APPENDIX C

Cost Effectiveness Analysis
For Draft Amendments to Rule 4308

August 22, 2013

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COST EFFECTIVENESS ANALYSIS FOR DRAFT RULE 4308

I. Summary

Per California Health and Safety Code (CH&SC) Section 40920.6(a), the District conducts absolute and incremental cost effectiveness analyses of available emission control options to evaluate the economic reasonableness of a 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 rule amendment project would lower the NOx emission limit for natural gas-fired instantaneous water heaters with a rated heat input of 0.075-0.4 MMBtu/hr (instantaneous units) from 55 ppmv to 20 ppmv. As a point-of-sale rule, this draft rule amendment would mandate that any instantaneous units supplied, sold, or installed in the San Joaquin Valley (Valley) meet a 20 ppmv NOx emission limit effective on and after January 1, 2015.

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 Draft Rule 4308

Number of Units Affected	Differential Cost for a 20 ppmv Compliant Unit (Low-End Estimate)	Differential Cost for a 20 ppmv Compliant Unit (High-End Estimate)	Absolute Cost Effectiveness
609	$3.00 to $185.00	-$45.00 to $489.00	$18,062-$47,727/ton of NOx reductions

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. There are no additional engineering costs, labor costs, or costs from new safety requirements resulting from this draft rule amendment. Installation costs are not expected to vary for 20 ppmv and 55 ppmv compliant units. Therefore, compliance costs for this draft rule amendment consist of the price differential between 20 ppmv and 55 ppmv compliant instantaneous units.

South Coast Air Quality Management District (SCAQMD) currently maintains a list of natural gas-fired water heaters certified to meet SCAQMD Rule 1146.2 emission limits.[1] This list is organized by the respective manufacturer, the size of the models, and the NOx emission limit achievable by that model (either 20 or 55 ppmv). The following six water heater manufacturers produce instantaneous units:

1. Bosch
2. Navien America, Inc.
3. Noritz America Corp.
4. Paloma Industries, Inc.
5. Rinnai
6. Takagi Industrial Co. USA, Inc.

All six manufacturers confirmed that they sell their units to Valley suppliers, wholesalers, and/or contractors for distribution to Valley businesses and residents. Five of the manufacturers produce both 20 ppmv and 55 ppmv compliant instantaneous units, while Navien America only produces 20 ppmv compliant units due to the rules in place in the SCAQMD and Bay Area Air Quality Management District. Many of the manufacturers that still produce 55 ppmv compliant units have discontinued several of their 55 ppmv models and replaced them with instantaneous units capable of meeting a NOx limit of 20 ppmv.

Using the model numbers provided in the SCAQMD list of certified units, District staff conducted research and collected data on the prices of the various 20 ppmv and 55 ppmv compliant units through a variety of water heater retailers, suppliers, and wholesalers; this list is available in Section VI (References).

Cost data for luxury units, such as condensing gas combination boilers, is not included in this cost effectiveness analysis. Condensing gas combination boilers are water heaters in which a high efficiency (typically greater than 90%) is achieved by using the waste heat to preheat the cold water entering the boiler. These units are generally three to five times more expensive than a typical instantaneous unit and are not representative of the price range for the majority of instantaneous units.

Most of the instantaneous units sold in the 0.075-0.4 MMBtu/hr size range have a rated heat input capacity of 0.12-0.2 MMBtu/hr. In addition, the majority of cost data available is for instantaneous units with a rated heat input capacity of 0.12-0.2 MMBtu/hr. As such, Table C-2 below summarizes cost information for instantaneous units in two size categories: 0.12-0.16 MMBtu/hr and 0.161-0.20 MMBtu/hr. The table includes low-end and high-end cost estimates of 20 ppmv and 55 ppmv compliant units, as well as the price differential between 20 ppmv and 55 ppmv compliant units.

[1] South Coast Air Quality Management District [SCAQMD]. (2013, July 9). *List of Certified Units Pursuant to Rule 1146.2*. Diamond Bar, CA. Retrieved from http://www.aqmd.gov/rules/doc/r1146/r1146_2table.pdf

Table C-2: Compliance Costs for 55 ppmv Compliant Units vs. 20 ppmv Compliant Units

Unit Size (MMBtu/hr)	20 ppmv Compliant Unit Cost	55 ppmv Compliant Unit Cost	Price Differential Between 20 ppmv and 55 ppmv Compliant Units
Low-End Estimates			
0.12 to 0.16	$549.00	$546.00	$3.00
0.161 to 0.20	$744.00	$559.00	$185.00
High-End Estimates			
0.12 to 0.16	$1,554.00	$1,065.00	$489.00
0.161 to 0.20	$2,234.00	$2,279.00	-$45.00

III. Absolute Cost Effectiveness Analysis

Absolute cost effectiveness of a control option is the additional annual compliance cost, in dollars per year, to meet the proposed 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 20 ppmv compliant instantaneous unit and a 55 ppmv compliant instantaneous unit and the emission reductions anticipated from lowering the NOx emission limit to 20 ppmv for these 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 instantaneous units to 20 ppmv:

1. **Price Differential**: A $185 price differential (highest price differential for the low-end cost estimates) and $489 price differential (highest price differential for the high-end cost estimates) are used for these calculations in order to conduct a conservative absolute cost effectiveness analysis (see Table C-2).

2. **Annualized Compliance Cost (ACC) Formula**:

   ACC = Price Differential x Capital Recovery Factor (CRF)

   The CRF converts the price differential into equal annual payments over a specified time, at a specified interest rate.

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

Where:

i = Interest rate (10%)

n = Equipment life (20 years[2])

3. **Total Number of Units:** Based on information from Appendix B (Emission Reduction Analysis), there are 609 instantaneous units in the Valley.

4. **Total Annualized Cost (TAC) Formula:**

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

5. **Total Emission Reductions**: Based on the analysis in Appendix B (Emission Reduction Analysis), this rule amendment will result in a total of 0.73 tpy of NOx reductions from instantaneous units.

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

   ACE = (TAC) / (Total Emission Reductions)

B. Annualized Compliance Cost

ACC = Price Differential x CRF

$ACC_{(\text{low-end estimate})}$ = ($185) x (0.117)
$ACC_{(\text{low-end estimate})}$ = $21.65 per unit

$ACC_{(\text{high-end estimate})}$ = ($489) x (0.117)
$ACC_{(\text{high-end estimate})}$ = $57.21 per unit

C. Total Annualized Cost (TAC)

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

$TAC_{(\text{low-end estimate})}$ = ($21.65) x (609)
$TAC_{(\text{low-end estimate})}$ = $13,185

$TAC_{(\text{high-end estimate})}$ = ($57.21) x 609
$TAC_{(\text{high-end estimate})}$ = $34,841

[2] Department of Energy [DOE]: Tankless or Demand-Type Water Heaters. (2012). Retrieved June 11, 2013 from http://energy.gov/energysaver/articles/tankless-or-demand-type-water-heaters

D. Absolute Cost Effectiveness (ACE)

ACE = (TAC) / (Annual NOx Emission Reductions)

$ACE_{(low\text{-}end\ estimate)}$ = ($13,185/year) / (0.73 tpy of NOx)
$ACE_{(low\text{-}end\ estimate)}$ = $18,062/ton of NOx reduced

$ACE_{(high\text{-}end\ estimate)}$ = ($34,841/year) / (0.73 tpy of NOx)
$ACE_{(high\text{-}end\ estimate)}$ = $47,727/ton of NOx reduced

IV. Incremental Cost Effectiveness

The incremental cost effectiveness is the difference in cost between two successively more effective controls, divided by the additional emission reductions achieved. For this rule-amending project, the draft NOx limit is considered the lowest achievable NOx limit in practice. An incremental cost effectiveness analysis is not applicable to this project.

V. Conclusion

The additional cost for a 20 ppmv compliant instantaneous unit is $3.00 to $185.00 for the low-end cost estimates and -$45.00 to $489.00 for the high-end cost estimates. This differential cost is distributed over the 20 year lifetime of the unit, which reduces the financial impact for stakeholders. Also, the absolute cost effectiveness ranges from $18,062 per ton of NOx reduced (low-end cost estimate) to $47,727 per ton of NOx reduced (high-end cost estimate). Thus, lowering the NOx emission limit to 20 ppmv for instantaneous units in this size range is a cost effective and economically reasonable draft rule amendment.

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