Bridget McCann
Manager, Technical and Regulatory Affairs

November 18, 2019

Michael Krause
Manager, Planning and Rules
South Coast Air Quality Management District
21865 Copley Drive
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Via e-mail at: mkrause@aqmd.gov

Re: Use of EPA SCR Cost Model to Estimate Refinery Heater and Boiler Control Costs and Cost Effectiveness under SCAQMD Proposed Rule 1109.1, Refinery Equipment

Dear Mr. Krause,

Western States Petroleum Association (WSPA) appreciates this opportunity to provide feedback on South Coast Air Quality Management District (SCAQMD or District) Proposed Rule 1109.1, Refinery Equipment. The District has stated that this proposed rulemaking is part of the District's larger project to transition facilities in the Regional Clean Air Incentives Market (RECLAIM) program to a command-and-control structure (i.e., the "RECLAIM Transition Project").

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 and other facilities in the South Coast Air Basin that are within the purview of the RECLAIM Program administered by the South Coast Air Quality Management District's (District or SCAQMD) and will be impacted by PR1109.1. We are providing the following comments on AQMD's proposed use of the U.S. Environmental Protection Agency (EPA) Selective Catalytic Reduction (SCR) Cost Model to estimate SCR installation costs for refinery equipment which would be subject to Proposed Rule 1109.1 (PR1109.1).

The California Health & Safety Code requires the District to demonstrate that a proposed Best Available Retrofit Control Technology (BARCT) standard is both technically feasible and cost effective.[1] Cost effectiveness is defined as the annual cost, in dollars, of the control alternative, divided by the annual emission reduction benefits, in tons, of the control alternative.[2] If the cost per ton of emissions reduced is less than the established cost effectiveness threshold, then the control method is considered to be cost effective. Cost effectiveness evaluations need to consider both capital costs (e.g., equipment procurement, shipping, engineering, construction and installation) and operating (including expenditures associated with utilities, labor, and replacement) costs. SCAQMD has used a variety of cost effectiveness thresholds, but recently has been applying a cost effectiveness threshold to BARCT rulemakings of $50,000 per ton of NO_X emissions reduced.

[1] California Health & Safety Code §40406, Best Available Retrofit Control Technology.

[2] California Health & Safety Code §40920.6.

1. The EPA SCR Cost Model was intended for electric utility boilers of a much larger scale than most refinery heaters/boilers subject to PR1109.1. The model was not intended for refinery equipment.

SCAQMD is reportedly evaluating the potential cost effectiveness of SCR installation on refinery boilers and heaters based on the EPA SCR Cost Model.[3] This model is based on EPA Clean Air Markets Division Integrated Planning Model (IPM) (version 5.13), which was intended to analyze the projected impact of environmental policies on the electric power sector.[4] EPA developed the SCR cost estimation spreadsheet which allows users to estimate capital and annualized operating costs for SCR devices.[5] The calculation methodologies in the spreadsheet are described in the EPA's Air Pollution Control Cost Manual.[6]

> *"The equations for utility boilers are identical to those used in the IPM. However, the equations for industrial boilers were developed based on the IPM equations for utility boilers. This approach provides study-level estimates (±30%) of SCR capital and annual costs… The actual costs may vary from those calculated here due to site-specific conditions."*

Per EPA, the cost estimation spreadsheet was intended to be used for calculation of SCR costs for the following types of combustion units:

- Coal-fired utility boilers with full load capacities greater than or equal to 25 MW.
- Fuel oil- and natural gas-fired utility boilers with full load capacities greater than or equal to 25 MW.
- Coal-fired industrial boilers with maximum heat input capacities greater than or equal to 250 MMBtu/hour.
- Fuel oil- and natural gas-fired industrial boilers with maximum heat input capacities greater than or equal to 250 MMBtu/hour.

The model was not intended for estimation of costs for refinery equipment. Additionally, it was not intended for refinery gas fueled boilers or refinery heaters, or equipment with heat input capacities less than 250 MMBtu/hour.

The modeled cost of the SCR is based primarily on five parameters:

- Boiler size or heat input
- Type of fuel burned
- Required level of NOx reduction

[3] SCAQMD Proposed Rule 1109.1 Working Group Meeting #7 Presentation. Available at: http://www.aqmd.gov/docs/default-source/rule-book/Proposed-Rules/1109.1/pr1109-1-wgm7.pdf?sfvrsn=6. Accessed: September, 2019.

[4] US EPA Clean Air Markets – Power Sector Modeling. Available at: https://www.epa.gov/airmarkets/clean-air-markets-power-sector-modeling. Accessed: September 2019.

[5] US EPA SCR Cost Calculation Spreadsheet. Available at: https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution. Accessed: September, 2019.

[6] US EPA Air Pollution Control Cost Manual, Section 4, Chapter 2: Selective Catalytic Reduction. Available at: https://www.epa.gov/sites/production/files/2017-12/documents/scrcostmanualchapter7thedition_2016revisions2017.pdf. Accessed: September, 2019.

- Reagent consumption rate
- Catalyst costs

The model calculates Total Capital Investment (TCI) based on a few different factors, depending on the type of equipment. For natural gas-fired industrial boilers between 205 and 4,100 MMBtu/hr, the TCI is calculated based on the heat input rate, the elevation factor and the retrofit factor. The EPA SCR Cost Model calculates the annual costs by summing maintenance, reagent replacement and storage, electricity, and catalyst costs, as well as indirect costs such as administrative charges and capital recovery costs.

2. The EPA SCR Cost Model appears to yield costs which are lower than the 2015 Norton Engineering Consultants (NEC) cost model.

On WSPA's behalf, Ramboll US Corporation (Ramboll) used the EPA SCR Cost Model to estimate costs using information from the "SCAQMD 2018 Survey Questionnaire for NOx Emission-Producing Equipment at Refinery Facilities" (2018 SCAQMD Survey) using EPA Cost Model defaults. The following data from the 2018 survey was used:

- Heat input rating
- Higher heating value of fuel
- Annual fuel consumption
- Inlet NOx emissions to SCR
- NOx removal efficiency: Ramboll calculated the NOx removal efficiency based on the control efficiency required to control to a hypothetical BARCT endpoint of 2 ppm.

Appendix A lists the data Ramboll used in the EPA SCR Cost Model to calculate estimated costs for installation of an SCR. Ramboll used the data to calculate modeled cost estimates for 5 randomly selected boilers/heaters with an assumed 2 ppm BARCT endpoint.[7] Present Weight Value (PWV) was then calculated based on the following SCAQMD formula:

$$PWV = (TIC + 15.62 \times AC) \times Marshall\ Index$$

Where:

TIC = Total Installed Costs, $
AC = Annual Operating Cost, $
15.62 = a factor to estimate the cumulative annual operating costs during a 25-year life of a control device
Marshall Index: The SCAQMD Draft Final Staff Report for Proposed Amendments to Regulation XX Regional Clean Air Incentives Market (RECLAIM), NOx RECLAM.[8] (2015 Staff Report) reported the Marshall Index between 1.09-1.64 depending on the type of

[7] The data presented herein was calculated for all boilers and heaters, regardless of the companies' reported technical feasibility of the 2 ppm BARCT endpoint. This letter makes no representations as to the technical feasibility of 2 ppm for any affected device or class/categories of equipment.

[8] Draft Final Staff Report: Proposed Amendments to Regulation XX, Regional Clean Air Incentives Market (RECLAIM) NOx RECLAIM. Available at: http://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2015/2015-dec4-030.pdf?sfvrsn=9. Accessed: September 2019.

heater. Ramboll used the average of the low and high Marshall Index values from the 2015 Staff Report.

The PWV results were then graphed and a line fit was used to establish a PWV cost equation that could be used at all ratings. The EPA Cost Model does not differentiate between equipment currently equipped with SCR and those without. Therefore, if the device already had an existing SCR it was assumed that the total estimated cost would be ~10% of the PWV for similarly sized equipment with no SCR installed.[9]

SCAQMD estimated the control costs required to meet a BARCT level of 5 ppm using the following equation:

$$PWV = 0.0547\ \times (Maximum\ rating\ of\ unit)$$

SCAQMD had previously assumed that the PWV for a device without an SCR would be roughly 10% higher than the cost required to meet a BARCT level of 5 ppm. And for devices with an existing SCR, it was assumed that the PWV to meet 2 ppm would be the same as that to meet 5 ppm.

The EPA SCR Cost Model results were then compared to the control costs estimated by SCAQMD in the 2015 Staff Report as well as the cost model provided by the SCAQMD's refinery expert, Norton Engineering Consultants (NEC). In the 2015 Staff Report, NEC estimated control costs to meet a BARCT level of 2 ppm using the following cost model:

$$PWV = 3.4838\ \times\ (Maximum\ rating\ of\ unit)^{0.3947}$$

Figure 1A and Figure 1B present comparisons of the estimated control costs for refinery equipment with and without existing SCR using: (1) the EPA SCR Cost Model with 2018 SCAQMD refinery equipment survey data and default values, (2) the NEC cost model presented in the SCAQMD's 2015 Staff Report, and (3) the SCAQMD Staff cost model as presented in the 2015 Staff Report.

[9] This assumption is the same as the SCAQMD Staff's methodology for the 2015 Regulation XX BARCT equivalency analysis and is used for consistency in comparing to the SCAQMD's cost estimates from that rulemaking. However, there is no known basis for this assumption.

Figure 1A: Comparison of Cost Model Results for Equipment with Existing SCR

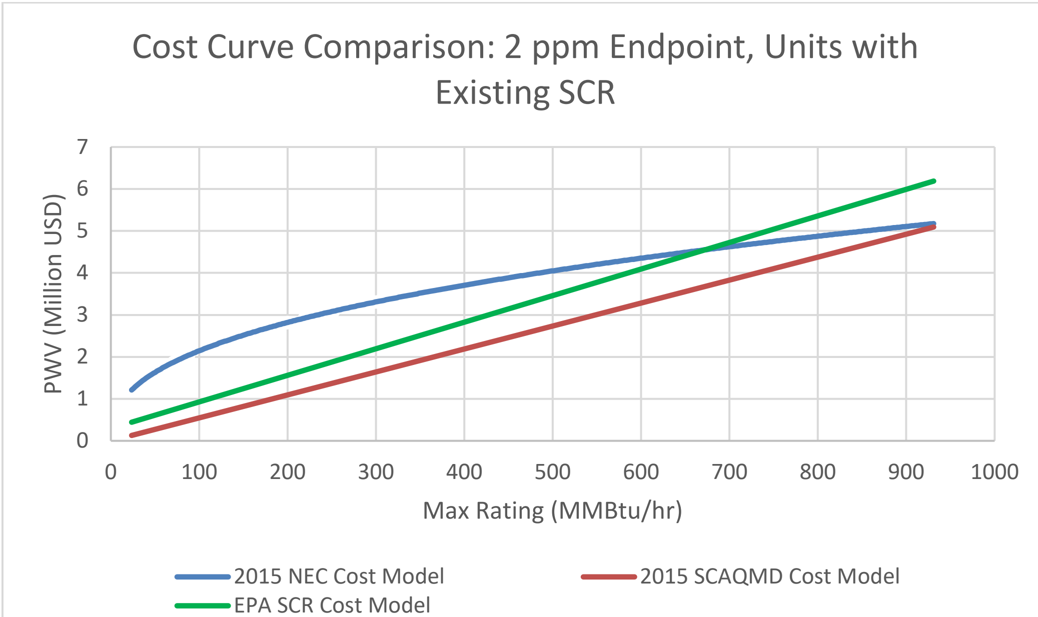
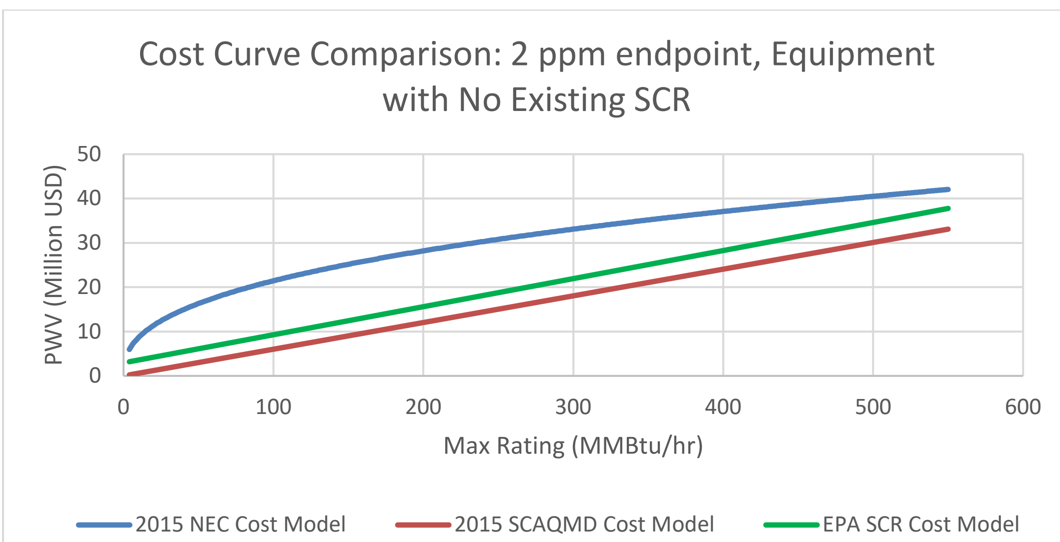


Figure 1B: Comparison of Cost Model Results for Equipment without SCR



As shown above, the EPA SCR Cost Model would generally yield higher cost estimates than those generated with the 2015 SCAQMD cost model, but lower estimates than those predicted using the 2015 NEC model.

3. The SCAQMD Staff's recent adjustments and revised assumptions to the EPA SCR Cost Model also yield cost estimates which are lower than the 2015 NEC cost model for most equipment sizes.

At the April 2019 PR1109.1 Working Group Meeting, SCAQMD Staff proposed the following adjustments to the model defaults:[10]

- Retrofit factor of 1.2 if a retrofit factor was not explicitly specified by the facility in the 2018 refinery survey
- Inlet NOx emissions assumed equals to the NOx permit limit or CEMS data if there is no NOx emission limit specified on device's current Permit to Operate
- NOx Removal Efficiency set equal to the reduction required to achieve the proposed BARCT limit
- SCR reagent assumed to be 19% aqueous ammonia
- Electricity Cost assumed at 0.128 $/kWh
- Operating hours increased to 24 hours/day
- Installation cost adjustment: SCAQMD reportedly assumed that 40% of the capital investment would be increased by 20% to account for higher labor rates in California due to Senate Bill 54 (SB54)

Appendix B lists the SCAQMD adjusted data used in the EPA SCR Cost Model to calculate estimated costs for installation of an SCR.

Ramboll again used the SCAQMD adjusted data to model cost estimates for 5 individual boilers and heaters with an assumed 2 ppm BARCT endpoint using the same PWV equation listed above.

Figure 2A and Figure 2B present comparisons of the costs for equipment with and without existing SCR using: (1) the EPA SCR Cost Model with 2018 SCAQMD refinery equipment survey data and default values, (2) the 2015 NEC cost model, (3) the 2015 SCAQMD Staff cost model, and (4) the 2019 SCAQMD Adjusted EPA SCR Cost Model.

[10] SCAQMD, Presentation for the PR1109.1 Working Group Meeting, April 2019.

Figure 2A: Comparison of Cost Model Results for Equipment with Existing SCR, Including SCAQMD Adjusted EPA SCR Cost Model

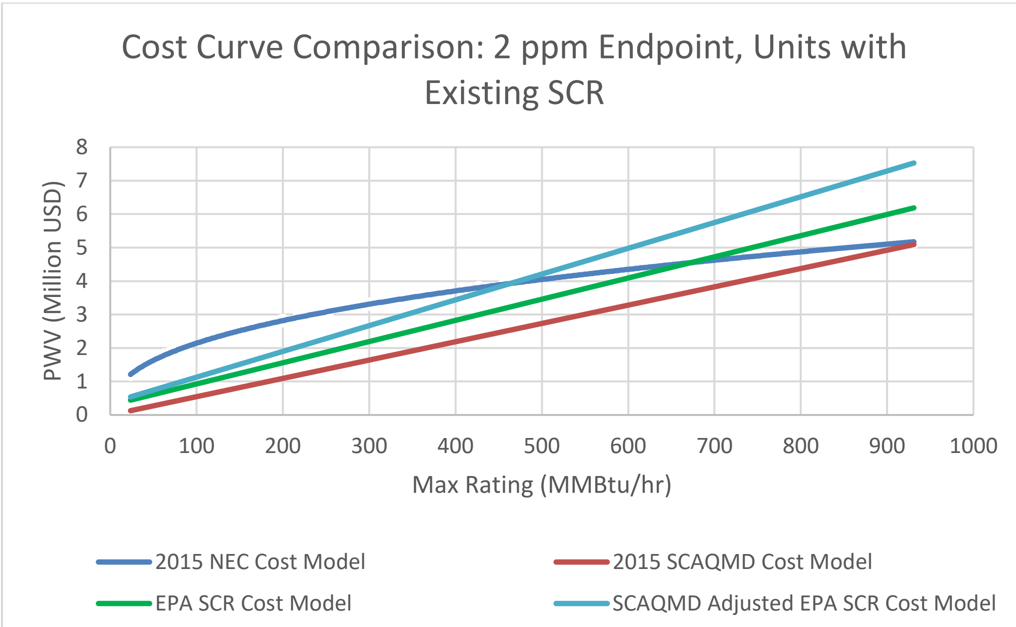
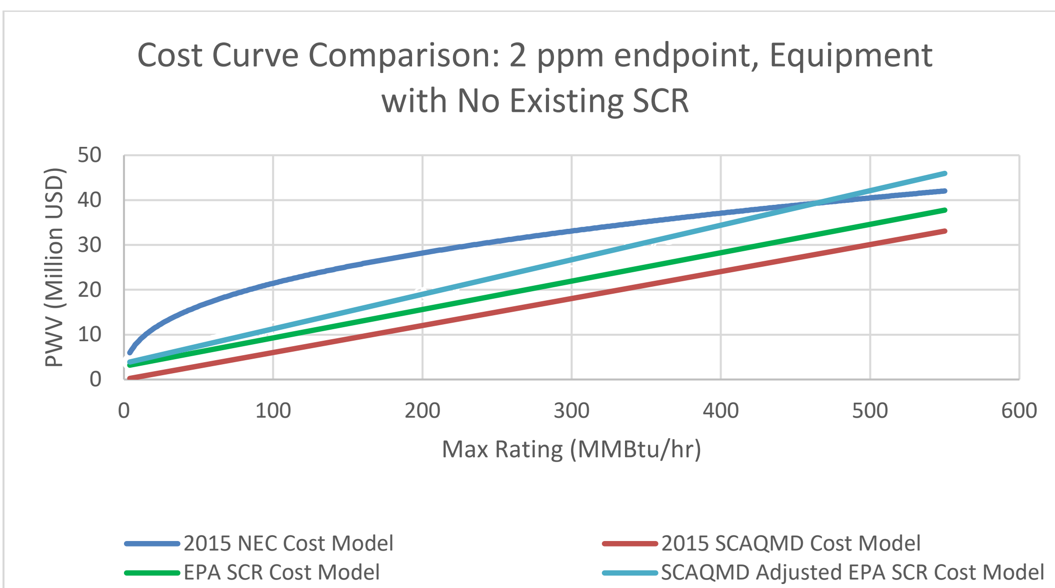


Figure 2B: Comparison of Cost Model Results for Equipment without SCR, Including SCAQMD Adjusted EPA SCR Cost Model

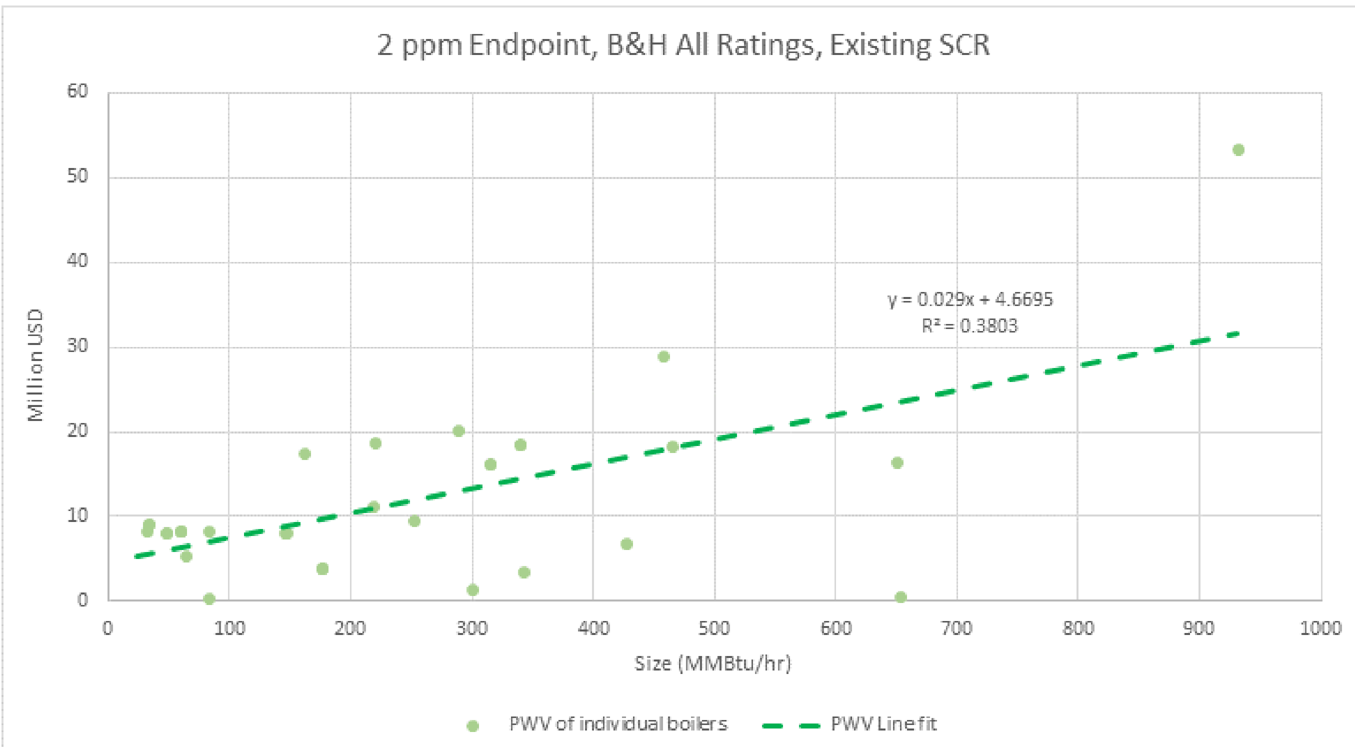


As shown above, the adjustments recently proposed by SCAQMD Staff do yield higher cost estimates compared to the non-adjusted EPA SCR Cost Model or the 2015 SCAQMD Staff cost model. But those estimated costs are still significantly below comparable estimates from the 2015 NEC model.

4. All of SCAQMD Staff's cost models are significantly lower than control cost estimates from the affected refinery facilities.

On behalf of WSPA, Ramboll conducted a confidential, projected cost survey of WSPA members to understand the companies' current cost projections for complying with potential PR1109.1 BARCT outcomes.[11] Ramboll aggregated and deidentified the heater/boiler cost data to create industry cost models for heater/boiler equipment both with, and without existing SCR. These results for refinery heaters and boilers are presented in Figure 3A and Figure 3B.

Figure 3A: WSPA Member Cost Survey for Heaters/Boilers with Existing SCR



[11] WSPA members provided their current cost estimates for installation and operation of emission control equipment which might be needed to comply with PR1109.1 at each of their Southern California refineries. Most of these estimates were reported as "intermediate" or "preliminary" cost estimates. Such estimates would be based on an early project scope definition and, due to project stage, will be rougher than later stage project cost estimates once detailed engineering and/or procurement activities have been undertaken.

Figure 3B: WSPA Member Cost Survey for Heaters/Boilers without Existing SCR

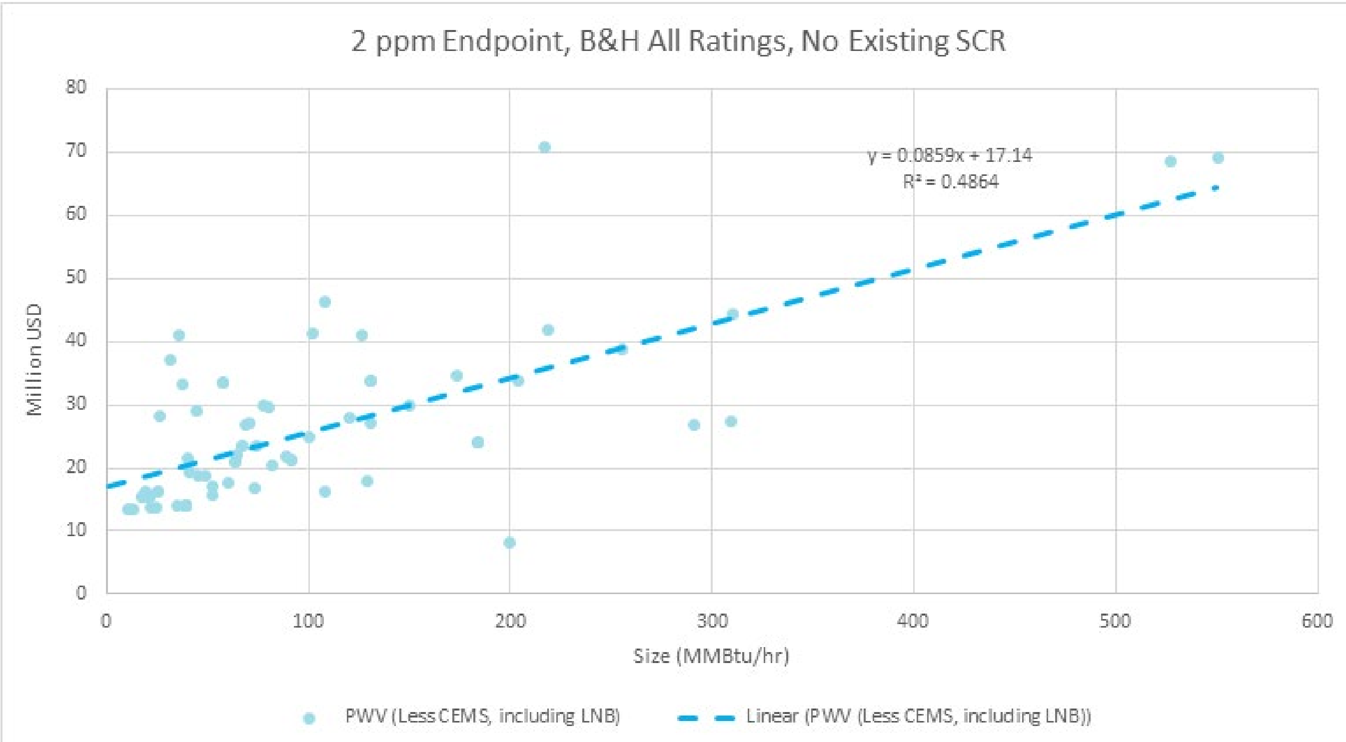


Figure 4A and Figure 4B compare the estimated control costs for equipment with and without existing SCR equipment as modelled by: (1) the EPA SCR Cost Model using 2018 survey data and default values, (2) NEC in the 2015 Staff Report, (3) SCAQMD in the 2015 Staff Report, (4) the SCAQMD Adjusted EPA SCR Cost Model, and (5) the WSPA Cost Model.

Figure 4A: Comparison of Cost Model Results for Equipment with Existing SCR, Including Cost Models Based on WSPA Member Data

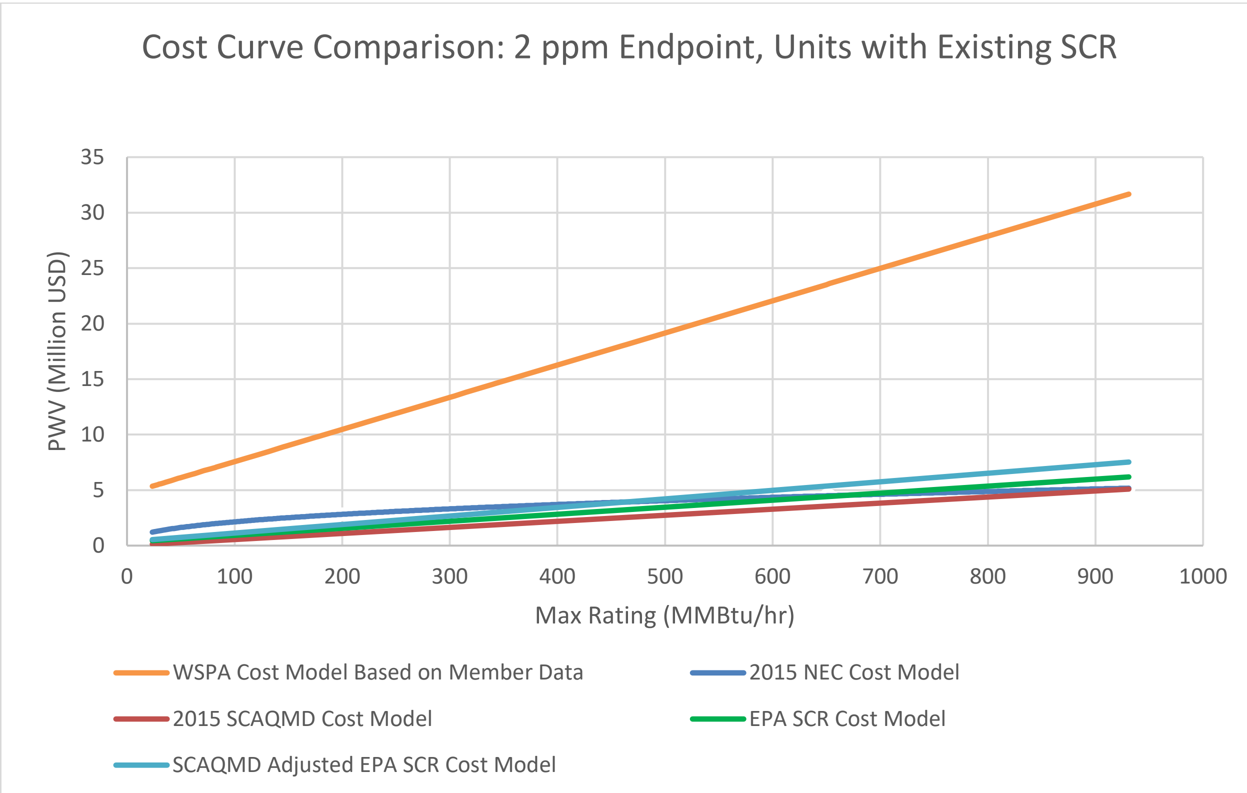
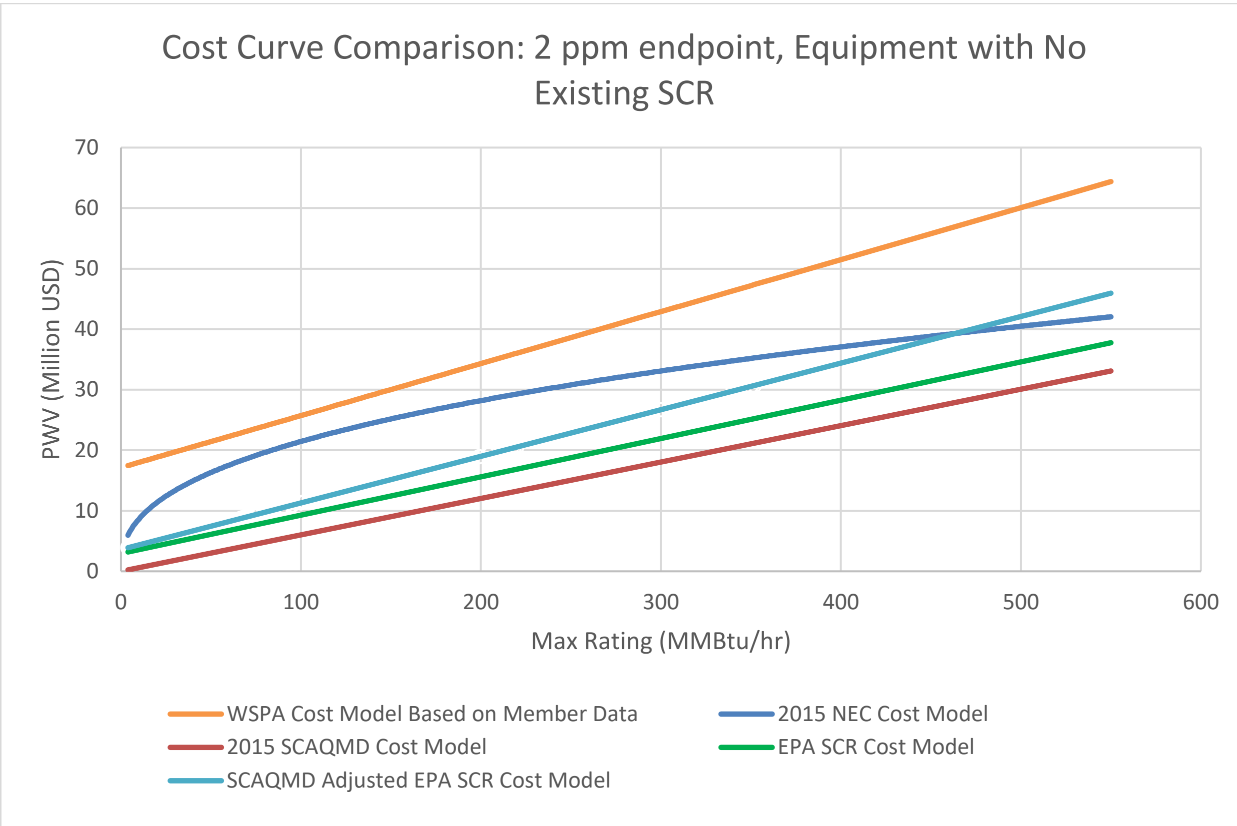


Figure 4B: Comparison of Cost Model Results for Equipment without SCR, Including Cost Models Based on WSPA Member Data



As shown above, WSPA Cost Model projections suggest control costs would be significantly higher than all of the cost models recently presented by SCAQMD Staff.

5. **The AQMD staff's use of the EPA SCR Cost Model appears to be significantly understating potential control costs due to limitations of the model design. SCAQMD staff should consider how it can minimize such variances with improved cost inputs and/or further model adjustments.**

As noted above, the EPA Cost Model was designed for large electric utility boilers; not for petroleum refineries or the lower equipment ratings (based on heat input) found at those refineries. We note a couple other potential deficiencies with the cost model design as related to the PR1109.1 application.

The EPA SCR Cost Model does not incorporate Balance of Plant Costs (BPC) for natural gas units. While BPC is a valid cost consideration for boilers running on any fuel type, the EPA model does not consider potential costs associated with replacing, maintaining, or retrofitting burners, control systems, new fuel gas systems, or reconfiguring exhaust paths for new or expanded SCR catalyst systems. These can be significant cost factors for retrofit applications within existing refineries. Additionally, it is not clear if reagent storage tanks are included in the capital cost estimates.

Also, the EPA SCR Cost Model uses a default labor rate of $60/hr, inclusive of benefits, which is likely not reflective of the California labor market. The EPA's default labor rate was sourced from EPA's Power Sector Modeling Platform v6 Using the Integrated Planning Model and was specific to the electric power sector. In 2013, the California legislature enacted, and the governor signed, Senate Bill 54: Hazardous Materials Management: Stationary Sources: Skilled and Trained Workforce (SB54).[12] SB 54 relies on federal and state environmental laws as a basis for setting wages in the private sector by requiring refineries subject to the California Accidental Release Prevention (CalARP) program to comply with modified prevailing wage, apprenticeship and journeyperson qualifications and training requirements on private refinery construction. SB54 has significantly increased labor costs at refineries since its enactment.

We understand that SCAQMD staff are working with two third party refinery experts to obtain better information concerning the technical feasibility and cost effectiveness of different control technologies under PR1109.1. WSPA and its members welcome the opportunity to continue working with SCAQMD staff to address these cost variances and would hope that information from the 3rd party experts would help address these differences.

WSPA appreciates the opportunity to provide comments related to PR 1109.1. We look forward to continued discussion of this important rulemaking. If you have any questions, please contact me at (310) 808-2146 or via e-mail at bridget@wspa.org.

[12] California Health & Safety Code §25536.7. Senate Bill 54, Hazardous Materials Management: Stationary Sources: Skilled and Trained Workforce. Available at: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB54 Accessed: September, 2019.

Sincerely,

Cc: Wayne Nastri
Dr. Philip Fine
Susan Nakamura
Tom Umenhofer
Patty Senecal

Appendix A

Category	Parameter	EPA Cost Model Value	Units	Notes
Retrofit type	Boiler type	Industrial		
	Fuel	Natural Gas		
	Retrofit Factor	1		Default for average retrofit difficulty
Equipment Information	Heat input rating [1]	From Survey	MMBtu/hr	
	Higher heating value of fuel [1]	From Survey	Btu/scf	
	Annual fuel consumption [1]	From Survey	scf/yr	
	Net plant heat input rate	8.2	MMBtu/MW	Default value
	Plant Elevation	100	Feet	Altitude above sea level
Design Parameters	Number of days SCR operates	365	days	
	Number of days the boiler operates	365	days	
	Inlet NOx Emissions to SCR [1]	From Survey	lb/MMBtu	
	NOx removal efficiency [1]	From Survey	%	Control required to get to endpoint
	Stoichiometric Ratio Factor	1.05		Default value
	Estimated operating life of the catalyst	24,000	hours	Typical catalyst life of 3 years
	Estimated SCR equipment life	10 or 25	years	
	Concentration of reagent as stored	29	%	Aqueous ammonia
	Density of reagent as stored	56	lb/ft^3	Aqueous ammonia
	Number of days reagent is stored	14	Days	Default value
	Reagent used	Ammonia		
Cost Data	Number of SCR reactor chambers	1		Default value
	Number of catalyst layers	3		Default value
	Number of empty catalyst layers	1		Default value
	Ammonia slip	5	ppm	
	Volume of catalyst layers	UNK	ft^3	
	Fuel gas flow rate	UNK	acfm	
	Gas temperature at the SCR inlet	650	deg F	Default value
	Base case fuel gas volumetric flow rate factor[2]	425.65	ft^3/min-MMBtu/hr	
	Desired dollar year	2018		
	CEPCI for 2018[3]	610.1		2018 CEPCI
	Annual Interest Rate	7	%	Default value
	Reagent	3.56	$/gal	For a 19 or 29% solution
	Electricity	0.071	$/kWh	
	Catalyst Cost	160	$\$/ft^3$	Default value
	Operator Labor Rate	60	$/hr	Default value
	Operator hours/day	4	hrs/day	Default value

Notes:
1. Ramboll used data from the 2018 SCAQMD Survey to complete calculations
2. EPA did not provide default data. Two examples were found online and averaged:
   https://documents.deq.utah.gov/air-quality/pm25-serious-sip/DAQ-2018-006882.pdf
   https://ecology.wa.gov/DOE/files/dc/dca20004-74a8-4939-ad5e-601c73690d4d.pdf
3. 2017 CEPCI: https://www.chemengonline.com/cepci-updates-january-2018-prelim-and-december-2017-final/?printmode=1
   CEPCI increased by 7.5% for 2018: https://www.chemengonline.com/2018-cepci-updates-december-preliminary-and-november-final/

Appendix B

Category	Parameter	SCAQMD Assumed Value	Units	Notes
Retrofit type	Boiler type	Industrial		
	Fuel	Natural Gas		
	Retrofit Factor	1.2		
Equipment Information	Heat input rating	From Survey	MMBtu/hr	
	Higher heating value of fuel	From Survey	Btu/scf	
	Annual fuel consumption	From Survey	scf/yr	
	Net plant heat input rate	8.2	MMBtu/MW	Default value
	Plant Elevation	100	Feet	
Design Parameters	Number of days SCR operates	Based on operating hours in 2018 survey	days	
	Number of days the boiler operates	Based on operating hours in 2018 survey	days	
	Inlet NOx Emissions to SCR	NOx permit limit or CEMS data	lb/MMBtu	
	NOx removal efficiency provided by vendor	NOx permit limit or CEMS data	%	Control required to get to endpoint
	Stoichiometric Ratio Factor	1.05		Default value
	Estimated operating life of the catalyst	24,000	hours	Typical catalyst life of 3 years
	Estimated SCR equipment life	25	years	
	Concentration of reagent as stored	19	%	Aqueous ammonia
	Density of reagent as stored	58	lb/ft^3	Aqueous ammonia
	Number of days reagent is stored	14	Days	Default value
	Reagent used	Ammonia		
Cost Data	Number of SCR reactor chambers	1		Default value
	Number of catalyst layers	3		Default value
	Number of empty catalyst layers	1		Default value
	Ammonia slip	5	ppm	
	Volume of catalyst layers	UNK	ft^3	
	Fuel gas flow rate	UNK	acfm	
	Gas temperature at the SCR inlet	650	deg F	Default value
	Base case fuel gas volumetric flow rate factor	484	ft^3/min-MMBtu/hr	
	Desired dollar year	2018		
	CEPCI for 2018	616		December 2018 CEPCI
	Annual Interest Rate	4	%	Default value
	Reagent	3.56	$/gal	For a 19 or 29% solution
	Electricity	0.128	$/kWh	
	Catalyst Cost	285	$\$/ft^3$	Default value
	Operator Labor Rate	60	$/hr	Default value
	Operator hours/day	24	hrs/day	Default value