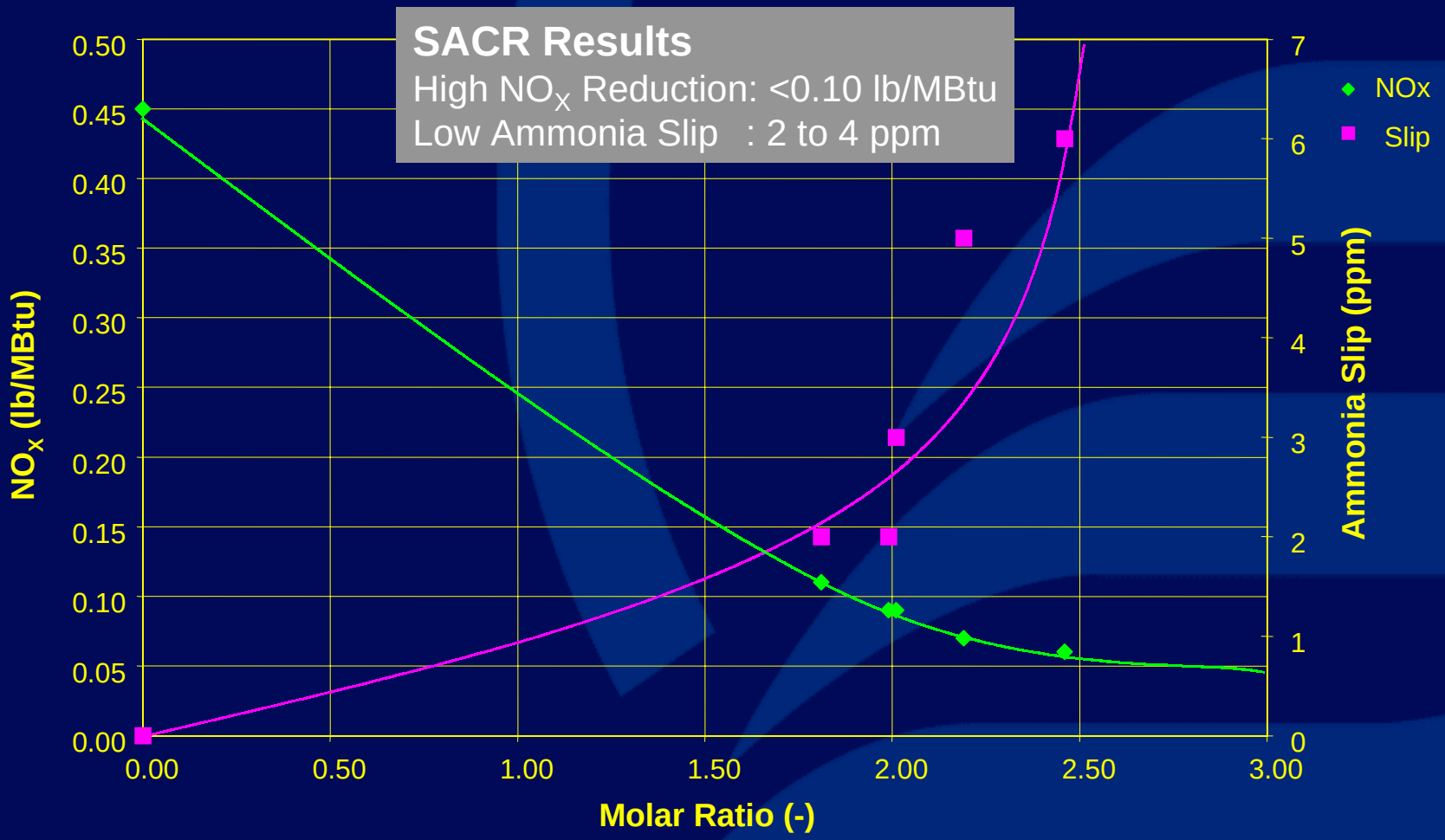

Mitsui Babcock

# SACR Development – Small Scale

- Parametric Testing
  - $NH_3$:$NO_X$ molar ratio
  - Hydrocarbon type
  - Hydrocarbon heat input
  - Injector arrangement
  - Flue gas temperature
  - Residence time
  - Inlet $NO_X$ level
  - Coal
  - Cooling surface
- Performance
  - Input parameters
  - Outlet $NO_X$ / $NO_X$ reduction
  - $NH_3$ slip
  - CO

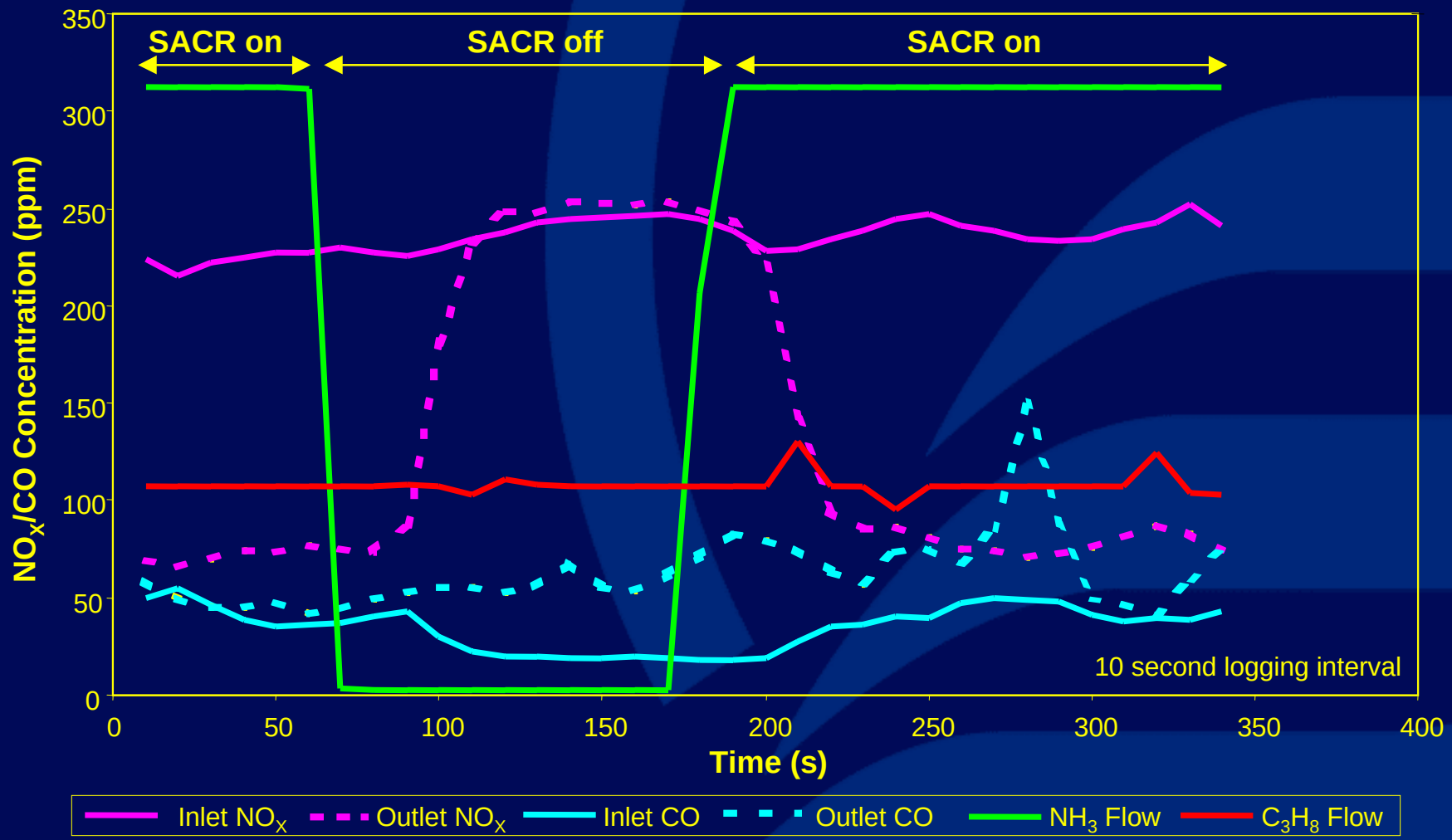
Mitsui Babcock

# SACR Development – Small Scale




Mitsui Babcock

# SACR Development – Small Scale




Mitsui Babcock

# SACR Development – Small Scale

- High $NO_X$ reduction achieved
  - Less than 0.10 lb/MBtu (75 ppm)
  - 80% reduction from inlet of 0.45 lb/MBtu (325 ppm)
- Low ammonia slip
  - 2 to 4 ppm
  - Ammonia continues to reduce downstream of reaction zone
- Wide temperature window
  - $NO_X$ reductions achieved as low as 1450°F (790°C)
  - Better reduction at higher temperature

Mitsui Babcock

# SACR Development – Small Scale

- Low hydrocarbon input
  - Sufficient to create plasma
  - Natural gas and propane equally effective
- Insensitive to coal type
  - USA, UK, world traded bituminous coals tested

Mitsui Babcock

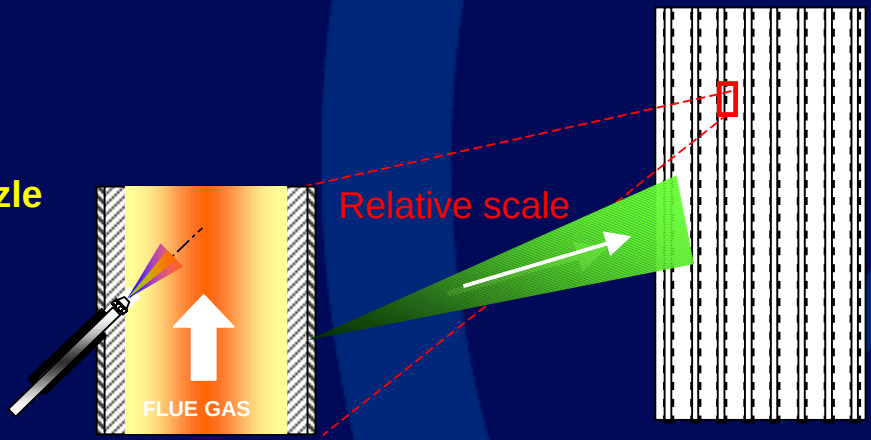
# SACR Development – Large Scale

- Large scale – 135 MBtu/h (40 MWt)
  - Rig capacity 305 MBtu/h (90 MWt)
  - Injection lances physically similar to full scale
- Aims
  - Demonstrate scale up and mechanical design
  - Multi-nozzle arrangement
  - Process control
- Testing completed October 2001

Mitsui Babcock

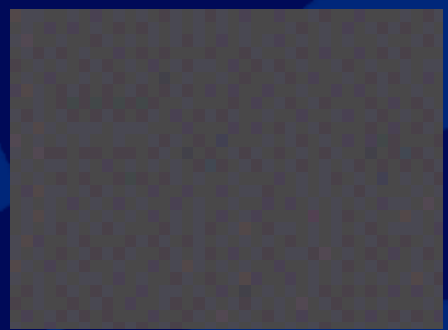
# SACR Development – Large Scale

Single Nozzle




Relative scale

Multi-Nozzle SACR grid
8 lances (15 ft working length)

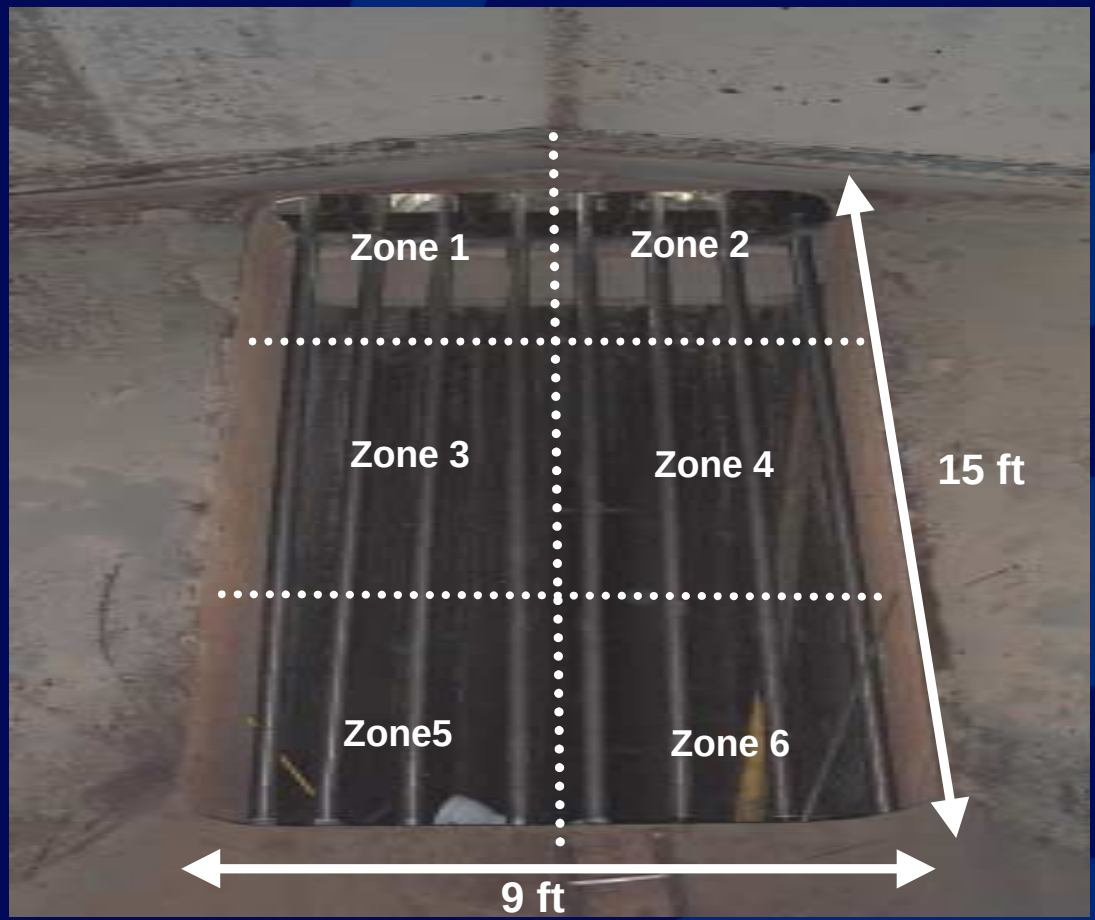


0.55 MBtu/h (160 kWt)

135 MBtu/h (40MWt)

Mitsui Babcock

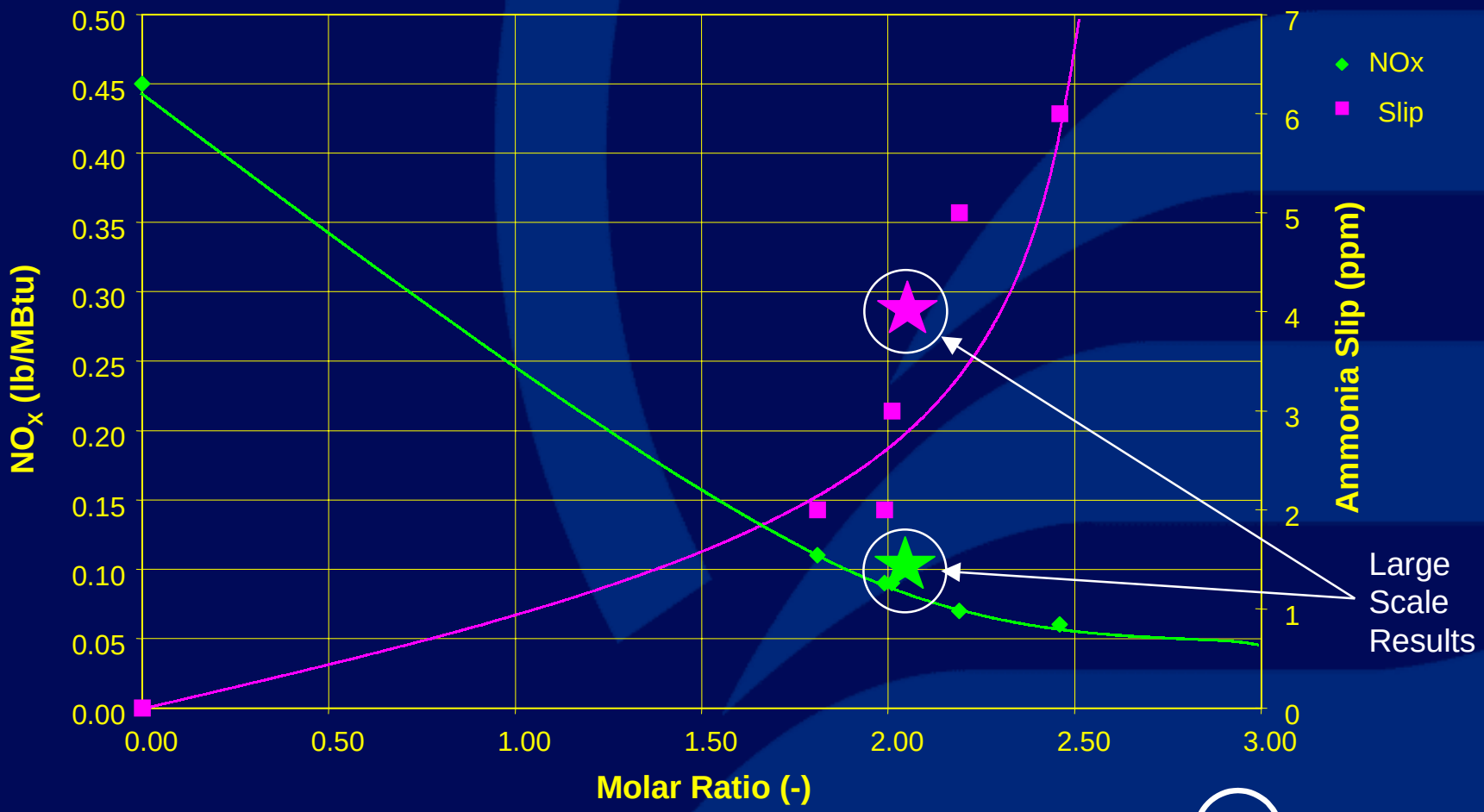
# SACR Development – Large Scale




Mitsui Babcock

# SACR Development – Large Scale

135 MBtu/h performance superimposed on 0.55 MBtu/h results



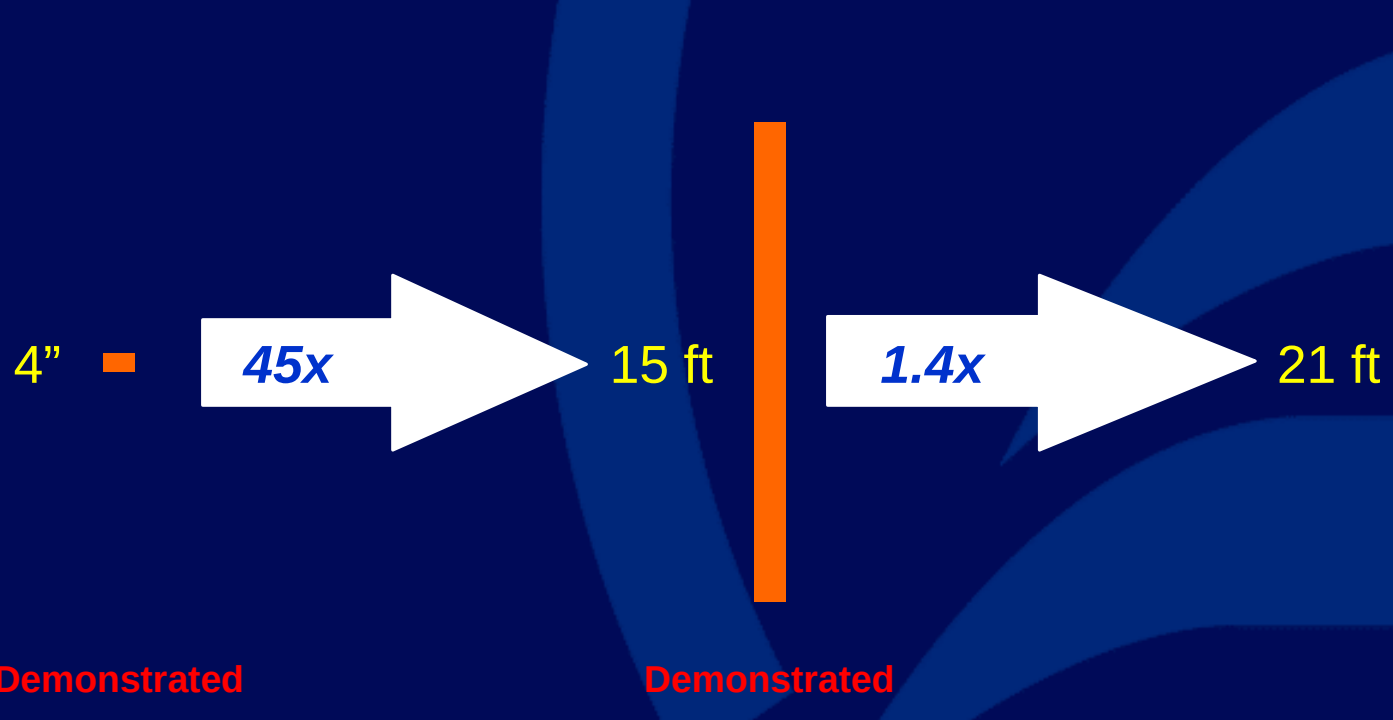

Mitsui Babcock

# SACR Development – Large Scale

- Mechanical integrity of grid proven
  - Design identical to full scale plant application
- Process scale-up demonstrated
  - Multiple injection nozzles
  - Non-uniform flow and temperature profiles
- Process control demonstrated
  - Matching of reagent flows to individual zones
  - Ability to control ammonia slip

Mitsui Babcock

# Scale-up – Relative Size of Injection Lances




**Demonstrated**

**Single Nozzle**
**0.55 MBtu/h**
**Single Zone**

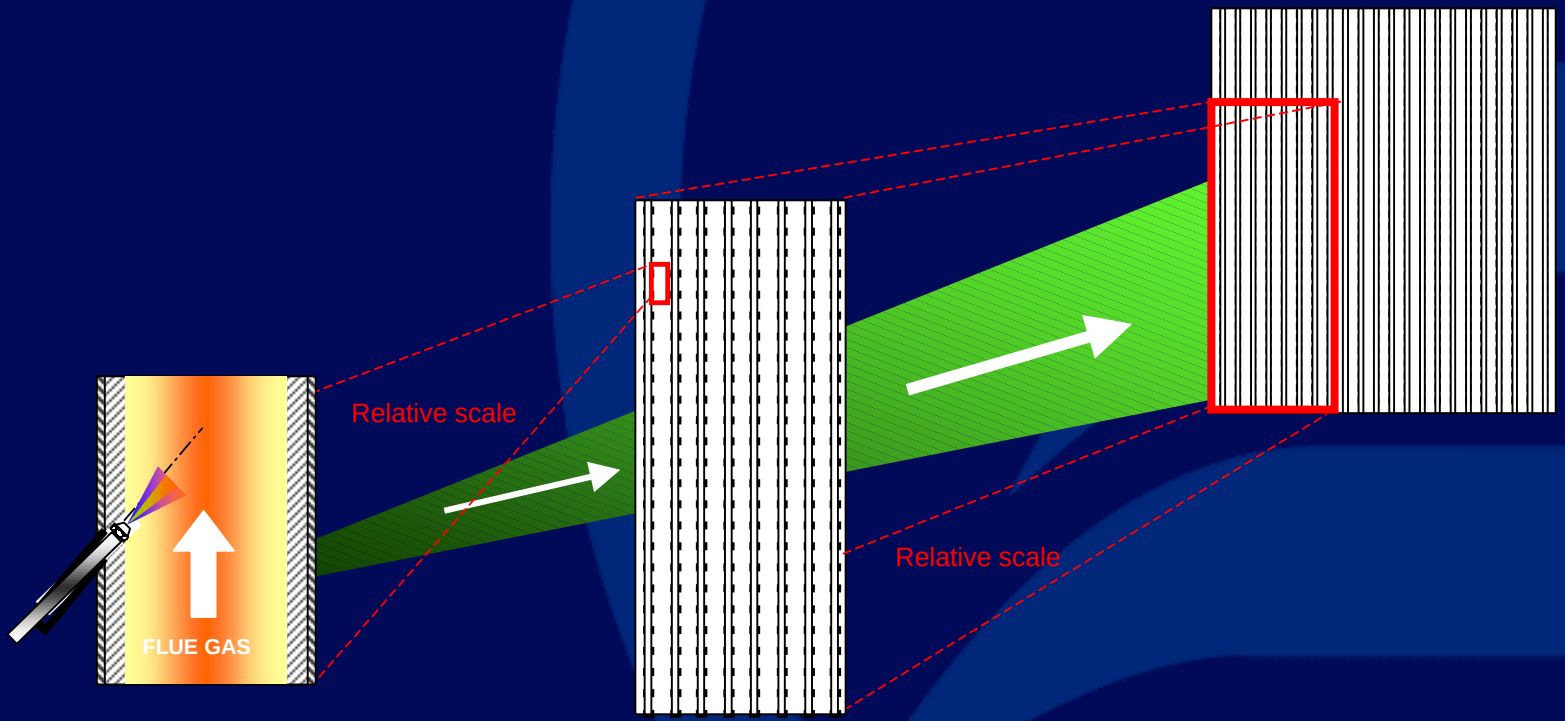
**Demonstrated**

**Multi-Nozzle Grid**
**135 MBtu/h**
**6 Control Zones**

**Full Scale Plant**
**200 MWe**
**9 Control Zones**

Mitsui Babcock

# Scale-up to Utility Plant




**Single Nozzle**
**0.55 MBtu/h**
**Single Zone**

**Multi-Nozzle Grid**
**135 MBtu/h**
**6 Control Zones**
**8 Lances (15 ft)**

**Full Scale Plant**
**200 MWe**
**2 x 9 Control Zones**
**2 x 22 Lances (21 ft)**

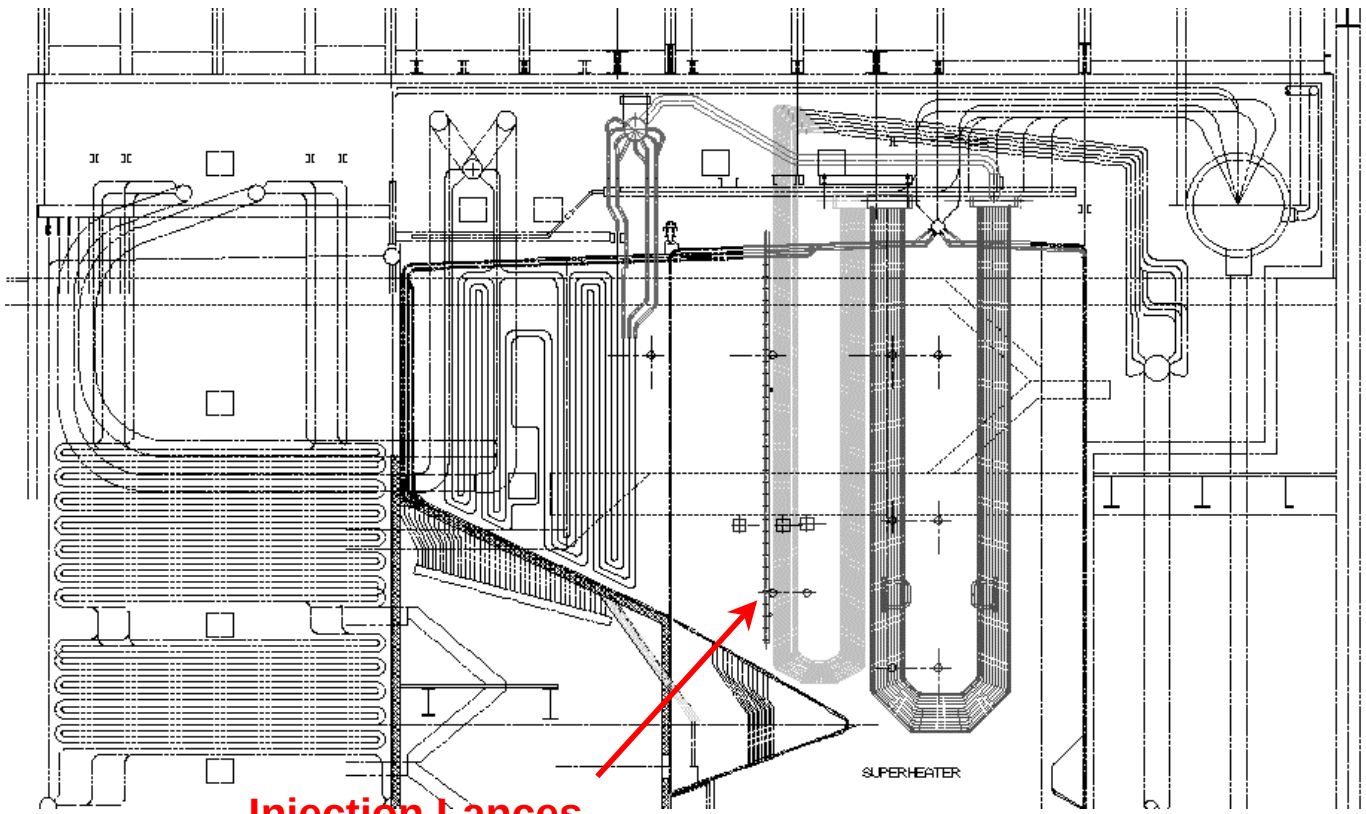
Mitsui Babcock

# SACR Development – Plant Scale

- Full Scale Plant Demonstration
  - 200 MWe
  - Tangentially fired twin-furnace design
  - Baseline $NO_X$ 0.55 lb/MBtu
- Status
  - Hardware installed
  - System commissioned
  - Optimisation testing ongoing

Mitsui Babcock

# SACR Development – Plant Scale




Mitsui Babcock

# SACR Development – Plant Scale

- Latest performance results
  - 54% $NO_X$ reduction
  - 3 ppm $NH_3$ slip
- Optimisation testing ongoing
  - Further improvements expected
- Below 0.15 lb/MBtu $NO_X$ achievable in combination with combustion modifications (e.g. OFA)

Mitsui Babcock

# SACR Conclusions

- SACR process successfully demonstrated for pulverised coal firing at conditions relevant to utility boiler plant
  - $NO_X$ < 0.10 lb/MBtu
  - 2 to 4 ppm ammonia slip
- Scale-up to multi-nozzle, prototype lance design proven
  - Mechanical integrity of lance design proven
  - Multi-zone process control demonstrated
- Scale-up to full scale utility plant successfully demonstrated

Mitsui Babcock