Appliance Standards Awareness Project
American Council for an Energy-Efficient Economy
Consumer Federation of America
National Consumer Law Center

February 23, 2023

Mr. Lucas Adin
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-2022-BT-TP-0028: Request for Information on Test Procedures for Central Air Conditioners and Heat Pumps

Dear Mr. Adin:

This letter constitutes the comments of the Appliance Standards Awareness Project (ASAP), the American Council for an Energy-Efficient Economy (ACEEE), the Consumer Federation of America (CFA), and the National Consumer Law Center (NCLC) on behalf of its low-income clients on the request for information on test procedures for central air conditioners (CACs) and heat pumps. 88 Fed. Reg 4091 (January 24, 2023). We appreciate the opportunity to provide input to the Department.

We encourage DOE to move from a test procedure that relies on unrealistic fixed control settings to one that requires units to operate under native controls. We believe that an important outcome of this rulemaking is a revised test procedure that captures CAC and heat pump performance that can be achieved when the unit operates under its own controls. The current test procedure in 10 CFR Appendix M1 to Subpart B of Part 430 ("Appendix M1") tests variable-speed units with fixed settings (compressor speed and airflow). However, operating in such a test mode is insufficient to properly characterize the performance of these units. In the RFI, DOE describes several load-based testing approaches that incorporate the impact of native controls. DOE has categorized load-based testing into two categories. The first is a pseudo steady-state test in which the reconditioning equipment removes or supplies heat at a constant rate.[1] The second is a virtual building load that attempts to reflect realistic building loads (and captures the dynamic response between the building and the equipment) that would be encountered by equipment in the field–in this procedure, the reconditioning equipment of the psychrometric chamber iteratively updates the indoor room temperature and humidity in response to the UUT (unit under test). The first is most similar to the existing test procedure in Appendix M1, but it does not capture the full range (some of the finer details) of dynamic behavior of a UUT.

[1]DOE describes the inherent steady-state nature of this test. https://www.regulations.gov/document/EERE-2022-BT-TP-0028-0001. p. 19.

There are certainly merits to both approaches, and we believe that significantly better information about how a CAC or heat pump would perform in the field can be gained from any approach that employs testing under native controls, compared to the current test procedure in Appendix M1. At a minimum, a revised DOE test procedure must ensure that the level of performance suggested by total cooling capacity, total heating capacity, and efficiency performance metrics could actually be attained under native controls. For instance, the DOE Cold Climate Heat Pump Challenge specification v1.2 ("CCHP spec") allows heating performance to be derived from steady-state regulatory tests, but requires additional validation with the UUT removed from test mode. DOE could consider employing a similar strategy for both heating and cooling tests.[2]

Alternatively, the load-based test in CSA SPE07:2023 requires no additional controls verification, as the measured performance is based completely on unlocked controls.[3] We understand that there were a number of changes made in SPE07 compared to the prior draft (CSA EXP07:2019), largely in order to improve reproducibility. We also understand that testing is ongoing to address representativeness (the results will allow a comparison of SPE07 and Appendix M1).[4] We encourage DOE to examine those results to inform their determination of the most appropriate update to the CAC and heat pump test procedure.

We believe that Appendix M1 falls short in properly accounting for the cyclic performance of units, including single- and two-stage CACs and heat pumps. Cyclic behavior is simulated in Appendix M1, through optional transient-type cyclic tests.[5] However, the actual cycling behavior of a UUT is not captured in this procedure. Further, the current approach adjusts the performance of a cycling unit, which requires the application of a cyclic degradation coefficient (to calculate the part-load factor). The coefficient is either calculated from these cyclic tests or a default value is used. However, shortcomings in the cyclic degradation coefficient calculation have been identified.[6]

While test procedures requiring the operation under native controls will undoubtedly enhance the ability to differentiate the performance between variable-speed equipment, particularly at part-load operation, we think that there are also benefits to applying the approach to single- and two-stage equipment.

We encourage DOE to investigate the impact of thermostat selection and ensure that the test procedure includes appropriate provisions related to the thermostat. We understand that with any testing in which native controls freely operate, the thermostat is likely to be an integral component of the test setup. For this reason, we think that it makes sense that the thermostat is certified as part of the tested combination. However, since the performance could be impacted by different thermostats, it is important to understand this variance. We therefore encourage DOE to perform an investigation to quantify the impact of the integration of different thermostats on the performance ratings of CACs and

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[2] https://www.energy.gov/sites/default/files/2021-10/bto-cchp-tech-challenge-spec-102521.pdf. Appendix B describes the development of the HSPF2 adjustments for measured gaps in turndown capacity and/or COP within the Challenge performance specification.

[3] CSA EXP07:2019 has been revised and was published in January 2023 as CSA SPE07:2023.

[4] The NEEP Heat Pump Rating Representativeness Project. https://comedemergingtech.com/project/hp-rating-representativeness

[5] In Appendix M1, DOE defines a cyclic test to be "a test where the unit's compressor is cycled on and off for specific time intervals. A cyclic test provides half the information needed to calculate a degradation coefficient." However, a unit operating under native controls will not necessarily cycle regularly or at the predefined intervals in Appendix M1, so the cycling behavior remains unknown.

[6] https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=3011&context=iracc. p. 3.

heat pumps. This investigation should not be limited to variable-speed equipment, as this information would also be important should a revised native controls test procedure include testing single- and two-stage equipment. We also encourage DOE to develop appropriate provisions to ensure that the thermostat selected for testing is likely to be representative of the one selected in the field.

We understand that because the airflow and distribution of temperature in the indoor room of a psychrometric chamber can vary between test labs, that this could have contributed to some of the reproducibility issues arising from some procedures in which the thermostat is an integral component (such as in EXP07). However, we understand that the thermostat environment emulator (TEE) described in Annex I of SPE07 is designed to alleviate this issue by isolating the thermostat in a more controlled environment than the open air of the indoor chamber where it could be impacted by installation. We encourage DOE to adopt such a provision in the DOE test procedure.

We encourage DOE to consider adopting a cut-in and cut-out temperature validation test. In the RFI, DOE explains that the Department has found that manufacturers of heat pumps have used cut-out temperatures in the calculation of HSPF2 that are lower than what is indicated by the operating envelope depicted in compressor manufacturer literature. If DOE determines that this contributes to unrepresentative ratings of seasonal heating performance, we encourage DOE to consider adopting a test to validate cut-in and cut-out temperatures, instead of relying on manufacturer-provided values. The CCHP spec requires such a validation test.

We encourage DOE to select more representative indoor air conditions for cooling tests. Appendix M1 requires 80°F/67°F dry bulb/wet bulb indoor air conditions for cooling tests, but this is unlikely to be representative. For example, one paper suggested that 75°F/63°F would be more representative.[7] We note that a recent ASRAC working group for commercial unitary air conditioners and heat pumps recommended that the indoor conditions for cooling tests used in calculating the seasonal performance metric be changed from 80°F/67°F to 77°F/64°F.[8]

We encourage DOE to improve the measurement of defrost impact and provide better differentiation between defrost control methods. Appendix M1 currently incorporates a 'transient test' to capture some of the impact of defrost operation of heat pumps (i.e., frost accumulation test at 35°F). However, since tests are performed without auxiliary resistance heat (which would otherwise be activated to maintain supply air temperature), there is no way to measure the actual amount of energy consumption associated with a defrost cycle. In the RFI, DOE noted that through testing according to the CCHP spec, the Department has found that resistance element operation during defrost can vary widely.[9] A recent study of a 3-ton single-stage heat pump calculated a COP at 34°F that was 10% lower when the auxiliary heat was allowed to operate in defrost.[10]

Appendix M1 attempts to reward better defrost controls through the calculation of a demand defrost credit, which is applied to increase the HSPF2 value (by up to several percent). However, we think this approach falls short in fully differentiating control strategies. The credit is based only upon the time between defrosts, but in the definition of demand defrost control system, DOE acknowledges the

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[7] https://www.aceee.org/files/proceedings/2006/data/papers/SS06_Panel1_Paper24.pdf
[8] https://www.regulations.gov/document/EERE-2022-BT-STD-0015-0065.
[9] https://www.regulations.gov/document/EERE-2022-BT-TP-0028-0001. p. 60.
[10] Note the 34 degree outdoor ambient test condition was from EXP07 https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=3475&context=iracc. p. 6.

different types of controls which can include parameters that vary with the amount of frost accumulated on the outdoor coil (coil to air differential temperature, coil differential air pressure, outdoor fan power or current, or optical sensors). These strategies may provide additional energy savings. Therefore, if a revised test procedure maintains the treatment of defrost separately (as a separate test), we encourage DOE to provide a more sophisticated calculation of the credit.

We note that in SPE07, the energy consumption of defrost operation is handled seamlessly in the load-based test procedure. Units that go into defrost operation will meet different convergence criteria, but there is no separate test (however, similar to Appendix M1, auxiliary resistance is deactivated).

We encourage DOE to consider additional reporting requirements. The ability for various stakeholders to calculate performance in any climate will likely be very important in the adoption of heat pumps in the coming years. We encourage DOE to engage stakeholders to determine which additional performance reporting requirements would be beneficial (for instance, capacity maintenance or COP at various temperatures).

Thank you for considering these comments.

Sincerely,

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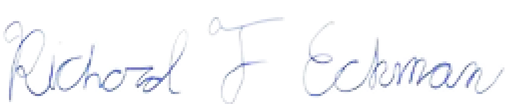

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