APPENDIX C

Cost Effectiveness Analysis
For Revised Proposed Amendments to Rule 4905

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COST EFFECTIVENESS ANALYSIS FOR REVISED PROPOSED AMENDMENTS TO RULE 4905

I. SUMMARY

Per California Health and Safety Code (CH&SC) Section 40920.6(a), the San Joaquin Valley Air Pollution Control District (District) conducts absolute and incremental cost effectiveness analyses of available emission control options to evaluate the economic reasonableness of a new rule or rule amendment prior to adoption. A cost effectiveness analysis examines the added cost (in dollars per year) of the control technology or technique, divided by the emission reductions achieved (in tons per year (tpy)).

$$\text{Cost Effectiveness } (\$/ton) = \frac{\text{Compliance Cost } (\$/year)}{\text{Emission Reductions } (ton/year)}$$

This proposed rule amendment would lower the NOx emission limit to 14 nanograms per joule (ng/J) for natural gas-fired, fan-type, residential central furnaces with a rated heat input of less than 175,000 British thermal units per hour (Btu/hr), and for combination heating and cooling units a rated cooling capacity of less than 65,000 Btu/hr (referenced in this document as residential units). Proposed amendments would also expand applicability to include units installed in manufactured homes and units installed in commercial buildings (commercial units).

As Rule 4905 is a point-of-sale rule, the proposed amendments require any units supplied, sold, or installed in the San Joaquin Valley (Valley) to meet the proposed NOx emission limits effective on and after the dates specified in Table 1 in the Proposed Rule (see Staff Report). Manufacturers that are unable to commercialize compliant units, or unable to meet the increased demand for compliant units before the compliance dates would have the option of paying a per unit emission fee for up to 36 months after the applicable compliance deadline to sell noncompliant units in the Valley.

Based on the analysis in this appendix, the absolute cost effectiveness is summarized in Table C-1. Incremental cost effectiveness is not applicable to this project.

Table C-1 Cost Effectiveness Analysis Findings for Proposed Rule 4905

Number of Units Affected*	Differential Cost for a 0.0325 lb/MMBtu (or 20 ppmv) Compliant Unit	Absolute Cost Effectiveness ($ per ton NOx reduced)
1,252,190	$18.73 to $24.94	$30,598 to $40,808

*Rule 4905 is point-of-sale; therefore, units would not be replaced immediately, but would instead be replaced at the end of the useful life.

II. ESTIMATED COMPLIANCE COSTS

Estimated compliance costs for a rule project can include, but are not limited to, capital equipment costs, engineering design costs, additional labor or fuel costs, installation costs, and costs incurred from implementing new safety requirements. The District does not expect any additional engineering costs, labor costs, installation costs, or costs from new safety requirements resulting from this proposed rule amendment. Therefore, compliance costs for this rule amendment consist solely of the price differential between 14 ng/J and 40 ng/J compliant units.

Units installed in manufactured homes are already in compliance with the proposed NOx emission limit of 40 ng/J without requiring modifications;[1] therefore, there are no costs associated with these proposed amendments. The final cost effectiveness for weatherized units and units installed in manufactured homes that would comply with the proposed 14 ng/J NOx emission limit is expected to be similar to that of other unit types; therefore a separate cost effectiveness analysis was not performed for these units because cost information is not currently available.

III. ABSOLUTE COST EFFECTIVENESS ANALYSIS

Absolute cost effectiveness of a control option is additional annual compliance cost, in dollars per year, to meet the amended rule's requirements divided by the emission reductions achieved in tons of pollutant reduced per year. This absolute cost effectiveness analysis examines the differential cost of a 14 ng/J compliant unit and a 40 ng/J compliant unit and the emission reductions anticipated from lowering the NOx emission limit to 14 ng/J for residential units and adding a 14 ng/J NOx emission limit for commercial units.

A. Assumptions and Formulas

The following assumptions and formulas were used for calculating the absolute cost effectiveness of lowering the NOx emission limit for residential units to 14 ng/J and adding this same limit for commercial units. As these sources are not permitted or registered, and the new compliant units are not yet commercially available, the number of units subject to proposed amendments and the price differential have been estimated using the best available data.

[1] SCAQMD. (2009, November 6). *Final Staff Report with Socioeconomic Impact Assessment*. Retrieved 9/16/14 from http://www3.aqmd.gov/hb/2009/November/091130a.htm.

1. Price Differential (PD):

The estimated price differential for 14 ng/J and 40 ng/J compliant units is taken from the SCAQMD Staff Report from the September 2014 amendment to their Rule 1111.[2] The emission fee option for SCAQMD, $150 for non-condensing units and $200 for condensing units, was set to match the highest estimates of the final price increases to consumers for new compliant units.[3]

Commercially available units currently range from approximately $800 to $2,500, with the largest price difference being between condensing and non-condensing units. It is expected that new units will be more efficient than the units they replace, which will help mitigate the price increase over the life of the unit.

The District calculated a cost effectiveness range based on the SCAQMD emission fees, where the low estimate for the price differential was set to the fee for non-condensing units and the high estimate was set to the fee for condensing units. The $150 to $200 price differential range would represent scenarios where either all sales are non-condensing units, at $150 increase to each consumer, or all sales are condensing units, at $200 increase to each consumer. Actual sales will be some fraction of each unit type, but accurate estimates were not available for those sales fractions. Because the final price differentials for both non-condensing and condensing units are expected to be significantly lower than $150 and $200, respectively, this cost-effectiveness analysis conservatively represents a worst case scenario.

The SCAQMD emission fees are assumed to be valued in 2014 dollars. Because 2014 is the latest year available in the BLS *Inflation Calculator*, the average annual inflation rate for years 2010-2014 was calculated by taking the arithmetic mean of the annual differences in adjusted dollar values of the price differential (PD_{2010}, PD_{2011}, PD_{2012}, PD_{2013}, PD_{2014}). The average annual inflation rate was used to calculate the low and high estimates for the price differential in 2017. The low and high estimates for the price differential (PD) in 2017 were calculated as follows:

$PD_{2014\ Dollars,\ Low\ Estimate}$ = Emission fee option for non-condensing units sold in SCAQMD
= $150

[2] SCAQMD. (2014, September 5). *Governing Board Agenda Item, September 5, 2014: Amend Rule 1111 – Reduction of NOx Emissions from Natural-gas-fired, Fan-type Central Furnaces.* Retrieved 9/9/14 from http://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2014/2014-sep5-032.pdf?sfvrsn=2.
[3] SCAQMD. (2014, September 5). *Governing Board Agenda Item, September 5, 2014: Amend Rule 1111 – Reduction of NOx Emissions from Natural-gas-fired, Fan-type Central Furnaces.* Retrieved 9/9/14 from http://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2014/2014-sep5-032.pdf?sfvrsn=2.

$PD_{\{2010,2011,2012,2013,2014\}}$ = Adjusted value of ($PD_{2014\ Dollars,\ Low\ Estimate}$) in years 2010-2014, based on BLS *Inflation Calculator*
= {$137.52, $141.86, $144.79, $146.91, $150}

Average Annual Inflation Rate = {[(PD_{2011}/PD_{2010}) + (PD_{2012}/PD_{2011}) + (PD_{2013}/PD_{2012}) + (PD_{2014}/PD_{2013})]/4} – 1
= {[(141.86/137.52) + (144.79/141.86) + (146.91/144.79) + (150/146.91)]/4} – 1
= 0.022 (or 2.2%)

$PD_{2017\ Dollars,\ Low\ Estimate}$ = ($PD_{2014\ Dollars,\ Low\ Estimate}$) x (1 + Average annual inflation rate)^3
= $150 x $(1 + 0.022)^3$
= $160.12

$PD_{2014\ Dollars,\ High\ Estimate}$ = Emission fee option for condensing units sold in SCAQMD
= $200

Because the inflation rates in the BLS *Inflation Calculator* are independent of the dollar amount being adjusted, the Average Annual Inflation Rate calculated above is the same for both the high and low price differential estimates.

Average Annual Inflation Rate = 0.022 (or 2.2%) (same as calculated above for the low estimate PD)

$PD_{2017\ Dollars,\ High\ Estimate}$ = ($PD_{2014\ Dollars,\ High\ Estimate}$) x (1 + Average annual inflation rate)^3
= $200 x $(1 + 0.022)^3$
= $213.49

2. Annualized Compliance Cost (ACC) Formula:

The annualized compliance cost (ACC) shows the price differential per year of purchasing a new unit over the entire lifespan of the unit. The ACC was calculated as follows:

ACC = Price Differential x Capital Recovery Factor (CRF)

The capital recovery factor (CRF) is used to convert the price differential into equal annual payments over a specified time, at a specified interest rate. The CRF was calculated as follows:

$$\text{CRF} = \frac{i(1+i)^n}{(1+i)^n - 1} = \frac{0.1(1+0.1)^{20}}{(1+0.1)^{20} - 1} = 0.117$$

Where:

i = Interest rate (10%)
n = Equipment life (20 years)[4]

3. **Total Number of Units:** The number of homes in the Valley was obtained from the 2010 Census[5] for the years 2010-2012.

Number of homes in 2010 = 1,332,454
Number of homes in 2011 = 1,336,374
Number of homes in 2012 = 1,338,667

The average rate of increase in number of homes was calculated for that period by taking the arithmetic mean of the annual rates of increase, and used to estimate the number of homes in 2017 as follows:

Average rate of increase$_{2010\text{-}2012}$ = {[(# of Homes$_{2011}$/ # of Homes$_{2010}$) + (# of Homes$_{2012}$/ # of Homes$_{2011}$)]/2} – 1
= {[(1,336,374/1,332,454) + (1,338,667/1,336,374)]/2} – 1
= 0.0023 (or 0.23 %)

Number of homes in 2017 = (number of homes in 2012) x (1 + average rate of increase in number of homes from 2010-2012)^5
= 1,338,667 x (1 + 0.0023)^5
= 1,354,133 homes in 2017

The estimated number of homes in 2017 was multiplied by the estimated percent of homes using gas heating[6] to obtain the number of residential units subject to Rule 4905 in the Valley. It was assumed that all homes using gas heating use a natural-gas-fired, fan-type central furnace in the applicable size range. The

[4] SJVAPCD. (2005, October 20). *Adopt Proposed Rule 4905 (Natural Gas-Fired, Fan-type Residential Central Furnaces)*. Retrieved 12/17/13 from http://www.valleyair.org/Board_meetings/GB/agenda_minutes/Agenda/2005/2005-Oct-20/Item-10/GB_Agenda_2005_Oct_20_Item-10.pdf.
[5] U.C. Census Bureau (2010). *United States Census 2010*. Retrieved 12/17/13 from http://www.census.gov/2010census/.
[6] KEMA, Inc. (Prepared for California Energy Commission). (2010, October). *2009 California Residential Appliance Saturation Study*. Retrieved 9/17/13 from http://www.energy.ca.gov/2010publications/CEC-200-2010-004/CEC-200-2010-004-ES.PDF.

number of residential units subject to Proposed Rule 4905 in 2017 was calculated as follows:

Residential units in 2017 = Number of homes in 2017 x percent of homes using gas heating
= 1,354,133 x (0.71)
= 961,434 homes subject to Rule 4905 in 2017

The number of commercial units was estimated by multiplying the number of residential units by the ratio of emissions from commercial units to residential units. The emissions were taken from Appendix B of this Final Draft Staff Report. It is assumed that commercial units subject to Rule 4905 are, on average, the same size as residential units, and the usage patterns are similar. The number of commercial units subject to Proposed Rule 4905 in 2017 was calculated as follows:

Commercial units in 2017 = Number of residential units subject to Proposed Rule 4905 in 2017 x (emissions from commercial units/emissions from residential units)
= 961,434 x (0.75/2.48)
= 290,756

The total number of residential and commercial units subject to Proposed Rule 4905 in 2017 was calculated as follows:

Total number of units = Residential units in 2017 + Commercial units in 2017
= 961,434 + 290,756
= 1,252,190 units subject to Proposed Rule 4905 in 2017

4. Total Annualized Cost (TAC) Formula:

The total annualized cost (TAC) shows the total annual cost of replacing all applicable units over the lifetime of those units. The TAC was calculated as follows:

TAC = (ACC) x (Total Number of Units)

5. **Total Emission Reductions:** The total emission reductions upon full turnover of existing units in 2036 were calculated based on the analysis in Appendix B as follows:

Total Reductions$_{tpd}$	=	2.10 tons per day in 2036 (from Appendix B)
Total Reductions$_{tpy}$	=	(Total Reductions$_{tpd}$) x 365 days/year
	=	2.10 tpd x 365 days/year
	=	766.5 tons per year

6. **Absolute Cost Effectiveness (ACE) Formula:**

The absolute cost effectiveness, as defined above, is the total annual cost of replacing all applicable units, in dollars per year, divided by the total annual emission reductions upon full turnover of existing units. The ACE was calculated as follows:

ACE	=	(TAC) / (Total Emission Reductions)

B. Annualized Compliance Cost Calculations

ACC	=	Price Differential x CRF
ACC$_{Low\ Estimate}$	=	\$160.12 x 0.117
	=	\$18.73 (low estimate)
ACC$_{High\ Estimate}$	=	\$213.49 x 0.117
	=	\$24.98 (high estimate)

C. Total Annualized Cost (TAC) Calculations

TAC	=	(ACC) x (Total Number of Units)
TAC$_{Low\ Estimate}$	=	\$18.73 x 1,252,190
	=	\$23,453,518.70 (low estimate)
TAC$_{High\ Estimate}$	=	\$24.94 x 1,252,190
	=	\$31,229,618.60 (high estimate)

D. Absolute Cost Effectiveness (ACE) Calculations

ACE	=	(TAC) / (Total Emission Reductions)

$ACE_{Low\ Estimate}$ = $23,453,518.70 / 766.5 tpy
= $30,598.20 per ton of NOx reduced (low estimate)

$ACE_{High\ Estimate}$ = $31,279,706.20 / 773.8 tpy
= $40,808.49 per ton of NOx reduced (high estimate)

IV. INCREMENTAL COST EFFECTIVENESS ANALYSIS

The incremental cost effectiveness is the difference in cost between successively more effective controls divided by the additional emission reductions achieved. The proposed NOx emission limit is considered the lowest feasible achievable NOx emission limit. An incremental cost effectiveness analysis is not applicable to this project.

V. CONCLUSION

The additional cost for a 0.0325 lb/MMBtu (or 20 ppmv) compliant unit is expected to range from $160.12 to $213.49 in 2017. The differential cost is distributed over the 20 year lifetime of the unit, which reduces the financial impact for stakeholders. Also, the absolute cost effectiveness is estimated to range from $30,598.20 to $40,808.49 per ton of NOx reduced. Therefore, lowering the NOx emission limit to 0.0325 lb/MMBtu (or 20 ppmv) for natural gas-fired, fan-type central furnaces in this size range and expanding rule applicability to include commercial units and units installed in manufactured homes is a cost effective and economically reasonable proposed rule amendment.