**San Joaquin Valley**
**Unified Air Pollution Control District**

## Best Performance Standard (BPS) x.x.xx

Date: February 22, 2011

<table>
<tr><td>Class</td><td>Gaseous Fuel-Fired Boilers</td></tr>
<tr><td>Category</td><td>New Hot Water Boilers, Fired Exclusively on Natural Gas or LPG</td></tr>
<tr><td rowspan="2">Best Performance Standard</td><td>Applicability Note: Hot water boilers fired with gaseous fuels other than natural gas or LPG (either exclusively or mixed with natural gas or LPG) and which meet the following standards shall be considered to meet BPS for their respective category.</td></tr>
<tr><td>Hot water boilers meeting this Best Performance Standard must comply with all three elements of this BPS (items 1, 2 and 3 listed below) where applicable:<br><br>1. The boiler shall meet the following design criteria or shall be equipped with an approved alternate heat recovery system which will collectively provide equivalent boiler efficiency. Equivalent heat recovery systems may utilize recovered heat for purposes other than steam generation provided such uses offset other fuel usage which would otherwise be required.<br><br><u>Design Criteria</u><br><br>A. Except for boilers subject to the requirements of item B below, the boiler shall be designed at full firing capacity to achieve a minimum thermal efficiency of 89 percent when operating with a return water temperature of 100°F and a temperature rise of 20°F.<br><br>B. Boilers for which more than 75% of the annual hours of operation will be with a cold water or return water temperature which is equal to or greater than 140°F or boilers which operate as secondary boilers in hydronic heating systems in which the primary or lead boiler is a condensing boiler meeting the requirements of item A above, shall be designed at full firing capacity to achieve a minimum thermal efficiency of 84 percent when operating with a return water temperature of 140°F and a temperature rise of 20°F.<br><br>2. Electric motors driving combustion air fans or induced draft fans shall have an efficiency meeting the standards of the National Electrical Manufacturer's Association (NEMA) for "premium efficiency" motors and shall each be operated with a variable speed control or equivalent for control of flow through the fan.<br><br>3. Hydronic boiler systems shall incorporate the applicable requirements of the 2008 California Energy Efficiency Standards, Subchapter 5, Section 144j. (Hydronic System Measures).</td></tr>
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|---|---|
| **Percentage Achieved GHG Emission Reduction Relative to Baseline Emissions** | **6.2%** |

| | |
|---|---|
| **District Project Number** | C-1100388 |
| **Evaluating Engineer** | Dennis Roberts, P.E. |
| **Lead Engineer** | Martin Keast |
| **Initial Public Notice Date** | April 8, 2010 |
| **Final Public Notice Date** | January 19, 2011 |
| **Determination Effective Date** | February 22, 2011 |

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# I. Best Performance Standard (BPS) Determination Introduction

## A. Purpose

To assist permit applicants, project proponents, and interested parties in assessing and reducing the impacts of project specific greenhouse gas emissions (GHG) on global climate change from stationary source projects, the San Joaquin Valley Air Pollution Control District (District) has adopted the polic*y: District Policy – Addressing GHG Emission Impacts for Stationary Source Projects Under CEQA When Serving as the Lead Agency.* This policy applies to projects for which the District has discretionary approval authority over the project and the District serves as the lead agency for CEQA purposes. Nonetheless, land use agencies can refer to it as guidance for projects that include stationary sources of emissions. The policy relies on the use of performance based standards, otherwise known as Best Performance Standards (BPS) to assess significance of project specific greenhouse gas emissions on global climate change during the environmental review process, as required by CEQA. Use of BPS is a method of streamlining the CEQA process of determining significance and is not a required emission reduction measure. Projects implementing BPS would be determined to have a less than cumulatively significant impact. Otherwise, demonstration of a 29 percent reduction in GHG emissions, from business-as-usual, is required to determine that a project would have a less than cumulatively significant impact.

## B. Definitions

Best Performance Standard for Stationary Source Projects is – a specific Class and Category, the most effective, District approved, Achieved-In-Practice means of reducing or limiting GHG emissions from a GHG emissions source, that is also economically feasible per the definition of achieved-in-practice. BPS includes equipment type, equipment design, and operational and maintenance practices for the identified service, operation, or emissions unit class and category.

Business-as-Usual is - the emissions for a type of equipment or operation within an identified class and category projected for the year 2020, assuming no change in GHG emissions per unit of activity as established for the baseline period, 2002-2004. To relate BAU to an emissions generating activity, the District proposes to establish emission factors per unit of activity, for each class and category, using the 2002-2004 baseline period as the reference.

Category is - a District approved subdivision within a “class” as identified by unique operational or technical aspects.

Class is - the broadest District approved division of stationary GHG sources based on fundamental type of equipment or industrial classification of the source operation.

### C. Determining Project Significance Using BPS

Use of BPS is a method of determining significance of project specific GHG emission impacts using established specifications. BPS is not a required mitigation of project related impacts. Use of BPS would streamline the significance determination process by pre-quantifying the emission reductions that would be achieved by a specific GHG emission reduction measure and pre-approving the use of such a measure to reduce project-related GHG emissions.

GHG emissions can be directly emitted from stationary sources of air pollution requiring operating permits from the District, or they may be emitted indirectly, as a result of increased electrical power usage, for instance. For traditional stationary source projects, BPS includes equipment type, equipment design, and operational and maintenance practices for the identified service, operation, or emissions unit class and category.

## II. Summary of BPS Determination Phases

The District has established *New Hot Water Boilers Fired Exclusively on Natural Gas or LPG* as a separate class and category which requires implementation of a Best Performance Standard (BPS) pursuant to the District's Climate Change Action Plan (CCAP). The District's determination of the BPS for this class and category has been made using the phased BPS development process established in the District's Final Staff Report, Addressing Greenhouse Gas Emissions under the California Environmental Quality Act. A summary of the specific implementation of the phased BPS development process for this specific determination is as follows:

| **BPS Development Process Phases for *New Hot Water Boilers Fired Exclusively on Natural Gas or LPG*** | | | |
|---|---|---|---|
| **Phase** | **Description** | **Date** | **Comments** |
| 1 | Initial Public Process | 02/10/10 | The District's intent notice sent by email to interested parties registered on the District's GHG web site for this class is attached as Appendix A. Comment received during the initial public process with District's responses are attached as Appendix B. |
| 2 | BPS Development | N/A | See Section III of this evaluation document. |
| 3 | Public Participation: Public Notice Start Date | 1/19/11 | The District's draft BPS determination was posted on the date indicated. |
| 4 | Public Participation: Public Notice End Date | 2/18/11 | No public comments were received during the period. |
| 5 | Finalization | 2/22/11 | The BPS established in this evaluation document is effective on the date of finalization. |

# III. Class and Category

***Gaseous Fuel-Fired Boilers*** is recognized as a distinct class based on the following:

- Boilers represent a distinct operation (indirect heat transfer from combustion to heat or boil water) when compared to all other permit units currently regulated by the District.
- The District already considers this a distinct class with respect to Best Available Control Technology (BACT) for criteria pollutant emissions.
- This is a distinct class with respect to the District's prohibitory rules for criteria pollutant emissions (Rules 4306 - 4308 and 4320).
- The District's current prohibitory rules currently only allow gaseous fuel firing (with liquid fuel allowed as a backup only for PUC natural gas during curtailment periods) or solid fuel-fired boilers (Rule 4352). Gaseous fuel fired units differ substantially from solid fuel units with respect to design requirements and thus are considered to be a separate class.

***"New Hot Water Boilers Fired Exclusively on Natural Gas or LPG"*** is recognized as a distinct category of boilers based on the following:

- New boilers are significantly less restrained by site specific conditions and thus have significantly more options in terms of implementing energy efficiency measures when compared to existing units. New boilers therefore comprise a separate category from existing.
- Gaseous fuels other than natural gas or LPG may have characteristics which will limit certain GHG emission reduction measures and therefore the firing of natural gas or LPG is considered to be a separate category,
- Hot Water Boilers form a distinct category of boiler which does not actually produce steam. Instead, the unit only delivers hot water. Physically, steam boilers and hot water boilers may be similar and many standard fire tube units can be configured to perform either operation. In recent years, hot water boiler designs have tended toward a once-through water tube design (no drum), more akin to a process heater. The hot water boiler category would include both 1) hydronic boilers which heat a re-circulating water stream which is used to supply heat indirectly to users (primarily used for space heating) and 2) hot water supply boilers which provide a supply of heated water for direct use in institutional and industrial facilities. Also, distinct from steam boilers, hot water boilers do not operate with blowdown or utilize a deaerator. Since typical hot water supply is 180-200$^{o}$F with a feedwater or return water temperature of 60 to 140$^{o}$F, low stack temperatures can be achieved resulting in high boiler efficiencies. In addition, the ratio of the mass flow of feedwater to the mass flow of flue gas is very large compared to that of a steam boiler which allows for a more cost efficient use of economizers to enhance heat recovery.

# IV. Public Notice of Intent

Prior to the development of BPS for this class, the District published a Notice of Intent. Public notification of the District's intent to develop BPS for this class was sent on April 1, 2010 to individuals registered with the CCAP list server. The District's notification is attached as Appendix A.

Comments received during the initial public outreach are presented in Appendix B. These comments have been used in the development of this BPS as presented below.

# V. BPS Development

## STEP 1. Establish Baseline Emissions Factor for Class and Category

The Baseline Emission Factor (BEF) is defined as the three-year average (2002-2004) of GHG emissions for a particular class and category of equipment in the San Joaquin Valley (SJV), expressed as annual GHG emissions per unit of activity. The Baseline Emission Factor is calculated by first defining an operation which is representative of the average population of units of this type in the SJV during the Baseline Period and then determining the specific emissions per unit throughput for the representative unit.

### A. Representative Baseline Operation

For *New Hot Water Boilers Fired Exclusively on Natural Gas or LPG*, the representative baseline operation has been determined to be a steam boiler with the following attributes:

- *Natural gas-fired forced draft hot water boiler (hydronic) with a rated temperature rise of 40*°F *and a return water temperature of 140*°F
- *Thermal efficiency 82% at maximum firing rate*
- *Ultra Low NOx burner operating with 20% flue gas recirculation (FGR)*
- *Oxygen content of 4.0 volume % dry basis in the stack gas.*

This determination was based on discussions with boiler manufacturer representatives which indicate that currently, as well as during the baseline period, hydronic applications represent the predominant hot water boiler usage in the San Joaquin Valley and that typical operating conditions applicable to the baseline period would be a thermal efficiency of 82%, a return temperature of 140°F and a supply temperature of 180°F.

An operating stack oxygen content of 4.0% and an FGR rate of 20% were selected for the baseline period based on estimates by boiler manufacturer representatives which were in turn based on typical excess air and FGR requirements for operation of with an ultra low NOx burner at a 30 ppmv NOx emission level (consistent with the District's prohibitory rule for boilers during the Baseline Period).

## B. Basis and Assumptions

- All direct GHG emissions are produced due to combustion of natural gas in this unit.
- The GHG emission factor for natural gas combustion is 117 lb-$CO_2$(e)/MMBtu per CCAR document[1].
- GHG emissions are stated as "$CO_2$ equivalents" ($CO_2$(e)) which includes the global warming potential of methane and nitrous oxide emissions associated with gaseous fuel combustion.
- Convection/radiation loss from the boiler is assumed to be 0.5% of fuel firing.
- Water supply temperature from the boiler is 180$^o$F
- Water return temperature to the boiler is 140$^o$F
- Stack temperature estimated at 387 $^o$F for 82% eff.
- Based upon a boiler heat and mass balance for the given conditions, the following quantities are applicable:
  - Net hot water production is 20,481 lb-hot water/MMBtu fired or a Specific Fuel Consumption (SFC) of 1,000,000/0.02048 = 48.8 MMBtu/MMlb hot water
  - Flue gas rate is 12,303 scf/MMbtu fired
  - Combustion air rate is 11,302 scf/MMBtu fired
- Indirect emissions produced due to operation of the combustion air fan will be considered. Indirect emissions from other electric motors associated with the boiler are not considered significant.
- Static efficiency of the combustion air fan is assumed to be 60%.
- Flue gas side pressure drop for the burner + boiler is assumed to be 20 inches water column when operating without FGR with a flue gas rate of 12,303 scf/MMBtu (12 "WC for burner, 8 "WC for boiler).
- An allowance for additional dynamic loss in the boiler due to FGR will be added which is assumed to be proportional to the square of the mass flow. For an FGR rate of 20 %, flow through the boiler is estimated as:
  12,302 x 1.2 = 14,762 scf/MMBtu fired

  Pressure drop through the system is then calculated as:

  Burner 12.0 " WC

[1] California Climate Change Action Registry (CCAR), Version 3.1, January, 2009 (Appendix C, Tables C.7 and C.8)

| | | |
|---|---|---|
| Boiler | 8" WC x $(14{,}762/12{,}302)^2$ = | 11.5 |
| Total | | 23.5 |

- Electric motor efficiency is estimated at 87% for a conventional electric motor.
- Indirect emissions from electric power consumption are calculated based on the current PG&E electric power generation factor of 0.524 lb-CO2(e) per kWh.

## C. Unit of Activity

To relate Business-as-Usual to an emissions generating activity, it is necessary to establish an emission factor per unit of activity, for the established class and category, using the 2002-2004 baseline period as the reference.

The resulting emissions factor is the combination of:

GHG emission reductions achieved through technology, and
GHG emission reductions achieved through changes in activity efficiencies

A unit of activity for this class and category will be taken as 1,000,000 lb (1 MMlb) of hot water supplied.

For purposes of this BPS determination, it will be assumed that GHG emissions reductions achieved through changes in activity efficiencies are not significant. This assumption has been made based on:

- This class and category of equipment is used at a wide range of facilities, diverse in operation and size, making it difficult to characterize specific efficiency improvements.

- A search of available literature did not yield any data which would support an estimate of GHG emission from boilers in this class and category based on changes in activity efficiencies.since the baseline period .

## D. Calculations

The Baseline Emission Factor (BEF) is the sum of the direct ($GHG_D$) and indirect ($GHG_I$) emissions (on a per unit of activity basis), stated as lb-CO2 equivalent:

$BEF = GHG_D + GHG_I$

Direct Emissions:

$GHG_D = E_f \times SFC$

$E_f$ = GHG emission factor = 117 lb- $CO_{2(e)}$/MMBtu of natural gas

SFC = Specific Fuel Consumption = 48.8 MMBtu/1000 MMlb water as stated in the basis.

Direct emissions are then calculated as:

$GHG_D$ = 117 lb-$CO_{2(e)}$/MMBtu x 48.8 MMBtu/MMlb water
= 5,710 lb/MMlb water

Indirect Emissions

Indirect emissions produced from operation of electric motors are determined by the following:

GHG (electric motor) = Electric Utility GHG Emission Factor x kWh consumed

To determine kWh consumption per MMlb water produced it is necessary to first determine the Bhp requirement for the gas compression operation by the combustion air blower. Specific brake horsepower requirement by the combustion air fan is calculated from the following equation for adiabatic compression of an ideal gas[2]:

Bhp-hr/1000 lb steam = (T/520) x (0.001072M/n$E$) x $[(p_2/p_1)^n-1]$

T = gas temperature, $^oR$. Assuming constant heat capacity, gas temperature is based on the mix temperature of fresh combustion air (at 68 F) plus 20 % FGR (at 380 F):

$$T = \frac{11{,}302 \text{ scf} \times 68^o + 12{,}303 \text{ scf} \times 20\% \times 380^o}{11{,}302 \text{ scf} + 12{,}302 \text{ scf} \times 20\%}$$

T = 124 $^o$F or 584 $^o$R
M = scf combustion air + flue gas x $\%_{FGR}$ (per 1000 lb water)
= (11,302 scf air/MMbtu + 12,302 scf flue gas/MMBtu x 20%) x 60.8 MMBtu/1000 lb water = 837,000 scf gas/MMlb water
n = 0.2857 (typical for diatomic gases)
$E$ = efficiency = 60%
$p_1$ = atmospheric pressure = 407 “WC
$p_2$ = atmospheric pressure + pressure drop
= 407.0 + 23.5 = 430.5 “WC

Substituting the given values into the equation:

Bhp-hr/MMlb water = 95.0

[2] See: Clarke, Loyal and Robert Davidson, Manual for Process Engineering Calculations, 2nd Edition, McGraw-Hill, New York, 1975, p.360.

Converting to kWh based on an 87% efficient electric motor and a conversion factor of 0.7457 kWh/bhp:

= (95.0 x 0.7457)/87% = 81.4 kWh/MMlb water

$GHG_I$ = GHG (electric motors)
= 0.524 lb-$CO_{2(e)}$/kWh x 81.4 kWh/MMlb water
= 42.7 lb $CO_{2(e)}$ per MMlb water

The Baseline Emission Factor is the sum of the direct and the indirect emissions:

BEF = *5,710 + 42.7 = 5,753 lb-* $CO_2$(e)/ MMlb water

## STEP 2. Technologically Feasible GHG Emission Control Measures

### A. Analysis of Potential Control Measures

Direct Recovery of Low Temperature Heat

Hot water boiler efficiency is largely determined by the extent to which low temperature energy is recovered from the boiler flue gases. This is accomplished by providing sufficient heat transfer surface in a water tube design or by adding an economizer section to a fire tube design. When the flue gas temperature is lowered to approximately 135$^o$F, condensing operation occurs due to the bulk condensation of moisture in the flue gas. At this point, significant additional heat recovery is possible due to the recovery of latent heat fro the condensation. Generally, return water or feedwater temperatures must be below approximately 130$^o$F to allow this level of heat recovery. In general practice, units operating with stack temperatures below 140 $^o$F are considered to be in condensing service while units operating over 140 $^o$F are considered to be in non-condensing service.

Hot water boilers typically operate as either 1) hot water supply units which heat water on a once-through basis for use in commercial or industrial operations or 2) hydronic boilers which heat a re-circulating water stream (typically used in commercial and institutional space heating applications). Hot water supply boilers typically operate with cold feedwater (50-60$^o$F) and supply water at 180-200$^o$F to the facility on a once-through basis. Since potential boiler efficiency is largely a function of the temperature of the feedwater to the unit (with lower temperatures resulting in higher potential efficiency), these units can achieve efficiencies significantly in excess of 90% when return water temperatures are sufficiently low by utilizing condensing economizer technology.

Hydronic boilers operate with variable return water temperatures which depend primarily on ambient temperatures. California Energy Standards now require new hydronic heating systems to be either equipped with variable flow or temperature reset controls which result in significantly reduced return water temperatures during low heating demand periods (periods of mild ambient conditions, occurring extensively during the spring and fall, less during winter months). Such reduced demand periods may constitute up to 75% of the annual operation of the unit. During the coldest periods of the winter, return temperatures may rise to 140-160$^{o}$F when the space heating system is operating at maximum capacity. Units designed for condensing operation provide significant efficiency gains during the spring, fall and during mild periods of the winter; however, during peak heating periods, units equipped with condensing economizers may not provide significant efficiency improvement over non-condensing units due to the higher return water temperatures. For this reason, hydronic boiler systems may be designed as “hybrid” systems comprised of a condensing lead boiler carrying the heating load during most of the heating system and a secondary non-condensing unit which is brought into service during peak demand periods when return water temperatures exceed 140$^{o}$F. Such a system can provide overall thermal efficiencies which are equivalent to a 100 % condensing boiler design but offer capital cost savings.

The efficiency of a particular hot water boiler is typically specified based on a given return water temperature (or feedwater temperature) and a given temperature rise in the boiler (the difference between the hot water supply temperature and the return water or feedwater temperature). Condensing units are typically rated at a return water temperature of 100$^{o}$F or less whereas non-condensing units are typically rated at 140$^{o}$F which is the minimum return temperature allowed for these units. Both condensing and non-condensing units are typically rated based on a temperature rise of 20$^{o}$F.

Air Pre-heaters

Another way to recover heat from the boiler flue gases is by use of an air preheater. In this case the recovered heat is transferred to the incoming combustion air and returned to the boiler, improving boiler efficiency. Air pre-heaters may be used in conjunction with an economizer to further enhance heat recovery; however, air pre-heaters are rarely used with hot water boilers. When compared to economizers, they are generally more expensive per unit of energy recovery, require more space, and consume additional electrical energy to move the combustion air through the heat exchanger. In addition, use of heated combustion air may be problematic due potential impacts on $NO_x$ emissions from the unit. In general, where other low temperature heat receptors are available, the economizer is the more economical approach for increasing thermal efficiency of the unit while avoiding potential increases in $NO_x$ emissions associated with air pre-heaters. Based on the above discussion, air pre-heaters are determined to not be technologically feasible for a general designation as BPS. However, the BPS would allow use of air preheaters in lieu of economizers where it is demonstrated that the proposed system achieves the same level of heat recovery from the stack gases.

Limiting Excess Air and Flue Gas Recirculation

The combustion process in a boiler generally requires an excess of air (air in excess of the stoichiometric requirement for combustion of the fuel) to ensure efficient combustion and safe operation. Operations which exceed the minimum amount of excess air as required for clean and safe operation result in a loss of efficiency as a due to the increased stack losses. When boiler burners are manually tuned on a periodic basis, they are typically adjusted to a conservatively high excess air value, ensuring safe operation over the entire operating range of the boiler.

Additionally, low efficiency burners or those employing high flue gas recirculation rates to control $NO_x$ emissions may require operation with up to 4-5% excess oxygen to ensure stable operation. From an efficiency standpoint, the excess $O_2$ means that there are not only energy losses incurred to heat the excess air up to the stack temperature but, in addition, incremental electrical energy consumption is required by the combustion air blower to handle higher excess air, leading to additional indirect GHG emissions.

FGR is utilized to control combustion temperature at the burner with recirculation rates up to 40-45% in some ultra low NOx applications. This recirculation has a negative impact on boiler performance since it typically reduces the turndown capability, requires operation at higher excess air rates and requires substantial fan horsepower to operate.

While limiting excess air and flue gas recirculation are achieved-in-practice GHG reduction measures for higher pressure boilers, hot water boilers have fewer options available to meet emission limits on NOx; their options are primarily limited to burner technology since their stack temperatures are generally not sufficiently high for operation of selective catalytic reduction systems. Burner options to meet NOx emission limits are generally either high FGR designs or designs which use high excess air in lieu of FGR for controlling flame temperature. Based on this, placing limits on excess air and flue gas recirculation rates is not considered to be a feasible GHG reduction measure for this category of boiler.

Use of Premium Efficiency Motors with Speed Control for Combustion Air Fans

An electric motor efficiency standard is published by the National Electrical Manufacturers Association (NEMA) which is identified as the “NEMA Premium Efficiency Electric Motors Program”. For large motors, the NEMA premium efficiency motor provides a gain of approximately 5-8 percentage points in motor efficiency when compared to a standard efficiency motor. The NEMA specification covers motors up to 500 horsepower and motors meeting this specification are in common use and are available from most major electric motor manufacturers.

Control of the combustion air fan operation by use of a variable speed electric motor will provide substantial energy savings when compared to operation at a fixed speed and controlled by throttling the discharge flow. The most common and economical variable speed drive is the variable frequency drive (VFD) which has become commonly available in the last decade and is typical for new boiler fan applications. The VFD provides especially significant energy savings when a boiler is operated at substantial turndown rations which can result in throttling away more than half the rated energy output of the motor.

Use of High Efficiency Combustion Air Fans
The peak efficiency of centrifugal fans may vary from 60 to 80% depending upon fan design and application. Use of a higher efficiency fan provides savings in either the indirect GHG emissions due to the significant reduction in electric motor horsepower for motor-driven fans or savings in the direct GHG emissions when the fan is driven by a steam turbine. However, the absolute value of efficiency which can be achieved is highly dependent upon the specific operating conditions including flow, pressure, and temperature, all of which may vary significantly for any specific boiler. Given this variability as well as the absence of any effective industry standard for fan efficiency, the District's opinion is that specification of combustion air fan efficiency cannot be realistically included as a technologically feasible reduction measure in the BPS for boilers at this time.

Use of prescriptive requirements for hydronic systems from the 2008 California Energy Efficiency Standard
Prescriptive requirements of the 2008 California Energy Efficiency Standard require that hydronic systems be designed for variable flow and that they utilize either variable flow control or temperature reset controls. These measures impact the hydronic boiler by reducing the return temperature to the minimum required to meet the thermal load of the facility. Operation at the minimum return water temperature serves to maximize the efficiency of the boiler.

## B. Listing of Technologically Feasible Control Measures

For the specific equipment or operation being proposed, all technologically feasible GHG emissions reduction measures are listed, including equipment selection, design elements and best management practices, that do not result in an increase in criteria pollutant emissions compared to the proposed equipment or operation.

**Table 1**
**Technologically Feasible GHG Reduction Measures for *New Hot Water Boilers Fired Exclusively on Natural Gas or LPG***

| Reduction Measure | Qualifications |
|---|---|
| **1.** The boiler shall meet the following design criteria or shall be equipped with an approved alternate heat recovery system which will collectively provide equivalent boiler efficiency. Equivalent heat recovery systems may utilize recovered heat for purposes other than steam generation provided such uses offset other fuel usage which would otherwise be required. | |
| Design Criteria<br><br>A. Except for boilers subject to the requirements of item B below, the boiler shall be designed at full firing capacity to achieve a minimum thermal efficiency of 89 percent when operating with a return water temperature of 100°F and a temperature rise of 20°F. | *The specified level of performance represents use of a condensing boiler which allows enhanced energy efficiency for the boiler when return water or feedwater temperatures are lower.* |
| B. Boilers for which more than 75% of the annual hours of operation will be with a cold water or return water temperature which is equal to or greater than 140 °F or boilers which operate as secondary boilers in hydronic heating systems in which the primary or lead boiler is a condensing boiler meeting the requirements of item A above, shall be designed at full firing capacity to achieve a minimum thermal efficiency of 84 percent when operating with a return water temperature of 140°F and a temperature rise of 20°F. | *The specified level of performance represents use of a high efficiency non-condensing boiler in applications where a condensing boiler would not provide a significant energy efficiency advantage.* |
| **2.** Electric motors driving combustion air fans or induced draft fans shall have an efficiency meeting the standards of the National Electrical Manufacturer's Association (NEMA) for "premium efficiency" motors and shall each be operated with a variable speed control or equivalent for control of flow through the fan. | *Use of premium efficiency motors with variable speed drives significantly reduces electric power consumption by the boiler operation, particularly during periods of reduced-rate operation.* |
| **3.** Hydronic boiler systems shall incorporate the requirements of the 2008 California Energy Efficiency Standards, Subchapter 5, Section 144j. (Hydronic System Measures). | *The specified requirements result in operation of the system with the minimum return water temperature required to transfer the heating load to the facility and allow maximum efficiency for hydronic boilers.* |

All of the control measures identified above are consistent with control equipment for criteria pollutants which meets current regulatory requirements. None of the identified control measures would result in an increase in emissions of criteria pollutants.

**STEP 3. Identify all Achieved-in-Practice GHG Emission Control Measures**

For all technologically feasible GHG emission reduction measures, all GHG reduction measures determined to be Achieved-in-Practice are identified. Achieved-in-Practice is defined as any equipment, technology, practice or operation available in the United States that has been installed and operated or used at a commercial or stationary source site for a reasonable period of time sufficient to demonstrate that the equipment, the technology, the practice or the operation is reliable when operated in a manner that is typical for the process. In determining whether equipment, technology, practice or operation is Achieved-in-Practice, the District will consider the extent to which grants, incentives or other financial subsidies influence the economic feasibility of its use.

The following findings or considerations are applicable to this class and category:

1. The District reviewed current manufacturer's standard guaranteed performance specifications for hot water boilers as well as the achieved-in-practice performance for an existing unit located at Growers Transplanting Inc. in Salinas, CA. The unit at Growers Transplanting operates with a 170$^{o}$F return temperature and a 30$^{o}$F temperature rise. Flue gas exits the boiler at 225$^{o}$F, yielding an estimated basic efficiency of approximately 85.5% for the boiler without consideration of the economizer. An analysis of the economizer operation, which heats a separate circulating water stream with a 100 $^{o}$F return temperature and an 11$^{o}$F temperature rise, indicates that the combined boiler/economizer operation has a thermal efficiency of approximately 93.5%, supporting the proposed BPS performance. Review of manufacturer's published thermal efficiency rating for high efficiency hydronic boilers, such as those for Fulton Boilers (Fulton Heating Solutions, Pulaski, New York) and for Bryan Boilers (Bryan Steam LLC, Peru, Indiana) indicates that the published ratings generally equal or exceed the proposed BPS performance.

2. Use of NEMA Premium Efficiency motors and the use of variable speed drives are commonplace in industry in general and are generally recognized to be achieved-in-practice technology for combustion air fans.

3. Hydronic system measures per the California Building Energy Efficiency Standards are already a prescriptive requirement for new building projects and thus can be considered to be achieved in practice.

All technologically feasible GHG reduction measures listed in Table 1 meet the following criteria:

<u>All technology listed is in current commercial use.</u>

All technologically feasible GHG reduction measures listed in Table 1 are based on technology (condensing hot water boilers, high efficiency motors with variable speed drives, hydronic system efficiency measures) which is currently in commercial use. This technology has been in place for a significant number of years and was developed and implemented without benefit of grants, incentives or other financial subsidies.

<u>Implementation of all listed technology does not result in an increase in criteria pollutant emissions.</u>

In general, since all proposed measures do not affect the criteria pollutant emission factors and generally result in a reduction in the firing of fuel, criteria pollutant emissions will generally be reduced with implementation of BPS.

Therefore, all items are deemed to be Achieved-in-Practice. Since all of the achieved-in-practice measures identified are independent of each other, concurrent implementation of all measures results in a strictly additive benefit (none of the measures are mutually exclusive). Therefore, all identified reduction measures are considered to be a single measure in effect. Since there are no other mutually exclusive measures identified, there is, in effect, a single achieved in practice reduction measure identified and the District proposes to deem the concurrent implementation of all identified achieved-in-practice reduction measures as BPS for this class and category.

## STEP 4. Quantify the Potential GHG Emission and Percent Reduction for Each Identified Achieved-in-Practice GHG Emission Reduction Measure

For each Achieved-in-Practice GHG emission reduction measure identified:

a. Quantify the potential GHG emissions per unit of activity ($G_a$)
b. Express the potential GHG emission reduction as a percent ($G_p$) of Baseline GHG emissions factor per unit of activity (BEF)

As stated above, there is a single identified achieved in practice control measure for this class and category. Therefore, the GHG emission quantification will be presented as a single value based on the additive contribution of each individual measure incorporated into the overall control measure.

## A. Basis and Assumptions:

- As previously stated, a hydronic hot water boiler is most representative of this category of boiler in the San Joaquin Valley
- The boiler is equipped with a surface stabilized combustion burner utilizing high excess air rate and no FGR for control of NOx emissions. Stack $O_2$ concentration is assumed to be 5.5%.
- Due to the application of variable flow and/or temperature reset controls, it is assumed that the typical average return water temperature will be reduced by 20 $^oF$, to 120 $^oF$.
- Based on typical manufacturers curves for efficiency versus return temperature, it is estimated that a boiler meeting this specification will exhibit an efficiency of approximately 86.8% with a return water temperature of 120 $^oF$.
- Based upon a boiler heat and mass balance for the given conditions, the following quantities are applicable:
  - Net hot water production is 21,719 lb-hot water/MMBtu fired or a Specific Fuel Consumption (SFC) of 1,000,000/.021719 = 46.0 MMBtu/MMlb hot water
  - Flue gas rate is 13,197 scf/MMbtu fired
  - Combustion air rate is 12,200 scf/MMBtu fired
- Flue gas side pressure drop for the boiler is adjusted from the baseline case to account for revised flow through the boiler for this case relative to the baseline assumptions. For the BPS case with 0% FGR, flue gas rate through the boiler is 13,197 x 1.0 = 13,197 scf/MMBtu fired. For the baseline case, a boiler pressure drop of 11.5 "WC was determined based on a flow rate of 14,762 scf/MMBtu. Correcting this to the lower flow rate for this case yields the following boiler pressure drop:

  11.5 "WC x $(13{,}197/14{,}762)^2$ = 9.2 "WC

- Since the BPS unit is assumed to be equipped with an economizer, an additional pressure drop of 1 "WC will be included.
- Total system flue gas pressure drop is calculated as follows:

| | |
|---|---|
| Burner | 12.0 "WC |
| Boiler | 9.2 "WC |
| Extended Surface | 1.0 |
| Total | 22.2 "WC |

- A 30% reduction in net specific electric power consumption is attributed to use of VSD during turndown periods.
- All other assumptions and basis are the same as the baseline case.

## B. Calculation of Potential GHG Emissions per Unit of Activity ($G_a$):

$G_a$ is the sum of the direct ($GHG_D$) and indirect ($GHG_I$) emissions (per unit of activity):

$G_a = GHG_D + GHG_I$

<u>Direct Emissions:</u>

$GHG_D = E_f \times SFC$

$E_f$ = GHG emission factor = 117 lb- $CO_{2(e)}$/MMBtu of natural gas

SFC = Specific Fuel Consumption = 46.0 Btu/MMlb water (as stated in basis)

Direct emissions are then calculated as:

$GHG_D$ = 117 lb-$CO_{2(e)}$/MMBtu x 46.0 MMBtu/MMlb water
= 5,382 lb/ MMlb water

<u>Indirect Emissions</u>

Indirect emissions consist of emissions from operation of the electric motor driving the combustion air fan. These determined by the following:

GHG (electric motor) = Electric Utility GHG Emission Factor x kWh consumed

To determine kWh consumption per 1000 lb steam produced it is necessary to first determine the Bhp requirement for the gas compression operation by the combustion air blower. Specific brake horsepower requirement by the combustion air fan is calculated from the following equation for adiabatic compression of an ideal gas[3]:

Bhp-hr/1000 lb steam = $(T/520) \times (0.001072M/nE) \times [(p_2/p_1)^n-1]$

| | | |
|---|---|---|
| T | = | gas temperature, $^oR$. T =68 $^oF$ or 528 $^oR$ |
| M | = | 13,197 scf air/MMbtu x 46.0 MMBtu/MMlb water |
| | = | 607,062 scf gas/ MMlb water |
| n | = | 0.2857 (typical for diatomic gases) |
| *E* | = | efficiency = 60% |
| $p_1$ | = | atmospheric pressure = 407 "WC |
| $p_2$ | = | atmospheric pressure + pressure drop |
| | = | 407.0 + 22.2 = 429.2 "WC |

[3] See: Clarke, Loyal and Robert Davidson, Manual for Process Engineering Calculations, 2nd Edition, McGraw-Hill, New York, 1975, p.360.

Substituting the given values into the equation:

Bhp-hr/MMlb water = 58.9

Applying a 30% reduction to account for the use of a VFD:

| | | |
|---|---|---|
| Combustion air fan specific energy consumption | = | (1-30%) x 57.3 |
| | = | 41.2 Bhp-hr/MMlb water |

Converting to kWh based on an 95% efficient electric motors and a conversion factor of 0.7457 kWh/bhp:

= (41.2 x 0.7457)/95% = 32.3 kWh/ MMlb water

GHG (electric motors) = 0.524 lb- $CO_{2(e)}$/kWh x 32.3 kWh/ MMlb water
= 16.9 lb $CO_{2(e)}$ per MMlb water

Total Indirect Emissions:

$GHG_i$ = GHG (electric motors) = 16.9 lb $CO_{2(e)}$ per MMlb water

GHG Emissions per Unit of Activity is then calculated as:

$G_a = GHG_D + GHG_I$ = *5,382 + 16.9 = 5,399 lb*- $CO_{2(e)}$/ MMlb water

**C. Calculation of Potential GHG Emission Reduction as a Percentage of the Baseline Emission Factor ($G_p$):**

$G_p$ = (BEF - $G_a$) / BEF = (5,753 – 5,399)/5,753 = 6.2%

**STEP 5. Rank all Achieved-in-Practice GHG emission reduction measures by order of % GHG emissions reduction**

Since only a single achieved in practice control measure is identified, no ranking is necessary.

## STEP 6. Establish the Best Performance Standard (BPS) for this Class and Category

For Stationary Source Projects for which the District must issue permits, Best Performance Standard is – "For a specific Class and Category, the most effective, District approved, Achieved-In-Practice means of reducing or limiting GHG emissions from a GHG emissions source, that is also economically feasible per the definition of achieved-in-practice. BPS includes equipment type, equipment design, and operational and maintenance practices for the identified service, operation, or emissions unit class and category".

Based on the definition above, Best Performance Standard (BPS) for this class and category is determined as:

***Best Performance Standard for New Boilers with Rated Steam Pressure Less Than 75 psig, Fired Exclusively on Natural Gas or LPG***

**Hot water boilers meeting this Best Performance Standard must comply with all three elements of this BPS (items 1, 2 and 3 listed below) where applicable:**

1. **The boiler shall meet the following design criteria or shall be equipped with an approved alternate heat recovery system which will collectively provide equivalent boiler efficiency. Equivalent heat recovery systems may utilize recovered heat for purposes other than steam generation provided such uses offset other fuel usage which would otherwise be required.**

   **Design Criteria**

   A. **Except for boilers subject to the requirements of item B below, the boiler shall be designed at full firing capacity to achieve a minimum thermal efficiency of 89 percent when operating with a return water temperature of 100$^{o}$F and a temperature rise of 20$^{o}$F.**

   B. **Boilers for which more than 75% of the annual hours of operation will be with a cold water or return water temperature which is equal to or greater than 140$^{o}$F or boilers which operate as secondary boilers in hydronic heating systems in which the primary or lead boiler is a condensing boiler meeting the requirements of item A above, shall be designed at full firing capacity to achieve a minimum thermal efficiency of 84 percent when operating with a return water temperature of 140$^{o}$F and a temperature rise of 20$^{o}$F.**

2. **Electric motors driving combustion air fans or induced draft fans shall have an efficiency meeting the standards of the National Electrical Manufacturer's Association (NEMA) for "premium efficiency" motors and shall each be operated with a variable speed control or equivalent for control of flow through the fan.**

3. **Hydronic boiler systems shall incorporate the requirements of the 2008 California Energy Efficiency Standards, Subchapter 5, Section 144j. (Hydronic System Measures).**

### STEP 7. Eliminate All Other Achieved-in-Practice Options from Consideration as Best Performance Standard

The following Achieved-in-Practice GHG control measures, identified in Section II.4 and ranked in Table 3 of Section II.5 are specifically eliminated from consideration as Best Performance Standard since they have GHG control efficiencies which are less than that of the selected Best Performance Standard as stated in Section II.6:

No other Achieved-in-Practice options were identified.

## V. Appendices

| | |
|---|---|
| Appendix A: | Public Notice of Intent |
| Appendix B: | Comments Received after Initial Public Outreach |

# Appendix A
# Public Notice of Intent

**Notice Of Development Of**
# Best Performance Standards

NOTICE IS HEREBY GIVEN that the San Joaquin Valley Air Pollution Control District solicits public comment on development of Best Performance Standards for the following Stationary Source class and category of greenhouse gas emissions:

## BOILERS
## Subject to District Permitting Requirements

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The District is soliciting public input on the following topics for the subject Class and Category of greenhouse gas emission source:

- Recommendations regarding the scope of the proposed Class and Category (Stationary GHG sources group based on fundamental type of equipment or industrial classification of the source operation),
- Recommendations regarding processes or operational activities the District should consider when establishing Baseline Emissions for the subject Class and Category,
- Recommendations regarding processes or operational activities the District should consider when converting Baseline Emissions into emissions per unit of activity, and
- Recommendations regarding technologies to be evaluated by the District, when establishing Best Performance Standards for the subject Class and Category.

Information regarding development of Best Performance Standard for the subject Class and Category of greenhouse gas emission source can be obtained from the District's website at http://www.valleyair.org/Programs/CCAP/CCAP_idx.htm.

Written comments regarding the subject Best Performance Standard should be addressed to Dennis Roberts by email, dennis.roberts@valleyair.org, or by mail at SJVUAPCD, 1990 East Gettysburg Avenue, Fresno, CA 93726 and must be received by **February 23, 2010**. For additional information, please contact Dennis Roberts by e-mail or by phone at (559) 230-5919.

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Information regarding the District's Climate Action Plan and how to address GHG emissions impacts under CEQA, can be obtained from the District's website at http://www.valleyair.org/Programs/CCAP/CCAP_idx.htm.

# Appendix B
# Comment Received After Initial Public Outreach

# Comments Received During the Public Notice of Intent and Responses to Comments

**Stakeholders Written Comments:**

Nationwide Boiler Incorporated (NBI)
Plains All America, L.P. (PAA)
Kern Oil and Refining Co. (KOR)
Enviro Tech Consultants, Inc. (ETC)
Berry Petroleum Company (BPC)
R.F. McDonald Co. (RFM)

1. **Comment:** In going forward with development of BPS for process heaters it is important to recognize that in certain facilities plant off gas is accountable for a large quantity of the fuel. The Plains LPG frac and isom facility in Shafter is currently under the refinery regulated portion of rule 4306 and 4320 for the heaters on site. It may be important to distinguish between PUC gas and plant off gas in future BPS requirements (PAA)

**Response:** The District recognizes that fuels other than natural gas or LPG may have specific limitations with respect to energy efficiency technology. The BPS will be clarified to reflect that it is applicable to these fuels only.

2. **Comment:** I would advocate that the strict prohibitory rules recently placed on this division of heaters through 4320, 4623 and 4455 would already have satisfactory BPS in place. (PAA, ETC)

**Response:** The District's prohibitory rules do not address GHG emission or energy efficiency and thus would not represent BPS.

3. **Comment:** In my opinion the District can not receive adequate information to form BPS without first meeting with industry and their representatives to discuss what the baseline period equipment is. A blanket request for information will only create confusion and the submittal of information that can only be applied to a single company. Once the District understands the difference not only between industrial types, but the differences within the same industry, can the District begin receiving adequate information to form an achievable and economical BPS. (BPC)

**Response:** The District recognizes the importance of industry responses to specific proposals. The draft BPS will be posted for public comments to ensure this input is received.

4. **Comment:** There are multiple types of equipment, facility design, and operational characteristics that make establishment of "BPS" difficult. We

recommend that the District structure BPS following the existing categories and organization of the District's BACT guidelines. (ETC)

**Response:** Since BACT addresses only criteria pollutants and is determined under criteria different from that of BPS, the District cannot necessarily utilize the classifications established for BACT. To the extent that the BACT classification forms a reasonable classification for GHG emissions, it will be considered.

5. **Comment:** BPS needs to provide exemptions for small sources of GHG emissions. EPA is proposing a threshold of 25,000 MT CO2e, and a similar threshold should be part of any BPS determination. (ETC)

**Response:** Comment noted. Since this comment is general and not specific to the BPS for boilers, the District will not respond to this comment as a part of this document.

6. **Comment:** Cost effectiveness needs to be considered when determining BPS. (ETC)

**Response:** Cost effectiveness is included to the extent that is required under the definition of achieved-in-practice.