Rule 1109.1 - Refinery Equipment

Working Group Meeting #3

August 1, 2018

Agenda

- Summary of Working Group Meeting #2
- Progress of Rule Development & Survey Questionnaire Status
- Western States Petroleum Association (WSPA) Comments
- Other Air Districts & SCAQMD District Rules
- Refinement of Equipment Emissions Data
- Next Steps

Progress of Rule Development

Summary of Working Group #2 (6/14/18)

- Updated universe of facilities
- Overview of the BARCT process (technology assessment)
- Presented preliminary equipment emissions data
- Stakeholders provided comment/input regarding data

Since last Working Group Meeting

- Revised data
- Initial analysis of NOx control technologies currently in use
- Drafted the Request for Proposal (RFP) for 3rd party BARCT validation
- Assessment of NOx pollution control technologies
- Scheduled site visits

Survey Feedback

Survey Questionnaire

- Distributed end of May
- Due date August 10, 2018
- Progress of survey?
- If necessary, staff welcomes stakeholder meetings

Will provide essential equipment information

- Up-to-date equipment information (e.g., age, design, and usage levels)
  - Reassess BARCT limits
  - Determine cost effectiveness

WSPA Comments on RECLAIM Transition Rules

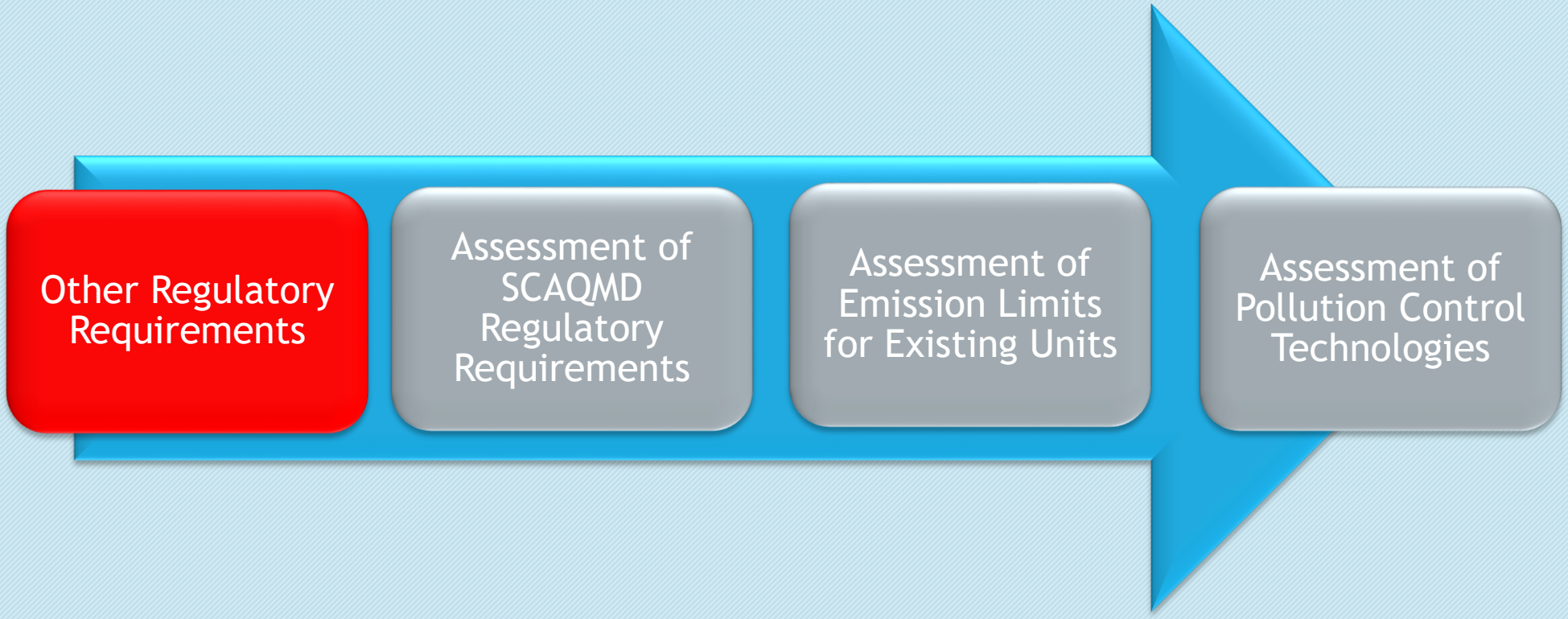
Comment	Response
BARCT analysis must be conducted specific to each class of equipment within a category	BARCT takes into account equipment by use, fuel type, size, as appropriate
BARCT must be cost effective	Cost effectiveness is a part of the BARCT analysis
Equipment forced retirement	Established BARCT considers ways facilities can comply. District sets limits, but stakeholders decide how they want to proceed in meeting the limit
Timeframe for transition to command-and-control	Compliance timeline pursuant to board directive and state law

BARCT

- The statutory definition of “best available retrofit control technology” does not preclude replacing existing equipment with new cleaner equipment
- Health & Safety Code §40406 provides: “As used in this chapter, ‘best available retrofit control technology’ means an emission limitation that is based on the maximum degree of emission reduction achievable, taking into account environmental, energy, and economic impacts by each class or category of source”
- BARCT is an emission limitation, and is not limited to a particular technology, whether add-on or replacement. This definition does not preclude replacement technologies

Other District NOx Rules & Limits

BARCT Technology Assessment Approach



Other District Regulations

- BARCT analysis includes review of other Air District Regulations
- Evaluated NOx limits being achieved nationally
- Staff evaluated:
  - Source specific regulations and other NOx programs
  - Specific equipment (e.g., boilers, heaters, turbines)
  - Air Districts with petroleum refineries (*presenting most relevant data*):
    - Texas Department of Environmental Quality
    - New Jersey Department of Environmental Protection
    - Bay Area Air Quality Management District (AQMD)
    - San Joaquin Valley Air Pollution Control District (APCD)
    - San Luis Obispo County APCD
    - Eastern Kern APCD

Other District Regulations – Boilers/Heaters

New Jersey State Department of Environmental Protection				
TABLE 8 - Industrial Commercial Boiler or other Indirect Heat Exchanger at a Petroleum Refinery				
Title 7, Chapter 27, Subchapter 19, 19.6				
Heat Input Rate (MMBTU/hr)	Fuel/Boiler Type	Maximum Allowable NOx (ppm*) Firing Method		
		Tangential	Face	Cyclone
50 to <100	Natural gas	82*	82*	82
	Refinery fuel gas and other gaseous fuels	108*	108*	N/A
>100	Natural gas	82*	82*	82*
	Refinery fuel gas and other gaseous fuels	179*	179*	N/A

* Converted from lb/MMBTU
  - Natural gas – 1050 MMBtu/MMft^3
  - Refinery gas -1150 MMBtu/MMft^3

Other District Regulations – Boilers/Heaters

San Joaquin Valley APCD				
Rule 4306 Boiler, Steam Generators, and Process Heaters - Phase 3				
Refinery Units (MMBtu/hr)	Operated on Gaseous Fuel		Operated on Liquid Fuel	
	NOx Limit (ppmv)	CO Limit (ppmv)	NOx Limit (ppmv)	CO Limit (ppmv)
5 – 65	30	400	40	400
65 – 110	25	400	40	400
>110	5	400	40	400

Other District Regulations – Boilers/Heaters

Bay Area AQMD	
Regulation 9-10-301	
Description	NOx Limit - Operating Day **(ppm*)**
Refinery-wide NOx limit for boilers, steam generators and process heaters, excluding CO boilers	30

* Converted from lb/MMBTU
  - Natural gas – 1050 MMBtu/MMft^3
  - Refinery gas -1150 MMBtu/MMft^3

Other District Regulations – Gas Turbines

Bay Area AQMD					
Regulation 9, Rule 9 - Limits Emissions of NOx from Stationary Gas Turbines					
	Turbine Heat Input Rating (MMBTU/hr)		Natural Gas (ppmv)	Refinery Fuel Gas, Waste Gas or LPG (ppmv)	Non-Gaseous Fuel (ppmv)
Emission Limits, General	> 50 – 150	No retrofit	42	50	65
		WI/SI[1]	35	50	65
		DLN[2]	25	50	65
	> 150 – 250		15	15	42
	> 250 – 500		9	9	25
	> 500		5	9	25
Emission Limits, Low Usage	50 – 150		42	N/A	65
	> 150 – 250		42	N/A	65
	>250 – 500		25	N/A	42
	> 500		25	N/A	42

1. Water inject/steam injection
2. Dry low NOx

Low usage: <877 hours in any 12 month period (not counting hours of emergency)

Other District Regulations – Gas Turbines

Texas Department of Environmental Quality	
Title 30, Part 1 Chapter 117, Subchapter B, Division 3, RULE §117.310	
Stationary Gas Turbine Rating (MW)	**NOx Limit (ppm*)**
≥ 10	29
1 - 10	135
< 1	233

* Converted from lb/MMBTU
  - Natural gas – 1050 MMBtu/MMft^3
  - Refinery gas -1150 MMBtu/MMft^3

Other District Regulations – Primary Internal Combustion Engines (ICE) > 50 BHP

Bay Area AQMD		
Regulation 9, Rule 8		
Regulation	**Compression-Ignited Engine (bhp)**	**NOx Limit (ppmv, dry 15% O_2)**
9-8-304.1	51 to 175	180
9-8-304.2	> 175	110
Regulation	**Spark-Ignited Engine (>50 bhp)**	**NOx Limit (ppmv, dry 15% O_2)**
9-8-301.1	Rich Burn	56
9-8-301.2	Lean Burn	65

Other District Regulations – Primary Internal Combustion Engines (ICE) > 50 BHP

San Luis Obispo County APCD		
Rule 431		
Fuel Type	**Engine Type**	**NOx (ppmv)**
Gaseous or liquid fuel, including gasoline, natural gas, field gas, waste gas, liquefied petroleum gas (LPG), or diesel fuel	Rich-Burn	50
	Lean-Burn	125

Other District Regulations – Fluidized Catalytic Cracking Unit (FCCU)

Texas Department of Environmental Quality	
Title 30, Part 1 Chapter 117, Subchapter B, Division 3, Rule §117.310	
Description	**NOx Emission Limit (one of the following)**
FCCU (including carbon monoxide (CO) boilers, CO furnaces, and catalyst regenerator vents)	40 ppmv at 0% O_2, dry basis
	90% NOx reduction of the exhaust concentration used to calculate the daily NOx emissions

Other District Regulations – Fluidized Catalytic Cracking Unit (FCCU)

Bay Area AQMD	
Regulation 9-10-307 – Refinery NOx Emission Limit for CO boilers	
NOx Limit - Operating Day (ppm, 3% O_2, dry)	NOx Limit – Calendar Year (ppm, 3% O_2, dry)
125	85

Other District Regulations – SRU/TG Incinerators

Texas Department of Environmental Quality	
Title 30, Part 1 Chapter 117, Subchapter B, Division 3, RULE §117.310	
Incinerators	**NOx Limit**
Incinerators (excluding vapor streams resulting from vessel cleaning routed to an incinerator, provided that fuel usage is quantified using good engineering practices)	27 ppm*(@3%, O2, dry)
	80% reduction from the daily NOx emissions

* Converted from lb/MMBTU
  - Natural gas – 1050 MMBtu/MMft^3
  - Refinery gas -1150 MMBtu/MMft^3

Other Districts – Calciner/Kilns

Texas Department of Environmental Quality	
Title 30, Part 1 Chapter 117, Subchapter B, Division 3, RULE §117.310	
Kiln	**NOx Limit**
Lightweight Aggregate Kilns	1.25 lbs/ton of product
Lime Kilns	0.66 lbs/ton of product

Other District Regulations – Calciner/Kilns

San Joaquin Valley APCD	
Rule 4313 - Limit Emissions of NOx Compounds from Lime Kilns	
Fuel Type	**NOx (ppm*)@3% O2, dry**
Gaseous	90
Distillate	108
Residual	179

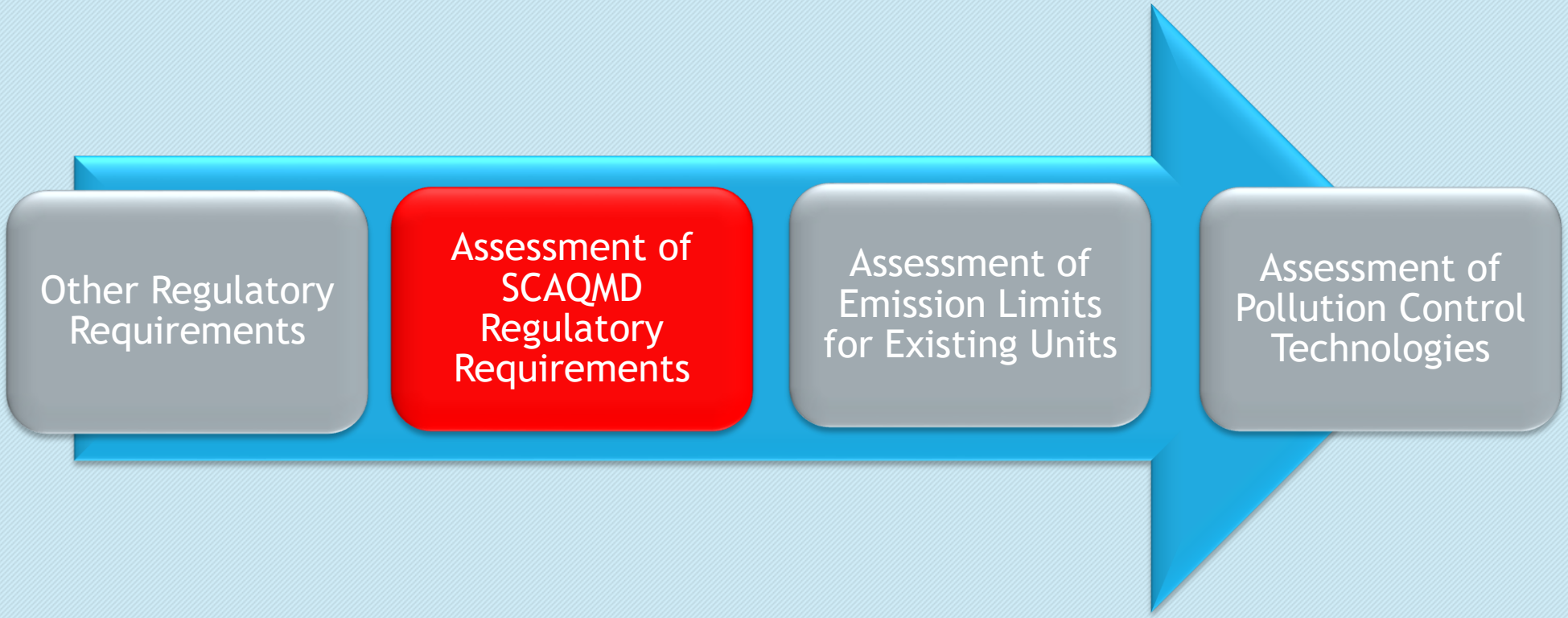
* Converted from lb/MMBTU
  - Natural gas – 1050 MMBtu/MMft^3
  - Refinery gas -1150 MMBtu/MMft^3

Other District Regulation Findings

- 1st of the 4 steps in the BARCT technology assessment
- Other air district limits generally higher than SCAQMD limits
- Lower limits have been achieved

SCAQMD Rules & Limits

BARCT Analysis Approach

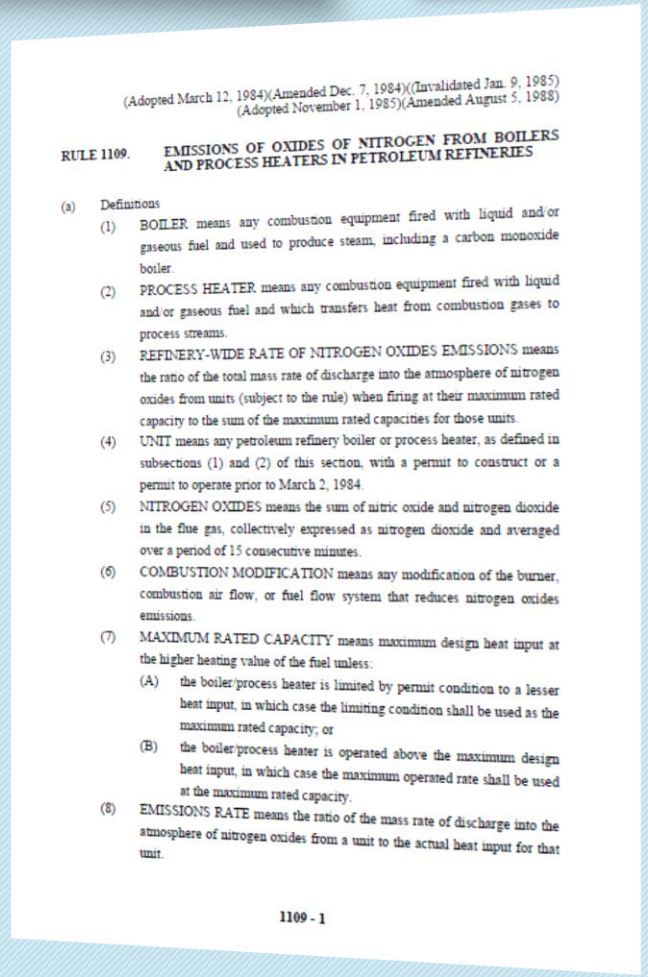


SCAQMD Rules and Limits

- BARCT analysis includes review of SCAQMD Regulations
- Staff evaluated:
  - NOx limits achieved in non-refinery settings – technology transfer
  - Source specific regulations
  - Specific equipment (e.g., boilers, heaters, turbines)

SCAQMD Rule 1109 - Emission of NOx from Boilers and Process Heaters in Petroleum Refineries

- Adopted March 12, 1984, last amended August 5, 1988
- Applicable to Petroleum Refinery Boilers and Process Heaters >40 MMBtu/hr
  - NOx limit - 0.03 lb/MMBtu (~27 ppm)
- Included Alternative Emissions Control Plan (AECP)
  - EPA issued limited approval/disapproval due to insufficient monitoring and recordkeeping
- October 1993, all Rule 1109 sources became subject to RECLAIM



(Adopted March 12, 1984)(Amended Dec. 7, 1984)(Invalidated Jan. 9, 1985)
(Adopted November 1, 1985)(Amended August 5, 1988)

RULE 1109. EMISSIONS OF OXIDES OF NITROGEN FROM BOILERS AND PROCESS HEATERS IN PETROLEUM REFINERIES

(a) Definitions

(1) BOILER means any combustion equipment fired with liquid and/or gaseous fuel and used to produce steam, including a carbon monoxide boiler.

(2) PROCESS HEATER means any combustion equipment fired with liquid and/or gaseous fuel and which transfers heat from combustion gases to process streams.

(3) REFINERY-WIDE RATE OF NITROGEN OXIDES EMISSIONS means the ratio of the total mass rate of discharge into the atmosphere of nitrogen oxides from units (subject to the rule) when firing at their maximum rated capacity to the sum of the maximum rated capacities for those units.

(4) UNIT means any petroleum refinery boiler or process heater, as defined in subsections (1) and (2) of this section, with a permit to construct or a permit to operate prior to March 2, 1984.

(5) NITROGEN OXIDES means the sum of nitric oxide and nitrogen dioxide in the flue gas, collectively expressed as nitrogen dioxide and averaged over a period of 15 consecutive minutes.

(6) COMBUSTION MODIFICATION means any modification of the burner, combustion air flow, or fuel flow system that reduces nitrogen oxides emissions.

(7) MAXIMUM RATED CAPACITY means maximum design heat input at the higher heating value of the fuel unless:

(A) the boiler/process heater is limited by permit condition to a lesser heat input, in which case the limiting condition shall be used as the maximum rated capacity; or

(B) the boiler/process heater is operated above the maximum design heat input, in which case the maximum operated rate shall be used at the maximum rated capacity.

(8) EMISSIONS RATE means the ratio of the mass rate of discharge into the atmosphere of nitrogen oxides from a unit to the actual heat input for that unit.

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SCAQMD Rules and Limits - Boilers/Heaters

Refinery Rule Limits and Assessments	
2005 RECLAIM BARCT	
Boilers, Heaters, Steam Generators >110 MMBtu/hr	5 ppm
2015 RECLAIM BARCT	
Boilers, Heaters >40 MMBtu/hr	2 ppm @3% O_2 (natural gas)

SCAQMD Rules and Limits - Boilers/Heaters (cont.)

Non-Refinery Rule Limits and Assessments	
Utility Boilers at Electric Power Generating Systems	
2005 BARCT	7 ppm
Rule 1146 – Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters	
>75 MMBtu/hr	5 ppm
>25 but <75 MMBtu	9 ppm

SCAQMD Rules and Limits - FCCU

Refinery NOx Limit Assessment	
2005 RECLAIM BARCT	85% Reduction
2015 RECLAIM BARCT	2 ppm NOx @ 3% O_2, dry
CO Boiler	85% Reduction

SCAQMD Rules and Limits – Combined Cycle Gas Turbines

Refinery NOx Limit Assessment	
2015 RECLAIM BARCT	2 ppm NOx @ 15% O_2, dry
Non-Refinery Rule Limits	
Proposed Amended Rule 1135 – NOx Emissions from Electric Generating Facilities	2 ppm NOx @ 15% O_2, dry (NG)
	5 ppm NH_3 slip

SCAQMD Rules and Limits – Simple Cycle Gas Turbines

Refinery NOx Limit Assessment	
2015 RECLAIM BARCT	2 ppm NOx @ 15% O_2, dry
Non-Refinery Rule Limits	
Proposed Amended Rule 1135 – NOx Emissions from Electric Generating Facilities	2.5 ppm NOx @ 15% O_2, dry (NG)
	5 ppm NH_3 slip

SCAQMD Rules and Limits – Prime Internal Combustion Engines (ICE)

Non-Refinery Rule Limits	
SCAQMD Rule 1110.2 - Engines >50 BHP	
Engine Type	**NOx Emission Limit**
New non-emergency electric generating (natural gas)	3 ppm @ 15% O2, dry, 15 minute average
Existing non-emergency electric generating (natural gas)	11 ppm @ 15% O2, dry, 15 minutes average
Engines that operate <500 hr/yr or use <100 MMbtu/year of fuel are exempt	

SCAQMD Rules and Limits – Incinerator and Calciner

Refinery Rule Limits and Assessments	
2005 RECLAIM BARCT	
Petroleum Refining, Calciner	30 ppm
2015 RECLAIM BARCT	
Petroleum Refining, Calciner	10 ppm
Non-Refinery Rule Limits	
SCAQMD Rule 1147	
Incinerator, Afterburner, Remediation Unit, and Thermal Oxidizer	60 ppm or 0.073 lbs/MMBTU
Calciner & Kiln (≥1200 °F)	

SCAQMD Rules and Limits – Sulfur Recovery Unit/Tail Gas Incinerator

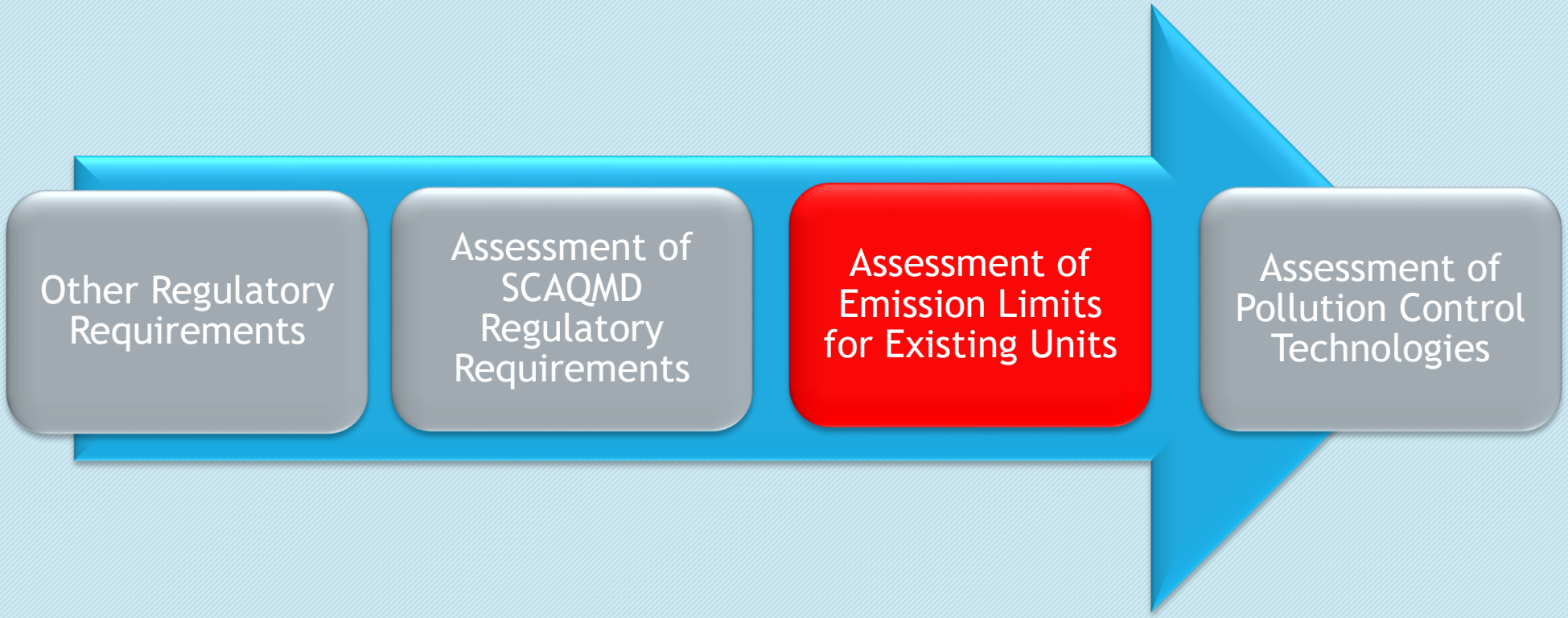
Refinery NOx Limit Assessment	
2015 RECLAIM BARCT	95% Reduction 2 ppm NOx @ 3% O_2 (NG)

SCAQMD District Rules and Limits Findings

- 2nd of the 4 steps in BARCT technology assessment
- Lower limits have been achieved for same equipment
- Need to consider different fuel type

Revised Emissions Data

BARCT Analysis Approach



Revised Emissions Data

Stakeholders provided input/comments during last working group

- Include averaging times
- Compare CEMS (RATA) versus permits for existing devices

Staff refined:

- Current existing controls technologies for existing equipment
- Focused on equipment with low permit limits

Evaluation will help understand what emissions levels can be achieved

Emissions Data Analysis

- Presented overview of equipment in Working Group Meetings #1 and #2
- Staff continues to compile additional data:
  - Filled some data gaps (some data still missing or unavailable)
  - Included installed control devices
  - Compared CEMS (RATA) data to permit limits
    - Included average deviation and percent throughput

Emissions Data Analysis

Evaluated Entire Universe

- Coke Calciner (1 unit)
- FCCU (6 units)
- Primary ICE (6 units)
- SRU/TG incinerator (27 units)
- Turbines (13 units)

Evaluated Partial Universe

- Boilers/Heaters (20 of the 276 total units)
  - Evaluated units with lowest emission limits

BARCT for equipment categories with fewer units could be established sooner

Boiler/Heaters Fueled by Refinery Gas

NOx limits from 5 – 7 ppm

Size (MMBtu /hr)	Device	Process	NOx Permit Limit (ppm)	CEMS(RATA) NOx ppm @3% O2	Raw CEMS NOx ppm (Avg Dev)	CEMS/ RATA (%Thru put)	Control	2016 NOx Emissions (tpy)
315	Crude Atm Charge Heater	Crude Distillation	5	6.1	0.39	69	LNB,SCR	6.6
177	Catalytic Reforming Heater	Catalytic Reforming	5	1.7	0.17	55	LNB, SCR	1.0
123	Catalytic Reforming Heater	Catalytic Reforming	5	1.7	0.17	76	LNB, SCR	0.9
88	Catalytic Reforming Heater	Catalytic Reforming	5	1.7	0.17	42	LNB, SCR	0.5
78	NHT heater	Hydrotreating	5	2.3	0.25	37	LNB, SCR	0.2
653	Hydrogen Reforming Heater	Hydrogen Generation	5	4.2	0.04	67	LNB, SCR	9.5
199	Catalytic Reforming Heater	Catalytic Reforming	5	2.5	0.06	64	LNB, SCR, FGR	1.2
304	Steam Boiler	Steam Generation	7	10.2	0.20	45	LNB, SCR, FGR	9.3
460	Hydrogen Reforming Heater	Hydrogen Generation	7	3.8	0.09	67	LNB, SCR	5.9
245	Boiler	Steam Generation	7	7.3	0.16	73	LNB, SCR	8.6

Boiler/Heaters Fueled by Refinery Gas (cont.)

NOx limits from 8 – 30 ppm

Size (MMBtu/hr)	Device	Process	NOx Permit Limit (ppm)	CEMS (RATA) NOx ppm @3% O2	Raw CEMS NOx ppm (Avg Dev)	CEMS/ RATA (%Thru put)	Control	2016 NOx Emissions (tpy)
30	Heater	Naphtha Hydrotreater Charge Heater	8	9.5	0.18	70	LNB, SCR	1.2
650	Hydrogen Reforming Heater	Hydrogen Generation	9	9.6	1.43	81	LNB, SCR	44.2
352	Steam Boiler	Steam Generation	12	7.2	0.18	64	LNB, FGR	15.8
255	Catalytic Reforming Heater	Catalytic Reforming	14	18.8	0.15	85	LNB	18.6
220	Column Heater Reboiler	Hydrocracker	16	29.4	0.19	123	LNB	19.8
457	Crude Atm Charge Heater	Crude Distillation	17	19.4	1.05	98.2	LNB, SCR	41.9
200	Hot Oil Heater	Naphtha Hydrotreater Heater	19	9.5	0.18	87.1	LNB, SCR	9.2
310	Catalytic Reforming Heater	Catalytic Reforming	20	28.3	0.20	56	LNB	25.6
365	Column Heater Reboiler	Hydrocracker	21	23.0	0.24	76	LNB	70.9
136	Crude Heater	Crude Distillation	30	17.5	0.21	89	LNB	13.4

Boiler/Heaters - Summary

20 units with low emission levels (≤ 30 ppm, refinery gas)

17 Process Heaters

- NOx Permit Limit*
  5 ppm to 30 ppm
- CEMS (RATA)**
  1.7 ppm to 29.4 ppm
- NOx Control Device
  11 – LNB, SCR
  5 – LNB
  1 – LNB, SCR, FGR

3 Boilers

- NOx Permit Limit*
  7 ppm to 12 ppm
- CEMS (RATA)**
  7 ppm to 10.2 ppm
- NOx Control Device
  1 –LNB, SCR, FGR
  1- LNB, FGR
  1 – LNB, SCR

Total units: 276 (Permit Limits)
- 224 Heater/Furnaces
  - Refinery Gas: 5 ppm to 101 ppm*
  - Natural Gas: 5 ppm to 190 ppm*
- 52 Boilers
  - Refinery Gas: 5 ppm to 165 ppm*
  - Natural Gas: 5 ppm to 82 ppm*

Refinery Gas- 2 ppm to 145 ppm (CEMS)**

* Permit limits: averaged over 3 hours @ 3% O2, dry

** CEMS (RATA): 9 runs averaged over approximately an 8 hour period

Boilers/Heaters - Findings

- Boilers and heaters can achieve low NOx limit
  - 7 out of 276 achieving 5 ppm limit
- RATA data shows some units well below permit limit and some above
  - Snapshot of CEMS – 9 runs averaged over 8 hour period
  - Staff reviewing data points that indicate emissions greater than permit limit
- Staff compiling ammonia concentrations, will present at subsequent Working Group Meeting

Coke Calciner - Data

Size (MMBtu/hr)	Fuel Type	Device	Process	NOx Permit Limit (ppm)	CEMS(RATA) NOx ppm @3% O2	CEMS Raw NOx ppm (Avg Dev)	CEMS/RATA (%Thru put)	Control	2016 NOx Emissions (tpy)
120	Natural Gas	Rotary Kiln	Coke Calcining	No Permit Limit	79.0	4.0	60	No Control	210.0
130		Afterburner							

Coke Calciner - Findings

- One unit with two devices
- High emission reduction potential
- Staff will evaluate available technology
  - Evaluate NOx reduction or multi-pollutant control
- BARCT can be established quickly due to limited units/data points

FCCU - Data

Size (MMBtu/ hr)	Fuel Type	Device/ Class	NOx Permit Limit (ppm)	Avg. Time	CEMS (RATA) NOx ppm @3% O2	CEMS Raw NOx ppm (Avg Dev)	CEMS/ RATA (% Throughput)	Control & Year Installed	2016 NOx Emissions (tons/year)
		Regenerator	40	7 d	14.0	1.50	92	SCR, 2008	70
		Regenerator	60	7 d	5.0	0.60	97	SCR, 2003	7
		Regenerator	40	7 d	14.2	0.34		SCR, 2000	24
464	Refinery Gas	CO Boiler	20					LNB	10
300	Refinery Gas	CO Boiler						LNB	32
		Regenerator	89	24 hr	18.7	1.57		no SCR	In CO Boiler
		Regenerator	40	7 d	14.1	0.46	87	no SCR	58
		Regenerator	82	7 d	26.1	2.88	89	no SCR	112

FCCU – Summary

6 FCCU units - 100% operate below permit limits

3 FCCU w/ SCR

- NOx Permit Limits: 40 ppm to 60 ppm
- CEMS (RATA)**: 5 ppm to 14 ppm
- NOx Control Device - SCRs installed in 2000, 2003, and 2008

3 FCCU w/ no SCR

- NOx Permit Limit*: 40 ppm to 89 ppm
- CEMS (RATA)**: 18 ppm to 26 ppm
- No SCR

Total units: 6 units

- 2 FCCU units have CO boilers
  - CO boilers have low NOx Burners (LNB)
  - LNB not in use, CO boilers used as heat recovery devices

* Permit limits: average times @ 0% O2, dry. Applies at all times except during startup, shutdown, and malfunction of the FCCU

** CEMS (RATA): 9 runs averaged over approximately a 7 hour period

FCCU - Findings

- 6 units – one scheduled for shutdown in October
- 100% operate below permit limits
- Higher the deviation, less confidence in RATA data
- Potential for further emission reductions from control technology
- BARCT can be established quickly due to limited units/data points

Primary Internal Combustion Engine - Data

Size	Fuel Type	Process	NOx Emission Factor (ppm @ 15% O2, dry)*	Control	2016 NOx Emissions (tons/year)
700 bhp	Diesel	Cogeneration A Startup	880	Turbocharged	0.1
700 bhp	Diesel	Cogeneration B Startup	880	Turbocharged	0.03
1095 hp	Diesel	Cogen Start up & Cool down	882	No Control	0.4
~~880 hp**~~	~~Natural Gas~~	~~Electric Generation~~	~~878~~	~~No Control~~	~~0.0~~
~~60 hp**~~	~~Gasoline~~	~~Electric Generation~~	~~191~~	~~No Control~~	~~0.0~~

*Converted from lb/1000 gal
**ICE decommissioned or removed from site

Averaging time 1 hour @ 15 % O2, dry

Primary Internal Combustion Engines – Summary

3 ICE units - All units are low usage (<0.5 ton/year)

3
Diesel Units

- NOx Emission Factors
  880 ppm and 882 ppm
- Cogeneration Start up and Cool down
- NOx Control Device
  2 units are turbocharged

Primary Internal Combustion Engine - Findings

- High NOx permit limit but low annual emissions
- Data suggests units are not used as prime engines
- Opportunity for SIP-creditable reductions without impacting the existing activity
- Could consider low-use exemption w/ permit conditions (<200 hours)

SRU/TG Incinerators Data – Sulfur Recovery

Size (MMBTU/hr)	Fuel Type	Device/Class	Process	NOx Permit Limit (ppm)	CEMS (RATA) NOx ppm @3% O2	CEMS Raw NOx ppm (Avg Dev)	CEMS/ RATA (% Thru put)	Control	2016 NOx Emissions (tpy)
45	Natural Gas	Incinerator	Sulfur Recovery	110					2.3
52	Natural Gas	Incinerator	Sulfur Recovery		92	1.9	11.4		6.8
35.8	Natural Gas	Thermal Oxidizer	Sulfur Production		107	0.9	100	LNB	3.7
44.5	Refinery Gas	Thermal Oxidizer	Sulfur Plant		43.2	0.74	78.1		20.3
50	Natural Gas	Incinerator	Sulfur Plant	41	3.7	0.072	67	Ultra-LNB	8.3
19.5	Refinery Gas	Incinerator	Sulfur Production						4.5
19.5	Refinery Gas	Incinerator	Sulfur Production						0.31
15	Refinery Gas	Thermal Incinerator	Sulfur Production						0.0002
27.5	Refinery Gas	Thermal Oxidizer	Sulfur Production						15.2
39.5	Refinery Gas	Thermal Oxidizer	Sulfur Recovery	49					11.5
100	Refinery Gas	Thermal Oxidizer	Sulfur Production					LNB	6.2
30	Refinery Gas	Oxidizer	Sulfur Production		32.7	0.68	54		11
30	Refinery Gas	Oxidizer	Sulfur Production		41	0.16	110		11.3
58	Refinery Gas	Oxidizer	Sulfur Production		53	0.98	59		18
10	Natural Gas	Incinerator	Sulfur Recovery		146	2.4	56.1		5.0

SRU/TG Incinerators Data - Other

Size (MMBtu/hr)	Fuel Type	Device/Class	Process	NOx Permit Limit (ppm)	CEMS (RATA) NOx ppm @3% O2	CEMS Raw NOx ppm (Avg Dev)	CEMS/ RATA (% Thru put)	Control	2016 NOx Emissions (tpy)
4	Refinery Gas	Incinerator	Wastewater	41					3.6
60	Refinery Gas	Incinerator	Loading/Unloading Process						2.6
4	Refinery Gas	Incinerator (spare)	Wastewater						0.6
3.4	Refinery Gas	Thermal Oxidizer	Oil/Water Sep(ETP)	150				LNB	3.4
1	LPG	Incinerator	Air Pollution Control(APC)	8.46*					0.02
3	Refinery Gas	Thermal Oxidizer	Air Pollution Control(APC)	100					13.8
2	Natural Gas	Incinerator	Air Pollution Control(APC)	102					0.26
1.4	Natural Gas	Incinerator	Naptha Loading(APC)	106					2.4
14	Natural Gas	Incinerator	Air Pollution Control(APC)	45					1.4
30	Natural Gas	Incinerator	Asphalt Blowing Plant		69	0.46	41.1		5.6
6	Natural Gas	Thermal Oxidizer	Soil Remediation	101.4					0.26
4	Natural Gas	Thermal Oxidizer	Soil Remediation	101.4					0.19

* lb/1000 gallons

Permit limit - averaging time 60 min

SRU/TG Incinerators - Summary

Total of 27 Devices

15 Sulfur Recovery	7 Air Pollution Control	3 Wastewater	2 Soil Remediation
7 Incinerators	6 Incinerators	2 Incinerators	2 Thermal Oxidizers
8 Thermal Oxidizers	1 Thermal Oxidizers	1 Thermal Oxidizer	

Permit Limits

- Natural Gas – 15 ppm to 110 ppm
- Refinery Gas – 17 ppm to 150 ppm

CEMS (RATA)

- Natural Gas – 3.7 ppm to 107 ppm
- Refinery Gas - 32.7 ppm to 146 ppm

Control Device

- 3 equipped with LNB
- 1 equipped with ULNB

SRU/TG Incinerators - Findings

- Incinerators used in different processes at the refineries
- Incomplete dataset
  - Permit limits and/or CEMS missing for 60% of devices
- Survey will provide up-to-date information for missing data
- Emissions and usage vary widely
- Could consider separate categories for BARCT determination
- Could consider low-use/emissions exemption w/ permit conditions

Gas Turbine Data – Combined Cycle

Size (MMBtu/ hr)	Fuel Type	Device (MW)	Process	NOx Permit Limit (ppm)	CEMS (RATA) NOx ppm @15% O_2	CEMS Raw NOx ppm (Avg Dev)	CEMS/ RATA (% Thru put)	Control & Year	2016 NOx Emissions (tpy)
508.6	Natural Gas	44	Electric Generation	2	1.0	0.02	94	DLNB, SCR, CO	9.3
985.5	Refinery Gas	83	Electric Generation	8	3.2	0.09		DLE, SCR, CO, WI - 88	78.1
985.5	Refinery Gas	83	Electric Generation	8	3.0	0.07		SCR,CO, WI - 98	80.7
985.5	Refinery Gas	83	Electric Generation	8	2.8	0.07		SCR,CO, WI - 88	86.6
985.5	Refinery Gas	83	Electric Generation	8	2.9	0.13		SCR,CO, WI - 88	71.6
506	Natural Gas	46	Electric Generation	9	5.2	0.09	98	SCR, CO, WI - 96	48.6
560	Natural Gas	46	Electric Generation	9	6.0	0.1	92	SCR, CO, WI - 95	52.1
560	Natural Gas	46	Electric Generation	9	2.8	0.04	83	SCR, CO, WI - 95	44.4
646.3	Refinery Gas	58.5	Electric Generation	9	5.9	0.13	91	SCR, CO - 86	50.3

Gas Turbines Data – Simple Cycle

Size (MMBtu/ hr)	Fuel Type	Device (MW)	Process	NOx Permit Limit (ppm)	CEMS (RATA) NOx ppm @15% O_2	CEMS Raw NOx ppm (Avg Dev)	CEMS/ RATA (%Thru put)	Control & Year	2016 NOx Emissions (tpy)
316	Natural Gas	23*	Electric Generation/ Hydrogen Production	160	9 *	0.44	75	SCR – 87	1.7
392	Refinery Gas	30	Electric Generation	96	11.2	0.24	79.5	SCR, CO, WI	50.6
392	Refinery Gas	30	Electric Generation	96	5.7	0.2	74.7	SCR, CO, WI	41.5

* Attached to heater- Turbine exhaust goes to heater. The facility uses heat input of the 2 equipment to proportion the emissions when they do emissions report

Gas Turbines - Summary

Total of 13 Units

10 Combined Cycle

Permit Limit
Natural Gas – 2 ppm to 9 ppm
Refinery Gas – 8 ppm to 9 ppm

CEMS
Natural Gas – 1 ppm to 6 ppm
Refinery Gas -3 ppm to 5.9 ppm

Control
6 equipped w/ SCR, CO, WI
2 equipped w/ DLNB, SCR, CO
1 equipped w/ DLE, SCR, CO, WI
1 equipped w/ SCR, CO

3 Simple Cycle

Permit Limit
Natural gas – 160 ppm
Refinery Gas – 96 ppm

CEMS
Natural Gas – 9 ppm
Refinery Gas - 5.7 ppm to 5.9 ppm

Control
2 equipped w/ SCR, CO, WI
1 equipped w/ SCR

100% of all units operate below their permit limit

- Combined cycle includes duct burners
- 1 simple cycle turbine attached upstream of heater
- 1 combined cycle unit not in operation (permitted at 2.5 ppm)

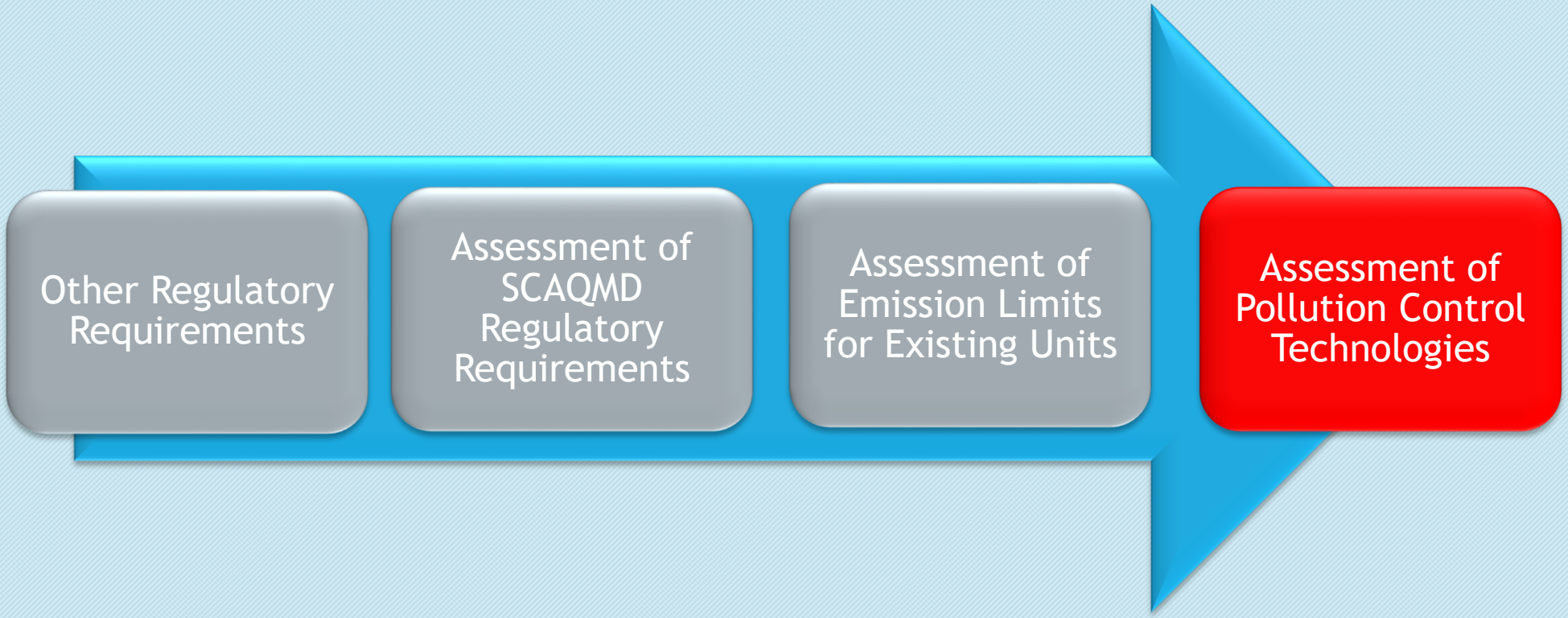
* Limits stated in permit conditions are based on 1-hour average, @15% O2, dry

** CEMS (RATA) are based on 9 runs averaged over an 8 hour period

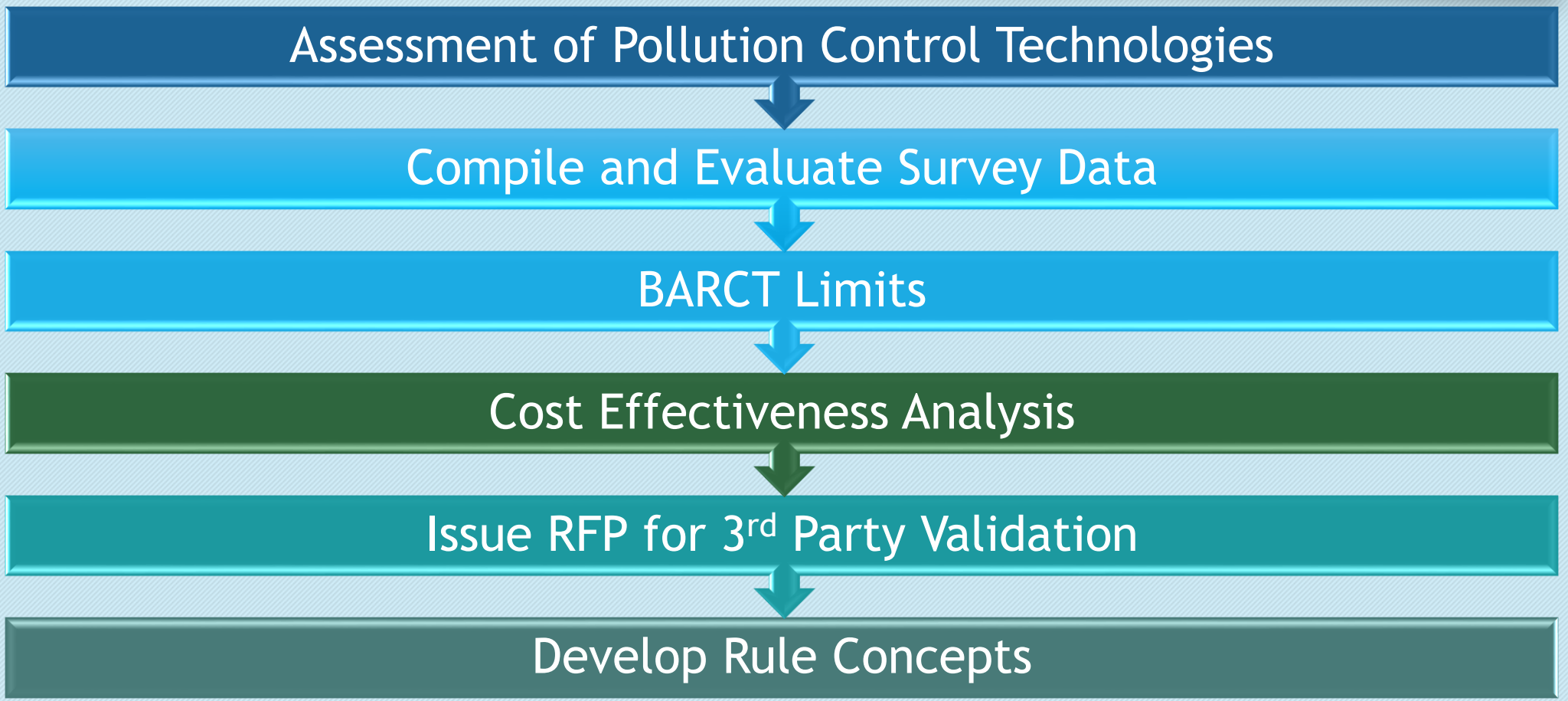
Gas Turbines - Findings

- Permit limits and CEMS vary between natural gas and refinery gas
- Combined cycle turbines larger than simple cycle turbines
- Combined cycle much lower permit limits than simple cycle
- Higher usage of combined cycle compared to the simple cycle
- 100% operate below their permit limits
- 100% have some type of control device

BARCT Analysis Approach – Next WGM #4



Next Steps


Assessment of Pollution Control Technologies
Compile and Evaluate Survey Data
BARCT Limits
Cost Effectiveness Analysis
Issue RFP for 3rd Party Validation
Develop Rule Concepts

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