Rule 1109.1 – NOx Emission Reduction for Refinery Equipment

Working Group Meeting #11

May 21, 2020

Agenda

- Progress of Rule Development
- Impacts of COVID-19 and Comments Received
- BARCT Assessment: SMR Heaters
- BARCT Assessment: Internal Combustion Engines
- Averaging Times
- Next Steps

Progress of Rule Development

Summary of Working Group #10 (2/18/20)

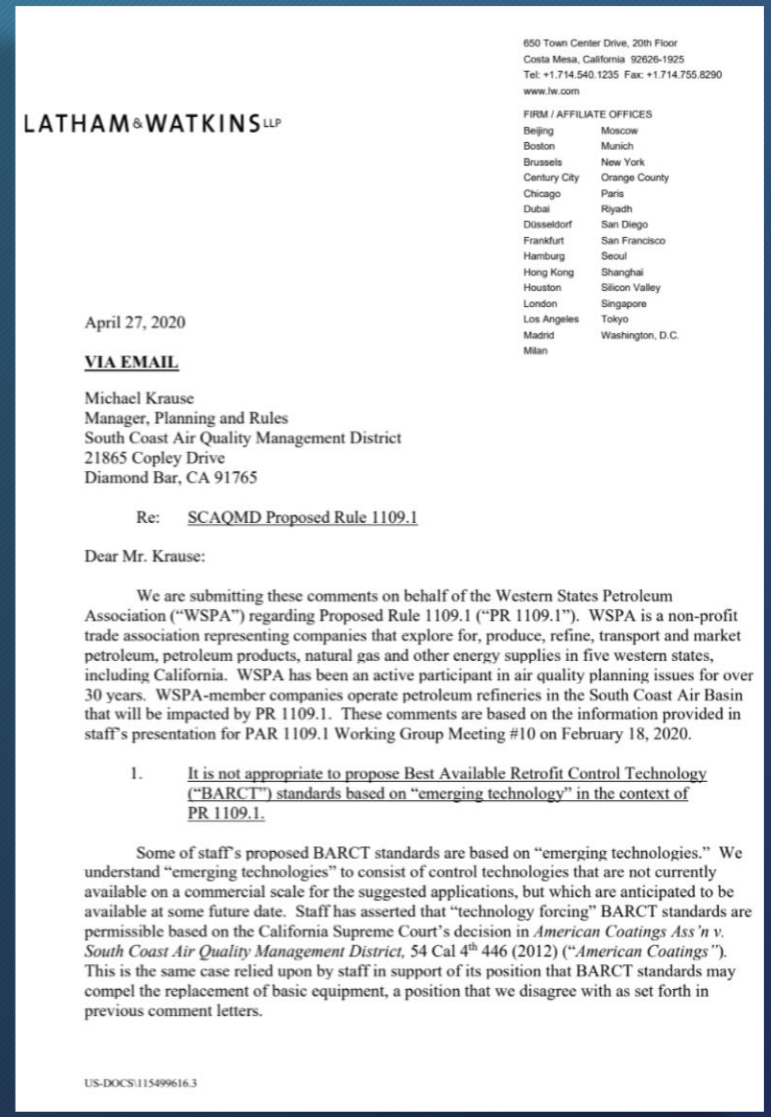
- Fuel gas sulfur survey for impacted stakeholders
- ClearSign Core™ Demonstration project update
- Discussed revised cost-effectiveness calculations for boiler and heaters
- Proposed BARCT limits for gas turbines, FCCU, and SRU/TG Incinerators

Since Last Working Group Meeting

- Impacted stakeholders submitted fuel gas sulfur survey data
- Discussion with consultants
- Stakeholder meetings and site visits
- Continued discussions with control technology suppliers

WSPA Comment Letter

- Comment Letter received from Latham & Watkins on behalf of the Western States Petroleum Association (WSPA)
- Key comments:
  - BARCT should not be based on emerging technologies
  - NOx BARCT limit should not trigger BACT PM
  - Impacts should be assessed if sunsetting SOx RECLAIM
  - Along with BARCT limits, staff should identify averaging time, schedule, and NH_3 limit
  - NH_3 slip limit should be included in Rule 1109.1
  - Rule 1109.1 should address the availability of Alternative Emission Compliance Plans
- These issues will be addressed in the upcoming meetings



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April 27, 2020

VIA EMAIL

Michael Krause
Manager, Planning and Rules
South Coast Air Quality Management District
21865 Copley Drive
Diamond Bar, CA 91765

Re: SCAQMD Proposed Rule 1109.1

Dear Mr. Krause:

We are submitting these comments on behalf of the Western States Petroleum Association ("WSPA") regarding Proposed Rule 1109.1 ("PR 1109.1"). WSPA is a non-profit trade association representing companies that explore for, produce, refine, transport and market petroleum, petroleum products, natural gas and other energy supplies in five western states, including California. WSPA has been an active participant in air quality planning issues for over 30 years. WSPA-member companies operate petroleum refineries in the South Coast Air Basin that will be impacted by PR 1109.1. These comments are based on the information provided in staff's presentation for PAR 1109.1 Working Group Meeting #10 on February 18, 2020.

1. It is not appropriate to propose Best Available Retrofit Control Technology ("BARCT") standards based on "emerging technology" in the context of PR 1109.1.

Some of staff's proposed BARCT standards are based on "emerging technologies." We understand "emerging technologies" to consist of control technologies that are not currently available on a commercial scale for the suggested applications, but which are anticipated to be available at some future date. Staff has asserted that "technology forcing" BARCT standards are permissible based on the California Supreme Court's decision in *American Coatings Ass'n v. South Coast Air Quality Management District,* 54 Cal 4th 446 (2012) ("*American Coatings*"). This is the same case relied upon by staff in support of its position that BARCT standards may compel the replacement of basic equipment, a position that we disagree with as set forth in previous comment letters.

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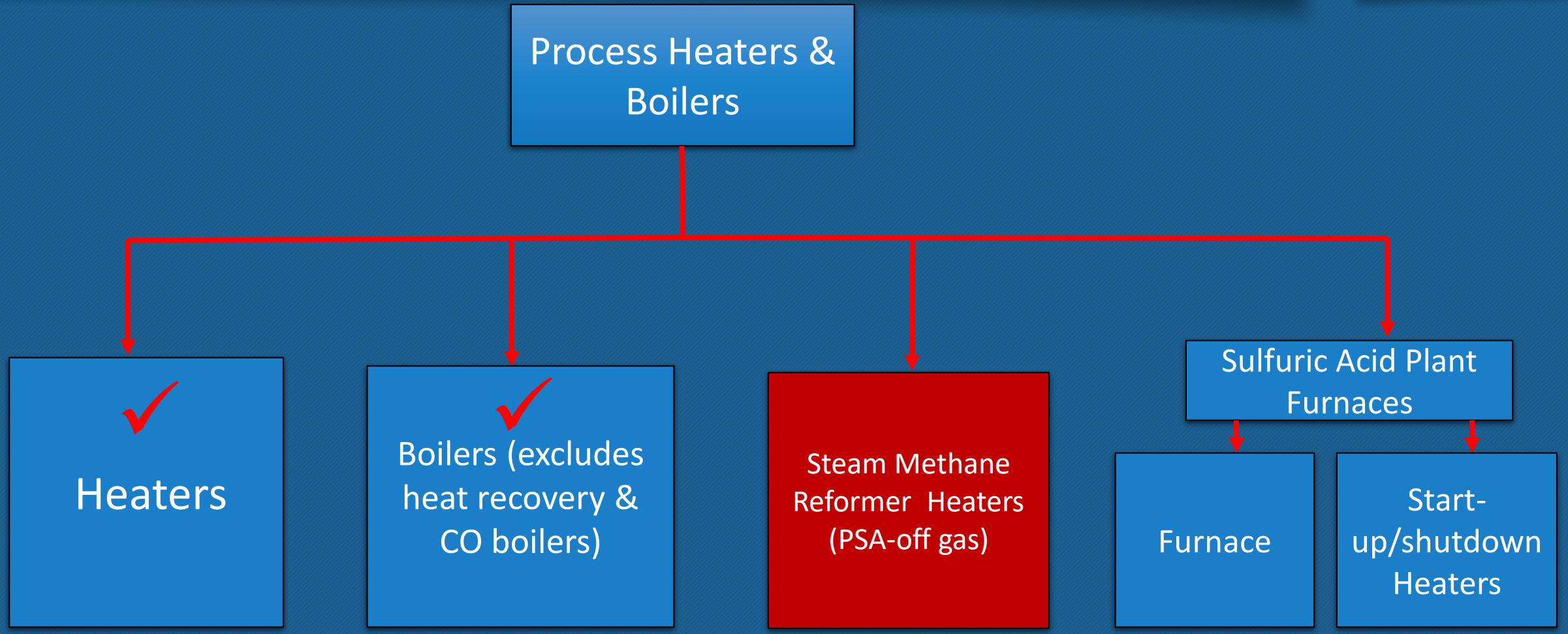
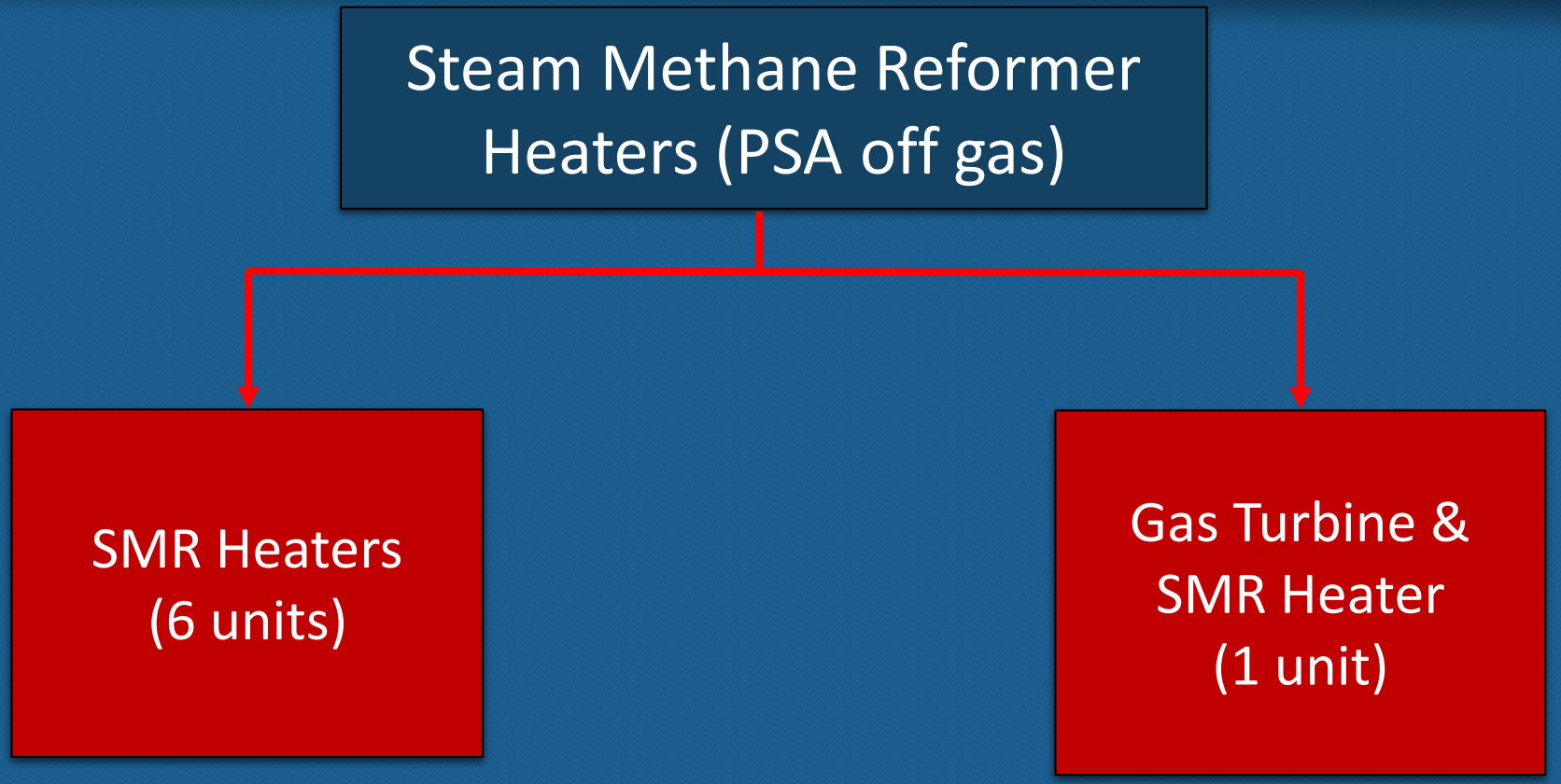
BARCT Assessment Continued

Heaters & Boilers by Category



Steam Methane Reformer Heaters (SMR) Assessment

SMR Heaters by Category



SMR Heater Background

- All SMR heaters are >110 MMBtu/hour
  - Large number of burners, typically, double the number of traditional process heaters
  - Burners are specialized for reforming process
- SMR heaters produce bulk hydrogen from natural gas feedstock and steam
- Hydrogen required at petroleum refineries to:
  - Meet stringent sulfur-content limits and to remove contaminants from fuels
  - Convert and improve product properties in the refining process

SMR Heater Challenges

- Primary combustion fuel is pressure swing adsorption (PSA) gas supplemented with natural gas or refinery gas
  - High hydrogen content contributes to higher adiabatic flame temperatures
  - PSA gas composition varies
- Higher average operating temperature than typical refinery heaters, higher NOx potential
  - Firebox temperature (~ 2,100°F) versus typical process heater (~1,600°F)
  - Higher temperatures required to drive endothermic reaction in process tubes
  - Metallurgy of process tubes can impact SCR catalyst (deactivate)

Technical Feasibility

- Combination of SCR and ULNBs will achieve maximum NOx removal:
  - Burner manufacturers guarantee between 40 – 60 ppm for SMR heaters
  - Properly engineered and designed SCRs can achieve up to 95% NOx reduction
- Existing SCRs achieving less than 90% NOx reductions can be optimized with additional catalyst layers, catalyst upgrades, and ammonia injection upgrades
- 2 ppm NOx is technically feasible with burner and SCR upgrades
- All SMR heaters have existing SCRs and LNBs
  - Existing SMR burners achieve between 36 - 61 ppm NOx (source test data)
  - Annual average NOx concentrations (CEMS data):
    - Five units achieving less than 5 ppm @ 3% O_2 (92 - 95% reduction)
    - One achieving greater than 5 ppm @ 3% O_2 (80% Reduction)

SMR Heaters: Permit Limit versus Performance

- All SMR heaters perform below their NOx permit limits
- Five of six SMR heaters performing at ~5 ppm or less on annual basis
- One performing greater than 5 ppm on an annual basis

Heater	NOx Permit Limit @3% O_2	Permitted Avg Time (hrs)	Annual CEMS NOx Conc. (ppmv)	NH_3 Permit Limit (ppmv)	NH_3 Conc.* (ppmv)
1	12	Not specified	7.2	20	12.2
2	12	Not specified	5.1	20	1.8
3	7	Not specified	3.8	20	6.0
4	5	3 hour	3.6	20	5.4
5	5	3 hour	3.7	5	3.9
6	9	24 hour	4.9	20	6.6

*Source test

SMR Heaters Assessment

	RECLAIM 2015 BARCT	Existing Units	Other Regulatory	Technology Assessment	Initial BARCT NOx Limit	Cost-Effectiveness
SMR Heaters	2 ppm	3.6 - 7.2 ppm	5 ppm*	2 - 5 ppm	2 - 5 ppm	Need to conduct cost-effectiveness on initial BARCT NOx limit

* San Joaquin Valley APCD Rule 4320 NOx limit for refinery process heaters greater than 110 MMBtu/hr (limit not specific to SMR heaters)

Initial BARCT NOx Limits for Cost-Effectiveness for SMR Heaters

2 ppm

New LNB and SCR Optimization

Potential NOx BARCT Emission Limit

5 ppm

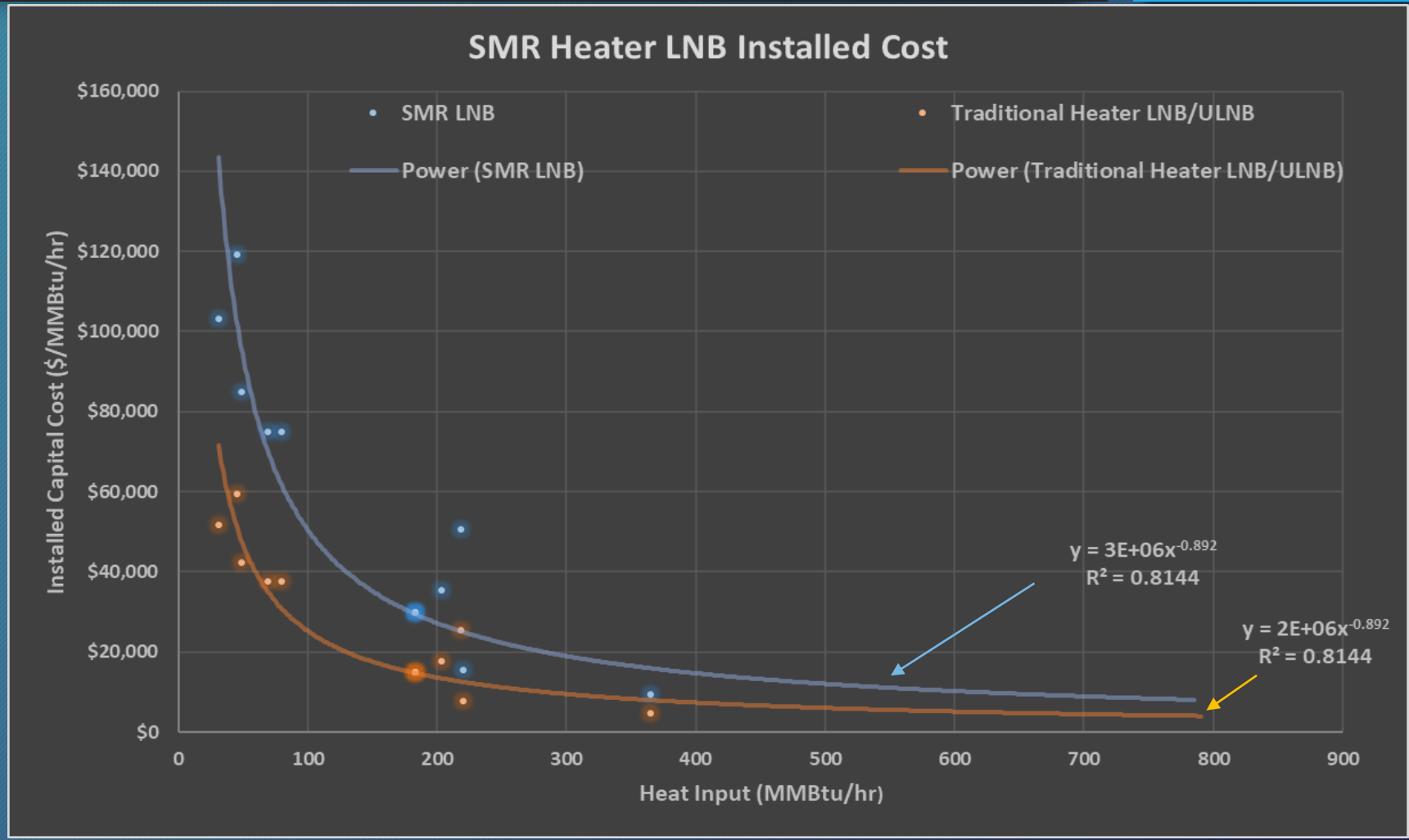
SCR Catalyst upgrades and/or Optimization

Currently Performing

Total NOx emission for category is 0.31 tpd

Burner Cost Assumptions

- Staff reviewed the burner cost curve
- SMR heaters typically have twice as many burners as other heaters
  - Up to 360 burners in a single SMR heater
- Burner vendors indicate commercially available ULNB for SMR heaters is about twice the cost of conventional ULNBs



SCR Upgrade Cost Assumptions

- SCRs can achieve up to 95% NOx emission reductions with proper engineering and design
- All units currently have SCRs
- SCR NOx removal efficiency can be improved by:
  - SCR upgrades (e.g., ammonia injection grid, ammonia mixing, catalyst upgrades, deeper catalyst or additional catalyst beds)
- SCR upgrade cost assumptions:
  - Based on technology vendor installation, SCR upgrades cost are 20 - 25% the cost of a new SCR system installation
    - New SCR cost calculated using modified U.S. EPA cost spreadsheet
  - O&M estimated to be 10% of current annual O&M cost reported by facility
    - Increased O&M costs associated with SCR upgrades

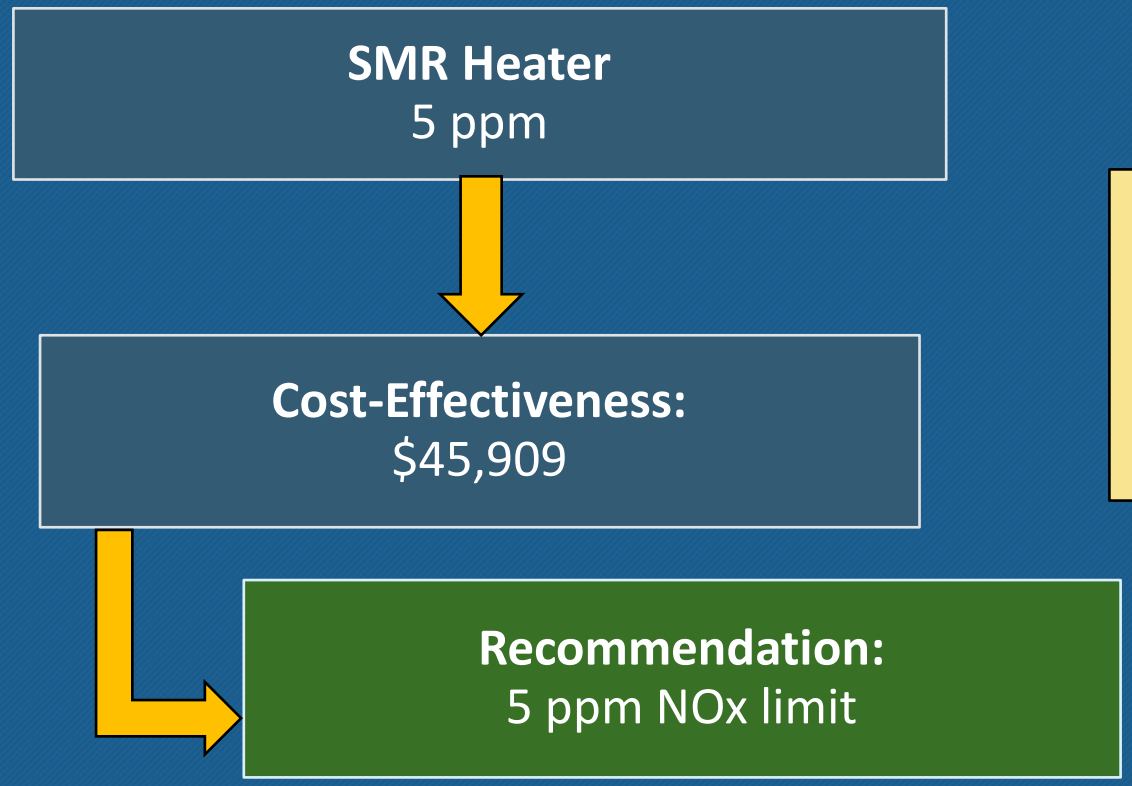
Cost-Effectiveness for SMR Heaters using PSA Gas

Cost-Effectiveness		
Heater Category	2 ppm (LNB & SCR)	5 ppm (SCR Upgrade)
SMR Heaters	$138,781	$45,909*

* Units at ~5 ppm or less not included in the cost analysis

- Evaluated cost-effectiveness of reducing existing units to 2 ppm and 5 ppm
- 2 ppm NOx limit
  - Require burner replacement and SCR upgrade
  - Low emission reductions, most units currently perform at 5 ppm or below
  - 2 ppm NOx limit is determined to be not cost-effective
- 5 ppm NOx limit
  - One unit greater than 5 ppm would require burner replacement and/or SCR upgrade
  - 5 out of the 6 affected heaters are performing at ~5 ppm or less (not included in cost analysis)
  - 5 ppm NOx limit is determined to be cost-effective

Cost-Effectiveness for SMR Heaters



Staff Recommendation:

- 5 ppm at 3% O_2 NOx limit for all SMR heaters using PSA gas
- Keep current ammonia permit limit

SMR Heater with Integrated Gas Turbine

SMR Heater with integrated Gas Turbine Background

- Unit is a unique arrangement comprised of a gas turbine and a SMR heater that share a common stack
- Originally installed in 1988 and equipped with LNB and SCR
- NOx permit limit of 9 ppm at 15% O_2
- Gas turbine located upstream of heater and generates electricity for facility
- Under normal integrated operation, a portion of the gas turbine exhaust provides combustion air for LNB in the SMR heater and the remaining exhaust exits the stack

SMR Heater with integrated Gas Turbine Feasibility

- Unit has a unique, integrated configuration so will be evaluated as a system in it's own category
- Gas Turbine combustor upgrade not feasible due to age of equipment
- Existing SCR control estimated to be at 93% reduction efficiency using compliance/source test
  - Current emissions are less than 5 ppm @ 15% O_2 on an annual basis
- SCR can be upgraded to improve NOx reduction efficiency to 95%
  - Large unit with influence of gas turbine will increase SCR upgrade costs:
    - Assumed 30% of new SCR
    - 20% increase in O&M cost associated with upgrade

SMR Heaters: Permit Limit versus Performance

- Unit currently performs below permit limits

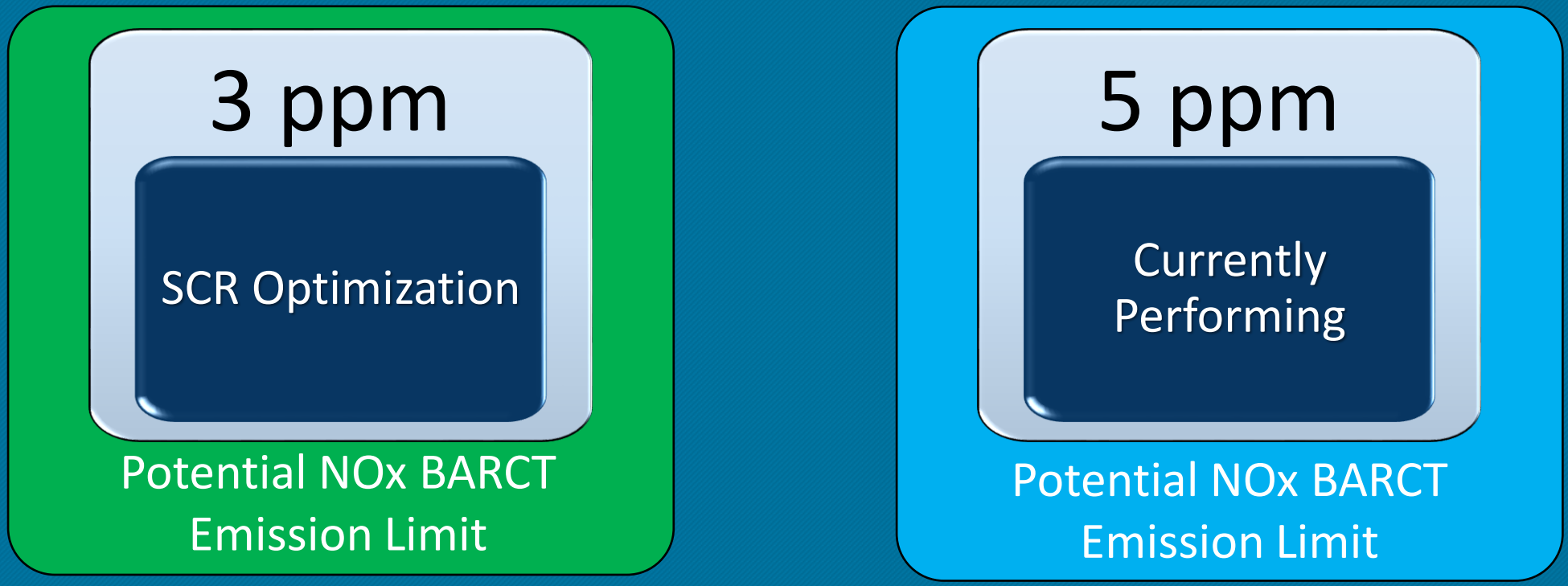
Heater	NOx Permit Limit (ppmv @15% O_2)	Annual CEMS NOx Conc. (ppmv @15% O_2)	NH_3 Permit Limit (ppmv)	NH_3 Conc* (ppmv)
GTG/SMR	9	4.4	20	11.5

*Source test

SMR Heater with integrated Gas Turbine Assessment

	RECLAIM 2015 BARCT	Existing Units	Other Regulatory	Technology Assessment	Initial BARCT NOx Limit	Cost-Effectiveness
SMR and Gas Turbine	n/a	4.4 ppm (15% O_2)	n/a	3 to 5 ppm (15% O_2)	3 to 5 ppm (15% O_2)	Need to conduct cost-effectiveness on initial BARCT limit

Initial BARCT NOx Limits for Cost-Effectiveness for SMR Heaters



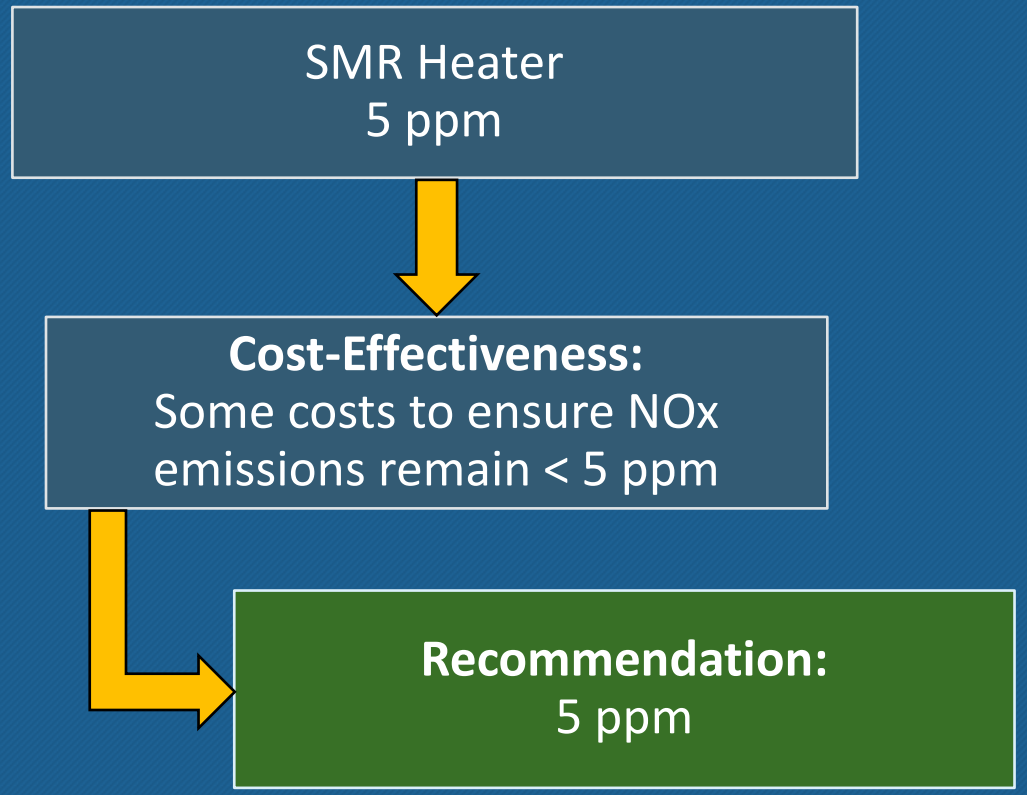
Total NOx emission is 0.08 tpd

Cost-Effectiveness for SMR with GTG

Cost-Effectiveness		
Heater Category	3 ppm (New SCR)	5 ppm (SCR Upgrade)
SMR and Gas Turbine	$69,054	Currently Achieving

- Evaluated cost-effectiveness of reducing existing units to 3 ppm and 5 ppm
- 3 ppm @ 15% O_2 NOx limit
  - 3 ppm achieved with SCR upgrades
    - Cost determined using modified U.S. EPA cost spreadsheet
  - Unit currently performs at less than 5 ppm, low emission reduction potential
  - 3 ppm NOx limit is determined to be not cost-effective
- 5 ppm @ 15% O_2 NOx limit
  - Unit already performing at less than 5 ppm
  - Some cost associated with upgrades to ensure NOx emissions remain less than 5 ppm

Cost-Effectiveness for SMR Heater with Gas Turbine



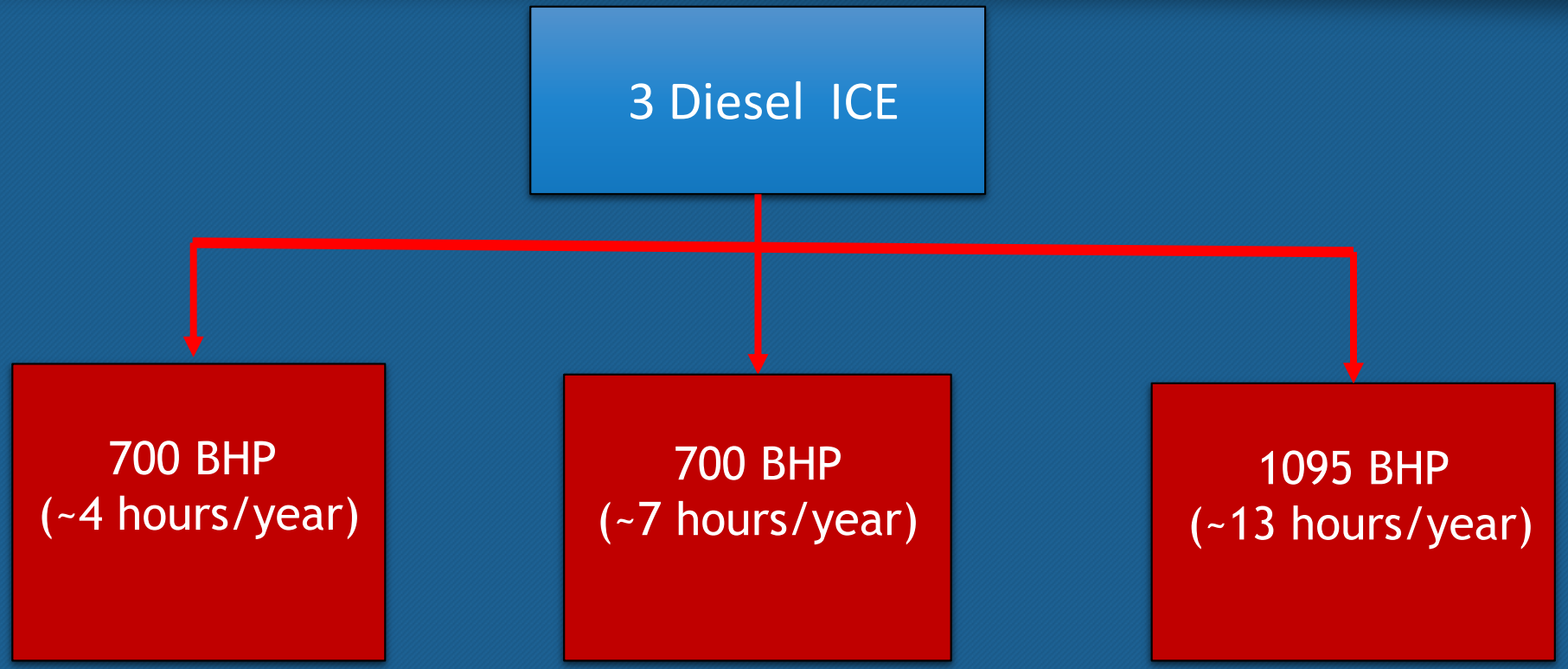
Staff Recommendation:

- 5 ppm at 15% O_2 NOx limit for SMR Heater with integrated gas turbine
- Keep current ammonia permit limit

South Coast AQMD

Internal Combustion Engines (ICE)

ICE Universe



Total NOx emission for ICE category is 0.0007 tpd

ICE Background

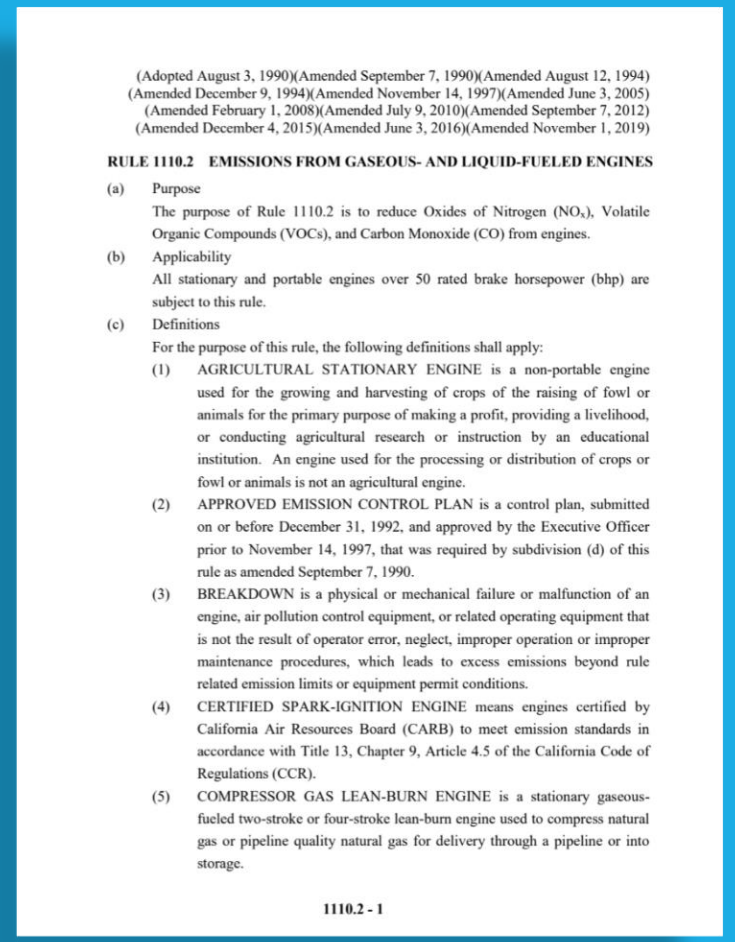
- All ICEs in Rule 1109.1 universe are:
  - Large stationary diesel engines (>600 hp)
  - Permitted as non-emergency ICE
  - Permit limit of 880 ppm NOx
  - Units used for cogeneration (gas turbine) start-up only
  - Low-use
    - All used <20 hours annually
    - Permit condition limits usage to:
      - 30 hours (two ICEs)
      - 100 hours (one ICE)
  - Low-emissions
    - Less than 0.0007 tpd for all ICEs
    - Auxiliary ICEs used to start-up turbines exempt from Rule 1110.2 emission limits

Control Technology Feasibility

- SCR is most effective for NOx control
  - SCR system includes an entire enclosure system that can be retrofitted and integrated into existing stationary ICE
  - SCR manufacturers will guarantee 93 to 95% NOx reduction using 32.5% Urea system at 100% engine load
  - Effectiveness is dependent on fuel quality and load fluctuations which impacts exhaust temperature and NOx concentration
- NOx reduction by SCR retrofit may not be feasible for startup engines
  - Only run for a few hours and may not reach 100% load for SCR efficiency
  - Exhaust gas will not reach optimal SCR temperature for NOx reduction
  - Exhaust gas heating may be possible, but will add NOx emissions and cost
- Engine replacement may be required to achieve significant NOx reductions

Existing NOx Requirements for ICEs

- If engine replacement is required, BACT would apply, BACT is based on Rule 1110.2 requirements
- Rule 1110.2 applies to emissions from gaseous- and liquid-fueled engines
  - Stationary ICE must comply with 11 ppm NOx limit
  - Higher NOx limits are allowed for low-use engines (less than 500 hours/year)
    - Low-use ICEs greater than 500 bhp must comply with 36 ppm NOx limit



(Adopted August 3, 1990)(Amended September 7, 1990)(Amended August 12, 1994)
(Amended December 9, 1994)(Amended November 14, 1997)(Amended June 3, 2005)
(Amended February 1, 2008)(Amended July 9, 2010)(Amended September 7, 2012)
(Amended December 4, 2015)(Amended June 3, 2016)(Amended November 1, 2019)

RULE 1110.2 EMISSIONS FROM GASEOUS- AND LIQUID-FUELED ENGINES

(a) Purpose

The purpose of Rule 1110.2 is to reduce Oxides of Nitrogen (NO_x), Volatile Organic Compounds (VOCs), and Carbon Monoxide (CO) from engines.

(b) Applicability

All stationary and portable engines over 50 rated brake horsepower (bhp) are subject to this rule.

(c) Definitions

For the purpose of this rule, the following definitions shall apply:

(1) AGRICULTURAL STATIONARY ENGINE is a non-portable engine used for the growing and harvesting of crops of the raising of fowl or animals for the primary purpose of making a profit, providing a livelihood, or conducting agricultural research or instruction by an educational institution. An engine used for the processing or distribution of crops or fowl or animals is not an agricultural engine.

(2) APPROVED EMISSION CONTROL PLAN is a control plan, submitted on or before December 31, 1992, and approved by the Executive Officer prior to November 14, 1997, that was required by subdivision (d) of this rule as amended September 7, 1990.

(3) BREAKDOWN is a physical or mechanical failure or malfunction of an engine, air pollution control equipment, or related operating equipment that is not the result of operator error, neglect, improper operation or improper maintenance procedures, which leads to excess emissions beyond rule related emission limits or equipment permit conditions.

(4) CERTIFIED SPARK-IGNITION ENGINE means engines certified by California Air Resources Board (CARB) to meet emission standards in accordance with Title 13, Chapter 9, Article 4.5 of the California Code of Regulations (CCR).

(5) COMPRESSOR GAS LEAN-BURN ENGINE is a stationary gaseous-fueled two-stroke or four-stroke lean-burn engine used to compress natural gas or pipeline quality natural gas for delivery through a pipeline or into storage.

1110.2 - 1

ICE Assessment

	Existing Units	Other Regulatory	Technology Assessment	Initial BARCT NOx Limit	Cost-Effectiveness
IC Engines	Up to 880 ppm	11 ppm/ 36 ppm*	36 ppm	36 ppm	Need to conduct cost-effectiveness on initial BARCT limit

* Rule 1110.2: stationary engines 11 ppm at 15% O_2, low-use engines greater than 500 bhp – 36 ppm at 15% O_2

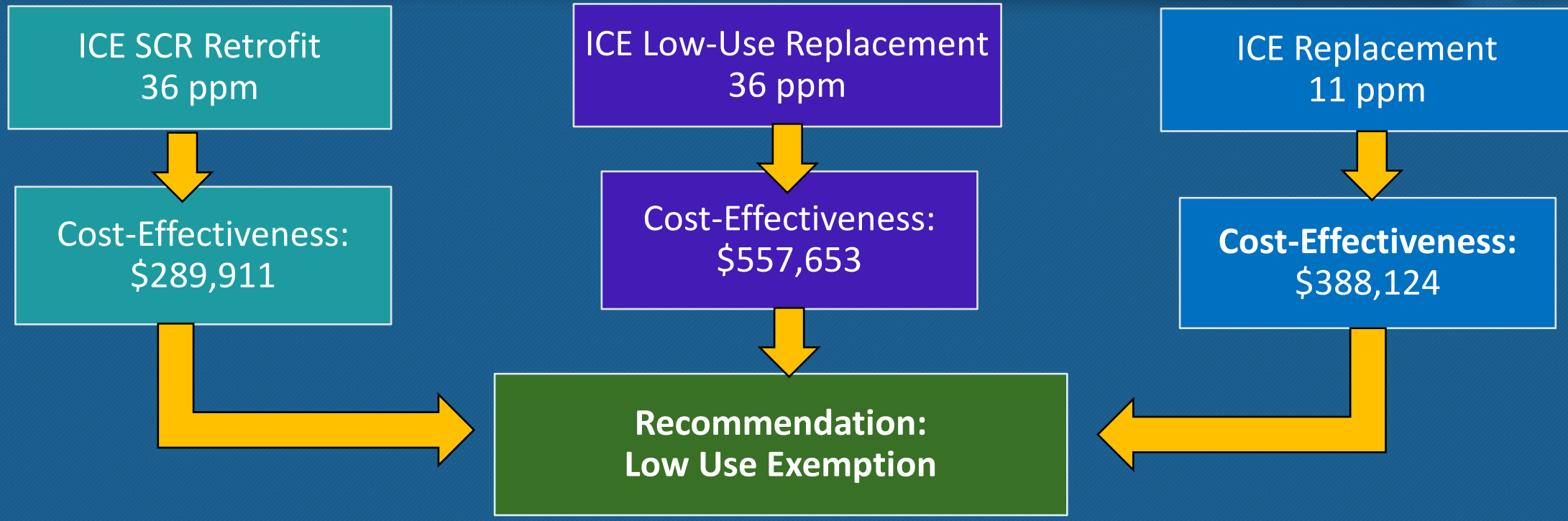
Cost-Effectiveness for ICE SCR Retrofit

- Staff assessed SCR retrofit to meet 36 ppm NOx limit
- For SCR retrofit, cost-effectiveness calculation:
  - Quotes received from technology vendor (includes equipment and accessories such as urea tank, air compressor, and control system)
  - Staff added 20% to vendor quote to account for Senate Bill 54
  - O&M cost assumed 30% of TIC

Cost-Effectiveness for ICE Replacement

- Staff assessed engine replacement costs because SCR retrofit and may not be feasible
- Engine replacement cost determined using quotes from vendors and suppliers
  - Tier 4 final replacement cost estimates range from $192,000 to $200,000
  - O&M assumed to be 30% of engine TIC

SCR Cost-Effectiveness for ICE



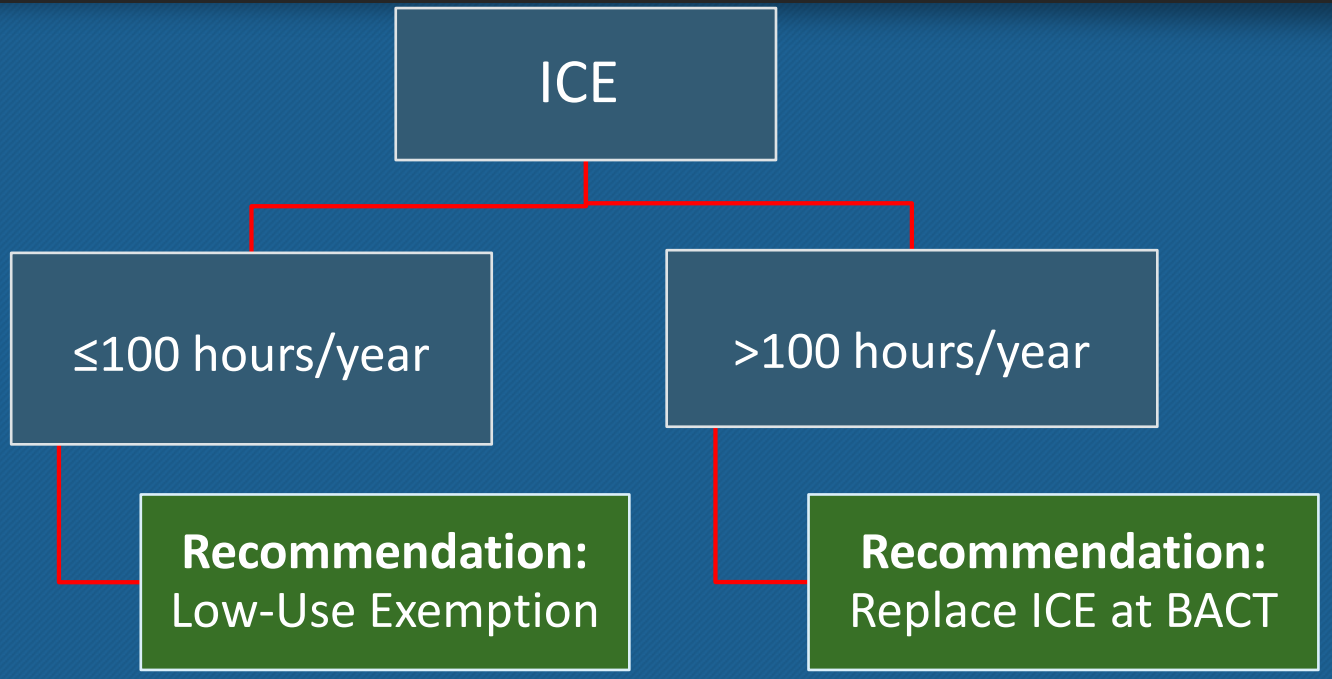
Staff Recommendation:

- SCR retrofit or ICE replacement is not cost-effective due to low-use/emissions
- Include a low-use exemption for IC Engines

Low-Use Exemption

- Rule 1110.2 has two low-use provision/exemptions:
  - ICEs that operate less than 500 hours/year are allowed higher NOx limits
  - Emergency standby ICE that operate less than 200 hours/year are exempt from NOx limits
  - Auxiliary ICE used to power gas turbines during startup are exempt from NOx limits – no usage limitation
- Existing ICEs at refineries:
  - Limited operation (startup) – 30/100 hour permit limit in a calendar year
  - Very high potential to emit – 880 ppm NOx limit
  - Used solely to power gas turbines during startup
- Staff recommends maintaining the low hourly operating limits, lower than allowed in Rule 1110.2
  - Recommending low-use exemption of 100 hours/year

Recommendations for ICE



Staff Recommendation:

- Low-use exemption for existing ICE (100 hours or less per year)
- If use exceeds low-use exemption, facility will be required to replace ICE
- New ICEs will be required to meet BACT

Proposed Averaging Time

Averaging Time Considerations

- Averaging times will be based on following considerations:
  - Class and category
  - Size or complexity of a unit
    - Large units with longer response time where NOx is influenced by feedstock (e.g., FCCUs and coke calciner)
      - Process units not individual pieces of equipment
      - Process variability
      - Multi-pollutant emissions
  - Start-up, shutdown, and malfunction provisions will be included in rule

Proposed Averaging Time: *Heaters & Boilers*

Equipment Category	Proposed BARCT Limit (ppmv)	Percent Oxygen	Proposed Averaging Time (Rolling)
Process Heaters			
<20 MMBtu/hr	40/9*	3	2/8 hour**
20 - 40 MMBtu/hr			
≤ 40 ppm	40/9*	3	2/8 hour**
>40 ppm	30/9*	3	2/8 hour**
40 - 110 MMBtu/hr	2	3	8 hour
>110 MMBtu/hr	2	3	8 hour
Boilers			
<40 MMBtu/hr	40/5	3	2/8 hour
40 - 110 MMBtu/hr	2	3	8 hour
>110 MMBtu/hr	2	3	8 hour

*9 ppm limit based on emerging technology and will apply at a future date

** Units will require CEMS to allow for 8 hour averaging time due to source test constraints, otherwise 2 hour averaging time will apply

Proposed Averaging Time: *Heaters cont.*

Equipment Category	Proposed BARCT Limit (ppmv)	Percent Oxygen	Proposed Averaging Time (Rolling)
SMR Heaters			
PSA-off Gas/RFG/NG	5	3	8 hour
SMR Heater & Gas Turbine	5	15	8 hour

Proposed Averaging Time: *Gas Turbines*

Equipment Category	Proposed BARCT Limit (ppmv)	Percent Oxygen	Proposed Averaging Time (Rolling)
Gas Turbines with Duct Burners			
Natural Gas	2	15	8 hour
RFG/Mixed Gas	2	15	8 hour
Gas Turbines without Duct Burners			
RFG	2	15	8 hour
Natural Gas	2	15	8 hour

Proposed Averaging Time: *FCCU*

Equipment Category	Proposed BARCT Limit (ppmv)	Percent Oxygen	Proposed Averaging Time (Rolling)
FCCU			
Regenerator/CO Boiler	2	0	2 ppm at 365 days 5 ppm at 7 days*
SU Heaters(1 ULSD)	Low-Use Exemption ≤200 hours/year		--

* Considering how to address emissions from startup, shutdown, and malfunctions in the short-term and long-term NOx limits.

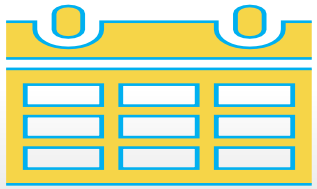
Proposed Averaging Time: *SRU & ICE*

Equipment Category	Proposed BARCT Limit (ppmv)	Percent Oxygen	Proposed Averaging Time (Rolling)
SRU/TG Incinerators			
Incinerators **Stack Heaters**	30	3	8 hour
Auxiliary ICE			
Diesel	Low-Use Exemption ≤100 hours/year		--

Next Working Group Meeting

Proposed BARCT limits for remaining equipment categories

- Sulfuric acid heaters
- Coke calciner
- Thermal oxidizers and flares



Implementation schedule and approaches for proposed BARCT limits

Address the Latham and Watkins/WSPA Comments

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