CASE Boilers: Response to Comments from **8/17/11 CEC Staff Workshop**

Comments from Jim Smelcer, Lochinvar; email to Michael McGaraghan dated 8/25/11

CASE Topic: Combustion air positive shut-off for new commercial and process boilers

Comment 1): The following comments relative to Proposal #1 are based on the Title 24 proposal and supporting analyses to mandate "flue" dampers. It could be easily inferred based on the assumptions used that the intended goal is to mandate "vent" dampers. If this is the case, the comments below should be received as relative to "flue" dampers, and serve as arguments to support that consideration to mandate flue dampers based on the analysis provided is flawed.

Response: This measure applies only to new atmospheric boilers and requires positive shutoff of airflow across the combustion chamber when the burner is off. Either a flue damper or vent damper would qualify. The term flue damper is mentioned in the overview of the measure as an example of a common device used for this purpose but use of a vent damper also meets the intent of the measure.

Comment 2): The assumption that a flue damper is readily available for most atmospheric boilers is false. A flue damper assembly must be tailored for the flue opening of a boiler. Flue openings vary both in size and geometry for a given input, and there is no standardization between manufacturers for a common off the shelf purchased flue damper assembly as opposed to, for instance, a vent damper. Flue dampers are usually designed by the boiler manufacturer as an integral part of the boiler.

Response: Both flue dampers and vent dampers are available from a number of suppliers, including Enervex (866-619-2513) and Field Controls (248-330-0526). They supply dampers to boiler OEMs and offer after-market products. Flue and vent dampers up to 16" diameter are currently being manufactured by Field Controls and up to 36" by Enervex. Conversations with these manufacturers indicate they can accommodate future requirements if larger dampers are required, however this is unlikely. The technology has been readily available for many years. Virtually all new installations of large boilers are forced draft, and therefore exempt from this requirement. Therefore, it is likely this measure would impact smaller atmospheric boilers, which already has a supply base of dampers.

Comment 3): There is no consideration given for additional wiring construction and safety controls for a flue damper assembly. It would have to be interconnected within the boiler system and provisions made to do that. It is not a common practice for wiring harnesses on atmospheric boilers in the market place to have add-on connections for a flue damper assembly as an aftermarket option. Also, considering the size of the boiler as a variable requiring varying damper motor torques to function over the range of models, stronger, higher torque motors will be needed, requiring higher VA transformer ampacities with significantly higher costs that are not considered in the analysis as well.

Response: Different damper assemblies will have different power requirements and configurations. For example, some are powered from the boiler while others are powered separately with a 120V power connection. Feedback from the damper manufacturers indicates integrating a flue or vent damper into the boiler controls isn't a problem and they accomplish this all the time as part of their business.

Additional costs associated with a higher VA transformer were not considered in the cost analysis of this measure because it typically wouldn't be necessary. Please provide additional data to support the claim that modifications to the boiler controls would be required at a significant cost.

Comment 4): Due to the environment associated with where a flue damper shutoff would be applied, provisions must be made to remotely locate and connect a flue damper motor with the external linkage assemblies to allow the motor to be free of exposure to high flue temperatures and corrosive flue gas environments. This also is generally unique to every boiler, and the costs associated with the construction are not mentioned, nor appear to be accounted for.

Response: Flue damper assemblies are designed to withstand their environment. Again, the difference between flue damper and vent damper comes into play. Flue dampers, installed directly on the outlet of the boiler, need to withstand higher temperatures than vent dampers and are constructed accordingly. Flue and vent dampers are rated to withstand temperatures up to 500oF and have operated successfully in boiler applications for years without operational problems. Dampers are constructed of stainless steel providing resistance to corrosion and are typically covered by a 5 to 10 year warranty. A damper replacement within 15 years of operation is unusual.

The incremental cost of this measure is $1,500, which is a factor of two times greater than the expected initial cost. This is a conservative estimate and large enough to account for additional costs for any unique installations.

Comment 5): The estimated maintenance costs of $150 over a 10 year period for the flue damper assembly, given the complexity of the design, are most likely underestimated. There are more working parts to a flue damper assembly other than the motor, and $100 for a motor, or for any component, is not taking inflation into account over the 10 year period.

Response: This estimate was provided by damper manufacturers and reflects typical repairs. This estimate accounts for inflation using a discount rate of 3%. The life cycle cost analysis (LCCA) methodology prescribed by the CEC can be found here: http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/general_cec_documents/2011-01-14_LCC_Methodology_2013.pdf

Comment 6): The estimated energy costs used to calculate the payback period also do not mention adjustments for inflation. This should also be accounted for.

Response: As stated in section 3 Methodology, Architectural Energy Corporation (AEC) provided energy costs for use in the analysis that consider the average time dependent valuation of energy across all California climate zones for the 15 year measure lifetime. A 3% real discount rate (adjusted for inflation) was used. This is consistent with all CASE proposals.

Comment 7): The statement that no additional verification costs or acceptance testing is required is false. Flue damper assemblies installed on a boiler must be examined by the certifying agency with the flue damper in place as required by the boiler test standard. It is uncommon today for a boiler offering to be certified with a flue damper.

Response: The damper can be included with the boiler from the boiler OEM or as an after market field installation. After market damper installations may need to be inspected by a local boiler inspector, but this would be an insignificant addition to the many other points under inspection during a new boiler installation and startup. If the boiler manufacturer chooses to include the damper assembly with their boiler, it may need to be certified. Based on feedback from Field Controls, dampers that they currently include with boiler offerings from OEMs are certified.

Comment 8): Given the response in 6 (verification costs), there would be additional production and inventory costs for setting up and maintaining new models for California with these requirements. These costs are not accounted for in the analyses.

Response: If the boiler manufacturer chooses to include a damper with the boiler, they would have to account for procuring the dampers, but since this measure can be an after market installation, it's not a mandatory responsibility of the boiler OEM.

Comment 9): The energy savings of $1791 for a 700,000 Btu/Hr input boiler over a 15 year period of time for a mandated flue damper is based entirely on an estimated off-cycle savings, and given that the assumptions were flawed, a revised calculated payback would most certainly be extended beyond the maximum 11.9 years payback period permitted under Title 24.

Response: The revised energy savings calculation is now based on 26% of the boiler hours in standby mode, or 760 hrs/year for process boilers. The revised damper requirement is now 2.5 MMBtuh rather than 0.7 MMBtuh.

Comment 10): There were no specifics related to the analyses for applications of flue dampers for an indoor versus an outdoor installation, although it is assumed that the analyses are based on an indoor application. Off-cycle losses for an outdoor application are not presented, and would be a higher percentage of the total losses (more than 2%), and should be included as part of the analysis given that outdoor/unheated space boiler applications do exist in California. For these purposes, consideration for flue dampers for outdoor applications only might be in order.

Response: Boiler room installation was considered for this measure because it was the conservative approach. Regardless, many process boilers installed indoors use an outdoor air intake to supply combustion air. An outdoor installation would likely result in higher standby losses because of the lower ambient temperatures.

CASE TOPIC: Combustion Fan VFD for commercial and process boilers

Comment 11): There were no considerations given to non-VFD multi-speed conventional combustion fan motors as a viable alternative. The control strategy, timeframe to implement, and incremental cost adder, and the payback for this option could be attractive, and certainly more favorable, and should be included in the analysis.

Response: Multi-speed fans are a better option than constant speed fans, but they are not commonly installed and VFDs are the preferred option. This measure applies to fan motors 10hp and larger. Multi-speed fans may be worthwhile for smaller fan motors. The proposed language would allow a multi-speed fan if it met the requirements of limiting fan motor demand to no more than 30% design wattage at 50% design air volume.

Comment 12): The report states that motor sizes of 10 HP or greater will be mandated as VFD, but that VFD drives are available as low as 1.5 HP. VFD drives are actually available and used in volume at fractional horsepower sizes today in commercial boilers. Is it assumed that the payback period limitation under Title 24 of 11.9 years is exceeded for motor sizes less than 5 HP? An analysis of a typical ½ or ¾ HP applications would have been good to include in the analyses as verification to see if this fact correlates to the smaller, more predominantly used VFD's today.

Response: The life cycle cost analysis for this measure showed cost effectiveness on combustion fan motors of 5 hp and larger for process boilers and 10 hp and larger for commercial boilers. VFD on smaller motors would not be cost effective. Communication with stakeholders in multiple stakeholder meetings in 2010 and 2011 indicates a VFD on the combustion fan motor is available down to 1.5 HP but is most commonly installed on 10HP fan motors and larger. For this reason, for a conservative approach, and for consistency, combustion air fans with motors 10 HP or larger were included in this measure for both process and commercial boilers.

Comment 13): Similar comments related to the need for additional acceptance testing apply here as well as for mandating flue dampers. See 6 above.

Response: Good practice is to include boiler flue damper in scheduled maintenance activity. There are currently no acceptance requirements for flue or vent dampers.

CASE Topic: Parallel position and O2 trim control for process boilers

Comment 14): Were NOx emissions tests conducted at more than one firing rate? Recent SCAQMD rulings have dictated that NOx testing will be conducted at full and minimum firing rates, and could include others depending upon what firing condition the boiler is in when arriving to conduct audits. Even though the protocol only requires testing at full firing rate, was this taken into consideration when examining NOx performance at other than full firing rate conditions?

Response: The requirement for O2 trim control applies to process boilers with an input capacity greater than 10 MMBtu/h, and requires that excess O2 be maintained at or below 3% over the entire firing range. This is mutually compatible with the NOx emissions standards. O2 trim controls will compliment the NOx requirements by ensuring a consistent excess O2 % across the entire firing rate. In fact, parallel position control comes standard with low- and ultra-

low-NOx burners used to meet the NOx standards in the various air districts. Per conversations with staff scientists at various air districts, this proposed standard is not in conflict with their NOx regulations.

Comment 15): It is common knowledge that there are applications limitations for many styles of commonly used high turndown burner head designs because they exhibit resonant burner noise when operating at low burner turndown conditions if excess air is less than 40%. Was this taken into consideration? If this practice is mandated, the result would most lead to a complete burner redesign of major proportions.

Response: Limiting excess O2 may pose a challenge for some boiler/burner designs due to resonant burner noise at low excess air conditions, but our research suggests this isn't common. Excess O2 levels of 3% and 5% are readily achievable with the use of O2 trim control and parallel positioning, respectively.

Comment 16): The application of parallel positioning controls to achieve reduced excess air levels is something that some of us in the industry are not familiar with at all, therefore, the cost analysis comparisons cannot be verified due to lack of knowledge. However, the incremental cost adder of between $8000 and $9000 dollars is substantial to achieve a marginal energy cost savings estimate of $829 annually and hard to justify, especially when the maintenance costs are estimated "conservatively" at $400 per year based on boiler control representatives and not owner/operators. The data is lacking credibility without their input. It is also amusing to note that these calculations using their estimates arrive at exactly the maximum payback period allowed by Title 24. There's no room for error.

Response: Parallel position control comes standard with low- and ultra-low-NOx burners used to meet the NOx standards in the various air districts, thus it is a very common technology. Our research is based on interviews with equipment manufacturers and owner/operators. The incremental cost for this measure is based on information from both groups. Following the approved CEC life cycle cost methodology, the analysis proved it to be cost effective at a boiler size of 2.8 MMBtuh and larger. Again, following a conservative approach, minimum recommended boiler size for inclusion in this measure is 5 MMBtuh, leaving some room for error.

Comments from Joe Wallace, A.O. Smith Water Products Co. per letter to the CEC dated August 30, 2011.

Comment 17): ASHRAE Standard 90.1 and the various NOx requirements already sufficiently address energy efficiency.

ASHRAE Standard 90.1 addresses minimum boiler efficiency and heating hot water system requirements. Changes to ASHRAE 90.1 are in process, which will address boiler part load efficiency requirements, but these changes are many years from completion and will complement the measures proposed here. The various NOx requirements address emissions only, with the exception of certain efficiency requirements not related to the measures presented in these proposals. Therefore all of the proposals presented here complement both ASHRAE 90.1 and the various NOx emissions standards.

Comment 18): Ongoing ASHRAE 90.1 discussion about commercial boiler efficiency should be considered.

Same as above.

Comment 19): Other technologies have been discounted and/or not considered. Applying prescriptive requirements to process boilers is not justified.

Response: The measures included in the proposals are readily available and already in wide use. While other measures may be considered for future code revisions, the measures investigated here have been determined to be cost effective by the CEC cost methodology. The proposed code language is not written in prescriptive form, to allow a variety of potential compliance approaches.

Comment 20): The CEC has ignored new technologies that may be available in the industry, and applying these prescriptive requirements on current boiler design could actually hurt efficiency.

Response: Please provide additional details explaining how efficiency is compromised.

Comment 21): Some of the proposed measures are not applicable to all space heating commercial boiler designs.

Response: Please provide additional details to clarify your comment.

Comment 22): Recommends delaying the proposed changes to commercial boilers because other (better) energy efficient options are currently available and more are coming with ASHRAE 90.1.

Response: Current 90.1 requirements specify minimum boiler efficiency requirements and heating hot water system requirements. Changes to these standards are likely many years away. These proposals do not conflict with the 90.1 standards.

Notes from Jon McHugh and Mike McGaraghan from the CEC workshop on August 17, 2011

Comment 23): AO Smith would have a problem with any add on that changes gas/air mixtures. A 3rd party certifying body would as well.

Response: The measures included in the proposals are readily available and already in wide use. The proposed code language is written to allow a variety of potential compliance approaches. An exception is now included for higher efficiency commercial boilers. Commercial boilers with steady state full-load thermal efficiency 85% or higher are exempt from the requirement of maintaining excess oxygen concentrations at less than or equal to 5.0%.

Comment 24): Lochinvar has a fixed gas nozzle assembly that induces the right amount of gas for a given airflow, and is not set up to have separate gas and air controls. Therefore they aren't compatible with parallel positioning controls.

Response: This measure only applies to boilers 5MMBtuh and larger. Some burners may not qualify. An exception is now included for higher efficiency commercial boilers per comment 23.

Comment 25): DOE does not recognize savings on flue dampers

Response: The California LCCA methodology is unique to Title 24.

Comment 26): Flue dampers are not commercially available

See response to Comment 2) above.

Comment 27): Consider providing an exception for boilers with efficiencies above XX% such as for condensing boilers

Response: An exception is now included for higher efficiency commercial boilers. Commercial boilers with steady state full-load thermal efficiency 85% or higher are exempt from the requirement of maintaining excess oxygen concentrations at less than or equal to 5.0%.

Letter from Frank Stanonik, Chief Technical Advisor, AHRI

Comment 28): The proposed measures affecting commercial boilers are inappropriate and the analysis has significant flaws. Energy savings have been overestimated and the costs underestimated.

Response: Energy savings methodology followed the CEC Life Cycle Cost Methodology as required by the CEC. The strategy was to conservatively estimate costs and energy savings. Cost data were directly obtained from equipment manufacturers.

Comment 29): Process boilers currently are not covered by federal efficiency regulations or CEC Title 20 appliance efficiency regulations. Commercial boilers have been subject to efficiency regulations for at least 20 years. These two products have different baselines for measuring the benefits of efficiency improvement measures.

Response: An exception is now included for higher efficiency commercial boilers. Commercial boilers with steady state full-load thermal efficiency 85% or higher are exempt from the requirement of maintaining excess oxygen concentrations at less than or equal to 5.0%.

Comment 30): Process boilers are significantly different in design and function compared to commercial boilers.

Response: The proposed measures are currently being applied to both commercial and process boilers.

Comment 31): Title 24 covers efficiency requirements of hydronic heating systems and service hot water distribution systems. There are no corresponding efficiency regulations for systems connected to process boilers.

Response: The proposed measures are part of the boiler itself, not the hot water distribution system.

Comment 32): Emissions regulations applicable to commercial boilers in various AQMD's impact boiler design and combustion efficiency of commercial boilers. This is not the case with process boilers.

Response: The proposed measures are currently being applied to both commercial and process boilers. An exception is now included for higher efficiency commercial boilers.

Comment 33): There are more stringent federal minimum efficiency standards for commercial boilers becoming effective March 2, 2012.

Response: For a conservative approach, the boiler efficiency used in the LCCA exceeds the 2012 Federal standards. For example, boiler efficiency of 85% was considered in the baseline case for the parallel position controls measure, whereas the minimum boiler efficiency in the new standard is 80% - 84% for hot water boilers and 79% - 81% for steam boilers. Therefore the energy savings calculations are conservative in their estimates, assuming a baseline boiler performance exceeding the new standards.

Comment 34): The analysis of the flue damper measure assumes a 2% energy savings benefit and is based on the difference between the combustion efficiency and thermal efficiency when the burner is on. The 2722 hours of operation in the analysis includes the times when the burner is on. There is no energy benefit when the burner is on. The value of the energy savings benefit is significantly less than 2% of the boilers input.

Response: The revised energy savings calculation is now based on 26% of the boiler hours in standby mode, or 707 hrs/year for commercial boilers. The revised damper requirement is now 2.5 MMBtuh rather than 0.7 MMBtuh.

Comment 35): The provisions that address two or more boilers connected to the same stack don't adequately address the common control strategy of having a back up boiler that operates sporadically.

Response: New boilers are subject to this requirement regardless of their anticipated fire time.

Comment 36): The analysis has not considered the actual installations variations of commercial boilers in indoor, outdoor, and conditioned spaces. Each present a different scenario for considering standby losses.

Response: See Comment 10.

Comment 37): Combustion air fan VFD proposal doesn't consider the overall effect of the fan on the safe and efficient operation of the boiler. A similar proposal was rejected by the ASHRAE 90.1 committee.

Response: These changes apply to new boilers and VFD fan motors are typically included as an offering from the manufacturer. Discussion with Jeff Stein at Taylor Engineering suggests the ASHRAE Standard 90.1 committee rejected the required use of VFDs on combustion fans because it seemed too prescriptive. This requirement is written as performance-based rather than prescriptive language.

Comment 38): The analysis of boiler run times is not adequately explained to evaluate its accuracy.

Response: Run time of 2722 hrs for commercial boilers is based on a series of energy simulations performed for commercial buildings. 2920 hrs for process boilers is a conservative estimate based on a single 8-hour shift every day of the year. The boiler run time histogram was provided by Enovity, which is a compilation of boilers they monitored as part of their third-party commercial and industrial boiler program.

Comment 39): The analysis doesn't consider current designs of boilers that employ multi-speed conventional combustion fan motors.

Response: See Comment 11.

Comment 40): Figure 16 in the commercial boiler proposal that shows boiler efficiency and excess air should be updated to reflect current boiler designs.

Response: The physics of this curve have not changed. Actual performance will be better than this theoretical curve. The combustion efficiency presented in this graph is conservative and reasonable to use in the baseline calculation, especially considering the low stack temperature (170 deg. F).

Comment 41): The parallel positioning measure baseline considers a boiler whose efficiency is unregulated. This is true for process boilers, but not for commercial boilers. The benefit of this measure for commercial boilers must be analyzed in terms of the current efficiencies and corresponding excess air levels of commercial boilers. It must also assess the influence of California emission regulations.

Response: See Comment 33.

Comment 42): The use of parallel positioning controls on commercial boilers is not common practice. The cost estimates to implement this measure should be further scrutinized, particularly maintenance costs.

Response: Cost data was provided by boiler controls reps from Autoflame, Alzeta, Cleaver Brooks, and Fireye.

Comment 43): The statement that parallel positioning control is standard with low and ultra low NOx burners may be true for process boilers, but we are not aware of its widespread use in commercial boilers complying with NOx emission regulations in California.

Response: Parallel positioning controls are widely available. Regardless, an exception is now included for higher efficiency commercial boilers as described earlier.

We are grateful to the following people who provided input to these responses:

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