Appliance Standards Awareness Project
Alliance to Save Energy
American Council for an Energy-Efficient Economy
Natural Resources Defense Council
Northwest Energy Efficiency Alliance

June 22, 2016

Ms. Brenda Edwards
U.S. Department of Energy
Building Technologies Program
Mailstop EE-5B
1000 Independence Avenue, SW
Washington, DC 20585

RE: Docket Number EERE–2013–BT–STD–0030/RIN 1904–AD01: Notice of Proposed Rulemaking for Energy Conservation Standards for Commercial Packaged Boilers

Dear Ms. Edwards:

This letter constitutes the comments of the Appliance Standards Awareness Project (ASAP), Alliance to Save Energy, American Council for an Energy-Efficient Economy (ACEEE), Natural Resources Defense Council (NRDC), and Northwest Energy Efficiency Alliance (NEEA) on the notice of proposed rulemaking (NOPR) for energy conservation standards for commercial packaged boilers. 81 Fed. Reg. 15836 (March 24, 2016). We appreciate the opportunity to provide input to the Department.

We urge DOE to adopt TSL 3. In the NOPR, DOE proposes to adopt TSL 2.[1] TSL 3 is identical to TSL 2 except TSL 3 contains a condensing efficiency level (95%) for small, gas-fired hot water commercial packaged boilers. DOE's analysis shows that TSL 3, which is cost effective for purchasers, would more than double national energy savings from 0.39 quads at TSL 2 to 0.97 quads at TSL 3.[2] DOE's analysis also shows that more than 25% of small, gas-fired hot water boiler models already meet TSL 3.[3] At TSL 3, DOE estimates that average LCC savings would be $300 for purchasers of small, gas-fired hot water boilers,[4] and that total NPV would be $0.3-2.6 billion.[5] As we describe below, we believe that DOE is likely underestimating the energy savings and overestimating the repair costs associated with condensing boilers, which would mean that the economic savings at TSL 3 are even larger than shown in the NOPR. We also note that the current Federal Energy Management Program (FEMP) efficiency requirement

[1] 81 Fed. Reg. 15911.
[2] 81 Fed. Reg. 15901.
[3] Technical Support Document. p. 8-36. TSL 3 for small, gas-fired hot water boilers represents a thermal efficiency of 95%.
[4] 81 Fed. Reg. 15890.
[5] 81 Fed. Reg. 15903-04.

for gas-fired hot water commercial boilers is 94%,[6] which means that gas-fired hot water boilers purchased by federal agencies must now all be condensing.

We strongly support DOE's proposal not to differentiate commercial packaged boilers based on draft type. The current standards for commercial packaged boilers include separate equipment classes for gas-fired steam boilers based on draft type. In the NOPR, DOE proposes to consolidate the equipment classes that are currently divided by draft type. We agree with DOE's conclusion that there is no distinct performance-related utility that is provided by natural draft boilers, and that consequently there is no justification to maintain separate equipment classes for natural draft boilers.[7]

DOE's analysis for the NOPR likely underestimates the energy savings associated with condensing commercial packaged boilers. In the NOPR, DOE estimates that on average, small, gas-fired hot water condensing boilers with a rated efficiency of 95% reduce energy consumption by 12% relative to non-condensing boilers with a rated efficiency of 80%.[8] NREL conducted an assessment of five GSA buildings at the Denver Federal Center. In three of the buildings, condensing boilers with rated efficiencies of 95% replaced 80% efficient non-condensing boilers without making any changes to the heating distribution systems.[9] In these three buildings, NREL estimated weather-normalized savings of 16-19%.[10] The assessment noted that even greater savings could be achieved through some simple steps such as implementing a more aggressive outdoor reset schedule.

PNNL conducted a similar assessment of a 31-story Federal office building (Peachtree Summit Federal Building) where condensing boilers with rated efficiencies of 95% replaced non-condensing boilers. The analysis found that the condensing boilers operated at an average efficiency of 93.5%, reducing energy consumption by 14% relative to an 80% efficient boiler plant.[11] We note that due to the impacts of high return water temperature operation and cycling, which both decrease average operational efficiency, a typical non-condensing boiler with a rated efficiency of 80% would operate with an annual efficiency below 80%. For example, in the NREL assessment, the pre-retrofit hot water boilers which had rated efficiencies of 80% had estimated actual annual efficiencies of 72-76%.[12] Therefore, savings from the condensing boilers in the PNNL assessment relative to boilers rated at 80% efficiency are likely significantly greater than 14%. Further, the assessment noted that greater savings could be achieved through a modification to the Building Automation System (BAS) to further lower the supply water temperature and the hot water flow rate during periods when the building is unoccupied.

We believe that DOE's return water temperature distributions for condensing boilers represent overly conservative scenarios. In the analysis for the NOPR, DOE assumes two different return water temperature (RWT) scenarios for condensing boilers: a "low RWT"

[6] http://energy.gov/eere/femp/covered-product-category-commercial-boilers.
[7] 81 Fed. Reg. 15851.
[8] Technical Support Document. p. 7-13.
[9] Buildings 25, 54, and 810.
[10] http://www.nrel.gov/docs/fy14osti/56402.pdf. p. 26.
[11] http://www.gsa.gov/portal/mediaId/163539/fileName/GPG_Condensing_Boiler_-_FINAL_DRAFT_4-15-13_508.action. p. 3.
[12] Boilers in buildings 25, 54, and 810.

distribution, where the RWT varies from 84 F to 140 F based on outdoor temperature, and a "high RWT" distribution, where the RWT varies from 110 F and 160 F as shown in the table below.[13] The "low RWT" distribution is applied to all condensing boilers in the new construction market, 25% of replacement boilers in buildings built after 1990, and 5% of replacement boilers in buildings built before 1990, while the "high RWT" distribution is applied to all other condensing boiler installations.[14]

Table 7B.2.2 Return Water Temperatures at Each Outside Air Temperature Bin

Temperature Bin	Condensing Units - Low RWT *°F*	Condensing Units – High RWT *°F*	Non-Condensing Units – High RWT *°F*
Over 68 °F	-	-	-
50–68 °F	84	110	135
41–50 °F	112	132	150
28–41 °F	116	136	155
14–28 °F	129	149	160
At or below 14 °F	140	160	160

Condensing boilers operate in condensing mode at return water temperatures below about 130 F.[15] In the "high RWT" scenario, RWTs for condensing boilers are assumed to be below 130 F only at outdoor temperatures above 50 F. However, we understand that even in existing buildings where the heating systems were not designed for condensing boilers, condensing boilers should be able to operate in condensing mode for a substantial portion of the heating season.[16]

Below is an outdoor reset schedule from an installation, operation and maintenance manual for an Aerco commercial packaged boiler.[17] The manual notes that the default building reference temperature is 70 F and the default reset ratio is 1.2.[18] With these default settings and assuming a ΔT of 20 F,[19] the RWT would be below 130 F at outdoor temperatures of 5 F and above. If we instead look at a reset ratio of 2.0, where the header temperature would be 180 F at an outdoor temperature of 15 F (similar to DOE's "high RWT" scenario), the RWT would be below 130 F at outdoor temperatures above 30 F.

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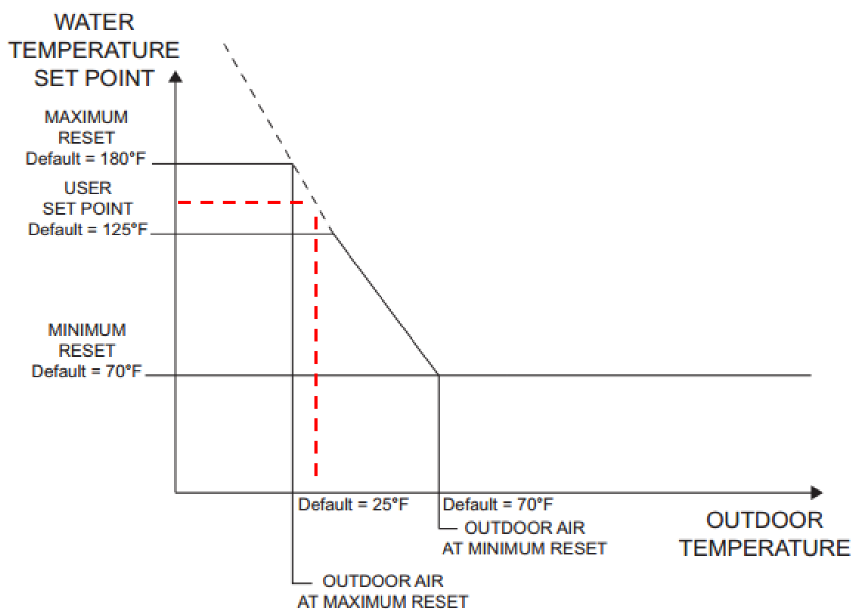
[13] Technical Support Document. p. 7B-4.
[14] Technical Support Document. p. 7-9.
[15] http://www.revisionenergy.com/pdfs/condensing-boiler-article.pdf. Figure 2.
[16] https://www.indoorcomfortmarketing.com/can-high-temperature-baseboard-co-exist-with-condensing-boilers.html.
[17] http://aerco.com/sites/default/files/document/document/OMM-0082_0K_GF-130_BMK750_%26_1000_G-16-0450_and%20UP_03-11-16.pdf. p. 148.
[18] http://aerco.com/sites/default/files/document/document/OMM-0082_0K_GF-130_BMK750_%26_1000_G-16-0450_and%20UP_03-11-16.pdf. p. 45.
[19] ΔT is the difference between the supply water temperature and the return water temperature.

Table D-4. Header Temperature for a Building Reference Temperature = 70°F

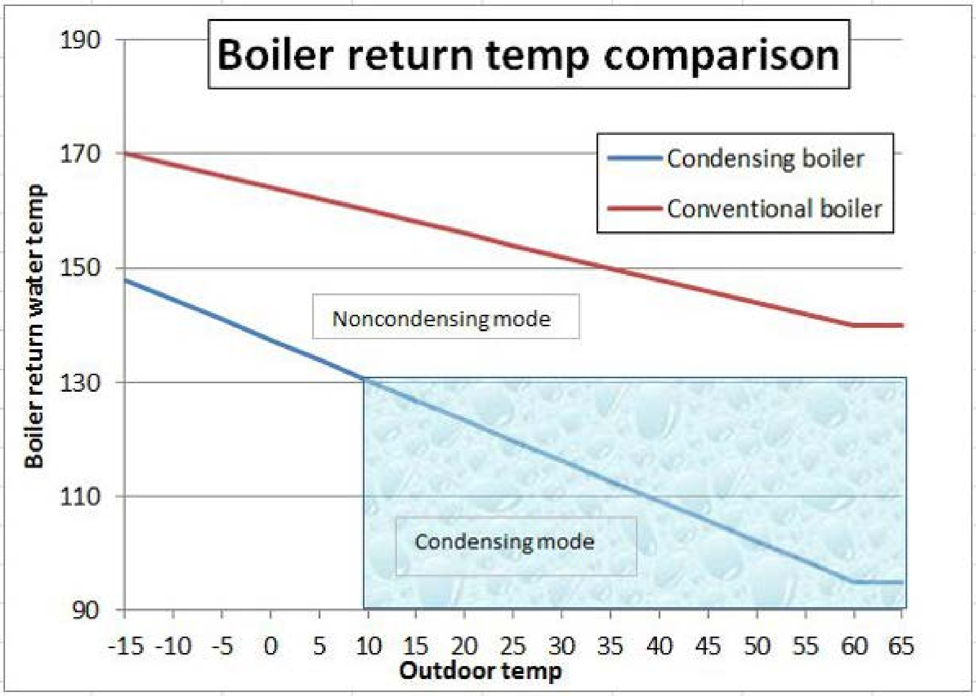
Air Temp °F	Air Temp °C	RESET RATIO 0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4
70	**21.1**	70	70	70	70	70	70	70	70	70	70
65	**18.3**	73	74	75	76	77	78	79	80	81	82
60	**15.6**	76	78	80	82	84	86	88	90	92	94
55	**12.8**	79	82	85	88	91	94	97	100	103	106
50	**10.0**	82	86	90	94	98	102	106	110	114	118
45	**7.2**	85	90	95	100	105	110	115	120	125	130
40	**4.4**	88	94	100	106	112	118	124	130	136	142
35	**1.7**	91	98	105	112	119	126	133	140	147	154
30	**-1.1**	94	102	110	118	126	134	142	150	158	166
25	**-3.9**	97	106	115	124	133	142	151	160	169	178
20	**-6.7**	100	110	120	130	140	150	160	170	180	190
15	**-9.4**	103	114	125	136	147	158	169	180	191	202
10	**-12.2**	106	118	130	142	154	166	178	190	202	214
5	**-15.0**	109	122	135	148	161	174	187	200	213	
0	**-17.8**	112	126	140	154	168	182	196	210		
-5	**-20.6**	115	130	145	160	175	190	205			
-10	**-23.3**	118	134	150	166	182	198	214			
-15	**-26.1**	121	138	155	172	189	206				
-20	**-28.9**	124	142	160	178	196	214				

The figure below shows the default outdoor reset curve for a Lochinvar commercial packaged boiler.[20] The maximum supply temperature is 180 F at an outdoor temperature of 25 F. Based on the curve and assuming a ΔT of 20 F, the RWT would remain below 130 F (with the water temperature set point below 150 F) at outdoor temperatures above 37 F.



[20] http://www.lochinvar.com/_linefiles/KBX-SER-Rev%20F.pdf. p. 19.

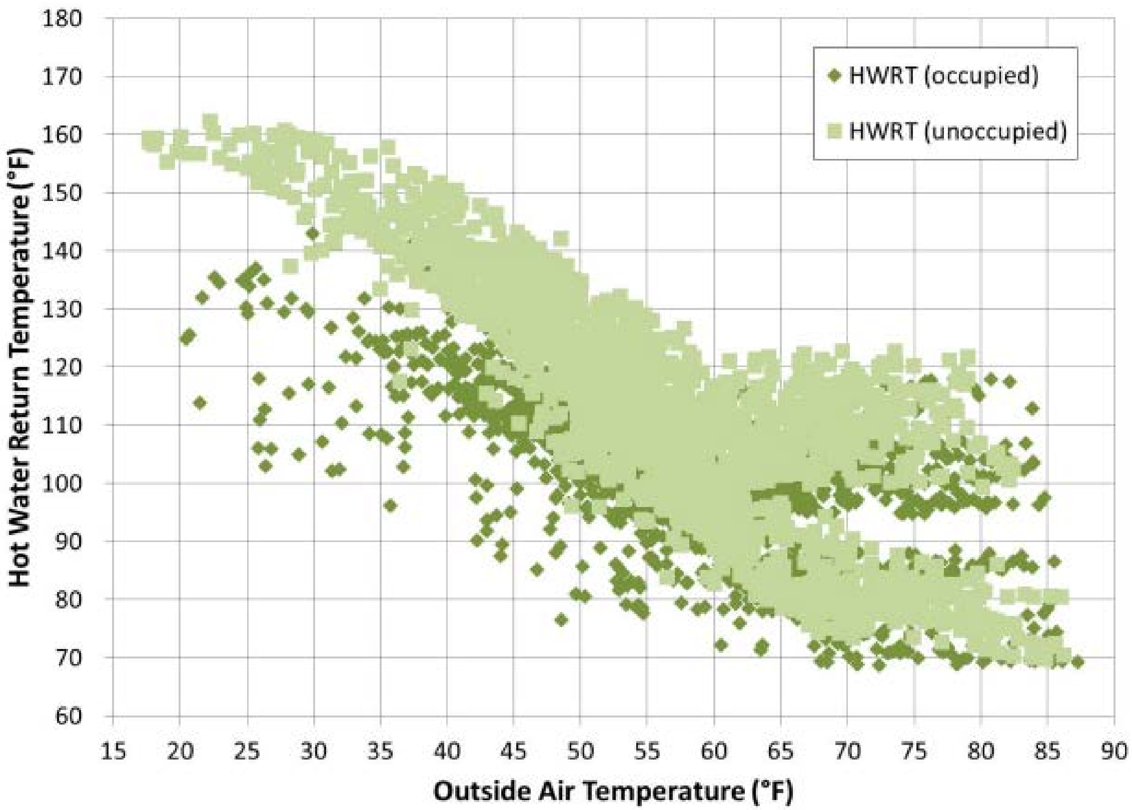
Below is a figure from the Minnesota Department of Commerce showing typical return water temperatures for both condensing and non-condensing boilers. The figure shows that in cold climates where the design day temperature may be around -15 F, condensing boilers can operate in condensing mode at outdoor temperatures above about 10 F. A facilities and safety manager for Beltrami County, MN reported that at the Beltrami County Jail, where condensing boilers replaced non-condensing boilers, at an outdoor temperature of 42 F, the RWT was 109 F, which reflects the condensing boiler RWT curve in the figure.[21]



Finally, the Peachtree Federal Summit Building, which was the subject of the PNNL assessment noted above, was constructed in 1975,[22] and was heated with non-condensing boilers before the recent retrofit, which means that the building likely would fall into DOE's "high RWT" scenario. DOE's analysis assumes that the lowest RWTs are 84 F and 110 F in the "low RWT" and "high RWT" scenarios, respectively. However, as shown in the figure below from the PNNL assessment, the condensing boilers operated with RWTs below 110 F for a significant portion of the time.[23] Notably, the boilers operated with RWTs as low as about 70 F, which is lower than the lowest RWT assumed in DOE's "low RWT" scenario.

[21] http://mn.gov/commerce/media/blog/success-stories/?id=17-71392#/list/appId//filterType//filterValue//page//sort//order/.
[22] http://www.gsa.gov/portal/mediaId/163539/fileName/GPG_Condensing_Boiler_-_FINAL_DRAFT_4-15-13_508.action. p. 9.
[23] http://www.gsa.gov/portal/mediaId/163539/fileName/GPG_Condensing_Boiler_-_FINAL_DRAFT_4-15-13_508.action. p. 29.

Figure 9: Hot Water Return Temperature (HWRT) versus Outside Air Temperature for Occupied and Unoccupied Operating Status



In sum, both default outdoor reset schedules from manufacturers of condensing boilers and real-world implementations of condensing boilers replacing non-condensing boilers suggest that condensing boilers can operate a greater portion of the heating season in condensing mode than that assumed in DOE's analysis. Operating a greater portion of the time in condensing mode significantly increases the savings from condensing boilers relative to non-condensing boilers.

There are various strategies that can be implemented in both new and existing buildings to reduce the RWT so that a condensing boiler can operate more of the time in condensing mode. DOE's "low RWT" scenario shown above assumes that at design conditions the boiler will operate with a RWT of 140 F. However, in new buildings and in scenarios where an existing building heating distribution system is being retrofitted, heating coils can be designed with ΔTs of 50-60 F.[24] With ΔTs of 50-60 F and a supply temperature even as high as 180 F, condensing boilers will always operate in condensing mode since the return water temperature will always be no higher than 130 F.

In existing buildings where the heating system was designed for non-condensing boilers, there are several no-cost or low-cost strategies to reduce the RWTs. For example, heating distribution systems tend to be oversized. An oversized heating distribution system means that even though the system may have been designed for 180 F supply water at design conditions, a maximum

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[24] http://www.nrel.gov/docs/fy14osti/56402.pdf. p. 14.

supply water temperature of 160 F may be sufficient.[25] In addition, many existing buildings have likely had building envelope improvements such as the installation of new windows and/or additional insulation, which reduce the heating load and allow the heating system to operate with lower supply temperatures than the original design temperature.[26] With a lower maximum supply water temperature and no change to the slope of the outdoor reset curve, the number of hours a condensing boiler operates in condensing mode can be increased significantly. Second, utilizing a load-based reset schedule can result in more hours of operation in condensing mode compared to an outdoor air reset schedule. A load-based reset schedule resets supply water temperature based on heating coil valve position and can provide more precise control than an outdoor air reset.[27] Finally, installing variable-speed drives on circulation pump motors can lower the RWT by increasing the temperature drop through the system.[28]

In the absence of data to the contrary, DOE should assume the same heat exchanger failure rates for condensing and non-condensing boilers. DOE has assumed that condensing boiler heat exchangers have a mean failure year of 15 and a 50% repair rate and that non-condensing boiler heat exchangers have a mean failure year of 20 and a 17% repair rate. DOE states that these estimates are in response to references made during the rulemaking that condensing boilers have shorter lifetimes than non-condensing boilers. DOE theorizes that condensing boiler lifetime could be affected by heat exchanger degradation.[29] We are not aware of any data either supporting DOE's assumption that condensing boiler heat exchangers have higher failure rates than those of non-condensing boilers or the comment that condensing boilers have shorter lifetimes. As DOE notes, heat exchanger warranties are consistent across condensing and non-condensing boilers.[30] DOE's assumption of a 10-year warranty for both condensing and non-condensing heat exchangers is consistent with our review of boiler warranties. Furthermore, we are not aware of any data supporting the assertion that condensing boilers have shorter lifetimes than non-condensing boilers. In the absence of data to the contrary, DOE should assume the same heat exchanger failure rates and overall lifetime distribution for condensing and non-condensing boilers.

DOE's estimates of incremental installation costs at higher efficiency levels appear to be reasonable. At the DOE public meeting on April 21, several manufacturers suggested that DOE has not adequately captured the incremental installation costs at higher efficiency levels.[31] For the NOPR, DOE conducted a detailed analysis of installation costs which incorporated any incremental costs associated with venting modifications. The analysis included such factors as whether a particular boiler was being installed in a new building or as a retrofit, and whether a retrofit would require chimney relining or a new venting system. The analysis also incorporated the additional installation costs for condensate removal for condensing boiler installations.[32] It

[25] https://buildingenergy.cx-associates.com/2012/04/getting-the-most-out-of-your-commercial-condensing-boiler/.
[26] http://mn.gov/commerce/media/blog/success-stories/?id=17-71392#/list/appId//filterType//filterValue//page//sort//order/.
[27] http://www.nrel.gov/docs/fy14osti/56402.pdf. p. 36.
[28] http://www.gsa.gov/portal/mediaId/163539/fileName/GPG_Condensing_Boiler_-_FINAL_DRAFT_4-15-13_508.action. p. 34.
[29] Technical Support Document. p. 8E-3.
[30] 81 Fed. Reg. 15873.
[31] Public Meeting Transcript. pp. 145, 148-150.
[32] Technical Support Document. Appendix 8D.

appears that DOE's analysis for the NOPR has appropriately captured incremental installation costs at higher efficiency levels.

In conclusion, we urge DOE to adopt TSL 3 in the final rule, which would more than double the national energy savings compared to the standards proposed in the NOPR. DOE found TSL 3 to be cost effective even with assumptions that we believe are conservative. As described above, DOE is likely underestimating the energy savings and overestimating the repair costs associated with condensing boilers, which would mean that the economic savings at TSL 3 are even larger than the $0.3-2.6 billion NPV savings shown in the NOPR.

Thank you for considering these comments.

Sincerely,

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