Appliance Standards Awareness Project
American Council for an Energy-Efficient Economy
Natural Resources Defense Council

August 10, 2020

Mr. Bryan Berringer
U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Building Technologies Office, EE-5B
1000 Independence Avenue SW
Washington, DC 20585

RE: Docket Number EERE–2017–BT–TP–0012/RIN 1904–AD47: Notice of Proposed Rulemaking for Test Procedures for Room Air Conditioners

Dear Mr. Berringer:

This letter constitutes the comments of the Appliance Standards Awareness Project (ASAP), American Council for an Energy-Efficient Economy (ACEEE), and Natural Resources Defense Council (NRDC) on the notice of proposed rulemaking (NOPR) for test procedures for room air conditioners. 85 Fed. Reg. 35700 (June 11, 2020). We appreciate the opportunity to provide input to the Department.

We appreciate the significant amount of investigative testing that DOE conducted for the NOPR, and we strongly support amending the room AC test procedure to capture the benefits of variable-speed compressors. DOE's investigative testing for the NOPR found that variable-speed units can provide large efficiency gains at reduced cooling loads.[1] However, we urge DOE to ensure that the proposed fixed compressor speeds are representative of real-world operation and that the method for calculating the CEER value for variable-speed units reflects seasonal efficiency. We also urge DOE to consider incorporating "boost compressor speed" in the test procedure. For all units, we strongly urge DOE to capture off-cycle mode power and network mode power to improve representativeness. We also urge DOE to consider future amendments to the test procedure to test all room ACs at multiple outdoor temperature conditions using a load-based test and to capture the real-world efficiency impact of manufacturer-provided installation materials.

We urge DOE to ensure that the proposed fixed compressor speeds are representative of real-world operation. In the NOPR, DOE proposes that variable-speed units would be tested at fixed compressor speeds at four outdoor temperature conditions: 95°F, 92°F, 87°F, and 82°F. Specifically, variable-speed units would be tested at the "full" compressor speed at the 95°F and 92°F conditions, at the "intermediate" compressor speed at the 87°F condition, and at the "low" compressor speed at the 82°F condition. For the analysis for the NOPR, DOE calculated that an outdoor temperature of 82°F would correspond to a cooling load of 57% of full-load cooling capacity.[2] However, DOE proposes to define "low compressor speed" such that the capacity at the 82°F condition "is not less than 47 percent and not greater than 57 percent" of the capacity at the 95°F condition.[3] We are concerned that the

[1] 85 Fed. Reg. 35707-08.
[2] 85 Fed. Reg. 35714.
[3] Ibid.

proposed definition for low compressor speed could lead to measured efficiency values that are not representative. Specifically, we understand that under DOE's proposal, manufacturers may have an incentive to test at the 82°F condition at the compressor speed that provides a cooling capacity as close as possible to 47% of the full-load capacity since efficiency typically increases at lower compressor speeds. And yet providing 47% of the full-load cooling capacity would not meet the cooling load at 82°F. Furthermore, because DOE is proposing that "intermediate compressor speed" be defined based on the difference between the low compressor speed and the full compressor speed, a low compressor speed that is lower than the operating speed in the field could also result in the intermediate compressor speed being artificially low.

DOE explains in the NOPR that a range is necessary for defining the low compressor speed since variable-speed units may use compressors that vary their speed in discrete steps, and such units may not be able to operate at a speed that provides exactly 57% cooling capacity. The NOPR further states that DOE's rationale for defining the upper bound of the 10% range as 57% is to "ensure that a variable-speed room AC is capable of matching the representative cooling load (57 percent of the maximum) at the 82°F outdoor test condition, while providing the performance benefits associated with variable-speed operation."[4] We note that a variable-speed unit that cannot provide 57% cooling capacity cannot in fact "match" the representative cooling load at the 82°F condition. Furthermore, the test procedure should reflect the potential efficiency gains of variable-speed units that can vary their speed continuously (or in smaller discrete steps) relative to units with compressors with larger discrete steps. We urge DOE to ensure that the proposed fixed compressor speeds are representative of real-world operation.

The application of the proposed weighting factors should reflect seasonal efficiency. In the NOPR, DOE proposes to calculate a weighted-average CEER value for variable-speed units using the interim CEER values at each of the four cooling mode test conditions with respective weighting factors.[5] We are concerned that this approach of calculating a weighted average of individual efficiency values will not reflect seasonal efficiency. Specifically, the proposed approach will result in underweighting performance at the higher outdoor temperature conditions and overweighting performance at the lower temperature conditions. We instead encourage DOE to provide a method for calculating the CEER value for variable-speed units that reflects the total cooling provided divided by the total energy consumed. Such an approach would be similar to how an average efficiency (CFM/W) is calculated in the test procedure for ceiling fans as shown in the equation below.[6]

$$\textbf{\textit{Ceiling Fan Efficiency}}\ (CFM/W) = \frac{\sum_i (CFM_i \times OH_i)}{W_{Sb} \times OH_{Sb} + \sum_i (W_i \times OH_i)} \qquad \textbf{Eq. 1}$$

Where:
CFM_i = airflow at speed i,
OH_i = operating hours at speed i,
W_i = power consumption at speed i,
OH_{Sb} = operating hours in standby mode, and
W_{Sb} = power consumption in standby mode.

We encourage DOE to further investigate the use of the "boost compressor speed" and to consider incorporating it in the test procedure. DOE explains in the NOPR that the "full" compressor speed of a variable-speed unit may not be its fastest speed, and that a unit's fastest speed (i.e. its "boost

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[4] Ibid.
[5] 85 Fed. Reg. 35711-12.
[6] 81 Fed. Reg. 48644 (July 25, 2016).

compressor speed") may be used for a brief period to rapidly reduce the indoor temperature.[7] DOE proposes in the NOPR not to address boost compressor speed. We are concerned that not testing the "boost compressor speed" may result in excluding a significant component of the energy use of these units. Even if the boost compressor speed is used for a limited duration, the resulting energy use could be significant if the power consumption associated with the boost compressor speed is significantly higher than that at the speeds measured in the test procedure. We encourage DOE to further investigate the use of the "boost compressor speed" and to consider incorporating it in the test procedure.

We urge DOE to incorporate a measurement of off-cycle mode power consumption. Capturing off-cycle mode power consumption, including fan operation, would provide a better representation of actual efficiency in the field and more accurate information to consumers. In the NOPR, DOE found that although most units tested cycled the fan throughout the test period and consumed an average of 10.7 W, two of the units consumed an average of 270.1 W in off-cycle mode.[8] In the rulemaking for portable AC test procedures, DOE determined that units that are cooling-only products spend 880 hours in off-cycle mode.[9] DOE also stated that "because the primary cooling function is similar between portable ACs and room ACs, DOE believes that the mode hours in cooling season would be apportioned similarly for both products."[10] This means that room AC units with continuous fan operation can consume close to 240 kWh/year of energy in off-cycle mode alone. If off-cycle mode is not captured in the test procedure, a consumer will have no way of knowing that a unit with continuous fan operation will consume significantly more energy than a comparable unit with cyclical fan operation. Furthermore, capturing off-cycle mode power consumption would help improve consistency with the portable AC test procedure.

We urge DOE to incorporate a measurement of network mode power consumption. DOE states in the NOPR that network functions on room ACs "may operate continuously during all operating modes, and therefore may impact the power consumption in all operating modes."[11] However, rather than propose a method for capturing this power consumption to provide a more representative measure of room AC energy use, DOE instead is proposing that units with network capabilities be tested with the network settings disabled.[12] We urge DOE to incorporate a measurement of the standby power consumed when a room AC with network functions is connected to a network to ensure that the efficiency ratings are providing accurate information to consumers.

We encourage DOE to consider future amendments to the test procedure to test all room ACs at multiple outdoor temperature conditions using a load-based test. While DOE is proposing to test variable-speed room ACs at four outdoor temperature conditions, single-speed units would continue to be tested at a single condition (95°F). Since all room ACs operate at a range of outdoor temperature conditions, testing all room AC units at multiple conditions would better represent real-world efficiency. As part of its investigative testing for the NOPR, DOE measured the cooling capacity and electrical power draw for 14 single-speed room ACs at 92°F, 87°F, and 82°F.[13] Table 1 below shows the calculated EER at

[7] 85 Fed. Reg. 35710.
[8] 85 Fed. Reg. 35728.
[9] 80 Fed. Reg. 10236 (February 25, 2015).
[10] Ibid.
[11] 85 Fed. Reg. 35729-30.
[12] 85 Fed. Reg. 35730.
[13] 85 Fed. Reg. 35710.

each temperature for each of the units (along with the EER at 95°F) in addition to the weighted-average EER using the proposed weighting factors for variable-speed units.

Table 1. EER of Single-Speed Room ACs at Multiple Temperature Conditions

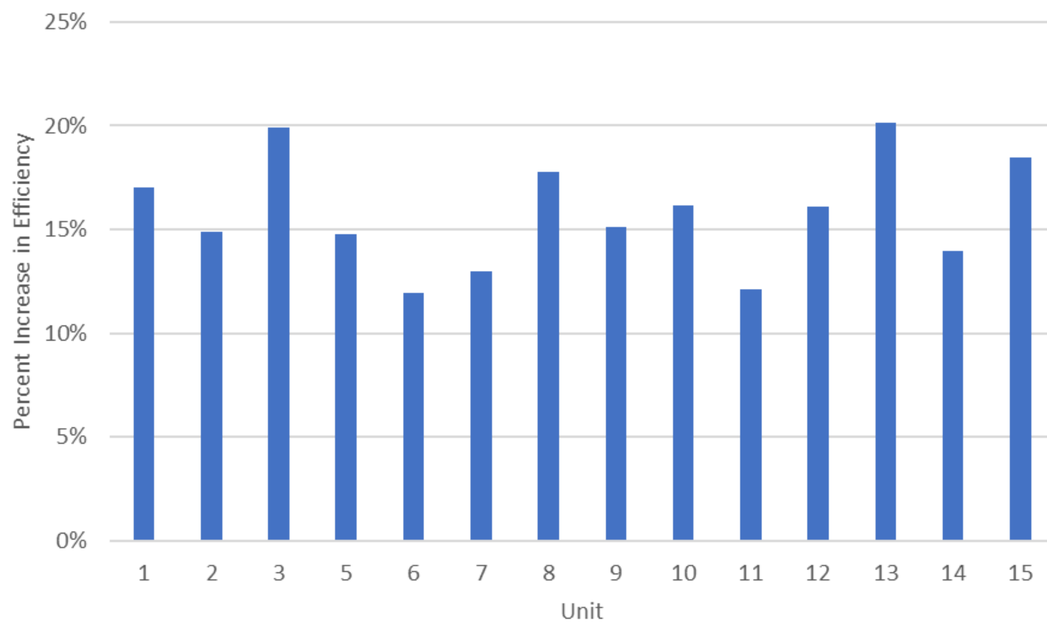
Unit	EER (Btu/Wh)				Weighted-Average EER (Btu/Wh)
	95 °F	92 °F	87 °F	82 °F	
1	13.5	14.2	15.4	16.8	15.8
2	11.6	12.2	13.1	14.0	13.3
3	11.7	12.5	13.7	14.9	14.0
5	10.9	11.5	12.3	13.2	12.5
6	11.7	12.1	12.8	13.6	13.0
7	10.5	11.0	11.8	12.4	11.9
8	11.7	12.6	13.6	14.6	13.8
9	12.6	13.1	14.2	15.3	14.5
10	11.9	12.7	13.7	14.4	13.8
11	11.5	12.0	12.7	13.5	12.9
12	11.7	12.3	13.2	14.5	13.6
13	12.0	12.8	14.0	15.5	14.5
14	13.0	13.4	14.6	15.5	14.8
15	10.0	10.9	11.6	12.5	11.9

Notes: EER at 95°F was calculated using the tested cooling capacity and power consumption at 92°F and the proposed capacity and electrical power adjustment factors. Weighted-average EER was calculated using the proposed CEER weighting factors in the NOPR for variable-speed units.[14]

Figure 1 shows the percent increase in efficiency of the weighted-average EER relative to the 95°F EER for each unit. While the weighted-average EERs of all the units are higher than their respective EERs at 95°F as expected, the data show that different room AC units respond differently to the lower temperature conditions. Specifically, the increase in the weighted-average EER relative to the 95°F EER ranges from 12% to 20%. The impact of this range of lower-temperature performance can be seen, for example, with Units 3 and 6. As shown in Table 1, while both units had a tested EER of 11.7 at 95°F, Unit 3 has a weighted-average EER of 14.0, while Unit 6 has a weighted-average EER of 13.0.

[14] 85 Fed. Reg. 35711-12.

Figure 1. Percent Increase in Efficiency of Weighted-Average EER Relative to 95°F EER



In addition, a load-based test would better reflect the real-world operation of both single-speed and variable-speed units. For single-speed units, a load-based test would capture the impact of cycling losses. In the NOPR, DOE proposes to use assumed cycling loss factors ranging from 0.875 at the 82°F condition to 1.0 at the 95°F condition as part of the calculation of the "performance adjustment factor" for variable-speed units,[15] but these cycling losses are not captured for single-speed units. Furthermore, we would expect that cycling losses may vary among individual single-speed units, but the current test procedure provides no way to reflect this potential differentiation. For variable-speed units, load-based testing would capture the impact of control strategies that determine compressor and fan speed operation and would ensure that the test procedure reflects the real-world operation of these units. We appreciate the investigative load-based testing that DOE conducted for the NOPR, and we encourage DOE to investigate how a future test procedure could address the challenges associated with load-based testing.

We encourage DOE to consider future amendments to the test procedure to capture the impact of manufacturer-provided installation materials for louvered units. In the NOPR, DOE indicates that they found no consistent difference in cooling capacity when utilizing the manufacturer-provided installation materials compared to the standard test procedure conditions.[16] However, NREL performed laboratory performance testing of louvered units in which they found that standard testing simulations do not account for leakage in operation due to manufacturer-provided installation materials. Leakage from the manufacturer-provided materials was equivalent to a 27-42 in^2 hole in the wall, and an improved installation has the potential to reduce this leakage by 65-85%.[17] DOE explains in the preliminary technical support document (TSD) that because DOE's investigative testing was conducted with no pressure difference between the rooms, the tests were not able to measure the real-world impacts of

[15] 85 Fed. Reg. 35711.
[16] 85 Fed. Reg. 35720.
[17] http://s3.amazonaws.com/szmanuals/f50601c1a4960b3d7627df44cc951d28. p. 34.

infiltration.[18] The current test procedure therefore does not capture potentially significant inefficiencies in typical installations. We encourage DOE to investigate how the test procedure could capture the effects of real-world installations of room AC units. Capturing the impact of manufacturer-provided installation materials in the test procedure would provide an incentive to manufacturers to offer improved installation materials such that leakage is reduced. In addition to saving energy, reducing leakage would also improve cooling performance by reducing the amount of hot air entering from outdoors, which ultimately would improve consumer comfort.

Thank you for considering these comments.

Sincerely,

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[18] https://www.regulations.gov/document?D=EERE-2014-BT-STD-0059-0013. p. 3-32.