

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

December 29, 2021

Dr. Stephanie Johnson  
U.S. Department of Energy  
Office of Energy Efficiency and Renewable Energy  
Building Technologies, EE-2J  
1000 Independence Avenue SW, Washington, DC 20585

**RE: Docket Number EERE-2017-BT-STD-0003: Notice of Webinar and Availability of Preliminary Technical Support Document for Refrigerators, Refrigerator-Freezers, and Freezers**

Dear Dr. Johnson:

This letter constitutes the comments of the Appliance Standards Awareness Project (ASAP), the American Council for an Energy-Efficient Economy (ACEEE), and the National Consumer Law Center (NCLC) on behalf of its low-income clients on the notice of webinar and availability of technical support document (TSD) for residential refrigerators, refrigerator-freezers, and freezers. 86 Fed. Reg. 57378 (October 15, 2021). We appreciate the opportunity to provide input to the Department.

DOE's preliminary analysis shows that very large cost-effective savings can be achieved by strengthening the existing standards for refrigerators, refrigerator-freezers, and freezers. However, we believe that improvements to DOE's analysis could allow for delivering even larger cost-effective savings. First, DOE should evaluate higher "max-tech" levels for certain product classes. Second, DOE should reorder the design options for two important product classes—Product Classes 5A and 7—which would significantly improve the cost-effectiveness of intermediate efficiency levels. Third, DOE should ensure that the energy savings from vacuum-insulated panels (VIPs) and improved compressor efficiency are being appropriately captured. In addition, in considering potential amended standard levels, DOE should not attribute conversion costs associated with the refrigerant transition to updated efficiency standards. Manufacturers are already transitioning to alternative refrigerants, and these conversion costs will be incurred irrespective of any amended standards.

**We encourage DOE to reconsider the max-tech levels for certain product classes.** As shown in Table 1, for Product Classes 5A, 7, and 11A, there are models listed in DOE's Compliance Certification Database (CCD)<sup>1</sup> that are more efficient than the "max-tech" levels evaluated in the preliminary TSD. We urge DOE to reevaluate the max-tech efficiency levels for these three product classes so that they represent true max-tech levels. For Product Class 11A, we recognize that many of the most efficient models are powered coolers that have small adjusted volumes. However, we encourage DOE to investigate the design features present in these very high efficiency models to determine if such design features are more broadly applicable to the product class.

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<sup>1</sup> As of December 13, 2021.

**Table 1. DOE “max-tech” level and the most efficient model in the DOE CCD**

Product Class	DOE “max-tech” level (% energy savings relative to the current standard)	Most efficient model in DOE CCD (% energy savings relative to the current standard)
5A. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with through-the-door ice service	22%	25%
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service	21%	22%
11A. Compact all-refrigerators—manual defrost	33%	54%

**DOE is significantly overestimating the incremental cost to meet intermediate efficiency levels for Product Classes 5A and 7.** DOE generally introduces design options in order of decreasing cost-effectiveness.<sup>2</sup> However, for Product Classes 5A and 7, DOE took a different approach for the preliminary analysis that resulted in significantly overestimating the incremental cost to meet intermediate efficiency levels.

Table 2 shows the incremental installed costs for Product Classes 5A and 7 for each efficiency level transition (e.g., from EL2 to EL3). The incremental costs going from EL1 to EL2 are very large for both product classes relative to the incremental costs at other efficiency level transitions. At the public meeting on December 1, DOE confirmed that these high incremental costs are attributed to adding dual evaporators.<sup>3</sup> The TSD explains that because DOE observed dual evaporators in teardown units at EL2, the Department included dual evaporators as a design option at EL2.<sup>4</sup> However, dual evaporators are a premium feature whose main purpose is to help keep food fresher longer.<sup>5</sup> Given their high cost, it is not reasonable to assume that dual evaporators would be employed to meet intermediate ELs (i.e., EL2 and EL3) if those ELs became the minimum standard.

<sup>2</sup> For example, the TSD states that for compact products, “DOE modeled VIPs incorporated into half of the cabinet surface area for product class 11A before a switch to a variable-speed compressor so as to introduce design options in order of decreasing cost effectiveness.” <https://www.regulations.gov/document/EERE-2017-BT-STD-0003-0020>. p. 5-19.

<sup>3</sup> <https://www.regulations.gov/document/EERE-2017-BT-STD-0003-0030>. p. 27.

<sup>4</sup> <https://www.regulations.gov/document/EERE-2017-BT-STD-0003-0020>. p. 2-19.

<sup>5</sup> See, for example: <https://products.geappliances.com/appliance/gea-support-search-content?contentId=21695>.

**Table 2. Incremental installed costs for Product Classes 5A and 7<sup>6</sup>**

Efficiency level transition	Design options added	Incremental installed cost for Product Class 5A	Incremental installed cost for Product Class 7
EL0 to EL1	Variable-speed R-134a compressor, brushless DC fan	\$37	\$31
EL1 to EL2	Dual evaporator and single VIP <sup>7</sup>	\$483	\$396
EL2 to EL3	Variable-speed R-600a compressor	\$0.15	\$32
EL3 to EL4	VIPs covering half of the cabinet	\$47	\$38

In addition, while DOE introduced R-600a (isobutane) as a design option at either EL1 or EL2 for all other product classes, for Product Classes 5A and 7, DOE did not incorporate R-600a until EL3, stating that R-600a was not observed in teardown units at EL2.<sup>8</sup> However, as described below, manufacturers are already transitioning to R-600a; the Association of Home Appliance Manufacturers (AHAM) has stated that most refrigerators will no longer use HFC refrigerants by 2022 and that a phaseout of HFCs in all home appliances is likely by 2024, which is well before any amended DOE standards for refrigerators and freezers would take effect. Any proposed efficiency levels should therefore assume the use of R-600a.

In summary, since the design options for refrigerators and freezers are independent of one another and can be applied in any order, we urge DOE to introduce more cost-effective design options—including R-600a—at lower efficiency levels for Product Classes 5A and 7, and to only introduce dual evaporators at the max-tech level. This change would better reflect the actual incremental cost of meeting intermediate efficiency levels and would significantly improve the cost-effectiveness of those levels. We also urge DOE to add additional efficiency levels for Product Classes 5A and 7 so that dual evaporators are not combined with other technology options, such as VIPs, in the same efficiency level.

**We urge DOE to reevaluate its modeling of VIPs to ensure that the energy savings from VIPs are being appropriately captured.** We have two specific concerns with the VIP analysis in the TSD. First, we believe that DOE may be underestimating VIP performance by relying on outdated information and/or otherwise inappropriate assumptions. Second, the energy savings from VIPs presented in the preliminary analysis appear to be notably smaller than those found in a 2018 study. Since VIPs are an important technology option that could lead to large energy savings, it is imperative that DOE ensure that the analysis is appropriately reflecting the energy savings from VIPs.

In the previous rulemaking, DOE stated that due to variation in the “level of performance benefit” from VIPs reported by manufacturers (from 0-100% of the levels predicted by the EPA Refrigerator Analysis software) during the NOPR stage, the Department applied a degradation factor of 50% to “account for this variation in experience.”<sup>9</sup> DOE did not provide an explanation for how it determined that the 50% value was appropriate. In the current rulemaking, DOE again refers to the 50% degradation factor, this time calling it a scaling factor that accounts for the “actual vs. expected performance of VIPs.” However, it is unclear how DOE is applying the scaling factor in its analysis. It appears that the scaling factor may function to reduce the thermal resistivity of the composite wall (VIP/PU assembly). A reduction in effective

<sup>6</sup> <https://www.regulations.gov/document/EERE-2017-BT-STD-0003-0020>. Tables 5.5.1, 8.5.5, and 8.5.7.

<sup>7</sup> At the public meeting on December 1, DOE stated that there is an error in Table 5.5.1 of the TSD, where the dual evaporator is listed as a design option at EL1 for Product Class 5A. It should be listed at EL2. We have assumed that the dual evaporator replaces the “max-efficient R-134a variable-speed compressor” listed at EL2. <https://www.regulations.gov/document/EERE-2017-BT-STD-0003-0030>. p. 27.

<sup>8</sup> <https://www.regulations.gov/document/EERE-2017-BT-STD-0003-0020>. p. 5-15.

<sup>9</sup> <https://www.regulations.gov/document/EERE-2008-BT-STD-0012-0128> pp. 5-63 to 5-64.

surface resistivity will result in increased heat flow out of the cabinet and lead to higher energy consumption of the refrigerator or freezer. Because of the impact on energy savings, it is critical that DOE apply the scaling factor in a way that accurately represents expected performance impacts in order to fully capture the energy savings that are achievable with VIPs. Further, by assuming the same scaling factor as in the last rulemaking, DOE may be disregarding significant technology advancements over the past decade. We therefore urge DOE to investigate an appropriate updated scaling factor informed by recent interviews with manufacturers rather than simply relying on the performance data from the previous rulemaking.

Further, the application of VIPs on half of the cabinet area in DOE's analyses appears to yield energy savings of 5 to 7% for standard refrigerators, 3 to 6% for standard freezers, and less than 1% for compact freezers,<sup>10</sup> which are much lower than we would expect. A 2018 study found that the installation of VIPs in the rear cabinet wall reduced the energy consumption of a top-mount refrigerator-freezer by 5%.<sup>11</sup> When VIPs were added to the doors (of both the freezer and fresh-food compartments), the total reduction in energy consumption was almost 12%. Finally, with VIPs added to the side walls and to the top wall—the case where VIPs covered approximately half of the cabinet area—the total reduction in energy consumption was almost 20%. DOE's modeled energy savings from the installation of VIPs on half of the cabinet area therefore seem to be inconsistent with published studies.<sup>12</sup>

In summary, we urge DOE to reevaluate its modeling of VIPs to ensure that the energy savings from VIPs are being appropriately captured.

**We urge DOE to ensure that the energy savings from improved compressor efficiency are being appropriately captured.** In the TSD, DOE states that the EERs for variable speed compressors (VSCs) are typically consistent with the EERs of the highest available efficiency single-speed compressors (SSCs) at the same capacity.<sup>13</sup> However, this is not the case for low-capacity compressors (generally models less than ¼ hp or 500 BTU/hr) that would typically be present in compact product classes. As shown in Figure 1, for both R-134a and R-600a compressors, the EER of a VSC can be 1 to 2 points higher than that of the most-efficient SSC at the same capacity (<500 BTU/hr). Assuming the same EER when transitioning from a single-speed to a variable-speed compressor therefore does not accurately represent DOE's data for low-capacity compressors. Importantly, by assuming the same EER, it appears that DOE may be underestimating the savings from variable-speed compressors for compact product classes by failing to capture the improved full-load efficiency in addition to the part-load savings.

In addition, DOE notes that a typical capacity for a compressor in a refrigerator-freezer is around 950 Btu/hr (or about ⅓ HP); for this regime, DOE's assumption that the EER is the same for the most efficient SSC and VSC seems appropriate for the R-134a compressors shown in Figure 1a. However, for the R-600a compressors shown in Figure 1b, the most-efficient VSCs tend to have higher EERs than the most-efficient SSCs. Therefore, we urge DOE to ensure that its analysis is appropriately capturing the savings from the highest-efficiency R-600a VSCs.

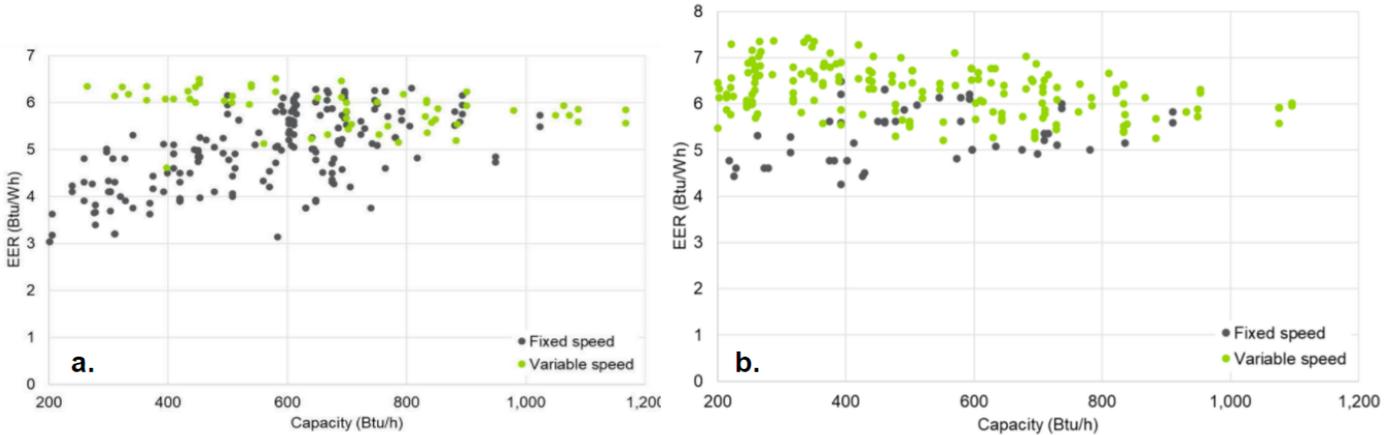
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<sup>10</sup> For all analyzed product classes (except 11A), DOE introduced VIPs on half of the cabinet area at the "max-tech" level. To determine the energy savings from VIPs (half of cabinet area), we calculated the energy savings going from EL3 to EL4 for these product classes, not including Product Classes 5A or 7 because these already included a single VIP at EL2. Specifically, we calculated the energy savings based on the average annual energy use values presented in Tables ES.2.7, ES.2.8, and ES.2.9 of the TSD. The very small energy savings for compact freezers may be due to the diminished effect of VIPs relative to the increased insulation thickness introduced at EL1 for this product class and the smaller cabinet surface area.

<sup>11</sup> <https://www.sciencedirect.com/science/article/pii/S0140700718303281>.

<sup>12</sup> Verma and Singh (2020) present a summary of studies that use VIPs in refrigerator insulation, which show reductions in energy consumption of 20-49%. <https://bura.brunel.ac.uk/bitstream/2438/19790/2/FullText.pdf>. p. 7-8.

<sup>13</sup> <https://www.regulations.gov/document/EERE-2017-BT-STD-0003-0020>. p. 5-24.



**Figure 1. Efficiency Curve for R-134a Compressors (a), Efficiency Curve for R-600a Compressors (b) [source: TSD Figures 5.5.1 and 5.5.2]**

**We support DOE’s approach of analyzing the same potential efficiency increases for built-in product classes as those for corresponding freestanding product classes.** DOE describes in the TSD that the information in the CCD for built-in models indicates a range of potential efficiency improvements similar to those for freestanding models.<sup>14</sup> We therefore believe that it makes sense to analyze the same efficiency increases for built-in product classes as those for the freestanding product classes.

**DOE should not attribute conversion costs associated with the refrigerant transition to updated efficiency standards.** In the preliminary analysis, DOE assumed that the per-unit cost of using R-600a as the refrigerant instead of R-134a is negligible, but notes that there may be a significant conversion cost associated with R-600a as a design option.<sup>15</sup> DOE further states that it would consider these costs as part of the manufacturer impact analysis for the NOPR. However, due to recent state laws and the American Innovation and Manufacturing (AIM) Act, manufacturers of residential refrigerators and freezers are already transitioning to R-600a, and we expect a full transition to occur well before any amended DOE standards would take effect.

The AIM Act<sup>16</sup>, signed in 2020, authorizes EPA to restrict the use of HFCs; the step-down approach, with increased restrictions every few years, will reduce the use of HFCs by about 85% over a 15-year horizon. R-134a, an HFC refrigerant, will be subject to EPA’s phasedown schedule. California and 11 other states have finalized laws that go further, prohibiting R-134a and certain other HFCs in new residential refrigerators and freezers.<sup>17</sup> Several other states have proposed similar regulations to phase out HFCs. Importantly, EPA’s ability to limit HFCs under the AIM Act is broad: under subsection (i), a person may petition the EPA to restrict the use of a regulated substance; if granted, EPA must promulgate a final rule no later than 2 years from the date the petition was granted. In October 2021, EPA granted a petition to

<sup>14</sup> <https://www.regulations.gov/document/EERE-2017-BT-STD-0003-0020>. p. 5-5.

<sup>15</sup> <https://www.regulations.gov/document/EERE-2017-BT-STD-0003-0020> p. 5-28

<sup>16</sup>

[https://www.epa.gov/sites/default/files/2021-03/documents/aim\\_act\\_section\\_103\\_of\\_h.r.\\_133\\_consolidated\\_appropriations\\_act\\_2021.pdf](https://www.epa.gov/sites/default/files/2021-03/documents/aim_act_section_103_of_h.r._133_consolidated_appropriations_act_2021.pdf).

<sup>17</sup> Compliance dates based on date of manufacture for units sold in the states of California, Colorado, Maryland, Massachusetts, New Jersey, New York, Washington, Vermont of 1/1/2021 for compact units, 1/1/2022 for standard units, and 1/1/2023 for built-in units. Delaware, Maine, Rhode Island, and Virginia have slightly different compliance dates.

replicate HFC prohibitions under the Significant New Alternatives Policy (SNAP) Rules 20 and 21.<sup>18,19</sup> The petitioners, the Natural Resources Defense Council (NRDC), the Colorado Department of Public Health & Environment (CDPHE), and the Institute for Governance & Sustainable Development (IGSD) petitioned that R-134a in residential refrigerators and freezers be prohibited effective January 1, 2023. The EPA must promulgate a final rule by October 2023, so it is very likely that R-134a will be prohibited at the federal level before new energy efficiency standards take effect. Furthermore, according to AHAM, “most refrigerators will no longer use HFCs by [2022],” and a phaseout of HFCs in all home appliances is likely by 2024.<sup>20</sup>

In summary, because the costs associated with the conversion to R-600a will already be incurred by manufacturers, DOE should not attribute costs related to the conversion of refrigerants to updated energy efficiency standards.

Thank you for considering these comments.

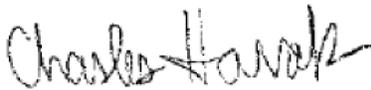
Sincerely,



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American Council for an Energy-Efficient Economy



Charles Harak, Esq.  
National Consumer Law Center  
(On behalf of its low-income clients)

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<sup>18</sup> <https://www.regulations.gov/document/EPA-HQ-OAR-2021-0289-0007>.

<sup>19</sup>

<https://www.federalregister.gov/documents/2021/10/14/2021-22318/notice-of-determination-to-grant-or-partially-grant-certain-petitions-submitted-under-subsection-j>.

<sup>20</sup> <https://yoursourcenews.com/2021/05/appliance-biz-bids-goodbye-to-greenhouse-gases/>.