NOx RECLAIM Working Group Meeting

January 7, 2015

Agenda

- Welcome & Introductions
- BARCT Analysis
  - Refinery Sector
    - FCCUs
    - Gas Turbines and Duct Burners
    - Coke Calciner
    - Sulfur Recovery/Tail Gas Incinerators
    - Refinery Boilers/Heaters
  - Non-Refinery Sector
    - Cement Kilns
    - Container Glass Furnaces
    - Sodium Silicate Furnace
    - Metal Heat Treating Furnaces
    - ICEs
    - Gas Turbines
- RTC Reduction Exemption Mechanisms
- Preview: CEQA and Socioeconomic Scoping Meeting
- Next Steps

Overall BARCT Methodology

- Technical feasibility
- Cost effectiveness
  - Incremental cost effectiveness beyond 2000/2005 BARCT
  - Based on 2011 activity

REFINERY SECTOR

Consultant's Analysis

Consultant's Analysis

- Norton Engineering Consultant (NEC) selected for Refinery Sector
- Scope of NEC's analysis

  1) Visited refineries in October to evaluate units with space constraint requested by refineries
     - 100 Boilers and Heaters at all 6 refineries
     - 2 FCCUs at Phillips66 and Valero
     - 2 Gas Turbines Duct Burners at Tesoro and Paramount
     - 3 SRU/TG Incinerators at Tesoro and Paramount
     - 20 SCRs at all 6 refineries

Consultant's Analysis (Cont.)

2) Provided recommendations to Staff on December 10
   - Recommended BARCT levels
   - Total installed costs and Present Worth Values (PWV) for Selective Catalytic Reductions (SCRs)
   - Size and space for SCR systems
   - Time for installation additional SCRs
   - Comments on Staff's preliminary write-ups

- Staff estimated incremental cost effectiveness using NEC's PWVs

Consultant's Analysis (Cont.)

- NEC's recommendations and results:
  - BARCT feasible and cost-effective levels
    - 2 ppmv for FCCUs, Gas Turbines and Duct Burners, SRU/TG Incinerators, and Boilers and Heaters >40 mmbtu/hr
    - 5 ppmv – 10 ppmv for Coke Calciner
  - Overall emission reductions 5.7 tpd (versus 6.2 tpd of Staff's preliminary proposal) at 2011 reported emissions
  - Cumulative PWV and average cost effectiveness within range of Staff's preliminary estimates

REFINERY SECTOR

FCCUs

NEC's Recommendations for FCCUs

- 2 ppmv NOx feasible with SCRs
- Sufficient space available
- NEC's approach for PWV estimation
  - Selected Refinery 9's FCCU as Base Case
  - Adjusted Manufacturer C's costs to NEC's design of 10 ft/sec velocity for a vertical SCR with 3 beds of catalysts

    (Note: Manufacturer C recommended SCR with 3 beds, 2 beds filled with catalysts and 1 spare, designed at 12.8 ft per second velocity)

NEC's Recommendations for FCCUs (Cont.)

- NEC's approach for PWV estimation (Cont.)
  - New ammonia facility and skid for 29% aqueous ammonia
  - New CEMS for 2 ppmv
  - Prorated Refinery 9's PWV to other FCCUs based on barrels per day capacity to the 0.6 power
- 2 - 3 years for implementation

SCR's PWVs for FCCUs

Refinery	AQMD's Estimates [1] $ Million	NEC's Estimates $ Million
5	<33 [2]	<46 [2]
6	<57 [2]	<46 [2]
7	27	42
4	16 [3]	38 [3]
9	19	39
Total	152	211

Note:

1) Presented at the January 22, 2014 WGM
2) Overestimated because of the inclusion of SCR costs that already have been installed
3) FCCU is expected to be dismantled in a near future

Incremental Cost Effectiveness for FCCUs

- 2005 BARCT: $139 M for 0.48 tpd NOx reduced (1)
- 2014 BARCT: $152 - $211 M for 0.91 tpd NOx reduced
- Range of incremental cost effectiveness (DCF)
  - Staff: $(152 - 139) M / (0.91 – 0.48) tpd /25/365
    = **$3,444 per ton NOx reduced** (1, 2)
  - NEC: $(211 - 139) M / (0.91 – 0.48) tpd /25/365
    = **$18,350 per ton NOx reduced** (3)

Note: 1) Staff's estimates presented at the January 22, 2014 WGM
2) LCF = $5.7K per ton
3) LCF = $30 K per ton

REFINERY SECTOR

Gas Turbines & Duct Burners

NEC's Recommendations for Gas Turbines and Duct Burners

- 2 ppmv NOx at 15% O_2 feasible with SCRs
- Space available for catalyst addition
- NEC's approach for PWV estimation
  - Increased catalyst costs provided by manufacturer by 10% and added labor costs
  - Increased costs for ammonia usage by 10%
  - Sufficient CEMS for 2 ppmv
- 1 - 1.5 years for implementation

SCR's PWVs for Gas Turbines

No of Units	Rating MW	Current NOx Levels ppmv (1)	AQMD's Estimates $ Million (2)	NEC's Estimates $ Million
1	59	5.7	15.7 (new SCR)	5.1 (add catalysts)
3	46	3 – 4	12.6 (new SCR)	4.0 (add catalysts)
2	30	6	8.9 (new SCR)	2.6 (add catalysts)
1	23	5.7	7.2 (new SCR)	2.0 (add catalysts)
4	83	2.5 – 3.5	4.8 (add catalysts)	7.1 (add catalysts)
		Total	**97.7**	**52.7**

Note: 1) Current NOx levels with DLE/DLN, Cheng Low NOx and existing SCR
2) Presented in March 18, 2014 WGM

Incremental Cost Effectiveness Gas Turbines and Duct Burners

- Incremental emission reductions = 4.14 tpd (1)
- Range of incremental cost effectiveness (DCF)
  - Staff: $97.7 M/4.14/25/365 = **$2,586 per ton NOx** (2)
  - NEC: $52.7 M/4.14/25/365 = **$1,395 per ton NOx** (3)

Note: 1) Presented at March 18, 2014 WGM
2) LCF = $4.3K/ton
3) LCF = $2.3K/ton

REFINERY SECTOR

Coke Calciner

NEC's Recommendations for Coke Calciner

- 5 ppmv – 10 ppmv feasible with LoTOx
- NEC's approach for PWV estimation
  - Additional retrofit and process development cost
  - Larger scrubber for additional residence time
  - Larger ozone supply and higher ozone usage with multiple stage injection
  - Higher utility costs
- Space available - no site visit requested
- 2-3 years for implementation

Incremental Cost Effectiveness for Coke Calciner

- Estimated PWV = $39.5 Million (1)
- Incremental emission reductions = 0.17 – 0.21 tpd (2)
- Incremental cost effectiveness (DCF)

  $39.5 M/0.21/25/365 = **$20,613 per ton NOx** (3, 4)

  $39.5 M/0.17/25/365 = **$25,463 per ton NOx** (3, 4)

Note:

1) In comparison to $22.1 million estimated by Staff presented in the July 31, 2014 WGM
2) Incremental emission reductions from 2005 BARCT level of 30 ppmv to 2014 NEC's proposed BARCT level of 5-10 ppmv would be 0.17 tpd if BARCT is set at 10 ppmv and 0.21 tpd if BARCT is set at 5 ppmv
3) LCF = $34 K - $42 K per ton
4) Staff estimated presented in the July 31, 2014 WGM for incremental cost effectiveness = $10K - $11K per ton (DCF) and $17K - $18K per ton (LCF)

REFINERY SECTOR

SRU/TG Incinerators

NEC's Recommendations for SRU/TGs

- 2 ppmv NOx feasible with SCRs
- Space available
- NEC's approach for PWV estimation
  - Costs for SCRs prorated from FCCU's SCR costs
  - Added Waste Heat Boiler $4 million and prorated to other units
  - Added new ammonia facility for 29% aqueous ammonia and new CEMS
- 2-3 years implementation

Comparison of NEC's and Staff's Estimates SRU/TG Incinerators

	AQMD's Estimates (1)	NEC's Estimates
Control Technology	SCR, LoTOx, KnowNOx	SCR
PWVs	$ 8 M - $11 M	$ 10 M - $26 M
Cost Effective Units	10	9 (2)
Emission Reductions	0.35 tpd	0.32 tpd (2)
Cost Effectiveness (DCF)	$15 K - $21 K per ton	$16 K - $48 K per ton (2)
Cost Effectiveness (LCF)	$25 K - $36 K per ton	$26 K - $79 K per ton (2)

Note: 1) Refer to July 31, 2014 WGM, 2) Staff's estimates based on NEC's PWV information

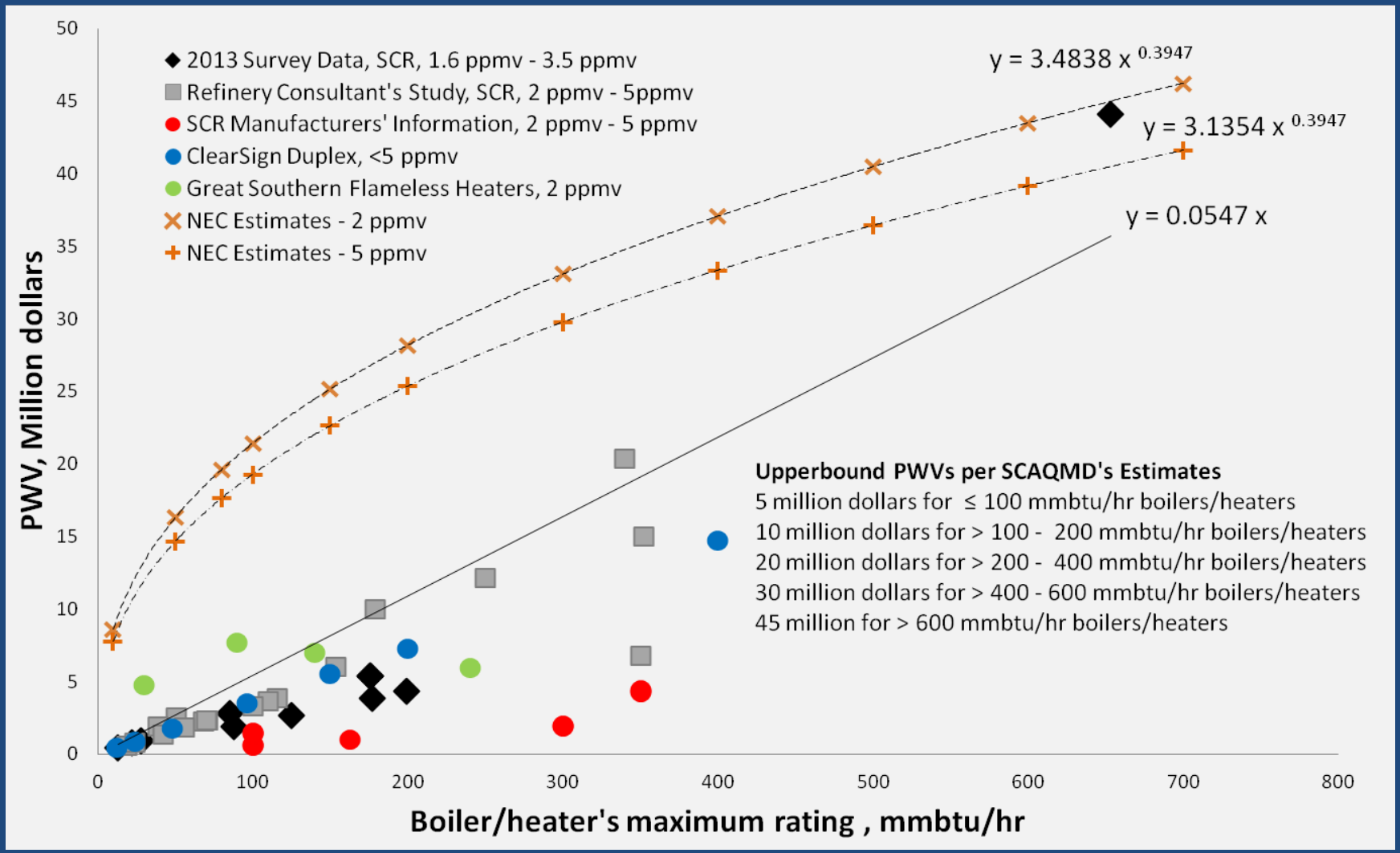
REFINERY SECTOR

NEC's Analysis for Boilers/Heaters

NEC's Recommendations for Boilers/Heaters

- 2 ppmv NOx feasible with SCRs
- Space available
- NEC's approach for PWV estimation
  - SCR costs prorated from FCCU's SCR costs
  - SCR with 3 layers of SCR catalysts
  - Added 1 layer of Ammonia Slip Catalyst to handle Refinery Fuel Gas Variation
  - Added Waste Heat Boiler, new ammonia facility, and CEMS
  - Adjustment factors for site specific situations
- 2 - 3 years implementation

Comparison for NEC's and Staff's Estimates for Boilers/Heaters



Comparison of NEC's and Staff's Estimates for Boilers/Heaters

	AQMD's Estimates (1)	NEC's Estimates
Control Technology	SCR, Great Southern Flameless, ClearSign, LoTOx	SCR
Cost Effective Units	103	48 (2)
Total PWVs	$254.5 Million	$162 Million (2)
Emission Reductions	1.05 tpd	0.61 tpd (2)
Average Cost Effectiveness (DCF)	$26,520 per ton	$29,377 per ton (2)
Average Cost Effectiveness (LCF)	$44,288 per ton	$49,059 per ton (2)

Note: 1) Refer to July 31, 2014 WGM, 2) Staff's estimates based on NEC's PWV information

REFINERY SECTOR

Summary

BARCT Control Options for Refinery Sector

Equipment Category	Proposed Revised 2014 BARCT	AQMD's Estimates (2011 Inventory Emissions)		Estimates w NEC's Recommendations (2011 Inventory Emissions)		Range of Incremental Cost Effectiveness
		Reductions (tpd)	PWVs ($ M)	Reductions (tpd)	PWVs ($ M)	$ per ton NOx Reduced
Gas Turbines	2 ppmv	4.14	97.7	4.14	52.7	1K – 3K
FCCUs	2 ppmv	0.43	152	0.43	211	3K – 18K
Coke Calciner	5 ppmv	0.21 (1)	22 - 61	0.17 (2)	39.5	11K – 25K
Boilers/Heaters > 40 mmbtu/hr	2 ppmv	1.05	254.5	0.61	162	27K – 29K
SRU/TG Incinerators	2 ppmv	0.35	49 - 68	0.32	120	15K – 48K
	Total	**6.2**	**575 - 633**	**5.7**	**585**	**7K – 12K (3)**

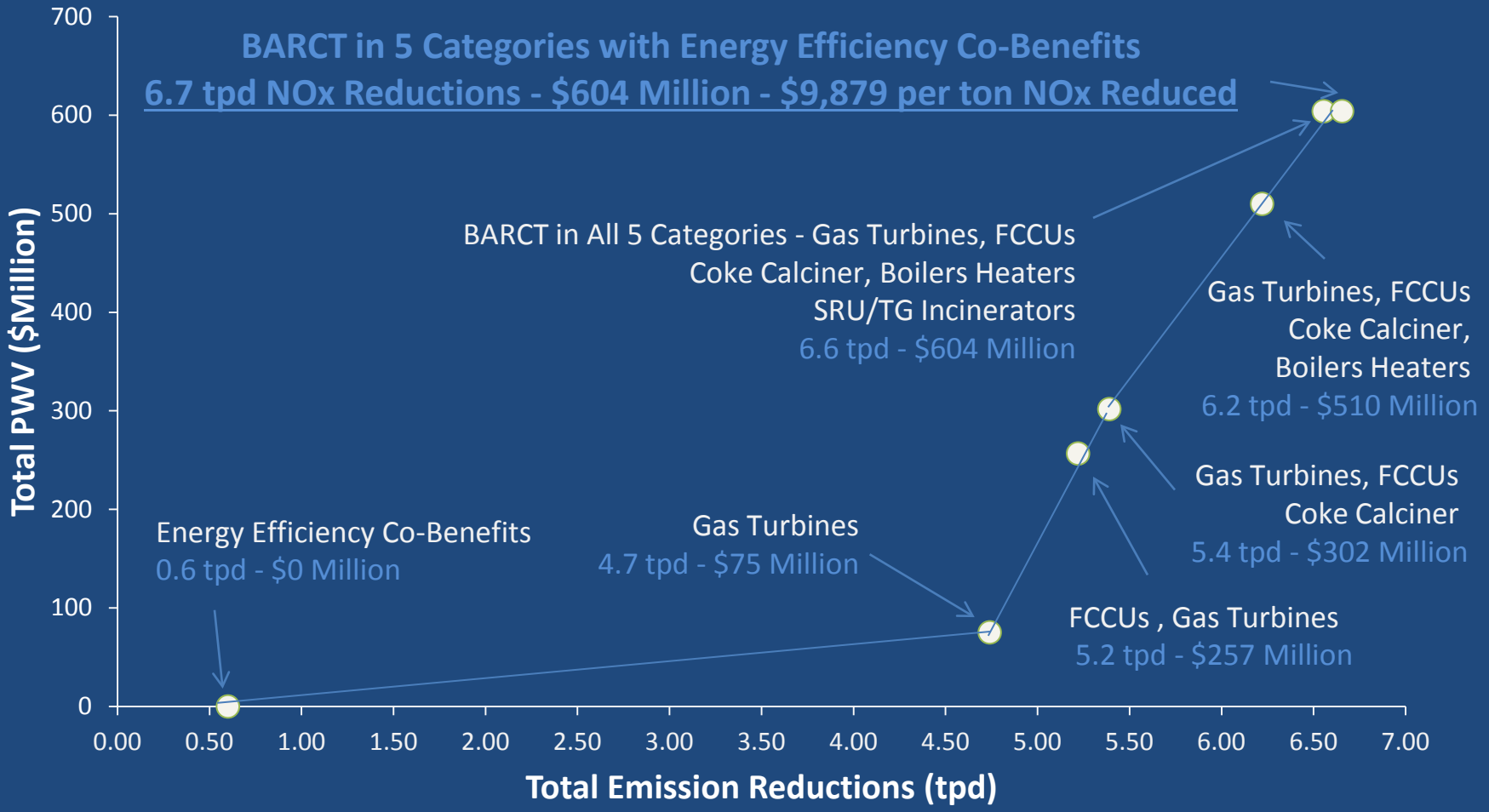
Range: 5.7 tpd – 6.2 tpd NOx Reductions at $575 Million – $633 Million

Note: 1) Reflect 5 ppmv BARCT 2) Reflect 10 ppmv BARCT 3) Weighted average by NOx reductions

Energy Efficiency Assessment for Refinery Sector

- Information submitted by refineries to CARB for energy efficiency projects to reduce GHG and provide concurrent co-benefits reduction of NOx and PM2.5
- Projects cover Boilers, Steam Generators, and other combustion processes
- Emission reductions estimated for three categories
  - Completed & on going (2007-2011): 0.6 tpd NOx reduction
  - Scheduled: 0.05 tpd NOx reduction
  - Under investigation: 0.07 tpd – 0.08 tpd NOx reduction
- Refer to http://www.arb.ca.gov/cc/energyaudits/eeareports/refinery.pdf

BARCT Analysis Results for Refinery Sector



Average numbers are used in this graph to include all feasible control technologies and reconcile estimates from various sources of information.

NON-REFINERY SECTOR

Consultant's Analysis

Scope of Consultant's Analysis

- Review SCAQMD staff's BARCT feasibility and cost effectiveness analysis for the following equipment categories
  - Cement Kilns
  - Container Glass Melting Furnace
  - Sodium Silicate Furnace
  - Metal Heat Treating Furnace >150 MMBTU/hr
  - Gas Turbines (non-power-plant)
  - IC Engines (non-power plant, non-offshore)
  - Boilers >40 MMBTU/hr

Scope of Consultant's Analysis

- Field visits and reassessment of feasibility and costs
  - Field visits conducted for the container glass and cement sector
- ETS, Inc. provided the following:
  - Emission reduction levels
  - Implementation date
  - Cost and performance warranty
  - Cost effectiveness analysis

Cement Kilns

- ETS concurs that the control technology to achieve the proposed BARCT levels is either SCR or the dry scrubbing ceramic filtration system
- The emission reductions are technically feasible with any of the three vendor control technologies evaluated
- Sufficient plot space available

Cement Kilns

- A project contingency of 15% was applied to the total direct and indirect capital costs

	Vendor 1 SCAQMD (ETS)	Vendor 2 SCAQMD (ETS)	Vendor 3 SCAQMD (ETS)
PWV ($)	34,016,551 (36,259,151)	45,622,000 (50,122,000)	107,214,017 (112,004,843)
Cost Effectiveness DCF ($/ton)	2,897 (3,088)	3,885 (4,268)	9,130 (9,538)

Vendor 1: SCR
Vendor 2: Ceramic Filtration System with Dry Scrubbing
Vendor 3: SCR with Wet Scrubbing and Heat Exchanger

Container Glass Melting Furnace

- While plot space considerations are more complex, ETS concurs that there is sufficient plot space for an SCR system
- While recognized that the ceramic filter system would replace the existing control equipment, specific details of how that would occur were not discussed
- Additional cost considerations may be required for either a remote location or the removal of the existing control equipment prior to installation of the ceramic filter system

Container Glass Melting Furnace (Cont.)

- Vendor 3 facility-derived costs were not evaluated because they were not based on actual equipment supplier estimates
- ETS concurs that the NOx emission reduction level that can be achieved is 80%, with either SCR or the ceramic filtration system

Container Glass Melting Furnace (Cont.)

- A 15% contingency was added to the Vendor 1 and 2 capital costs, along with other capital and operating cost adjustments

	Vendor 1 SCAQMD (ETS)	Vendor 2 (1 SCR) SCAQMD (ETS)	Vendor 2 (3 SCR) SCAQMD (ETS)
PWV ($)	14,003,287 (14,522,859)	4,139,195 (6,448,737)	7,823,677 (11,040,686)
Cost Effectiveness DCF ($/ton)	6,442 (6,695)	1,904 (2,967)	3,599 (5,079)

Sodium Silicate Furnace

- ETS concurs that the NOx emission level that can be achieved is 80%
- Both SCR and ceramic filtration technologies are considered technically feasible
- A contingency of 15% was applied to both vendor capital cost estimates

	Vendor 1 SCAQMD (ETS)	Vendor 2 SCAQMD (ETS)
PWV ($)	2,792,193 (3,032,193)	4,579,663 (4,602,745)
Cost Effectiveness DCF ($/ton)	3,470 (3,768)	5,691 (5,719)

Vendor 1: SCR
Vendor 2: Ceramic Filtration System

Metal Heat Treating Furnace >150MMBTU/hr

- ETS concurs that the NOx emission reduction level that can be achieved is 80% with SCR technology
- The costing is generally useful and no revisions were made

IC Engines (Non-Power Plant, Non-Offshore)

- ETS concurs that the NOx emission level can be achieved for this source category with SCR technology at 11 ppm @15%O_2
- No revisions were made to the costing

Non-Refinery, Non-Power Plant Stationary Gas Turbines

- ETS concurs that a 2 ppm level (@15% O_2) would be achievable for units emitting >40 ppm if these units would install either wet or dry combustion controls in addition to SCR
- NOx emission reductions of 90% to 95% are technically feasible with SCR alone
- No revisions were made to the costing

Non-Refinery Boilers >40 MMBTU/hr

- ETS concurs that meeting the emission level evaluated is not cost effective for this source category (>$70K per ton)

Implementation Dates

- The typical installation time for an SCR system is approximately 24 months after selection of an engineering firm to develop the specifications and commence the design engineering
- Depending on the engineering firm selection time, the total implementation time is estimated to be 27-30 months

Implementation Dates (Cont.)

- For smaller systems, the implementation dates would potentially be shorter
- The implementation dates are projected to be from 2017 to 2018

BARCT Summary for Non-Refinery Sector

Source Category	Proposed 2014 BARCT	Emission Reductions (TPD)	SCAQMD PWV ($MM)	ETS PWV ($MM)	Incremental DCF CE ($/ton)*
Cement Kilns	0.5 lb/ton clinker	1.32	34 – 107	36 – 112	3 – 10K
Container Glass	0.24 lb/ton pulled	0.24	4 – 14	6 – 15	3 – 7K
Sodium Silicate Furnace	1.28 lb/ton pulled	0.09	2.8 – 4.6	3 – 4.6	4 – 6K
Metal Heat Treating Furnaces >150 MMBTU/hr	9 ppm @3%O_2	0.56	8 – 10	8 – 10	3 – 3.8K
Gas Turbines	2 ppm @15%O_2 or 95% reduction	1.04	3 – 14	3 – 14	5 – 36K
ICEs	11 ppm @15%O_2	0.84	0.9 – 4	0.9 – 4	5 – 8K
Boilers >40 MMBTU/hr	No new BARCT	0	0	0	0
TOTAL		**4.09**	**53 – 154**	**57 – 160**	**4 – 15K****

* LCF ranges from $5,000 to $57,000 per ton

** Weighted average by NOx reductions

RTC REDUCTION EXEMPTION MECHANISMS

RTC Reduction Exemption

- Rule 2002(i)
- January 7, 2005 Amendment
- Limited exemption
- Two options
- Must meet certain criteria

Exemption Options

1. Practically no equipment with proposed BARCT and required Cost Assessment
2. All equipment at BARCT (existing and proposed)

RTC Reduction Exemption
Option #1 Criteria

- Existing facility (since 1994)
- At least 99 percent of the facility's emissions are:
  - not from equipment with the proposed NOx RECLAIM NOx ending emission factors; and
  - less than or equal to the lowest existing or proposed NOx RECLAIM emission factor for the applicable equipment

RTC Reduction Exemption
Option #1 Criteria (Cont.)

- RTCs from the facility's initial allocation have never been sold or transferred for 2016 or later compliance years; and
- The cumulative compliance costs to meet the shave exceeds the costs that otherwise would have occurred under a command-and-control.
- Exempt credits not tradable

RTC Reduction Exemption

Option #1 Compliance Cost Parameters

- Capital and total annual costs, excluding costs related to the proposed emission factors
- Revenues and expenditures resulting from the buying and selling of RTCs
- Cost savings resulting from any NOx emission strategy, such as:
  - Fuel savings; and
  - Increased production or sale

RTC Reduction Exemption

Option #1 Compliance Cost Parameters (Cont.)

- Costs not to be included:
  - Complying with NSR or other state or federal requirements limiting NOx emissions;
  - Resulting only in process efficiency or product quality; and
  - Legal costs not directly related NOx emission reductions

RTC Reduction Exemption

Option #1 Exemption Request Submittal

- A detailed description of each RECLAIM NOx reduction project;
- Detailed calculations of the emission reductions;
- Itemized revenue and expenditures for each RTC trading activity;
- Itemized costs for each project; and
- Cost savings resulting from each projects

RTC Reduction Exemption

Option #2 Criteria

Information demonstrating that:

- The starting and year 2000 Allocations were calculated using the same emission factors;
- All equipment meets the lower applicable existing or proposed BARCT emission limits; and
- RTCs for 2016 or later compliance years has not been sold or transferred

RTC Reduction Exemption

Option #2 Exemption Request Submittal

- Current demonstrated rate for each piece of equipment; and
- Any other pertinent data demonstrating exemption status

Preview: CEQA and Socioeconomic Scoping Meeting

- CEQA & Socioeconomic Scoping Meeting: Tomorrow, January 8, 2015 at 10:00 AM in the Auditorium
- Identify affected industries/facilities
- Describe approaches
- Solicit stakeholder input
- Identify key issues

Next Steps

- CEQA & Socioeconomic Scoping Meeting – January 8, 2015
- Continued Working Group meetings
- Stationary Source Committee Meeting (1st and 2nd Quarters)
- Public Workshop - 1st quarter 2015
- Rule adoption: 2nd quarter 2015

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