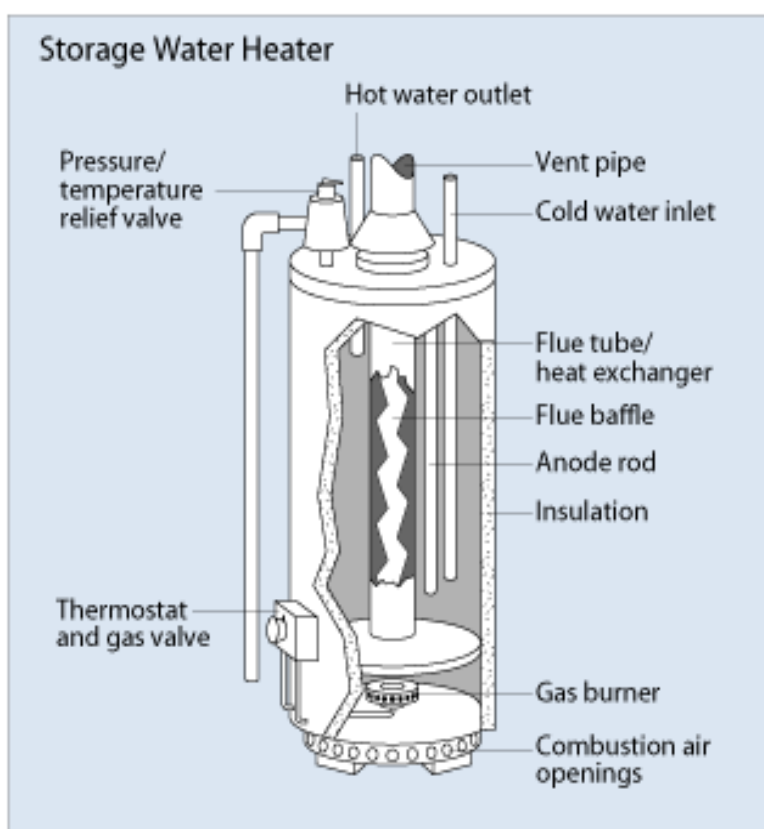


Bay Area Air Quality Management District

939 Ellis Street
San Francisco, CA 94109

Bay Area 2005 Ozone Strategy
Control Measure SS 13

BAAQMD Regulation 9, Rule 6: Nitrogen Oxides from Natural Gas-Fired Water Heaters and Small Boilers



Staff Report
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STAFF REPORT
REGULATION 9, RULE 6: Nitrogen Oxides from Natural Gas-Fired
Water Heaters and Small Boilers

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I. EXECUTIVE SUMMARY

This Staff Report provides information regarding proposed amendments to Bay Area Air Quality Management District (“BAAQMD” or the “Air District”) Regulation 9, Rule 6: Nitrogen Oxides from Natural Gas-Fired Water Heaters (“Regulation 9-6”). Staff proposes these amendments to Regulation 9-6 to reduce emissions of nitrogen oxides (NO_x) by updating the NO_x emissions requirements for residential water heaters and by extending lower NO_x limits to commercial and industrial water heaters and small steam and hot water boilers not currently regulated by Regulation 9-6, thus implementing Control Measure SS-13 in the Air District’s 2005 Ozone Strategy.

NO_x compounds are precursors in the formation of ground level ozone. In addition, NO_x reacts in the atmosphere to form fine particulate matter. The Bay Area is in non-attainment status for the State 1-hour and 8-hour, and federal 8-hour ozone standards, and has committed to implement all feasible measures to reduce emissions of ozone precursors, including NO_x. The Bay Area is currently in attainment of the federal PM₁₀ (particulate matter of 10 microns or less in diameter) standard; but like most of the state, is designated as non-attainment for the California PM₁₀ and PM_{2.5} (particulate matter of 2.5 microns or less in diameter) standards. The Bay Area has not yet been designated for the newer federal PM_{2.5} standard. It is important to reduce the public’s exposure to both ozone and particulate matter to protect public health.

Regulation 9, Rule 6 is currently a “point of sale” type regulation, limiting sale and installation of new water heaters to only those that achieve the NO_x emissions standards specified in the Rule. Proposed amendments continue use of this strategy, but would further reduce NO_x emissions by requiring low NO_x combustion burners on new water heaters, and by extending the lower NO_x emissions standards to large water heaters and small boilers not currently subject to the Rule.

Existing Bay Area residential water heaters emit an estimated 3.3 tons per day (tpd) of NO_x. Emissions reductions expected as a result of the proposed amendments are based on lower emissions for each water heater sold starting in 2009 and an estimated 12 year life expectancy for a typical water heater. NO_x reductions are estimated to start at 0.2 tpd in mid-2009 and accrue to a total reduction of 2.5 tpd by 2021.

Current NO_x emissions from large water heaters and small boilers are estimated to be 0.5 tons per day. The South Coast, the Santa Barbara, the Ventura, and the San Joaquin Valley air districts have already enacted regulations that limit NO_x emissions from similar new large water heaters and small boilers. The implementation strategy for these units is also based on replacement of existing large water heaters and small boilers when they reach the end of useful life. These large water heaters and small boilers typically have a longer life expectancy – estimated at 25 years. Expected NO_x reductions from extending this regulation to larger water heaters and small boilers in the

Bay Area are estimated at 0.4 tpd when the proposed amendments are fully implemented.

The Air District is proposing NO_x limits on mobile home water heaters, sources that are not currently subject to BAAQMD regulations. Mobile home water heaters are similar in design to power assist vent style water heaters, and have technology available to control emissions.

The Air District is also proposing NO_x limits on large pool and spa heaters, sources that are not currently subject to BAAQMD or other districts' regulations. Residential pool heaters are seldom used for significant periods so will remain exempt, but the larger pool and spa heaters used at commercial, institutional, and public pools in hotels, schools and fitness facilities operate all year, and are sources of significant NO_x emissions. Manufacturers of large pool and spa heaters can adapt low NO_x burners to successfully reduce NO_x.

The technology to achieve these proposed limits is available now. New low-emission water heaters will replace higher emission water heaters at the end of their useful life. Low-emission water heaters cost 15 - 20% more than previous designs, but also achieve higher energy efficiency and have been designed to meet more stringent safety standards. Higher efficiency means that less natural gas is burned for the amount of hot water generated. Replacement of existing water heaters with more energy-efficient models to meet new NO_x standards would also reduce emissions of CO₂, a greenhouse gas.

Consumer and industry impact is expected to be minimal. A socio-economic analysis of the proposed rule amendments has found that they would not have significant adverse effects. An initial study of the proposed amendments concludes that there would not be significant adverse environmental impacts, and as a result, Staff proposes the adoption of a California Environmental Quality Act (CEQA) Negative Declaration.

In preparing these amendments, staff consulted with water heater manufacturers, the PG&E Food Service Technology Center, the Gas Appliance Manufacturers Association, and the Project Manager of Valley Energy Efficiency Corp's Super Efficient Gas Water Heating Appliance Initiative (SEGWHAI) project. A workshop to discuss the proposal was conducted on June 29, 2007. Comments from the workshop have been incorporated into the final proposal.

II. BACKGROUND

A. Introduction

This report describes the work Air District staff conducted in considering amendments to Regulation 9-6 in order to reduce the emissions of nitrogen oxides in the Bay Area.

Boilers and water heaters burn fuel, typically natural gas, to heat water and/or generate steam. Fuel burns with oxygen in the air to form carbon dioxide (CO₂) and water vapor (H₂O). An unwanted byproduct of this combustion occurs when nitrogen (N₂) in the air also burns with oxygen to form NO and NO₂. The ratios of NO and NO₂ vary with flame temperatures and excess oxygen levels, so the combined sum of both is described as nitrogen oxides (NO_x).

NO_x compounds are precursors in the formation of ground level ozone. The Air District is in non-attainment status for the State 1-hour and 8-hour, and the federal 8-hour ozone standard, and has committed to implement all feasible measures to reduce emissions of ozone precursors, including NO_x. In addition, NO_x reacts in the atmosphere to form fine particulate matter. The Bay Area is currently in attainment of the federal PM₁₀ (particulate matter of 10 microns or less in diameter) standard; but like most of the state, is designated as non-attainment for the California PM₁₀ and PM_{2.5} (particulate matter of 2.5 microns or less in diameter) standards. The Bay Area has not yet been designated for the newer federal PM_{2.5} standard. It is important to reduce the public's exposure to both ozone and particulate matter to protect public health. Ozone causes eye irritation and affects the respiratory system by irritating the mucous membranes in the nose and throat and lung tissue. Normal functioning of lungs is impaired, thus reducing the ability to perform physical exercise. These effects are more severe on people with chronic lung disease such as asthma and emphysema and on the very young, elderly, and athletes. Inhalation of PM₁₀ and PM_{2.5} deep into the lungs reduces human pulmonary function. Regulation 9, Rule 6 currently establishes NO_x emissions limits for residential water heaters.

The Air District's 2005 Ozone Strategy Control Measure SS-13 identified water heaters and small boilers as a source category from which emissions reductions could be attained. Control Measure SS-13 suggested reducing emissions of nitrogen oxides (NO_x) by updating the NO_x emissions requirements for residential water heaters. Control Measure SS-13 also suggested reducing NO_x emissions from commercial and industrial water heaters and small steam and hot water boilers that are larger than those currently regulated by Regulation 9-6.

B. Regulatory History

Regulation 9, Rule 6 was adopted in 1992. It prohibits the sale and installation of any water heater within the Air District that does not achieve NO_x emissions of 40 nanograms (ng) NO_x, or less, per joule of heat output. Regulation 9, Rule 6 currently

applies to water heaters with a rated heat input capacity of 75,000 Btu/hr or less. These water heaters are conventional storage tank water heaters typically found in single-family residences. A typical home water heater is a 40 gallon storage tank water heater with a 40,000 Btu/hr heat input rating.

Large boilers are regulated by the Air District under three separate rules. Two rules apply to large industrial boilers at refineries and power plants (Regulation 9, Rules 10 and 11 respectively). The third rule, Regulation 9, Rule 7 ("Regulation 9-7"), imposes a 30 ppm NO_x limit on industrial, institutional, and commercial boilers with a rated heat input of 10 million Btu/hr or more. Regulation 9-7 was adopted September 15, 1993. Control Measures SS-12 and SS-13 in the Air District's 2005 Ozone Strategy proposed review of Regulation 9-6 and Regulation 9-7, and closure of the gap that currently exists between the two regulations. Control Measure SS-12 committed the Air District to consider extending coverage of Regulation 9-7 to smaller boilers (less than 10 million Btu/hr heat input) that are currently exempt. Control Measure SS-13 committed the Air District to review NO_x emission limits for residential water heaters and to consider extending coverage of Regulation 9-6 to larger water heaters, with a heat input greater than 75,000 Btu/hr, and small boilers.

Water heaters between 75,001 and 400,000 Btu/hr heat input are usually tank type water heaters similar in appearance, design, and construction to the smaller water heaters subject to Regulation 9, Rule 6. Instantaneous water heaters are also in this heat input range. Units larger than 400,000 Btu/hr are typically small boilers and are different in appearance, design, and construction from water heaters. The small boilers to which this measure applies are generally sold as "package boilers" that are prefabricated, equipped and shipped complete with burners and control systems. Boilers in this size range generally rely on natural draft rather than mechanical (fan assisted) draft. They are used in office buildings, hotels, schools, and commercial and industrial facilities to supply heat, hot water, or steam. Regulation 9-6 does not apply to any other kind of space heaters, process fluid heaters, or other industrial heaters in this size range.

The South Coast Air Quality Management District ("SCAQMD") adopted Rule 1121 in 1978, then amended it into a "technology forcing" regulation in 1995, requiring water heaters to meet 20 ng/joule by 2002, and 10 ng/joule by 2005. This regulation has subsequently been amended twice as delays occurred in adapting this technology to water heaters. Discussions with SCAQMD staff and water heater manufacturers validate that natural draft storage tank water heaters of less than 50 gallons capacity now appear to be able to meet the 10 ng/joule NO_x limit and that units able to meet that limit will be commercially available in the fourth quarter of 2007. Similarly, manufacturers appear to be on track to produce natural draft storage tank water heaters of greater than 50 gallons that will meet the 10 ng/joule NO_x limit by 2009. They also appear to be on track to produce storage tank water heaters with power assisted draft that will meet the 10 ng/joule limit by 2010.

SCAQMD Rule 1146.2 – Emissions of Oxides of Nitrogen from Large Water Heaters and Small Boilers, adopted on January 9, 1998, established NO_x emission limits for large water heaters and small boilers ranging from 75,001 Btu/hr up to and including 2 million (MM) Btu/hr with various effective dates from 2000 to 2006, and expected NO_x reductions between 2010 and 2012. As with Rule 1121, these timetables have been amended to match with the actual technology development. The Santa Barbara, Ventura, and San Joaquin Valley air districts have subsequently enacted similar regulations that reflect the South Coast limits and amended implementation schedules.

C. Source Description

A wide variety of products are available to heat water in residential and commercial applications. Four primary companies make residential water heaters, and several other manufacturers produce boilers; electric and gas-fired storage tank water heaters; electric and gas-fired instantaneous water heaters; and hot water storage tanks where water is heated by another source such as a boiler or by solar heating. Water heater manufacturing companies also make combination solar and electric water heater tanks. In other countries, combination solar and gas-fired water heaters are also available.

Within the category of gas-fired storage tank water heaters with heat input of 75,000 Btu/hr or less, there are four styles which differ in the way combustion air and combustion exhaust gases are handled.

- Typical home gas-fired storage tank water heaters are designed to have combustion air enter at the bottom of the unit and combustion products are vented through an exhaust duct to the outside of the building. These are known as atmospheric (natural draft) water heaters.
- There are also three water heater designs that use fan assist to draw air in, or exhaust gases out of the water heater. These designs have various names:
 - power-vent;
 - direct-vent; and
 - power direct-vent

Each of these styles fall under the label of “Power Assist” storage tank water heaters. Each design is based on the ducting required for combustion air inlet, and exhaust gas outlet.

Large water heaters are also tank type water heaters, similar in appearance, design, and construction to the smaller water heaters. These larger water heaters range in size from 75,000 to 400,000 Btu/hr and are used in small hotels, apartment buildings, office buildings, and industrial and commercial facilities to supply hot water. A newer style of water heater in this heat input range is an instantaneous, tank-less water heater. Instantaneous water heaters heat water “on demand”, and are becoming more popular for specific use needs, and may be more efficient because they have less heat loss during non-use periods.

Units larger than 400,000 Btu/hr are typically small boilers and are different in appearance, design, and construction from water heaters. These small boilers are generally sold as “package boilers” that are prefabricated, equipped and shipped complete with burners and control systems. Boilers in this size range generally rely on natural draft rather than mechanical draft equipment. They are used in office buildings, hotels, schools, and industrial facilities to supply heat, steam, or hot water. These units are not currently regulated by an Air District rule.

Each system for water heating (other than solar) results in emissions of nitrogen oxides. Electric water heaters do not emit nitrogen oxides directly, but they result in increased power plant emissions. Solar water heating is the technology with the greatest potential to reduce overall emissions from the heating of water for residential and commercial use. A variety of solar water heating systems are now available. However, for most applications, an additional source of heat is needed when sunlight is not available.

Mobile home water heaters are very similar in design to Power Vent style water heaters. These water heaters have technology to control NO_x emissions to 40 ng/joule of heat output.

Pool and spa water heaters are designed to warm water, rather than generate hot water. They combust natural gas to create heat, but generally warm the circulating water stream by only 10 – 15°F. Pool and spa heaters used for residential pools are usually in the 75,000 to 400,000 Btu/hr heat input range. Large pool and spa heaters used for commercial and industrial pools and spas are typically in the 400,000 to 2,000,000 Btu/hr heat input range.

D. Current Technology for Reducing NO_x Emissions

All natural gas fired water heaters and boilers rely on a burner to combust fuel to generate heat that in turn heats the water. Manufacturers have tested a variety of burner types to achieve low NO_x emissions. The principle technique involves premixing of fuel and air before combustion takes place. This results in a lower and more uniform flame temperature. A lower flame temperature reduces formation of NO_x. Some premix burners also use staged combustion with a fuel rich zone to start combustion and stabilize the flame and a fuel lean zone to complete combustion and reduce the peak flame temperature. Burners can also be designed to spread flames over a larger area to reduce hot spots and lower NO_x emissions. For residential water heaters, manufacturers have focused on pre-mixed radiant burners. These burners mix fuel and air before the mixture is ignited at the surface of the burner. Radiant burners with ceramic, sintered metal or metal fiber heads spread the flame and produce more radiant heat while at the same time reducing flame temperature. When a burner produces more radiant heat, it can result in less heat escaping the boiler through exhaust gases. In addition, radiant burners evenly distribute the heat of combustion which stabilizes the

flame and prevents "hot spots." When hot spots are prevented, NO_x emissions are also minimized.

The technology to produce water heaters that emit less than 10 ng/joule of heat output is currently available. Manufacturers have integrated these low NO_x burners into a re-design of their water heaters that started with the 50 gallon and smaller water heaters. The re-design was required to meet U.S. Department of Energy Regulations¹, and California Energy Commission Appliance Efficiency Standards². These standards require greater than 80% efficiency, and enhanced safety requirements including Flammable Vapor Ignition Resistance (FVIR). Each manufacturer is now certifying their parts suppliers and manufacturing process to ensure each water heater meets all requirements. Manufacturers expect to be able to supply water heaters that meet the efficiency, safety, and NO_x standards by late 2007. Manufacturers expect to supply water heaters over 50 gallons that meet all requirements by 2009, and power assisted ventilation water heaters that meet all requirements by 2010.

Low NO_x burners for large heaters and small boilers can achieve NO_x emissions of less than 14 ng/joule. Manufacturer certification test results provided to SCAQMD show that manufacturers have made substantial progress in reducing the NO_x emissions from large water heaters and small boilers, and appear to be on track to develop low NO_x capability. Approximately 20% of the large water heaters providing test results in the 75,001 to 400,000 Btu/hr units size range meet the proposed Regulation 9, Rule 6 limit of 14 ng NO_x/joule. Approximately 45% of the small boilers and boiler type water heaters in the 400,001 to 2,000,000 Btu/hr size range units tested under the SCAQMD certification program meet the proposed limit. While no instantaneous water heaters currently meet the proposed emission limit, manufacturers have reported they are making progress, and indicate they are on-track to achieve these standards by 2012.

III. PROPOSED RULE AMENDMENTS

A. Introduction

Regulation 9, Rule 6 is a "point of sale" type regulation, currently limiting sale and installation of new water heaters to only those that achieve the NO_x emissions standards specified in the Rule. Proposed amendments continue this strategy, but reduce NO_x emissions by requiring lower NO_x emission standards for new water heaters, by extending the lower NO_x emissions standards to larger water heaters and small boilers, and by establishing NO_x emissions standards for water heaters not currently subject to the Rule. All proposed changes apply to new water heaters and boilers only. No retrofits of existing facilities' water heaters and boilers are proposed.

Air District staff proposes no change for most existing exemptions. Water heaters for recreational vehicles and those using any fuel other than natural gas are exempt.

D. Mobile Home Water Heaters

Water heaters used exclusively for mobile homes are similar in design to those with power assist vent systems. Staff recommends requiring any new heaters to meet a NO_x emissions standard of 40 ng/joule, effective July 1, 2008. This water heater technology is now readily available, so mobile home water heaters should no longer be exempt from this regulation.

E. Pool/Spa Heaters

Water heaters used exclusively for swimming pools and spas have been exempt from this regulation in the past. Pool and spa heaters are specifically designed for pool and spa applications, but are similar in design and rated heat input capacity to larger commercial water heaters. Residential pool/spa heaters are typically less than 400,000 Btu/hr rated heat input capacity. Residential pools are seldom heated year-round, so emissions from these units are minimal. Commercial, institutional and public swimming pools are typically larger, and equipped with larger heaters. In addition, these pools are normally heated all year, and therefore can be significant sources of NO_x emissions. Staff recommends requiring any new pool and spa heaters greater than 400,000 Btu/hr rated heat input capacity to meet a NO_x emissions standard of 40 ng/joule (~55 ppm), effective January 1, 2008. This water heater technology is now readily available, and large swimming pool and spa heaters should no longer be exempt from this regulation. Further, staff recommends that these large commercial, institutional, and public pool and spa water heaters be required to meet a 14 ng/joule NO_x emission limit by January 1, 2013, consistent with other large commercial water heaters.

F. Other Amendments

Administrative Requirements for certifying heater models for use and sale within the District have been clarified and strengthened. Manufacturers will be required to obtain written confirmation from an independent testing laboratory that the specific make and model of water heater or boiler they intend to sell or distribute in the District is compliant with the appropriate NO_x emissions standards. Re-certification is required every three years to ensure these products remain compliant. In addition, application requirements for District certification of water heaters are clarified. The District will continue to accept SCAQMD certification where the NO_x standards are identical, in lieu of duplicate emissions tests and applications for certification.

The standards for determining emissions from water heaters are established in Section 9-6-600: Manual of Procedures. The methods set out in section 9-6-601 include those normally used when the District conducts compliance testing on an emissions source. Section 9-6-601 also provides alternate methods, including the SCAQMD protocol for water heater NO_x testing.

IV. EMISSIONS AND EMISSION REDUCTIONS

Emissions Subject to Control

Emissions from water heaters currently included in the Air District emission inventory are shown in Table 1:

Table 1

Source Category	Description	Emissions: tons per day
284	Fuels Combustion – Domestic <ul style="list-style-type: none"> • Residential water heaters 	3.29 tpd
1590	Fuels Combustion – Other External Combustion <ul style="list-style-type: none"> • Estimate for large water heaters 	7.03 tpd 0.46 tpd
307	Other natural gas combustion <ul style="list-style-type: none"> • Estimate for large water heaters 	3.49 tpd 0.08 tpd

Emissions from residential water heaters along with emissions from larger residential, commercial and industrial combustion equipment are included in the BAAQMD inventory in three different categories. Emissions from residential water heaters are included in the emission inventory Source Category 284, called Fuels Combustion – Domestic. NO_x emissions from residential water heaters in this category are estimated to be 3.29 tons of NO_x per day based on estimated volumes of natural gas burned for water heating from Pacific Gas & Electric (PG&E). Mobile home water heaters are included in this estimate.

Estimated emissions from larger residential, commercial and industrial combustion equipment, 75,001 through 2,000,000 Btu/hr heat input that are not permitted as point sources are captured as area source emissions in Category 1590, Fuels Combustion – Other External Combustion. Commercial and institutional pool and spa heaters are included in this category. Emissions from this category are 7.03 tons per day, including emissions from devices with input heat ratings less than 2 MM Btu/hr. An inspection of boiler population data provided by the San Francisco Department of Building Inspection (DBI) for 2003 shows that devices rated less than 2 MM Btu/hr constitute one third of the total number of devices rated less than 10 MM Btu/hr. We expect this information to be representative of other commercial installations throughout the Bay Area. However, because devices rated less than 2 MM Btu/hr have a maximum fuel consumption that is one fifth of the largest devices (10 MM Btu/hr), the NO_x emissions from these devices will be assumed to be only 20% of that suggested by their population:

$$(7.03 \text{ ton/day})(0.33)(0.20) = 0.46 \text{ ton/day NO}_x$$

Emissions from permitted point sources are captured in Category 307. These sources are permitted for some other reason than their NO_x emissions – as part of a larger

facility or from their potential to burn liquid fuels. Category 307 NO_x emissions are estimated to be 3.49 tpd from “other” natural gas combustion – some of which may be water heating. Staff analyzed these point sources using source codes for Industrial – Other, and Commercial / Institutional. Expansion of the rule will include a small number of large water heaters whose emissions appear to be relatively small – no more than 0.01 tpd. Similar analysis of small boilers indicates their emissions appear to be no more than 0.07 tpd.

The conclusion from the above data is that the NO_x emissions subject to control from water heaters in the 75K through 2 MM Btu/hr range is approximately 0.5 tons per day.

Emission Reductions Expected

Emissions reductions from the proposed amendments are shown in Table 2:

Table 2

Heat Input Range	Emissions	Emission Reductions
Water Heaters: 75,000 Btu/hr heat input or less	3.29 tpd	2.47 tpd
Large Water Heaters and Small Boilers: 75,001 – 2,000,000 Btu/hr	0.54 tpd	0.40 tpd

Current emissions for residential water heaters are estimated at 3.29 tons per day (tpd). The proposed amendments will reduce NO_x by 75%, or 2.47 tpd. These emission reductions will occur as new water heaters replace the existing higher emissions water heaters. Typical life expectancy for a residential water heater is 12 years. Staff proposes that this element of the rule amendments go into effect on January 1, 2009, thus reducing NO_x emissions by a cumulative 0.2 tpd for each of the subsequent 12 years.

Current estimates for NO_x emissions from commercial, institutional, and industrial water heaters from 75K through 2 MM Btu/hr heat input in the Air District inventory are a cumulative 0.5 tpd. The NO_x emission reductions staff expects will occur in two phases. The first phase is a reduction from uncontrolled NO_x emissions (~74 ng/joule) to 40 ng/joule beginning in 2008. The second phase is a reduction from 40 ng/joule to 14 ng/joule beginning in 2013. Large water heaters and small boilers also have a longer lifespan – estimated at 25 years, which equates to 4% replacement each year. NO_x reductions will be 0.01 tpd each year beginning in 2008. NO_x reductions will increase to 0.016 tpd in 2013. Since this is a relatively small amount of potential NO_x reduction, staff proposes the strategy of replacement with new low emission water heaters and package boilers when they reach their end of useful life, rather than require a retrofit or accelerated replacement. The total NO_x emissions reduced from these larger water heaters will be 0.4 tpd.

These NO_x reductions will also contribute to reduced emissions of fine particulate matter. PM_{2.5} (particulate matter of 2.5 microns diameter or less) is formed from a conversion of NO_x to ammonium nitrate (NH₄NO₃). District staff has estimated the ratio between NH₄NO₃ formation to NO_x emissions to range between 1:6 and 1:10. Assuming an average ratio of 1:8 conversion, the 2.9 tpd reduction in NO_x emission will reduce PM_{2.5} by 0.36 tpd.

V. ECONOMIC IMPACTS

A. Compliance Costs

Cost of a typical residential 40 gallon, 40,000 Btu/hr heat input water heater is \$400 to \$500, plus additional costs for installation. Additional cost for a low-NO_x residential water heater is approximately \$50. These water heaters have also been redesigned to be more energy efficient, as required by Department of Energy standards. The additional cost for increased energy efficiency of the new water heater is approximately \$60. The average residential water heater burns 200 Therms/year, producing 1.08 lbs. of NO_x. NO_x reductions are estimated at 0.81 lbs. of NO_x per year. The cost effectiveness for these residential water heaters is about \$17,300/ton of NO_x reduced, excluding consideration of energy savings. However, new residential water heaters are required to be at least 5% more efficient, and are estimated to actually be ~9% more energy efficient. Estimated energy savings are \$20 per year, generating a simple payback period of less than 6 years for the expense of both increased efficiency and lower NO_x emissions. Costs are similar for Power Vent style water heaters, and water heaters for mobile homes.

Water heaters from 75,000 through 400,000 Btu/hr heat input range in cost from \$2500 to \$10,000 plus installation. Incremental costs for low NO_x capability in large water heaters are estimated to be \$100 - 200 per unit. A 100,000 Btu/hour commercial heater is expected to burn 876 Therms/year, generating 4.65 lbs of NO_x. NO_x reductions are estimated at 3.72 lbs. of NO_x per year. The cost effectiveness for this size range is \$7500 – 15,000/ton NO_x reduced. Potential improvements in energy efficiency for these larger units are less clear. These units are required to be at least 80% energy efficient. Energy efficiency improvements for new heaters and small boilers is less quantifiable because there have been no mandatory improvements required for these units. In addition, these large water heaters and small boilers vary more in size and design. These new units are expected to be at least 5% more efficient, and will save 44 Therms, or approximately \$48/year.

Small boilers from 400,001 through 2,000,000 Btu/hr heat input range in cost from \$10,000 to \$50,000 plus installation. Additional costs for low NO_x capability are estimated to be \$400 – 800 per unit. A 1,000,000 Btu/hour commercial heater is expected to burn 8760 Therms/year, generating 46.5 lbs of NO_x. NO_x reductions are estimated at 37.2 lbs. of NO_x per year. The cost effectiveness for these units is \$3000 -

6000/ton NO_x reduced. Estimates of improved efficiency for these larger water heaters and small boilers is also approximately 5%, generating savings of 438 Therms, or about \$480/year.

B. Incremental Cost Effectiveness

Section 40920.6 of the California Health and Safety Code requires an air district to perform an incremental cost analysis for any proposed Best Available Retrofit Control Technology rule or feasible measure. The air district must: (1) identify one or more control options achieving the emission reduction objectives for the proposed rule; (2) determine the cost effectiveness for each option; and (3) calculate the incremental cost effectiveness for each option. To determine incremental costs, the air district must “calculate the difference in the dollar costs divided by the difference in the emission reduction potentials between each progressively more stringent potential control option as compared to the next less expensive control option.”

Low NO_x burners are the only reasonable, feasible way to reduce NO_x emissions from residential water heaters. Since there are no viable alternatives, cost effectiveness is calculated by dividing the annualized incremental capital cost by the tons of NO_x emissions reduced. Cost effectiveness for low NO_x residential water heaters are estimated at \$17,300 per ton. Benefits from improved thermal efficiency are specifically excluded from this analysis.

Similarly, low NO_x burners are the only viable way to reduce NO_x from large water heaters ranging from 75,001 through 400,000 Btu/hr heat input. Cost effectiveness for these large water heaters is estimated at \$7,500 per ton. Again, any improvements in thermal efficiency are specifically excluded from this analysis.

Low NO_x burners are the lowest cost, most efficient means to reduce NO_x emissions from small boilers ranging from 400,001 through 2MM Btu/hr heat input. Cost effectiveness for these small boilers is estimated at \$3,800 per ton. Flue gas recirculation is another viable means of reducing NO_x from boilers. Flue gas recirculation can, at best, reduce NO_x down to ~10 ppm. This would provide an additional reduction of 4.65 lbs. per year of NO_x for a 1,000,000 Btu/hr heat input boiler. However, flue gas recirculation capital costs are at least three times more than those for low NO_x burners, and may have the added cost of operating a flue gas blower. Even assuming that flue gas recirculation can be achieved with natural draft, annualized capital costs are an additional \$140/year for each small boiler. Incremental cost effectiveness of flue gas recirculation over low NO_x burners is very expensive, estimated at \$60,000 per ton of NO_x reduced. Catalytic reduction is the other technology available to reduce NO_x emissions from boilers. Catalytic reduction capital costs are even higher than those for flue gas recirculation, and have an impact on boiler efficiency. Catalytic reduction can reasonably reduce NO_x down to ~5 ppm. This would provide an additional reduction of 7.0 lbs. per year of NO_x for each small boiler. However, catalytic reduction capital and operating costs are at least five times more

than those of a low NO_x burner, estimated at \$280/year for each small boiler. Incremental cost effectiveness of catalytic reduction over flue gas recirculation is also quite expensive, estimated at \$80,000 per ton of NO_x reduced. Neither of these options can compete with the simplicity and effectiveness of low NO_x burners for water heaters and small boilers. Because of these reasons, and the poor incremental cost effectiveness associated with flue gas recirculation and catalytic reduction technologies, the proposed limits reflect emissions achievable with low NO_x burners.

C. Socioeconomic Impacts

Section 40728.5 of the California Health and Safety Code requires an air district to assess the socioeconomic impacts of the adoption, amendment or repeal of a rule if the rule is one that “will significantly affect air quality or emissions limitations.” Applied Development Economics of Walnut Creek, California has prepared a socioeconomic analysis of the proposed amendments to Regulation 9, Rule 6. The analysis concludes that the affected facilities and individuals should be able to absorb the costs of compliance with the proposed rule when water heaters or small boilers require replacement without significant economic dislocation or loss of jobs.

VI. ENVIRONMENTAL IMPACTS

Pursuant to the California Environmental Quality Act, the BAAQMD has had an initial study for the proposed amendments prepared by Environmental Audit, Inc. The initial study concludes that there are no potential significant adverse environmental impacts associated with the proposed amendments. A negative declaration is proposed for adoption by the BAAQMD Board of Directors. The initial study and negative declaration is to be circulated for public comment prior to consideration by the Board of Directors.

Regulation 9, Rule 6 supports efficiency and energy conservation as a primary preventive approach to pollution. The rule currently has NO_x standards defined in terms of nanograms of NO_x per joule of heat output. The current rule uses the “output based” emission limits, as recommended by USEPA. A more efficient water heater will generate less NO_x because it uses less fuel. The proposed amendments continue this approach, but do, where appropriate, accommodate the industry norm of also stating emission standards in flue gas volumetric parts per million (ppm) on a dry gas basis at 3% oxygen. The output based limits support and reinforce the preventive approach to pollution. Reducing pollution while promoting efficiency is crucial to reducing CO₂ emissions and their impact on global climate change.

VII. REGULATORY IMPACTS

Section 40727.2 of the Health and Safety Code requires an air district, in adopting, amending, or repealing an air district regulation, to identify existing federal and district air pollution control requirements for the equipment or source type affected by the proposed change in air district rules. The air district must then note any difference between these existing requirements and the requirements imposed by the proposed change.

There are no federal or state air pollution control requirements for water heaters. Several California air districts currently have NO_x requirements for water heaters and small boilers. The proposed amendments to Regulation 9, Rule 6 meet or exceed these other air district standards.

District Staff Impacts

Implementation of the proposed amendments is not expected to impose a significant administrative burden for the Air District. BAAQMD air quality permits are not currently required for water heaters and boilers, and will not be required under the proposed amendments. NO_x limits for these units will continue to be enforced by requiring certification of any water heaters sold, or installed.

VIII. RULE DEVELOPMENT PROCESS

The Air District developed proposed amendments and documented rationale for these proposals in a workshop report. These proposals were based on existing regulations in the Santa Barbara, Ventura, San Joaquin Valley, and South Coast air districts, and e-mail information exchange and discussions with water heater manufacturers, PG&E's Food Technology Center personnel, and individuals from the Valley Energy Efficiency Corporation's Super Efficient Gas Water Heating Appliance Initiative (SEGWHAI) Project. A public workshop was held on June 29, 2007. Thirteen people representing water heater manufacturers, PG&E, and affected users participated in the workshop, providing oral and written comments. Staff incorporated these comments into the current proposed amendments, as appropriate.

IX. CONCLUSIONS

Pursuant to the California Health and Safety Code Section 40727, before adopting, amending, or repealing a rule the Board of Directors must make findings of necessity, authority, clarity, consistency, non-duplication and reference. The proposal is:

- Necessary to supplement the District's ability to attain the State one-hour and eight-hour ozone standards,;
- Authorized by California Health and Safety Code Section 40702;
- Clear, in that the new regulation specifically delineates the affected industries, compliance options and administrative and monitoring requirements for industry subject to this rule;
- Consistent with other District rules, and not in conflict with state or federal law;
- Non-duplicative of other statutes, rules or regulations; and
- The proposed regulation properly references the applicable District rules and test methods and does not reference other existing law.

A socioeconomic analysis prepared by Applied Development Economics has found that the proposed amendments would not have a significant economic impact or cause regional job loss. District staff have reviewed and accepted this analysis. A California Environmental Quality Act analysis prepared by Environmental Audit, Inc., concludes that the proposed amendments would not result in adverse environmental impacts. District staff have reviewed and accepted this analysis as well. A Negative Declaration for the proposed amendments has been prepared and will be circulated for comment.

Staff recommends the adoption of the proposed amendments to Regulation 9, Rule 6: *Nitrogen Oxides from Natural Gas-Fired Water Heaters and Small Boilers*, and approval of the CEQA Negative Declaration.

X. REFERENCES

1. 10 CFR Part 430, Energy Conservation Program for Consumer Products: Energy Conservation Standards for Water Heaters; Final Rule, January 17, 2001; and U.S. Department of Energy, 42 U.S.C. Sections 6302(a)(5), 6316(a), and 6316(b)(1)
2. California Energy Commission, APPLIANCE EFFICIENCY REGULATIONS, CEC-400-2006-002-Rev1, Revised July 2006
3. Control Measure 13, 2005 Ozone Strategy, September 2005 Draft, Volume II, Bay Area Air Quality Management District Base Year 2005 Emission Inventory, Category 284 for residential water heaters, Categories 299 and 307 for point sources and Category 1590 for other area sources, BAAQMD, February, 2007
4. South Coast Air Quality Management District Rule 1121 – Control of Nitrogen Oxides from Residential Type, Natural Gas-Fired Water Heaters, Amended September 2004
5. SCAQMD Staff Report, Proposed Amended Rule 1121 – Control of Nitrogen Oxides from Residential Type, Natural Gas-Fired Water Heaters, August 2004
6. South Coast Air Quality Management District Rule 1146.2 – Emission of Oxides of Nitrogen from Large Water Heaters and Small Boilers and Process Heaters, Amended May 5, 2006
7. SCAQMD Staff Report, Proposed Amended Rule 1146.2 – Emission of Oxides of Nitrogen from Large Water Heaters and Small Boilers and Process Heaters, April 2006
8. SCAQMD Staff Report, Proposed Amended Rule 1146.2 – Emission of Oxides of Nitrogen from Large Water Heaters and Small Boilers and Process Heaters, December 2004
9. San Joaquin Valley Air Pollution Control District Rule 4308 – Boilers, Steam Generators, and process Heaters – 0.075 MM Btu/hr to 2.0 MM Btu/hr, Adopted 10/20/2005
10. Santa Barbara County APCD Rule 352 - Natural Gas-Fired Fan Type Central Furnaces and Residential Water Heaters, Adopted 9/16/1999
11. Santa Barbara County APCD Rule 360 - Emissions of Oxides of Nitrogen From Large Water Heaters and Small Boilers, Adopted 10/17/2002
12. Ventura County APCD Rule 74.11 – Natural Gas-Fired Residential Water Heaters – Control of NO_x, Adopted 4/9/85
13. Ventura County APCD Rule 74.11.1 – Large Water Heaters and Small Boilers, Adopted 9/14/1999
14. Internal District Memorandum, A First Look at NO_x/Ammonium Nitrate tradeoffs, BAAQMD, 9/8/1997