SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT RULE 1109.1 STUDY FINAL REPORT

Fossil Energy Research Corp.

Laguna Hills, CA

SCAQMD Working Group Presentation

December 10, 2020

FERCo

MP321

FERCo EXPERIENCE

- Founded in 1984
- Involved with SCR Technology Since Early 1980's
- Experience Includes:
  - Overall SCR system design
  - Cold flow modeling of SCR systems
  - Start-up and optimization testing
  - Pilot plant studies
  - Fundamental laboratory studies
- In-house Catalyst Test Facilities

OBJECTIVES

- **Visited 5 Major Refineries**
  - **Chevron**
  - **Marathon**
  - **Phillips 66**
  - **Torrance**
  - **Valero**

- **Goal Was to Observe First Hand Facility Constraints**
  - **Meet with facility staff and tour the facilities**
  - **Discuss challenges of implementing SCR on specific refinery systems**
  - **Review drawings of on-going SCR work, suggest configuration modifications to improve performance**

- **Assess Possibility of Improvements to Existing SCR Systems to Meet the Upcoming PR 1109.1 NO_x Requirements**

OBSERVATIONS

- All Sites Exhibited Space Limitations to Varying Degrees
  - Existing open space needed for maintenance work, not available for the SCR
  - Workarounds have included:
    - Vertical system orientation
    - Running ductwork over existing roads
    - Replace air heater with SCR reactor

- Old Sites Hold Many Unknowns
  - Electrical Capacity for the SCR
  - Pipe Rack Capacity for NH_3 transport to the SCR
  - Uncertainties about underground pipes, complicates digging, foundation work

- Existing SCR Systems Not Designed for High (>90%) Removals

Key SCR Issues and Parameters

Catalyst Activity (K)

- How active the material is in reducing NO_x
- f (material, geometry)

Reactor Potential

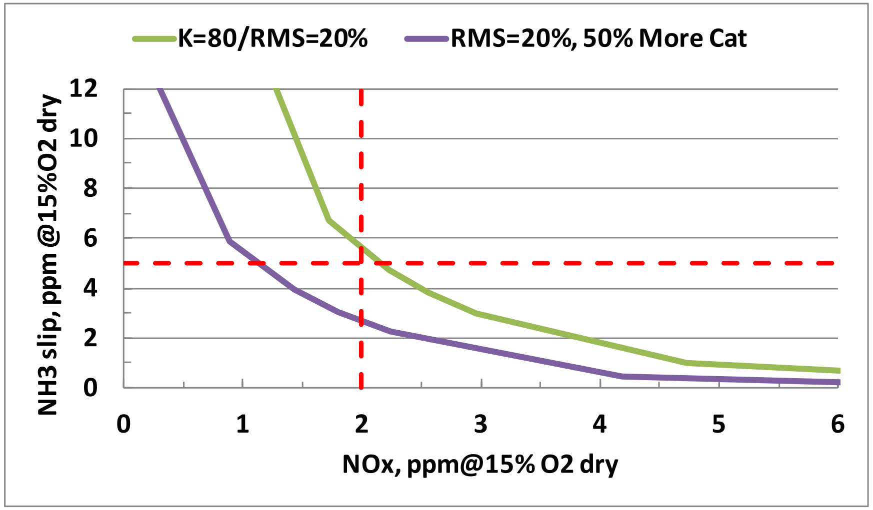
- Ability of the catalyst bed to reduce NO_x
- $RP = K^*A_{sp}^*V_{cat}/Q_{fg}$
- ***Defines the Needed Catalyst Volume***
- ***$RP = f(NOx_{in}, dNO_x, NH_3$ slip)***

NH_3/NO_x Distribution

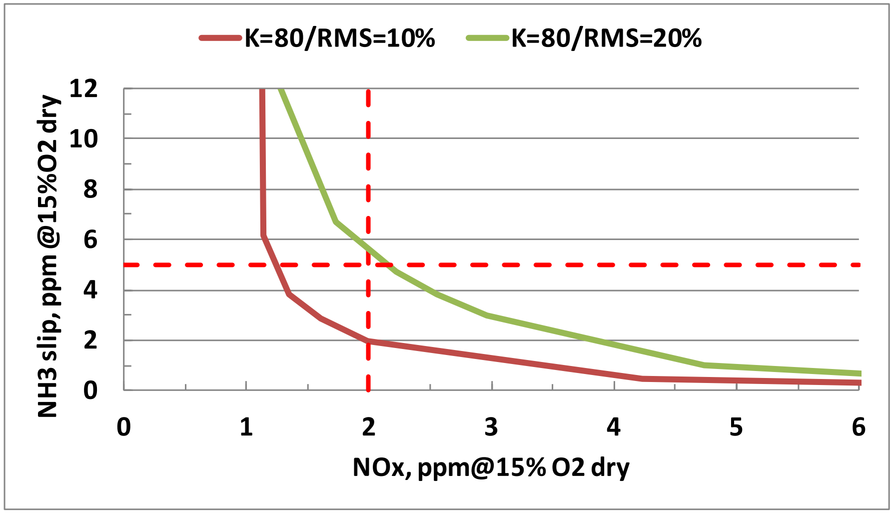
- Want NH_3/NO_x uniform across the catalyst
- Local $NH_3/NO_x>1=NH_3$ slip
- ***dNO_x Requirement Defines NH_3/NO_x Uniformity Requirement***
- ***AIG (Ammonia Injection Grid) - Mechanism by which the NH_3 is injected***
- ***Characterized by RMS (STD Deviation of the NH_3/NO_x distribution entering the catalyst***
- ***Higher dNO_x requires lower RMS!***

How Important is the NH3/NOx Distribution?

RMS = 20% Add Catalyst



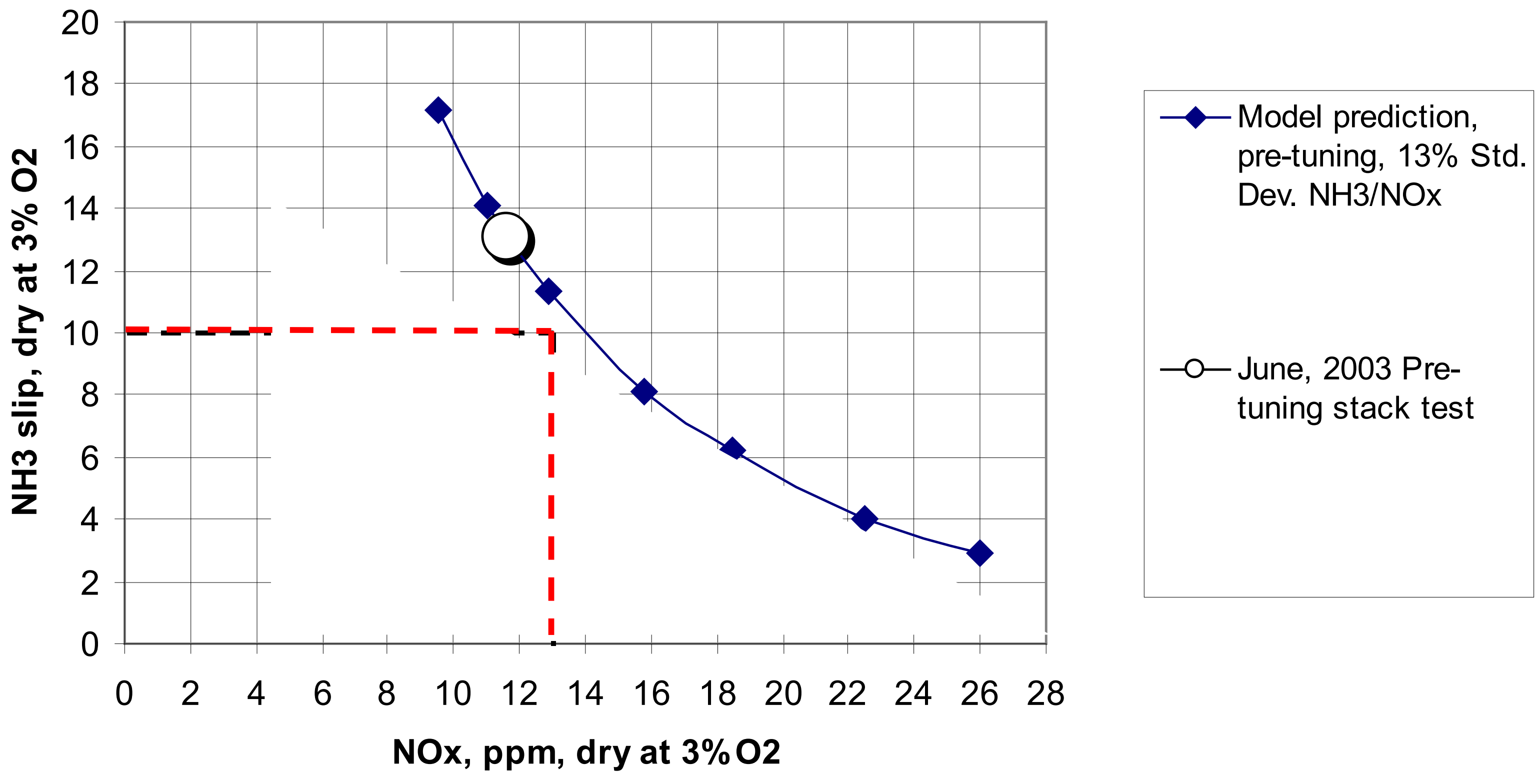
Tune AIG to RMS = 10%



- Just tuning the AIG allows 2 ppm NO_x to be achieved
- Adding 50% more catalyst helps, but not as much as tuning

How Important is the NH_3/NO_x Distribution

AIG Tuning at South Bay 1: 141MW Boiler (2003)



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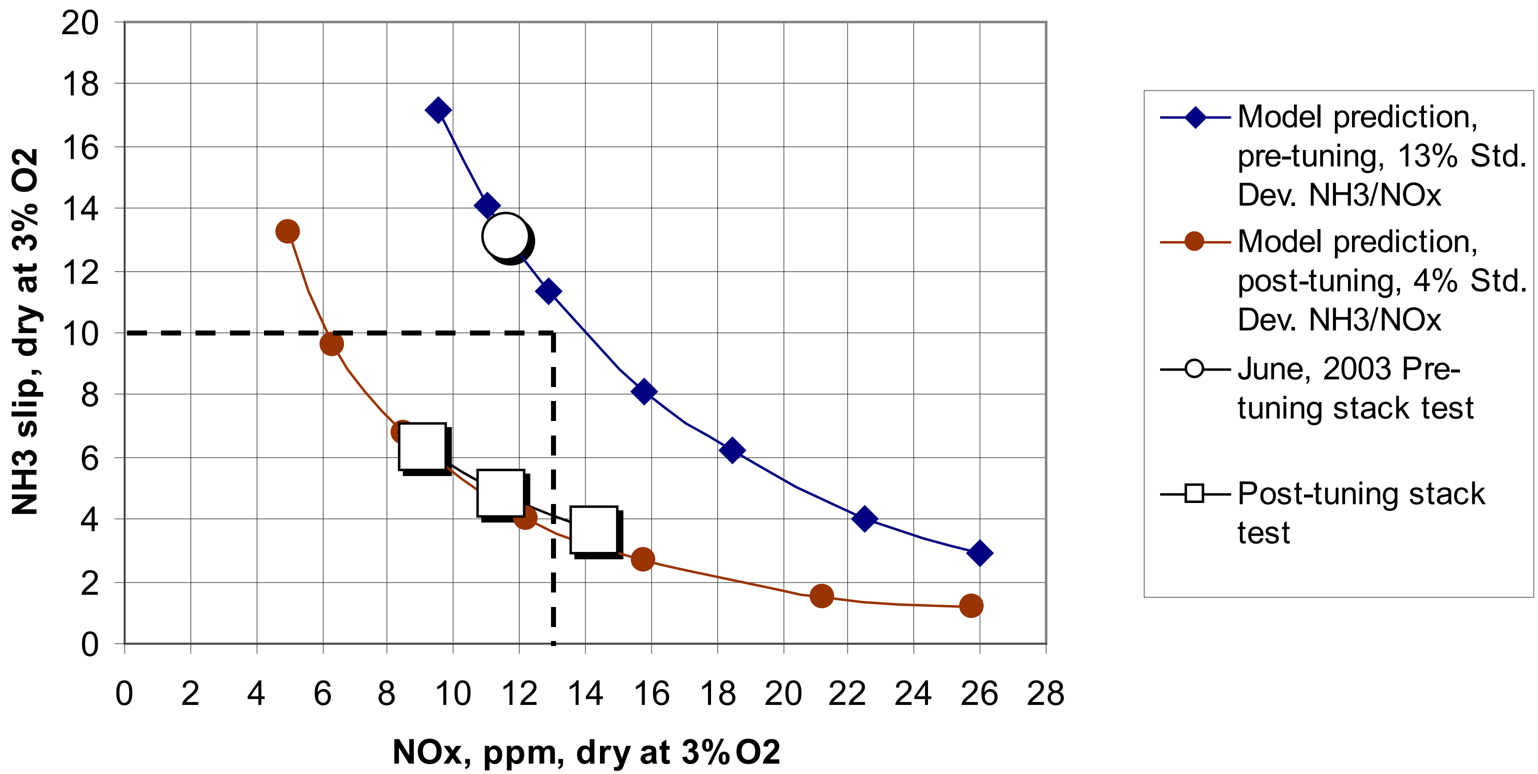
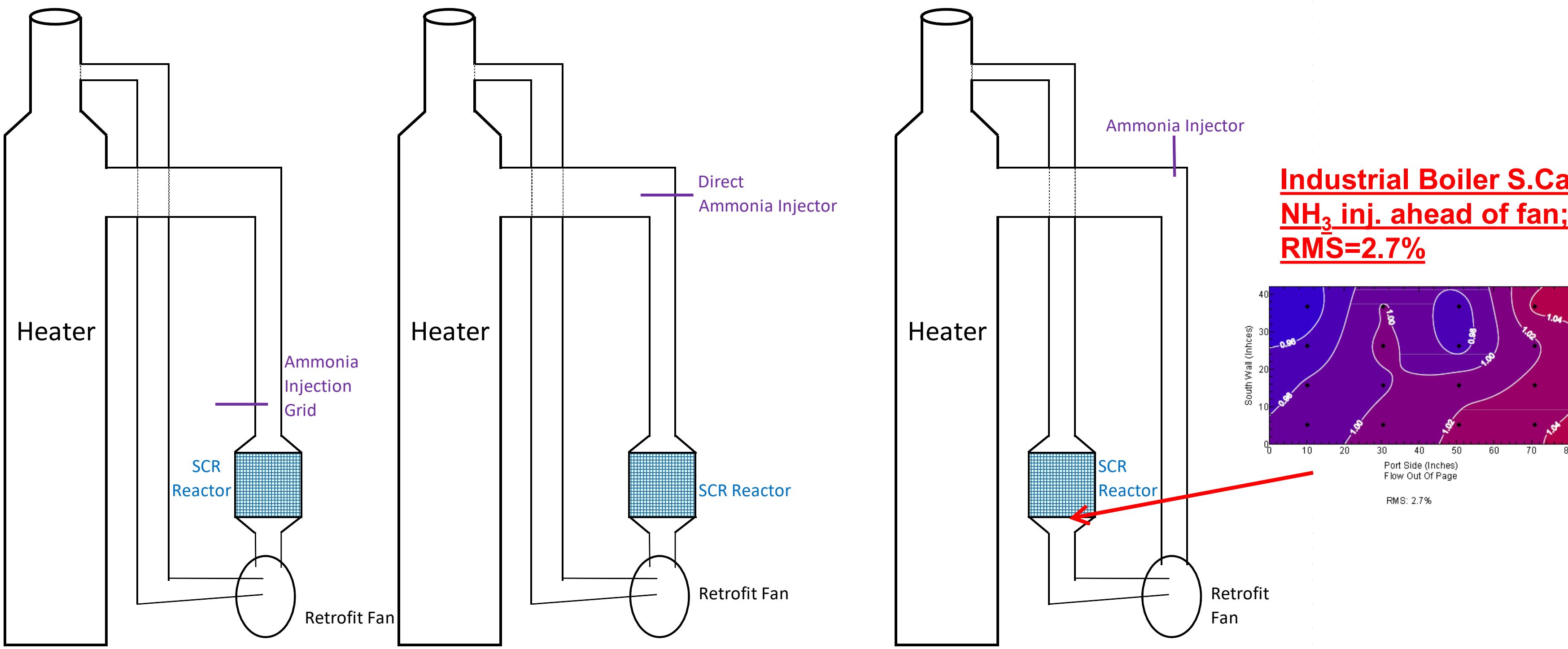


Cylindrical Heater SCR Arrangement

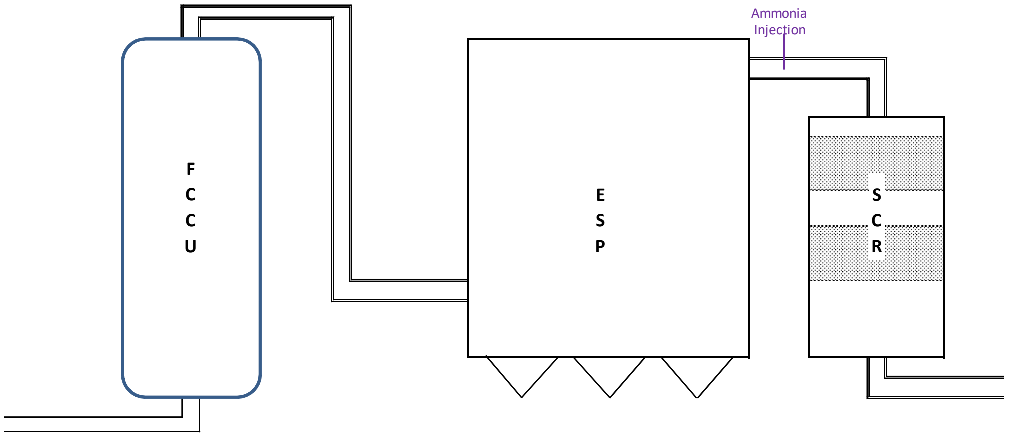


Traditional Arrangement

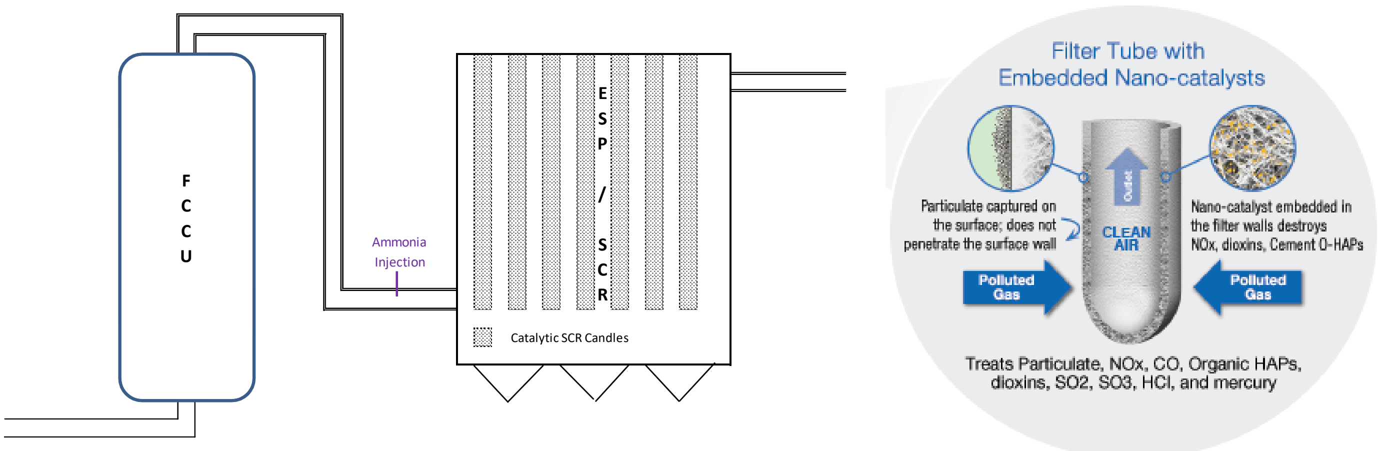
Traditional Arrangement with Direct Injection

Direct Injection Using Fan as Mixing Device

FCCU NOx CONTROL OPTIONS

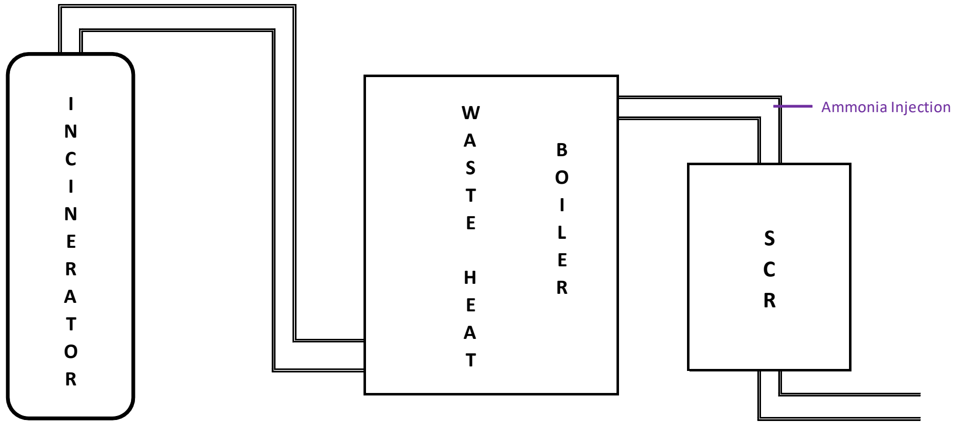


a) Traditional with Separate ESP & SCR

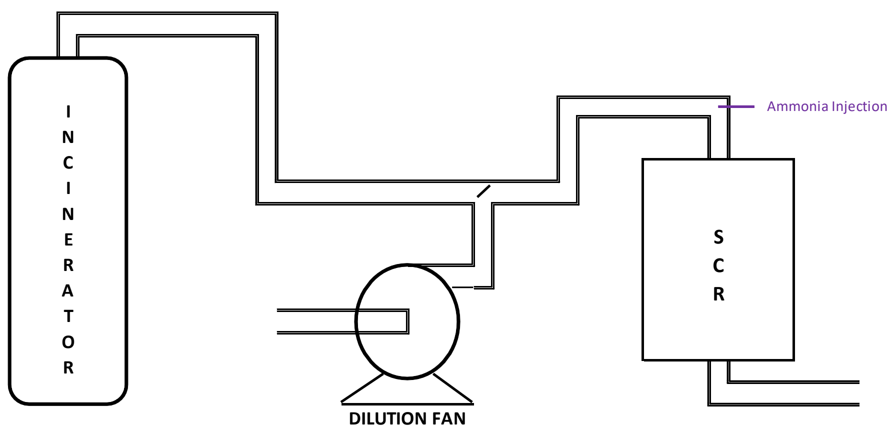


b) SCR Incorporated into ESP Using Catalytic Candle Filters

INCINERATOR NOx CONTROL OPTIONS



a) Waste Heat Boiler



b) Dilution Air Fan

LOW NOx BURNERS

When Firing Refinery Gas:

- Low NO_x Burners ~ 30 – 40 ppm NO_x
- Current Ultra Low NO_x Burners ~ 20 pm NO_x
- Next Generation Ultra Low NO_x Burners < 10 ppm NO_x

The Next Generation Ultra Low NO_x Burners Include the ClearSign Core Burner and John Zink Hamworthy's SOLEX Burner

Status

- ClearSign
  - World Oil Testing Scheduled Week of November 16
  - Retrofit Scheduled for Q1 2021
- John Zink Hamworthy
  - ?

COST EVALUATION

Three Sources of Cost Estimates

- EPA SCR Cost model
- Unit-specific costs derived for refiners
- Western States Petroleum Association (WSPA) capital cost relationship

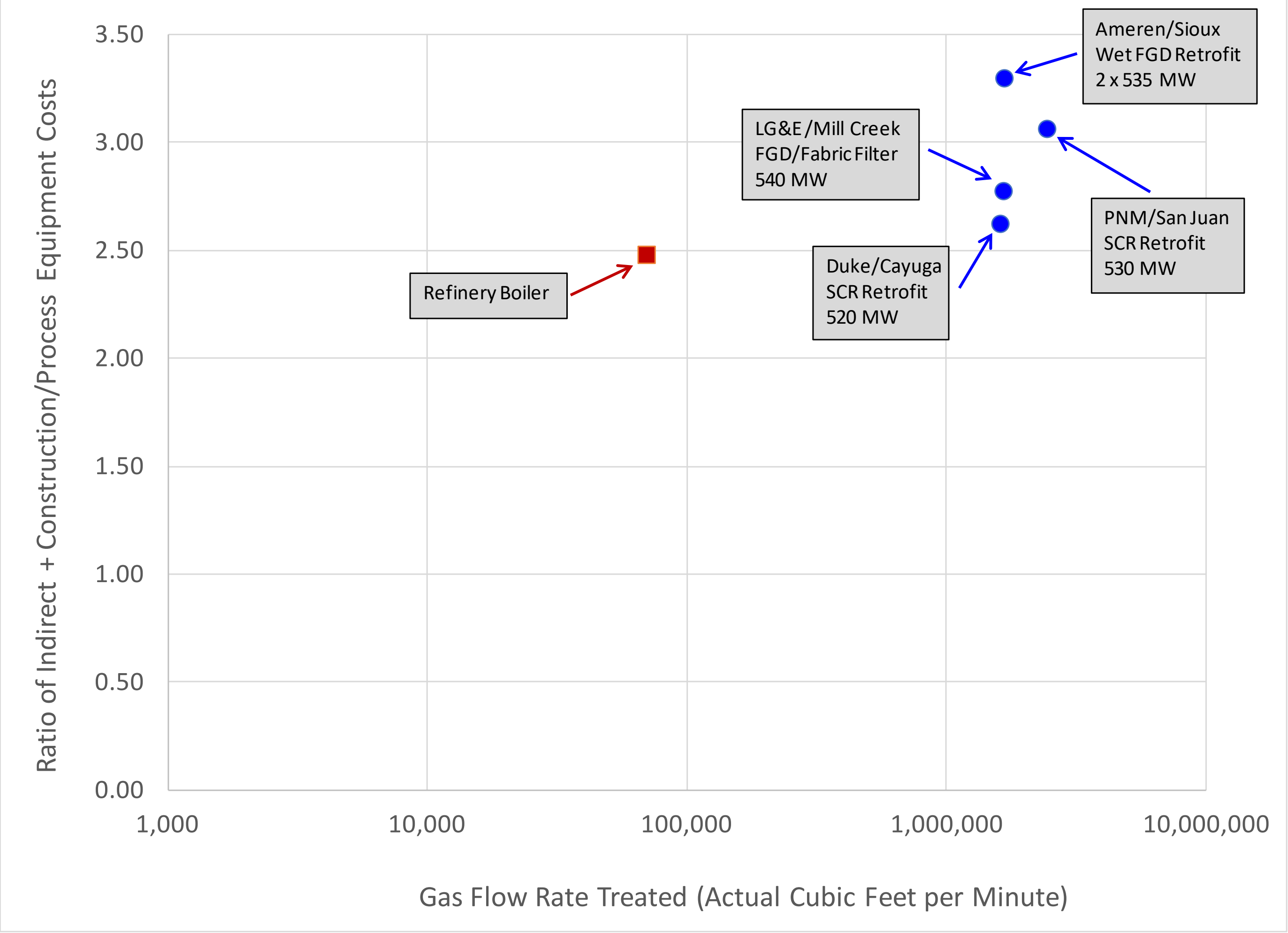
Revise EPA SCR Cost Model per Additional Inputs

- WSPA, refiner-specific data used to modify cost relationships
- Catalyst volume assignment, “refined” per additional data from catalyst suppliers
- Variable, fixed O&M costs adjusted to reflect refinery (not power generation) experience

INDIRECT/DIRECT COST RATIO

Indirect Costs 2X-3X Direct Costs

Broadly Observed: Electric Generating Units, Refinery Applications



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Questions?

www.ferco.com

lmuzio@ferco.com