South Coast AQMD

Rule 1109.1 – NOx Emission Reduction for Refinery Equipment

Working Group Meeting #10

February 18, 2020

Call-in Information

Call-in Number: 1-866-705-2554

Meeting Number: 219723

Agenda

- Summary of Working Group Meeting #9
- Progress of Rule Development
- Updates from Last Working Group Meeting
- BARCT Assessments for Gas Turbines, FCCU, and SRU/TGI
- Next Steps

Progress of Rule Development

Summary of Working Group #9 (12/12/19)

- John Zink Hamworthy Presentation on SOLEX^{TM} Burner Technology
- Discussed potential SOx RECLAIM sunset
- Baseline emission calculations
- U.S. EPA SCR cost spreadsheet revision
- Proposed BARCT limits for Heater and Boiler categories

Since Last Working Group Meeting

- Adjusted cost-effectiveness calculations to reflect stakeholder comments
- Discussions with consultants
- Stakeholder meetings and site visits
- Discussions with control technology suppliers
- ClearSign Core^{TM} Demonstration Project Update

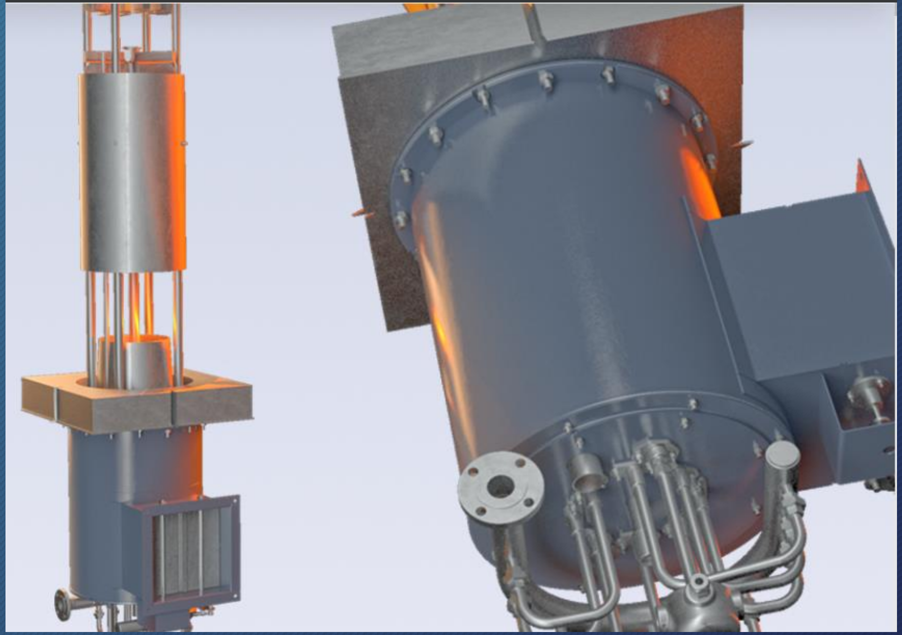
SOx/PM Survey

- Some stakeholders expressed concern of co-pollutant impacts due to ammonia from SCRs
- Primary concern is sulfur in the fuel gas
  - Some facilities already remove sulfur from fuel gas
- Staff needs to gather data to understand full scope of the issue for impacted facilities
- Sending out a survey to gather the following information:
  - Current sulfur concentration in the fuel gas system(s)
  - Number and type of existing treatment system(s)
  - Volume of gas treated
  - Anticipated upgrades and/or additional units required
  - Any potential NOx emissions increase associated with upgrades or expansions
  - Cost of gas clean up to meet Rule 431.1 sulfur limit

ClearSign Core^{TM} Demonstration Project Update

- ClearSign Core^{TM} burner technology was retrofitted in a multi-burner process heater
- Initial tests showed NOx emissions less than 4 ppm with natural gas
- Initial results showed burner-to-burner interaction limited the maximum firing capacity of the heater
- Decision was made to reinstall the original burners and temporarily suspend field test
- Further offsite product refinement and demonstration ongoing to address issue
- Seeking to resume field demonstration later this year

ClearSign
Better Solutions



Areas of Discussion on Cost-Effectiveness Calculation

- Burner Cost
- Facility versus Spreadsheet Cost Estimates
- NOx Concentration
- LCF versus DCF

Cost-Effectiveness Calculation - Burner Cost

Background[1]

- Combination of SCR and Ultra-Low NOx Burners (ULNB) can achieve 2 ppm
- Units that require >95% NOx reduction will require burner control
- Staff proposed the following burner cost:
  - <40 MMBtu/hr - \$2.2MM/unit
  - ≥40 MMBtu/hr - \$2.8MM/unit

Stakeholders Comment

- Scale burner cost based on heater size – similar to SCR power curve relationship

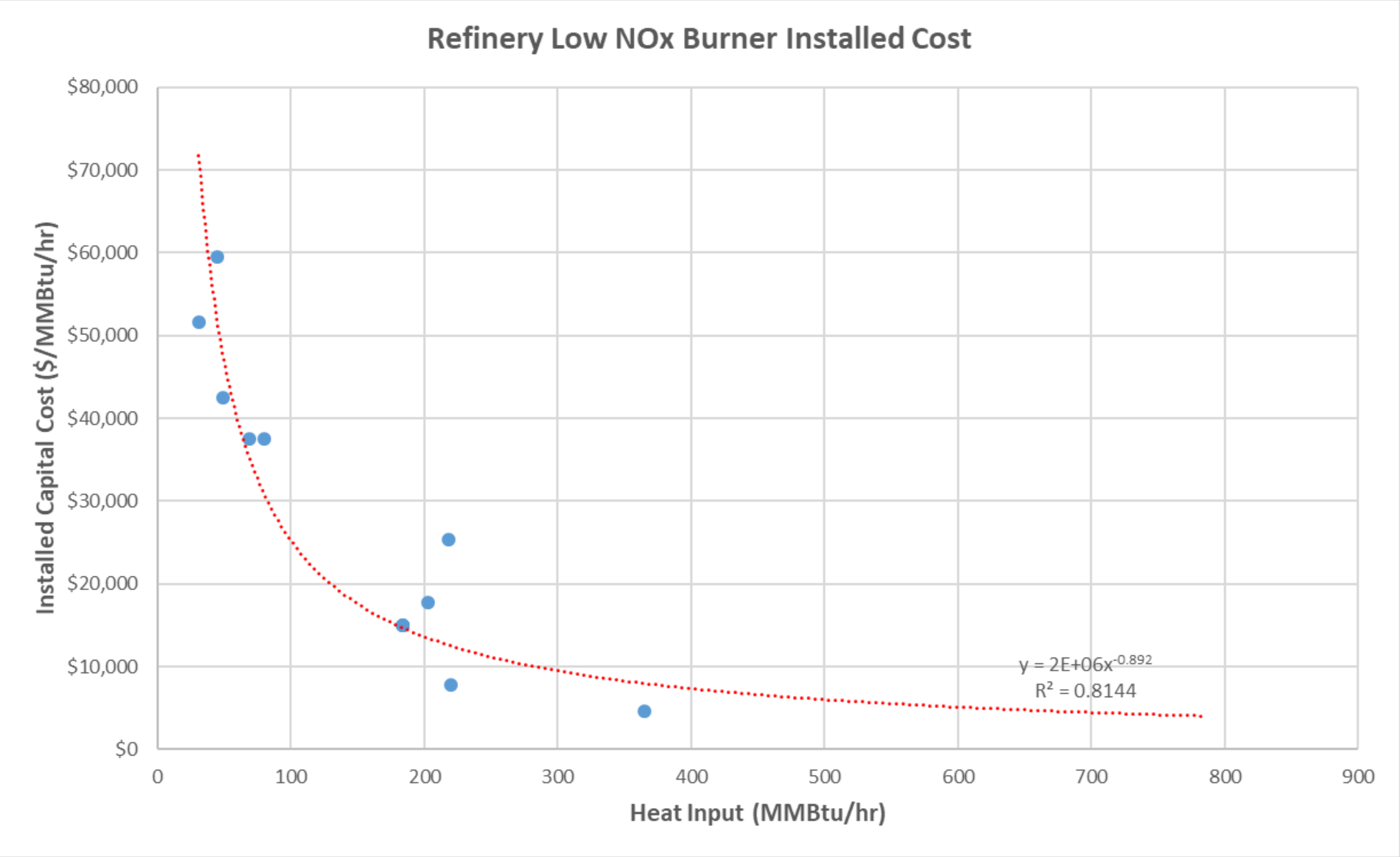
Staff Response

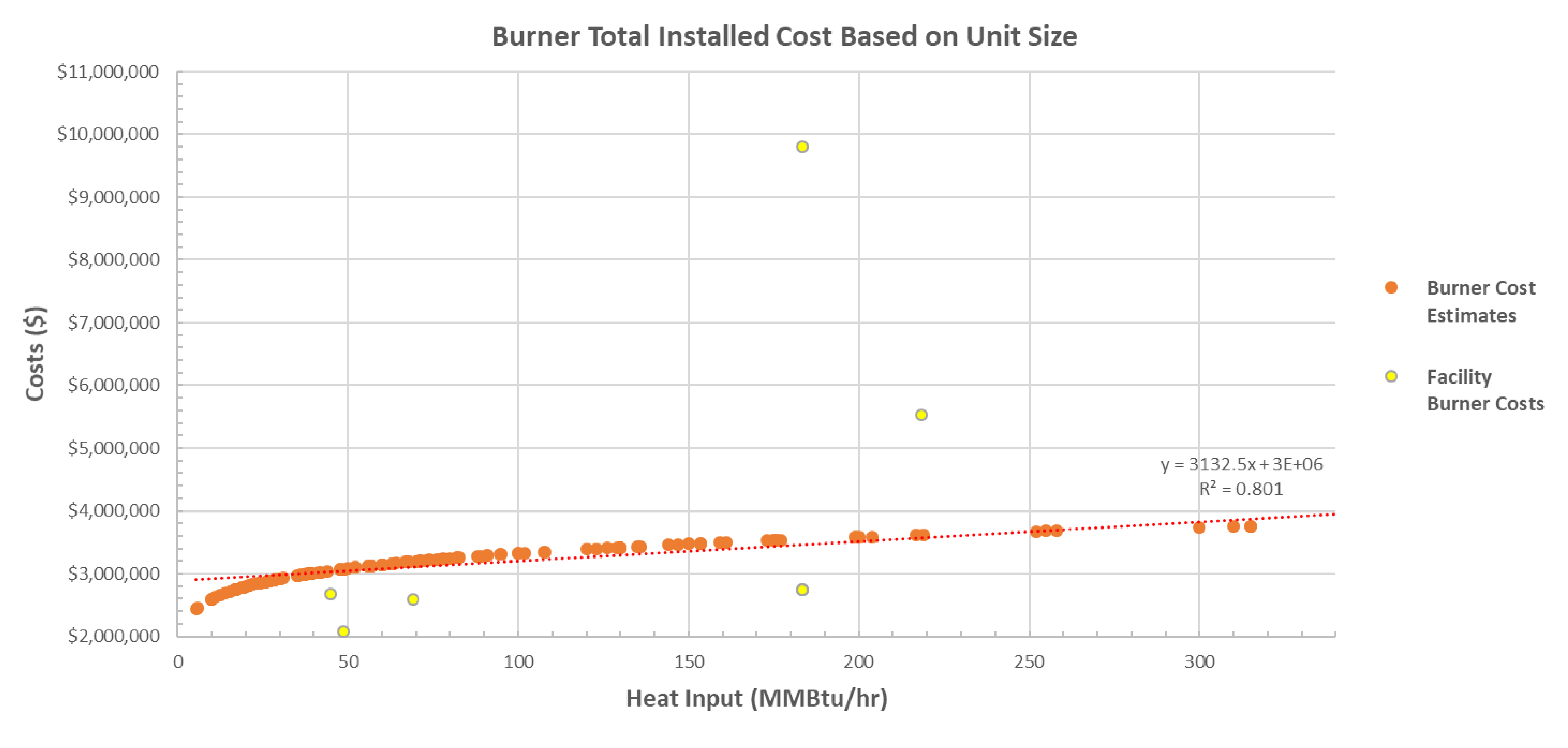
- Staff agrees

1. Staff proposal from Working Group Meeting #9.

Cost-Effectiveness Calculation – Burner Cost (*con't*)

- Facilities provided cost for 13 burner installations
  - Cost ranged from $1.6MM to $9.8 MM
  - Power curve generated based on $ per MMBtu/hr
- Based on the power curve, burner cost is:
  - $y = \$23,137\ (150/x)^{0.892}$





*Curve generated from 13 estimated burner costs provided by facilities (some points represent multiple units)

Cost-Effectiveness Calculation – LCF versus DCF

Background

- Staff relied on U.S. EPA SCR spreadsheet for cost-effectiveness calculations provided in last working group meeting

Stakeholders Comment

- U.S. EPA relies on LCF for cost-effectiveness calculations

Staff Response

- Revised cost-effectiveness calculations to reflect DCF

Cost-Effectiveness Calculation – NOx Concentration

Background

- Staff proposed back-calculating NOx emissions based on Annual Emission Reported (AER) value (annual mass)

Stakeholders Comment

- Back-calculated emissions did not agree with survey due to the use of “actual” versus “dry standard” cubic feet/minute (acfm versus scfm)

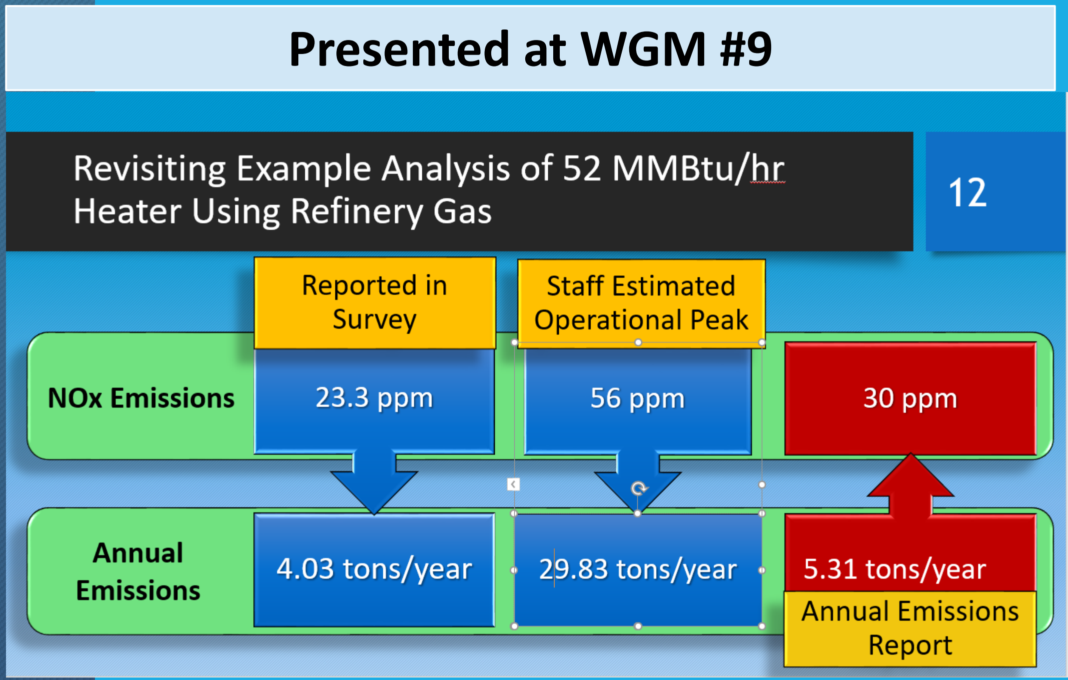
Staff Response

- Use NOx concentration as reported in survey (CEMS annual average) and mass emissions as reported in AER
  - Example calculation on next slide

Cost-Effectiveness Calculation – NOx Concentration (*con't*)

- Survey NOx Concentration (CEMS annual average) = 23.3 ppm
  - Percent reduction to achieve 2 ppm = 91.4%
    - ✓Technically feasible with SCR only
  - Annual emissions (AER) = 5.31 tpy
  - Emission reductions

$$5.31\ tpy \times 91.4\% = 4.85\ tpy$$



Cost-Effectiveness Calculation – Facility versus Spreadsheet Cost Estimates for SCR

Background

- Staff modified U.S. EPA SCR spreadsheet to estimate SCR cost provided by facilities

Stakeholders Comment

- Use facility cost estimates if provided

Staff Response

- Cost-effectiveness has been revised
  - Used facility cost if provided
  - If no facility cost was provided, used modified cost curve
- Cost-effectiveness based on class and category, not for individual units

Cost-Effectiveness Calculation – Facility versus Spreadsheet Cost Estimates

- Some units are have much higher costs due to challenging retrofits
- Cost curve cannot account for outliers
  - Retrofit factor in EPA SCR spreadsheet designed to address outliers

Comparison of facility supplied Total Install Costs (TIC) and Operations and Maintenance Costs (O&M) versus costs generated from modified U.S. EPA SCR spreadsheet

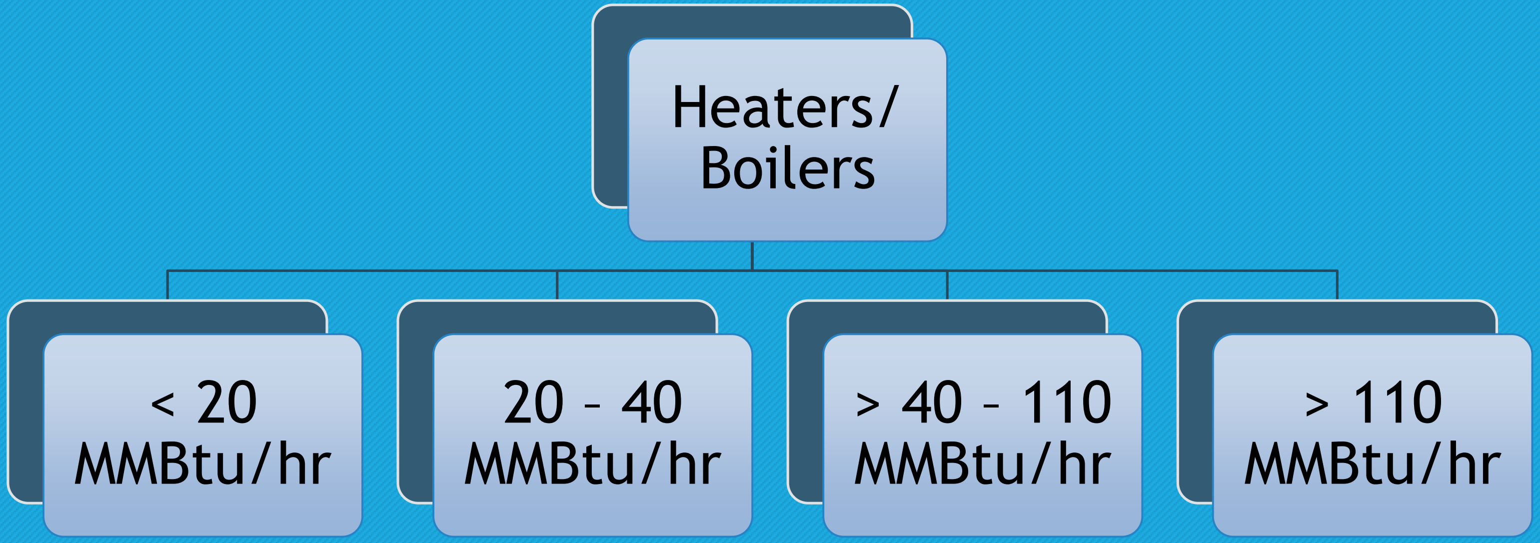
Size (MMBtu/hr)	Facility TIC	EPA TIC	Facility O&M	EPA O&M
67	$7 MM	$8 MM	$140 M	$99 M
91	$8 MM	$9 MM	$140 M	$120 M
135	$11.8 MM	$11 MM	$140 M	$140 M
173	$22.2 MM	$13 MM	$170 M	$220 M
340	$17 MM	$18 MM	$160 M	$370 M
527	$32 MM	$22 MM	$160 M	$370 M

Staff Adjustments to Cost-Effectiveness Calculation

- Developed cost curve to estimate burner replacement costs
- Used actual facility cost estimates when available
- Used NOx concentration from survey to calculate percent reduction and applied to mass emissions from AER
- Recalculated based on DCF

Revised Cost-Effectiveness Analysis for Heaters and Boilers

- Staff revised the cost-effectiveness calculations for each heater/boiler category presented in Working Group Meeting #9



- Following slides details the changes to the cost-effectiveness and staff recommended NOx concentrations limits
- Staff still evaluating outliers and units with existing SCR

Revised Cost-Effectiveness Analysis for Heaters and Boilers (cont.)

Revised cost and emissions resulted in some cost increases and some cost decreases

Increased Cost

- Estimated costs from facilities
- NOx from survey*[1]
- Burner cost curve

Decreased Cost

- Estimated costs from facilities
- NOx from survey*[2]
- DCF versus LCF

* NOx concentration from survey lower than back-calculated value

1. Lower emission reductions increased cost-effectiveness values
2. For some units, the recalculated SCR removal efficiency could achieve proposed NOx limit without the need/cost of burner replacement

Heaters <40 MMBtu/hr using Refinery Gas

Revised cost-effectiveness analysis (cont.)

Presented at WGM #9

Cost-Effectiveness Analysis for 9 ppm (Heaters <40 MMBtu/hr Using Refinery Gas)

Cost-Effectiveness at 9 ppm

Heater Category	Burners Replaced Before Useful Life	Burners Replaced After Useful Life
<20 MMBtu/hr	$98,017	No cost increase, possibly savings
20 to 40 MMBtu/hr	$48,746	

- Evaluation of 9 ppm using refinery gas
  - Based on emerging technologies: ClearSign or SOLEX
  - Implementation schedule will need to account for technology development
- Evaluated two heater sizes:
  - < 20 MMBtu/hr
  - 20 to 40 MMBtu/hr
- For each of the heater sizes, evaluated two scenarios:
  - Burner replacement before useful life
  - Burner replacement after useful life, if replacement before useful life is not cost-effective
- Assumptions
  - ClearSign is <$1 MM
  - Used cost based on traditional low-NOx burner ~$2.2 MM (conservative assumption)
  - Assumed 25 years useful life

39

Revised Cost-Effectiveness at 9 ppm

Heater Category	Burners Replaced *Before* Useful Life	Burners Replaced *After* Useful Life
<20 MMBtu/hr	$212,421 (14 units)	Potential additional cost beyond what the facility will already incur
20 to 40 MMBtu/hr	$77,664* (36 units)	

** No longer cost-effective, changed recommendation*

Revised Staff Recommendation:

- 9 ppm at end of burner useful life for all heaters <40MMBtu/hr
  - ✓ Assess maturity of emerging technology, an implementation schedule will be established

Heaters >40 ppm, <40 MMBtu/hr using Refinery Gas

Revised cost-effectiveness analysis (cont.)

Presented at WGM #9

Cost-Effectiveness Analysis for 30 ppm (Heaters >40 PPM, <40 MMBtu/hr Using Refinery Gas)

Cost-Effectiveness at 30 ppm

Heater Category	NOx Limit 30 ppm
<20 MMBtu/hr	$525,603
20 to 40 MMBtu/hr	$20,558

- Most heaters are achieving NOx concentration <40 ppm
- Three heaters with NOx concentrations > 40 ppm
  - 2 heaters are < 20 MMBtu/hr
  - 1 heater is 20 to 40 MMBtu/hr
- Commercially proven low-NOx burners can achieve < 30 ppm
  - Burner manufacturers will guarantee 30 ppm using refinery gas
- Evaluated cost-effectiveness of interim NOx concentration limit of 30 ppm for heaters currently > 40 ppm for two heater sizes:
  - < 20 MMBtu/hr
  - 20 to 40 MMBtu/hr
- Assumptions
  - Average cost for burners is $2.2 MM
  - Assumed 25 years useful life

41

Revised Cost-Effectiveness at 30 ppm

Heater Category	30 ppm
<20 MMBtu/hr	$276,058 (2 units)
20 to 40 MMBtu/hr	$50,109 (1 unit)

Maintain Staff Recommendation:

- 30 ppm for heaters 20 to 40 MMBtu/hr
- 9 ppm at end of useful life
  - ✓ Assess maturity of emerging technology, an implementation schedule will be established

Heaters >40 MMBtu/hr using Refinery Gas

Revised cost-effectiveness analysis (cont.)

Presented at WGM #9

Cost-Effectiveness Analysis for 2 ppm (Heaters ≥40 MMBtu/hr Using Refinery Gas)

Cost-Effectiveness at 2 ppm	
Heater Category	2 ppm
≥40 to 110 MMBtu/hr	$48,892
>110 MMBtu/hr	$40,682

- Burner costs included for units requiring >95% reduction from SCR
  - $2.8MM/unit for installation of ULNB
  - ULNB can achieve < 30 ppm
  - 14 units will require burner upgrades
- Cost-effectiveness calculated using U.S. EPA cost spreadsheet
  - Average cost-effectiveness of all heaters >40 MMBtu/hr < $50,000/ton NOx reduced
  - Units with existing SCR (37) not included in cost-effectiveness calculation
    - Assume new catalyst(s), ammonia injection grid upgrades, and tuning can improve removal efficiency
    - Will not require complete SCR retrofit installation
    - Cost will be less than a complete retrofit installation
    - Staff still evaluating costs and potential reductions for units with existing SCRs

48

Revised Cost-Effectiveness at 2 ppm	
Heater Category	2 ppm
≥40 to 110 MMBtu/hr	$56,366 (44 units)
>110 MMBtu/hr	$39,857 (33 units)

Maintain Staff Recommendation:

- 2 ppm for heaters >40 MMBtu/hr
- Outliers and units with existing SCR currently being evaluated

Boilers <40 MMBtu/hr using Natural Gas

- Working Group Meeting #9, staff evaluated 2 ppm, 5 ppm and 9 ppm NOx limits for boilers <40 MMBtu/hr
  - All boilers <40 MMBtu/hr fueled by natural gas
  - 2 ppm not cost-effective
  - 9 ppm achieved in practice
  - Considered 5 ppm using Solex™
    - John Zink indicated the Solex burner is not applicable to boilers but commercially available burner technology currently can achieve 5 ppm on natural gas

Revised

Boilers <40 MMBtu/hr using Natural Gas

Revised cost-effectiveness analysis (cont.)

Presented at WGM #9

Cost-Effectiveness Analysis for 2, 5, and 9 ppm (Boilers <40 MMBtu/hr, Natural Gas)

Cost-Effectiveness at 2, 5, and 9 ppm

Boiler Category	2 ppm	5 ppm*	9 ppm
<20 MMBtu/hr	$167,149	No additional Cost	$55,563
20 to 40 MMBtu/hr	$42MM	No additional Cost	$0 Achieved

* After burner useful life

- Combination of SCR (95% reduction) and ULNB (< 30 ppm) can achieve 2 ppm
  - SCR cost-estimates based on U.S. EPA cost spreadsheet with adjustments (previous slides)
- Evaluation of 5 ppm based on burner replacement after burner reaches useful life
- Evaluation of 9 ppm using natural gas based on use of LNB
- Evaluated two heater sizes:
  - < 20 MMBtu/hr
  - 20 to 40 MMBtu/hr
- Assumptions
  - Used cost based on traditional LNB burner ~$2 MM
  - Assumed 25 years useful life

57

Revised Cost-Effectiveness at 2 and 5 ppm

Boiler Category	2 ppm	5 ppm	5 ppm *after* useful life
<20 MMBtu/hr	$93,604	$67,983	Potential additional cost beyond what the facility will already incur
	(2 units)		
20 to 40 MMBtu/hr	$512,110	$413,055	
	(2 units)		

Maintain Staff Recommendation:

- 5 ppm at end of burner useful life, keep current permit limit

Revised

Boilers ≥40 MMBtu/hr Using Refinery Gas

Revised cost-effectiveness analysis (cont.)

Presented at WGM #9

Cost-Effectiveness Analysis for 2 ppm (Boilers ≥40 MMBtu/hr Using Refinery Gas)

Cost-Effectiveness at 2 ppm

Heater Category	2 ppm
≥40 to 110 MMBtu/hr	$36,578
>110 MMBtu/hr	$31,461

- Burner costs included for units requiring >95% reduction from SCR
  - $2.8MM/unit
  - NOx reduced to 30 ppm
  - 8 boilers will require burner upgrades
- Cost-effectiveness calculated using U.S. EPA cost spreadsheet
  - Average cost-effectiveness for all boilers ≥ 40 MMBtu/hr < $50,000/ton NOx reduced
  - Units with existing SCR (7) not included in cost-effectiveness analysis
    - Assume new catalyst(s), ammonia injection grid upgrades, and tuning can improve removal efficiency
    - Will not require complete SCR retrofit installation
    - Cost will be less than a complete retrofit installation
    - Staff still evaluating cost and potential reductions for units with existing SCR

65

Revised Cost-Effectiveness at 2 ppm

Boiler Category	2 ppm
≥40 to 110 MMBtu/hr	$50,042 (2 units, 1 standby not included)
>110 MMBtu/hr	$19,286 (11 units)

Maintain Staff Recommendation:

- 2 ppm for boilers ≥40 MMBtu/hr

Summary of Proposed BARCT Limits for Boilers and Heaters

24

Proposed BARCT NOx Limit for Heaters

Size (MMBtu/hr)	Proposed BARCT NOx Limit*	Revised Cost-Effectiveness
<20	40 ppm[1]/9 ppm[2]	$0/Potential additional cost
20 to 40	30 ppm/9 ppm[2]	$50,109/Potential additional cost
≥40 to 110	2 ppm	$56,366
>110	2 ppm	$39,857

1. Two units > 40 ppm – not cost- effective to retrofit (no action required)
2. Future effective limit of 9 ppm at end of burner useful life (technology forcing based on emerging technologies)

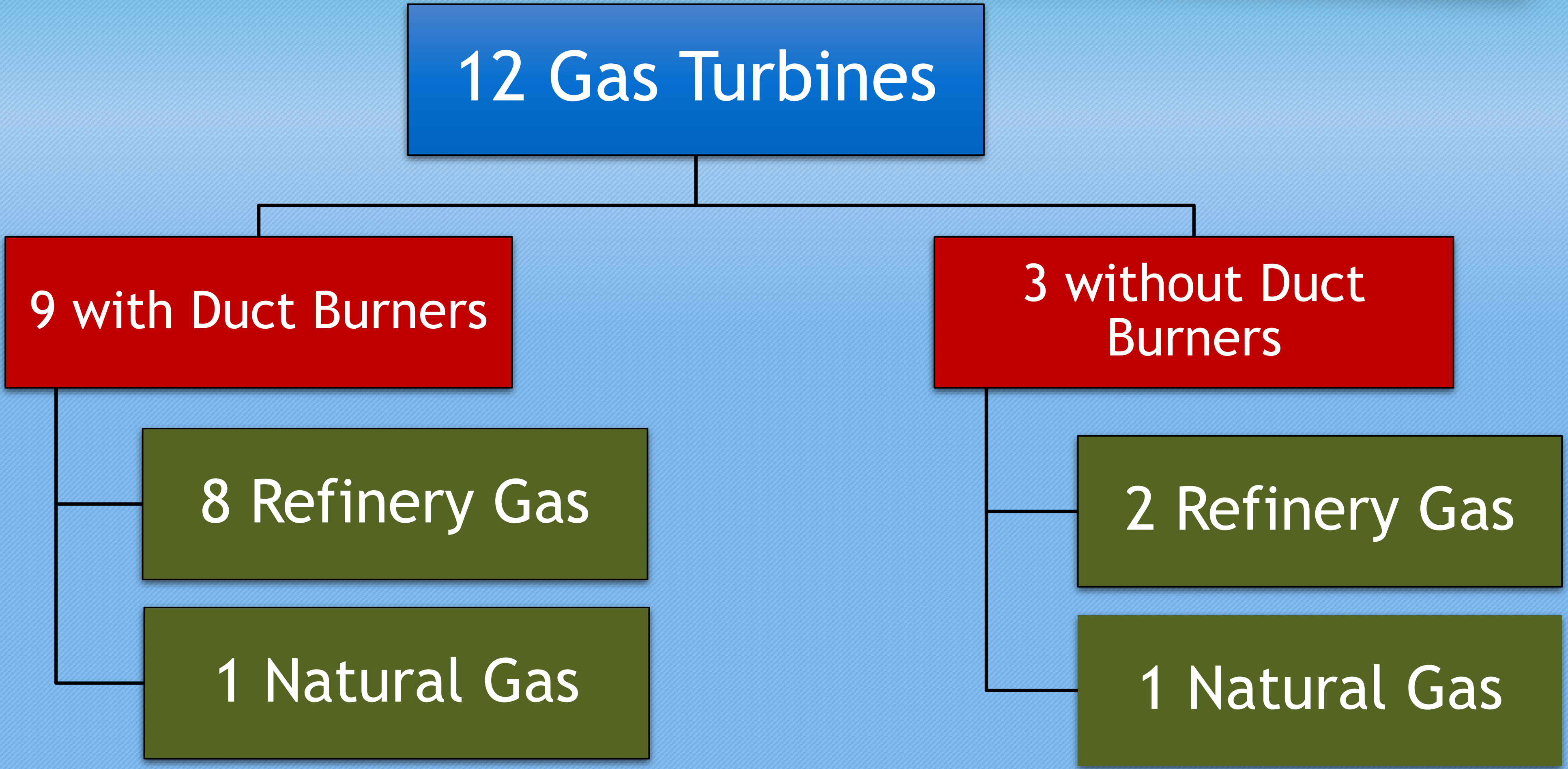
Proposed BARCT NOx Limit for Boilers

Size (MMBtu/hr)	Proposed BARCT NOx Limit	Revised Cost-Effectiveness
<20	5 ppm[1]	Potential additional cost
20 to 40	5 ppm[1]	Potential additional cost
≥40 to 110	2 ppm	$50,042
>110	2 ppm	$19,286

[1] Staff proposing a future effective limit at end of burner useful life due to high cost-effectiveness. Commercially available burner technology can achieve 5 ppm.

Gas Turbines Assessment

Gas Turbines Categories



Technical Feasibility for Gas Turbines

- Combination of dry-low NOx (DLN) combustor and SCR can achieve 2 ppm with proper engineering and design
- DLN combustors can achieve:
  - 9 – 25 ppm fired with natural gas
  - 10 – 27.5 ppm fired with refinery gas (~10% higher NOx emissions)
- SCR can achieve ~95% NOx reduction
- 2015 BARCT Assessment and Norton report concurred a 2 ppm NOx limit is technically feasible

Gas Turbines Fired with Natural Gas

Technical Feasibility for Gas Turbines (Natural Gas)

- Recent BARCT Assessments for combined cycle gas turbines fired with natural gas established 2 ppm
  - Rule 1134 – Emissions of Oxides of Nitrogen from Stationary Gas Turbines
  - Rule 1135 – Emissions of Oxides of Nitrogen from Electricity Generating Facilities
- Both gas turbines fired with natural gas have existing SCRs and CO catalysts
  - Average NOx removal efficiency of existing SCRs is 94%
  - Both units currently achieving < 2 ppm NOx

Gas Turbines Assessment (Natural Gas)

	RECLAIM 2015 BARCT	Existing Units	Other Regulatory	Technology Assessment	Initial BARCT NOx Limit	Cost-Effectiveness
Natural Gas	2 ppm	1.14 – 1.85 ppm	2 – 42 ppm	2 ppm	2 ppm	$0, Achieved-in-practice

Cost-Effectiveness for 2ppm (Gas Turbines with Natural Gas)

Cost-Effectiveness at 2 ppm
2 ppm with SCR
$0/Achieved-in-practice

- All existing natural gas units achieving 2 ppm

Staff BARCT Recommendation:

- 2 ppm for Gas Turbines using Natural gas
  - ✓ Achieved-in-practice

Gas Turbines Fired with Refinery Gas

Technical Feasibility for Gas Turbines (Refinery Gas)

- All gas turbines have existing SCRs and CO catalysts with the following characteristics:
  - SCR NOx removal efficiency: 70 - 89%
  - Catalysts age range: 1–12 years
  - Catalyst beds range: 1 - 2
- NOx removal efficiency can be improved by:
  - SCR upgrades (e.g., ammonia injection grid, catalyst, additional catalyst beds)
  - Possibility of combustor upgrade (10 – 27.5 ppm)
- Combination of DLN combustor and maximized SCR removal efficiency can achieve 2 ppm NOx
- 2 ppm achieved-in-practice with refinery gas (DLN combustor and SCR) based on stack test

Gas Turbine Assessment (Refinery Gas)

	RECLAIM 2005/2015 BARCT	Existing Units	Other Regulatory	Technology Assessment	Initial BARCT NOx Limit	Cost-Effectiveness
Refinery Gas or Refinery Mixed Gas	2 ppm	2.8 - 10 ppm	9 - 50 ppm	2 ppm	2 ppm	Need to conduct cost-effectiveness on initial BARCT NOx limit

Initial BARCT NOx Limits for Cost-Effectiveness for Gas Turbines (Refinery Gas)

2 ppm

Upgrade existing SCR to achieve 95% reduction

OR

Upgrade existing SCR and DLN combustor

Potential NOx BARCT Emission Limit

Total NOx emission is 1.41 tpd

Cost-Effectiveness for 2 ppm (Gas Turbines with Refinery Gas)

Cost-Effectiveness at 2 ppm
2 ppm with SCR
$35,573

- SCR upgrades are most cost-effective option to achieve 2 ppm
- Cost-effectiveness analysis based on **new** SCR installation (worse-case cost assumption)
  - Used U.S. EPA cost model with a 20% increase for labor costs (SB54)
    - Did not use modified cost curve (reflects costs for heaters/boilers)

Staff Recommendation:

2 ppm for Gas Turbines using Refinery Gas

Gas Turbine Assessment (Refinery Gas)

	RECLAIM 2005/2015 BARCT	Existing Units	Other Regulatory	Technology Assessment	Initial BARCT NOx Limit	Cost-Effectiveness
Refinery Gas or Refinery Mixed Gas	2 ppm	2.8 - 10 ppm	9 - 50 ppm	2 ppm	2 ppm	$35,573 (10 Units)

Cost-Effectiveness for Gas Turbines

Natural Gas
at 2 ppm

Cost-Effectiveness:
$0, Achieved

Staff Recommendation:
2 ppm

Refinery Gas
at 2 ppm

Cost-Effectiveness:
$35,573

Staff Recommendation:
2 ppm

Staff BARCT Recommendation:

- 2 ppm for Gas Turbines

Gas Turbine Summary

Proposing 2 ppm NOx limit for all gas turbines

- Natural Gas and Refinery Gas
- Achieved-in-practice, technically feasible, and cost-effective

Considerations

- Averaging Time
- Ammonia limit
  - ✓ Some units currently have 20 ppm ammonia permit limit

FCCU Assessment

FCCU Categories

5 FCCUs

- 3 with SCR
  - Current NOx Concentration
  - 1.2 – 15 ppm
- 2 without SCR
  - Current NOx Concentration
  - 13 – 36 ppm

Technical Feasibility of 2 ppm for FCCU

- Three technologies identified for NOx control in FCCU applications
  - DeNOx additive
    - ~45% reduction dependent on configuration
  - LoTOx
    - 95% reduction
    - One FCCU installation at Marathon, Texas City
  - SCR
    - 95% reduction
- 2 ppm is technically feasible with SCR
  - One existing FCCU
  - One planned FCCU retrofit (SCR) engineered for 2 ppm

FCCU Assessment

	RECLAIM 2015 BARCT	Existing Units	Other Regulatory	Technology Assessment	Initial BARCT NOx Limit	Cost-Effectiveness
FCCU	2 ppm	1.2 – 36 ppm	40 – 125 ppm	2 ppm	2 ppm	Need to conduct cost-effectiveness on initial BARCT NOx limit

Initial BARCT NOx Limits for Cost-Effectiveness for FCCU

2 ppm

SCR, LoTOx, and DeNOx additive

Potential NOx BARCT Emission Limits

Total NOx emission for is 0.67 tpd

Cost-Effectiveness for FCCU

Cost-Effectiveness at 2 ppm
2 ppm with SCR
$36,509

- Evaluated cost-effectiveness for all units not achieving 2 ppm
- Cost estimates:
  - Facilities provided two capital cost estimates ($57 MM and $19.5 MM)
  - Staff used those data points to estimated costs for other units
    - Scaled cost based on flow rate
  - Annual O&M Cost assumed 0.5% of Total Capital Investment Cost
    - Consistent with boilers/heaters estimates
- Cost based on new SCR installation
  - Units with existing SCR could optimize SCR to achieve reductions

<u>Staff Recommendation:</u>

2 ppm for FCCU

Cost-Effectiveness for FCCU

FCCU
at 2 ppm

Cost-Effectiveness:
$36,509

Recommendation:
2 ppm

Staff Recommendation:

- 2 ppm for FCCU

FCCU Summary

<u>Proposing 2 ppm NOx limit</u>

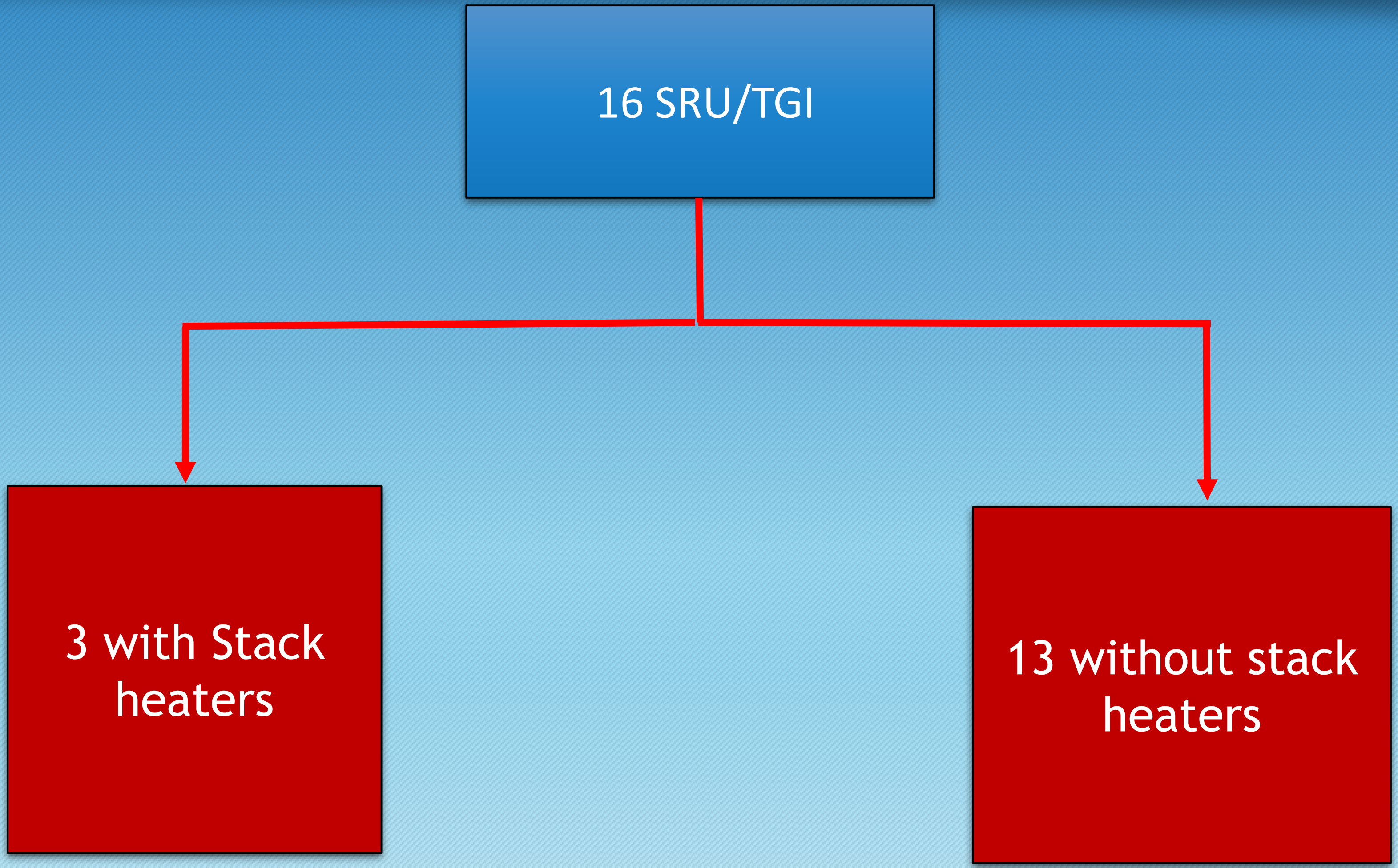
- One unit achieved-in-practice
- One planned installation unit designed to meet 2 ppm
- Technically feasible and cost-effective

<u>Considerations</u>

- Averaging time
- Ammonia limit
  - ✓ All units currently have 10 ppm ammonia permit limit pursuant to Rule 1105.1

Sulfur Recovery Units /Tail Gas Incinerators (SRU/TGI)

SRU/TGI Universe



SRU/TG Incinerator Background

- Sulfur recovery units (SRU) convert hydrogen sulfide into elemental sulfur
- SRU converts ~95 percent of the hydrogen sulfide into sulfur and the tail gas incinerators (TGI) converts the remaining hydrogen sulfide into SO_2
- Tail gas is vented to a thermal/catalytic oxidizer/incinerator
- SRU/TGI are classified as major sources of NOx

SRU/TGI Challenges

- Currently no units have been retrofitted with post combustions controls
- Challenging retrofits
  - High stacks adds to installation costs
  - Flue temperatures above maximum SCR temperatures
    - Waste heat boiler or excess air needed to cool gas
- Hydrogen sulfide rich gas contains NOx precursors
  - Not all NOx from burner

Technical Feasibility for SRU/TGI

- Combination of SCR (95% reduction) and ULNB (< 30 ppm) can achieve 2 ppm with proper engineering and design
  - Waste heat boiler or tempered air needed to reduce flue gas temperature
- LoTOx™ is another control option with ULNB that can achieve >95% NOx reduction
  - Operating temperature even lower than SCR
    - Waste heat boiler or tempered air
  - Used in combination with wet scrubber to control NOx, SOx, and PM
  - No ammonia use, but ozone is required
  - Waste effluent treatment system required
- 2015 BARCT Assessment and Norton report concurred that a 2 ppm NOx limits was technically feasible

Initial BARCT NOx Limit for SRU/TGI

	RECLAIM 2015 BARCT	Existing Units	Other Regulatory	Technology Assessment	Initial BARCT NOx Limit	Cost-Effectiveness
All Units	2 ppm	4 - 74 ppm	27 ppm*	2 ppm	2 – 30 ppm	Need to conduct cost-effectiveness on initial BARCT NOx limit

* Texas Department of Environmental Quality Title 30, Part 1 Chapter 117, Subchapter B, Division 3, Rule 117.310 for Industrial Incinerators

Initial BARCT NOx Limits for Cost-Effectiveness Analysis for SRU/TGI

- Evaluated three NOx concentration limits
  - 2 ppm using SCR/ ULNBs or LoTOx™
  - 5 ppm using SCR or LoTOx™
  - 30 ppm using ULNB only

2 ppm

SCR and ULNB or LoTOx™ and ULNB

5 ppm

SCR or LoTOx™

30 ppm

ULNB (< 30 ppm)

Potential NOx BARCT Emission Limits

Total NOx emission for SRU/TGTU is 0.43 tpd

Cost-Effectiveness Analysis for 2 and 5 ppm using SCR

Cost-Effectiveness at 2 and 5 ppm	
2 ppm (SCR and ULNB)	5 ppm (SCR)
$90,000	$89,000

- Staff received one cost estimate for a SCR retrofit (~ $60 MM for two units with common SCR)
- Cost estimates for remaining units:
  - SCR cost ~$45 per standard cubic feet/minute flow rate
  - Waste heat boiler ~ $100,000
  - Installation ~ 4.5 times capital cost (Based on 2015 BARCT Norton recommendation)
  - Operating and Maintenance ~ $150,000/year
- ULNB installation and cost
  - 8 units exceed 95% reduction to achieve 2 ppm and would need to replace burners
    - Burner cost curve used to estimate cost
  - No units need to replace burners to achieve 5 ppm
- Technically feasible to retrofit to 2 or 5 ppm with SCR but not cost-effective

Staff Recommendation

2 and 5 ppm is not cost-effective for SRU/TGI using SCR

Revised

Cost-Effectiveness Analysis for 2 and 5 ppm using LoTOx™

Cost-Effectiveness at 2 and 5 ppm	
2 ppm (LoTOx™ and ULNB)	5 ppm (LoTOx™)
$96,000	$95,000

- Staff relied on 2015 BARCT assessment to estimate costs (3 data points)
  - Scaled costs up using 4% interest rate
  - Created cost curve for total install and O&M costs
- ULNB installation and cost
  - 8 units exceed 95% reduction to achieve 2 ppm and would need to replace burners
    - Burner cost curve used to estimate cost
  - No units need to replace burners to achieve 5 ppm
- Technically feasible to retrofit to 2 ppm or 5 ppm with LoTOx™ but not cost-effective

Staff Recommendation

2 and 5 ppm is not cost-effective for SRU/TGI using LoTOx™

Cost-Effectiveness Analysis for 30 ppm

Cost-Effectiveness at 30 ppm
ULNB
$51,700

- Cost estimates for burner retrofit:
  - Staff used the burner cost curve to estimate burner costs (average cost ~ $3.1 MM)
  - Operating and Maintenance ~ $2,000/year
  - 9 units currently operating above 30 ppm would need to be retrofit
- Based on current cost estimates, 30 ppm is cost-effective

Staff Recommendation

30 ppm is cost-effective for SRU/TGI using ULNB

Staff Recommendation for SRU/TGI

SRU/TGI

Cost-Effectiveness: $51,700*

Recommendation: 30 ppm

Staff Recommendation

- 30 ppm

*Cost per ton of NOx reduced

Proposed BARCT NOx Limit for SRU/TGI

	RECLAIM 2015 BARCT	Existing Units	Other Regulatory	Technology Assessment	Proposed BARCT NOx Limit	
All Units	2 ppm	4 - 74 ppm	27 ppm*	2 ppm	30 ppm	16 units (9 retrofits)

* Texas Department of Environmental Quality Title 30, Part 1 Chapter 117, Subchapter B, Division 3, Rule 117.310 for Industrial Incinerators

SRU/TGI Summary

Staff proposing 30 ppm NOx limit

- Based on burner technology
- Technically feasible and cost effective

Considerations

- Challenging to retrofit
  - High stacks
  - High flue gas temperature
  - Limited space
  - Moderate emissions

Next Steps

- Distribute sulfur fuel gas survey
- Working Group Meeting #11 – Evening meeting held in Wilmington/Carson
- Final Assessment Report from Consultants
- Finalize BARCT Limits
- Draft Rule Language
- Governing Board

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