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

November 6, 2023

Mr. Troy Watson
U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Building Technologies Office, EE-2B
1000 Independence Avenue SW
Washington, DC 20585

RE: Docket Number EERE-2017-BT-STD-0009: Energy Conservation Standards for Walk-In Coolers and Freezers

Dear Mr. Watson:

This letter constitutes the comments of the Appliance Standards Awareness Project (ASAP), American Council for an Energy-Efficient Economy (ACEEE), Natural Resources Defense Council (NRDC), and the Northwest Energy Efficiency Alliance (NEEA) on the notice of proposed rulemaking (NOPR) for walk-in coolers and freezers. 88 Fed. Reg. 60746 (September 5, 2023). We appreciate the opportunity to provide input to the Department.

DOE's analysis shows that the proposed standards would save 1.5 quads of energy and yield net present value savings for purchasers of up to $3.7 billion,[1] primarily from amended standards for unit coolers (UCs), dedicated condensing units (DCUs), and non-display doors. However, we believe that greater cost-effective energy savings may be possible. First, for medium-temperature outdoor DCUs, we urge DOE to consider adopting a standard that is equivalent to the proposed standard plus the addition of a variable-speed condensing fan. Next, we encourage DOE to include improved single-speed compressor efficiency as a design option and to further investigate variable-speed compressor costs. We also disagree with DOE's assumptions regarding walk-in refrigeration maintenance costs, which has a significant impact on the cost-effectiveness of higher efficiency refrigeration systems. Finally, we encourage DOE to further investigate walk-in door and panel lifetimes and to ensure that any additional installation costs associated with thermal barriers are applied appropriately. These topics and others are outlined in more detail below.

We urge DOE to consider a standard level for outdoor DCUs that assumes use of a variable-speed condensing fan (VSCF). DOE's analysis suggests that VSCFs would be a cost-effective design option, particularly for the medium-temperature outdoor DCU (DC.M.O) equipment class. For example, for the 25 kBtu/hr representative unit (RU), DOE's engineering analysis in the Technical Support Document (TSD) shows that a VSCF would yield energy savings of about 4% with an increase in manufacturer selling

[1] 88 Fed. Reg. 60750.

price (MSP) plus shipping cost of less than 1%, only $25.[2] Further, based on DOE's LCC analysis spreadsheet, we estimate that TSL 2 plus a VSCF would result in a discounted lifetime operating cost that is several hundred dollars less than at TSL 2.[3] Therefore, we suggest that DOE reorder the design options for the outdoor DCU classes such that the addition of a VSCF comes before a larger condensing coil and that the Department consider adopting standards that reflect the use of a VSCF. More generally, DOE should ensure that the order of design options analyzed in the engineering analysis puts cost-effective design options before ones that are not cost-effective.

We encourage DOE to analyze improved single-speed compressor efficiency as a design option. DOE notes in the NOPR that lower capacity refrigeration systems have greater difficulty attaining high efficiencies in part because smaller compressors are generally less efficient than larger compressors.[4] Since the current walk-in standards have limited dependence on capacity,[5] it's likely that larger capacity units have an easier time reaching current standard levels; DOE's engineering analysis supports this assertion as baseline levels at lower capacities are assumed to require use of more design options to meet the current standards. Because the walk-in market is very price sensitive, manufacturers may not be implementing the most efficient single-speed compressors available in some baseline units, particularly for larger units, and instead are using the lowest cost compressor capable of meeting current walk-in standards.

DOE states in the TSD that more efficient single-speed compressors were not analyzed due to potential limitations on availability and utility concerns related to customer preferences for specific compressor types.[6] However, we understand that there is a range of single-speed compressor efficiencies available even when selecting for a given compressor type, capacity, input voltage, power supply (i.e., singe vs. polyphase), and refrigerant.[7] We also suspect that the availability of more efficient single-speed compressors would increase in response to amended standards for walk-ins. Thus, we encourage DOE to analyze improved single-speed compressor efficiency as a design option.

We encourage DOE to further consider electronic expansion valves (EEVs) as a design option for outdoor refrigeration systems. While DOE included EEVs in both the 2017 final rule analysis as well as the 2022 preliminary TSD for outdoor DCUs and single-packaged units, they were omitted as a design option in the NOPR analysis due to concerns that further reducing head pressure may impact utility.[8] In the Notification of Data Availability (NODA) issued in September 2023, DOE further stated that because

---

[2]Table 5A.5.3. TSD, p. 5A-37. Comparing EL 4 and EL 6, a VSCF would improve AWEF from 8.37 to 8.72 with MSP+shipping cost increasing from $2812 to $2837. The 25 kBtu/hr RU is the closest to DOE's estimated shipment-weighted capacity of 23.1 kBtu/hr for the DC.M.O equipment class (Table 9.4.1, TSD, p. 9-11). www.regulations.gov/document/EERE-2017-BT-STD-0009-0046

[3]Life-Cycle Cost Analysis for Systems (NOPR) Spreadsheets. From the "Sample" sheet in "wicf_nopr_ecs_lcc_dcmo_systems_DOE". www.regulations.gov/document/EERE-2017-BT-STD-0009-0050

[4]88 Fed. Reg. 60764.

[5]For example, the current standards for both medium temperature DCU classes do not vary with capacity.

[6]TSD, p. 5-47. www.regulations.gov/document/EERE-2017-BT-STD-0009-0046

[7]See: coolselectoronline.danfoss.com. For a 60 Hz, 115 V single-phase, 4.4 kBtu/hr low-temperature application, R404A, single-speed, hermetic reciprocating compressors with EERs of 7.7 and 7.3 are available. For a 60 Hz, 200-230 V polyphase, ~50 kBtu/hr medium-temperature application, R449A, single-speed, scroll compressors with EERs of 12.8 and 12.1 are available. While we acknowledge these two examples may not be representative of the entire walk-in market, they do suggest a range of single-speed efficiencies are available over a range of applications.

[8]TSD, p. 5-51. www.regulations.gov/document/EERE-2017-BT-STD-0009-0046

the refrigeration system tests are steady-state tests, a test performed with a thermostatic expansion valve (TXV) would result in the same measured efficiency as a test of the same unit performed with an EEV.[9] However, we understand that EEVs could allow refrigeration systems to operate at lower head pressure relative to thermostatic expansion valves (TXVs), saving energy even during steady-state tests (e.g., DOE's test procedure). EEVs are much more precise in controlling temperatures and pressures while floating head pressure versus mechanical TXVs. Thus, a refrigeration system utilizing an EEV may be able to reliably operate at lower head pressures without impacting utility or reliability. Further, we understand that EEV floating head pressure controls are used in the market today, and that it is a technology likely to be implemented by manufacturers to improve efficiency of outdoor refrigeration systems.

We are concerned that DOE may be overestimating the cost of variable-speed compressors. DOE's analysis considers variable-speed compressors at the maximum technologically feasible (max-tech) levels for walk-in DCUs and single-packaged units. Though DOE's engineering analysis suggests that variable-speed compressors can improve efficiency by up to about 16%,[10] the economic analysis does not show levels incorporating variable-speed compressors to be cost-effective in part due to their large assumed incremental costs.[11] However, DOE's recent analysis for commercial refrigeration equipment (CRE) standards suggests a much lower incremental cost associated with variable-speed compressors. For example, DOE estimates that the manufacturer production cost (MPC) of a small 2,000 Btu/hr low-temperature, indoor single-packaged walk-in system increases by $386 with the addition of a variable-speed compressor.[12] In comparison, DOE's recent CRE analysis estimates that inclusion of a variable-speed compressor in a vertical, transparent door, self-contained freezer with a refrigeration load of about 2100 Btu/hr[13] increases MPC by only $94.[14] We understand that the Department may be using pricing for variable-speed compressors for walk-ins that include extra features and that lower-cost variable-speed compressors could be available. Thus, we encourage DOE to further investigate the cost of variable-speed compressors.

We encourage DOE to include learning rates for variable-speed compressor controls. In contrast to DOE's recent CRE standards NOPR analysis, DOE did not include learning rates for variable-speed compressor controls in the walk-ins analysis. In the CRE analysis, consistent with other motor-related rulemakings, DOE assumed that the price of variable-speed controls would decrease by about 6%/year based on the semiconductor Producer Price Index (PPI).[15] Given the similarities between variable-speed compressor controls in CRE and walk-ins, we encourage DOE to include price learning for variable-speed compressor controls in the walk-ins analysis.

---

[9]88 Fed. Reg. 66710, 66713. www.regulations.gov/document/EERE-2017-BT-STD-0009-0061

[10]Tables 5A.5.2 to 5A.5.27. TSD, pp. 5A-36 to 5A-61. www.regulations.gov/document/EERE-2017-BT-STD-0009-0046

[11]DOE's max-tech level also includes design options (e.g., larger condenser coil) that are not cost-effective, obscuring the potential cost-effectiveness of just a variable-speed compressor. As noted separately, assumptions about maintenance costs at higher ELs also have a significant impact on the overall LCC analysis.

[12]Table 5A.26. TSD, p. 5A-60. www.regulations.gov/document/EERE-2017-BT-STD-0009-0046

[13]Commercial Refrigeration Equipment Engineering Analysis Spreadsheet Model (NOPR), "Results" sheet. www.regulations.gov/document/EERE-2017-BT-STD-0007-0055

[14]Table 5.8.13. CRE TSD, p. 5-39. www.regulations.gov/document/EERE-2017-BT-STD-0007-0051

[15]CRE TSD, p. 8-7. www.regulations.gov/document/EERE-2017-BT-STD-0007-0051

We disagree with DOE's assumptions regarding walk-in refrigeration maintenance costs. DOE's analysis for the NOPR assumes that yearly refrigeration system maintenance cost is equal to 10% of the product's MSP plus shipping. This assumption results in a significant increase in lifetime maintenance costs that contributes heavily to the negative LCC savings at higher evaluated efficiency levels (ELs).[16] The two design options that increase MSP and resulting maintenance costs most significantly for walk-in outdoor DCUs are a larger condensing coil and a variable-speed compressor; DOE's assumption results in up to a ~$3300 increase in yearly maintenance for a variable-speed compressor and up to a ~$300 increase in yearly maintenance with a larger condensing coil.[17] In contrast, citing a lack of data, the 2016 Final Rule for commercial air conditioners (ACs) assumed there was no increase in maintenance cost with increasing efficiency.[18] In the recent CRE standards NOPR, DOE assumed that maintenance costs increased for only one design option, a microchannel condenser coil, which resulted in a modest $15/year increase.[19]

Consistent with DOE's recent CRE analysis and the 2016 commercial AC Final Rule, it seems unlikely to us that a variable-speed compressor would result in an increase in maintenance cost.[20] For larger condenser coils, DOE discussed at the public meeting that a larger unit (e.g., a larger condenser coil) may require additional time to clean and maintain.[21] This may be analogous to DOE's CRE analysis assuming a microchannel condenser coil would cost an additional $15/year for cleaning, but it is unclear if and how this might scale for larger walk-ins. In the absence of additional information, we encourage DOE to assume that maintenance costs do not vary with efficiency except for a larger condensing coil and to further investigate the additional costs associated with cleaning larger condenser coils.

We encourage DOE to further investigate walk-in door and panel lifetimes. The NOPR assumes that the average lifetimes of panels, non-display doors, and display doors are 12 years, 12 years, and 8.5 years, respectively, comparable to that assumed for refrigeration systems (10.5 years).[22] While discussion of panel/door lifetimes was omitted from the TSD, in Ch. 3 of the preliminary TSD, DOE discusses that in contrast to refrigeration systems, walk-in panels and doors may not have a clear failure point;[23] the Department also cited an industry report estimating door and panel lifetimes at 12-25 years and mentioned that anecdotal evidence suggests they may last even longer.[24] For walk-in panels, we have found that many manufacturers offer warranties of 15 to 20 years,[25] which suggests that the expected lifetime of walk-in panels may be significantly longer than that estimated by DOE. Thus, we encourage DOE to consider increasing the assumed panel and door lifetimes based on this available information.

---

[16]DOE's assumption results in lifetime maintenance costs more than $1000 greater at TSL 3 vs. TSL 2 for the 25 kBtu/hr DC.M.O unit.

[17]Tables 5A.5.6, 5A.5.15. TSD, pp. 5A-40, 5A-49. www.regulations.gov/document/EERE-2017-BT-STD-0009-0046

[18]2016 Commercial AC Final Rule TSD, p. 8-24. www.regulations.gov/document/EERE-2013-BT-STD-0007-0105

[19]CRE TSD, p. 8-20. www.regulations.gov/document/EERE-2017-BT-STD-0007-0051

[20]We also understand that variable-speed compressors may increase system reliability and lifetime, particularly in installations where a single speed compressor cycles on and off frequently, such as in an oversized refrigeration system. This could result in a lifetime reduction in maintenance and/or repair costs.

[21]Public meeting transcript, p. 43. www.regulations.gov/document/EERE-2017-BT-STD-0009-0065

[22]Table IV.41. 88 Fed. Reg. 60798.

[23]Walk-ins preliminary TSD, p. 3-16. www.regulations.gov/document/EERE-2017-BT-STD-0009-0024

[24]Arthur D. Little. Energy Savings Potential for CRE, p. 67, 1996. sites.uclouvain.be/energie-plus/local/fileadmin/resources/04_technique/14_froid_alimentaire/Etudes/bilan_energie_commerce_usa.pdf

[25]See, for example: www.commercialcooling.com/en/warranty

We are concerned that DOE is adding additional unwarranted installation costs for panel insulation greater than 4 inches. DOE's analysis appears to assume that all walk-in panels with insulation greater than 4 in. will have a $0.50/ft^2 installation cost increase associated with required thermal barriers for non-sprinklered building installations.[26] However, we believe that DOE may be misinterpreting prior comments and the building code requirements[27] that may necessitate use of a thermal barrier. First, we understand that this metal facing requirement is only relevant for non-sprinklered buildings, which we expect represent a very small portion of walk-in installations. Additionally, we interpret this metal facing requirement to be inclusive of panels with 4 in. of insulation in non-sprinklered buildings. Since DOE assumes a baseline low-temperature panel is 4 in. thick, this would suggest that there would be no additional cost for metal facing at higher insulation thicknesses for low-temperature panels.

Importantly, this assumption has a meaningful impact on the overall LCC analysis, particularly for low-temperature panels. Based on DOE's published LCC spreadsheets,[28] we estimate that the total installed cost increase for EL 1 (increasing panel insulation from 4 in. to 5 in.) absent this additional $0.50/ft^2 is about $1.20/ft^2 greater than EL 0. Concurrently, we estimate that the discounted lifetime electricity cost savings at EL 1 is about $1.20/ft^2. These results suggest that a standard level effectively requiring 5 in. of insulation is much closer to cost-effectiveness than what DOE's NOPR analysis shows, particularly if longer, more realistic panel lifetimes were considered. We note that while manufacturers expressed concern about significant increases to insulation thickness, the TSD notes that most of the existing production equipment is designed to produce non-display doors and panels up to 5 inches thick.[29]

We generally support DOE's refrigerant assumptions in the engineering analysis but note that they may result in conservative standard levels. EPA recently published a NOPR outlining new refrigerant regulations regarding global warming potential (GWP). As a result of this EPA rulemaking, DOE expects that all relevant walk-in refrigeration systems will have transitioned to low-GWP refrigerants in advance of the compliance date of amended efficiency standards.[30] However, due to a lack of performance data with newer refrigerants, DOE used R-448A as the baseline refrigerant for low and medium-temperature DCUs and single-packaged units, R-404A for low- and medium-temperature UCs, and R-134A for high-temperature units. DOE determined that R-454A is the most likely low-GWP replacement for R-448A/449A in low- and medium-temperature systems and that R-454A may improve efficiency versus R-448A/449A.[31] Available information also shows that both R-454A[32] and R-471A,[33] another promising low-GWP refrigerant for medium-temperature applications, may exceed the efficiency of R-404A over a broad range of operating conditions. We also understand that R-513A, currently used in ENERGY STAR-rated service-over-counter CRE, is a likely low-GWP replacement for R-134A in high-temperature

---

[26] 88 Fed. Reg. 60796.
[27] 2603.4.1.3 Walk-in Coolers. codes.iccsafe.org/content/IBC2018P2/chapter-26-plastic
[28] Life-Cycle Cost Analysis for Systems (NOPR) Spreadsheets. From the "Sample" sheet in "wicf_nopr_ecs_lcc_psl_envelope_DOE". www.regulations.gov/document/EERE-2017-BT-STD-0009-0051
[29] TSD, p. 12-6. www.regulations.gov/document/EERE-2017-BT-STD-0009-0046
[30] 88 Fed. Reg. 60772.
[31] TSD, p. 5-33. www.regulations.gov/document/EERE-2017-BT-STD-0009-0046
[32] Chemours, Opteon XL40 (R-454A) Refrigerant, 2016. www.opteon.com/fr/-/media/files/opteon/opteon-xl40-pib-en.pdf?rev=aa99f21f12894385884b047ed6c967c8
[33] K. Gao et al. Performance Evaluation of R471A in Refrigerated Display Cabinet and Walk-In-Cooler, Intern. Refrig. and Air Cond. Conference, 2578, 2022. docs.lib.purdue.edu/cgi/viewcontent.cgi?article=3489&context=iracc

applications with similar reported efficiency.[34] While we generally support DOE's engineering analysis approach of using refrigerants with well understood performance characteristics, available data suggests that DOE's proposed standards may be conservative, particularly for low- and medium-temperature systems, when considering the upcoming switch to low-GWP refrigerants.

We encourage DOE to revisit the proposed efficiency levels for certain single-packaged equipment classes. DOE's proposed standard levels are based on TSL 2, which is intended to reflect the combination of design options that results in the greatest energy savings with a positive NPV at 7% for a given equipment class.[35] However, for several single-packaged equipment classes, it appears that either the proposed standards do not reflect TSL 2 or that higher standard levels than those proposed would satisfy the criteria for TSL 2:

- SP.M.O equipment class: DOE's proposed standard at and above 9 kBtu/hr is 7.11 AWEF (EL 1) even though TSL 2 is stated to be EL 3 for the 9 kBtu/hr RU;[36] EL 3 appears to be cost-effective based on DOE's analysis.[37]
- SP.L.O equipment class: DOE proposed the baseline level (EL 0) even though EL 2, associated with improved crankcase heater controls, appears to be cost-effective.[38]
- SP.H.I equipment class: DOE's LCC results show positive savings at TSL 3 (equivalent to EL 2 for both RUs).[39] It is therefore unclear whether DOE has selected the correct EL to satisfy the TSL 2 criteria for this equipment class.
- SP.H.ID, SP.H.OD equipment classes: It does not appear that DOE's proposed levels reflect TSL 2. For example, TSL 2 is stated to represent EL 6 (4.83 AWEF) for the SP.H.OD 7 kBtu/hr RU,[40] but the proposed standard is only 4.41 AWEF,[41] which does not correspond to any evaluated EL.

Thank you for considering these comments.

Sincerely,

Jeremy Dunklin, PhD
Technical Advocacy Associate
Appliance Standards Awareness Project

Amber Wood
Director, Buildings Program
American Council for an Energy-Efficient Economy

[34] Refrigerant Changeover Guidelines, R-134a to R-513A or R-450A for High and Medium Temperature Applications. webapps.emerson.com/online-product-information/Publication/LaunchPDF?Index=AEB&PDF=2021ECT-19
[35] 88 Fed. Reg. 60786.
[36] Table IV.26. 88 Fed. Reg. 60787.
[37] Table 5A.5.21.TSD, p. 5A-55. EL 3 yields a 5.5% efficiency increase for an MSP+shipping cost increase of only 0.5% versus EL 1. www.regulations.gov/document/EERE-2017-BT-STD-0009-0046
[38] Tables 5A.5.24, 5A.5.25. TSD, pp. 5A-58, 5A-59. For example, EL 2 for the 2 kBtu/hr RU yields a 6% efficiency increase for an MSP+shipping cost increase of only about 0.1 % versus EL 0. www.regulations.gov/document/EERE-2017-BT-STD-0009-0046
[39] Tables V.27, V.28. 88 Fed. Reg. 60818.
[40] Table IV.26. 88 Fed. Reg. 60787.
[41] Table I.2. 88 Fed. Reg. 60748.

Joe Vukovich
Energy Efficiency Advocate
Natural Resources Defense Council

Blake Ringeisen
Sr. Engineer, Codes and Standards
Northwest Energy Efficiency Alliance