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DEPARTMENT OF ENERGY

10 CFR Part 430

[EERE-2021-BT-STD-0011]

RIN 1904-AE99

Energy Conservation Program: Energy Conservation Standards for Ceiling Fans

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Notice of proposed rulemaking and announcement of public meeting.

SUMMARY: The Energy Policy and Conservation Act, as amended ("EPCA"), prescribes energy conservation standards for various consumer products and certain commercial and industrial equipment, including ceiling fans. EPCA also requires the U.S. Department of Energy ("DOE") to periodically determine whether more-stringent, standards would be technologically feasible and economically justified, and would result in significant energy savings. In this notice of proposed rulemaking ("NOPR"), DOE proposes new and amended energy conservation standards for ceiling fans, and also announces a public meeting to receive comment on these proposed standards and associated analyses and results.

DATES: *Comments*: DOE will accept comments, data, and information regarding this NOPR no later than [**INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER***].

Meeting: DOE will hold a public meeting via webinar on Thursday, July 27, 2023 from 1:00 p.m. to 4:00 p.m. See section IV, "Public Participation," for webinar registration information, participant instructions and information about the capabilities available to webinar participants." Comments regarding the likely competitive impact of the proposed standard should be sent to the Department of Justice contact listed in the

ADDRESSES section on or before [**INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER***].

ADDRESSES: Interested persons are encouraged to submit comments using the Federal eRulemaking Portal at *www.regulations.gov* under docket number EERE–2021–BT–STD-0011. Follow the instructions for submitting comments. Alternatively, interested persons may submit comments, identified by docket number EERE-2021-BT-STD-0011, by any of the following methods:

Email: *CeilingFans2021STD0011@ee.doe.gov*. Include the docket number EERE-2021-BT-STD-0011 in the subject line of the message.

Postal Mail: Appliance and Equipment Standards Program, U.S. Department of Energy, Building Technologies Office, Mailstop EE-5B, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 287-1445. If possible, please submit all items on a compact disc ("CD"), in which case it is not necessary to include printed copies.

Hand Delivery/Courier: Appliance and Equipment Standards Program, U.S. Department of Energy, Building Technologies Office, 1000 Independence Ave., SW, Washington, DC, 20585. Telephone: (202) 287-1445. If possible, please submit all items on a CD, in which case it is not necessary to include printed copies.

No telefacsimiles ("faxes") will be accepted. For detailed instructions on submitting comments and additional information on this process, see section VII of this document.

Docket: The docket for this activity, which includes *Federal Register* notices, comments, and other supporting documents/materials, is available for review at *www.regulations.gov*. All documents in the docket are listed in the *www.regulations.gov* index. However, not all documents listed in the index may be publicly available, such as information that is exempt from public disclosure.

The docket webpage can be found at *www.regulations.gov/docket/EERE-2021-BT-STD-0011*. The docket webpage contains instructions on how to access all documents, including public comments, in the docket. See section VII of this document for information on how to submit comments through *www.regulations.gov*.

EPCA requires the Attorney General to provide DOE a written determination of whether the proposed standard is likely to lessen competition. The U.S. Department of Justice Antitrust Division invites input from market participants and other interested persons with views on the likely competitive impact of the proposed standard. Interested persons may contact the Division at *energy.standards@usdoj.gov* on or before the date specified in the **DATES** section. Please indicate in the "Subject" line of your email the title and Docket Number of this proposed rulemaking.

FOR FURTHER INFORMATION CONTACT:

Mr. Jeremy Dommu, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Office, EE-5B, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 506-9870. Email: *ApplianceStandardsQuestions@ee.doe.gov*.

Mr. Nolan Brickwood, U.S. Department of Energy, Office of the General Counsel, GC-33, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 586-4498. Email: *nolan.brickwood@hq.doe.gov*.

For further information on how to submit a comment, review other public comments and the docket, or participate in the public meeting, contact the Appliance and

Equipment Standards Program staff at (202) 287-1445 or by email:

ApplianceStandardsQuestions@ee.doe.gov.

SUPPLEMENTARY INFORMATION:

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I. Synopsis of the Proposed Rule

The Energy Policy and Conservation Act, Pub. L. 94-163, as amended ("EPCA"),[1] authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. (42 U.S.C. 6291–6317) Title III, Part B of EPCA[2] established the Energy Conservation Program for Consumer Products Other Than Automobiles. (42 U.S.C. 6291 –6309) These products include ceiling fans, the subject of this proposed rulemaking.

Pursuant to EPCA, any new or amended energy conservation standard must be designed to achieve the maximum improvement in energy efficiency that DOE determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) Furthermore, the new or amended standard must result in a significant conservation of energy. (42 U.S.C. 6295(o)(3)(B)) EPCA also provides that not later than 6 years after issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a notice of proposed rulemaking ("NOPR") including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m))

In accordance with these and other statutory provisions discussed in this document, DOE proposes amended energy conservation standards for ceiling fans. The proposed standards, which are expressed in cubic feet per minute per watt ("CFM/W") for standard and hugger ceiling fans and ceiling fan energy index ("CFEI") for large-diameter ceiling fans ("LDCFs") and high-speed belt-driven ("HSBD") ceiling fans, are shown in Table I.1. These proposed standards, if adopted, would apply to all ceiling fans

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[1] All references to EPCA in this document refer to the statute as amended through the Energy Act of 2020, Pub. L. 116-260 (Dec. 27, 2020), which reflect the last statutory amendments that impact Parts A and A-1 of EPCA.

[2] For editorial reasons, upon codification in the U.S. Code, Part B was redesignated Part A.

listed in Table I.1 manufactured in, or imported into, the United States starting on the date 3 years after the publication of the final rule for this proposed rulemaking.

Table I.1 Proposed Energy Conservation Standards for Ceiling Fans

Equipment Class	CFM/W
Standard Ceiling Fans*	D ≤ 53 in.: 0.69 D+53.25 D > 53 in.: 1.31 D +52.08
Hugger Ceiling Fans*	D ≤ 53 in.: 0.56 D+48.75 D > 53 in.: 1.37 D +38.5
Equipment Class	**CFEI**
Large-Diameter Ceiling Fans	1.22 at high speed 1.31 at 40 percent speed or the nearest speed that is not less than 40 percent speed.
High-Speed Belt-Driven Ceiling Fans	1.89 at high speed

* D is the representative value of blade span as determined in accordance with the DOE test procedure at appendix U to subpart B of 10 CFR part 430 and applicable sampling plans.

A. Benefits and Costs to Consumers

Table I.2 presents DOE's evaluation of the economic impacts of the proposed standards on consumers of ceiling fans, as measured by the average life-cycle cost ("LCC") savings and the simple payback period ("PBP").[3] The average LCC savings are positive for all product classes, and the PBP is less than the average lifetime of ceiling fans, which is estimated to be 14.6 years (see section IV.F.6 of this document).

Table I.2 Impacts of Proposed Energy Conservation Standards on Consumers of Ceiling Fans (TSL 3)

Ceiling Fan Class	Average LCC Savings *$2022*	Simple Payback Period *years*
Standard	16.69	4.1
Hugger	5.14	6.6
HSBD	663.92	2.1
Large-Diameter	68.20	5.8

[3] The average LCC savings refer to consumers that are affected by a standard and are measured relative to the efficiency distribution in the no-new-standards case, which depicts the market in the compliance year in the absence of new or amended standards (see section IV.F.8 of this document). The simple PBP, which is designed to compare specific efficiency levels, is measured relative to the baseline product (see section IV.C of this document).

DOE's analysis of the impacts of the proposed standards on consumers is described in section IV.F of this document.

B. Impact on Manufacturers

The industry net present value ("INPV") is the sum of the discounted cash flows to the industry from the base year through the end of the analysis period (2023–2057). Using a real discount rate of 7.4 percent, DOE estimates that the INPV for manufacturers of ceiling fans in the case without new and amended standards is $2,329 million in 2022$. Under the proposed standards, the change in INPV is estimated to range from -4.4 percent to -1.8 percent, which is approximately -$101 million to -$43 million. In order to bring products into compliance with new and amended standards, it is estimated that the industry would incur total conversion costs of $107.2 million.

DOE's analysis of the impacts of the proposed standards on manufacturers is described in section IV.J of this document. The analytic results of the manufacturer impact analysis ("MIA") are presented in section V.B.2 of this document.

C. National Benefits and Costs[4]

DOE's analyses indicate that the proposed energy conservation standards for ceiling fans would save a significant amount of energy. Relative to the case without new and amended standards, the lifetime energy savings for ceiling fans purchased in the 30-year period that begins in the anticipated first full year of compliance with the new and amended standards (2028–2057) amount to 0.92 quadrillion British thermal units ("Btu"), or quads[5], of full-fuel-cycle energy savings. This represents a savings of 9 percent

[4] All monetary values in this document are expressed in 2022 dollars.
[5] The quantity refers to full-fuel-cycle ("FFC") energy savings. FFC energy savings includes the energy consumed in extracting, processing, and transporting primary fuels (*i.e.*, coal, natural gas, petroleum fuels), and, thus, presents a more complete picture of the impacts of energy efficiency standards. For more information on the FFC metric, see section IV.H.1 of this document.

relative to the energy use of these products in the case without new and amended standards (referred to as the "no-new-standards case").

The cumulative net present value ("NPV") of total consumer benefits of the proposed standards for ceiling fans ranges from 1.84 billion USD (at a 7-percent discount rate) to 4.96 billion USD (at a 3-percent discount rate). This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased product costs for ceiling fans purchased in 2028–2057.

In addition, the proposed standards for ceiling fans are projected to yield significant environmental benefits. DOE estimates that the proposed standards would result in cumulative emission reductions (over the same period as for energy savings) of 18.3 million metric tons ("Mt")[6] of carbon dioxide ("CO_2"), 4.5 thousand tons of sulfur dioxide ("SO_2"), 31.3 thousand tons of nitrogen oxides ("NO_X"), 141 thousand tons of methane ("CH_4"), 0.15 thousand tons of nitrous oxide ("N_2O"), and 0.03 tons of mercury ("Hg").[7]

DOE estimates the value of climate benefits from a reduction in greenhouse gases (GHG) using four different estimates of the social cost of CO_2 ("SC-CO_2"), the social cost of methane ("SC-CH_4"), and the social cost of nitrous oxide ("SC-N_2O"). Together these represent the social cost of GHG (SC-GHG). DOE used interim SC-GHG values developed by an Interagency Working Group on the Social Cost of Greenhouse Gases (IWG).[8] The derivation of these values is discussed in section IV.L of this document. For

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[6] A metric ton is equivalent to 1.1 short tons. Results for emissions other than CO_2 are presented in short tons.

[7] DOE calculated emissions reductions relative to the no-new-standards case, which reflects key assumptions in the *Annual Energy Outlook 2023* ("AEO 2023"). AEO 2023 represents current Federal and state legislation and final implementation of regulations as of the time of its preparation. See section IV.K of this document for further discussion of AEO 2023 assumptions that effect air pollutant emissions.

[8] To monetize the benefits of reducing GHG emissions this analysis uses the interim estimates presented in the Technical Support Document: *Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990 published in February 2021 by the IWG. ("February 2021 SC-GHG TSD"). www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.*

presentational purposes, the climate benefits associated with the average SC-GHG at a 3-percent discount rate are estimated to be \$0.95 billion. DOE does not have a single central SC-GHG point estimate and it emphasizes the importance and value of considering the benefits calculated using all four sets of SC-GHG estimates.

DOE estimated the monetary health benefits of SO_2 and NO_X emissions reductions using benefit per ton estimates from the scientific literature, as discussed in section IV.L of this document. DOE estimated the present value of the health benefits would be \$0.6 billion using a 7-percent discount rate, and \$1.7 billion using a 3-percent discount rate.[9] DOE is currently only monetizing (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions.

Table I.3 summarizes the monetized benefits and costs expected to result from the proposed standards for ceiling fans. There are other important unquantified effects, including certain unquantified climate benefits, unquantified public health benefits from the reduction of toxic air pollutants and other emissions, unquantified energy security benefits, and distributional effects, among others.

[9] DOE estimates the economic value of these emissions reductions resulting from the considered TSLs for the purpose of complying with the requirements of Executive Order 12866.

Table I.3 Summary of Monetized Benefits and Costs of Proposed Energy Conservation Standards for Ceiling Fans (TSL 3)

	Billion 2022$
3% discount rate	
Consumer Operating Cost Savings	6.43
Climate Benefits*	0.95
Health Benefits**	1.70
Total Benefits†	9.08
Consumer Incremental Product Costs	1.47
Net Benefits	7.61
7% discount rate	
Consumer Operating Cost Savings	2.66
Climate Benefits* (3% discount rate)	0.95
Health Benefits**	0.64
Total Benefits†	4.25
Consumer Incremental Product Costs	0.82
Net Benefits	3.43

Note: This table presents the costs and benefits associated with ceiling fans shipped in 2028−2057. These results include benefits to consumers which accrue after 2028 from the products shipped in 2028−2057.
* Climate benefits are calculated using four different estimates of the social cost of carbon (SC-CO_2), methane (SC-CH_4), and nitrous oxide (SC-N_2O) (model average at 2.5 percent, 3 percent, and 5 percent discount rates; 95th percentile at 3 percent discount rate) (see section IV.L of this document). Together these represent the global SC-GHG. For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3 percent discount rate are shown; however, DOE emphasizes the importance and value of considering the benefits calculated using all four sets of SC-GHG estimates. To monetize the benefits of reducing GHG emissions, this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the IWG.
** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. See section IV.L of this document for more details.
† Total and net benefits include those consumer, climate, and health benefits that can be quantified and monetized. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate.

The benefits and costs of the proposed standards can also be expressed in terms of annualized values. The monetary values for the total annualized net benefits are (1) the reduced consumer operating costs, minus (2) the increase in product purchase prices and installation costs, plus (3) the monetized value of climate and health benefits of emission reductions, all annualized.[10]

The national operating cost savings are domestic private U.S. consumer monetary savings that occur as a result of purchasing the covered products and are measured for the lifetime of ceiling fans shipped in 2028–2057. The benefits associated with reduced emissions achieved as a result of the proposed standards are also calculated based on the lifetime of ceiling fans shipped in 2028–2057. Total benefits for both the 3-percent and 7-percent cases are presented using the average GHG social costs with 3-percent discount rate. Estimates of SC-GHG values are presented for all four discount rates in section IV.L.1 of this document.

Table I.4 presents the total estimated monetized benefits and costs associated with the proposed standard, expressed in terms of annualized values. The results under the primary estimate are as follows.

Using a 7-percent discount rate for consumer benefits and costs and health benefits from reduced NOx and SO_2 emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated monetized cost of the standards proposed in this rule is $86.6 million per year in increased equipment costs, while the estimated annual benefits are $281.1 million in reduced equipment operating costs, $54.7 million in monetized climate benefits, and $67.5 million in monetized health benefits. In this case the net monetized benefit would amount to $316.7 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated monetized cost of the proposed standards is $84.6 million per year in increased equipment costs,

[10] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2023, the year used for discounting the NPV of total consumer costs and savings. For the benefits, DOE calculated a present value associated with each year's shipments in the year in which the shipments occur, and then discounted the present value from each year to 2023. Using the present value, DOE then calculated the fixed annual payment over a 30-year period, starting in the compliance year, that yields the same present value.

while the estimated annual benefits are $369.3 million in reduced operating costs, $54.7 million in monetized climate benefits, and $97.5 million in monetized health benefits. In this case, the net monetized benefit would amount to $436.9 million per year.

Table I.4 Annualized Benefits and Costs of Proposed Energy Conservation Standards for Ceiling Fans (TSL 3)

	Million 2022$/year		
	Primary Estimate	**Low-Net-Benefits Estimate**	**High-Net-Benefits Estimate**
3% discount rate			
Consumer Operating Cost Savings	369.3	343.9	387.6
Climate Benefits*	54.7	52.4	55.5
Health Benefits**	97.5	93.6	98.9
Total Monetized Benefits†	521.4	489.9	542.1
Consumer Incremental Product Costs	84.6	85.8	81.3
Net Benefits	436.9	404.1	460.7
7% discount rate			
Consumer Operating Cost Savings	281.1	263.2	294.3
Climate Benefits* (3% discount rate)	54.7	52.4	55.5
Health Benefits**	67.5	65.1	68.5
Total Monetized Benefits†	403.3	380.7	418.3
Consumer Incremental Product Costs	86.6	87.7	83.6
Net Monetized Benefits	316.7	293.0	334.7

Note: This table presents the costs and benefits associated with ceiling fans shipped in 2028−2057. These results include benefits to consumers which accrue after 2057 from the products shipped in 2028−2057. The Primary, Low Net Benefits, and High Net Benefits Estimates utilize projections of energy prices from the AEO 2023 Reference case, Low Economic Growth case, and High Economic Growth case, respectively. The methods used to derive projected price trends are explained in sections IV.F.1 and IV.H.2 of this document. Note that the Benefits and Costs may not sum to the Net Benefits due to rounding.
* Climate benefits are calculated using four different estimates of the global SC-GHG (see section IV.L of this notice). For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3 percent discount rate are shown; however, DOE emphasizes the importance and value of considering the benefits calculated using all four sets of SC-GHG estimates. To monetize the benefits of reducing GHG emissions, this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the IWG.
** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. See section IV.L of this document for more details.

† Total benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate.

DOE's analysis of the national impacts of the proposed standards is described in sections IV.H, IV.K and IV.L of this document.

D. Conclusion

DOE has tentatively concluded that the proposed standards represent the maximum improvement in energy efficiency that is technologically feasible and economically justified, and would result in the significant conservation of energy. Specifically, with regards to technological feasibility products achieving these standard levels are already commercially available for all product classes covered by this proposal. As for economic justification, DOE's analysis shows that the benefits of the proposed standard exceed, to a great extent, the burdens of the proposed standards.

Using a 7-percent discount rate for consumer benefits and costs and NO_x and SO_2 reduction benefits, and a 3-percent discount rate case for GHG social costs, the estimated monetized cost of the proposed standards for ceiling fans is $86.6 million per year in increased ceiling fan costs, while the estimated annual monetized benefits are $281.1 million in reduced ceiling fan operating costs, $54.7 million in monetized climate benefits and $67.5 million in monetized health benefits. The net monetized benefit amounts to $316.7 million per year.

The significance of energy savings offered by a new or amended energy conservation standard cannot be determined without knowledge of the specific circumstances surrounding a given rulemaking.[11] For example, some covered products

[11] Procedures, Interpretations, and Policies for Consideration in New or Revised Energy Conservation Standards and Test Procedures for Consumer Products and Commercial/Industrial Equipment, 86 FR 70892, 70901 (Dec. 13, 2021).

and equipment have substantial energy consumption occur during periods of peak energy demand. The impacts of these products on the energy infrastructure can be more pronounced than products with relatively constant demand. Accordingly, DOE evaluates the significance of energy savings on a case-by-case basis.

As previously mentioned, the standards are projected to result in estimated national energy savings of 0.92 quad FFC for ceiling fans shipped between 2028 and 2057, the equivalent of the primary annual energy use of almost 10 million homes. In addition, they are projected to reduce CO_2 emissions by 18.3 million metric tons for ceiling fans shipped from 2028 to 2057.[12] Based on these findings, DOE has initially determined the energy savings from the proposed standard levels are "significant" within the meaning of 42 U.S.C. 6295(o)(3)(B). A more detailed discussion of the basis for these tentative conclusions is contained in the remainder of this document and the accompanying technical support document.

DOE also considered more-stringent energy efficiency levels as potential standards, and is still considering them in this rulemaking. However, DOE has tentatively concluded that the potential burdens of the more-stringent energy efficiency levels would outweigh the projected benefits.

Based on consideration of the public comments DOE receives in response to this document and related information collected and analyzed during the course of this rulemaking effort, DOE may adopt energy efficiency levels presented in this document that are either higher or lower than the proposed standards, or some combination of level(s) that incorporate the proposed standards in part.

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[12] These results include benefits to consumers which accrue after 2057 from the products shipped in 2028−2057.

II. Introduction

The following section briefly discusses the statutory authority underlying this proposed rule, as well as some of the relevant historical background related to the establishment of standards for ceiling fans.

A. Authority

EPCA authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. Title III, Part B of EPCA established the Energy Conservation Program for Consumer Products Other Than Automobiles. These products include ceiling fans, the subject of this document. (42 U.S.C. 6292(a)(20)) This NOPR covers those consumer products that meet the definition of “ceiling fans” codified at 10 CFR 430.2 as nonportable devices suspended from a ceiling for circulating air via the rotation of fan blades. EPCA, as amended, prescribed energy conservation standards for these products and authorized DOE to consider energy efficiency or energy use standards for the electricity used by ceiling fan to circulate air in a room[13]. (42 U.S.C. 6295(ff)(6))

EPCA further provides that, not later than 6 years after the issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a NOPR including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m)(1))

The energy conservation program under EPCA consists essentially of four parts: (1) testing, (2) labeling, (3) the establishment of Federal energy conservation standards,

[13] While ceiling fans are often sold with light kits, this notice only considers the electricity used by ceiling fans to circulate air in a room. DOE evaluates energy efficiency standards associated with ceiling fan light kits in a separate rulemaking (Docket No. EERE-2019-BT-STD-0040).

and (4) certification and enforcement procedures. Relevant provisions of EPCA specifically include definitions (42 U.S.C. 6291), test procedures (42 U.S.C. 6293), labeling provisions (42 U.S.C. 6294), energy conservation standards (42 U.S.C. 6295), and the authority to require information and reports from manufacturers (42 U.S.C. 6296).

Federal energy efficiency requirements for covered products established under EPCA generally supersede State laws and regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6297(a)-(c)) DOE may, however, grant waivers of Federal preemption for particular State laws or regulations, in accordance with the procedures and other provisions set forth under EPCA. (See 42 U.S.C. 6297(d))

Subject to certain criteria and conditions, DOE is required to develop test procedures to measure the energy efficiency, energy use, or estimated annual operating cost of each covered product. (42 U.S.C. 6295(o)(3)(A) and 42 U.S.C. 6295(r)) Manufacturers of covered products must use the prescribed DOE test procedure as the basis for certifying to DOE that their products comply with the applicable energy conservation standards adopted under EPCA and when making representations to the public regarding the energy use or efficiency of those products. (42 U.S.C. 6293(c) and 42 U.S.C. 6295(s)) Similarly, DOE must use these test procedures to determine whether the products comply with standards adopted pursuant to EPCA. (42 U.S.C. 6295(s)) The DOE test procedures for ceiling fans appear at title 10 of the Code of Federal Regulations ("CFR") part 430, subpart B, appendix U.

DOE must follow specific statutory criteria for prescribing new or amended standards for covered products, including ceiling fans. Any new or amended standard for a covered product must be designed to achieve the maximum improvement in energy efficiency that the Secretary of Energy determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A) and 42 U.S.C. 6295(o)(3)(B)) Furthermore, DOE may not adopt any standard that would not result in the significant conservation of energy. (42 U.S.C. 6295(o)(3))

Moreover, DOE may not prescribe a standard: (1) for certain products, including ceiling fans, if no test procedure has been established for the product, or (2) if DOE determines by rule that the standard is not technologically feasible or economically justified. (42 U.S.C. 6295(o)(3)(A)–(B)) In deciding whether a proposed standard is economically justified, DOE must determine whether the benefits of the standard exceed its burdens. (42 U.S.C. 6295(o)(2)(B)(i)) DOE must make this determination after receiving comments on the proposed standard, and by considering, to the greatest extent practicable, the following seven statutory factors:

(1) The economic impact of the standard on manufacturers and consumers of the products subject to the standard;

(2) The savings in operating costs throughout the estimated average life of the covered products in the type (or class) compared to any increase in the price, initial charges, or maintenance expenses for the covered products that are likely to result from the standard;

(3) The total projected amount of energy (or as applicable, water) savings likely to result directly from the standard;

(4) Any lessening of the utility or the performance of the covered products likely to result from the standard;

(5) The impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from the standard;

(6) The need for national energy and water conservation; and

(7) Other factors the Secretary of Energy ("Secretary") considers relevant.

(42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII))

Further, EPCA establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the energy savings during the first year that the consumer will receive as a result of the standard, as calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii))

EPCA also contains what is known as an "anti-backsliding" provision, which prevents the Secretary from prescribing any amended standard that either increases the maximum allowable energy use or decreases the minimum required energy efficiency of a covered product. (42 U.S.C. 6295(o)(1)) Also, the Secretary may not prescribe an amended or new standard if interested persons have established by a preponderance of the evidence that the standard is likely to result in the unavailability in the United States in any covered product type (or class) of performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as those generally available in the United States. (42 U.S.C. 6295(o)(4))

Additionally, EPCA specifies requirements when promulgating an energy conservation standard for a covered product that has two or more subcategories. DOE must specify a different standard level for a type or class of product that has the same function or intended use, if DOE determines that products within such group: (A) consume a different kind of energy from that consumed by other covered products within such type (or class); or (B) have a capacity or other performance-related feature which other products within such type (or class) do not have and such feature justifies a higher or lower standard. (42 U.S.C. 6295(q)(1)) In determining whether a performance-related feature justifies a different standard for a group of products, DOE must consider such factors as the utility to the consumer of the feature and other factors DOE deems appropriate. *Id*. Any rule prescribing such a standard must include an explanation of the basis on which such higher or lower level was established. (42 U.S.C. 6295(q)(2))

Finally, pursuant to the amendments contained in the Energy Independence and Security Act of 2007 ("EISA 2007"), Pub. L. 110-140, any final rule for new or amended energy conservation standards promulgated after July 1, 2010, is required to address standby mode and off mode energy use. (42 U.S.C. 6295(gg)(3)) Specifically, when DOE adopts a standard for a covered product after that date, it must, if justified by the criteria for adoption of standards under EPCA (42 U.S.C. 6295(o)), incorporate standby mode and off mode energy use into a single standard, or, if that is not feasible, adopt a separate standard for such energy use for that product. (42 U.S.C. 6295(gg)(3)(A)-(B)) DOE's current test procedures for ceiling fans does address measuring standby mode and off mode energy use. In this rulemaking, for small-diameter ceiling fans[14] DOE intends to incorporate such energy use into any amended energy conservation standards that it may adopt. For LDCFs[15] and HSBD ceiling fans, DOE has determined that incorporating this energy use into a single standard and establishing a separate standard is not justified under 42 U.S.C. 6295(o).

[14] A small-diameter ceiling fan is a ceiling fan that is less than or equal to seven feet in diameter. 10 CFR part 430 subpart B appendix U section 1.18.

[15] A large-diameter ceiling fan is a ceiling fan that is greater than seven feet in diameter. 10 CFR part 430 subpart B appendix U section 1.12.

B. Background

1. Current Standards

In a final rule published on October 18, 2005, DOE codified the design standards prescribed by EPCA for ceiling fans. 70 FR 60407, 60413. These standards are set forth in DOE's regulations at 10 CFR 430.32(s)(1) and require all ceiling fans manufactured on or after January 1, 2007, to have: (1) fan speed controls separate from any lighting controls; (2) adjustable speed controls (either more than one speed or variable speed); and (3) the capability for reverse action (other than fans sold for industrial or outdoor application or where safety would be an issue). (42 U.S.C. 6295(ff)(1)(A))

In a final rule published on January 19, 2017, ("January 2017 ECS Final Rule"), DOE prescribed the current energy conservation standards for ceiling fans manufactured in, or imported into, the United States on and after January 21, 2020. 82 FR 6826, 6827.

On December 27, 2020, the Energy Act of 2020 (Pub. L. 116-260) was signed into law. The Energy Act of 2020 amended performance standards for LDCFs. (42 U.S.C. 6295(ff)(6)(C)(i), as codified) Pursuant to the Energy Act of 2020, LDCFs are subject to standards in terms of the CFEI metric, with one standard based on operation of the fan at high speed and a second standard based on operation of the fan at 40 percent speed or the nearest speed that is not less than 40 percent speed. (42 U.S.C. 6295(ff)(6)(C)(i), as codified)

On May 27, 2021, DOE published a final rule to amend the current regulations for LDCFs ("May 2021 Technical Amendment"). 86 FR 28469. The May 2021 Technical Amendment was published to codify provisions enacted by Congress through the Energy Act of 2020. Specifically, section 1008 of the Energy Act of 2020 amended section 325(ff)(6) of EPCA to specify that LDCFs manufactured on or after January 21, 2020, are not required to meet minimum ceiling fan efficiency requirements in terms of the ratio of the total airflow to the total power consumption, as established in the January 2017 ECS

Final Rule, and instead are required to meet specified minimum efficiency requirements based on the CFEI metric. 86 FR 28469, 28469-28470. On November 28, 2022, DOE also published a final rule to implement the full scope of standards for LDCFs as set forth in the Energy Act of 2020. 86 FR 72863.

The current standards are set forth in DOE's regulations at 10 CFR 430.32(s) and are summarized in Table II.1.

Table II.1 Current Federal Energy Conservation Standards for Ceiling Fans

Product Class as Defined in Appendix U [of 10 CFR 430.32(s)]	**Minimum Efficiency (CFM/W)[1]**
Very small diameter (VSD)	$D \leq 12$ in.: 21.
	$D > 12$ in.: 3.16D - 17.04.
Standard	0.65D + 38.03.
Hugger	0.29D + 34.46.
High-speed small diameter (HSSD)	4.16D + 0.02.
[1]D is the ceiling fan's blade span, in inches, as determined in Appendix U of [10 CFR 430.32(s)].	
Product Class as Defined in Appendix U [of 10 CFR 430.32(s)]	**Minimum Efficiency (CFEI)**
Large-diameter ceiling fans (LDCFs)	1.00 at high speed
	1.31 at 40 percent speed or the nearest speed that is not less than 40 percent speed.

2. History of Standards Rulemaking for Ceiling Fans

On May 7, 2021, DOE published a notice that it was initiating an early assessment review to determine whether any new or amended standards would satisfy the relevant requirements of EPCA for a new or amended energy conservation standard for ceiling fans and a request for information ("RFI"). 86 FR 24538 ("May 2021 RFI").

On February 10, 2022, DOE published a notice of public webinar and availability of preliminary technical support document ("TSD"). 87 FR 7758 ("February 2022 Preliminary Analysis"). The purpose of the February 2022 Preliminary Analysis was to make publicly available the initial technical and economic analyses conducted for ceiling fans and present initial results of those analyses. DOE held the public webinar on March 16, 2022, to present its preliminary analysis and to seek comments from interested parties.

DOE received comments in response to the February 2022 Preliminary Analysis from the interested parties listed in Table II.2.

Table II.2 February 2022 Preliminary Analysis Written Comments

Commenter(s)	Abbreviation	Comment Number in the Docket	Commenter Type
American Lighting Association	ALA	26	Trade Association
Air Movement and Control Association	AMCA	23	Trade Association
Pacific Gas and Electric Company, Southern California Edison, San Diego Gas & Electric Company	CA IOUs	22	Utilities
Appliance Standards Awareness Project, American Council for an Energy-Efficient Economy, Natural Resources Defense Council, New York State Energy Research and Development Authority	Efficiency Advocates	25	Efficiency Organizations
Lutron Electronics Co.	Lutron	24	Controller Manufacturer
Northwest Energy Efficiency Alliance	NEEA	27	Efficiency Organization

A parenthetical reference at the end of a comment quotation or paraphrase provides the location of the item in the public record.[16] To the extent that interested parties have provided written comments that are substantively consistent with any oral comments provided during the March 2022 public meeting, DOE cites the written comments throughout this document. Any oral comments provided during the webinar that are not substantively addressed by written comments are summarized and cited separately throughout this document.

[16] The parenthetical reference provides a reference for information located in the docket of DOE's rulemaking to develop energy conservation standards for ceiling fans. (Docket No. EERE-2021-BT-STD-0011, which is maintained at *www.regulations.gov*). The references are arranged as follows: (commenter name, comment docket ID number, page of that document).

C. Deviation from Appendix A

In accordance with section 3(a) of 10 CFR part 430, subpart C, appendix A ("appendix A"), DOE notes that it is deviating from the provision in appendix A regarding the NOPR stage for an energy conservation standard rulemaking. Section 6(f)(2) of appendix A specifies that the length of the public comment period for a NOPR will vary depending upon the circumstances of the particular rulemaking, but will not be less than 75 calendar days. DOE is opting to deviate from this step by providing a 60-day comment period. As previously discussed, DOE requested comment on its analytical approach in section ES.3 of the February 2022 Preliminary Analysis TSD and provided stakeholders with a 60-day comment period. Given that this NOPR relies largely on the same analytical approach taken in the February 2022 Preliminary Analysis, DOE believes a 60-day comment period is appropriate and will provide interested parties with a meaningful opportunity to comment on the proposed rule.

III. General Discussion

DOE developed this proposal after considering oral and written comments, data, and information from interested parties that represent a variety of interests. The following discussion addresses issues raised by these commenters.

A. General Comments

This section summarizes general comments received from interested parties regarding rulemaking timing and process.

NEEA commented generally that they support DOE's continued development of energy conservation standards and use of transparent and comparable efficiency metrics to encourage market adoption of efficient products. (NEEA, No. 27 at p. 1)

B. Product Classes and Scope of Coverage

When evaluating and establishing energy conservation standards, DOE divides covered products into product classes by the type of energy used or by capacity or other performance-related features that justify differing standards. In determining whether a performance-related feature justifies a different standard, DOE must consider such factors as the utility of the feature to the consumer and other factors DOE determines are appropriate. (42 U.S.C. 6295(q)) This NOPR covers those consumer products that meet the definition of "ceiling fans," as codified at 10 CFR 430.2. See section IV.A.1 of this document for discussion of the scope of coverage and product classes analyzed in this NOPR.

C. Test Procedure

EPCA sets forth generally applicable criteria and procedures for DOE's adoption and amendment of test procedures. (42 U.S.C. 6293) Manufacturers of covered products must use these test procedures to certify to DOE that their product complies with energy conservation standards and to quantify the efficiency of their product. DOE's current energy conservation standards for ceiling fans are expressed in terms of CFM/W and CFEI. (*See* 10 CFR 430.32(s)(2).)

D. Technological Feasibility

1. General

In each energy conservation standards rulemaking, DOE conducts a screening analysis based on information gathered on all current technology options and prototype designs that could improve the efficiency of the products or equipment that are the subject of the rulemaking. As the first step in such an analysis, DOE develops a list of technology options for consideration in consultation with manufacturers, design engineers, and other interested parties. DOE then determines which of those means for improving efficiency are technologically feasible. DOE considers technologies incorporated in commercially-available products or in working prototypes to be technologically feasible. Sections 6(b)(3)(i) and 7(b)(1) of appendix A to 10 CFR part 430 subpart C ("Process Rule").

After DOE has determined that particular technology options are technologically feasible, it further evaluates each technology option in light of the following additional screening criteria: (1) practicability to manufacture, install, and service; (2) adverse impacts on product utility or availability; (3) adverse impacts on health or safety, and (4) unique-pathway proprietary technologies. Sections 6(b)(3)(ii)-(v) and 7(b)(2)-(5) of the Process Rule. Section IV.B of this document discusses the results of the screening analysis for ceiling fans, particularly the designs DOE considered, those it screened out, and those that are the basis for the standards considered in this proposed rulemaking. For further details on the screening analysis for this rulemaking, see chapter 4 of the NOPR technical support document ("TSD").

2. Maximum Technologically Feasible Levels

When DOE proposes to adopt an amended standard for a type or class of covered product, it must determine the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such product. (42 U.S.C. 6295(p)(1)) Accordingly, in the engineering analysis, DOE determined the maximum technologically feasible ("max-tech") improvements in energy efficiency for ceiling fans, using the design parameters for the most efficient products available on the market or in working prototypes. The max-tech levels that DOE determined for this rulemaking are described in section IV.C of this proposed rule and in chapter 5 of the NOPR TSD.

E. Energy Savings

1. Determination of Savings

For each trial standard level ("TSL"), DOE projected energy savings from application of the TSL to ceiling fans purchased in the 30-year period that begins in the first full year of compliance with the proposed standards (2028–2057).[17] The savings are measured over the entire lifetime of ceiling fans purchased in the previous 30-year period. DOE quantified the energy savings attributable to each TSL as the difference in energy consumption between each standards case and the no-new-standards case. The no-new-standards case represents a projection of energy consumption that reflects how the market for a product would likely evolve in the absence of amended energy conservation standards.

DOE used its national impact analysis ("NIA") python programming language model to estimate national energy savings ("NES") from potential amended or new standards for ceiling fans. The NIA python programming language model (described in section IV.H of this document) calculates energy savings in terms of site energy, which is the energy directly consumed by products at the locations where they are used. For electricity, DOE reports national energy savings in terms of primary energy savings, which is the savings in the energy that is used to generate and transmit the site electricity. DOE also calculates NES in terms of FFC energy savings. The FFC metric includes the energy consumed in extracting, processing, and transporting primary fuels (*i.e.*, coal, natural gas, petroleum fuels), and thus presents a more complete picture of the impacts of energy conservation standards.[18] DOE's approach is based on the calculation of an FFC

[17] Each TSL is composed of specific efficiency levels for each product class. The TSLs considered for this NOPR are described in section V.A of this document. DOE conducted a sensitivity analysis that considers impacts for products shipped in a 9-year period.
[18] The FFC metric is discussed in DOE's statement of policy and notice of policy amendment. 76 FR 51282 (Aug. 18, 2011), as amended at 77 FR 49701 (Aug. 17, 2012).

multiplier for each of the energy types used by covered products or equipment. For more information on FFC energy savings, see section IV.H.1 of this document.

2. Significance of Savings

To adopt any new or amended standards for a covered product, DOE must determine that such action would result in significant energy savings. (42 U.S.C. 6295(o)(3)(B))

The significance of energy savings offered by a new or amended energy conservation standard cannot be determined without knowledge of the specific circumstances surrounding a given rulemaking.[19] For example, some covered products and equipment have most of their energy consumption occur during periods of peak energy demand. The impacts of these products on the energy infrastructure can be more pronounced than products with relatively constant demand. Accordingly, DOE evaluates the significance of energy savings on a case-by-case basis, taking into account the significance of cumulative FFC national energy savings, the cumulative FFC emissions reductions, and the need to confront the global climate crisis, among other factors. DOE has initially determined the energy savings from the proposed standard levels are "significant" within the meaning of 42 U.S.C. 6295(o)(3)(B).

F. Economic Justification

1. Specific Criteria

As noted previously, EPCA provides seven factors to be evaluated in determining whether a potential energy conservation standard is economically justified. (42 U.S.C.

[19]The numeric threshold for determining the significance of energy savings established in a final rule published on February 14, 2020 (85 FR 8626, 8670), was subsequently eliminated in a final rule published on December 13, 2021 (86 FR 70892).

6295(o)(2)(B)(i)(I)-(VII)) The following sections discuss how DOE has addressed each of those seven factors in this proposed rulemaking.

a. Economic Impact on Manufacturers and Consumers

In determining the impacts of a potential amended standard on manufacturers, DOE conducts an MIA, as discussed in section IV.J of this document. DOE first uses an annual cash-flow approach to determine the quantitative impacts. This step includes both a short-term assessment—based on the cost and capital requirements during the period between when a regulation is issued and when entities must comply with the regulation—and a long-term assessment over a 30-year period. The industry-wide impacts analyzed include (1) INPV, which values the industry on the basis of expected future cash flows, (2) cash flows by year, (3) changes in revenue and income, and (4) other measures of impact, as appropriate. Second, DOE analyzes and reports the impacts on different types of manufacturers, including impacts on small manufacturers. Third, DOE considers the impact of standards on domestic manufacturer employment and manufacturing capacity, as well as the potential for standards to result in plant closures and loss of capital investment. Finally, DOE takes into account cumulative impacts of various DOE regulations and other regulatory requirements on manufacturers.

For individual consumers, measures of economic impact include the changes in LCC and PBP associated with new or amended standards. These measures are discussed further in the following section. For consumers in the aggregate, DOE also calculates the national net present value of the consumer costs and benefits expected to result from particular standards. DOE also evaluates the impacts of potential standards on identifiable subgroups of consumers that may be affected disproportionately by a standard.

b. Savings in Operating Costs Compared to Increase in Price (LCC and PBP)

EPCA requires DOE to consider the savings in operating costs throughout the estimated average life of the covered product in the type (or class) compared to any increase in the price of, or in the initial charges for, or maintenance expenses of, the covered product that are likely to result from a standard. (42 U.S.C. 6295(o)(2)(B)(i)(II)) DOE conducts this comparison in its LCC and PBP analysis.

The LCC is the sum of the purchase price of a product (including its installation) and the operating expense (including energy, maintenance, and repair expenditures) discounted over the lifetime of the product. The LCC analysis requires a variety of inputs, such as product prices, product energy consumption, energy prices, maintenance and repair costs, product lifetime, and discount rates appropriate for consumers. To account for uncertainty and variability in specific inputs, such as product lifetime and discount rate, DOE uses a distribution of values, with probabilities attached to each value.

The PBP is the estimated amount of time (in years) it takes consumers to recover the increased purchase cost (including installation) of a more-efficient product through lower operating costs. DOE calculates the PBP by dividing the change in purchase cost due to a more-stringent standard by the change in annual operating cost for the year that standards are assumed to take effect.

For its LCC and PBP analysis, DOE assumes that consumers will purchase the covered products in the first full year of compliance with new or amended standards. The LCC savings for the considered efficiency levels are calculated relative to the case that reflects projected market trends in the absence of new or amended standards. DOE's LCC and PBP analysis is discussed in further detail in section IV.F of this document.

c. Energy Savings

Although significant conservation of energy is a separate statutory requirement for adopting an energy conservation standard, EPCA requires DOE, in determining the economic justification of a standard, to consider the total projected energy savings that are expected to result directly from the standard. (42 U.S.C. 6295(o)(2)(B)(i)(III)) As discussed in section III.D of this document, DOE uses the NIA python programming language model to project national energy savings.

d. Lessening of Utility or Performance of Products

In establishing product classes and in evaluating design options and the impact of potential standard levels, DOE evaluates potential standards that would not lessen the utility or performance of the considered products. (42 U.S.C. 6295(o)(2)(B)(i)(IV)) Based on data available to DOE, the standards proposed in this document would not reduce the utility or performance of the products under consideration in this proposed rulemaking.

e. Impact of Any Lessening of Competition

EPCA directs DOE to consider the impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from a proposed standard. (42 U.S.C. 6295(o)(2)(B)(i)(V)) It also directs the Attorney General to determine the impact, if any, of any lessening of competition likely to result from a proposed standard and to transmit such determination to the Secretary within 60 days of the publication of a proposed rule, together with an analysis of the nature and extent of the impact. (42 U.S.C. 6295(o)(2)(B)(ii)) DOE will transmit a copy of this proposed rule to the Attorney General with a request that the Department of Justice ("DOJ") provide its determination on this issue. DOE will publish and respond to the Attorney General's determination in the final rule. DOE invites comment from the public regarding the competitive impacts that are likely to result from this proposed rule. In addition, stakeholders may also provide comments separately to DOJ regarding these potential impacts. See the **ADDRESSES** section for information to send comments to DOJ.

f. Need for National Energy Conservation

DOE also considers the need for national energy and water conservation in determining whether a new or amended standard is economically justified. (42 U.S.C. 6295(o)(2)(B)(i)(VI)) The energy savings from the proposed standards are likely to provide improvements to the security and reliability of the Nation's energy system. Reductions in the demand for electricity also may result in reduced costs for maintaining the reliability of the Nation's electricity system. DOE conducts a utility impact analysis to estimate how standards may affect the Nation's needed power generation capacity, as discussed in section IV.M of this document.

DOE maintains that environmental and public health benefits associated with the more efficient use of energy are important to take into account when considering the need for national energy conservation. The proposed standards are likely to result in environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases ("GHGs") associated with energy production and use. DOE conducts an emissions analysis to estimate how potential standards may affect these emissions, as discussed in section IV.K of this document; the estimated emissions impacts are reported in section V.B.6 of this document. DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section IV.L of this document.

g. Other Factors

In determining whether an energy conservation standard is economically justified, DOE may consider any other factors that the Secretary deems to be relevant. (42 U.S.C.

6295(o)(2)(B)(i)(VII)) To the extent DOE identifies any relevant information regarding economic justification that does not fit into the other categories described previously, DOE could consider such information under "other factors."

2. Rebuttable Presumption

As set forth in 42 U.S.C. 6295(o)(2)(B)(iii), EPCA creates a rebuttable presumption that an energy conservation standard is economically justified if the additional cost to the consumer of a product that meets the standard is less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable DOE test procedure. DOE's LCC and PBP analyses generate values used to calculate the effects that proposed energy conservation standards would have on the payback period for consumers. These analyses include, but are not limited to, the 3-year payback period contemplated under the rebuttable-presumption test. In addition, DOE routinely conducts an economic analysis that considers the full range of impacts to consumers, manufacturers, the Nation, and the environment, as required under 42 U.S.C. 6295(o)(2)(B)(i). The results of this analysis serve as the basis for DOE's evaluation of the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification). The rebuttable presumption payback calculation is discussed in section V.B.1.c of this proposed rule.

IV. Methodology and Discussion of Related Comments

This section addresses the analyses DOE has performed for this rulemaking with regard to ceiling fans. Separate subsections address each component of DOE's analyses.

DOE used several analytical tools to estimate the impact of the standards proposed in this document. The first tool is a spreadsheet that calculates the LCC savings and PBP of potential amended or new energy conservation standards. The national impacts analysis uses a second spreadsheet set that provides shipments projections and calculates national energy savings and net present value of total consumer costs and savings expected to result from potential energy conservation standards. DOE uses the third spreadsheet tool, the Government Regulatory Impact Model ("GRIM"), to assess manufacturer impacts of potential standards. These three spreadsheet tools are available on the DOE website for this rulemaking: *www.regulations.gov/docket/EERE-2021-BT-STD-0011*. Additionally, DOE used output from the latest version of the Energy Information Administration's ("EIA's") *Annual Energy Outlook* ("*AEO*"), a widely known energy projection for the United States, for the emissions and utility impact analyses.

A. Market and Technology Assessment

DOE develops information in the market and technology assessment that provides an overall picture of the market for the products concerned, including the purpose of the products, the industry structure, manufacturers, market characteristics, and technologies used in the products. This activity includes both quantitative and qualitative assessments, based primarily on publicly-available information. The subjects addressed in the market and technology assessment for this rulemaking include (1) a determination of the scope of the rulemaking and product classes, (2) manufacturers and industry structure, (3) existing efficiency programs, (4) shipments information, (5) market and industry trends; and (6) technologies or design options that could improve the energy efficiency of ceiling fans. The key findings of DOE's market assessment are summarized in the following sections. See chapter 3 of the NOPR TSD for further discussion of the market and technology assessment.

1. Product Classes

When evaluating and establishing energy conservation standards, DOE may establish separate standards for a group of covered products (*i.e.*, establish a separate product class) if DOE determines that separate standards are justified based on the type of energy used, or if DOE determines that a product's capacity or other performance-related feature justifies a different standard. (42 U.S.C. 6295(q)) In making a determination whether a performance-related feature justifies a different standard, DOE must consider such factors as the utility of the feature to the consumer and other factors DOE determines are appropriate. (*Id.*)

DOE currently defines separate energy conservation standards for the following ceiling fan product classes: hugger, standard, very small diameter ("VSD"), high-speed small diameter ("HSSD"), and LDCF. 10 CFR 430.32(s)(2).

In section 2.2 of the February 2022 Preliminary Analysis TSD, DOE requested comment on VSD ceiling fans, HSBD ceiling fans, high- and low-airflow LDCFs, and very-close mount hugger ceiling fans. These comments are discussed in detail as follows:

a. Very Small Diameter Ceiling Fans

A VSD ceiling fan is defined as a small-diameter ceiling fan less than or equal to 18 inches. Appendix U to subpart B of part 430 ("appendix U"). On August 16, 2022, DOE published a test procedure final rule for ceiling fans ("August 2022 TP Final Rule"). 87 FR 50396. The August 2022 TP Final Rule amended the definition of ceiling fan to clarify that a ceiling fan must provide circulating air, and clarified that "a ceiling fan that has a ratio of fan blade span (in inches) to maximum rotation rate (in revolutions per minute) greater than 0.06 provides circulating air.” *Id.* at 87 FR 50402.

DOE included VSD fans in the February 2022 Preliminary Analysis, but in section 2.2.1 of the preliminary analysis TSD stated that all VSD fans DOE was aware of had a diameter-to-maximum operating speed ratio of less than or equal to 0.06 inches to revolutions per minute (“in/RPM”). Therefore, with the amended definition of “circulating air”, DOE expected that there would no longer be any ceiling fans on the market that would meet the definition of a VSD ceiling fan. In the February 2022 Preliminary Analysis, DOE requested comment on its observation that all VSD ceiling fans would have a diameter-to-maximum operating speed ratio of less than or equal to 0.06 in/RPM.

In response, ALA supported delineating air circulating fan heads from ceiling fans using the 0.06 ratio, and provided data that shows a distinct difference in the ratio for air circulating fan heads and ceiling fans. (ALA, No. 26 at p. 7) The Efficiency Advocates encouraged DOE to cover VSD ceiling fans in the fans and blowers rulemaking. (Efficiency Advocates, No. 25 at p. 3)

DOE notes that comments related to scope and definitions for fans and blowers are available at Docket No. EERE-2021-BT-TP-0021. DOE did not receive any comments identifying VSD fans that exceed the 0.06 ratio. Further, DOE notes that the maximum diameter for a VSD fan is 18 inches. Based on the 0.06 ratio, a VSD fan would have to operate at a maximum of 300 rpm to meet the definition of circulating air and therefore meet the definition of a ceiling fan. Most fans with blade spans 18 inches or less on the market advertise blade speeds greater than 1,000 rpm.

In theory, a ceiling fan could exist that meets the definition of both circulating air and VSD ceiling fan. In that case, the DOE test procedure at appendix U to subpart B of part 430 would be applicable, and the current energy conservation standards for VSD ceiling fans at 10 CFR 430.32(s)(2) would apply. However, DOE does not expect fans to enter the market that meet the definition of both ceiling fan and VSD ceiling fan because a fan with a blade span of 18 inches or less spinning at fewer than 300 rpm would provide limiting cooling utility for consumers. As such, for this NOPR, DOE has assumed that VSD ceiling fan shipments are zero, and has not evaluated amended energy conservation standards for VSD ceiling fans.

DOE requests comment on its assumption that there are zero products on the market that meet the definition of both ceiling fan and VSD ceiling fan, and its decision not to evaluate amended energy conservation standards for VSD ceiling fans on that basis.

b. High-Speed Belt-Driven Ceiling Fans

Belt-driven ceiling fans are defined as “a ceiling fan with a series of one or more fan heads, each driven by a belt connected to one or more motors that are located outside of the fan head.” Appendix U to subpart B of part 430. On July 25, 2016, DOE published a test procedure final rule (“July 2016 TP Final Rule”), in which it stated it would not propose standards for belt-driven ceiling fans due to the limited number of basic models and lack of available data. 81 FR 48619, 48622. In the January 2017 ECS Final Rule, DOE noted that belt-driven ceiling fans were generally highly customizable, and that customers can decide on the number of fan heads, distance from the motor to the fan head, and type of belt. (See chapter 3 of the January 2017 ECS Final Rule TSD). While DOE did establish a definition and product class, belt-driven ceiling fans were exempt from the test procedure, and energy conservation standards were therefore not established. 81 FR 48619, 48622, 48624.

In response to the May 2021 RFI, BAF[20] and AMCA commented that a new type of belt-driven ceiling fan that uses a larger motor and higher tip speeds has recently entered the market. (BAF, No. 14 at p. 2; AMCA, No. 9 at p. 4) BAF and AMCA recommended that DOE create a high-speed product class and a low-speed product class for these belt-driven ceiling fans. *Id.* BAF and AMCA additionally suggested that the HSBD ceiling fans be subject to testing according to the American National Standards Institute ("ANSI")/AMCA Standard 230-15 "Laboratory Methods of Testing Air Circulating Fans for Rating and Certification" ("AMCA 230-15"). *Id*. BAF also recommended that HSBD ceiling fans be subject to energy conservation standards, but that low-speed belt-driven ceiling fans should be exempted. (BAF, No. 14 at p. 2) The CA IOUs identified one of these HSBD ceiling fans (drum-type circulating ceiling fan) and asked DOE to clarify whether industrial belt-driven fans are covered as ceiling fans or as fans and blowers. (CA IOUs, No. 12 at p. 4-5)

In its August 2022 TP Final Rule, DOE defined HSBD ceiling fan, stated that these fans shall be tested according to AMCA 230-15, and stated that HSBD ceiling fans will use the CFEI metric. 87 FR 50396. DOE did not establish separate definitions for small- and large-diameter HSBD fans, but rather included all HSBD ceiling fans into one definition. *Id.* at 87 FR 50404. DOE notes that belt-driven ceiling fans that do not meet the definition of HSBD remain exempt from the DOE test procedure. *See* appendix U.

[20] This notice uses BAF to refer to comments from Big Ass Fans, a manufacturer of ceiling fans.

DOE notes that a ceiling fan must be "distributed in commerce with components that enable it to be suspended from a ceiling." 87 FR 50396, 50402. Belt-driven fans are often distributed in commerce without components that enable the fan to be suspended from a ceiling. For example, some belt-driven fans are sold connected to wheels or to a pedestal base. In this case, such a fan would not meet the definition of a ceiling fan because it has not been manufactured to be suspended from the ceiling, and therefore would not be subject to the HSBD test procedure or any potential energy conservation standards even though a consumer could independently purchase their own straps or chains and elect to hang this fan from the ceiling.

HSBD fans in contrast, are distributed in commerce with specific straps, chains, or other similar components that are designed and tested by the manufacturer to safely support the weight of the ceiling fan in an overhead configuration. Further, they circulate air, since they meet the 0.06 blade span to maximum rpm ratio.

Many belt-driven fans are housed (meaning the fan blades are contained within a cylindrical enclosure, often with solid metal sides and a cage on the front and back); however, the presence of a housing is not relevant in determining whether a product meets the definition of ceiling fan. While a housing is generally included to better direct air, a housing could be added to a ceiling fan, including those that are clearly intended to circulate air. As such, DOE emphasizes that the definition of a ceiling fan requires that fan to be "suspended from a ceiling" and to "circulate air", rather than the presence or absence of a fan housing.

In this NOPR, DOE has evaluated potential energy conservation standards for HSBD ceiling fans.

c. High- and Low-Airflow Large-Diameter Ceiling Fans

BAF and AMCA previously commented that two product classes, separated based on airflow, may be justified for LDCFs to reflect unique characteristics for products intended for commercial versus industrial applications. (BAF, No. 14 at p. 2; AMCA, No. 9 at p. 7). In response to these comments, DOE considered whether to establish separate high-airflow and low-airflow product classes for LDCFs in section 2.4.1.1 of its February 2022 Preliminary Analysis TSD.

In response, the CA IOUs, AMCA, and NEEA all commented that DOE should not divide the LDCF product class into separate high- and low-airflow classes because doing so would not provide any benefit or be warranted by differences in features or technology. (AMCA, No. 23 at pp. 2-4; NEEA, No. 27 at p. 2; CA IOUs, No. 22 at pp. 2-4) The CA IOUs provided results from a study they conducted that analyzed the performance data of 90 AMCA-certified LDCFs. (CA IOUs, No. 22 at pp. 2-4) The results showed that 66 percent of fans were included in the low-airflow class and that many were near the airflow cutoff between the two classes that DOE defined in the February 2022 Preliminary Analysis. *Id.* They noted that slight changes in fan speed could therefore cause a fan to move from one class into another. *Id.* The CA IOUs suggested that the similarity in the airflow data therefore indicated that it is unnecessary to separate low- and higher-airflow fans, and that if different energy conservation standards were used for the two classes it could result in market distortion. *Id.* Additionally, the results also showed that commercial LDCFs generally had a higher CFEI than industrial LDCFs, which the CA IOUs attributed to commercial LDCFs often using more efficient motors. They stated that these results also indicate that airflow is not a driver of efficiency for LDCFs. *Id.*

To establish a separate product class, DOE must determine that a product has a capacity or other performance-related feature which other covered products do not have, and that such feature justifies a different standard through the feature's utility to the consumer and other factors. (42 U.S.C. 6295(q)) DOE reviewed the data provided by the CA IOUs and manufacturer literature and found that while some fans are marketed for lower airflow and commercial applications, and that others are marketed for higher-airflow, DOE agrees with commenters that there is not a clear performance-related distinction between the two. Therefore, DOE did not evaluate low- and high-airflow LDCFs as separate product classes in this analysis.

d. Very-Close Mount Hugger Ceiling Fans

Hugger ceiling fans offer consumer utility since they have less distance between the ceiling fan blades and the ceiling. This allows them to be installed in applications with lower ceilings, where a standard ceiling fan with a down rod could be a safety issue or would not be desirable to consumers.

In section 2.4.1.1 of the February 2022 Preliminary Analysis TSD, DOE discussed that moving a hugger fan further from the ceiling could increase airflow without an associated increase in power consumption, although this would be at the expense of consumer preferences for a very-close mounted fan. DOE requested comment on whether consumers consider all hugger ceiling fans equal, or if there is additional consumer utility associated with hugger fans that are closer to the ceiling.

ALA commented that there is no additional utility associated with hugger fans that are closer to the ceiling and encouraged DOE to maintain only one product class for hugger ceiling fans as doing so would avoid the need for additional testing. (ALA, No. 26

at p. 9) DOE did not receive any comment suggesting that very-close mount hugger fans warranted a separate equipment class.

In this NOPR, DOE did not further evaluate a separate product class for ceiling fans that are closer to the ceiling. However, DOE did modify its engineering analysis for hugger ceiling fans to reflect that moving a hugger fan further from the ceiling (although still less than or equal to 10 inches from the ceiling) represents a possible path toward meeting higher efficiency standards. This is discussed in greater detail in section IV.C of this document.

2. Test Procedure and Certification

DOE's test procedure for measuring the energy efficiency of ceiling fans is available at appendix U and requirements for certification in DOE's compliance certification database ("CCD") specific to ceiling fans are provided at 10 CFR 429.32. In section 2.3 of the February 2022 Preliminary Analysis TSD, DOE stated that proposed rules had been issued to amend both the ceiling fan test procedure and ceiling fan certification requirements. Since the February 2022 Preliminary Analysis, the August 2022 TP Final Rule (87 FR 50396) and a certification Final Rule ("July 2022 Certification Final Rule") (87 FR 43952) have published, and updates were included in their respective sections of the CFR.

In response to the February 2022 Preliminary Analysis, stakeholders commented on test procedure and certification issues. These comments are summarized and addressed as follows.

Regarding the test procedure for LDCFs, NEEA commented that they generally support use of the CFEI metric for LDCFs. (NEEA, No. 27 at pp. 1-2) AMCA recommended that DOE define a minimum testable configuration for LDCFs that specifies which components and accessories should and should not be included for testing. (AMCA, No. 23 at p. 9) Additionally, AMCA recommended that, for a minimum LDCF testable configuration, the fan should be tested as a complete fan with a single-fan controller and that any optional features that do not relate to air movement should not be energized during testing. (AMCA, No. 23 at p. 9)

Regarding AMCA's suggestion to test ceiling fans without including additional accessories and in a minimum testable configuration, DOE notes that appendix U requires that additional accessories not related to ceiling fan airflow be turned off during testing and that testing shall be completed with the default or minimally functional controller. Specifically, section 3.3.1 of appendix U lists specifications for testing with additional accessories for standard and hugger fans and section 3.5.1 of appendix U lists specifications for testing with additional accessories for LDCFs and HSBD fans.

AMCA also commented that additional parameters, like blade span, CFEI100, CFEI40, airflow at high speed, and airflow at 40 percent speed, should be included in the reporting requirements for the CCD so that the data can be used in the next rulemaking to adjust CFEI ratings and standby power requirements. AMCA added that standby power should also be reported for compliance filing. AMCA further stated that adding these reporting requirements would not create an additional burden on manufacturers because the additional data being reported would come directly from the test report that is already produced for DOE compliance testing. (AMCA, No. 23 at pp. 3, 7)

Regarding compliance with existing energy conservation standards, AMCA commented that, based on an internet market survey they conducted, they believe many

LDCFs on the market are not currently registered in DOE's CCD. AMCA estimated that less than half of the LDCF models available for sale in the United States were certified to DOE and that only 7 of the 23 LDCF manufacturers/importers they identified had registered products in the CCD. (AMCA, No. 23 at pp. 7, 14-15) Additionally, AMCA commented that some of the published performance data for fan models identified in their internet market survey may be physically impossible. (AMCA, No. 23 at pp. 14- 15; Ivanovich, Public Meeting Transcript, No. 21 at p. 10)

AMCA expressed concern that increased standards would have a disproportionate impact on manufacturers that are certifying their fans and working to meet the energy conservation standards, and they encouraged DOE to enforce its standards across the ceiling fan industry. (AMCA, No. 23 at pp. 14-15; Ivanovich, Public Meeting Transcript, No. 21 at p. 10)

AMCA estimated that the performance of many products identified through their internet market survey but not registered in the CCD may be below the current energy conservation standards. *Id.* AMCA further stated that these unregistered products could muddy DOE's analysis by suggesting that the current energy conservation standards are being easily met. (AMCA, No. 23 at pp. 1-2,7) AMCA commented that current energy conservation standards were met through investment by manufacturers, and enacting higher efficiency standards today would penalize manufacturers that have invested to comply with current energy conservation standards while rewarding bad actors who never invested. (AMCA, No. 23 at p. 1,2)

Regarding ceiling fan certification requirements, DOE notes that the July 2022 Certification Final Rule amended 10 CFR 429.32 to require additional data submission at the time of certification for LDCFS, including blade span, CFEI40, and CFEI100, amongst other data. 87 FR 43952, 43964-66. Further, DOE notes that 10 CFR 429.12(a) specifies that "[e]ach manufacturer, before distributing in commerce any basic model of a covered product or covered equipment subject to an applicable energy conservation standard set forth in parts 430 or 431, and annually thereafter on or before the dates provided in paragraph (d) of this section, shall submit a certification report to DOE certifying that each basic model meets the applicable energy conservation standard(s)." 10 CFR 429.12(a). DOE's current energy conservation standards are listed at 10 CFR 430.32(s)(2) and are relevant to all ceiling fans manufactured on or after January 21, 2020. Consistent with 10 CFR parts 429 and 430, manufacturers are required to submit a certification report to DOE that their basic models meet the relevant energy conservation standards at10 CFR 430.32(s)(2) along with the additional information as required in 10 CFR 429.32.

Regarding the sampling requirements when testing LDCFs, AMCA stated that the data they provided to DOE were based on single-sample tests, rather than the two-sample tests required by 10 CFR 429.32. AMCA also commented that the current Federal energy conservation standards are based on single-sample test data as well. AMCA provided calculations showing the impact of using the confidence limits in 10 CFR 429.32 to determine the represented CFEI values from two samples.

AMCA further commented that after the Energy Act of 2020 was published, which prescribed the current energy conservation standards at CFEI100 and CFEI40, a technical errata to AMCA 230-15 was published on May 15, 2021 to account for air density differences between test labs. (AMCA, No. 23 at pp. 12-13) AMCA commented that because DOE has incorporated the technical errata to AMCA 230-15 into DOE's test procedure, (*see* appendix U and 87 FR 50396, 50405), the manufacturer data on which DOE's analysis is based overestimates performance by an average of 3 percent.

AMCA estimated that correcting for the test lab air density, as required in the AMCA 230 technical errata, and two-sample requirements in 10 CFR 429.32 increase CFEI 100 and CFEI 40 by an average of 12 percent and 17 percent, respectively. (AMCA, No. 23 at pp. 2-3) AMCA encouraged DOE to both account for the impact of the technical errata and ensure that its analysis is based on two-sample data. (AMCA, No. 23 at pp. 13-14) Given the impact of the technical errata and the requirement to use two-sample test data, AMCA commented that the current energy conservation standards are stricter than congress intended and therefore AMCA recommended that DOE maintain the current CFEI requirements of CFEI100 = 1.00 and CFEI40 = 1.31 in this proposed rulemaking. (AMCA, No. 23 at p. 3)

DOE disagrees with AMCA's comment that the statistical requirements in 10 CFR 429.32 result in a more stringent standard when conducting a two-sample test. 10 CFR 429.32(a)(2)(i) states that reported airflow should use the lower of "the mean of the sample" or "the lower 90 percent confidence limit (LCL) of the true mean divided by 0.9." Similarly, 10 CFR 429.32(a)(2)(ii) states that reported power consumption should use the higher of "the mean of the sample" or "the upper 95 percent confidence limit (UCL) of the true mean divided by 1.1." In the example data AMCA included in their comments (AMCA No. 23 at p. 14), the values listed as "Represented Value" are the 90 percent lower confidence limit ("LCL") of the true mean of the airflow and the 95 percent upper confidence limit ("UCL") of the true mean of the power consumption. These values do not include the "divided by 0.9" in 10 CFR 429.32(a)(2)(i)(B) and the "divided by 1.1" in 10 CFR 429.32(a)(2)(ii)(B). If the statistical calculations were applied as written in 10 CFR 429.32(a)(2), the mean of the sample is lower than the 90 percent LCL of the true mean divided by 0.9 and therefore the mean of the sample should be used to represent the airflow. Similarly, the mean of the power consumption is greater than the mean of the 95 percent UCL of the true mean divided by 1.1 and therefore the mean of the sample should be used to represent power consumption.

DOE notes that the only time the mean of the two-sample test is not used is when there is a large deviation between the measured results of the two tests. Even in a scenario where the two-sample test requirement results in large deviation, manufacturers have the option to conduct additional tests to increase the confidence of the sample mean. Therefore, DOE has not modified its analysis to reflect any difference between reported single-sample results and two-sample results in this NOPR.

Regarding using the AMCA 230-15 technical errata, DOE agrees that if manufacturer data did not correct for air density, it may overstate a CFEI values for a given LDCF. DOE notes that current energy conservation standards must be met using appendix U, which includes the AMCA 230-15 technical errata. However, DOE has modified its analysis of higher efficiency levels in this NOPR to reflect the possibility that some manufacturer data on which DOE's analysis is based may not include air density corrections. This modification is discussed in more detail in section IV.C.2.b of this document.

3. Technology Options

In the preliminary market analysis and technology assessment, DOE identified several technology options that would be expected to improve the efficiency of ceiling fans, as measured by the DOE test procedure. As previously discussed, standard and hugger ceiling fan efficiency is based on a weighted average CFM/W metric, whereas LDCF and HSBD ceiling fan efficiency is evaluated using CFEI. Standard and hugger ceiling fans are also typically installed in residential applications whereas LDCF and HSBD ceiling fans are typically installed in commercial and/or industrial applications. The differences in metric, market, and utility mean that the technology options for improving the efficiency as measured by the DOE test procedure are unique for each product class.

In section 2.4.3 of the February 2022 Preliminary Analysis TSD, DOE identified technologies for improving the efficiency of each ceiling fan product class. The following sections discuss the technology options identified in the February 2022 Preliminary Analysis, stakeholder comment, and DOE's technology options included in this NOPR analysis.

a. Standard and Hugger Ceiling Fans

Generally, at both low and high speeds an increase in standard and hugger ceiling fan efficiency can be achieved by increasing airflow and decreasing power consumption. In section 2.4.3 of the February 2022 Preliminary Analysis TSD, DOE identified three primary categories for increasing standard and hugger fan efficiency: (1) more efficient motors, including larger direct-drive single-phase induction motors and brushless direct current ("BLDC") motors; (2) more efficient ceiling fan blades using common blade materials, twisted blades, and beveled blades; and (3) advanced ceiling fan controls, including occupancy sensors, wind sensors, and temperature sensors.

As discussed previously, moving a hugger fan further from the ceiling is one way of increasing the CFM/W for these fans because it increases airflow without reducing power consumption. Hugger ceiling fans with fan blades very close to the ceiling can create a vacuum between the fan blades and the ceiling that prevents air from returning to the input side of the fan (*i.e.,* the air choking effect). However, certain consumers may prefer closely mount ceiling fans, despite the reduced airflow, because they do not protrude as far into the ceiling. DOE requested data regarding the impact that the distance between the ceiling fan blades and the ceiling had on airflow.

In response, ALA conducted testing in which they measured high speed CFM for multiple fan models while increasing the distance between the fan blades and the ceiling. (ALA, No. 26 at pp. 9-11) ALA's said that their test data showed that for most models the benefit of having a fan closer to the ceiling than 10 inches decreases significantly for each additional inch closer to the ceiling, and that hugger fan airflow approximately doubled when the distance between the fan blades and the ceiling increased from 6 inches to 10 inches. *Id.*

DOE interprets the "benefit of having a fan closer to the ceiling than 10 inches decreases significantly" stated in ALA's comment to mean that the airflow of a hugger fan decreases below 10 inches. DOE does not interpret this text to mean that there is no reason for consumers to want a fan that is mounted closer than 10 inches from the ceiling. DOE has previously determined that ceiling fans mounted closer to ceiling (*i.e.*, hugger fans) warrant a separate energy conservation standard. 86 FR 6826, 6841. The fact that fans exist on market that are fewer than 10-inchesfrom the ceiling indicate that there are some consumer preferences for these fans, even if the airflow is somewhat reduced. Specifically, the ability for that fan to be installed in areas with low ceilings where additional clearance between the ceiling fan and the floor are desired.

In this NOPR, DOE included increasing the distance from the ceiling as a possible technology option for hugger ceiling fans but has retained flexibility in its maximum technology options for fans to be fewer than 10 inches from the ceiling.

b. Large-Diameter Ceiling Fans

An increase in LDCF efficiency is associated with a reduction in power consumption while maintaining airflow. In section 2.4.3 of the February 2022 Preliminary Analysis TSD, DOE identified three primary technology options: (1) more efficient motors, including three-phase geared induction motors, three-phase geared premium induction motors, and permanent magnet direct-drive motors; (2) more efficient ceiling fan blades, including twisted blades and blade attachments; and (3) advanced ceiling fan controls, including occupancy sensors, wind sensors, and temperature sensors.

AMCA commented that changing from a lower-efficiency geared motor to an IE3[21] motor would improve the efficiency of a LDCF. (AMCA, No. 23 at p. 2) However, AMCA stated that all its members that manufacture gear-driven ceiling fan already use IE3 motors. *Id.*

AMCA is correct that IE3 motors, or similarly efficient motors (for those below 1 horsepower ("HP") where IE3 levels do not exist) are typical in the industry. Therefore, DOE is no longer considering three-phase geared induction motors that are not premium efficiency as a technology option in this NOPR. DOE did not receive any other

[21] "IE3" is the International Electrotechnical Commission ("IEC") designation for premium efficiency motors. IE3, National Electrical Manufacturers Association ("NEMA") premium, and EISA 2007 standards for electric motors are often considered equivalent efficiency requirements, although the actual values differ depending on pole, horsepower and enclosure.

comments regarding other technology options and therefore has retained them in this analysis.

In addition to the technology options identified in the February 2022 Preliminary Analysis, DOE has identified LDCF optimization as an additional technology option evaluated in this NOPR for improving the efficiency of LDCFs.

Section 1008 of the Energy Act of 2020, as codified in appendix U, specifies that LDCF CFEI be calculated using AMCA 208-18[22] with modifications. Broadly, the CFEI metric is the evaluation of the real-world performance of a given fan relative to the performance of a theoretical reference fan. In determining the power required for a reference fan, the CFEI calculation assumes the power input that would be required to produce the tested airflow, given the ceiling fan blade span. AMCA 208-18 assumes four efficiency metrics for the reference fan: (1) airfoil efficiency; (2) transmission efficiency; (3) motor efficiency; and (4) controller efficiency.

The reference fan calculation in AMCA 208-18 assumes that airfoil blades are 42 percent efficient and that controllers are 100 percent efficient. Further, the reference fan calculation assumes the transmission efficiency is consistent with a perfectly sized V-belt drive. DOE notes that LDCF manufacturers typically use a two-stage helical gearbox rather than a V-belt drive; however, in interviews, manufacturers stated that the reference fan V-belt drive efficiency is a reasonable approximation of a two-stage helical gearbox. The reference fan calculation also assumes the motor efficiency is consistent with a perfectly sized (relative to the required input power) IE3 motor. DOE notes that IE3 motor specifications exist at distinct motor sizes and not as a smooth curve across all

[22] ANSI/AMCA Standard 208-18 ("AMCA 208-18"), Calculation of the Fan Energy Index, ANSI approved January 24, 2018.

possible motor horsepower sizes. Therefore, the motor efficiency formula in AMCA 208-18 is only an approximation. Further, motors are typically sold at distinct horsepower sizes, and therefore the motor size used will not exactly align with the assumed reference fan horsepower and the efficiency may vary.

To meet higher CFEI, some manufacturers may increase fan motor efficiency, others may increase airfoil efficiency, and others may increase transmission efficiency. Further, these various efficiencies can compound with one another. A higher airfoil efficiency means that a smaller gearbox and a smaller motor, with less energy loss, can be used since more power input to the fan blades is converted to airflow.

For example, a 24-foot LDCF with a high-speed airflow of 230,000 CFM has a reference fan power consumption of 1,683 W. A fan with the same efficiency characteristics of the reference fan would have a CFEI100 equal to 1.00 and use 1,683 W at 100 percent speed. If a manufacturer were to improve the airfoil efficiency by one percent (from the reference value of 42 percent to 43 percent), that fan would consume 1,647 W, corresponding to a CFEI equal to 1.022.

LDCFs are commonly offered as a fan "family" with one brand name spanning a variety of blade spans. Typically, a single fan family will be offered in 8-, 10-, 12-, 14-, 16-, 18-, 20-, and 24-foot diameters. To reduce the number of custom parts, it is common for manufacturers to use the same motor/transmission part across several LDCF blade spans. While this practice reduces the burden on manufacturers, it means that the motor size and blade angle is better optimized for certain blade spans and less well optimized for others. This practice also results in a range of CFEI values on the market even within a single fan family, despite the fact that the motor size, transmission, and airflow may be similar. Therefore, in addition to the technology options evaluated in the February 2022 Preliminary Analysis, DOE included LDCF optimization as a technology option in this NOPR for improving the efficiency of LDCFs.

c. High-Speed Belt-Driven Ceiling Fans

Similar to LDCF efficiency, HSBD ceiling fan efficiency is achieved by reducing power consumption while maintaining airflow. In the February 2022 Preliminary Analysis, DOE stated that it did not have sufficient data to analyze a baseline efficiency level or evaluate higher efficiency levels for HSBD ceiling fans. DOE requested comment on technology options for improving HSBD ceiling fan efficiency. DOE received no comments regarding specific technology options for improving the efficiency of HSBD ceiling fans.

Given the similarities between large, housed, air-circulating fan heads and HSBD ceiling fans, DOE expects that technologies which improve air-circulating fan head efficiency would also improve HSBD ceiling fan efficiency. As such, the technology options evaluated for HSBD ceiling fans in this NOPR align with the technology options analyzed in the Fans and Blowers Notice of Data Availability regarding air circulating fans published October 13, 2022 ("Air Circulating Fans NODA"). The technology options analyzed in the Air Circulating Fans NODA included: split-phase motors, permanent split-capacitor ("PSC") motors, high-efficiency PSC motors, electronically commutated motors ("ECMs"), and aerodynamic redesign. 87 FR 62038, 62042.

d. Summary of Technology Options

For this NOPR, DOE has tentatively selected the technology options listed in Table IV.1 for its NOPR analysis.

Table IV.1 Technology Options and Descriptions

Technology option	Description
Small-diameter ceiling fans	
Larger direct-drive motors	Direct-drive, single-phase, PSC motors with an external rotor are the most common type of motor used in ceiling fans. These motors typically have a flat, pancake-style construction. Larger direct-drive motors have increased mass and/or use steel with better energy efficiency characteristics for the stator and rotor stack. These motors also typically have improved lamination design which increases the cross section and/or length of the copper wiring inside the motor.
BLDC motors	BLDC motors are electronically commutated, synchronous motors with permanent magnets embedded in or on their rotors. BLDC motors are driven by a converter plus inverter combination control system, which converts the AC power supplied by a building into DC power and controls the power flow into the motor to create continuously switching currents in the motor phases. BLDC motors can be much more efficient than induction motors.
Blade materials	Use of alternative materials could enable more complex and efficient blade shapes (plywood vs. MDF vs. injection-molded resin, for example). Further, some ceiling fans use a natural material that is somewhat porous (*i.e.,* allows air to pass through the blades without contributing to airflow). Replacing this natural material with more common materials can increase ceiling fan efficiency.
Occupancy, wind, and temperature sensors and ceiling fan controls	Occupancy sensors use technologies that detect the presence of people through movement or body heat. Wind sensors measure airflow speed and can be used in conjunction with a ceiling fan to determine whether the fan is providing the ideal amount of airflow in a room. Temperature sensors measure the temperature of a room. Ceiling fans can be paired with these sensors and a control system to automatically adjust and optimize their power consumption. Control systems can be mounted into the wall to allow consumers to conveniently turn ceiling fans off or slow their speed as they leave a room or building, reducing unnecessary power consumption.
Distance from the ceiling (hugger ceiling fans only)	Ceiling fans mounted such that their blades are closer to the ceiling are unable to produce as much airflow as if their blades were further from the ceiling. Therefore, hugger ceiling fans mounted close to the ceiling have a reduced energy efficiency potential compared to those with a greater distance between the ceiling and the blades. Increasing this distance improves airflow and efficiency.
Large-diameter ceiling fans	
Permanent magnet direct-drive motors	Permanent magnet motors are able to offer high-torque even at low-speeds and as such are able to be used without a gear-box. The rotor spins in a synchronous manner (*i.e.*, the motor rotates at the same speed as the revolving magnetic field), which is why these motors are sometimes referred to as "permanent magnet synchronous motors." Permanent magnet motors can be significantly more efficient than induction motors. Several types of permanent magnet direct-drive motors are currently used in the large-diameter ceiling fans industry, including BLDC, permanent magnet AC, and transverse flux.
Fan Optimization	LDCFs are typically not optimized for every blade span for which they are offered. To minimize parts, manufacturers often use the same motor/transmission assembly across numerous blade spans, rather than having an optimized design for each blade span. Optimizing the fan for each blade span represents an opportunity to increase efficiency.
Airfoil blades	Airfoil blades increase ceiling fan efficiency by reducing drag and therefore reducing power consumption. Airfoil blades use curved surfaces to improve aerodynamics. The thickness is not uniform, and the top and bottom surfaces do not follow the same path from leading edge to trailing edge.

Beveled blades	Beveled fan blades are typically beveled at the blade edges from the motor casing to the blade tip. Beveled fan blades are more aerodynamic than traditional fan blades, which reduce drag and increase airflow efficiency.
Curved blades	Curved blades increase ceiling fan efficiency by reducing drag and therefore reducing power consumption. Curved blades are blades for which the centerline of the blade cross section is cambered. Curved blades generally have uniform thickness and no significant internal volume.
HSBD ceiling fans	
Improved Motor Efficiency	The efficiency of an HSBD fan can be increased by improving the efficiency of the HSBD motor. Several different motor technologies exist, ranging from split-phase motors, PSC motors, higher-efficiency PSC motors, and ECMs.
Improved aerodynamic design	The efficiency of a fan can be increased by improving the aerodynamic design of its components. This includes optimizing the blade shape to reduce drag and optimizing the housing or guard design to increase airflow.

B. Screening Analysis

DOE uses the following five screening criteria to determine which technology options are suitable for further consideration in an energy conservation standards rulemaking:

(1) *Technological feasibility.* Technologies that are not incorporated in commercial products or in commercially viable, existing prototypes will not be considered further.

(2) *Practicability to manufacture, install, and service.* If it is determined that mass production of a technology in commercial products and reliable installation and servicing of the technology could not be achieved on the scale necessary to serve the relevant market at the time of the projected compliance date of the standard, then that technology will not be considered further.

(3) *Impacts on product utility.* If a technology is determined to have a significant adverse impact on the utility of the product to subgroups of consumers, or result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes

that are substantially the same as products generally available in the United States at the time, it will not be considered further.

(4) *Safety of technologies.* If it is determined that a technology would have significant adverse impacts on health or safety, it will not be considered further.

(5) *Unique-pathway proprietary technologies.* If a technology has proprietary protection and represents a unique pathway to achieving a given efficiency level, it will not be considered further, due to the potential for monopolistic concerns.

10 CFR 431.4; 10 CFR part 430, subpart C, appendix A, sections 6(c)(3) and 7(b).

In summary, if DOE determines that a technology, or a combination of technologies, fails to meet one or more of the listed five criteria, it will be excluded from further consideration in the engineering analysis. The reasons for eliminating any technology are discussed in the following sections.

The subsequent sections include comments from interested parties pertinent to the screening criteria, DOE's evaluation of each technology option against the screening analysis criteria, and whether DOE determined that a technology option should be excluded ("screened out") based on the screening criteria.

1. Screened-Out Technologies

a. Standard and Hugger Ceiling Fans

In section 2.5 of the February 2022 Preliminary Analysis TSD, DOE screened out the following technology option for small-diameter ceiling fans: three-phase induction motors, blade shape, blade attachments, occupancy sensors, wind sensors, temperature sensors, and brushed DC motors. ALA commented that they agreed with the technologies DOE screened out in the February 2022 Preliminary Analysis. (ALA, No. 26 at p. 6)

In this NOPR, DOE has continued to screen these technology options. Each of these technology options is discussed further in Section 4 of the TSD.

In response to the May 2021 RFI, numerous stakeholders commented that the DOE CFM/W metric for small-diameter ceiling fans penalizes smart technologies that use standby power but does not credit any reduction in active mode power consumption that results from implementing advanced controls and smart technology. (AMCA, No. 9 at p. 9, 13; ALA No. 8 at p. 2) ALA and Center for the Built Environment ("CBE") recommended DOE credit products with smart technologies to account for active mode energy reduction and system wide energy reductions. (ALA, No. 8 at p. 2; CBE, No. 7 at pp. 2-4)) In section 2.4.3.3 of the February 2022 Preliminary Analysis TSD, DOE acknowledged that smart technologies have the potential to reduce ceiling fan CFM/W, on account of using additional power while in standby operation which is accounted for in an operating hour-based weighted average power consumption used in the denominator of the CFM/W metric, despite the fact that smart technologies may reduce operating hours. In response to stakeholder's suggestion that DOE's test procedure "credit" potential operating hour reductions in the CFM/W metric to better convey to consumers on the fan's label which products use less power, DOE noted that smart technologies are currently incorporated into high-efficiency products that easily exceed energy conservation standards, and therefore a smart technology credit was not needed.

Regarding ceiling fan smart technology's ability to reduce building wide energy usage, DOE noted in section 2.4.3.3 of the February 2022 Preliminary Analysis TSD that, while studies show there are potential system-wide energy savings associated with incorporation of automated controls, these studies reported connectivity challenges that led to DOE questioning whether any potential savings of automated controls would be fully realized by consumers. Therefore, DOE did not account for any potential operating hour savings in the February 2022 Preliminary Analysis.

In response, Lutron stated that, while smart technologies are typically used for high-efficiency fans, they can also be integrated into lower-efficiency fans to save energy. (Lutron, No. 24 at pp. 3-4) Lutron added that DOE's decision not to include operating hour savings associated with smart technologies is based on a single field study of a single fan model and that the issues described in this field study are uncommon with smart technologies. (Lutron, No. 24 at p. 3)

DOE agrees that smart technologies can be incorporated into lower-efficiency ceiling fans. In Table IV.2, DOE has provided example numbers to demonstrate why a credit is not needed for theoretical operating hour savings associated with smart technology.

Table IV.2 Example Smart Tech Power Consumption

	Fan 1 AC Motor – No smart tech	Fan 2 AC Motor – With smart tech	Fan 3 BLDC Motor – No smart tech	Fan 4 BLDC Motor – With smart tech
Airflow High (CFM)	4500	4500	4500	4500
Airflow Low (CFM)	1200	1200	1200	1200
Power High (W)	58.7	55.0	28.3	27.0
Power Low (W)	12.0	11.0	3.9	3.5
Standby Power (W)	0.0	1.4	0.7	1.4
CFM/W	80	77	157	149

In the CFM/W efficiency metric, the denominator is a weighted average of high-speed power consumption, low-speed power consumption and standby power consumption. In high-efficiency fans, such as fans with BLDC motors, standby power energy consumption can make up a much larger percentage of the denominator, because high-speed and low-speed power are relatively low. Therefore, more efficient active mode fans run the risk of appearing on consumer labels to be less efficient by having lower CFM/W. In Table IV.2, Fan 3 has a higher certified CFM/W than Fan 4, despite the fact that Fan 4 uses less power in active mode. However, as stated both fans are very efficient and there is little difference in power consumption. Therefore, there is no need to "credit" potential operating hour savings of Fan 4 such that it appears equally or more efficient than Fan 3.

Regarding lower-efficiency ceiling fans, and specifically fans with AC motors, DOE notes that high-speed and low-speed power consumption is considerably more than fans with BLDC motors and therefore the standby power usage contributes less to the denominator of the CFM/W metric and the difference in certified CFM/W values is going to be relatively small between fans with smart tech and fans without smart tech. In

Table IV.2, Fan 1 has a higher certified CFM/W than Fan 2, despite the fact that Fan 2 uses less power in active mode. Because standby power is a small component of total power consumption, there is only a 3 CFM/W difference between Fan 1 and Fan 2 and there is little risk to consumers in purchasing Fan 1, thinking it is more efficient than Fan 2. Therefore, there is no need to "credit" potential operating hour savings of Fan 2 such that it appears equally or more efficient than Fan 1.

DOE therefore maintains its position that a CFM/W "credit" is not needed for ceiling fans incorporating sensors or other smart technologies for the purpose of communicating to consumers which products are more efficient.

Regarding potential building-wide energy savings, DOE notes that regardless of whether smart technologies/automated controls are included in minimally compliant products or high-efficiency products, the operating hours impact would be the same. DOE does not expect that amended efficiency standards would impact the prevalence of smart technologies in ceiling fans and has therefore screened out smart technologies in this NOPR.

b. Large-Diameter Ceiling Fans

DOE screened out and did not receive comment on the following technology options for LDCFs in the February 2022 Preliminary Analysis: alternative blade materials; twisted blades; blade attachments; occupancy, wind, and temperature sensors; and brushed DC motors. DOE therefore continues to screen out these technology options in this NOPR. These technology options are discussed further in Chapter 4 of the TSD.

2. Remaining Technologies

Regarding DOE's decision to screen-in BLDC motors in the February 2022 Preliminary Analysis, several stakeholders suggested BLDC motors may not satisfy DOE's screening criteria. ALA commented that a standard level that eliminates ceiling fans with AC motors is not in the public interest and recommended non-mandatory measures, such as consumer education programs, a properly designed and promoted ENERGY STAR specification, utility rebates or other manufacturer incentives combined with a less stringent standard level can yield substantial energy savings by accommodating consumer design and utility preferences. (ALA, No. 26 at pp. 1-2) ALA added that when the ENERGY STAR program moved to a level that could be met only by BLDC motor ceiling fans, the result was a 70-percent reduction in ceiling fan ENERGY STAR units sold, and HSSD fans were almost eliminated when DOE's efficiency standard moved to requiring a DC motor. (ALA, No. 26 at p. 2) ALA commented that BLDC motor ceiling fans have a delayed start-up where they may change rotational direction (from clockwise to counterclockwise) which can be confusing and annoying to consumers. (ALA, No. 26 at p. 5)

ALA further commented that DC motor manufacturing relies on ferrite magnet materials and rare earth magnet materials sourced from China. They added that a standard that requires BLDC motors would further U.S. ceiling fan manufacturer reliance on Chinese imports. (ALA, No. 26 at p. 14) In section 2.6.3.3 of the February 2022 Preliminary Analysis TSD, DOE noted small-diameter ceiling fan manufacturers already rely on China for the vast majority of their production and it does not expect that a transition to BLDC motors would change this reliance. ALA provided no comment suggesting that BLDC motor ceiling fans are manufactured in a different location than AC motor ceiling fans.

Regarding ALA's comments that the ENERGY STAR level requiring BLDC motors resulted in a significant reduction in shipments, DOE notes that ENERGY STAR is a voluntary standard and ENERGY STAR products are typically offered at a price premium. BLDC motor ceiling fans sold today are not sold as the lowest price point products but as premium products with marketing for their sleek designs, additional speed controls, and quiet operation. In the case of amended efficiency standards, consumers choose between purchasing a ceiling fan and not purchasing a ceiling fan, not between purchasing an ENERGY STAR certified fan and a non-ENERGY STAR certified fan. Products that do not meet amended efficiency standards would no longer be an option for consumers to choose. In this analysis, DOE has accounted for purchase price elasticity between efficiency levels requiring BLDC motors and the no-new standards case (as discussed in section IV.G of this document), but DOE does not expect a 70-percent reduction in shipments or a similar dynamic as stakeholders suggested.

In section 2.4.3.3 of the February 2022 Preliminary Analysis TSD, DOE acknowledged that the control mechanism is different for AC motor ceiling fans and BLDC motor ceiling fans but did not determine that these differences represented a significant loss in consumer utility. DOE noted that while some AC motor ceiling fans are controlled with a remote control, the vast majority are controlled with electromechanical controllers, *e.g.,* a pull chain or a wired wall-control. BLDC motors, by contrast, require an electronic controller to operate with either a remote control or an electronic receiver.

In response, Lutron commented that setting an energy efficiency level where AC powered fans are removed from the market would not be in the public interest. (Lutron, No. 24 at p. 2) Lutron stated that the near-universal compatibility of wall-mounted fan speed controls with AC motors has allowed consumers to purchase fan speed controls for reliability, aesthetics, potential energy savings, and integration features. (Lutron, No. 24 at p. 2) Lutron commented that high-tech, integrated lighting and fan control systems do not control only ceiling fans, but can save significant energy in a home, and that a ceiling fan efficiency standard that requires BLDC motors would result in the elimination of this energy savings potential and consumer utility. (Lutron, No. 24 at pp. 2, 3) Lutron provided an example of an "All Off" button on an integrated control system that turns off all lights and fans in a home as a consumer is exiting the home and stated that without this feature, it's more likely for fans and lights to be left on for an extended period while nobody is home. *Id.*

Lutron and ALA commented that the adoption of an efficiency standard that requires BLDC motors would remove ceiling fans controllable by wall-mounted fan speed controls from the market, since quiet fan speed controls and variable speed controls cannot be integrated with BLDC motors. (Lutron, No. 24 at p. 2; ALA, No. 26 at p. 7) Lutron commented that they do not believe that DOE has the authority to set an efficiency standard that essentially requires BLDC motors since such a standard could remove wall-mounted control features from the market. (Lutron, No. 24 at p. 2) Lutron cited three specific examples where consumer utility is lost if consumers cannot use wired-wall mounted speed controls: (1) wall-mounted controls that incorporate both light and fan speed controls in the same device; (2) fan speed controls that coordinate with other switches and dimmers; and (3) conveniently located wall-mounted controls that interrupt power to the ceiling fan and its light kit. (Lutron, No. 24 at p. 2)

DOE agrees that existing wired wall controllers would not be compatible with BLDC motors, and that BLDC motors instead rely on wireless controls. However, DOE disagrees that this incompatibility results in the loss of consumer utility. DOE disagrees that wall mounted controls that incorporate both light and fan speed controls would no longer be available if BLDC motors were required for ceiling fans. Many BLDC fans on the market today are sold with wall controllers that provide both light and fan speed controls. Although wall controls for BLDC motors are more similar to a remote control, the interface with consumers offers the same functionality as a wired wall control.

In terms of style and design coordination with other switches and dimmers in the house, DOE notes that the external design for BLDC motor ceiling fan wall-controls are in many cases similar or identical to AC motor ceiling fan wall-control designs. DOE agrees that consumers may have to purchase a different brand wall-control from their light-switch; however, the style could still match other switches.

Regarding Lutron's comment that conveniently located wall-mounted controls that interrupt power to the ceiling fan and its light kit would not exist with BLDC motors, DOE reiterates that these controls do exist. BLDC control switches interrupt power to the fan in the same way that any other switch would. While this feature is not universal for BLDC wall controls, it is available for consumers who want this feature.

DOE acknowledges that BLDC wall controls are incompatible with existing AC motor wall controls. However, the consumer features provided by BLDC motors are identical to the features provided by AC motor wall controls – namely, a convenient, wall mounted system for controlling ceiling fan speed and lights. Therefore, DOE has evaluated BLDC motors as a design option for standard and hugger ceiling fans in this NOPR. DOE accounts for differences in BLDC motor production costs and manufacturer impacts in the downstream analyses.

Through a review of each technology, DOE tentatively concludes that all of the other identified technologies listed in section IV.A.3 of this document met all five screening criteria to be examined further as design options in DOE's NOPR analysis.

DOE has initially determined that these technology options are technologically feasible because they are being used or have previously been used in commercially available products or working prototypes. DOE also finds that all of the remaining technology options meet the other screening criteria (*i.e.*, practicable to manufacture, install, and service and do not result in adverse impacts on consumer utility, product availability, health, or safety, unique-pathway proprietary technologies). For additional details, see chapter 4 of the NOPR TSD.

C. Engineering Analysis

The purpose of the engineering analysis is to establish the relationship between the efficiency and cost of ceiling fans. There are two elements to consider in the engineering analysis: the selection of efficiency levels to analyze (*i.e.*, the "efficiency analysis"); and the determination of product cost at each efficiency level (*i.e.*, the "cost analysis"). In determining the performance of higher-efficiency products, DOE considers technologies and design option combinations not eliminated by the screening analysis. For each product class, DOE estimates the baseline cost, as well as the incremental cost for the product at efficiency levels above the baseline. The output of the engineering analysis is a set of cost-efficiency "curves" that are used in downstream analyses (*i.e.*, the LCC and PBP analyses and the NIA).

1. Representative Units

Ceiling fans are sold with a range of diameters or blade spans. Rather than model every possible set of characteristics a ceiling fan could have, DOE models certain representative units as the basis of its analysis. In section 2.6.1 of the February 2022 Preliminary Analysis TSD, DOE modeled three representative units for standard ceiling fans, a 44-inch standard fan, a 52-inch standard fan, and a 60-inch standard fan. For hugger ceiling fans, DOE modeled two representative units, a 44-inch ceiling fan and a 52-inch ceiling fan. These representative units were consistent with the blade spans used in the January 2017 ECS Final Rule, 82 FR 6826, 6852, and in section 2.6.1 of the February 2022 Preliminary Analysis TSD DOE stated that the units were still representative of the current market. In section 2.6.1 of the February 2022 Preliminary Analysis TSD, DOE requested comment and data regarding this assumption. In response, ALA commented that the blade spans used in the preliminary analysis are representative. (ALA No. 26 at p. 9). DOE did not receive any comment recommending alternative representative units be used. Therefore, DOE has included in this analysis the standard and hugger representative units and blades spans from the February 2022 Preliminary Analysis.

In section 2.6.4 of the February 2022 Preliminary Analysis TSD, DOE observed that the incremental costs to achieve higher efficiencies was lower for larger blade spans. In order to better evaluate the larger blade spans in the hugger ceiling fan product class, DOE has included an additional 60-inch hugger ceiling fan representative unit in this analysis in addition to the representative units and blade spans analyzed in the February 2022 Preliminary Analysis.

For LDCFs, DOE modeled three representative blades spans in the February 2022 Preliminary Analysis, an 8-foot fan, a 12-foot fan, and a 20-foot fan. In section 2.6.1 of the February 2022 Preliminary Analysis TSD, DOE evaluated a high-airflow product and a low-airflow product at each blade span. DOE requested comment on its consideration of a high- and low-airflow product class and representative units. DOE also requested data addressing why a 20-foot ceiling fan cost-efficiency curve would not be representative of a 24-foot ceiling fan cost efficiency curve.

As discussed in section IV.A.1.c of this document, DOE concluded that evaluation of a high-airflow and low-airflow product classes was not necessary. Manufacturers may market some LDCFs for the commercial market and other LDCFs for the industrial market; however there is overlap between these applications and one fan can typically be substituted for another. In accordance with this determination, DOE has removed the high- and low-airflow distinction in its representative units and has modeled one LDCF fan at each blade span, with the power usage modified to reflect typical values for the whole market.

Regarding differences between a 20-foot and 24-foot ceiling fan, AMCA commented that within a given product line, the general construction of the two products is similar but there may be cost differences due to longer blades, a larger shipping container, and a longer recommended extension-tube to provide additional clearance from the ceiling to avoid restriction of intake air. (AMCA, No. 23 at p. 5) DOE notes that all of the difference identified by AMCA are associated with minor cost-differences between a 20-foot and 24-foot fan, not with differences in the incremental costs associated with meeting amended efficiency standards. While a 24-foot ceiling fan may be slightly more expensive overall, the technologies (*i.e.,* permanent magnet direct drive motors, fan optimization, etc.) and incremental costs associated with improving the efficiency of a 24-foot ceiling fan are going to be similar to a 20-foot ceiling fan. Therefore, DOE has tentatively determined that a 20-foot fan is sufficient to represent the cost-efficiency relationship of 24-foot fans.

AMCA requested that DOE consider a “very low power” LDCF product class, stating data from their survey of LDCF manufacturers shows that lower-power LDCFs have high enough CFEI ratings and low enough standby powers to warrant a separate product class from high-volume LDCFs. (AMCA, No. 23 at pp. 2, 4) AMCA stated that these lower-power LDCFs have lower maximum airflows, smaller motors, and simpler controls than typical high-volume LDCFs. AMCA added that the constants used in the CFEI metric were derived using high-volume low-speed (“HVLS”) fans, so a different metric may be more appropriate for “very low power” LDCFs. *Id.*

Regarding AMCA’s comment that a different metric or different CFEI constants may be needed for “low-power” LDCFs, DOE notes that the CFEI metric and constants were prescribed at 42 U.S.C. 6295(ff)(6)(C) for “large-diameter ceiling fans” without regard to the power usage of those fans.

In DOE’s review of the market, the number of “low-power” LDCFs has increased since the January 2017 ECS final rule. These units are often produced by manufacturers that predominately manufacture small-diameter ceiling fans. In many cases, these “low-power” LDCFs leverage an existing small-diameter ceiling fan design, but with a diameter greater than 7 feet, and are therefore subject to LDCF regulations. These “low-power” LDCFs tend to have much smaller motors, blade spans between 7 and 10 feet, and are significantly less expensive both to manufacture and to sell. Since these fans require high torque to spin such large blades, they only use BLDC motors. Although DOE is not considering a different product class for “low-power” LDCFs in this analysis, DOE has evaluated an additional representative unit for “low-power” LDCFs because of the unique power consumption and selling price of these products. DOE notes that low-power LDCFs are subject to the same test procedure and energy conservation standards as all other LDCFs; however, the MIA analysis considers the industry cash flow for these units to be in line with the modeled costs for these units and not in line with the more expensive manufacturer selling prices (“MSPs”) for all other LDCFs.

For HSBD ceiling fans, DOE stated in section 2.6.2.4 of the February 2022 Preliminary Analysis TSD that it did not have sufficient data to evaluate higher efficiency standards and therefore did not model a representative HSBD unit. As discussed in section IV.A.1.b of this document, DOE recently revised the definition of ceiling fan such that a fan is only considered a ceiling fan if it has a blade span to rpm ratio greater than 0.06. DOE notes that a belt-driven, housed air-circulating fan shares many of the same performance characteristic with HSBD fans. In general, most housed air circulating fans have smaller diameters and higher maximum rpms than ceiling fans, however as the diameter increases, the rpm of the fans tend to decrease such that beyond a certain diameter, certain housed air circulating fans exceed the 0.06 ratio. In that case, the primary distinction between an air circulating fan and an HSBD fan is the presence of components that enable an HSBD fan to be mounted from the ceiling. Therefore, DOE has only considered the largest representative unit from the Air Circulating Fans NODA for the HSBD analysis. Specifically, DOE selected a 50-inch HSBD ceiling fan as a representative HSBD fan for its NOPR analysis.

DOE requests comment and data on the distribution of HSBD blade spans.

DOE requests comment and data regarding whether a 50-inch fan is representative of an HSBD ceiling fan.

2. Efficiency Analysis

DOE typically uses one of two approaches to develop energy efficiency levels for the engineering analysis: (1) relying on observed efficiency levels in the market (*i.e.*, the efficiency-level approach), or (2) determining the incremental efficiency improvements associated with incorporating specific design options to a baseline model (*i.e.*, the design-option approach). Using the efficiency-level approach, the efficiency levels established for the analysis are determined based on the market distribution of existing products (in other words, based on the range of efficiencies and efficiency level "clusters" that already exist on the market). Using the design option approach, the efficiency levels established for the analysis are determined through detailed engineering calculations and/or computer simulations of the efficiency improvements from implementing specific design options that have been identified in the technology assessment. DOE may also rely on a combination of these two approaches. For example, the efficiency-level approach (based on actual products on the market) may be extended using the design option approach to "gap fill" levels (to bridge large gaps between other identified efficiency levels) and/or to extrapolate to the max-tech level (particularly in cases where the max-tech level exceeds the maximum efficiency level currently available on the market).

In this analysis, DOE relied on a combination of these two approaches to estimate the energy use and cost of meeting a given efficiency level. As previously discussed, the efficiency of a ceiling fan can be influenced by both the airflow and the power usage of the models and the decision to attempt to meet amended standards via increasing airflow versus decreasing power consumption will vary by manufacturer and basic model.

a. Baseline Efficiency

For each product/equipment class, DOE generally selects a baseline model as a reference point for each class, and measures changes resulting from potential energy conservation standards against the baseline. The baseline model in each product/equipment class represents the characteristics of a product/equipment typical of that class (e.g., capacity, physical size). Generally, a baseline model is one that just meets current energy conservation standards, or, if no standards are in place, the baseline is typically the most common or least efficient unit on the market.

Standard and Hugger Ceiling Fans

In the February 2022 Preliminary Analysis, DOE evaluated a baseline unit as one that just meets the current energy conservation standards for hugger and standard ceiling fans. DOE did not receive any comments in opposition to this approach and therefore has followed the same approach for assigning a baseline unit in this analysis.

DOE determined baseline energy consumption in the February 2022 Preliminary Analysis by dividing typical airflows for standard and hugger ceiling fans by the baseline CFM/W. DOE evaluated higher efficiency levels by assuming that manufacturers would maintain the airflow of their products and meet efficiency standards by decreasing power usage.

In response to the February 2022 Preliminary Analysis, ALA provided data comparing ALA member EnergyGuide labels of baseline fans to EnergyGuide labels of max-tech fans and stated that DOE is overestimating the consumer savings between baseline and max-tech. (ALA, No. 26 at p. 14).

In manufacturer interviews, manufacturers commented that to meet higher efficiency levels for a given fan model without using a BLDC motor, they would evaluate ways to both increase airflow and decrease power consumption. Further, manufacturers pointed out that some of their baseline fans are minimally efficient on account of having lower airflow, not necessarily higher power consumption.

For this NOPR, DOE reevaluated its assumption that manufacturers would maintain airflow when designing models with a higher CFM/W value while still using AC motors. Specifically, DOE leveraged the California Energy Commission Database ("CEC database"), which includes certified CFM/W values, high-speed airflow, high-speed power measurements, low-speed airflow, and low-speed power measurements, to identify change in power consumption and change in airflow associated with higher certified CFM/W values.

From the CEC Database, DOE observed that ceiling fans on the market with higher CFM/W include a combination of higher airflow and lower power consumption. In other words, baseline ceiling fans tend to have relatively high power consumption and relatively low airflows, instead of relatively high power consumptions and typical airflows.

For this NOPR analysis, DOE has maintained the baseline standard and hugger ceiling fan as one that just meets current energy conservation standards. However, DOE has modified the energy use analysis to better align with market data which that suggests that baseline market minimum ceiling fans have lower airflow in addition to higher power consumption. This approach is described in greater detail in Chapter 5 of the TSD.

DOE requests comment on the difference in airflow and power consumption between fans at baseline efficiency and higher efficiency levels while still using an AC motor.

Large-Diameter Ceiling Fans

In section 2.6.2.2 of the February 2022 Preliminary Analysis TSD, DOE assigned a baseline efficiency for LDCFs as a fan that is minimally compliant with current efficiency levels. DOE initially estimated a baseline airflow for low- and high-airflow LDCFs. DOE then relied on the minimally compliant CFEI100 and CFEI40 values to estimate the baseline power consumption at maximum speed and 40-percent speed. DOE used a cubic relationship to estimate the energy use at all other operating speeds.

As noted in section IV.C.1 of this document, DOE is not evaluating a separate high- and low-airflow LDCF in this NOPR. Therefore, DOE has revised its baseline airflow to reflect a value representative of all LDCFs, *i.e.* between the February 2022 Preliminary Analysis high- and low-airflow models so that the LDCF baseline representative unit is reflective of all LDCF fans.

For this NOPR analysis, DOE conducted additional manufacturer interviews where it received additional data on LDCFs. As noted in section IV.A.3.b of this document, manufacturers typically offer a "family" of LDCFs at multiple blade spans and do not optimize their motor/transmission assembly across every blade span. Manufacturers instead rely on using reasonably efficient motor/transmission designs and airfoil designs to exceed energy conservation standards while minimizing component inventory. As such, the least efficient products on the market typically exceed the CFEI100 standard of 1.00 by a considerable margin because manufacturers are not trying to just barely meet energy conservation standards. Rather, they are trying to exceed them by a sufficient amount so they can meet standards without having to optimize every single model.

DOE observed a significant discrepancy in public CFEI40 values depending on whether manufacturers marketed 40-percent speed power consumption at high voltage (3-phase, 380-480 V) instead of lower voltage (3-phase, 200-277 V). DOE notes that this discrepancy in power consumption based on input voltage is much greater at low-speeds, while measured power is nearly equal at 100-percent speed. See Chapter 5 of the TSD for data demonstrating how test voltage impacts power consumption.

Most LDCF basic models are rated to operate with both high and low voltage. Operating voltage is not a consumer choice, because the driving factor for operating voltage is whatever voltage a consumer has at the fan's installation location. In the August 2022 TP Final Rule, DOE clarified the test voltage required for certification after receiving stakeholder feedback that the previous wording was unclear. 87 FR 50396, 50408. Further, technologies that improve high-speed efficiency, such as airfoil design or better transmission efficiency (i.e., permanent magnet direct-drive motors), are also likely to improve the efficiency at CFEI40.

Since the least efficient fans on the market exceed the minimum energy conservation standards, in this NOPR, DOE has revised its baseline LDCF models to reflect the average CFEI100 and CFEI40 that meet current standards but do not meet EL1 (*i.e.,* the fans that would have to be redesigned in the presence of an amended standard). DOE used these average CFEI100 and CFEI40 values to calculate the baseline power given the representative airflow. DOE used a cubic relationship to estimate power consumption at all other operating speeds.

High-Speed Belt-Driven Ceiling Fans

In section 2.6.2.4 of the February 2022 Preliminary Analysis TSD, DOE included preliminary market research on HSBD ceiling fans and noted that it would evaluate whether energy conservations standards would be technologically feasible and economically justified for these products. DOE requested comment on the sales and distribution of efficiencies of HSBDs currently on the market.

The CA IOUs recommended that DOE include HSBD ceiling fans in the HSSD product class and large-diameter belt-driven ceiling fans in the LDCF class, because belt-driven ceiling fans do not provide additional utility in any consumer use case that would warrant a separate class. (CA IOUs, No. 22 at p. 4) The Efficiency Advocates encouraged DOE to evaluate potential standards for belt-driven ceiling fans. (Efficiency Advocates, No. 25 at p. 3)

DOE did not receive any data regarding the current efficiency distribution for HSBD ceiling fans. Given the overlap between large air-circulating fan heads and HSBD ceiling fans, DOE relied on data for large air-circulating fan heads to estimate the performance of HSBD ceiling fans for its NOPR analysis. Specifically, DOE relied on efficiency levels similar to those evaluated in the Air Circulating Fans NODA (Docket No. EERE-2022-BT-STD-0002-0011).

DOE notes that, while the Air Circulating Fans NODA models multiple air-circulating fans head diameters, HSBD ceiling fans need to have a blade span/RPM ratio greater than 0.06 in order to meet the ceiling fan definition. In general, smaller air circulating fans have relatively high rpms and those rpms decrease as the blade span get larger. Therefore, only the large air circulating fans with a blade span/RPM ratio greater than 0.06, if sold in a ceiling mounted configuration, would meet the definition of an HSBD ceiling fan. As such, DOE has relied on only the 50-inch representative unit evaluated in the Air Circulating Fans NODA for its analysis in this NOPR, since these fans are most likely to "circulate air". DOE notes that the Air Circulating Fans NODA presents efficiency in both CFM/W and fan energy index ("FEI"). 87 FR 62038, 62043. To convert CFM/W and FEI to CFEI, DOE relied on the Bioenvironmental and Structural System Laboratory[23] ("BESS Labs") database to identify the average airflow of a 50-inch fan. DOE evaluated a baseline energy consumption for HSBD ceiling fans by calculating high-speed power consumption from the CFM/W ratio at the EL0 evaluated in the Air Circulating Fans NODA assuming average airflow. From the airflow and power consumption, DOE calculated the baseline CFEI value.

DOE requests data as to the average airflow of HSBD ceiling fans and the range of airflows available.

b. Higher Efficiency Levels

As part of DOE's analysis, the maximum available efficiency level is the highest efficiency unit currently available on the market. DOE also defines a "max-tech" efficiency level to represent the maximum possible efficiency for a given product.

[23]BESS Labs is a research, product-testing and educational laboratory. BESS Labs provides engineering data to air in the selection and design of agricultural buildings and assists equipment manufactures in developing better products. Test reports for circulating fans are publicly available at *bess.illinois.edu/current.asp*. (Last accessed November 22, 2022)

Standard and Hugger Ceiling Fans

In section 2.6.2.1 of the February 2022 Preliminary Analysis, DOE relied on market data to estimate typical airflows for ceiling fans at both low and high speeds. DOE evaluated higher efficiency levels by assuming that manufacturers would maintain the airflow of their products and meet efficiency standards by decreasing power usage. Specifically, DOE modeled two efficiency levels that assumed continued use of AC motors, corresponding to a 10-percent and 20-percent reduction in power consumption. DOE also evaluated two efficiency levels that assumed a transition to BLDC motors, one that aligned with ENERGY STAR levels and assumed a BLDC motor with inefficient fan blades and a second efficiency level that corresponded to BLDC motors with common blade materials.

DOE noted that one concern with assuming manufacturers would maintain their airflow was that many manufacturers could increase fan efficiency by moving hugger ceiling fans further from the ceiling, results in increased airflow with no change in power consumption.

In response, ALA provided test data from eight ceiling fans demonstrating that moving a ceiling fan from a very close mount, for example 6 inches between the fan blades and the ceiling to 10 inches, can double the CFM. (ALA, No. 26 at pp. 9-11)

For this NOPR analysis, DOE modified its energy use assumptions to incorporate the fact that AC motor ceiling fans meet higher ELs by both increasing airflow and decreasing power consumption. For standard ceiling fans, DOE maintained the CFM/W levels of EL0, EL1, and EL2 from the February 2022 Preliminary Analysis. However, instead of associating an increase in efficiency with maintaining airflow and reducing power consumption, DOE used a regression analysis to estimate the typical airflow and typical power usage associated with a given CFM/W for AC motor ceiling fans. Specifically, DOE modeled two different means of achieving higher efficiency levels, one being via maintaining airflow and reducing power consumption through more efficient motors and a second approach via maintain power consumption and increasing airflow through aerodynamic design and optimization. DOE then aggregated the two approaches to align with the regression analysis. This analysis is discussed in Chapter 5 of the TSD and better reflects the variety of methods manufacturers can use to meet a given energy conservation standard, including both decreasing power consumption and increasing airflow.

For hugger ceiling fans, the ability to improve CFM/W without necessarily decreasing power is more pronounced since manufacturers have an additional option to move hugger ceiling fans further from the ceiling. As ALA's test data demonstrate, each additional inch of distance between a ceiling fan blades and the ceiling increases airflow, until around 10 inches, where the airflow begins to level off. To better reflect that a hugger ceiling fan is a similar product to a standard ceiling fan, in this NOPR, DOE modified its EL1 and EL2 hugger levels to better reflect the characteristics of a standard ceiling fan moved closer to the ceiling. Specifically, DOE evaluated what the CFM/W would be of an EL1 and EL2 standard ceiling fan if it (1) were moved from 11 inches of space between the fan blades and the ceiling to 8 inches of space between the fan blades and the ceiling and (2) high-speed airflow was reduced in accordance with the typical reduction in airflow associated with moving a fan closer to the ceiling. DOE then calculated the efficiency of that model to determine the EL1 and EL2 CFM/W for hugger ceiling fans.

To acknowledge that hugger ceiling fan and standard ceiling fan models are not the same, DOE relied on CEC trendline data for hugger ceiling fans to estimate the airflow and power consumption of typical hugger ceiling fans on the market that meet a given efficiency level. The full analysis demonstrating how the hugger ceiling fan efficiency levels and energy consumption were calculated is discussed in Chapter 5 of the TSD.

DOE notes that, for both hugger ceiling fans and standard ceiling fans, baseline ceiling fans in the February 2022 Preliminary Analysis generally used more power than baseline fans in this NOPR analysis. These revised values better reflect the multitude of choices manufacturers have for meeting a higher efficiency level and are not overly optimistic in assuming all CFM/W gains would be associated only with decreasing energy consumption.

As noted in section 2.6.2.1 of the February 2022 Preliminary Analysis TSD, DOE assumed two ELs associated with a transition to BLDC motors. EL3 corresponded to the current ENERGY STAR levels and was associated with BLDC motors with inefficient blades. EL4 corresponded to BLDC motors with common blade materials. In the February 2022 preliminary analysis, the energy use at EL3 and EL4 was equivalent; however, the inefficient blades were assumed to have less airflow, resulting in a lower CFM/W.

While the February 2022 Preliminary Analysis generally assumed that ENERGY STAR levels require BLDC motors, further investigation demonstrated that many ceiling fans were capable of meeting ENERGY STAR levels without transitioning to BLDC motors. Specifically, moving a hugger ceiling fan further from the ceiling, while still being less than 10 inches from the ceiling, could enable a manufacturer to meet hugger ENERGY STAR levels without reducing power consumption.

To include an efficiency level associated with BLDC motors that is unlikely to be met with certain AC fan models, DOE combined the two BLDC efficiency levels from the February 2022 Preliminary Analysis into one efficiency level in this NOPR analysis. The NOPR BLDC level is higher than the ENERGY STAR level in the February 2022 Preliminary Analysis, but lower than the max-tech level in the February 2022 Preliminary Analysis and is based on the minimum CFM/W values that cannot be obtained with AC motors. Like the February 2022 Preliminary Analysis, all blade designs and common blade materials currently on the market for fans with BLDC motors will exceed the NOPR BLDC efficiency level, many by a considerable margin. But the BLDC levels provide sufficient flexibility for all blade designs and blade materials and will permit hugger ceiling fans to have sufficient flexibility in terms of distance between the fan blades and the ceiling.

In response to DOE's acknowledgment that many BLDC ceiling fans will exceed the CFM/W of even the max-tech efficiency levels, the Efficiency Advocates encouraged DOE to evaluate higher max-tech efficiency levels, consistent with the most efficient ceiling fans on the market. (Efficiency Advocates, No. 25 at p. 2-3) They stated that ceiling fans currently available on the market more than double DOE's max-tech efficiency level in the February 2022 Preliminary analysis, noting that these models generally combine higher efficiency motors and more aerodynamic blades. *Id.* Regarding the specific model the Efficiency Advocates identified, DOE notes that linked manufacturer literature cited by the Efficiency Advocates and the ENERGY STAR data cited by the Efficiency Advocates report two different CFM/W values. Based on the manufacturer literature for the basic model, the cited input power at high-speed appears to actually be a weighted average value and not a high-speed value.

DOE's review of the ceiling fan market indicates that for ceiling fans using BLDC motors, the power usage is relatively constant, with the key factor distinguishing between CFM/W being the amount of airflow from a given fan at both low and high speed. In most settings, provided the maximum airflow is sufficient to meet a consumer's needs, there is not additional utility to providing more airflow beyond what a consumer would want. Ceiling fan manufacturer balance fan aesthetics and airflow in designing ceiling fans. DOE has not evaluated higher efficiency levels with BLDC motors since those levels would limit minimum distance that ceiling fan blades could be from the ceiling for hugger ceiling fans (as described in section IV.A.3.a of this document), consumer features (such as additional sensors, connectivity, or receivers) which may decrease CFM/W by consuming additional power in standby mode (as described in IV.B.1.a of this document), blade shape (which DOE has screened out as a technology option due to the negative impacts on consumer utility, as described in Chapter 4 of the TSD), and minimum and maximum airflows (as described in Chapter 5 of the TSD). DOE has provided examples of BLDC motor power usage and CFM/W ratings in Chapter 5 of the TSD which demonstrate that BLDC power consumption is approximately constant across all certified CFM/W values.

In addition to the technology-based efficiency levels described previously, DOE observed that the BLDC technology option shows a natural inclination for certain blade spans. Specifically, DOE observed that for standard and hugger fans below 52", fewer than 20 percent of basic models included BLDC motors and an even smaller market share used BLDC motors. However, for ceiling fans with blade spans greater than or equal to

52”, there was a large increase in the share of basic models using BLDC motors such at 60”, over 50 percent of basic models use BLDC motors and at the largest blades spans, virtually all ceiling fans use BLDC motors (*See* Chapter 5 of the NOPR TSD). This is because beyond 52”, manufacturers are typically designing and marketing products to higher income consumers where the aesthetic appeals, smaller motor sizes, and additional features associated with BLDC motors along with the higher torque of BLDC motors creates a favorable market for BLDC motors. As such, DOE has considered a step-function efficiency level wherein ceiling fans that are less than or equal to 53” in span use a more efficient AC motor and ceiling fans that are greater than 53” use a BLDC motors.

Table IV.3 Standard and Hugger Ceiling Fan Efficiency Levels

Efficiency Level	Description
EL0	Baseline
EL1	More Efficient AC Motor
EL2	More Efficient AC Motor
EL3	Market Based Step-Function. ≤53” = More Efficient AC Motors. >53” = BLDC Motors
EL4	BLDC Motor

<u>Large-Diameter Ceiling Fans</u>

As discussed previously, the CFEI metric takes into consideration the performance of a given fan relative to the performance of a reference fan. The reference fan assumes a certain airfoil, transmission, motor, and controller efficiency. To meet a higher CFEI value, some manufacturers may increase fan motor efficiency, while others may increase their airfoil efficiency or transmission efficiency. Further, these efficiencies are not necessarily independent and can impact one another. For example, higher airfoil efficiency may mean that a smaller motor can be used since more of the power input to the fan blades is converted to airflow.

In the February 2022 Preliminary Analysis, DOE noted that it relied on a combination of public data sources and aggregated confidential data sources to evaluate the distribution of efficiencies available on the market. DOE considered two efficiency levels in the February 2022 Preliminary Analysis: EL1, corresponding to a level that could still be met with gear-driven IE3 motors, and EL2, corresponding to permanent magnet direct-drive motors.

AMCA commented that ELs 1 and 2 in the February 2022 Preliminary Analysis are too strict and that the results of a survey of its members that manufacture LDCFs indicated that about 50 percent of LDCF products would fail EL1 and 60 percent would fail EL2. They expressed concern that implementing these ELs could damage the market. As a result, AMCA requested that DOE reconsider its requirements for ELs 1 and 2. (AMCA, No. 23 at p. 2) AMCA stated that, while EL1 in the February 2022 Preliminary Analysis was intended to represent a change from lower-efficiency gearmotors to IE3 gearmotors, all AMCA members with gear-driven ceiling fans already use IE3 motors. (AMCA, No. 23 at p. 2) In relation to this, AMCA commented that the way the ELs were considered in the February 2022 Preliminary Analysis TSD was erroneous. They commented that the TSD wrongly assumed a CFEI100 value of 1.00 would be met using an IE1 motor, but AMCA 208 specifies that a CFEI100 of 1.00 is based on an IE3 motor. AMCA's survey of its member companies and their products indicated that no gear-driven HVLS ceiling fans use IE1 motors. AMCA stated that DOE's estimation that changing from an IE1 motor to an IE3 motor could reduce power consumption by 25 percent was highly unlikely and not representative of the typical power savings that could be achieved when switching from an IE1 motor to an IE3 motor. (AMCA, No. 23 at p. 15-19) AMCA also commented that its survey of its members that manufacture LDCFs indicated that 20 percent of direct-drive LDCF models would fail EL1, even though EL1 is intended to represent gear-driven fans with IE3 motors and EL2 is intended to represent direct-drive fans. AMCA added that the apparent assumption in the February 2022 Preliminary Analysis that switching from a gear-driven to direct-driven setup improves efficiency is not always correct. (AMCA, No. 23 at p. 2)

AMCA is correct that utilizing an IE1 motor as the assumed baseline motor is a poor characterization of baseline LDCF efficiency. While it is true that AMCA 208 assumes an IE3 motor in the reference fan and that most manufacturers use an IE3 motor, the AMCA 208 calculations also assume a perfectly-sized motor relative to the airfoil efficiency and transmission efficiency of the reference fan. As noted in section IV.C.2.a and demonstrated in data plots provided both in CA IOUs' (CA IOU, No. 22 at p. 4) and AMCA's (AMCA, No. 9 at p. 16) public comments, the least efficient LDCFs on the market tend to exceed the energy conservation standards by a considerable margin. In this NOPR, DOE has modified its baseline energy use analysis to reflect that with an IE3 motor at baseline, manufacturers consistently exceed a CFEI100 of 1.00 and CFEI40 of 1.31.

DOE notes that manufacturer data show that EL1 represents an efficiency level that is achievable with an IE3 motor. While AMCA's comment states that 64.4 percent of gear-driven ceiling fans would fail the February 2022 Preliminary Analysis EL1 level, that similarly means 35.6 percent of IE3 motors are capable of meeting EL1 levels. Manufacturers did not identify unique characteristics about the gear-driven ceiling fans that exceed EL1 levels from those that do not, and AMCA comments suggest that both are using motors of similar efficiencies.

As stated previously, many LDCFs are offered in a variety of blade spans, often ranging from 8 feet to 24 feet, where the motor size used for a given fan model is identical across several of the blade spans. In interviews, manufacturers stated that LDCFs are typically not optimized across every single blade span offered for sale to minimize the number of parts. Rather, one motor and gearbox assembly will span several blade spans. This ability to optimize ceiling fans for a given blade span explains why some gear-driven ceiling fans can meet EL1 levels while others cannot. Since a third of gear-driven ceiling fans in AMCA's database are capable of meeting EL1 levels, DOE has retained its EL1 level in this NOPR but has recharacterized it as corresponding to an IE3 motor with LDCF optimized for the given blade span. DOE has modified its cost analysis to reflect that, while optimization of a fan does not inherently have additional cost, there are production cost impacts associated with having every blade span optimized, rather than using the same motor-gearbox combination across a range of blade spans.

Regarding AMCA's comment that transitioning from a gear-driven fan to a direct-drive fan does not inherently increase efficiency, this is partially correct. While it is not impossible for a gear-driven ceiling fan model to have a higher CFEI100 than a direct-drive fan, when all other things are held equal, a direct-drive fan is not going to have transmission losses. With no transmission losses, the highest CFEI models on the market tend to be direct-drive models.

Like gear-driven ceiling fans, direct-drive ceiling fans have a range of CFEI100 values depending on how well they are optimized for a given application. AMCA commented that 54.1 percent of the direct-drive fans in their database meet EL2 levels. Further, AMCA commented that the average CFEI100 value for 20-foot and 24-foot ceiling fans is 1.44 and 1.41, respectively, both of which exceed EL2 levels. (AMCA, No. 23 at p. 5)

DOE notes that the percentage of models that would have to be modified to meet a higher efficiency level is generally not indicative of whether or not that efficiency level is economically justified. Rather, economic justification is determined by analyzing the costs of an amended standard relative to the cost savings of the more efficient product. Further, the EL2 efficiency level is clearly technologically feasible since 40 percent of models are already meeting DOE's max-tech efficiency level.

Regarding the number of models that would have failed at the EL1 and EL2 levels evaluated in the February 2022 Preliminary Analysis, DOE notes that stakeholders did not specify if the failure was on account of not meeting CFEI100 values, not meeting CFEI40 values, or not meeting some theoretical standby power limitation. As discussed previously, DOE observed considerable difference in CFEI40 values depending on the voltage manufacturers used to test their LDCFs. While the test voltage has not changed, the August 2022 TP Final Rule clarified the test voltage in response to stakeholder feedback that the previous language was unclear. As such, some of the data stakeholders are referencing as failing a given efficiency level may be based on testing at the higher voltage configurations. Given that higher CFEI100 values tend to correlate with higher CFEI40 values, DOE only evaluated higher CFEI100 efficiency levels and did not evaluate higher efficiency standards at the CFEI40 value. DOE expects that the vast majority of LDCFs exceed the current CFEI40 standards and those instances cited as being close to the standard may have been tested at higher voltages. This interpretation was supported by AMCA, who commented that the average CFEI40 value for 20-foot and 24-foot fans was 2.19 and 2.31, respectively, easily exceeding the current CFEI40 standards.

In DOE's energy use analysis for this NOPR, DOE relied on market data to estimate the average CFEI40 values of fans at a given efficiency level, rather than assuming LDCFs were minimally compliant at the CFEI40 value.

AMCA commented that increasing the energy conservation standard requirements for CFEI would have unintended and negative impacts on both the ceiling fan industry and consumers. (AMCA, No. 23 at p. 1) AMCA commented that a correction made to the input power calculation in the AMCA 230-15 technical errata in 2021 would slightly increase the calculated input power and therefore decrease the calculated CFEI. They stated that, because this correction was made after the current energy conservation standards were set, the current standard is more strict than intended and that this should be considered when new energy conservation standards are set. AMCA provided results from a study of over 300 ceiling fan test reports showing that CFEI could decrease by about 3 percent as a result of the correction. (AMCA, No. 23 at pp. 12-13)

DOE notes that its test procedure includes the technical errata and therefore manufacturers need to meet the current energy conservation standards, namely, CFEI100 equal to 1.00 and CFEI40 equal to 1.31. Given that some of the published data on which DOE's analysis is derived may have been conducted in testing environments with differing air densities, in this NOPR DOE has chosen to evaluate a more conservative EL1 and EL2 by reducing the CFEI100 EL1 and EL2 levels by 0.03 relative to the February 2022 Preliminary Analysis values.

High-Speed Belt-Driven Ceiling Fans

As discussed previously, DOE relied on the October 2022 Fans and Blowers NODA to evaluate efficiency levels for HSBD fans. Because the CFEI metric is relative to a reference fan performance that accounts for differences in airflow, DOE assumed the representative HSBD airflow would remain constant at higher efficiency levels and calculated the power consumption at each EL, maintaining the CFM/W values used in the October 2022 Fans and Blowers NODA. DOE then calculated the CFEI value based on the airflow and power consumption. See chapter 5 of the TSD for additional details on this methodology.

c. Large-Diameter Ceiling Fan Standby Power

In the May 2021 RFI, DOE discussed that the CFEI metric does not capture standby or off mode energy use and that DOE may need to develop a separate standby mode metric for LDCFs. 86 FR 24538, 24544. In section 2.6.2.3 of the February 2022 Preliminary Analysis TSD, DOE noted that it had not identified a way to incorporate standby power into the CFEI metric. Further, DOE did not identify technology options that would reduce LDCF standby power aside from removing energy saving controls and features. DOE did not evaluate higher standby power efficiency levels in the February 2022 Preliminary Analysis because it had not identified technology options for reducing standby power without impacting product utility through removal of controller features.

In the February 2022 Preliminary Analysis, DOE used an average standby power of 7 W, consistent with the January 2017 ECS Final Rule. DOE stated that it was considering establishing a standby power limit at 13 W, the maximum standby power observed in the market. DOE also stated that it was considering a credit-based approach where fans that are more efficient in active mode would be permitted to utilize more standby power in standby operation.

In section 2.6.2.3 of the February 2022 Preliminary Analysis TSD, DOE requested comment on technologies available to reduce standby power without reducing consumer utility, the maximum standby power on the market, potential future technologies that could increase standby power, and any possible active mode-based credit for standby power consumption.

Regarding specific technologies that increase or decrease standby power, AMCA stated that the standby power consumed by a ceiling fan can be affected by a wall controller powered from the variable frequency drive ("VFD") or separate wall plugin; a display used on the wall controller; a display used on the VFD; cooling fans on the VFD; communications devices; sensors; and an electronic filter. (AMCA, No. 23 at p. 5) AMCA added that increased drive efficiency paired with larger heat sink to eliminate drive cooling fans, redesign/replacement of the VFD to have cooling fans turn off under low loads, simplified wall controllers with no display, elimination of communication devices, and elimination of sensors could all reduce LDCF standby power. (AMCA, No. 23 at p. 6) AMCA commented that sensors, wireless devices, network communications, multi-fan/multiproduct controllers, grid-connected demand-management controls, air disinfection, and lighting are potential technologies that could be implemented into LDCFs in the future which would further increase standby power. (AMCA, No. 23 at p. 8)

Regarding the current maximum standby power on the market, AMCA provided data from their survey of member LDCF manufacturers showing that the highest standby power consumption in its survey was 19 W for a direct-drive fan and 12 W for a gear-driven fan. The average standby power consumption was 9.8 W for a direct-drive fan and 6.8 W for a gear-driven fan. (AMCA, No. 23 at p. 6) AMCA added that their analysis of the LDCF models manufactured by member companies yielded an average standby power of 8.8 W, rather than the 7 W that was previously determined from a smaller dataset. Therefore, AMCA recommended that DOE adjust the average standby power value to 8.8 W for LDCFs. (AMCA, No. 23 at p. 11) Additionally, AMCA stated that the results of the LDCF model analysis indicated that standby power accounts for 1.1 percent to 2.5 percent of the total power consumed by LDCFs and commented that enforcing strict standby power limits would place an unnecessary burden on manufacturers. (AMCA, No. 23 at p. 11)

AMCA stated that about half the models currently on the market would fail to meet a standard based only on an average standby power limit. (AMCA, No. 23 at p. 7) For the 13 W standby power limit cited in the February 2022 Preliminary Analysis, AMCA estimated that 18.1 percent of models would fail. (AMCA, No. 23 at p. 11) AMCA recommended that DOE propose a less aggressive standby power requirement than what was proposed in the February 2022 Preliminary Analysis, and revise its analysis to produce new average and maximum standby power data assumptions based on AMCA's LDCF manufacturer survey results.

AMCA supported DOE's suggestion for implementing a credit-based system for regulating standby power, where LDCFs that achieve higher active mode efficiencies are allowed more standby power. AMCA added that this active-mode approach would allow manufacturers more flexibility in LDCF design. (AMCA, No. 23 at p. 9) However, AMCA also stated that the requirements proposed by DOE in the February 2022

Preliminary Analysis for this credit-based standby power approach were too strict. AMCA supported this comment by providing data from their survey of LDCF member companies that showed failure rates of 50.6 percent at EL1 and 60.5 percent at EL2, assuming a 7 W average was used. Failure rates were 48 percent at EL1 and 59 percent at EL2 when a standby power limit of 13 W was used. (AMCA, No. 23 at pp. 3, 9-10) AMCA also recommended that DOE define the standby power allowance based on the CFEI rating of a fan by starting at a standby power allowance of 15 W for a CFEI of 1.00 and increasing the standby power allowance by 1.0 W for every 0.02 increase in CFEI. (AMCA, No. 23 at pp. 10-11)

ALA commented that DOE should not set a separate standby power standard for small-diameter fans. (ALA, No. 26 at p. 12)

42 U.S.C. 6295(gg)(2) requires DOE to incorporate standby power into its existing test procedures, if technically feasible. Section 3.6 of appendix U specifies the current test procedure for measuring the standby power consumption of LDCF. In the August 2022 TP Final Rule, DOE clarified that testing shall be conducted with either the default controller or, if multiple controllers are offered, the minimally functional controller and that standby power consumption is not required for the purpose of representations or certification until compliance is required with an energy conservation standard. 87 FR 50396, 50408. To the extent voluntary representations are made in writing or advertisements, appendix U is required, regardless of whether compliance with an energy conservation standard is applied. *See* 42 U.S.C. 6293(c).

Section 42 U.S.C. 6295(gg)(3) requires DOE to incorporate standby power into a single amended or new standard, if feasible. If not feasible, DOE is required to prescribe a separate standard for standby mode and off mode energy consumption, if justified under 42 U.S.C. 6295(o).

Regarding ALA’s comment on standby power for small-diameter ceiling fans, DOE notes that the existing CFM/W metric incorporates standby power and therefore a separate evaluation of a standby power standard for small-diameter ceiling fans is not needed.

One significant challenge in evaluating potential energy savings associated with standby power for LDCF fans is that while appendix U clarifies testing with the default controller or minimally functional controller, there is no industry standardized default controller. Depending on the intended application, a fan at default may include other devices, such as a larger controller display or network connectivity. Some of these sensors and devices may reduce energy consumption overall. AMCA identified additional controller technologies associated with connectivity with the greater grid and HVAC system that would be appealing energy saving options in the future, but may not be sold with the default controller today. Further, the only technologies identified by AMCA for reducing standby power that do not explicitly change consumer utility include elimination or reduction of cooling fans in the VFD. While these technologies could in theory be an option to reduce standby power consumption, the easier path for manufacturers to meet a standby power standard is by offering the product with fewer sensors and communication devices. Therefore, imposing a standby standard could increase overall energy consumption by causing manufacturers to forego these devices with higher energy-saving capacity.

DOE notes that many of the drive specific technologies identified by AMCA as potentially reducing standby power would also increase or decrease controller losses in active mode. As noted, controller efficiency is incorporated into the CFEI metric but assumed to be 100 percent for the reference fan. As manufacturers begin adding controller losses, including drive cooling fans, the measured active mode efficiency would decrease. Therefore, there is an existing incentive for manufacturers to reduce drive losses, absent a separate standby power standard.

Regarding AMCA's comment about a standby power efficiency standard that credits active-mode performance being a possible logical approach, DOE notes that standby power for LDCFs corresponds with the complexity of the default controller and not with active mode performance. In other words, increasing the CFEI of a given fan model would not be correlated with higher standby power. As such, all the existing concerns with reduced default controller features would apply with an active mode, credit-based system.

DOE notes that the most cost-effective means for manufacturers to reduce their standby power would be for manufacturers to remove display, network connectivity, and sensors from their default controller. Removing any or all these features would reduce standby power consumption and lower controller costs. Therefore, there would be no incremental costs associated with reducing standby power.

Simple controllers without displays, network connectivity, or sensors exist today. Because there are additional manufacturing costs associated with more advanced controllers, simple controllers are typically the default controllers for fans targeting the lowest price point. LDCFs targeting higher price points tend to offer controllers with additional features to help justify their higher selling price. LDCF manufacturers then offer several upgradable controllers with increasing functionality, and consumers select the controller that has their desired functionality.

As noted, Appendix U specifies testing standby power with the default controller or minimally functional controller. Under a maximum standby-power energy conservation standard, the most cost-effective way for manufacturers to meet such standards would be to offer a new minimally functional controller with fewer additional features. A standby-power energy conservation standard would not impact the standby power consumption of any of the upgradable controllers that consumers are purchasing, only the minimally functional controller. Energy savings for a standby power energy conservation standard would only be achievable if consumers opted for a controller with less functionality. As noted, consumers currently have the option to purchase fans with controllers that offer less functionality, and typically at lower costs than fans with more advanced controls. As far as DOE is aware, information on consumer behavior regarding LDCF controllers is not available, but DOE understands that consumers are already making the decision to purchase LDCFs and controllers with additional functionality, despite these products adding costs.

Therefore, DOE expects that any new standard for standby power for LDCFs would result in manufacturers offering new minimally functional controllers with reduced utility. These new controllers would likely not result in energy savings, however, since consumers would continue to select controllers with greater functionality when they purchase a LDCF, as they do in the current market.

As such, in accordance with DOE's requirements at 42 U.S.C. 6295(gg)(3), DOE has tentatively determined not to analyze a separate standard for standby mode and off mode energy consumption, since such a standard would not lead to energy savings.

DOE requests comment and data regarding its tentative determination that energy conservation standards for LDCF standby power would be met by removing consumer features from the default controller, and that this would likely not result in energy savings.

DOE requests comment and data on the primary factors that govern LDCF controller purchasing decisions.

Regarding AMCA's suggestion to increase the average standby power in DOE's modeling from 7 W to 8.8 W, DOE notes that the data provided by AMCA show a range of standby power consumption where the maximum standby power is considerably higher (19 W) than the median standby power (7.1 W) or the mean standby power (8.8 W). Given that DOE recently clarified in its August 2022 TP Final Rule that standby power is to be measured with the default controller, DOE expects that a subset of manufacturers may have provided data using a more advanced controller, resulting in a maximum standby power that is considerably greater than the median – potentially skewing the average. Because the median standby power in AMCA's data (7.1 W) aligns closely with the 7 W DOE has used in the February 2022 Preliminary Analysis, DOE has maintained a standby power of 7 W in its energy use analysis. DOE notes that standby power consumption is held constant across efficiency levels and therefore only influences the overall energy use and not the incremental energy use.

3. Cost Analysis

The cost analysis portion of the engineering analysis is conducted using one or a combination of cost approaches. The selection of cost approach depends on a suite of factors, including the availability and reliability of public information, characteristics of the regulated product, the availability and timeliness of purchasing the product on the market. The cost approaches are summarized as follows:

- *Physical teardowns*: Under this approach, DOE physically dismantles a commercially available product, component-by-component, to develop a detailed bill of materials for the product.

- *Catalog teardowns*: In lieu of physically deconstructing a product, DOE identifies each component using parts diagrams (available from manufacturer websites or appliance repair websites, for example) to develop the bill of materials for the product.

- *Price surveys*: If neither a physical nor catalog teardown is feasible (for example, for tightly integrated products such as fluorescent lamps, which are infeasible to disassemble and for which parts diagrams are unavailable) or cost-prohibitive and otherwise impractical (*e.g.*, large commercial boilers), DOE conducts price surveys using publicly available pricing data published on major online retailer websites and/or by soliciting prices from distributors and other commercial channels.

In the present case, DOE conducted the analysis using a combination of physical and catalog teardowns to build a “bottom up” manufacturing cost assessment. DOE discusses the specific cost assessment for each product class below. The resulting bill of materials provides the basis for the manufacturer production cost ("MPC") estimates.

a. Hugger and Standard Ceiling Fans

In section 2.6.3 of the February 2022 Preliminary Analysis TSD, DOE relied on physical and catalog teardowns to estimate costs for all components of baseline 44-inch standard and hugger ceiling fans. Specifically, DOE used manufacturer literature to estimate the motor size of minimally compliant ceiling fans. Based on the typical motor size of minimally compliant fans identified, DOE estimated the motor housing cost and the ceiling fan mounting assembly costs. DOE assumed that hugger and standard ceiling fans of equivalent blade span use similar motors and that the primary difference in cost is the addition of a down-rod in standard ceiling fans.

DOE then applied a variety of markups to the factory production cost to get a manufacturer production cost. These markups included factory overhead costs, a factory markup, tariffs, and shipping costs[24].

In response to the February 2022 Preliminary Analysis, the Efficiency Advocates supported DOE's approach for estimating ceiling fan manufacturing costs because it only reflected the cost associated with features increasing energy efficiency, rather than including the cost of other premium features, and noted they were not aware of information indicating DOE had underestimated the increase to costs from EL0 to EL4. (Efficiency Advocates, No. 25 at pp. 1-2)

[24] Factory costs, factory markups, and tariffs were derived from manufacturer interviews. Shipping costs were derived from shipping container costs and ceiling fan box sizes. These markups are detailed in Chapter 5 of the TSD.

Conversely, ALA commented that DOE overestimated the cost of EL0 standard and hugger ceiling fans and underestimated the cost of EL4 fans. ALA provided retail price data to show a larger price difference in the current market. (ALA, No. 26 at p. 12) ALA also shared aggregated incremental MPC estimates from a survey of nine ALA members, and stated that the price differentials were considerably more than those used in the February 2022 Preliminary Analysis TSD. ALA recommended that DOE incorporate these estimates into future analysis. (ALA, No. 26 at pp. 13-14)

Regarding ALA's comment on DOE underestimating the price of baseline ceiling fans, DOE notes that the example fans provided by ALA demonstrate that there are many ways to increase or decrease the cost of a ceiling fan that are unrelated to efficiency (*e.g.,* simpler or more complex motor housing designs, lower cost blade materials, smaller box-sizes, higher-volume products with lower margins, etc.). For ceiling fans with AC motors in the ALA dataset, the lowest cost ceiling fans are under $30 while other AC motor ceiling fans are over $130.

In interviews, DOE explored what was unique about ceiling fans in the $30 to $50 range. Manufacturers cited use of simple designs to reduce tooling costs, use of less expensive materials, small box sizes for reduced shipping costs, and retailer emphasis on low-price points, resulting in reduced markups and squeezing margins wherever possible. During interviews, manufacturers did not identify specific characteristics for these very low-cost ceiling fans that would change the incremental costs associated with meeting higher efficiency standards. Similarly, DOE did not identify any characteristics that would lead these very low-cost ceiling fans to have a higher incremental cost. Therefore, DOE expects that the increase in first cost for both a $30 AC motor ceiling fan and a $130 AC motor ceiling fan would be similar if transitioning to a more efficient motor.

Regarding the specific models ALA provided as examples of DOE overestimating the price of max-tech ceiling fans, DOE notes that there are certain characteristics of the BLDC fan prices that may not be representative of the incremental costs in the presence of amended efficiency standards. DOE notes that BLDC motors are not required to meet energy conservations standards today. Therefore, the ceiling fans with BLDC motors on the market today are typically targeting consumers for whom minimum price is not the dominant purchasing factor. Most ceiling fans with BLDC motors today include sleek designs, quiet operation, and a greater number of speed controls as key selling points. Consistent with manufacturers targeting a more affluent demographic, current basic models with BLDC motors are more likely to include more sophisticated designs, enhanced controls, and other features that would allow for marketing to a higher price-point.

In DOE's review of the market, DOE observed numerous BLDC ceiling fans marketed for retail at considerably lower costs than the BLDC motor fans included in ALA's cited data. Additionally, in reviewing similar products, DOE observed numerous residential pedestal fans on the market that use BLDC motors and are offered at less than $100.

For this NOPR analysis, DOE has updated its cost model to reflect updated material prices (*e.g.,* blade material costs, motor housing costs, motor costs, etc.). In evaluating higher efficiency levels that still use AC motors, DOE modified its cost-analysis to reflect the reality that higher efficiency levels would be met via a combination of motor efficiency improvements and aerodynamic redesigns and optimization. Similar to the efficiency analysis, DOE modeled two different means of achieving higher efficiency levels, one being via maintaining airflow and reducing power consumption through more efficient motors and a second approach via maintain power consumption and increasing airflow through aerodynamic design and optimization. In modeling costs associated with using a more efficient motor, DOE assumed that the motor housing cost and ceiling fan mounting assembly costs would increase with a larger motor and scaled costs based on the increase in motor weight. DOE assumed aerodynamic changes would not increase manufacturer production costs, although they would still require redesign costs similar that would be accounted for in the manufacturer impact analysis. DOE then aggregated the two approaches by assuming a similar weighting between the two approaches in the cost model as was used in the efficiency analysis. DOE has described this approach in detail in Chapter 5 of the TSD.

For max-tech efficiency levels, DOE supplemented its February 2022 Preliminary Analysis estimates for the incremental factory costs to transition to BLDC motors with additional data from manufacturer interviews.

<u>Shipping Costs</u>

DOE assumes that all small-diameter ceiling fans are manufactured in Asia and must be shipped to the U.S. for sale. While shipping costs vary by fan, DOE has traditionally applied a representative per-fan shipping cost to all representative units in its calculation of manufacturer production costs. In section 2.6.3.3 of the February 2022 Preliminary Analysis TSD, DOE noted that its shipping cost estimate was derived from manufacturer interviews and was abnormally high at the time because of supply chain related challenges.

ALA commented that DOE assumed a constant shipping cost of $7.77, while ALA members pay $15.85 per unit from China on average, where most residential fans are manufactured, and do not expect lower shipping costs in the future. (ALA, No. 26 at p. 14)

DOE acknowledges that shipping costs have been highly variable over the last 5 years. Prior to May 2020, the cost to send a 40-foot shipping container from China to the U.S. was typically less than $5,000. However, from May 2020 through mid-2022 there were unprecedented high shipping prices where in some cases the cost to send a 40-foot shipping container from China to the U.S. was exceeded $15,000. In recent months, these costs have decreased and as of October 2022 are near their historical norm.

To better reflect future changes in shipping prices, and to account for that the relationship between shipping cost and fan size, DOE changed its shipping estimates from a flat cost to a variable cost based on the cost of shipping a 40-foot container from China to the U.S. While the cost of shipping an individual fan model will vary based on that fan's specific design, DOE used manufacturer literature to develop a relationship between ceiling fan blade span and shipping container cube size. DOE then estimated the number of ceiling fan models that could fit in each 40-foot shipping container and divided that number by the cost to ship a 40-foot container from China to the U.S. This methodology is described in more detail in Chapter 5 of the TSD. The per fan shipping costs used in this analysis were $2.84 for 44-inch ceiling fans, $3.63 for a 52-inch ceiling fan, and $4.42 for a 60-inch ceiling fan.

DOE acknowledges that certain models may be able to fit more or fewer ceiling fans into a shipping container. This may result in certain models having higher or lower costs than estimated. However, DOE notes that the manufacturer literature DOE relied on to develop the relationship between cube size and blade span included ceiling fans across a range of efficiencies and did not show any trend between ceiling fan cube size and product efficiency, including for fans with BLDC motors. Therefore, shipping costs influence overall MPCs and do not influence the incremental costs associated with higher efficiency standards.

Motor Markup

Ceiling fan manufacturers, in determining their manufacturer production costs, typically apply a markup to account for estimated post-market costs associated with a product, including warranty coverage, product returns, and general customer support. DOE has grouped these costs together into a markup percentage known as a "motor markup". While manufacturers typically do not vary their motor markup for each individual product, they will use a different markup for products or technologies that may have greater post-market costs than average. For example, manufacturers use a different motor markup for AC products and BLDC products on account of differing post-market costs for consumers. Because of these different markups, DOE relied on interview feedback to derive a different motor markup for AC motor fans and BLDC fans.

Where exactly in the value chain these costs are accounted for depends on a manufacturer's specific production chain. Some manufacturers may apply a certain percentage to the total production cost depending on the motor technology. Other manufacturers may apply the markup directly to the motor. In the February 2022 Preliminary Analysis, DOE stated that it was applying an 8 percent motor markup for BLDC motor fans and a 1.2 percent motor markup for AC motor fans. DOE explained that manufacturers apply a greater markup to BLDC fans because greater post-market support is needed to accommodate the greater complexity of BLDC control electronics.

DOE applied this markup to the motor and controller costs when determining the factory production costs and noted that this was consistent with the average manufacturer estimates derived during manufacturer interviews conducted as part of both the January 2017 ECS Final Rule and the February 2022 Preliminary Analysis.

In response, the CA IOUs asked DOE to reduce the warranty rate for BLDC ceiling fans to be similar to the warranty rate for AC-powered ceiling fans, citing the required three-year warranty rate for ENERGY STAR-certified ceiling fans as evidence that manufacturers are confident in their products. (CA IOUs, No. 22 at p. 1) The CA IOUs added that improper installations and power surges often void the manufacturer warranty for a product, so neither one of these two cases can be used as justification for an increased warranty rate for BLDC products. (CA IOUs, No. 22 at p. 2) The Efficiency Advocates encouraged DOE to reevaluate the 8 percent warranty factor applied to DC motors and cited the 2014 furnace fan rulemaking as evidence of little difference in failure rate between AC and DC motors. (Efficiency Advocates, No. 25 at p. 2; Dunklin, Public Meeting Transcript, No. 21 at p. 66) They noted that the magnitude of the difference was not warranted and raised that an inappropriately high warranty rate may artificially inflate the manufacturer costs of using DC motors. *Id.*

In contrast, ALA and Westinghouse agreed with the motor markups DOE used in the February 2022 Preliminary Analysis for BLDC and AC motor ceiling fans. (ALA, No. 26 at p. 6; Gatto, Public Meeting Transcript, No. 21 at p. 66) ALA expanded that these costs are consistent with the average manufacturer cost associated with the warranty repair/replacement expenses based on actual ceiling fan manufacturer expenses incurred "after the sale". (ALA, No. 26 at p. 6)

While the CA IOUs and the Efficiency Advocates may be correct that a typical BLDC motor ceiling fan may not be several times more likely to fail during the fan's warranty period, the motor markup does not include only failures but instead is a general term encompassing all post-market costs. During manufacturer interviews conducted in support of this NOPR analysis, manufacturers uniformly agreed that they apply a greater warranty rate for BLDC motor ceiling fans than they did for AC motor ceiling fans. Manufacturers cited greater return rates due to more complex installations, occasional defective electronics that were covered by warranties, and greater customer support required for BLDC ceiling fans.

In section 2.6.3.2 of the February 2022 Preliminary Analysis TSD, DOE discussed that some manufacturers were including the BLDC motor electronic controller outside of the motor housing (*i.e.,* in the ceiling fan canopy as opposed to within the motor housing), making it more accessible to consumers and therefore easier to replace without needing to replace the entire fan. However, DOE noted that this practice was not yet widespread. In interviews, DOE explored whether the practice of moving an electronic controller to the canopy was a reasonable method of reducing the motor markup. In response, manufacturers cited that while moving the BLDC motor electronics to the canopy allows easier replacement of failed motor electronics, it requires consumers to do more complicated wiring and run more wires through the downrod, which requires increased consumer support and replacement rates.

Based on both public comments and confidential manufacturer interviews, an 8-percent motor markup for BLDC motor fans and a 1.2-percent motor markup for AC motor fans is consistent with the current markup rates applied to fans on the market today. Therefore, DOE has maintained these markup rates in this NOPR analysis.

Wall Controls

As discussed in section IV.B.2.a.i of this document, existing wired AC motor wall controls[25] are incompatible with BLDC motors. In the February 2022 Preliminary Analysis, DOE did not account for additional costs associated with replacement of existing wired AC wall controls.

ALA commented that 50 percent of existing ceiling fans are controlled by a wall dimmer or a wall speed control switch, and such controls are incompatible with BLDC motor ceiling fans and would need to be replaced. (ALA, No. 26 at pp. 3-4) Lutron stated that replacing AC motor-powered ceiling fans with fans powered by a BLDC motor would have a negative impact on consumers that currently have a fan speed control system installed. Lutron estimated the current installed base of fan speed controls to be about 25 million units. (Lutron, No. 24 at p. 3)

ALA commented that because BLDC wall controls are radio frequency ("RF")-based and proprietary to the ceiling fan manufacturer, switching from one BLDC motor-based ceiling fan to another will also require switching the wall control, possibly even if the prior wall control is from the same manufacturer. (ALA, No. 26 at p. 4) ALA further commented that because BLDC motor ceiling fan controls are proprietary, consumers will be limited to the few solutions offered by the particular manufacturer. (ALA, No. 26 at p. 4) Consumers may be left with a mix of control solutions throughout their home that do not function together or look uniform. *Id.* Further, ALA added that since BLDC controls are proprietary[26], consumers who wish to replace a broken or lost remote control

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[25] Wired wall controls are installed in similar locations to light switches and are connected to the ceiling fan power input. Wired wall controls include capacitors that allow for controlling a ceiling fan speed from the wall rather than via pull-chain speed controls.

[26] BLDC motors require electronic controllers to control operating speed. Manufacturers typically develop controllers specific to their fan models and replacements must include the correct product for that fan model.

may not be able to find a compatible remote or wall control solution and thus may be forced to purchase a new ceiling fan. (ALA, No. 26 at pp. 4-5) Hinkley commented that a standard requiring DC motors would result in significant costs to manufacturers to maintain DC motor controls and firmware after those products have been discontinued so that the controls and firmware could be used for replacement purposes. (Kachala, Public Meeting Transcript, No. 21 at p. 77)

Hunter and ALA commented that because AC wall controls are incompatible with BLDC wall controls DOE should incorporate the costs of existing AC wall controls that need to be replaced into its analysis. (Bacon, Public Meeting Transcript, No. 21 at p. 85; ALA, No. 26 at p. 4) ALA stated that the average BLDC motor wall controller costs $14.22, which at surveyed markups results in a $35.72 retail cost to consumers, before considering costs for consumers who utilize an electrician. (ALA, No. 26 at p. 14)

ALA commented that ceiling fans with DC motors are typically more difficult to install than ceiling fans with AC motors. ALA recommended that DOE also include the cost of hiring an electrician in the installation cost of BLDC fan wall controls for consumers not knowledgeable or comfortable with changing their own wall controls and the environmental costs associated with the disposal of millions of obsolete wall control systems and their required RF control replacements. (ALA, No. 26 at p. 4)

Conversely, the CA IOUs recommended that DOE exclude the cost of proprietary wall switches for BLDC ceiling fans because many BLDC ceiling fans are sold with a wall-mounted remote instead and can also be installed with a pull chain. (CA IOUs, No. 22 at p. 2)

DOE notes that while AC motor wall controls are generally universally compatible with pull-chain AC motor ceiling fans, there are several scenarios where a manufacturer would have to replace a wired wall-controller absent a BLDC motor purchase. Wired wall controls cannot be used with remote controls and therefore any consumer replacing a wired pull-chain ceiling fan with a remote-controlled ceiling fan would have to replace the wired wall control. Wired wall controls also require a separate power line for individual light controls and fan speed controls. If a consumer is controlling a ceiling fan without a light kit via a wired wall control and replaces that ceiling fan with a ceiling fan with a light kit, that consumer would likely need to replace their wired wall controller. Lastly, consumers have natural turn-over of their wall controls, absent any standards. In interviews, manufacturers estimated a typical lifetime for wall controls ranging from 10 to 20 years. This is in line with the average lifetime of ceiling fans, indicating that many wall controls are likely replaced at the time of ceiling fan replacement, regardless of what replacement fan is purchased.

As noted by the CA IOUs, BLDC ceiling fans are sold with a controller. DOE considers the cost of this controller in its MPCs. As such, consumers who purchase a BLDC motor ceiling fan do not need to go out and purchase a separate wall controller or worry about compatibility between models, since the controller is sold with the fan.

If a consumer has an existing wired wall control and purchases a BLDC motor ceiling fan, they will have to purchase a different switch as a replacement for their existing wired wall control. If a consumer wanted to maintain the functionality of a wall control, they would likely purchase a BLDC motor ceiling fan with a wall control. If the consumer does not care to maintain the wall control, they likely would replace their wired wall control with a simple on/off toggle switch. Simple on/off toggle switches commonly retail for less than one dollar. Given the low cost of simple on/off toggle switches, the multiple scenarios where a consumer would replace a wired wall switch absent any amended efficiency standard, and the fact BLDC motor ceiling fans are sold with controllers, DOE has not included additional costs for wall control replacements in its NOPR analysis.

Regarding stakeholder comments that DOE should include the costs of more complicated installation, DOE notes that BLDC motor ceiling fans are commonly sold with the controller in the motor housing. This is done to simplify consumer installation. As such, the number of wires to connect are generally identical between AC and DC motor ceiling fans and therefore DOE has not included differing installation costs. DOE notes that some BLDC motor ceiling fans include the controller in the ceiling fan canopy. This approach makes it easier for a consumer to replace the motor, but is more challenging to install. DOE notes that its BLDC motor markup includes the additional markup associated with more difficult installations, accounted for as higher consumer support costs.

Lastly, DOE notes that existing manufacturer literature markets wired wall controls as “universal.” Further, remote control ceiling fans, both AC motor and BLDC motor, do not typically market a lack of compatibility with existing wired wall controls as something that needs to be considered or overcome by consumers. This suggests that this issue has not been a concern for consumers. For the reasons stated previously, DOE has not incorporated additional wall-control replacement costs, aside from the general MPC costs for a BLDC controller required for all BLDC motor ceiling fans, in this NOPR.

b. Large-Diameter Ceiling Fans

Like small-diameter ceiling fans, DOE relied on physical and catalog teardowns to build a “bottom up” manufacturing cost assessment for large-diameter ceiling fans in the February 2022 Preliminary Analysis. DOE modeled the change in costs associated with going to a higher EL as a transition from a three-phase geared induction motor to a premium three-phase geared induction motor. DOE also modeled different motor sizes depending on whether the representative unit was a low-airflow LDCF or a high-airflow LDCF.

In accordance with stakeholder feedback to not establish separate product classes for low-airflow and high-airflow LDCFs, DOE has modeled only one cost for each blade span LDCF unit. Consistent with this approach, DOE has modified its motor sizing to be reflective of a 0.5 HP motor for 8-foot fans, 1 HP motor for 12-foot fans, and 2 HP motor for 20-foot fans.

As noted, all AMCA members typically use “premium” efficiency motors across all gear-driven products. Nevertheless, the gear-driven products on the market span a range of CFEI100 values, some of which exceed DOE’s EL1 value, even when the motor size and motor efficiency are approximately constant. As noted, manufacturers expressed in interviews an ability to optimize fans for a given diameter. This is observable in the manufacture literature, where the CFEI of a given model with identical blade shapes and motor size will vary across blade spans. Manufacturers stated that in order to reduce the number of parts, the motor gearbox size and angle of blade connection will be held constant across numerous blade spans, even though optimizing for every specific blade span may lead to higher efficiency. DOE has revised its cost associated with a transition from EL0 to EL1 to be reflective of maintaining motor size and motor efficiency but adding additional optimization of the fan.

Optimization of an LDCF does not inherently have additional costs to the consumer. There are additional costs to manufacturers to develop, redesign, and reoptimize fans, and DOE models these costs in its manufacturer impact analysis. But functionally all the material parts are the same. DOE teardown models take into account purchase volume discounts that a manufacturer will receive. In a scenario where manufacturers must purchase specific motor-gearbox combinations optimized for every blade span, these volume discounts are less. Accordingly, DOE modeled the incremental production cost increases associated with a transition from EL0 to EL1 as corresponding to a one-third reduction in motor-gearbox purchase volume quantity. This cost analysis reflects the fact that while gear-driven motors can achieve EL1 levels, they will require additional redesign and re-optimization, which will increase the manufacturer production costs of those models.

For DOE's max-tech efficiency level, DOE assumed a transition to a permanent-magnet direct-drive motor of the same size as the gear-driven motor.

c. High-Speed Belt-Driven Ceiling Fans

Like the efficiency analysis for HSBD ceiling fans, DOE did not have specific data on the incremental costs associated with improving the efficiency of HSBD fans. Therefore, DOE used the October 2022 Fans and Blower NODA for 50-inch fans to estimate the incremental costs associated with higher efficiency levels.

d. Manufacturer Markup

To account for manufacturers' non-production costs and profit margin, DOE applies a multiplier (the manufacturer markup) to the MPC. The resulting manufacturer selling price ("MSP") is the price at which the manufacturer distributes a unit into commerce. DOE developed an average manufacturer markup during the January 2017 Final Rule by examining the annual Securities and Exchange Commission (SEC) 10-K reports filed by publicly-traded manufacturers primarily engaged in ceiling fan manufacturing. DOE then adjusted these manufacturer markups based on feedback manufacturers provided during manufacturer interviews. 82 FR 6826, 6845. The manufacturer markups used in this NOPR analysis are discussed in more detail in section IV.J.2.d of this document and in chapter 12 of this NOPR TSD.

4. Cost-Efficiency Results

The results of the engineering analysis are reported as cost-efficiency data (or "curves") in the form of energy efficiency (in terms of CFM/W or CFEI) versus MPC (in dollars). DOE developed curves for each representative unit. The methodology for developing the curves started with determining the energy consumption for baseline equipment and MPCs for this equipment. Above the baseline, DOE implemented design options using the ratio of cost to savings. Design options were implemented until all available technologies were employed (*i.e.*, at a max-tech level). See TSD Chapter 5 for additional detail on the engineering analysis.

D. Markups Analysis

The markups analysis develops appropriate markups (e.g., retailer markups, distributor markups, contractor markups) in the distribution chain and sales taxes to convert the MSP estimates derived in the engineering analysis to consumer prices, which are then used in the LCC and PBP analysis and in the manufacturer impact analysis. At each step in the distribution channel, companies mark up the price of the product to cover business costs and profit margin.

For standard and hugger ceiling fans, consistent with the February 2022 Preliminary Analysis, DOE characterized four distribution channels to describe how such fans pass from manufacturers to consumers, as follows:

- Manufacturer → Home Improvement Center → Consumer
- Manufacturer/Home Improvement Center (in-store label) → Consumer
- Manufacturer → Wholesaler → Contractor → Consumer
- Manufacturer → Showroom → Consumer

For HSBD and LDCFs, DOE considered the following distribution channels:

Manufacturer → Dealer → Customer

Manufacturer → In-house Dealer → Customer

DOE assumed that the markup for in-house dealers and conventional dealers is the same; Therefore, the overall markup for these two channels is also the same.

DOE developed baseline and incremental markups for each actor in the distribution chain. Baseline markups are applied to the price of products with baseline efficiency, while incremental markups are applied to the difference in price between baseline and higher-efficiency models (the incremental cost increase). The incremental markup is typically less than the baseline markup and is designed to maintain similar per-unit operating profit before and after new or amended standards.[27]

ALA disagreed with DOE's incremental markups methodology and assumption that current margins would drop, and argued that according to ALA survey results BLDC motor ceiling fans (EL 4) have nearly identical markups as baseline (EL 0) ceiling fans with no indication this practice of maintaining fan markups across underlying technologies would change in the future. ALA added that DOE's justification of the incremental markup methodology in appendix 6A of the TSD, which compares ceiling fans to LCD TVs, is incorrect because the underlying electronics for TVs are shared with a myriad of technologies and products. (ALA, No. 26 at p. 3)

DOE's incremental markup approach assumes that an increase in profitability, which is implied by keeping a fixed markup when the product price goes up, is unlikely to be viable over time in reasonably competitive markets. DOE recognizes that home centers are likely to seek to maintain the same markup on appliances in response to changes in manufacturer sales prices after an amendment to energy conservation standards for ceiling fans. However, DOE believes that retail pricing is likely to adjust over time as retailers are forced to readjust their markups to reach a medium-term equilibrium in which per-unit profit is relatively unchanged before and after standards are implemented. To showcase the hypothesized conditions of efficiency standard implementation using real-world data, DOE would ideally analyze a household durable that has experienced a consistent rise in price, such as one that may occur as a result of

[27] Because the projected price of standards-compliant products is typically higher than the price of baseline products, using the same markup for the incremental cost and the baseline cost would result in higher per-unit operating profit. While such an outcome is possible, DOE maintains that in markets that are reasonably competitive it is unlikely that standards would lead to a sustainable increase in profitability in the long run.

standards. However, DOE was not able to obtain such data for household durable goods. In appendix 6A, the LCD TV data was not meant to be an equivalent case to ceiling fans; rather it illustrated a scenario when the cost of goods sold experienced a significant change (in this case, LCD TV costs were decreasing), the retailer's gross margin did not remain fixed. In other examples where DOE was able to acquire time series data demonstrating upward price trends, even though the industries are not directly related to ceiling fans, the observed percent retail gross margins have decreased during the same time.

DOE requests comment and data on the gross margin trends for household durables relevant to ceiling fans that experienced an increase in the cost of goods sold.

DOE acknowledges that home-center markup practices in response to amended standards are complex and varying with business conditions. However, DOE's analysis necessarily only considers changes in appliance offerings that occur in response to amended standards. Given the medium to high level of market competition among industry groups involved in appliance retail industry, DOE continues to maintain that its assumption that standards do not facilitate a sustainable increase in profitability is reasonable.[28] See appendix 6A for more details.

DOE relied on 10-K reports from the U.S. Securities and Exchange Commission (SEC) and economic data from the U.S. Census Bureau to estimate average baseline and incremental markups. Specifically, DOE used 10-K reports for major home improvement centers and the 2017 Annual Retail Trade Survey for the "building material and supplies

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[28] IBISWorld. US Industry Reports. (Last accessed November 22, 2022.) *https://www.ibisworld.com*

dealers" sector to develop home improvement center markups,[29] the 2017 Annual Wholesale Trade Survey for the "household appliances, and electrical and electronic goods merchant wholesalers" sector to estimate wholesaler markups,[30] 2021 RSMeans Electrical Cost Data to derive contractor markups,[31] and 10-K reports for key industrial supplier to develop dealer markups.

ALA provided an aggregated Home Center markup of independent label fans from a survey of nine ALA members. ALA pointed out that these markups are higher than those used for DOE in the preliminary analysis, and suggested that DOE adopt these higher home center markups in subsequent analysis. (ALA, No. 26 at p. 14)

DOE appreciates the data submitted by ALA. DOE's home improvement center markup methodology relies on publicly available data from the U.S. SEC's 10-K reports and the U.S. Census Bureau, which is a preferred approach as the results can be replicated and the data sources are updated on a regular basis. Moreover, the baseline markup value derived from the government data is in the similar range of the value provided by ALA, indicating that the 10-K report and U.S. Census are reliable sources for estimating the industry-wide markup value.

For more details on the distribution channels and the markups used by DOE, see chapter 6 of this NOPR TSD.

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[29] U.S. Census Bureau, Annual Retail Trade Survey. 2017. (Last accessed November 22, 2022.) *www.census.gov/programs-surveys/arts.html.*

[30] U.S. Census Bureau, Annual Wholesale Trade Survey. 2017. (Last accessed November 22, 2022.) *www.census.gov/awts.*

[31] RSMeans data. (Last accessed November 22, 2022.) *https://www.rsmeans.com/*.

E. Energy Use Analysis

The purpose of the energy use analysis is to determine the annual energy consumption of ceiling fans at different efficiencies in representative U.S. single-family homes, multi-family residences, and commercial buildings, and to assess the energy savings potential of increased ceiling fan efficiency. The energy use analysis estimates the range of energy use of ceiling fans in the field (*i.e.*, as they are actually used by consumers). The energy use analysis provides the basis for other analyses DOE performs, particularly assessments of the energy savings and the savings in consumer operating costs that could result from adoption of amended or new standards.

ALA commented that DOE is overestimating the consumer savings between EL 0 and EL 4 fans in all but one category, based on a survey of ALA members. (ALA, No. 26, at p. 14)

DOE's energy use analysis for standard and hugger ceiling fans considers daily operating hours, the fraction of time spent in each mode, power consumption at each mode from the engineering analysis, and an assumed consumption of 0.7 W while not in active mode for AC ceiling fans with a remote and all BLDC ceiling fans. While DOE appreciates ALA's efforts in conducting this survey, the information presented by ALA does not provide the assumptions used in calculating the average consumer savings between the baseline (EL 0) and max-tech (EL 4) ceiling fans (other than the assumed average electricity price of $0.12/kWh). Moreover, while there is no indication that the subset of ALA members who opted to complete the survey are representative of the broader standard and hugger ceiling fan markets, DOE has revised its efficiency analysis in this NOPR to better reflect the power consumption of baseline (EL 0) ceiling fans.

This revision should better align the EnergyGuide label's implied savings with those of DOE's analysis in this NOPR.

1. Inputs for Standard and Hugger Ceiling Fans

a. Sample of Purchasers

As in the February 2022 Preliminary Analysis, DOE has included only residential applications in the energy use analysis of standard and hugger ceiling fans. DOE used the Energy Information Administration (EIA) 2020 Residential Energy Consumption Survey (RECS)[32] to choose a random sample of households in which new ceiling fans could be installed. RECS is a national sample survey of housing units that collects statistical information on the consumption of, and expenditures for, energy in housing units, along with data on energy-related characteristics of the housing units and occupants. RECS collected data on nearly 18,500 housing units, and was constructed by EIA to be a national representation of the household population in the United States. In creating the sample of RECS households, DOE used the subset of RECS records that met the criterion that the household had at least one ceiling fan. DOE chose a sample of 10,000 households from RECS to estimate annual energy use for standard and hugger ceiling fans. Because RECS provides no means of determining the type of ceiling fan in a given household, DOE used the same sample for the standard and hugger product classes.

[32] U.S. Department of Energy–Energy Information Administration. 2020 Residential Energy Consumption Survey (RECS). 2020. (Last accessed November 11, 2022.) *https://www.eia.gov/consumption/residential/data/2020/*.

b. Operating Hours

Consistent with the February 2022 Preliminary Analysis, DOE used data from an LBNL study[33] that surveyed ceiling fan owners to estimate the total daily operating hours for each sampled RECS household. In that study, the authors asked a nationally representative sample of more than 2,500 ceiling fan users to report their ceiling fan operating hours for high, medium, and low speeds, as well as frequency of use throughout the year and hours of operation during the most-used month of the year and a month of relatively little ceiling fan use. The LBNL study reported a distribution of operating hours, with an average of 6.45 hours of operation per day. The operating hours for each sample household were drawn from the distribution of operating hours reported in the LBNL study, and further apportioned into operating hours at different fan speeds. As in the February 2022 Preliminary Analysis, DOE estimated that standard and hugger ceiling fans are operated 33 percent of the time in active mode on high speed, 38 percent on medium speed, and 29 percent on low speed. For each household sampled from RECS 2020, the fraction of time that the fan spends at each of low and medium speed was drawn from a uniform distribution over the interval between zero and twice the average fraction of time for that speed. Because the sum of fractions of time spent at each speed must equal one, the fraction of time spent at high speed is simply given by the remaining fraction. DOE then used these fractions to apportion the total hours of use into hours of use at high, medium, and low speeds. This method of sampling the amount of time for each operating mode is consistent with that of the February 2022 Preliminary Analysis as well as the January 2017 ECS Final Rule. AMCA commented that AMCA

[33] Kantner, C. L. S., S. J. Young, S. M. Donovan, and K. Garbesi. Ceiling Fan and Ceiling Fan Light Kit Use in the U.S.—Results of a Survey on Amazon Mechanical Turk. 2013. Lawrence Berkeley National Laboratory: Berkeley, CA. Report No. LBNL-6332E. (Last accessed November 11, 2022.) *http://www.escholarship.org/uc/item/3r67c1f9*.

does not have data that contradicts DOE's assumptions for the breakdown of operating hours. (AMCA, No. 23 at p. 11)

c. Power Consumption at Each Speed and Standby

DOE determined the power consumption at high, medium, and low speed for each representative fan size in the engineering analysis (see section IV.C of this document). These values are shown in chapter 5 of the NOPR TSD. DOE estimated that all ceiling fans with BLDC motors expend standby power, and that 15 percent of non-baseline standard and hugger ceiling fans with AC motors come with a remote, and therefore consume power while in standby mode. DOE further estimated 0.7 watts as the power consumption value for standby for all representative fans belonging to the standard and hugger product classes, based on testing conducted in association with developing the engineering analysis.

2. Inputs for Large-Diameter and High-Speed Belt-Driven Ceiling Fans

a. Sample of Purchasers

As in the February 2022 Preliminary Analysis, DOE has included only commercial and industrial applications in the energy use analysis of large-diameter and HSBD ceiling fans. Although some large-diameter and HSBD fans are used in residential applications, they represent a very small portion of the total market for large-diameter and HSBD ceiling fans. Similar to standard and hugger ceiling fans, DOE developed a sample of 10,000 fans to represent the range of large-diameter and HSBD ceiling fan energy use using RECS 2020. DOE did not use the 2018 Commercial Buildings Energy Consumption Survey (CBECS) because CBECS does not identify buildings with ceiling fans. By using RECS 2020 to construct the large-diameter and

HSBD ceiling fan samples, DOE implicitly assumed that the geographic distribution of commercial and industrial ceiling fans is equivalent to that of residential ceiling fans.

b. Operating Hours

DOE drew 10,000 samples from a uniform distribution between 6 hours per day and 18 hours per day when calculating the energy use of large-diameter ceiling fans. Without data indicating that the operating hours of HSBD ceiling fans differ from those of large-diameter ceiling fans, DOE used the same uniform distribution to draw operating hours for HSBD ceiling fans.

DOE assumed that all large-diameter ceiling fans spend an equal amount of time operating at 20 percent speed, 40 percent speed, 60 percent speed, 80 percent speed, and 100 percent speed. This assumption for large-diameter ceiling fans aligns with the February 2022 Preliminary Analysis. Due to insufficient data to estimate the time spent at each speed for HSBD ceiling fans, DOE assumed HSBD ceiling fans operate at high speed for all time spent in active mode. This assumption aligns with the one made in the January 2017 Final Rule for HSSD ceiling fans. AMCA commented that it does not have data that contradicts DOE's assumptions for the breakdown of operating hours. (AMCA, No. 23 at p. 11)

DOE requests comment and data as to whether the assumed operating hours and operating speeds are appropriate for HSBD ceiling fans.

c. Power Consumption at Each Speed and Standby

DOE determined the power consumption for a given representative large-diameter ceiling fan by the weighted average of power consumption at the five speeds discussed previously, where each speed was weighted by an equal fraction of time spent at that speed. The power consumption for HSBD ceiling fans was assumed to be the power consumption at high speed. DOE also considered all large-diameter and HSBD ceiling fans to have 7 W standby power, and that all hours not spent in active mode were in standby mode.

3. Impact on Air-Conditioning or Heating Equipment Use

As in the February 2022 Preliminary Analysis, DOE did not account for any interaction between ceiling fans and air-conditioning or heating equipment. In DOE's assessment, it appears unlikely that consumers would substantially increase air-conditioning use or forego purchasing a ceiling fan in lieu of an air-conditioning unit due to a modest increase in the initial cost of a ceiling fan as a result of an amended energy conservation standard. DOE agrees that ceiling fans have the hypothetical potential to be an inexpensive and effective replacement for air-conditioning use; however, the interaction between ceiling fan use and air-conditioning use is unlikely to be different in the case of amended standards than it would be in the no-new-standards case. The shipments analysis projects a modest change of shipments for standard and hugger fans of less than two percent in the compliance year under the proposed standard level, and it is unclear what would motivate consumers to change their air-conditioner's set point or otherwise change their air-conditioning behavior if they own a ceiling fan regardless of whether there is a new or amended standard. Therefore, the interaction between ceiling fan use and air-conditioning use would be unlikely to be different in the case of amended standards than it would be in the no-new-standards case.

DOE requests comment and data on the impact on air-conditioning or heating equipment use from the adoption of more stringent efficiency standards on ceiling fans.

Chapter 7 of the NOPR TSD provides details on DOE's energy use analysis for ceiling fans.

F. Life-Cycle Cost and Payback Period Analysis

DOE conducted LCC and PBP analyses to evaluate the economic impacts on individual consumers of potential energy conservation standards for ceiling fans. The effect of new or amended energy conservation standards on individual consumers usually involves a reduction in operating cost and an increase in purchase cost. DOE used the following two metrics to measure consumer impacts:

- The LCC is the total consumer expense of an appliance or product over the life of that product, consisting of total installed cost (manufacturer selling price, distribution chain markups, sales tax, and installation costs) plus operating costs (expenses for energy use, maintenance, and repair). To compute the operating costs, DOE discounts future operating costs to the time of purchase and sums them over the lifetime of the product.

- The PBP is the estimated amount of time (in years) it takes consumers to recover the increased purchase cost (including installation) of a more-efficient product through lower operating costs. DOE calculates the PBP by dividing the change in purchase cost at higher efficiency levels by the change in annual operating cost for the year that amended or new standards are assumed to take effect.

For any given efficiency level, DOE measures the change in LCC relative to the LCC in the no-new-standards case, which reflects the estimated efficiency distribution of ceiling fans in the absence of new or amended energy conservation standards. In contrast, the PBP for a given efficiency level is measured relative to the baseline product.

For each considered efficiency level in each product class, DOE calculated the LCC and PBP for a nationally representative set of housing units and commercial and industrial buildings. As stated previously, DOE developed household samples from the 2020 RECS for standard and hugger ceiling fans, and assumed the geographic distribution of large-diameter and HSBD ceiling fans used in commercial and industrial applications is equivalent to that of residential ceiling fans. For each sampled consumer, DOE determined the energy consumption for the ceiling fan and the appropriate energy price. By developing a representative sample of consumers, the analysis captured the variability in energy consumption and energy prices associated with the use of ceiling fans.

Inputs to the calculation of total installed cost include MPCs, manufacturer markups, retailer and distributor markups, and sales taxes. Consistent with the approach used in January 2017 ECS Final Rule (section IV.F.1 of this document)—which was supported at the time by Westinghouse, ALA, and BAS— DOE assumed that installation costs do not vary by efficiency level and therefore were not considered in the analysis. Inputs to the calculation of operating expenses include annual energy consumption, energy prices and price projections, product lifetimes, and discount rates. DOE created distributions of values for product lifetime, discount rates, and sales taxes, with probabilities attached to each value, to account for their uncertainty and variability. Repair and maintenance costs were assumed not to vary by efficiency level, and therefore were not considered in the analysis.

The computer model DOE uses to calculate the LCC relies on a Monte Carlo simulation to incorporate uncertainty and variability into the analysis. The Monte Carlo simulations randomly sample input values from the probability distributions and ceiling fan user samples. For this rulemaking, the Monte Carlo approach is implemented in the Python programming language. The model calculated the LCC for products at each efficiency level for 10,000 consumers per simulation run. The analytical results include a distribution of 10,000 data points showing the range of LCC savings for a given efficiency level relative to the no-new-standards case efficiency distribution. In performing an iteration of the Monte Carlo simulation for a given consumer, product efficiency is chosen based on its probability. If the chosen product efficiency is greater than or equal to the efficiency of the standard level under consideration, the LCC calculation reveals that a consumer is not impacted by the standard level. By accounting for consumers who already purchase more-efficient products, DOE avoids overstating the potential benefits from increasing product efficiency.

DOE calculated the LCC and PBP for consumers of ceiling fans as if each were to purchase a new product in the first full year of compliance with new or amended standards. For the purpose of its analysis, DOE assumed new and amended standards would apply to ceiling fans manufactured 3 years after the date on which any new or amended standard is published. At this time, DOE estimates publication of a final rule in the second half of 2024. Therefore, for purposes of its analysis, DOE used 2028 as the first full year of compliance with any new or amended standards for ceiling fans.

Table IV.2 summarizes the approach and data DOE used to derive inputs to the LCC and PBP calculations. The subsections that follow provide further discussion.

Details of the spreadsheet model, and of all the inputs to the LCC and PBP analyses, are contained in chapter 8 of the NOPR TSD and its appendices.

Table IV.4 Summary of Inputs for the LCC and PBP Analysis*

Inputs	Average or Typical Value	Characterization
Total Installed Cost Inputs		
Product Price	Varies by distribution channel, efficiency level, and product class	Single-point value
Sales Tax	7.3%	Varies by region
Operating Cost Inputs		
Power Rating	Varies by efficiency level and product class	Single-point value
Operating Hours	Standard and hugger ceiling fans: 6.45 hrs/day (average) Large-diameter and HSBD ceiling fans: 12.0 hrs/day (average)	Distribution (see chapter 7 of this TSD for details)
Electricity Prices	Residential: 0.15 $/kWh (avg), 0.14 $/kWh (mgl) Commercial: 0.11 $/kWh (avg), 0.11 $/kWh (mgl) Industrial: 0.09 $/kWh (avg), 0.08 $/kWh (mgl)	Vary by region for each sector
Electricity Price Trends	AEO 2023 reference case	Vary by region for each sector
Product Lifetime	Mean: 14.6 years Median: 14.0 years	Weibull distribution
Discount Rate	Residential sector: 4.3% Commercial sector: 6.7% Industrial sector: 7.2%	Residential: Vary by household income Commercial/Industrial: Distribution
First Full Year of Compliance	2028	Single-point value

* References for the data sources mentioned in this table are provided in the sections following the table or in chapter 8 of the NOPR TSD.

The Efficiency Advocates commented that the reported average LCC savings obscure the fact that a consumer's LCC savings are always greatest at the highest evaluated EL. (Efficiency Advocates, No. 25 at p. 3)

The LCC savings values DOE reports take into consideration the efficiency level of the ceiling fan each consumer would purchase in the absence of a new efficiency standard. This approach acknowledges that setting an efficiency standard at a given efficiency level may not impact all consumers. In the example analysis provided by the Efficiency Advocates, the reported LCC savings were compared to the difference in average LCC between each efficiency level and the baseline (EL 0) ceiling fan. This comparison is problematic because the results DOE reports in the LCC table (not the LCC savings table) assume the entire sample of 10,000 consumers purchase ceiling fans at each of the ELs. As a result, comparing the difference in average LCCs from the LCC table inherently assumes that every consumer would purchase a ceiling fan at EL 0 in the absence of a standard, which does not agree with DOE's market research. For details on the market efficiency distribution, see section IV.F.8 of this document.

1. Product Cost

To calculate consumer product costs, DOE multiplied the MPCs developed in the engineering analysis by the markups described previously (along with sales taxes). DOE used different markups for baseline products and higher-efficiency products, because DOE applies an incremental markup to the increase in MSP associated with higher-efficiency products.

DOE used a price trend to account for changes in the incremental BLDC motor price that are expected to occur between the time for which DOE has data for BLDC motor prices (2021) and the first full year of compliance (2028). For details on the price trend analysis, see section IV.G of this document. In order to account for the possibility that prices will not decrease, DOE performed a sensitivity analysis in which the price of fans with BLDC motors does not decrease. DOE applied sales tax, which varies by geographic location, to the total product cost. DOE collected sales tax data from the Sales Tax Clearinghouse[34] and used population projections from the Census Bureau[35] to

[34] Sales Tax Clearinghouse Inc. State Sales Tax Rates Along with Combined Average City and County Rates. June 6, 2022. (Last accessed November 22, 2022.) *http://thestc.com/STrates.stm*.
[35] U.S. Department of Commerce-Bureau of the Census. Table A1: Interim Projections of the Total Population for the United States and States: April 1, 2000 to July 1, 2030. Population Division, Interim State Population Projections. 2005. (Last accessed November 22, 2022.) *https://wonder.cdc.gov/wonder/help/populations/population-projections/SummaryTabA1.xls*.

develop population-weighted-average sales tax values for each state in the assumed first full year of compliance (2028).

2. Installation Cost

Installation cost includes labor, overhead, and any miscellaneous materials and parts needed to install the product. As in the February 2022 Preliminary Analysis, DOE assumed that installation costs do not vary by efficiency level. Therefore, DOE did not include installation costs in its analysis.

ALA and Lutron commented that if DOE were to adopt an efficiency standard requiring the use of brushless DC motors, wall-mounted fan-speed controls would become obsolete and/or require expensive retrofitting. This is because DC motors employ proprietary controls that are internal to the motor assembly and do not receive control signals through electrical wiring, but through a proprietary wireless remote. (ALA, No. 26, at pp. 1-2, 7; Lutron, No. 24 at p. 2) ALA further commented that even if switching between DC ceiling fans from the same manufacturer, the older existing DC wall control may no longer work because it has outdated technology. Consequently, consumers may also be forced to purchase a new ceiling fan if they lose or break their remote. (ALA, No. 26, at pp. 4-5)

ALA conducted a survey of nine ALA members, which resulted in an estimate of $14.22 manufacturing cost for an average DC wall controller, or a $35.72 retail cost to consumers, including markups but barring installation cost. (ALA, No. 26, at p. 14) ALA added that because of the installation difficulty, consumers may utilize an electrician to install a DC motor ceiling fan. ALA recommends that DOE determine the percentage of consumers who utilize electricians to install wall controls, and factor this into their installation costs. (ALA, No. 26, at p. 6)

In contrast, the CA IOUs commented that DOE should not include the cost of wall controls for DC ceiling fans because many DC ceiling fans are offered with a wall-mounted remote-control. (CA IOUs, No. 22 at p. 2)

DOE appreciates the insights of ALA, Lutron, and the CA IOUs regarding ceiling fan wall controls. As the CA IOUs mentioned, DOE finds that new DC motor ceiling fans typically come with remote controls and an option to wall-mount them. Thus, DOE is not considering the cost of DC wall controls themselves, nor the cost of retrofitting existing AC fan wall controls in its analysis. The remote controls packaged with DC-motor ceiling fans provide the same utility to consumers that have an existing wall control. Additionally, DOE does not have data quantifying how often consumers replace a ceiling fan due to a broken or lost remote, or what percentage of consumers hire electricians to install their fans. DOE continues to invite comments and data from stakeholders on this issue.

ALA added that the impact analysis doesn't attempt to assign value to the environmental costs associated with the disposal of millions of obsolete wall control systems and their required radio frequency (RF) control replacements. (ALA, No. 26, at p. 4) ALA is correct that DOE's preliminary analysis did not assign value to environmental costs associated with the mass disposal of obsolete wall control systems. Because DC-motor ceiling fans are typically sold with remote controls that provide the same utility as a consumer's existing ceiling fan wall control, DOE does not believe that a mass disposal of obsolete wall control systems would occur should a standard be set that requires DC-motor ceiling fans. Moreover, DOE believes that any existing wall controls that are disposed of would be treated as standard electronic waste, because such controls do not contain hazardous materials. In this NOPR, DOE has therefore continued to not evaluate environmental costs associated with disposal of obsolete wall control systems.

DOE requests comment and data on its assumption that installation costs do not vary by efficiency level for a given product class.

3. Annual Energy Consumption

For each sampled consumer, DOE determined the energy consumption for a ceiling fan at different efficiency levels using the approach described previously in section IV.E of this document.

4. Energy Prices

Because marginal electricity price more accurately captures the incremental savings associated with a change in energy use from higher efficiency, it provides a better representation of incremental change in consumer costs than average electricity prices. Therefore, DOE applied average electricity prices for the energy use of the product purchased in the no-new-standards case, and marginal electricity prices for the incremental change in energy use associated with the other efficiency levels considered.

DOE derived electricity prices in 2022 using data from EEI Typical Bills and Average Rates reports.[36] Based upon comprehensive, industry-wide surveys, this semi-annual report presents typical monthly electric bills and average kilowatt-hour costs to

[36] Edison Electric Institute. Typical Bills and Average Rates Report 2022. 2022. Winter 2022, Summer 2022: Washington, D.C.

the customer as charged by investor-owned utilities. For the residential sector, DOE calculated electricity prices using the methodology described in Coughlin and Beraki (2018).[37] For the commercial and industrial sectors, DOE calculated electricity prices using the methodology described in Coughlin and Beraki (2019).[38]

DOE's methodology allows electricity prices to vary by sector, region and season. In the analysis, variability in electricity prices is chosen to be consistent with the way the consumer economic and energy use characteristics are defined in the LCC analysis.

To estimate energy prices in future years, DOE multiplied the 2022 energy prices by the projection of annual average price changes for each of the nine census divisions from the Reference case in *AEO2023*, which has an end year of 2050.[39] To estimate price trends after 2050, a simple average of the 2046-2050 values was used for 2051 and all subsequent years.

See chapter 8 of the NOPR TSD for details.

5. Maintenance and Repair Costs

Repair costs are associated with repairing or replacing product components that have failed in an appliance; maintenance costs are associated with maintaining the operation of the product. Typically, small incremental increases in product efficiency entail no, or only minor, changes in repair and maintenance costs compared to baseline

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[37] Coughlin, K. and B. Beraki. 2018. Residential Electricity Prices: A Review of Data Sources and Estimation Methods. Lawrence Berkeley National Lab. Berkeley, CA. Report No. LBNL-2001169. (Last accessed November 22, 2022.) *https://ees.lbl.gov/publications/residential-electricity-prices-review*

[38] Coughlin, K. and B. Beraki. 2019. Non-residential Electricity Prices: A Review of Data Sources and Estimation Methods. Lawrence Berkeley National Lab. Berkeley, CA. Report No. LBNL-2001203. *https://ees.lbl.gov/publications/non-residential-electricity-prices* (last accessed November 22, 2022).

[39] EIA. Annual Energy Outlook 2023 with Projections to 2050. Washington, DC. Available at *www.eia.gov/forecasts/aeo/* (last accessed May 15, 2023).

efficiency products. As in the February 2022 Preliminary Analysis, DOE assumed that repair and maintenance costs do not vary by efficiency level. Therefore, DOE did not estimate repair or maintenance costs in this NOPR analysis.

6. Product Lifetime

DOE estimated ceiling fan lifetimes by fitting a survival probability function to data of historical shipments and the 2012 age distributions of installed stock. Data on the age distribution for the installed residential ceiling fan stock in 2012 was available from the LBNL study.[40] By combining data from the LBNL study with historic data on residential ceiling fan shipments, DOE estimated the percentage of appliances of a given age that are still in operation. Shipment data were only available for standard and hugger ceiling fans. DOE also added a constraint that the shipments history multiplied by the survival function sum to the estimate of installed stock from 2020 RECS. This is the same approach taken in the February 2022 Preliminary Analysis, but with updated data sources.

This survival function, which DOE assumed has the form of a cumulative Weibull distribution,[41] provides a mean of 14.6 years and a median of 14.0 years for ceiling fan lifetime. This represents an increase in the average ceiling fan lifetime of approximately 5.8 percent relative to the February 2022 Preliminary Analysis, which is a result of the updated data sources. Shipments data were available only for residential ceiling fans, so

[40] Kantner, C. L. S., S. J. Young, S. M. Donovan, and K. Garbesi. Ceiling Fan and Ceiling Fan Light Kit Use in the U.S.—Results of a Survey on Amazon Mechanical Turk. 2013. Lawrence Berkeley National Laboratory: Berkeley, CA. Report No. LBNL-6332E. (Last accessed November 11, 2022.) *http://www.escholarship.org/uc/item/3r67c1f9*.
[41] Weibull distributions are commonly used to model appliance lifetimes.

DOE assumed the survival probability function of large-diameter and HSBD ceiling fans is the same as that for standard and hugger ceiling fans.

DOE requests comment and data on its lifetime methodology and estimated survival probability distribution for ceiling fans. DOE also requests comment and data as to whether HSBD ceiling fans have a different lifetime than other ceiling fans.

ALA commented that DC motor-based ceiling fans include an electronic controller that is estimated to last 5-9 years depending on the electronics design and the quality of power in a particular consumer's home. (ALA, No. 26, at p. 5) ALA further commented that DC fan motor controller failures due to electronic overstress ("EOS") are as common as in computers and other consumer electronics. Moreover, protection against EOS is not possible over the duration of the average ceiling fan life used in the February 2022 Preliminary Analysis. (ALA, No. 26, at p. 7)

DOE appreciates ALA's insights into the expected lifetime of BLDC motor-based ceiling fan controls and the issue of EOS. However, DOE is unaware of representative data to corroborate different service lifetimes for BLDC ceiling fans and AC ceiling fans. Information from manufacturer interviews suggests that the service lifetime of AC and BLDC motors is similar, but the electronics required for BLDC motors may be a failure point. However, manufacturer feedback also indicates that the quality of DC electronics has improved over time and the BLDC motor electronics have therefore become more reliable. Moreover, due to the relative recent adoption of ceiling fans with BLDC motors in the U.S. market, there is insufficient data to properly characterize a different service lifetime for BLDC motors relative to AC motors. DOE notes that some sources, such as lumens.com, even indicate that BLDC motors effectively improve the ceiling fan's service life due to the BLDC motor generating less heat than an equivalent AC motor.[42] For this NOPR, DOE has continued to assume that ceiling fan lifetime does not depend on the motor type.

7. Discount Rates

In the calculation of LCC, DOE applies discount rates appropriate to residential and commercial consumers to estimate the present value of future operating cost savings. The subsections below provide information on the derivation of the discount rates by sector. See chapter 8 of the NOPR TSD for further details on the development of discount rates.

a. Residential

DOE estimated a distribution of residential discount rates for standard and hugger ceiling fans based on the opportunity cost of consumer funds. DOE applies weighted average discount rates calculated from consumer debt and asset data, rather than marginal or implicit discount rates.[43] The LCC analysis estimates net present value over the lifetime of the product, so the appropriate discount rate will reflect the general opportunity cost of household funds, taking this time scale into account. Given the long time horizon modeled in the LCC analysis, the application of a marginal interest rate associated with an initial source of funds is inaccurate. Regardless of the method of purchase, consumers are expected to continue to rebalance their debt and asset holdings over the LCC analysis period, based on the restrictions consumers face in their debt

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[42] Lumens.com offers over 40,000 products (including ceiling fans) from over 350 brands. *www.lumens.com/how-tos-and-advice/why-choose-dc-fans.html* (Last accessed November 22, 2022.)

[43] The implicit discount rate is inferred from a consumer purchase decision between two otherwise identical goods with different first cost and operating cost. It is the interest rate that equates the increment of first cost to the difference in net present value of lifetime operating cost, incorporating the influence of several factors: transaction costs; risk premiums and response to uncertainty; time preferences; interest rates at which a consumer is able to borrow or lend. The implicit discount rate is not appropriate for the LCC analysis because it reflects a range of factors that influence consumer purchase decisions, rather than the opportunity cost of the funds that are used in purchases.

payment requirements and the relative size of the interest rates available on debts and assets. DOE estimates the aggregate impact of this rebalancing using the historical distribution of debts and assets.

To establish residential discount rates for the LCC analysis, DOE identified all relevant household debt or asset classes in order to approximate a consumer's opportunity cost of funds related to appliance energy cost savings. It estimated the average percentage shares of the various types of debt and equity by household income group using data from the Federal Reserve Board's triennial Survey of Consumer Finances[44] ("SCF") starting in 1995 and ending in 2019. Using the SCF and other sources, DOE developed a distribution of rates for each type of debt and asset by income group to represent the rates that may apply in the year in which new or amended standards would take effect. DOE assigned each sample household a specific discount rate drawn from one of the distributions. The average rate across all types of household debt and equity and income groups, weighted by the shares of each type, is 4.3 percent.

b. Commercial and Industrial

For commercial and industrial consumers, DOE used the cost of capital to estimate the present value of cash flows to be derived from a typical company project or investment. Most companies use both debt and equity capital to fund investments, so the cost of capital is the weighted-average cost to the firm of equity and debt financing. This corporate finance approach is referred to as the weighted-average cost of capital. DOE used currently available economic data in developing commercial discount rates, with

[44] U.S. Board of Governors of the Federal Reserve System. Survey of Consumer Finances. 1995, 1998, 2001, 2004, 2007, 2010, 2013, 2016, and 2019. (Last accessed November 22, 2022.) https://www.federalreserve.gov/econres/scfindex.htm.

Damodaran Online being the primary data source.[45] The average discount rates for the commercial and industrial sectors are 6.7 percent and 7.2 percent, respectively.

8. Energy Efficiency Distributions in the No-New-Standards Case and Each Standard Case

To accurately estimate the share of consumers that would be affected by a potential energy conservation standard at a particular TSL, DOE's LCC analysis considered the projected distribution (market shares) of product efficiencies under the no-new-standards case (*i.e.*, the case without amended or new energy conservation standards) and each of the standard cases (*i.e.*, the cases where a standard would be set at each TSL) in the assumed first full year of compliance (2028).

The estimated market shares for the no-new-standards case and each standards case for ceiling fans in the assumed first full year of compliance (2028) are determined by the shipments analysis and are shown in Table IV.3 through Table IV.6. A description of each of the TSLs is located in section V.A. of this document. For further information on the derivation of the market efficiency distributions, see section IV.G of this document and chapter 8 of the NOPR TSD.

Table IV.5. Standard Ceiling Fan Market Efficiency Distribution by Trial Standard Level and Blade Span in 2028

Trial Standard Level	EL 0 (%)	EL 1 (%)	EL 2 (%)	EL 3 (%)	EL 4 (%)	Total* (%)
44-inch Blade Span						
No-New-Standards	46.4	30.7	21.7	1.3	100.0	
TSL 1	0.0	57.2	40.4	2.4	100.0	
TSL 2	0.0	0.0	94.5	5.5	100.0	
TSL 3	0.0	0.0	94.5	5.5	100.0	

[45] Damodaran, A. Data Page: Historical Returns on Stocks, Bonds and Bills-United States. 2021. (Last accessed November 22, 2022.) *https://pages.stern.nyu.edu/~adamodar/.*

Trial Standard Level	EL 0 (%)	EL 1 (%)	EL 2 (%)	EL 3 (%)	EL 4 (%)	Total* (%)
TSL 4	0.0	0.0	0.0	100.0		100.0
Trial Standard Level	**EL 0 (%)**	**EL 1 (%)**	**EL 2 (%)**	**EL 3 (%)**	**EL 4 (%)**	**Total* (%)**
52-inch Blade Span						
No-New-Standards	24.4	49.1	22.4	4.1		100.0
TSL 1	0.0	65.0	29.6	5.4		100.0
TSL 2	0.0	0.0	84.6	15.4		100.0
TSL 3	0.0	0.0	84.6	15.4		100.0
TSL 4	0.0	0.0	0.0	100.0		100.0
Trial Standard Level	**EL 0 (%)**	**EL 1 (%)**	**EL 2 (%)**	**EL 3 (%)**	**EL 4 (%)**	**Total* (%)**
60-inch Blade Span						
No-New-Standards	16.2	32.4	17.9	33.5		100.0
TSL 1	0.0	38.7	21.3	40.0		100.0
TSL 2	0.0	0.0	34.8	65.2		100.0
TSL 3	0.0	0.0	0.0	100.0		100.0
TSL 4	0.0	0.0	0.0	100.0		100.0

* The total may not sum to 100% due to rounding.

Table IV.6 Hugger Ceiling Fan Market Efficiency Distribution by Trial Standard Level and Blade Span in 2028

Trial Standard Level	EL 0 (%)	EL 1 (%)	EL 2 (%)	EL 3 (%)	EL 4 (%)	Total* (%)
44-inch Blade Span						
No-New-Standards	29.1	30.4	38.0	2.4		100.0
TSL 1	0.0	42.9	53.6	3.4		100.0
TSL 2	0.0	0.0	94.0	6.0		100.0
TSL 3	0.0	0.0	94.0	6.0		100.0
TSL 4	0.0	0.0	0.0	100.0		100.0
Trial Standard Level	**EL 0 (%)**	**EL 1 (%)**	**EL 2 (%)**	**EL 3 (%)**	**EL 4 (%)**	**Total* (%)**
52-inch Blade Span						
No-New-Standards	34.4	23.6	35.7	6.2		100.0
TSL 1	0.0	36.1	54.4	9.5		100.0
TSL 2	0.0	0.0	85.1	14.9		100.0
TSL 3	0.0	0.0	85.1	14.9		100.0

TSL 4	0.0	0.0	0.0	100.0		100.0
Trial Standard Level	**EL 0 (%)**	**EL 1 (%)**	**EL 2 (%)**	**EL 3 (%)**	**EL 4 (%)**	**Total* (%)**
60-inch Blade Span						
No-New-Standards	16.1	13.8	55.2	15.0		100.0
TSL 1	0.0	16.4	65.7	17.8		100.0
TSL 2	0.0	0.0	78.6	21.4		100.0
TSL 3	0.0	0.0	0.0	100.0		100.0
TSL 4	0.0	0.0	0.0	100.0		100.0

* The total may not sum to 100% due to rounding.

Table IV.7 Large-Diameter Ceiling Fan Market Efficiency Distribution by Trial Standard Level and Blade Span in 2028

Trial Standard Level	EL 0 (%)	EL 1 (%)	EL 2 (%)	Total* (%)
8-foot Blade Span				
No-New-Standards	10.4	15.3	74.3	100.0
TSL 1	0.0	25.7	74.3	100.0
TSL 2	0.0	25.7	74.3	100.0
TSL 3	0.0	25.7	74.3	100.0
TSL 4	0.0	0.0	100.0	100.0
12-foot Blade Span				
No-New-Standards	24.6	45.4	30.0	100.0
TSL 1	0.0	70.0	30.0	100.0
TSL 2	0.0	70.0	30.0	100.0
TSL 3	0.0	70.0	30.0	100.0
TSL 4	0.0	0.0	100.0	100.0
20-foot Blade Span				
No-New-Standards	14.5	63.5	22.0	100.0
TSL 1	0.0	78.0	22.0	100.0
TSL 2	0.0	78.0	22.0	100.0
TSL 3	0.0	78.0	22.0	100.0
TSL 4	0.0	0.0	100.0	100.0

* The total may not sum to 100% due to rounding.

Table IV.8 High-Speed Belt-Driven Ceiling Fan Market Efficiency Distribution by Trial Standard Level and Blade Span in 2028

Trial Standard Level	EL 0 (%)	EL 1 (%)	EL 2 (%)	EL 3 (%)	EL 4 (%)	Total* (%)
50-inch Blade Span						

No-New-Standards	24.0	10.3	6.9	58.7	0.0	100.0
TSL 1	0.0	0.0	41.3	58.7	0.0	100.0
TSL 2	0.0	0.0	41.3	58.7	0.0	100.0
TSL 3	0.0	0.0	0.0	100.0	0.0	100.0
TSL 4	0.0	0.0	0.0	0.0	100.0	100.0

* The total may not sum to 100% due to rounding.

9. Payback Period Analysis

The payback period is the amount of time (expressed in years) it takes the consumer to recover the additional installed cost of more-efficient products, compared to baseline products, through energy cost savings. Payback periods that exceed the life of the product mean that the increased total installed cost is not recovered in reduced operating expenses.

The inputs to the PBP calculation for each efficiency level are the change in total installed cost of the product and the change in the first-year annual operating expenditures relative to the baseline. DOE refers to this as a “simple PBP” because it does not consider changes over time in operating cost savings. The PBP calculation uses the same inputs as the LCC analysis when deriving first-year operating costs.

As noted previously, EPCA establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the first year’s energy savings resulting from the standard, as calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii)) For each considered efficiency level, DOE determined the value of the first year’s energy savings by calculating the energy savings in accordance with the applicable DOE test procedure, and multiplying those savings by the average energy price projection for the assumed first full year in which compliance with the new or amended standards would be required.

G. Shipments Analysis

DOE uses projections of annual ceiling fan shipments to calculate the national impacts of potential amended or new energy conservation standards on energy use, NPV, and future manufacturer cash flows.[46] The shipments model uses an accounting approach, where estimates of stock, demand, and retirements are modeled together to estimate future values. In the shipments analysis for ceiling fans, DOE considered three market segments contributing to demand: (1) demand for replacements, (2) demand for installations into existing buildings, and (3) demand for installations in new construction. DOE also accounted for retirement demand lost to demolitions that remove housing stock. DOE used estimates of historical shipments incorporated into the analysis for the January 2017 ECS Final Rule, as well as ENERGY STAR Unit Shipment Reports[47], to create an initial vintage distribution.

To compute demand for replacements, DOE used the lifetime estimated during the LCC analysis, which estimates a median lifetime of 14.0 years for ceiling fans. In each analysis year of the model, DOE calculated retirements across the vintage distribution and totaled in order to find all retirement demand. DOE used projections of housing starts coupled with ceiling fan saturation data to estimate demand for installations into new construction. To estimate demand for installation into existing buildings, DOE first estimated ceiling fan saturation in existing building stock and new

[46] DOE uses data on manufacturer shipments as a proxy for national sales, as aggregate data on sales are lacking. In general, one would expect a close correspondence between shipments and sales.
[47] U.S. Department of Energy and U.S. Environmental Protection Agency. Unit Shipment and Sales Data Archives. (Last accessed November 22, 2022.) *https://www.energystar.gov/partner_resources/products_partner_resources/brand_owner_resources/unit_shipment_data/archives.*

construction separately. DOE assumed that in each analysis year, if existing housing stock had not yet met the new construction saturation rate for ceiling fans, a small portion of all stock without ceiling fans would install them. DOE assumed that the average number of ceiling fans installed for those homes was the same as that for new construction.

To account for retirement demand lost to building demolitions, DOE first computed projected demolitions as the difference in annual housing stock changes and new construction estimates. DOE then assumed that the fraction of demolished homes with ceiling fans and the number of ceiling fans per demolished home were constant and for each year computed the number of retired ceiling fans that would not be replaced due to demolitions.

Once demand has been computed, it has to be allotted among representative units for each product class, at each available efficiency level. In order to allot demand for standard and hugger fans, DOE implemented a discrete consumer choice model that calculates market share for each representative ceiling fan option as a function of its price relative to that of similar ceiling fans. Qualitatively, higher-priced ceiling fan options will receive less market share. The sensitivity to price was estimated by examining online survey data on ceiling fan consumers from TraQline.[48] DOE computed and implemented adjustment factors to calibrate the consumer choice model to current market shares, so that the consumer choice model aligns with present efficiency distribution estimates, which were derived based on manufacturer interviews.

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[48] TraQline is a market research company that specializes in tracking consumer purchasing behavior across a wide range of products using quarterly online surveys. *www.traqline.com*

For this NOPR, DOE did not model how the market share of standard and hugger fans would change should the standards for these fans be set at different levels (e.g., a max-tech standard for all standard fans, and EL 2 for some or all hugger fans).

DOE seeks comment on the potential market response to a disparity in standards for standard and hugger product classes, including but not limited to the potential for product switching. Specifically, DOE seeks comment and data as to how the market would respond to a standard requiring BLDC motors for standard ceiling fans but not for hugger ceiling fans.

DOE assumed that the price of fans with BLDC motors would decrease over time to that of the most expensive representative unit with an AC motor, which results in the BLDC motor market share increasing over time. DOE estimated a 6.5 percent price decline rate associated with the electronics used to control brushless DC motor fans based on an analysis of the Producer Price Index (PPI) of semiconductor components.[49] This rate is applied only to the incremental cost between a brushless DC motor fans and their most expensive AC motor alternative, rather than the cost of the whole fan.

ALA commented that "the majority bill of materials cost of componentry passives and magnetics [in fans with BLDC motors] are common to all power devices and do not follow equivalent productivity curves" for electronics that rely heavily on integrated circuitry. (ALA, No. 26, at p. 7) DOE acknowledges uncertainty in the projection of prices for ceiling fans with BLDC motors, as well as uncertainty in the long-term effects of supply chain disruption on microchip and semiconductor components in all fans. In order to establish a range of economic outcomes, DOE performed an analysis for a

[49] PPI industry code PCU334413334413.

scenario in which retail prices of all fans remain fixed over time, which are presented in chapters 9 and 10 of the NOPR TSD. In regard to the present application of price learning for ceiling fans with BLDC motors, DOE points out that this projection methodology is consistent with that done for the January 2017 ECS Final Rule (see section IV.G.4 of this document). In DOE's analysis, price learning is applied to the incremental cost difference between the efficiency levels with the most expensive AC motor (EL2) and the EL with the BLDC motor (EL3 for 60" fans or EL4 across the board for standard and hugger fans). The primary driver in the increased costs for incorporating the BLDC motor technology is the electronic controller that is used with DC motors, to which a semiconductor PPI is used when applying the price learning. Based on this approach, the incremental cost delta becomes smaller between the most expensive AC motor and the BLDC motor technologies over time. DOE's analysis assumes, however, that price learning is insufficient to drive the cost of BLDC motors below the cost of the most expensive AC motor.

DOE requests comment on the long-term implications of supply chain disruption on the microchip and semiconductor cost components of affected ceiling fans.

DOE requests comment on its price learning assumption and methodology, including but not limited to data supporting existing or alternative price trends for fans with BLDC motors.

For large-diameter and HSBD fans, DOE allots demand using a constant efficiency distribution of shipments over time for the no-standards case. To estimate the efficiency distribution for these fans at each standard level, DOE followed a 'roll-up' approach. In this approach, at each standards case, ceiling fans that do not meet the standard are ‘rolled-up’ to the minimum qualifying EL at the standard level. The market share of fans above the standard level is left unchanged. As with standard and hugger fans, DOE assumed that the price of large-diameter and HSBD fans with brushless DC motors would decrease over time, though this does not affect the projected market shares.

ALA commented that it is not appropriate to model ceiling fans as price inelastic (ALA, No. 26 at p. 2). Manufacturers have commented that consumers may switch to cheaper fan options if ceiling fan price increases as a result of the proposed standards. Examples include choosing to purchase a box fan instead of a ceiling fan or choosing to forgo the purchase all together. DOE agrees that a standard requiring the purchase of higher priced fans may result in a reduction of fan shipments. For this reason, in this NOPR analysis DOE implemented price elasticity into its modeling of standard and hugger fan shipments, which is intended to capture the effect of changes to shipments as a result of increases in the price of ceiling fans. Estimates of the price elasticity used in this proposed rule are informed by a study of sensitivity of price with respect to purchases of home appliances. The elasticity value decreases over time (from -0.5 to -0.17 over 20 years, then constant thereafter), reflecting a gradual return to historical consumer purchasing frequencies. This results in a 10% decrease in shipments at the max-tech efficiency levels for standard and hugger at the assumed compliance year (2028), which is reduced over time as the elasticity effect moderates. ALA further commented that the implementation of an ENERGY STAR standard that could only be met by BLDC motor fans resulted in a dramatic reduction in the sale of fans with the ENERGY STAR label. DOE agrees with this assessment of available data, but not with the implied conclusion that a similar standard on ceiling fans would result in the same drop in total ceiling fan shipments. DOE assumes that the market share of fans capable of meeting the prior ENERGY STAR standard remained mostly unchanged after the new standard came into effect, and that the dramatic reduction in ENERGY STAR shipments is primarily the result of removing the ENERGY STAR label from the majority of previously qualifying market share. DOE did not find indication in the ENERGY STAR unit shipment reports that a higher ENERGY STAR standard impacted total ceiling fan sales as a whole, which would be the concern for modeling market price elasticity. Additionally, ALA commented that projected sales decreases are "based on its expectation of only a modest price increase due to the technology change required to deliver [DC] fans". DOE agrees that a larger price differential would result in a larger projected drop in total shipments in standards cases. For a discussion of how prices are derived for this analysis, see Chapter 5 of the NOPR TSD.

Chapter 9 of this TSD provides additional details regarding the shipments analysis.

DOE requests comment on its shipment projection methodology and assumptions, including the demand function and associated elasticities for ceiling fans used in the analysis.

H. National Impact Analysis

The NIA assesses the aggregate national impacts of potential energy conservation standards by estimating the NES and NPV at each proposed standard level. DOE determined the NPV and NES for each product class at each potential standard level. To compute NES and NPV, the NIA requires estimates of shipments and stock from the shipments analysis, as well as average annual energy consumption, purchase prices, and electricity prices from the LCC analysis. DOE combines ceiling fan stock at each proposed standard level with average annual energy use and electricity prices to derive both national energy consumption and national operating costs of ceiling fans. The analysis uses shipments at each proposed standard level and average purchase prices to derive total installed costs. While NES is computed by taking the difference between standards- and no-new-standards case consumption, NPV is calculated by taking the difference between national operating cost savings and installed cost increases. DOE calculates NES and NPV for ceiling fans shipped in the period 2028-2057.

Because DOE assumed that new standards would decrease the volume of shipments and stock, the standards-case stock and shipments were used to calculate energy and cost savings. In doing so, DOE more conservatively measures savings by excluding the anticipated reduction in total ceiling fan stock as a contributing factor in savings.

DOE accounts for the direct rebound effect in the NIA. Direct rebound is the concept that as appliances become more efficient, consumers use more of their service because their operating cost is reduced. In the case of ceiling fans, the rebound could be manifested in increased hours of use or in increased airflow. DOE has not found data to support a rebound effect for ceiling fans, and has assumed no rebound in this NOPR analysis.

DOE requests comment on the presence and size of a direct rebound effect for ceiling fans.

ALA commented that they are "concerned that there will be a rebound related to central air conditioning and heating in home energy consumption as a direct result of the substantially reduced affordability of air movement through a residential fan," and that consumers may opt to purchase less efficient tabletop and window box fans in the presence of a BLDC fan standard. (ALA, No. 26, at p. 12) DOE describes these effects as indirect rebound, and does not attempt to model the shipments and energy use of products outside the scope of a rulemaking that have not been analyzed. Furthermore, as discussed in section IV.E.3 of this document, DOE estimates that the interaction between ceiling fan use and air-conditioning use is unlikely to be different in the case of amended standards than it would be in the no-new-standards case.

DOE uses a model coded in the python programming language to calculate the energy savings and the national consumer costs and savings from each TSL. DOE exports the results of these analyses to an excel workbook, which can be found on the docket. Interested parties can review DOE's analyses by changing various input quantities within the spreadsheet.

Table IV.7 summarizes the inputs and methods DOE used for the NIA analysis for the NOPR. Discussion of these inputs and methods follows the table. See chapter 10 of the NOPR TSD for further details.

Table IV.9 Summary of Inputs and Methods for the National Impact Analysis

Inputs	Method
Shipments	Annual shipments from shipments model.
Compliance Date of Standard	2028
Efficiency Trends	No-new-standards case: Calibrated consumer choice for standard and hugger fans, fixed for all others. Standards cases: Calibrated consumer choice for standard and hugger fans, rollup for all others.
Annual Energy Consumption per Unit	Average annual per-unit energy use of ceiling fans at each EL.
Total Installed Cost per Unit	Average per-unit purchase price of ceiling fans at each EL. Incorporates projection of future product prices based on historical data.
Energy Price Trends	AEO 2023 projections (to 2050) and extrapolation thereafter.
Energy Site-to-Primary and FFC Conversion	A time-series conversion factor based on AEO 2023.
Discount Rate	3 percent and 7 percent
Present Year	2023

1. National Energy Savings

The national energy savings analysis involves a comparison of national energy consumption of the considered products between each potential standards case ("TSL") and the case with no new or amended energy conservation standards. DOE calculated the national energy consumption by multiplying the number of units (stock) of each EL of each product (by vintage or age) by the unit energy consumption. DOE calculated annual NES based on the difference in national energy consumption for the no-new standards case and for each higher efficiency standard case. DOE estimated energy consumption and savings based on site energy and converted the electricity consumption and savings to primary energy (*i.e.*, the energy consumed by power plants to generate site electricity) using annual conversion factors derived from AEO 2023. Cumulative energy savings are the sum of the NES for each year over the timeframe of the analysis.

In the NIA, DOE did not account for the possible change in energy use for those purchasers that would not purchase a ceiling fan, or delay their purchase of a ceiling fan, due to the higher purchase cost under the proposed standards. Consistent with an economic analysis that is responsive to EO 12866, DOE seeks comments and publicly-available data to improve its estimation of how the proposed standards may affect purchasers that would no longer own or delay purchase of a ceiling fan. DOE is committed to developing a framework that can support empirical quantitative tools for improved assessment of the consumer welfare impacts of appliance standards, including ceiling fans.

In 2011, in response to the recommendations of a committee on "Point-of-Use and Full-Fuel-Cycle Measurement Approaches to Energy Efficiency Standards" appointed by the National Academy of Sciences, DOE announced its intention to use

FFC measures of energy use and greenhouse gas and other emissions in the national impact analyses and emissions analyses included in future energy conservation standards rulemakings. 76 FR 51281 (Aug. 18, 2011). After evaluating the approaches discussed in the August 18, 2011 notice, DOE published a statement of amended policy in which DOE explained its determination that EIA's National Energy Modeling System ("NEMS") is the most appropriate tool for its FFC analysis and its intention to use NEMS for that purpose. 77 FR 49701 (Aug. 17, 2012). NEMS is a public domain, multi-sector, partial equilibrium model of the U.S. energy sector[50] that EIA uses to prepare its *Annual Energy Outlook*. The FFC factors incorporate losses in production and delivery in the case of natural gas (including fugitive emissions) and additional energy used to produce and deliver the various fuels used by power plants. The approach used for deriving FFC measures of energy use and emissions is described in appendix 10B of the NOPR TSD.

2. Net Present Value Analysis

The inputs for determining the NPV of the total costs and benefits experienced by consumers are (1) total annual installed cost, (2) total annual operating costs (energy costs and repair and maintenance costs), and (3) a discount factor to calculate the present value of costs and savings. DOE calculates net savings each year as the difference between the no-new-standards case and each standards case in terms of total savings in operating costs versus total increases in installed costs. DOE calculates operating cost savings over the lifetime of each product shipped during the projection period.

As discussed in section IV.G of this document, DOE developed ceiling fan price trends based on related historical PPI data for fan components. DOE applied the price

[50] For more information on NEMS, refer to The National Energy Modeling System: *An Overview 2009*, DOE/EIA-0581(2009), October 2009. Available at *https://www.eia.gov/outlooks/aeo/* (last accessed November 22, 2022).

trend to the incremental cost of BLDC fans over the most expensive AC alternative. By 2028, which is the modeled compliance year, the average incremental BLDC fan price is projected to drop 37 percent relative to 2021 incremental prices.

To evaluate the effect of uncertainty regarding the price trend estimates, DOE considered an additional ceiling fan price sensitivity scenario, wherein the price of all ceiling fan options remain constant during the analysis period. *See* Chapter 10 of the NOPR TSD for a summary of these scenario results.

The energy cost savings are calculated using the estimated energy savings in each year and the projected price of the appropriate form of energy. To estimate energy prices in future years, DOE multiplied the average regional energy prices by the projection of annual national-average sector-specific energy price changes in the Reference case from AEO 2023, which has an end year of 2050. To estimate price trends after 2050, the 2050 value was used for all years. As part of the NIA, DOE also analyzed scenarios that used energy price trend inputs from variants of the AEO 2023 Reference case that have lower and higher economic growth. Those cases have lower and higher energy price trends compared to the Reference case. NIA results based on these cases are presented in appendix 10C of the NOPR TSD.

In calculating the NPV, DOE multiplies the net savings in future years by a discount factor to determine their present value. For this NOPR, DOE estimated the NPV of consumer benefits using both a 3-percent and a 7-percent real discount rate. DOE uses these discount rates in accordance with guidance provided by the Office of Management and Budget ("OMB") to Federal agencies on the development of regulatory analysis.[51] The discount rates for the determination of NPV are in contrast to the discount rates used in the LCC analysis, which are designed to reflect a consumer's perspective. The 7-percent real value is an estimate of the average before-tax rate of return to private capital in the U.S. economy. The 3-percent real value represents the "social rate of time preference," which is the rate at which society discounts future consumption flows to their present value.

I. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended energy conservation standards on consumers, DOE evaluates the impact on identifiable subgroups of consumers that may be disproportionately affected by a new or amended national standard. The purpose of a subgroup analysis is to determine the extent of any such disproportional impacts. DOE evaluates impacts on particular subgroups of consumers by analyzing the LCC impacts and PBP for those particular consumers from alternative standard levels. For this NOPR, DOE analyzed the impacts of the considered standard levels on two subgroups: (1) low-income households (for standard and hugger ceiling fans) and (2) small businesses (for LDCFs and HSBD ceiling fans).

For low-income households, the consumer sample consisted of a subset of the RECS 2020 sample composed only of low-income households. DOE assumed these households had equivalent usage patterns and energy prices as the general population. Moreover, because discount rates are based on income group (see section IV.F.7 of this document), low-income households have higher discount rates, on average, than the

[51] United States Office of Management and Budget. Circular A-4: Regulatory Analysis. September 17, 2003. Section E. Available at *georgewbush-whitehouse.archives.gov/omb/memoranda/m03-21.html* (last accessed November 22, 2022).

general population. DOE separately analyzed different groups in the low-income household sample using data from RECS on home ownership status and on who pays the electricity bill. Low-income homeowners are analyzed equivalently to how they are analyzed in the standard LCC analysis. Low-income renters who do not pay their electricity bill are assumed to not be impacted by any new or amended standards. In this case, the landlord purchases the appliance and pays its operating costs, so is effectively the consumer and the renter is not impacted. Low-income renters who do pay their electricity bill are assumed to incur no first cost. DOE made this assumption to acknowledge that for a large appliance such as ceiling fans, renters are unlikely to be purchasers. Instead, the landlord would bear the cost, and some or none of the cost could get passed on to the renter. While some of the incremental cost of a standards-compliant ceiling fan could get passed on in rent, this would happen over time and would be far less than the energy savings received by renters who pay the energy bill.

Also, the results of this analysis on consumers is uncertain as DOE does not account for potential differences in the marginal cost of energy for low-income households relative to the general population. For example, there may be differences in energy prices faced by these households due to reduced marginal electricity tariffs offered to lower income household through programs that specifically reduce the energy expenses borne by these households.

DOE welcomes comment on how it may account for energy prices faced by low income households.

For small businesses, DOE applied discount rates specific to small businesses to the same consumer sample that was used in the standard LCC analysis. DOE used the

LCC and PBP model to estimate the impacts of the considered efficiency levels on these subgroups. Chapter 11 in the NOPR TSD describes the consumer subgroup analysis.

DOE requests comment and data on the overall methodology used for the consumer subgroup analysis.

J. Manufacturer Impact Analysis

1. Overview

DOE performed an MIA to estimate the financial impacts of new and amended energy conservation standards on manufacturers of ceiling fans and to estimate the potential impacts of such standards on employment and manufacturing capacity. The MIA has both quantitative and qualitative aspects and includes analyses of projected industry cash flows, the INPV, investments in research and development ("R&D") and manufacturing capital, and domestic manufacturing employment. Additionally, the MIA seeks to determine how new and amended energy conservation standards might affect manufacturing employment, capacity, and competition, as well as how standards contribute to overall regulatory burden. Finally, the MIA serves to identify any disproportionate impacts on manufacturer subgroups, including small business manufacturers.

The quantitative part of the MIA primarily relies on the Government Regulatory Impact Model ("GRIM"), an industry cash flow model with inputs specific to this rulemaking. The key GRIM inputs include data on the industry cost structure, unit production costs, product shipments, manufacturer markups, and investments in R&D and manufacturing capital required to produce compliant products. The key GRIM outputs are the INPV, which is the sum of industry annual cash flows over the analysis period, discounted using the industry-weighted average cost of capital, and the impact to domestic manufacturing employment. The model uses standard accounting principles to estimate the impacts of more-stringent energy conservation standards on a given industry by comparing changes in INPV and domestic manufacturing employment between a no-new-standards case and the various standards cases ("TSLs"). To capture the uncertainty relating to manufacturer pricing strategies following new and amended standards, the GRIM estimates a range of possible impacts under different markup scenarios.

The qualitative part of the MIA addresses manufacturer characteristics and market trends. Specifically, the MIA considers such factors as a potential standard's impact on manufacturing capacity, competition within the industry, the cumulative impact of other DOE and non-DOE regulations, and impacts on manufacturer subgroups. The complete MIA is outlined in chapter 12 of the NOPR TSD.

DOE conducted the MIA for this rulemaking in three phases. In Phase 1 of the MIA, DOE prepared a profile of the ceiling fan manufacturing industry based on the market and technology assessment, preliminary manufacturer interviews, and publicly available information. This included a top-down analysis of ceiling fan manufacturers that DOE used to derive preliminary financial inputs for the GRIM (*e.g.*, revenues; materials, labor, overhead, and depreciation expenses; selling, general, and administrative expenses ("SG&A"); and R&D expenses). DOE also used public sources of information to further calibrate its initial characterization of the ceiling fan manufacturing industry, including company filings of form 10-K from the SEC, corporate annual reports, the U.S. Census Bureau's *Economic Census*,[52] and reports from D&B Hoovers.[53]

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[52] *www.census.gov/programs-surveys/asm/data/tables.html.*
[53] *app.avention.com.*

In Phase 2 of the MIA, DOE prepared a framework industry cash-flow analysis to quantify the potential impacts of new and amended energy conservation standards. The GRIM uses several factors to determine a series of annual cash flows starting with the announcement of the standard and extending over a 30-year period following the compliance date of the standard. These factors include annual expected revenues, costs of sales, SG&A and R&D expenses, taxes, and capital expenditures. In general, energy conservation standards can affect manufacturer cash flows in three distinct ways: (1) creating a need for increased investment, (2) raising production costs per unit, and (3) altering revenue due to higher per-unit prices and changes in sales volumes.

In addition, during Phase 2, DOE developed interview guides to distribute to manufacturers of ceiling fans in order to develop other key GRIM inputs, including product and capital conversion costs, and to gather additional information on the anticipated effects of energy conservation standards on revenues, direct employment, capital assets, industry competitiveness, and subgroup impacts.

In Phase 3 of the MIA, DOE conducted structured, detailed interviews with representative manufacturers. During these interviews, DOE discussed engineering, manufacturing, procurement, and financial topics to validate assumptions used in the GRIM and to identify key issues or concerns. See section IV.J.3 of this document for a description of the key issues raised by manufacturers during the interviews. As part of Phase 3, DOE also evaluated subgroups of manufacturers that may be disproportionately impacted by new and amended standards or that may not be accurately represented by the average cost assumptions used to develop the industry cash flow analysis. Such manufacturer subgroups may include small business manufacturers, low-volume manufacturers ("LVMs"), niche players, and/or manufacturers exhibiting a cost structure that largely differs from the industry average. DOE identified four manufacturer subgroups for a separate impact analysis: small business manufacturers; standard and hugger ceiling fan manufacturers; large-diameter ceiling fan manufacturers; and high-speed belt-driven ceiling fan manufacturers. The small business subgroup is discussed in section VI.B, "Review under the Regulatory Flexibility Act" and in chapter 12 of the NOPR TSD. Impacts to the standard and hugger ceiling fan manufacturers; large-diameter ceiling fan manufacturers; and high-speed belt-driven ceiling fan manufacturers are discussed in sectionV.B.2.a of this document.

2. Government Regulatory Impact Model and Key Inputs

DOE uses the GRIM to quantify the changes in cash flow due to new and amended standards that result in a higher or lower industry value. The GRIM uses a standard, annual discounted cash-flow analysis that incorporates manufacturer costs, markups, shipments, and industry financial information as inputs. The GRIM models changes in costs, distribution of shipments, investments, and manufacturer margins that could result from new and amended energy conservation standards. The GRIM spreadsheet uses the inputs to arrive at a series of annual cash flows, beginning in 2023 (the base year of the analysis) and continuing to 2057. DOE calculated INPVs by summing the stream of annual discounted cash flows during this period. For manufacturers of ceiling fans, DOE used a real discount rate of 7.4 percent, which was derived from industry financials and then modified according to feedback received during manufacturer interviews.

The GRIM calculates cash flows using standard accounting principles and compares changes in INPV between the no-new-standards case and each standards case. The difference in INPV between the no-new-standards case and a standards case represents the financial impact of the new and amended energy conservation standard on manufacturers. As discussed previously, DOE developed critical GRIM inputs using a number of sources, including publicly available data, results of the engineering analysis, and information gathered from industry stakeholders during the course of manufacturer interviews. The GRIM results are presented in section V.B.2 of this document. Additional details about the GRIM, the discount rate, and other financial parameters can be found in chapter 12 of the NOPR TSD.

a. Manufacturer Production Costs

Manufacturing more efficient equipment is typically more expensive than manufacturing baseline equipment due to the use of more complex components, which are typically more costly than baseline components. The changes in the MPCs of covered products can affect the revenues, gross margins, and cash flow of the industry.

DOE relied on manufacturer teardown estimates for various efficiency levels to estimate the costs associated with baseline equipment and the incremental costs to achieve higher efficiency levels. For a complete description of the MPCs, see chapter 5 of the NOPR TSD.

b. Shipments Projections

The GRIM estimates manufacturer revenues based on total unit shipment projections and the distribution of those shipments by efficiency level. Changes in sales volumes and efficiency mix over time can significantly affect manufacturer finances. For this analysis, the GRIM uses the NIA's annual shipment projections derived from the shipments analysis from 2023 (the base year) to 2057 (the end year of the analysis period). *See* chapter 9 of the NOPR TSD for additional details.

c. Product and Capital Conversion Costs

New and amended energy conservation standards could cause manufacturers to incur conversion costs to bring their production facilities and product designs into compliance. DOE evaluated the level of conversion-related expenditures that would be needed to comply with each considered efficiency level in each product class. For the MIA, DOE classified these conversion costs into two major groups: (1) product conversion costs; and (2) capital conversion costs. Product conversion costs are investments in research, development, testing, marketing, and other non-capitalized costs necessary to make product designs comply with new and amended energy conservation standards. Capital conversion costs are investments in property, plant, and equipment necessary to adapt or change existing production facilities such that new compliant product designs can be fabricated and assembled.

DOE used data gathered from manufacturer interviews as well as information derived from the product teardown analysis and engineering models to estimate conversion costs ceiling fan manufacturers would incur for each product class at each efficiency level. Because each of these product class groups use similar technology options at each efficiency level, DOE used three unique but similar methodologies to estimate the conversion costs for all standard and hugger ceiling fan product classes, for all LDCF product classes, and for the HSBD ceiling fan product class.

Using data from DOE's publicly available Compliance Certification Database[54] ("CCD"), DOE estimated there are approximately 2,272 unique standard ceiling fan models and approximately 1,049 unique hugger ceiling fan models currently on the market. DOE used information gathered during manufacturer interviews to estimate the

[54] *https://www.regulations.doe.gov/certification-data/CCMS-4-Ceiling_Fans.html#q=Product_Group_s%3A%22Ceiling%20Fans%22*. (Last accessed on November 4, 2022.)

average per model capital and product conversion costs for a standard or hugger ceiling fan model.

For standard and hugger ceiling fan manufacturers, DOE estimated the per model capital conversion costs based on feedback received during manufacturer interviews. DOE estimated it would cost standard and hugger ceiling fan manufacturers approximately $30,000 in tooling costs for each non-compliant ceiling fan model that would need to be redesigned due to energy conservation standards.

Standard and hugger ceiling fan manufacturers would also incur two types of product conversion costs: redesign costs (in the form of engineering time) and re-testing costs (typically conducted at a third-party test lab). DOE estimates it would take approximately two months of engineering time (per model) to redesign a standard or hugger ceiling fan model, if that redesign continued to use an AC motor, and approximately four months of engineering time (per model) if that redesign needed to use a BLDC motor. DOE assumed standard and hugger ceiling fan models would use a more efficient AC motor to meet standards set at EL 1 and EL 2 (and EL 3 for standard and hugger ceiling fan models under 53 inches), while DOE assumed standard and hugger ceiling fan models would use a BLDC motor to meet standards set at EL 3 for ceiling fans over 53 inches and for all standard and hugger ceiling fan models at EL 4. Using data from the Bureau of Labor Statistics (BLS), DOE estimated the hourly cost to a ceiling fan manufacturer for an engineer to conduct this ceiling fan redesign effort. First, DOE estimated the hourly wage of a ceiling fan engineer. DOE estimated the hourly wage for an engineer is $46.64.[55] DOE then estimated that wage account for

[55] BLS, Occupational Employment and Wages, May 2021. 17-2141 Mechanical Engineers, mean hourly wage ($46.64). *www.bls.gov/oes/current/oes172141.htm*. (Last accessed on November 10, 2022.)

approximately 70.5 percent of total employer compensation.[56] Therefore, DOE estimates that it would cost an employer approximately $66.16 per hour for an engineer to conduct a ceiling fan redesign.[57] Using the hourly wage rates DOE estimated that standard and hugger ceiling fan manufacturers would incur approximately $21,171 per model[58] to redesign a standard or hugger ceiling fan model to meet efficiency levels that would like use an AC motor to meet the energy conservation standards (*i.e.,* for all standard and hugger ceiling fan models at EL 1 and EL 2; or at EL 3 for standard and hugger ceiling fan models that are under 53 inches only) and would incur approximately $42,342 per model[59] to redesign a standard or hugger ceiling fan model to meet efficiency levels that would like use an BLDC motor to meet the energy conservation standards (*i.e.,* at EL 3 for standard and hugger ceiling fan models that are over 53 inches only and for all standard and hugger ceiling fan models at EL 4).

In addition to the engineering resources, DOE estimated that it would cost standard and hugger ceiling fan manufacturers approximately $5,500 to test a standard or hugger ceiling fan model at a third-party test lab using DOE's ceiling fan test procedure (to demonstrate compliance with any energy conservation standard) and to meet a UL certification. All models that would be redesigned would incur this per model testing cost.

For large-diameter ceiling fans, DOE estimated conversion costs based on product families. Most large-diameter ceiling fan manufacturers design a family of large-diameter

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[56] BLS, Employer Costs for Employee Compensation, June 2022. Wages and Salaries for Private Industry Workers is 70.5 percent of compensation. *https://www.bls.gov/news.release/archives/ecec_09202022.pdf.* (Last accessed on November 10, 2022.)

[57] $46.64 ÷ 0.705 = $66.16 (rounded to the nearest cent)

[58] $66.16 (hourly wage rate) x 8 (hours in a workday) x 20 (workdays in a month) x 2 (months of engineering time) = $21,171

[59] $66.16 (hourly wage rate) x 8 (hours in a workday) x 20 (workdays in a month) x 4 (months of engineering time) = $42,342

ceiling fans that range in size from 8 feet to 24 feet. Typically, redesigns for product families like this can be applied to all sizes. Using information gathered from known large-diameter ceiling fan manufacturers' websites and DOE's CCD, DOE identified 85 large-diameter ceiling fan families that are sold in the United States.

To estimate capital conversion costs for LDCF manufacturers, DOE estimated that it would cost a LDCF manufacturer approximately $500,000 per product family in tooling equipment, production equipment, and prototype designs to convert a LDCF to meet standards set at EL 1. EL 1 would likely require LDCF manufacturers to optimize the airfoil blades and to optimize a gear-driven motor to each size of LDCF. DOE estimated that it would cost LDCF manufacturers an additional $500,000 per product family in production equipment (for a total of $1,000,000 in capital conversion costs per product family) to add a direct-drive motor to all sizes of LDCFs to meet the standards set at EL 2.

To estimated product conversion costs for LDCF manufacturers, DOE estimated that it would cost LCDF manufacturers approximately $150,000 in marketing costs, $50,000 in safety testing costs, and $10,000 in UL testing costs per product family to make any changes to a LDCF product family (*i.e.,* these same per product family costs would be incurred at EL 1 and EL 2 for all product families that would be redesigned). In addition to these marketing and testing costs, DOE estimated that LDCF manufacturers would incur approximately $250,000 to redesign a product family of LDCF models at EL 1 and approximately $550,000 to redesign a product family of LDCF models at EL 2.

In general, DOE assumes all conversion-related investments occur between the year of publication of the final rule and the year by which manufacturers must comply with the new and amended standards. The conversion cost estimates used in the GRIM can be found in Table IV.10 and in section V.B.2.a of this document. For additional information on the estimated capital and product conversion costs, see chapter 12 of the NOPR TSD.

Table IV.10 Summary of Ceiling Fan Conversion Costs by Efficiency Level

	Units	Product Class	Efficiency Level			
			EL 1	**EL 2**	**EL 3**	**EL 4**
Product Conversion Costs	*2022$ millions*	Standard	16.8	17.1	30.1	76.5
		Hugger	9.5	17.3	17.9	46.2
		LDCF	6.4	25.3		
		HSBD	0.2	0.2	0.3	1.7
Capital Conversion Costs	*2022$ millions*	Standard	18.9	19.3	25.5	47.9
		Hugger	10.7	19.5	19.7	29.0
		LDCF	7.0	18.0		
		HSBD	0.2	0.2	0.2	0.9
Total Conversion Costs*	*2022$ millions*	Standard	35.8	36.4	55.7	124.4
		Hugger	20.2	36.8	37.6	75.2
		LDCF	13.4	43.3		
		HSBD	0.3	0.3	0.5	2.6

* Numbers may not sum exactly due to rounding.

d. Markup Scenarios

MSPs include direct manufacturing production costs (*i.e.*, labor, materials, and overhead estimated in DOE's MPCs) and all non-production costs (*i.e.*, SG&A, R&D, and interest), along with profit. To calculate the MSPs in the GRIM, DOE applied non-production cost markups to the MPCs estimated in the engineering analysis for each product class and efficiency level. Modifying these markups in the standards case yields different sets of impacts on manufacturers. For the MIA, DOE modeled two standards-case markup scenarios to represent uncertainty regarding the potential impacts on prices and profitability for manufacturers following the implementation of new and amended energy conservation standards: (1) a preservation of gross margin scenario; and (2) a preservation of operating profit scenario. These scenarios lead to different markup values that, when applied to the MPCs, result in varying revenue and cash flow impacts.

DOE developed an average manufacturer markup for ceiling fans during the January 2017 Final Rule by examining the annual SEC 10-K reports filed by publicly traded manufacturers primarily engaged in ceiling fan manufacturing. The January 2017 Final Rule used an industry average manufacturer markup of 1.37 for all ceiling fans.[60] DOE conducted manufacturer interviews prior to the publication of this NOPR. During these manufacturer interviews, DOE asked ceiling fan manufacturers if this was an appropriate manufacturer markup to use as an average value for all ceiling fans covered by this rulemaking. During manufacturers interviews manufacturers of LDCF and HSBD ceiling fans stated that their manufacturer markups are higher than 1.37. Based on manufacturer feedback from manufacturer interviews, DOE increased the manufacturer markup for LDCFs and HSBD ceiling fans to 1.70.

ALA commented on the February 2022 Preliminary Analysis that the average manufacturer markup amongst a survey of nine ALA members was greater than the 1.37 manufacturer markup used in the February 2022 Preliminary Analysis. (ALA, No. 26 at p. 14) DOE received a variety of feedback on the use of 1.37 to represent an industry average manufacturer markup. While some standard and hugger ceiling fan manufacturers stated that this manufacturer markup was too low, other standard and hugger ceiling fan manufacturers stated in interviews that this was an appropriate industry average manufacturer markup for standard and hugger ceiling fans. DOE notes that while some ALA members might have a higher manufacturer markup than 1.37, DOE also notes that there are some high-volume low-cost standard and hugger ceiling

[60] 82 FR 6826, 6870.

fan manufacturers that have a manufacturer markup lower than 1.37. DOE still estimates the shipment weighted industry average manufacturer markup to be 1.37 for standard and hugger ceiling fan manufacturers.

For this NOPR analysis, DOE used a manufacturer markup of 1.37 for all standard and hugger ceiling fans and a manufacturer markup of 1.70 for all LDCFs and HSBD ceiling fans.[61]

Under the preservation of gross margin scenario, DOE applied a single uniform gross margin percentage across all efficiency levels, which assumes that manufacturers would be able to maintain the same amount of profit as a percentage of revenues at all efficiency levels within a product class. As MPCs increase with efficiency, this scenario implies that the absolute dollar value will increase as well. Therefore, DOE assumes that this scenario represents the upper bound to industry profitability under energy conservation standards.

Under the preservation of operating profit scenario, DOE modeled a situation in which manufacturers are not able to increase operating profit in proportion to increases in MPCs. Under this scenario, as the MPCs increase, manufacturers will reduce their manufacturer margin to maintain a cost competitive offering in the market. Therefore, gross margin (as a percentage) shrinks in the standards cases. This manufacturer markup scenario represents the lower bound to industry profitability under new and amended energy conservation standards.

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[61] This corresponds to a gross margin of approximately 27 percent for standard and hugger ceiling fans and a gross margin of approximately 41 percent for LDCFs.

A comparison of industry financial impacts under the two markup scenarios is presented in section V.B.2.a of this document. A full discussion of the manufacturer markups and the markup scenarios used in this NOPR analysis is discussed in chapter 12 of this NOPR TSD.

3. Manufacturer Interviews

DOE interviewed a variety of ceiling fan manufacturers. In these interviews, DOE asked manufacturers to describe their major concerns regarding this proposed rulemaking. The following section highlights manufacturer concerns that helped inform the projected potential impacts of amended energy conservation standards on the ceiling fan industry. Manufacturer interviews are conducted under non-disclosure agreements ("NDAs"), so DOE does not document these discussions in the same way that it does public comments in the comment summaries and DOE's responses throughout the rest of this document.

Price Sensitivity of Standard and Hugger Ceiling Fan Customers

Standard and hugger ceiling fan manufacturers stated that their customers are sensitive to increases in the price of standard and hugger ceiling fans. These manufacturers stated that an increase in the purchase price of standard and hugger ceiling fans would result in a reduction in the volume of standard and hugger ceiling fans sold. DOE's shipment analysis included price elasticity for standard and hugger ceiling fans, with the max-tech analyzed ELs resulting in an approximately 10 percent reduction in standard and hugger ceiling fans shipments at the compliance year. The MIA also accounts for the potential loss in revenue due to the decline in shipments.

Conversion Costs for Standard and Hugger Ceiling Fans

Standard and hugger ceiling fan manufacturers stated that if they must use BLDC motors in all of their standard and hugger ceiling fan models to meet energy conservation standards, enormous investments would have to be made by these standard and hugger ceiling fan manufacturers. Manufacturers stated that most of their current product offerings do not use a BLDC motor and they would be required to convert up to 90 percent of their current models to incorporate a BLDC motor to meet the max-tech ELs for the standard and hugger ceiling fan product classes. Manufacturers stated there would be tooling costs for each ceiling fan model that is redesigned, additional re-testing costs, and engineering resources needed to be able to complete this redesign effort. DOE accounts for these investments (i.e., conversion costs) that standard and hugger ceiling fan manufacturers would have to make at each analyzed EL as part of the MIA. The methodology for these conversion cost estimates is described in section IV.J.2.c of this document. The estimated conversion cost estimates are included in chapter 12 of this NOPR TSD.

Safety of Large-Diameter Ceiling Fan

Several LDCF manufacturers stated that safety is their number one concern when designing an LDCF model. Many LDCF manufacturers include multiple safety features in their LDCF models and put a significant number of resources (engineering time and safety testing) to make their LDCF models as safe as possible. LDCF manufacturers stated that any DOE energy conservation standard that would require LDCF manufacturers to redesign their LDCF models, would cause manufacturers to incur significant additional engineering time and testing to make sure any of their remodeled LDCFs continue to have these safety features. Some LDCF manufacturers stated that while energy efficiency is important, it should not interfere with the overall safety of an LDCF.

4. Discussion of MIA Comments

ALA commented that energy conservation standards requiring BLDC motors for standard and hugger ceiling fans would cause manufacturers to focus their efforts on converting their product lines to BLDC motor ceiling fans, rather than focusing on innovation or aesthetic updates. As a result of less aesthetically pleasing ceiling fans, many consumers will keep their older, more inefficient ceiling fans instead of purchasing modern, more efficient ceiling fans. Moreover, consumers will have fewer innovative ceiling fan options available to them. (ALA, No. 26 at p. 6) Hunter also commented that DOE regulations may impact turnover and innovation of products. (Catania, Public Meeting Transcript, No. 21 at p. 97, 98) ALA added that the current price points for ceiling fans with AC motors substantially contribute to the positive cash flow for the industry, and that a regulatory-driven increase in ceiling fan prices will harm ALA's small- to medium-sized members. (ALA, No. 26 at p. 6)

As part of the shipments analysis DOE modeled a reduction in the number of shipments for standard and hugger ceiling fans in the standards cases (with higher ELs resulting in a great reduction in the quantity of standard and hugger ceiling fans). Additionally, these potentially lower shipment volumes are included (as inputs) in the GRIM used in the MIA to calculate manufacturer cash flows. Lastly, the MIA estimates the cost on ceiling fan manufacturers to redesign any non-compliant ceiling fan models that would have to be redesigned due to energy conservation standards.

K. Emissions Analysis

The emissions analysis consists of two components. The first component estimates the effect of potential energy conservation standards on power sector and site (where applicable) combustion emissions of CO_2, NO_X, SO_2, and Hg. The second component estimates the impacts of potential standards on emissions of two additional greenhouse gases, CH_4 and N_2O, as well as the reductions to emissions of other gases due to "upstream" activities in the fuel production chain. These upstream activities comprise extraction, processing, and transporting fuels to the site of combustion.

The analysis of electric power sector emissions of CO_2, NO_X, SO_2, and Hg uses emissions factors intended to represent the marginal impacts of the change in electricity consumption associated with amended or new standards. The methodology is based on results published for the *AEO*, including a set of side cases that implement a variety of efficiency-related policies. The methodology is described in appendix 13A in the NOPR TSD. The analysis presented in this notice uses projections from *AEO2023*. Power sector emissions of CH_4 and N_2O from fuel combustion are estimated using Emission Factors for Greenhouse Gas Inventories published by the Environmental Protection Agency (EPA).[62]

FFC upstream emissions, which include emissions from fuel combustion during extraction, processing, and transportation of fuels, and "fugitive" emissions (direct leakage to the atmosphere) of CH_4 and CO_2, are estimated based on the methodology described in chapter 15 of the NOPR TSD.

[62] Available at *www.epa.gov/sites/production/files/2021-04/documents/emission-factors_apr2021.pdf* (last accessed July 12, 2021).

The emissions intensity factors are expressed in terms of physical units per MWh or MMBtu of site energy savings. For power sector emissions, specific emissions intensity factors are calculated by sector and end use. Total emissions reductions are estimated using the energy savings calculated in the national impact analysis.

1. Air Quality Regulations Incorporated in DOE's Analysis

DOE's no-new-standards case for the electric power sector reflects the *AEO*, which incorporates the projected impacts of existing air quality regulations on emissions. *AEO2023* generally represents current legislation and environmental regulations, including recent government actions, that were in place at the time of preparation of *AEO2023*, including the emissions control programs discussed in the following paragraphs.[63]

SO_2 emissions from affected electric generating units ("EGUs") are subject to nationwide and regional emissions cap-and-trade programs. Title IV of the Clean Air Act sets an annual emissions cap on SO_2 for affected EGUs in the 48 contiguous States and the District of Columbia (D.C.). (42 U.S.C. 7651 *et seq.*) SO_2 emissions from numerous States in the eastern half of the United States are also limited under the Cross-State Air Pollution Rule ("CSAPR"). 76 FR 48208 (Aug. 8, 2011). CSAPR requires these States to reduce certain emissions, including annual SO_2 emissions, and went into effect as of January 1, 2015.[64] *AEO2023* incorporates implementation of CSAPR, including the

[63] For further information, see the Assumptions to *AEO2023* report that sets forth the major assumptions used to generate the projections in the Annual Energy Outlook. Available at *www.eia.gov/outlooks/aeo/assumptions/* (last accessed May 10, 2023).
[64] CSAPR requires states to address annual emissions of SO_2 and NO_X, precursors to the formation of fine particulate matter ($PM_{2.5}$) pollution, in order to address the interstate transport of pollution with respect to the 1997 and 2006 $PM_{2.5}$ National Ambient Air Quality Standards ("NAAQS"). CSAPR also requires certain states to address the ozone season (May-September) emissions of NO_X, a precursor to the formation of ozone pollution, in order to address the interstate transport of ozone pollution with respect to the 1997 ozone NAAQS. 76 FR 48208 (Aug. 8, 2011). EPA subsequently issued a supplemental rule that included an additional five states in the CSAPR ozone season program; 76 FR 80760 (Dec. 27, 2011) (Supplemental Rule).

update to the CSAPR ozone season program emission budgets and target dates issued in 2016. 81 FR 74504 (Oct. 26, 2016). Compliance with CSAPR is flexible among EGUs and is enforced through the use of tradable emissions allowances. Under existing EPA regulations, any excess SO_2 emissions allowances resulting from the lower electricity demand caused by the adoption of an efficiency standard could be used to permit offsetting increases in SO_2 emissions by another regulated EGU.

However, beginning in 2016, SO_2 emissions began to fall as a result of the Mercury and Air Toxics Standards ("MATS") for power plants. 77 FR 9304 (Feb. 16, 2012). The final rule establishes power plant emission standards for mercury, acid gases, and non-mercury metallic toxic pollutants. In order to continue operating, coal power plants must have either flue gas desulfurization or dry sorbent injection systems installed. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions. Because of the emissions reductions under the MATS, it is unlikely that excess SO_2 emissions allowances resulting from the lower electricity demand would be needed or used to permit offsetting increases in SO_2 emissions by another regulated EGU. Therefore, energy conservation standards that decrease electricity generation would generally reduce SO_2 emissions. DOE estimated SO_2 emissions reduction using emissions factors based on *AEO2023.*

CSAPR also established limits on NO_X emissions for numerous States in the eastern half of the United States. Energy conservation standards would have little effect on NO_X emissions in those States covered by CSAPR emissions limits if excess NO_X emissions allowances resulting from the lower electricity demand could be used to permit offsetting increases in NO_X emissions from other EGUs. In such case, NO_X emissions would remain near the limit even if electricity generation goes down. A different case could possibly result, depending on the configuration of the power sector in the different regions and the need for allowances, such that NO_X emissions might not remain at the limit in the case of lower electricity demand. In this case, energy conservation standards might reduce NO_X emissions in covered States. Despite this possibility, DOE has chosen to be conservative in its analysis and has maintained the assumption that standards will not reduce NO_X emissions in States covered by CSAPR. Energy conservation standards would be expected to reduce NO_X emissions in the States not covered by CSAPR. DOE used *AEO2023* data to derive NO_X emissions factors for the group of States not covered by CSAPR.

The MATS limit mercury emissions from power plants, but they do not include emissions caps and, as such, DOE's energy conservation standards would be expected to slightly reduce Hg emissions. DOE estimated mercury emissions reduction using emissions factors based on *AEO2023*, which incorporates the MATS.

L. Monetizing Emissions Impacts

As part of the development of this proposed rule, for the purpose of complying with the requirements of Executive Order 12866, DOE considered the estimated monetary benefits from the reduced emissions of CO_2, CH_4, N_2O, NO_X, and SO_2 that are expected to result from each of the TSLs considered. In order to make this calculation analogous to the calculation of the NPV of consumer benefit, DOE considered the reduced emissions expected to result over the lifetime of products shipped in the projection period for each TSL. This section summarizes the basis for the values used for monetizing the emissions benefits and presents the values considered in this NOPR.

To monetize the benefits of reducing GHG emissions, this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the IWG.

1. Monetization of Greenhouse Gas Emissions

DOE estimates the monetized benefits of the reductions in emissions of CO_2, CH_4, and N_2O by using a measure of the SC of each pollutant (e.g., SC-CO_2). These estimates represent the monetary value of the net harm to society associated with a marginal increase in emissions of these pollutants in a given year, or the benefit of avoiding that increase. These estimates are intended to include (but are not limited to) climate-change-related changes in net agricultural productivity, human health, property damages from increased flood risk, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services.

DOE exercises its own judgment in presenting monetized climate benefits as recommended by applicable Executive orders, and DOE would reach the same conclusion presented in this proposed rulemaking in the absence of the social cost of greenhouse gases. That is, the social costs of greenhouse gases, whether measured using the February 2021 interim estimates presented by the Interagency Working Group on the Social Cost of Greenhouse Gases or by another means, did not affect the rule ultimately proposed by DOE.

DOE estimated the global social benefits of CO_2, CH_4, and N_2O reductions using SC-GHG values that were based on the interim values presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under*

Executive Order 13990, published in February 2021 by the IWG. The SC-GHGs is the monetary value of the net harm to society associated with a marginal increase in emissions in a given year, or the benefit of avoiding that increase. In principle, SC-GHGs includes the value of all climate change impacts, including (but not limited to) changes in net agricultural productivity, human health effects, property damage from increased flood risk and natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services. The SC-GHGs therefore, reflects the societal value of reducing emissions of the gas in question by one metric ton. The SC-GHGs is the theoretically appropriate value to use in conducting benefit-cost analyses of policies that affect CO_2, N_2O and CH4 emissions. As a member of the IWG involved in the development of the February 2021 SC-GHG TSD, DOE agrees that the interim SC-GHG estimates represent the most appropriate estimate of the SC-GHG until revised estimates have been developed reflecting the latest, peer-reviewed science.

The SC-GHGs estimates presented here were developed over many years, using transparent process, peer-reviewed methodologies, the best science available at the time of that process, and with input from the public. Specifically, in 2009, the IWG, which included the DOE and other executive branch agencies and offices, was established to ensure that agencies were using the best available science and to promote consistency in the social cost of carbon (SC-CO_2) values used across agencies. The IWG published SC-CO_2 estimates in 2010 that were developed from an ensemble of three widely cited integrated assessment models (IAMs) that estimate global climate damages using highly aggregated representations of climate processes and the global economy combined into a single modeling framework. The three IAMs were run using a common set of input assumptions in each model for future population, economic, and CO_2 emissions growth, as well as equilibrium climate sensitivity – a measure of the globally averaged temperature response to increased atmospheric CO_2 concentrations. These estimates were updated in 2013 based on new versions of each IAM. In August 2016 the IWG published estimates of the social cost of methane (SC-CH_4) and nitrous oxide (SC-N_2O) using methodologies that are consistent with the methodology underlying the SC-CO_2 estimates. The modeling approach that extends the IWG SC-CO_2 methodology to non-CO_2 GHGs has undergone multiple stages of peer review. The SC-CH_4 and SC-N_2O estimates were developed by Marten *et al*.[65]and underwent a standard double-blind peer review process prior to journal publication. In 2015, as part of the response to public comments received to a 2013 solicitation for comments on the SC-CO_2 estimates, the IWG announced a National Academies of Sciences, Engineering, and Medicine review of the SC-CO_2 estimates to offer advice on how to approach future updates to ensure that the estimates continue to reflect the best available science and methodologies. In January 2017, the National Academies released their final report, Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide, and recommended specific criteria for future updates to the SC-CO_2 estimates, a modeling framework to satisfy the specified criteria, and both near-term updates and longer-term research needs pertaining to various components of the estimation process (National Academies, 2017).[66] Shortly thereafter, in March 2017, President Trump issued Executive Order 13783, which disbanded the IWG, withdrew the previous TSDs, and directed agencies to ensure SC-CO_2 estimates used in regulatory analyses are consistent with the guidance contained in OMB's Circular A-4, "including with respect to the consideration of domestic versus international impacts and the consideration of appropriate discount rates" (E.O. 13783, Section 5(c)). Benefit-cost analyses following E.O. 13783 used SC-GHG estimates that

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[65] Marten, A. L., E. A. Kopits, C. W. Griffiths, S. C. Newbold, and A. Wolverton. Incremental CH4 and N2O mitigation benefits consistent with the US Government's SC-CO2 estimates. *Climate Policy*. 2015. 15(2): pp. 272–298.

[66] National Academies of Sciences, Engineering, and Medicine. *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide*. 2017. The National Academies Press: Washington, DC.

attempted to focus on the U.S.-specific share of climate change damages as estimated by the models and were calculated using two discount rates recommended by Circular A-4, 3 percent and 7 percent. All other methodological decisions and model versions used in SC-GHG calculations remained the same as those used by the IWG in 2010 and 2013, respectively.

On January 20, 2021, President Biden issued Executive Order 13990, which re-established the IWG and directed it to ensure that the U.S. Government's estimates of the social cost of carbon and other greenhouse gases reflect the best available science and the recommendations of the National Academies (2017). The IWG was tasked with first reviewing the SC-GHG estimates currently used in Federal analyses and publishing interim estimates within 30 days of the E.O. that reflect the full impact of GHG emissions, including by taking global damages into account. The interim SC-GHG estimates published in February 2021 are used here to estimate the climate benefits for this proposed rulemaking. The E.O. instructs the IWG to undertake a fuller update of the SC-GHG estimates by January 2022 that takes into consideration the advice of the National Academies (2017) and other recent scientific literature. The February 2021 SC-GHG TSD provides a complete discussion of the IWG's initial review conducted under E.O. 13990. In particular, the IWG found that the SC-GHG estimates used under E.O. 13783 fail to reflect the full impact of GHG emissions in multiple ways.

First, the IWG found that the SC-GHG estimates used under E.O. 13783 fail to fully capture many climate impacts that affect the welfare of U.S. citizens and residents, and those impacts are better reflected by global measures of the SC-GHG. Examples of omitted effects from the E.O. 13783 estimates include direct effects on U.S. citizens, assets, and investments located abroad, supply chains, U.S. military assets and interests abroad, and tourism, and spillover pathways such as economic and political destabilization and global migration that can lead to adverse impacts on U.S. national security, public health, and humanitarian concerns. In addition, assessing the benefits of U.S. GHG mitigation activities requires consideration of how those actions may affect mitigation activities by other countries, as those international mitigation actions will provide a benefit to U.S. citizens and residents by mitigating climate impacts that affect U.S. citizens and residents. A wide range of scientific and economic experts have emphasized the issue of reciprocity as support for considering global damages of GHG emissions. If the United States does not consider impacts on other countries, it is difficult to convince other countries to consider the impacts of their emissions on the United States. The only way to achieve an efficient allocation of resources for emissions reduction on a global basis—and so benefit the U.S. and its citizens—is for all countries to base their policies on global estimates of damages. As a member of the IWG involved in the development of the February 2021 SC-GHG TSD, DOE agrees with this assessment and, therefore, in this proposed rule DOE centers attention on a global measure of SC-GHG. This approach is the same as that taken in DOE regulatory analyses from 2012 through 2016. A robust estimate of climate damages that accrue only to U.S. citizens and residents does not currently exist in the literature. As explained in the February 2021 TSD, existing estimates are both incomplete and an underestimate of total damages that accrue to the citizens and residents of the U.S. because they do not fully capture the regional interactions and spillovers discussed previously, nor do they include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature. As noted in the February 2021 SC–GHG TSD, the IWG will continue to review developments in the literature, including more robust methodologies for estimating a U.S.-specific SC–GHG value, and explore ways to better inform the public of the full range of carbon impacts. As a member of the IWG, DOE will continue to follow developments in the literature pertaining to this issue.

Second, the IWG found that the use of the social rate of return on capital (7 percent under current OMB Circular A-4 guidance) to discount the future benefits of reducing GHG emissions inappropriately underestimates the impacts of climate change for the purposes of estimating the SC-GHG. Consistent with the findings of the National Academies (2017) and the economic literature, the IWG continued to conclude that the consumption rate of interest is the theoretically appropriate discount rate in an intergenerational context,[67] and recommended that discount rate uncertainty and relevant aspects of intergenerational ethical considerations be accounted for in selecting future discount rates.

Furthermore, the damage estimates developed for use in the SC-GHG are estimated in consumption-equivalent terms, and so an application of OMB Circular A-4's guidance for regulatory analysis would then use the consumption discount rate to calculate the SC-GHG. DOE agrees with this assessment and will continue to follow developments in the literature pertaining to this issue. DOE also notes that while OMB Circular A-4, as published in 2003, recommends using 3-percent and 7-percent discount rates as "default" values, Circular A-4 also reminds agencies that "different regulations

[67] Interagency Working Group on Social Cost of Carbon. *Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866*. 2010. United States Government. (Last accessed April 15, 2022.) *www.epa.gov/sites/default/files/2016-12/documents/scc_tsd_2010.pdf*; Interagency Working Group on Social Cost of Carbon. *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*. 2013. (Last accessed April 15, 2022.) *www.federalregister.gov/documents/2013/11/26/2013-28242/technical-support-document-technical-update-of-the-social-cost-of-carbon-for-regulatory-impact*; Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Technical Support Document: Technical Update on the Social Cost of Carbon for Regulatory Impact Analysis-Under Executive Order 12866. August 2016. (Last accessed January 18, 2022.) *www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf*; Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide. August 2016. (Last accessed January 18, 2022.) *https://www.epa.gov/sites/default/files/2016-12/documents/addendum_to_sc-ghg_tsd_august_2016.pdf*.

may call for different emphases in the analysis, depending on the nature and complexity of the regulatory issues and the sensitivity of the benefit and cost estimates to the key assumptions." On discounting, Circular A-4 recognizes that "special ethical considerations arise when comparing benefits and costs across generations," and Circular A-4 acknowledges that analyses may appropriately "discount future costs and consumption benefits…at a lower rate than for intragenerational analysis." In the 2015 Response to Comments on the Social Cost of Carbon for Regulatory Impact Analysis, OMB, DOE, and the other IWG members recognized that "Circular A-4 is a living document" and "the use of 7 percent is not considered appropriate for intergenerational discounting. There is wide support for this view in the academic literature, and it is recognized in Circular A-4 itself." Thus, DOE concludes that a 7-percent discount rate is not appropriate to apply to value the social cost of greenhouse gases in the analysis presented in this analysis.

To calculate the present and annualized values of climate benefits, DOE uses the same discount rate as the rate used to discount the value of damages from future GHG emissions, for internal consistency. That approach to discounting follows the same approach that the February 2021 TSD recommends "to ensure internal consistency—i.e., future damages from climate change using the SC-GHG at 2.5 percent should be discounted to the base year of the analysis using the same 2.5 percent rate." DOE has also consulted the National Academies' 2017 recommendations on how SC-GHG estimates can "be combined in RIAs with other cost and benefits estimates that may use different discount rates." The National Academies reviewed several options, including "presenting all discount rate combinations of other costs and benefits with [SC-GHG] estimates."

As a member of the IWG involved in the development of the February 2021 SC-GHG TSD, DOE agrees with the above assessment and will continue to follow developments in the literature pertaining to this issue. While the IWG works to assess how best to incorporate the latest, peer-reviewed science to develop an updated set of SC-GHG estimates, it set the interim estimates to be the most recent estimates developed by the IWG prior to the group being disbanded in 2017. The estimates rely on the same models and harmonized inputs and are calculated using a range of discount rates. As explained in the February 2021 SC-GHG TSD, the IWG has recommended that agencies revert to the same set of four values drawn from the SC-GHG distributions based on three discount rates as were used in regulatory analyses between 2010 and 2016 and were subject to public comment. For each discount rate, the IWG combined the distributions across models and socioeconomic emissions scenarios (applying equal weight to each) and then selected a set of four values recommended for use in benefit-cost analyses: an average value resulting from the model runs for each of three discount rates (2.5 percent, 3 percent, and 5 percent), plus a fourth value, selected as the 95th percentile of estimates based on a 3-percent discount rate. The fourth value was included to provide information on potentially higher-than-expected economic impacts from climate change. As explained in the February 2021 SC-GHG TSD, and DOE agrees, this update reflects the immediate need to have an operational SC-GHG for use in regulatory benefit-cost analyses and other applications that was developed using a transparent process, peer-reviewed methodologies, and the science available at the time of that process. Those estimates were subject to public comment in the context of dozens of proposed rulemakings as well as in a dedicated public comment period in 2013.

There are a number of limitations and uncertainties associated with the SC-GHG estimates. First, the current scientific and economic understanding of discounting approaches suggests discount rates appropriate for intergenerational analysis in the context of climate change are likely to be less than 3 percent, near 2 percent or lower.[68] Second, the IAMs used to produce these interim estimates do not include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature and the science underlying their "damage functions" – *i.e.*, the core parts of the IAMs that map global mean temperature changes and other physical impacts of climate change into economic (both market and nonmarket) damages – lags behind the most recent research. For example, limitations include the incomplete treatment of catastrophic and non-catastrophic impacts in the integrated assessment models, their incomplete treatment of adaptation and technological change, the incomplete way in which inter-regional and intersectoral linkages are modeled, uncertainty in the extrapolation of damages to high temperatures, and inadequate representation of the relationship between the discount rate and uncertainty in economic growth over long time horizons. Likewise, the socioeconomic and emissions scenarios used as inputs to the models do not reflect new information from the last decade of scenario generation or the full range of projections. The modeling limitations do not all work in the same direction in terms of their influence on the SC-CO_2 estimates. However, as discussed in the February 2021 TSD, the IWG has recommended that, taken together, the limitations suggest that the interim SC-GHG estimates used in this proposed rule likely underestimate the damages from GHG emissions. DOE concurs with this assessment.

[68] Interagency Working Group on Social Cost of Greenhouse Gases (IWG). 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. February. United States Government. Available at: *www.whitehouse.gov/briefing-room/blog/2021/02/26/a-return-to-science-evidence-based-estimates-of-the-benefits-of-reducing-climate-pollution/*. (Last accessed January 20, 2023).

DOE's derivations of the SC-CO_2, SC-N_2O, and SC-CH_4 values used for this NOPR are discussed in the following sections, and the results of DOE's analyses estimating the benefits of the reductions in emissions of these GHGs are presented in section V.B.6 of this document.

a. Social Cost of Carbon

The SC-CO_2 values used for this NOPR were based on the values presented for the IWG's February 2021 TSD. Table IV.11 shows the updated sets of SC-CO_2 estimates from the IWG's TSD in 5-year increments from 2020 to 2050. The full set of annual values that DOE used is presented in Appendix 14-A of the NOPR TSD. For purposes of capturing the uncertainties involved in regulatory impact analysis, DOE has determined it is appropriate to include all four sets of SC-CO_2 values, as recommended by the IWG.[69]

Table IV.11 Annual SC-CO_2 Values from 2021 Interagency Update, 2020–2050 (2020$ per Metric Ton CO_2)

Year	Discount Rate and Statistic			
	5% Average	3% Average	2.5% Average	3% 95th percentile
2020	14	51	76	152
2025	17	56	83	169
2030	19	62	89	187
2035	22	67	96	206
2040	25	73	103	225
2045	28	79	110	242
2050	32	85	116	260

Because the IWG's last year was 2050, , DOE used SC-CO_2 estimates published by EPA, for 2051 to 2070, adjusted to 2020$.[70] These estimates are based on methods, assumptions, and parameters identical to those used to develop the 2020-2050 estimates published by the IWG (which were based on EPA modeling). DOE expects additional

[69] For example, the February 2021 TSD discusses how the understanding of discounting approaches suggests that discount rates appropriate for intergenerational analysis in the context of climate change may be lower than 3 percent.
[70] *See* EPA, *Revised 2023 and Later Model Year Light-Duty Vehicle GHG Emissions Standards: Regulatory Impact Analysis*, Washington, D.C., December 2021. Available at *https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1013ORN.pdf* (last accessed January 13, 2023).

climate benefits to accrue for any longer-life ceiling fans after 2070, but a lack of available SC-CO_2 estimates for emissions years beyond 2070 prevents DOE from monetizing these potential benefits in this analysis.

DOE multiplied the CO_2 emissions reduction estimated for each year by the SC-CO_2 value for that year in each of the four cases. DOE adjusted the values to 2022$ using the implicit price deflator for gross domestic product ("GDP") from the Bureau of Economic Analysis. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the four cases using the specific discount rate that had been used to obtain the SC-CO_2 values in each case.

b. Social Cost of Methane and Nitrous Oxide

The SC-CH_4 and SC-N_2O values used for this NOPR were based on the values developed for the February 2021 TSD. Table IV.12 shows the updated sets of SC-CH_4 and SC- N_2O estimates from the latest interagency update in 5-year increments from 2020 to 2050. The full set of annual values used is presented in Appendix 14-A of the NOPR TSD. To capture the uncertainties involved in regulatory impact analysis, DOE has determined it is appropriate to include all four sets of SC-CH_4 and SC- N_2O values, as recommended by the IWG. DOE derived values after 2050 using the approach described above for the SC-CO_2.

Table IV.12 Annual SC-CH_4 and SC-N_2O Values from 2021 Interagency Update, 2020–2050 (2020$ per Metric Ton)

Year	SC-CH_4				SC-N_2O			
	Discount Rate and Statistic				Discount Rate and Statistic			
	5%	3%	2.5%	3%	5%	3%	2.5 %	3%
	Average	Average	Average	95th percentile	Average	Average	Average	95th percentile
2020	670	1500	2000	3900	5800	18000	27000	48000
2025	800	1700	2200	4500	6800	21000	30000	54000
2030	940	2000	2500	5200	7800	23000	33000	60000
2035	1100	2200	2800	6000	9000	25000	36000	67000
2040	1300	2500	3100	6700	10000	28000	39000	74000

2045	1500	2800	3500	7500	12000	30000	42000	81000
2050	1700	3100	3800	8200	13000	33000	45000	88000

DOE multiplied the CH_4 and N_2O emissions reduction estimated for each year by the SC-CH_4 and SC-N_2O estimates for that year in each of the cases. DOE adjusted the values to 2022$ using the implicit price deflator for gross domestic product ("GDP") from the Bureau of Economic Analysis. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the cases using the specific discount rate that had been used to obtain the SC-CH_4 and SC-N_2O estimates in each case.

2. Monetization of Other Emissions Impacts

For the NOPR, DOE estimated the monetized value of NO_X and SO_2 emissions reductions from electricity generation using the latest benefit per ton estimates for that sector from the EPA's Benefits Mapping and Analysis Program.[71] DOE used EPA's values for $PM_{2.5}$-related benefits associated with NO_X and SO_2 and for ozone-related benefits associated with NO_X for 2025, 2030, and 2040, calculated with discount rates of 3 percent and 7 percent. DOE used linear interpolation to define values for the years not given in the 2025 to 2040 period; for years beyond 2040 the values are held constant. DOE combined the EPA benefit per ton estimates with regional information on electricity consumption and emissions to define weighted-average national values for NO_X and SO_2 as a function of sector (see appendix 14B of the NOPR TSD).

DOE also estimated the monetized value of NO_X and SO_2 emissions reductions from site use of natural gas in ceiling fans using benefit-per-ton estimates from the EPA's

[71] *Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 21 Sectors*. *www.epa.gov/benmap/estimating-benefit-ton-reducing-pm25-precursors-21-sectors*

Benefits Mapping and Analysis Program. Although none of the sectors covered by EPA refers specifically to residential and commercial buildings, the sector called "area sources" would be a reasonable proxy for residential and commercial buildings.[72] The EPA document provides high and low estimates for 2025 and 2030 at 3- and 7-percent discount rates.[73] DOE used the same linear interpolation and extrapolation as it did with the values for electricity generation.

DOE multiplied the site emissions reduction (in tons) in each year by the associated $/ton values, and then discounted each series using discount rates of 3 percent and 7 percent as appropriate.

M. Utility Impact Analysis

The utility impact analysis estimates the changes in installed electrical capacity and generation projected to result for each considered TSL. The analysis is based on published output from the NEMS associated with *AEO2023*. NEMS produces the *AEO* Reference case, as well as a number of side cases that estimate the economy-wide impacts of changes to energy supply and demand. For the current analysis, impacts are quantified by comparing the levels of electricity sector generation, installed capacity, fuel consumption and emissions in the *AEO2023* Reference case and various side cases. Details of the methodology are provided in the appendices to chapters 13 and 15 of the NOPR TSD.

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[72] "Area sources" represents all emission sources for which states do not have exact (point) locations in their emissions inventories. Because exact locations would tend to be associated with larger sources, "area sources" would be fairly representative of small, dispersed sources like homes and businesses.

[73] "Area sources" are a category in the 2018 document from EPA, but are not used in the 2021 document cited above. See: *www.epa.gov/sites/default/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf.* (Last accessed January 20, 2023).

The output of this analysis is a set of time-dependent coefficients that capture the change in electricity generation, primary fuel consumption, installed capacity and power sector emissions due to a unit reduction in demand for a given end use. These coefficients are multiplied by the stream of electricity savings calculated in the NIA to provide estimates of selected utility impacts of potential new or amended energy conservation standards.

N. Employment Impact Analysis

DOE considers employment impacts in the domestic economy as one factor in selecting a proposed standard. Employment impacts from new or amended energy conservation standards include both direct and indirect impacts. Direct employment impacts are any changes in the number of employees of manufacturers of the products subject to standards, their suppliers, and related service firms. The MIA addresses those impacts. Indirect employment impacts are changes in national employment that occur due to the shift in expenditures and capital investment caused by the purchase and operation of more-efficient appliances. Indirect employment impacts from standards consist of the net jobs created or eliminated in the national economy, other than in the manufacturing sector being regulated, caused by (1) reduced spending by consumers on energy, (2) reduced spending on new energy supply by the utility industry, (3) increased consumer spending on the products to which the new standards apply and other goods and services, and (4) the effects of those three factors throughout the economy.

One method for assessing the possible effects on the demand for labor of such shifts in economic activity is to compare sector employment statistics developed by the Labor Department's Bureau of Labor Statistics ("BLS"). BLS regularly publishes its estimates of the number of jobs per million dollars of economic activity in different sectors of the economy, as well as the jobs created elsewhere in the economy by this same economic activity. Data from BLS indicate that expenditures in the utility sector generally create fewer jobs (both directly and indirectly) than expenditures in other sectors of the economy.[74] There are many reasons for these differences, including wage differences and the fact that the utility sector is more capital-intensive and less labor-intensive than other sectors. Energy conservation standards have the effect of reducing consumer utility bills. Because reduced consumer expenditures for energy likely lead to increased expenditures in other sectors of the economy, the general effect of efficiency standards is to shift economic activity from a less labor-intensive sector (*i.e.*, the utility sector) to more labor-intensive sectors (*e.g.*, the retail and service sectors). Thus, the BLS data suggest that net national employment may increase due to shifts in economic activity resulting from energy conservation standards.

DOE estimated indirect national employment impacts for the standard levels considered in this NOPR using an input/output model of the U.S. economy called Impact of Sector Energy Technologies version 4 ("ImSET").[75] ImSET is a special-purpose version of the "U.S. Benchmark National Input-Output" ("I-O") model, which was designed to estimate the national employment and income effects of energy-saving technologies. The ImSET software includes a computer-based I-O model having structural coefficients that characterize economic flows among 187 sectors most relevant to industrial, commercial, and residential building energy use.

[74] See U.S. Department of Commerce–Bureau of Economic Analysis. *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II)*. 1997. U.S. Government Printing Office: Washington, DC. Available at *https://apps.bea.gov/scb/pdf/regional/perinc/meth/rims2.pdf* (last accessed January 20, 2023).
[75] Livingston, O. V., S. R. Bender, M. J. Scott, and R. W. Schultz. *ImSET 4.0: Impact of Sector Energy Technologies Model Description and User Guide.* 2015. Pacific Northwest National Laboratory: Richland, WA. PNNL-24563.

DOE notes that ImSET is not a general equilibrium forecasting model, and that the uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET may over-estimate actual job impacts over the long run for this rule. Therefore, DOE used ImSET only to generate results for near-term timeframes (2028 - 2032), where these uncertainties are reduced. For more details on the employment impact analysis, see chapter 16 of the NOPR TSD.

V. Analytical Results and Conclusions

The following section addresses the results from DOE's analyses with respect to the considered energy conservation standards for ceiling fans. It addresses the TSLs examined by DOE, the projected impacts of each of these levels if adopted as energy conservation standards for ceiling fans, and the standards levels that DOE is proposing to adopt in this NOPR. Additional details regarding DOE's analyses are contained in the NOPR TSD supporting this document.

A. Trial Standard Levels

In general, DOE typically evaluates potential new or amended standards for products and equipment by grouping individual efficiency levels for each class into TSLs. Use of TSLs allows DOE to identify and consider manufacturer cost interactions between the product classes, to the extent that there are such interactions, and price elasticity of consumer purchasing decisions that may change when different standard levels are set.

In the analysis conducted for this NOPR, DOE analyzed the benefits and burdens of four TSLs for ceiling fans. DOE developed TSLs that combine efficiency levels for each analyzed product class. DOE presents the results for the TSLs in this document, while the results for all efficiency levels that DOE analyzed are in the NOPR TSD.

Table V.1 presents the TSLs and the corresponding efficiency levels that DOE has identified for potential amended energy conservation standards for ceiling fans. TSL 4 represents the maximum technologically feasible ("max-tech") energy efficiency for all product classes. TSL 3 corresponds to the highest efficiency level that can be met for standard and hugger ceiling fans without low-income purchasers experiencing a large increase in first cost, the highest efficiency level with positive LCC for LDCFs, and the highest efficiency level using the most efficient motor for HSBD fans without needing aerodynamic redesign for fan blades. TSL 2 corresponds to the highest efficiency level met with AC motors for standard and hugger ceiling fans, positive LCC for LDCFs, and using the most efficient PSC motors for HSBD ceiling fans. TSL 1 corresponds to using larger AC motors for standard and hugger ceiling fans, positive LCC for LDCFs, and using the most efficient PSC motor for HSBD ceiling fans[76].

Table V.1 Trial Standard Levels for Ceiling Fans

TSL	Standard	Hugger	LDCF	HSBD
TSL 1	EL 1	EL 1	EL 1	EL 2
TSL 2	EL 2	EL 2	EL 1	EL 2
TSL 3	EL 3	EL 3	EL 1	EL 3
TSL 4	EL 4	EL 4	EL 2	EL 4

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Consumers

DOE analyzed the economic impacts on ceiling fan consumers by looking at the effects that potential amended standards at each TSL would have on the LCC and PBP.

[76] DOE did not consider a TSL with HSBD set to EL1 because the LCC savings are negative at that EL.

DOE also examined the impacts of potential standards on selected consumer subgroups. These analyses are discussed in the following sections.

a. Life-Cycle Cost and Payback Period

In general, higher-efficiency products affect consumers in two ways: (1) purchase price increases and (2) annual operating costs decrease. Inputs used for calculating the LCC and PBP include total installed costs (*i.e.*, product price plus installation costs), and operating costs (*i.e*., annual energy use, energy prices, energy price trends, repair costs, and maintenance costs). The LCC calculation also uses product lifetime and a discount rate. Chapter 8 of the NOPR TSD provides detailed information on the LCC and PBP analyses.

Table V.2 through Table V.9 show the LCC and PBP results for the TSLs considered for each product class. In the first of each pair of tables, the simple payback is measured relative to the baseline product. In the second table, impacts are measured relative to the efficiency distribution in the no-new-standards case in the compliance year (see section IV.F.8 of this document). Because some consumers purchase products with higher efficiency in the no-new-standards case, the average savings are less than the difference between the average LCC of the baseline product and the average LCC at each TSL. The savings refer only to consumers who are affected by a standard at a given TSL. Those who already purchase a product with efficiency at or above a given TSL are not affected. Consumers for whom the LCC increases at a given TSL experience a net cost. DOE does not include consumers who no longer purchase ceiling fans (i.e., are "priced out" of the market) or delay their purchase in the percent of consumers that experience a net cost. As discussed in section IV.H.1, DOE seeks comment on this issue. However, DOE notes that low-income consumers who may no longer purchase ceiling fans are considered in the justification for the proposed TSL. See discussion in section V.C.1 for details.

Table V.2 Average LCC and PBP Results for Standard Ceiling Fans

Efficiency Level	Average Costs *2022$*				Simple Payback *years*	Average Lifetime *years*
	Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
Baseline	$121.61	$13.80	$161.90	$283.51	--	14.6
1	$124.55	$13.30	$156.05	$280.60	5.9	14.6
2	$129.33	$12.69	$148.89	$278.22	7.0	14.6
3	$131.39	$11.39	$133.54	$264.94	4.1	14.5
4	$148.03	$7.75	$90.89	$238.92	4.4	14.6

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.3 Average LCC Savings Relative to the No-New-Standards Case for Standard Ceiling Fans

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* *2022$*	Percent of Consumers that Experience Net Cost
1	1	$5.57	17%
2	2	$11.25	38%
3	3	$16.69	36%
4	4	$39.84	34%

* The savings represent the average LCC for affected consumers.

Table V.4 Average LCC and PBP Results for Hugger Ceiling Fans

Efficiency Level	Average Costs *2022$*				Simple Payback *years*	Average Lifetime *years*
	Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
Baseline	$108.73	$11.87	$140.02	$248.76	--	14.6
1	$111.06	$11.55	$136.24	$247.31	7.3	14.6
2	$112.26	$11.40	$134.44	$246.70	7.5	14.6
3	$112.55	$11.29	$133.09	$245.63	6.6	14.6
4	$136.47	$7.04	$82.84	$219.31	5.7	14.6

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.5 Average LCC Savings Relative to the No-New-Standards Case for Hugger Ceiling Fans

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* *2022$*	Percent of Consumers that Experience Net Cost
1	1	$2.10	28%
2	2	$3.80	33%
3	3	$5.14	33%
4	4	$28.48	42%

* The savings represent the average LCC for affected consumers.

Table V.6 Average LCC and PBP Results for High-Speed Belt-Driven Ceiling Fans

Efficiency Level	Average Costs *2022$*				Simple Payback *years*	Average Lifetime *years*
	Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
Baseline	$559.52	$586.27	$5,397.92	$5,957.44	--	14.5
1	$692.32	$579.64	$5,336.84	$6,029.16	20.0	14.5
2	$739.41	$514.24	$4,734.83	$5,474.24	2.5	14.5
3	$769.49	$484.86	$4,464.36	$5,233.85	2.1	14.5
4	$769.49	$312.36	$2,876.45	$3,645.94	0.8	14.5

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.7 Average LCC Savings Relative to the No-New-Standards Case for High-Speed Belt-Driven Ceiling Fans

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* *2022$*	Percent of Consumers that Experience Net Cost
1-2	2	$508.29	0%
3	3	$663.92	0%
4	4	$1,854.94	0%

* The savings represent the average LCC for affected consumers.

Table V.8 Average LCC and PBP Results for Large-Diameter Ceiling Fans

Efficiency Level	Average Costs *2022$*				Simple Payback *years*	Average Lifetime *years*
	Installed Cost	First Year's Operating Cost	Lifetime Operating Cost	LCC		
Baseline	$5,473.03	$170.58	$1,583.08	$7,056.11	--	14.6
1	$5,578.62	$152.31	$1,413.51	$6,992.13	5.8	14.6
2	$5,905.17	$133.83	$1,241.58	$7,146.75	11.8	14.6

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.9 Average LCC Savings Relative to the No-New-Standards Case for Large-Diameter Ceiling Fans

TSL	Efficiency Level	Life-Cycle Cost Savings	
		Average LCC Savings* ***2022$***	**Percent of Consumers that Experience Net Cost**
1-3	1	$68.20	4%
4	2	($183.40)	43%

* The savings represent the average LCC for affected consumers. Parentheses indicate negative savings.

DOE also performed a sensitivity analysis to account for the possibility that fans with BLDC motors will not decrease in price (see appendix 8D of the NOPR TSD). In this analysis, average LCC savings of affected consumers are smaller but remain positive for all equipment classes at the proposed TSL (TSL 3).

b. Consumer Subgroup Analysis

In the consumer subgroup analysis, DOE estimated the impact of the considered TSLs on two subgroups: (1) low-income households (for standard and hugger ceiling fans) and (2) small businesses (LDCFs and HSBD ceiling fans). Table V.10 compares the average LCC savings and PBP at each efficiency level for the consumer subgroups with similar metrics for the entire consumer sample for ceiling fans. In most cases, the average LCC savings and PBP for low-income households at the considered efficiency levels are improved (i.e., higher LCC savings and equal or lesser payback periods) from the average for all households. Chapter 11 of the NOPR TSD presents the complete LCC and PBP results for the subgroups.

Table V.10 Comparison of LCC Savings and PBP for Consumer Subgroups and All Consumers

TSL	Average LCC Savings* 2022$		Simple Payback years	
	Low-Income Households	All Households	Low-Income Households	All Households
Standard Ceiling Fans				
1	$7.92	$5.57	3.1	5.9
2	$15.05	$11.25	3.6	7.0
3	$21.81	$16.69	2.1	4.1
4	$52.89	$39.84	2.3	4.4
Hugger Ceiling Fans				
1	$3.59	$2.10	3.7	7.3
2	$6.05	$3.80	3.8	7.5
3	$8.21	$5.14	3.1	6.6
4	$42.44	$28.48	2.9	5.7
	Small Businesses	**All Businesses**	**Small Businesses**	**All Businesses**
Large-Diameter Ceiling Fans				
1-3	$44.47	$68.20	5.8	5.8
4	($213.59)	($183.40)	11.8	11.8
HSBD Ceiling Fans				
1-2	$419.41	$508.29	20.0	20.0
3	$552.80	$663.92	2.5	2.5
4	$1,593.49	$1,854.94	2.1	2.1

* The savings represent the average LCC for affected consumers. Parentheses indicate negative savings.

c. Rebuttable Presumption Payback

As discussed in section IV.F.9 of this document, EPCA establishes a rebuttable presumption that an energy conservation standard is economically justified if the increased purchase cost for a product that meets the standard is less than three times the value of the first-year energy savings resulting from the standard. In calculating a rebuttable presumption payback period for each of the considered TSLs, DOE used discrete values, and, as required by EPCA, based the energy use calculation on the DOE test procedure for ceiling fans. In contrast, the PBPs presented in section V.B.1.a of this document, were calculated using distributions that reflect the range of energy use in the field.

Table V.5 presents the rebuttable-presumption payback periods for the considered TSLs for ceiling fans. While DOE examined the rebuttable-presumption criterion, it considered whether the standard levels considered for the NOPR are economically justified through a more detailed analysis of the economic impacts of those levels, pursuant to 42 U.S.C. 6295(o)(2)(B)(i), that considers the full range of impacts to the consumer, manufacturer, Nation, and environment. The results of that analysis serve as the basis for DOE to definitively evaluate the economic justification for a potential standard level, thereby supporting or rebutting the results of any preliminary determination of economic justification.

Table V.11 Rebuttable Presumption Payback Periods

Efficiency Level	Rebuttable Payback Period *years*			
	Standard	Hugger	HSBD	Large-Diameter
1	4.9	5.9	21.1	5.8
2	5.8	6.0	2.6	12.0
3	3.6	4.6	2.2	--
4	--	--	0.8	--

2. Economic Impacts on Manufacturers

DOE performed an MIA to estimate the impact of new and amended energy conservation standards on manufacturers of ceiling fans. The following section describes the expected impacts on manufacturers at each considered TSL. Chapter 12 of the NOPR TSD explains the analysis in further detail.

a. Industry Cash Flow Analysis Results

In this section, DOE provides GRIM results from the analysis, which examines changes in the industry that would result from the analyzed standards. The following tables summarize the estimated financial impacts (represented by changes in INPV) of potential new and amended energy conservation standards on manufacturers of ceiling fans, as well as the conversion costs that DOE estimates manufacturers of ceiling fans would incur at each TSL. To evaluate the range of cash-flow impacts on the ceiling fan industry, DOE modeled two scenarios using different assumptions that correspond to the range of anticipated market responses to new and amended energy conservation standards: (1) the preservation of gross margin scenario and (2) the preservation of operating profit scenario.

In the preservation of gross margin scenario, ceiling fan manufacturers are able to maintain their margins (as a percentage), even as the MPCs of ceiling fans increase due to energy conservation standards. The same uniform margin of 27 percent is applied across standard and hugger ceiling fans, while the same uniform margin of 41 percent is applied across all LDCF and HSBD ceiling fans for all efficiency levels in the preservation of gross margin scenario.[77] In the preservation of operating profit scenario, in the standards cases manufacturers are not able to maintain their original margins of 27 percent for standard and hugger ceiling fans and 41 percent for LDCF and HSBD ceiling fans. Instead, manufacturers are only able to maintain the same operating profit (in absolute dollars) in the standards cases as in the no-new-standards case, despite higher MPCs.

Each of the modeled scenarios results in a unique set of cash-flows and corresponding industry values at each TSL for ceiling fan manufacturers. In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case and each standards case resulting from the sum of discounted cash-flows from 2023 through 2057. To provide perspective on the short-run cash-flow

[77] The gross margin percentage of 27 percent (for standard and hugger ceiling fans) is based on a manufacturer markup of 1.37 and the gross margin percentage of 41 percent (for LDCF and HSBD ceiling fans) is based on a manufacturer markup of 1.70.

impact, DOE includes in the discussion of results a comparison of free cash flow between the no-new-standards case and the standards case at each TSL in the year before new and amended standards are required.

DOE presents the range in INPV for all ceiling fan manufacturers in Table V.12andTable V.13. However, most ceiling fan manufacturers only manufacture one of the three categories of standard or hugger ceiling fans, LDCFs, or HSBD ceiling fans. DOE lists the impacts on those groups of ceiling fan manufacturers. DOE presents the range in INPV for standard and hugger ceiling fan manufacturers in Table V.14 and Table V.15; the range in INPV for LDCF manufacturers in Table V.16 and Table V.17; the range in INPV for HSBD ceiling fan manufacturers in Table V.18 and Table V.19.

Table V.12 Manufacturer Impact Analysis for All Ceiling Fans – Preservation of Gross Margin Scenario

	Units	No-New-Standards Case	Trial Standard Level*			
			1	2	3	4
INPV	*2022$ millions*	2,329	2,293	2,298	2,286	2,278
Change in INPV	*2022$ millions*	-	(35.8)	(30.8)	(42.6)	(50.8)
	%	-	(1.5)	(1.3)	(1.8)	(2.2)
Product Conversion Costs	*2022$ millions*	-	32.9	41.0	54.8	149.6
Capital Conversion Costs	*2022$ millions*	-	36.8	45.9	52.4	95.8
Total Conversion Costs	*2022$ millions*	-	69.7	87.0	107.2	245.5

* Numbers in parentheses indicate a negative value. Not all numbers sum exactly due to rounding.

Table V.13 Manufacturer Impact Analysis for All Ceiling Fans – Preservation of Operating Profit Scenario

	Units	No-New-Standards Case	Trial Standard Level*			
			1	2	3	4
INPV	*2022$ millions*	2,329	2,272	2,244	2,227	2,003
Change in INPV	*2022$ millions*	-	(56.9)	(84.8)	(101.3)	(325.7)
	%	-	(2.4)	(3.6)	(4.4)	(14.0)
Product Conversion Costs	*2022$ millions*	-	32.9	41.0	54.8	149.6
Capital Conversion Costs	*2022$ millions*	-	36.8	45.9	52.4	95.8
Total Conversion Costs	*2022$ millions*	-	69.7	87.0	107.2	245.5

* Numbers in parentheses indicate a negative value. Not all numbers sum exactly due to rounding.

Standard and Hugger Ceiling Fan Manufacturers

Table V.14 Manufacturer Impact Analysis for Standard and Hugger Ceiling Fans – Preservation of Gross Margin Scenario

	Units	No-New-Standards Case	Trial Standard Level*			
			1	2	3	4
INPV	*2022$ millions*	1,517	1,487	1,492	1,481	1,477
Change in INPV	*2022$ millions*	-	(29.2)	(24.1)	(35.8)	(39.2)
	%	-	(1.9)	(1.6)	(2.4)	(2.6)
Product Conversion Costs	*2022$ millions*	-	26.3	34.4	48.0	122.7
Capital Conversion Costs	*2022$ millions*	-	29.6	38.7	45.2	76.9
Total Conversion Costs	*2022$ millions*	-	55.9	73.2	93.2	199.6

* Numbers in parentheses indicate a negative value. Not all numbers sum exactly due to rounding.

Table V.15 Manufacturer Impact Analysis for Standard and Hugger Ceiling Fans – Preservation of Operating Profit Scenario

	Units	No-New-Standards Case	Trial Standard Level*			
			1	2	3	4
INPV	*2022$ millions*	1,517	1,470	1,442	1,425	1,242
Change in INPV	*2022$ millions*	-	(47.0)	(74.9)	(91.4)	(274.1)
	%	-	(3.1)	(4.9)	(6.0)	(18.1)
Product Conversion Costs	*2022$ millions*	-	26.3	34.4	48.0	122.7
Capital Conversion Costs	*2022$ millions*	-	29.6	38.7	45.2	76.9
Total Conversion Costs	*2022$ millions*	-	55.9	73.2	93.2	199.6

* Numbers in parentheses indicate a negative value. Not all numbers sum exactly due to rounding.

At TSL 4, for standard and hugger ceiling fan manufacturers, DOE estimates impacts on INPV will range from -$274.1 million to -$39.2 million, which represents a change of -18.1 percent to -2.6 percent, respectively. At TSL 4, industry free cash-flow decreases to $19.8 million, which represents a decrease of approximately 79.5 percent, compared to the no-new-standards case value of $96.3 million in 2027, the year before the modeled compliance date.

TSL 4 would set energy conservation standards at max-tech (EL 4) for all standard and hugger ceiling fans. DOE estimates that approximately 10 percent of the standard ceiling fan shipments and 5 percent of the hugger ceiling fan shipments would already meet the efficiency levels required at TSL 4 in 2028 in the no-new-standards case. Therefore, DOE estimates that manufacturers would have to redesign models representing approximately 90 percent of standard ceiling fan shipments and 95 percent of hugger ceiling fan shipments by the estimated compliance date.

At TSL 4, DOE expects standard and hugger ceiling fan manufacturers to incur approximately $122.7 million in product conversion costs to redesign all non-compliant standard and hugger ceiling fan models. Additionally, standard and hugger ceiling fan manufacturers would incur approximately $76.9 million in capital conversion costs to purchase new tooling and equipment necessary to produce compliant standard and hugger ceiling fan models to meet these energy conservation standards.

At TSL 4, the shipment-weighted average MPC for standard and hugger ceiling fans significantly increases by 24.9 percent relative to the no-new-standards case shipment-weighted average MPC in 2028. In the preservation of gross margin scenario, manufacturers fully pass on this cost increase. The increase in shipment weighted average MPC is outweighed by the $199.6 million in conversion costs, causing a negative change in INPV at TSL 4 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, manufacturers earn the same per-unit operating profit as would be earned in the no-new-standards case, but manufacturers do not earn additional profit from their investments or higher MPCs. In this scenario, the 24.9 percent shipment weighted average MPC increase results in a reduction in the manufacturer margin after the analyzed compliance year. This reduction in the manufacturer margin and the $199.6 million in conversion costs incurred by manufacturers cause a moderately negative change in INPV at TSL 4 under the preservation of operating profit scenario.

At TSL 3, for standard and hugger ceiling fan manufacturers, DOE estimates impacts on INPV will range from -$91.4 million to -$35.8 million, which represents a change of -6.0 percent to -2.4 percent, respectively. At TSL 3, industry free cash-flow decreases to $59.6 million, which represents a decrease of approximately 38.2 percent, compared to the no-new-standards case value of $96.3 million in 2027, the year before the modeled compliance date.

TSL 3 would set energy conservation standards at EL 3 for all standard and hugger ceiling fans. DOE estimates that approximately 28 percent of the standard ceiling fan shipments and 41 percent of the hugger ceiling fan shipments would already meet or exceed the efficiency levels required at TSL 3 in 2028, in the no-new-standards case. Therefore, DOE estimates that manufacturers would have to redesign models representing approximately 72 percent of standard ceiling fan shipments and 59 percent of hugger ceiling fan shipments by the estimated compliance date.

At TSL 3, DOE expects standard and hugger ceiling fan manufacturers to incur approximately $48.0 million in product conversion costs to redesign all non-compliant standard and hugger ceiling fan models. Additionally, standard and hugger ceiling fan manufacturers would incur approximately $45.2 million in capital conversion costs to purchase new tooling and equipment necessary to produce compliant standard and hugger ceiling fan models to meet these energy conservation standards.

At TSL 3, the shipment-weighted average MPC for standard and hugger ceiling fans moderately increases by 5.1 percent relative to the no-new-standards case shipment-weighted average MPC in 2028. In the preservation of gross margin scenario, manufacturers fully pass on this cost increase. The increase in shipment weighted average MPC is outweighed by the $93.2 million in conversion costs, causing a slightly negative change in INPV at TSL 3 under the preservation of gross margin scenario.

In the preservation of operating profit scenario, the 5.1 percent shipment weighted average MPC increase results in a reduction in the manufacturer margin after the analyzed compliance year. This reduction in the manufacturer margin and the $93.2 million in conversion costs incurred by manufacturers cause a slightly negative change in INPV at TSL 3 under the preservation of operating profit scenario.

At TSL 2, for standard and hugger ceiling fan manufacturers, DOE estimates impacts on INPV will range from -$74.9 million to -$24.1 million, which represents a change of -4.9 percent to -1.6 percent, respectively. At TSL 2, industry free cash-flow decreases to $67.1 million, which represents a decrease of approximately 30.3 percent, compared to the no-new-standards case value of $96.3 million in 2027, the year before the modeled compliance date.

TSL 2 would set energy conservation standards at EL 2 for all standard and hugger ceiling fans. DOE estimates that approximately 32 percent of the standard ceiling fan shipments and 42 percent of the hugger ceiling fan shipments would already meet or exceed the efficiency levels required at TSL 2 in 2028, in the no-new-standards case. Therefore, DOE estimates that manufacturers would have to redesign models representing approximately 68 percent of standard ceiling fan shipments and 58 percent of hugger ceiling fan shipments by the estimated compliance date.

At TSL 2, DOE expects standard and hugger ceiling fan manufacturers to incur approximately $34.4 million in product conversion costs to redesign all non-compliant standard and hugger ceiling fan models. Additionally, standard and hugger ceiling fan manufacturers would incur approximately $38.7 million in capital conversion costs to purchase new tooling and equipment necessary to produce compliant standard and hugger ceiling fan models to meet these energy conservation standards.

At TSL 2, the shipment-weighted average MPC for standard and hugger ceiling fans moderately increases by 4.6 percent relative to the no-new-standards case shipment-weighted average MPC in 2028. In the preservation of gross margin scenario, manufacturers fully pass on this cost increase. The increase in shipment weighted average MPC is outweighed by the $73.2 million in conversion costs, causing a slightly negative change in INPV at TSL 2 under the preservation of gross margin scenario.

In the preservation of operating profit scenario, the 4.6 percent shipment weighted average MPC increase results in a reduction in the manufacturer margin after the analyzed compliance year. This reduction in the manufacturer margin and the $73.2

million in conversion costs incurred by manufacturers cause a slightly negative change in INPV at TSL 2 under the preservation of operating profit scenario.

At TSL 1, for standard and hugger ceiling fan manufacturers, DOE estimates impacts on INPV will range from -$47.0 million to -$29.2 million, which represents a change of -3.1 percent to -1.9 percent, respectively. At TSL 1, industry free cash-flow decreases to $74.0 million, which represents a decrease of approximately 23.2 percent, compared to the no-new-standards case value of $96.3 million in 2027, the year before the modeled compliance date.

TSL 1 would set energy conservation standards at EL 1 for all standard and hugger ceiling fans. DOE estimates that approximately 75 percent of the standard ceiling fan shipments and 68 percent of the hugger ceiling fan shipments would already meet or exceed the efficiency levels required at TSL 1 in 2028, in the no-new-standards case. Therefore, DOE estimates that manufacturers would have to redesign models representing approximately 25 percent of standard ceiling fan shipments and 32 percent of hugger ceiling fan shipments by the estimated compliance date.

At TSL 1, DOE expects standard and hugger ceiling fan manufacturers to incur approximately $26.3 million in product conversion costs to redesign all non-compliant standard and hugger ceiling fan models. Additionally, standard and hugger ceiling fan manufacturers would incur approximately $29.6 million in capital conversion costs to purchase new tooling and equipment necessary to produce compliant standard and hugger ceiling fan models to meet these energy conservation standards.

At TSL 1, the shipment-weighted average MPC for standard and hugger ceiling fans slightly increases by 1.6 percent relative to the no-new-standards case shipment-weighted average MPC in 2028. In the preservation of gross margin scenario, manufacturers fully pass on this cost increase. The increase in shipment weighted average MPC is outweighed by the $55.9 million in conversion costs, causing a slightly negative change in INPV at TSL 1 under the preservation of gross margin scenario.

In the preservation of operating profit scenario, the 1.6 percent shipment weighted average MPC increase results in a reduction in the manufacturer margin after the analyzed compliance year. This reduction in the manufacturer margin and the $55.9 million in conversion costs incurred by manufacturers cause a slightly negative change in INPV at TSL 1 under the preservation of operating profit scenario.

Large-Diameter Ceiling Fan Manufacturers

Table V.16 Manufacturer Impact Analysis for Large-Diameter Ceiling Fans – Preservation of Gross Margin Scenario

	Units	No-New-Standards Case	Trial Standard Level*			
			1	2	3	4
INPV	*2022$ millions*	810	803	803	803	800
Change in INPV	*2022$ millions*	-	(6.6)	(6.6)	(6.6)	(10.1)
	%	-	(0.8)	(0.8)	(0.8)	(1.2)
Product Conversion Costs	*2022$ millions*	-	6.4	6.4	6.4	25.3
Capital Conversion Costs	*2022$ millions*	-	7.0	7.0	7.0	18.0
Total Conversion Costs	*2022$ millions*	-	13.4	13.4	13.4	43.3

* Numbers in parentheses indicate a negative value. Not all numbers sum exactly due to rounding.

Table V.17 Manufacturer Impact Analysis for Large-Diameter Ceiling Fans – Preservation of Operating Profit Scenario

	Units	No-New-Standards Case	Trial Standard Level*			
			1	2	3	4
INPV	*2022$ millions*	810	800	800	800	760
Change in INPV	*2022$ millions*	-	(9.6)	(9.6)	(9.6)	(49.8)
	%	-	(1.2)	(1.2)	(1.2)	(6.2)
Product Conversion Costs	*2022$ millions*	-	6.4	6.4	6.4	25.3
Capital Conversion Costs	*2022$ millions*	-	7.0	7.0	7.0	18.0
Total Conversion Costs	*2022$ millions*	-	13.4	13.4	13.4	43.3

* Numbers in parentheses indicate a negative value. Not all numbers sum exactly due to rounding.

At TSL 4, for LDCF manufacturers, DOE estimates impacts on INPV will range from -$49.8 million to -$10.1 million, which represents a change of -6.2 percent to -1.2 percent, respectively. At TSL 4, industry free cash-flow decreases to $15.9 million, which represents a decrease of approximately 51.3 percent, compared to the no-new-standards case value of $32.6 million in 2027, the year before the modeled compliance date.

TSL 4 would set energy conservation standards at max-tech (EL 2) for all LDCFs. DOE estimates that approximately 48 percent of all LDCF shipments would already meet the efficiency levels required at TSL 4 in 2028, in the no-new-standards case. Therefore, DOE estimates that manufacturers would have to redesign models representing approximately 52 percent of LDCF shipments by the estimated compliance date.

At TSL 4, DOE expects LDCF manufacturers to incur approximately $25.3 million in product conversion costs to redesign all non-compliant LDCF models. Additionally, LDCF manufacturers would incur approximately $18.0 million in capital conversion costs to purchase new tooling and equipment necessary to produce compliant LDCF models to meet the energy conservation standard.

At TSL 4, the shipment-weighted average MPC for LDCF moderately increases by 6.3 percent relative to the no-new-standards case shipment-weighted average MPC in 2028. In the preservation of gross margin scenario, manufacturers fully pass on this cost increase. The increase in shipment weighted average MPC is outweighed by the $43.3 million in conversion costs, causing a negative change in INPV at TSL 4 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, manufacturers earn the same per-unit operating profit as would be earned in the no-new-standards case, but manufacturers do not earn additional profit from their investments or higher MPCs. In this scenario, the 6.3 percent shipment weighted average MPC increase results in a reduction in the manufacturer margin after the analyzed compliance year. This reduction in the manufacturer margin and the $43.3 million in conversion costs incurred by manufacturers cause a moderately negative change in INPV at TSL 4 under the preservation of operating profit scenario.

At TSL 3, TSL 2, and TSL 1, for LDCF manufacturers, DOE estimates impacts on INPV will range from -$9.6 million to -$6.6 million, which represents a change of -1.2 percent to -0.8 percent, respectively. At these TSLs, industry free cash-flow decreases to $27.3 million, which represents a decrease of approximately 16.4 percent, compared to the no-new-standards case value of $32.6 million in 2027, the year before the modeled compliance date.

TSL 3, TSL 2, and TSL 1 would set energy conservation standards at EL 1 for all LDCFs. DOE estimates that approximately 86 percent of the LDCF shipments would already meet or exceed the efficiency levels required at these TSLs in 2028, in the no-new-standards case. Therefore, DOE estimates that manufacturers would have to redesign models representing approximately 14 percent of LDCF shipments by the estimated compliance date.

At TSL 3, TSL 2, and TSL 1, DOE expects LDCF manufacturers to incur approximately $6.4 million in product conversion costs to redesign all non-compliant LDCF models. Additionally, LDCF manufacturers would incur approximately $7.0 million in capital conversion costs to purchase new tooling and equipment necessary to produce compliant LDCF models to meet the energy conservation standard.

At TSL 3, TSL 2, and TSL 1, the shipment-weighted average MPC for LDCFs slightly increases by 0.4 percent relative to the no-new-standards case shipment-weighted average MPC in 2028. In the preservation of gross margin scenario, manufacturers fully pass on this slight cost increase. The increase in shipment weighted average MPC is outweighed by the $13.4 million in conversion costs, causing a slightly negative change in INPV at these TSLs under the preservation of gross margin scenario.

In the preservation of operating profit scenario, the 0.4 percent shipment weighted average MPC increase results in a reduction in the manufacturer margin after the analyzed compliance year. This reduction in the manufacturer margin and the $13.4 million in conversion costs incurred by manufacturers cause a slightly negative change in INPV at these TSLs under the preservation of operating profit scenario.

High-Speed Belt-Driven Ceiling Fan Manufacturers

Table V.18 Manufacturer Impact Analysis for High-Speed Belt-Driven Ceiling Fans – Preservation of Gross Margin Scenario

	Units	No-New-Standards Case	Trial Standard Level*			
			1	2	3	4
INPV	*2022$ millions*	2.6	2.6	2.6	2.5	0.9
Change in INPV	*2022$ millions*	-	(0.1)	(0.1)	(0.2)	(1.8)
	%	-	(2.1)	(2.1)	(6.3)	(66.7)
Product Conversion Costs	*2022$ millions*	-	0.2	0.2	0.3	1.7
Capital Conversion Costs	*2022$ millions*	-	0.2	0.2	0.2	0.9
Total Conversion Costs	*2022$ millions*	-	0.3	0.3	0.5	2.6

* Numbers in parentheses indicate a negative value. Not all numbers sum exactly due to rounding.

Table V.19 Manufacturer Impact Analysis for High-Speed Belt-Driven Ceiling Fans – Preservation of Operating Profit

	Units	No-New-Standards Case	Trial Standard Level*			
			1	2	3	4
INPV	*2022$ millions*	2.6	2.4	2.4	2.2	0.6
Change in INPV	*2022$ millions*	-	(0.3)	(0.3)	(0.4)	(2.0)
	%	-	(9.6)	(9.6)	(15.3)	(75.7)
Product Conversion Costs	*2022$ millions*	-	0.2	0.2	0.3	1.7
Capital Conversion Costs	*2022$ millions*	-	0.2	0.2	0.2	0.9
Total Conversion Costs	*2022$ millions*	-	0.3	0.3	0.5	2.6

* Numbers in parentheses indicate a negative value. Not all numbers sum exactly due to rounding.

At TSL 4, for HSBD ceiling fan manufacturers, DOE estimates impacts on INPV will range from -$2.0 million to -$1.8 million, which represents a change of -75.7 percent to -66.7 percent, respectively. At TSL 4, industry free cash-flow decreases to -$1.0 million, which represents a decrease of approximately 1015 percent, compared to the no-new-standards case value of $0.1 million in 2027, the year before the modeled compliance date. The negative cash flow implies that HSBD ceiling fan manufacturers would likely need to borrow money during the year(s) leading up to the energy conservation standard compliance date as they incur costly aerodynamic redesigns to all of their HSBD ceiling fan models.

TSL 4 would set energy conservation standards at max-tech (EL 4) for all HSBD ceiling fans. DOE estimates that there will be no HSBD ceiling fan shipments that would already meet the efficiency levels required at TSL 4 in 2028, in the no-new-standards case. Therefore, DOE estimates that manufacturers would have to redesign all HSBD ceiling fan models by the estimated compliance date.

At TSL 4, DOE expects HSBD ceiling fan manufacturers to incur approximately $1.7 million in product conversion costs to redesign all HSBD ceiling fan models. At this TSL, HSBD ceiling manufacturers would have to conduct a full aerodynamic redesign to all of their HSBD ceiling fan models. Additionally, HSBD ceiling fan manufacturers would incur approximately $0.9 million in capital conversion costs to purchase new tooling and equipment associated with these aerodynamically redesigned blades to produce compliant HSBD ceiling fan models to meet the energy conservation standard.

At TSL 4, the shipment-weighted average MPC for HSBD ceiling fans moderately increases by 10.9 percent relative to the no-new-standards case shipment-weighted average MPC in 2028. In the preservation of gross margin scenario, manufacturers fully pass on this cost increase. The increase in shipment weighted average MPC is significantly outweighed by the $2.6 million in conversion costs, causing a significantly negative change in INPV at TSL 4 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, manufacturers earn the same per-unit operating profit as would be earned in the no-new-standards case, but manufacturers do not earn additional profit from their investments or higher MPCs. In this scenario, the 10.9 percent shipment weighted average MPC increase results in a reduction in the manufacturer margin after the analyzed compliance year. This reduction in the manufacturer margin and the $2.6 million in conversion costs incurred by manufacturers cause a significantly negative change in INPV at TSL 4 under the preservation of operating profit scenario.

At TSL 3, for HSBD ceiling fan manufacturers, DOE estimates impacts on INPV will range from -$0.4 million to -$0.2 million, which represents a change of -15.3 percent to -6.3 percent, respectively. At TSL 3, industry free cash-flow decreases to -$0.1 million, which represents a decrease of approximately 189.4 percent, compared to the no-new-standards case value of $0.1 million in 2027, the year before the modeled compliance date. The negative cash flow implies that HSBD ceiling fan manufacturers would likely need to borrow money during the year(s) leading up to the energy conservation standards compliance date as they incur costly redesigns to a majority of their HSBD ceiling fan models.

TSL 3 would set energy conservation standards at EL 3 for all HSBD ceiling fans. DOE estimates that approximately 59 percent of the HSBD ceiling fan shipments would already meet or exceed the efficiency levels required at TSL 3 in 2028, in the no-new-standards case. Therefore, DOE estimates that manufacturers would have to redesign models representing approximately 41 percent of HSBD ceiling fan shipments by the estimated compliance date.

At TSL 3, DOE expects HSBD ceiling fan manufacturers to incur approximately $0.3 million in product conversion costs to redesign all non-compliant HSBD ceiling fan models. Additionally, HSBD ceiling fan manufacturers would incur approximately $0.2

million in capital conversion costs to purchase new tooling and equipment necessary to produce compliant HSBD ceiling fan models to meet the energy conservation standards.

At TSL 3, the shipment-weighted average MPC for HSBD ceiling fans moderately increases by 10.9 percent relative to the no-new-standards case shipment-weighted average MPC in 2028. In the preservation of gross margin scenario, manufacturers fully pass on this cost increase. The increase in shipment weighted average MPC is outweighed by the $0.5 million in conversion costs, causing a moderately negative change in INPV at TSL 3 under the preservation of gross margin scenario.

In the preservation of operating profit scenario, the 10.9 percent shipment weighted average MPC increase results in a reduction in the manufacturer margin after the analyzed compliance year. This reduction in the manufacturer margin and the $0.5 million in conversion costs incurred by manufacturers cause a moderately negative change in INPV at TSL 3 under the preservation of operating profit scenario.

At TSL 2 and TSL 1, for HSBD ceiling fan manufacturers, DOE estimates impacts on INPV will range from -$0.3 million to -$0.05 million, which represents a change of -9.6 percent to -2.1 percent, respectively. At TSL 2 and TSL 1, industry free cash-flow decreases to -$0.03 million, which represents a decrease of approximately 123.0 percent, compared to the no-new-standards case value of $0.1 million in 2027, the year before the modeled compliance date. The negative cash flow implies that HSBD ceiling fan manufacturers would likely need to borrow money during the year(s) leading up to the energy conservation standards compliance date as they incur costly redesigns to a majority of their HSBD ceiling fan models.

TSL 2 and TSL 1 would set energy conservation standards at EL 2 for all HSBD ceiling fans. DOE estimates that approximately 66 percent of the HSBD ceiling fan shipments would already meet or exceed the efficiency levels required at TSL 2 and TSL 1 in 2028, in the no-new-standards case. Therefore, DOE estimates that manufacturers would have to redesign models representing approximately 34 percent of HSBD ceiling fan shipments by the estimated compliance date.

At TSL 2 and TSL 1, DOE expects HSBD ceiling fan manufacturers to incur approximately $0.2 million in product conversion costs to redesign all non-compliant HSBD ceiling fan models. Additionally, HSBD ceiling fan manufacturers would incur approximately $0.2 million in capital conversion costs to purchase new tooling and equipment necessary to produce compliant HSBD ceiling fan models to meet the energy conservation standards.

At TSL 2 and TSL 1, the shipment-weighted average MPC for HSBD ceiling fans moderately increases by 8.7 percent relative to the no-new-standards case shipment-weighted average MPC in 2028. In the preservation of gross margin scenario, manufacturers fully pass on this cost increase. The increase in shipment weighted average MPC is outweighed by the $0.3 million in conversion costs, causing a slightly negative change in INPV at TSL 2 and TSL 1 under the preservation of gross margin scenario.

In the preservation of operating profit scenario, the 8.7 percent shipment weighted average MPC increase results in a reduction in the manufacturer margin after the analyzed compliance year. This reduction in the manufacturer margin and the $0.3 million in conversion costs incurred by manufacturers cause a moderately negative change in INPV at TSL 2 and TSL 1 under the preservation of operating profit scenario.

b. Direct Impacts on Employment

To quantitatively assess the potential impacts of new and amended energy conservation standards on direct employment in the ceiling fan industry, DOE used the GRIM to estimate the domestic labor expenditures and the number of direct employees in the no-new-standards case and in each of the standards cases during the analysis period.

Production employees are those who are directly involved in fabricating and assembling products within a manufacturer facility. Workers performing services that are closely associated with production operations, such as materials handling tasks using forklifts, are included as production labor, as well as line supervisors.

There is very limited domestic production employment for standard and hugger ceiling fans. Almost all the production for standard and hugger ceiling fans takes place in Asia. Domestic production employment for standard and hugger ceiling fans is mostly limited to assembling products imported into the U.S. DOE estimated that domestic employment would not be impacted by any of the analyzed TSLs for standard and hugger ceiling fans, as the assembling of a max-tech standard and hugger ceiling fan is similar to the assembling of a baseline AC motor standard and hugger ceiling fan.

For LDCF, DOE used the GRIM to calculate the number of production employees from labor expenditures. DOE used statistical data from the U.S. Census Bureau's 2021 Annual Survey of Manufacturers[78] ("ASM") and the results of the engineering analysis to calculate industry-wide labor expenditures. Labor expenditures related to product manufacturing depend on the labor intensity of the product, the sales volume, and an assumption that wages remain fixed in real terms over time. The total labor expenditures in the GRIM were then converted to domestic production employment levels by dividing production labor expenditures by the annual payment per production worker.

[78] *www.census.gov/programs-surveys/asm/data/tables.html*. Last accessed on November 10, 2022.

Non-production employees account for those workers that are not directly engaged in the manufacturing of the covered products. This could include sales, human resources, engineering, and management. DOE estimated non-production employment levels by multiplying the number of ceiling fan workers by a scaling factor. The scaling factor is calculated by taking the ratio of the total number of employees, and the total production workers associated with the industry NAICS code 333413 (industrial and commercial fan and blower and air purification equipment manufacturing) which covers LDCF manufacturing. Using data from manufacturer interviews, DOE estimated that all LDCFs that are sold in the U.S. are manufactured domestically.

Using the estimated labor content from the GRIM combined with data from the 2021 ASM, DOE estimates that there would be approximately 55 domestic production workers, and 24 domestic non-production workers involved in LDCF manufacturing in 2028 in the absence of new and amended energy conservation standards.   shows the range of the impacts of energy conservation standards on U.S. production of LDCFs.

Table V.20 Domestic Employment for Large-Diameter Ceiling Fans in 2028

	No-New-Standards Case	Trial Standard Level	
		1 - 3	4
Domestic Production Workers in 2028	55	55	58
Domestic Non-Production Workers in 2028	24	24	26
Total Direct Employment in 2028	79	79	84
Potential Change in Total Direct Employment in 2028	-	0	5 – (28)

At the upper range of the potential change in total direct employment for LDCFs and HSBD ceiling fans, DOE estimated that there could be an increase in the number of domestic employees involved in the production and non-production of LDCFs. For this upper bound scenario, the additional labor expenditures associated with manufacturing max-tech (EL 2) direct-drive LDCFs.[79] At the lower range of the potential change in total direct employment for LDCFs, DOE estimated that employment levels would remain constant for TSL 1-3. At TSL 4, DOE conservatively estimated that half of all domestic production employment could be relocated abroad. Almost all LDCF are manufactured in the U.S. and it would be unlikely that any energy conservation standards set for LDCF would cause domestic production to move abroad, due to the larger shipping costs and longer shipping time to customers.

For HSBD ceiling fans, DOE estimated that the majority of HSBD ceiling fans are manufactured in the U.S., However, due to the extremely low annual shipments DOE did not use the GRIM to estimate the total domestic employment levels for HSBD ceiling fans. Most HSBD ceiling fan manufacturers manufacture a variety of different type of fans and/or blower, some that would be covered in this proposed rulemaking as an LDCF and some fans and/or blowers that would not be covered by this proposed rulemaking. DOE does not estimate that there are any full-time domestic employees dedicated to exclusively producing HSBD ceiling fans that are covered in this proposed rulemaking. Instead, it is more likely that several domestic employees produce HSBD ceiling fans covered by this rulemaking in addition to producing other non-covered fans and/or blowers that are not covered by this proposed rulemaking.

DOE requests comment on the estimated potential domestic employment impacts on ceiling fan manufacturers presented in this NOPR. Specifically, DOE requests comment on the assumption that almost all standard and hugger ceiling fans are manufactured abroad and any energy conservation standards would not have a significant

[79] Based on the labor content from the engineering analysis, the labor expenditures is constant for baseline and EL 1 (both ELs use a geared AC motor), while the labor content increases at max-tech (EL 2) which uses a direct-drive DC motor.

impact on domestic employment for standard and hugger ceiling fan manufacturers; on the domestic employment impacts shown in for LDCF manufacturers; and on the assumption that while most HSBD ceiling fans are manufactured domestically, due to the extremely low annual shipment volumes, any energy conservation standards would not have a significant impact on domestic employment.

c. Impacts on Manufacturing Capacity

Manufacturers stated that any standards that would cause manufacturers to use BLDC motors for all standard and hugger ceiling fans would be very difficult to meet in a three-year timeframe.[80] Standard and hugger ceiling fans models with BLDC motors represent fewer than 10 percent of models offered by a standard and hugger ceiling fan manufacturer. Therefore, most standard and hugger ceiling fan manufacturers stated that converting more than 90 percent of their standard and hugger ceiling fan models would be difficult to do in a three-year compliance period.

At TSL 3 for standard and hugger ceiling fans, DOE estimates that only standard and hugger ceiling fans that are 53 inches or larger would use BLDC motors to meet the energy conservation standard. Based on the shipment analysis, standard and hugger ceiling fans that are 53 inches or larger represent approximately 11 percent of the standard and hugger ceiling fan market. Given the lower volume of shipments and smaller number of models of standard and hugger ceiling fans that are 53 inches or larger, DOE has initially determined that there would be a sufficient volume of BLDC motors available for standard and hugger ceiling fans that are greater than 53 inches or larger.

Additionally, some, but not all, LDCF manufacturers stated that any standards that would cause manufacturers to use a permanent magnet direct-drive motor for LDCFs

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[80] Based on the time between the publication of a potential final rule amended standards and the compliance date of those amended standards.

could be difficult to meet due to the potential unavailability of these direct-drive motors. These LDCF manufacturers stated that the permanent magnet direct-drive motors could become a DOE regulated product under the ongoing DOE energy conservation standards rulemaking for Electric Motors.[81] These LDCF manufacturers stated that regulations on these permanent magnet direct-drive motors may limit their availability in the LDCF marketplace.

All other ELs analyzed require making incremental improvements to existing designs or using more efficient AC motors and should not present manufacturing capacity constraints given the 3-year compliance period proposed in this NOPR.

DOE requests comment on the potential manufacturing capacity constraints placed on ceiling fan manufacturers (including any potential supply chain issues) at any of the TSLs presented in this NOPR.

d. Impacts on Subgroups of Manufacturers

As discussed in section IV.J.1 of this document, using average cost assumptions to develop an industry cash-flow estimate may not be adequate for assessing differential impacts among manufacturer subgroups. Small manufacturers, niche manufacturers, and manufacturers exhibiting a cost structure substantially different from the industry average could be affected disproportionately. DOE used the results of the industry characterization to group manufacturers exhibiting similar characteristics. Consequently, DOE considered four manufacturer subgroups in the MIA: standard and hugger ceiling fan manufacturers; LDCF manufacturers; HSBD ceiling fan manufacturers; and small business manufacturers as subgroups for separate impact analyses. DOE discussed the potential impacts on standard and hugger ceiling fan manufacturers; LDCF

[81] *www.regulations.gov/docket/EERE-2021-BT-STD-0011.*

manufacturers; and HSBD ceiling fan manufacturers separately in section V.B.2.a of this document.

For the small business subgroup analysis, DOE applied the small business size standards published by the Small Business Administration ("SBA") to determine whether a company is considered a small business. The size standards are codified at 13 CFR part 121. Standard and hugger ceiling fan manufacturers are categorized under NAICS code 335210, "small electrical appliance manufacturing." LDCF and HSBD ceiling fan manufacturers are categorized under NAICS code 333413, "industrial and commercial fan and blower and air purification equipment manufacturing." To qualify as a small business standard and hugger ceiling fan manufacturer, as categorized under NAICS code 335210, a business and its affiliates may employ a maximum of 1,500 employees. To qualify as a small business LDCF and HSBD ceiling fan manufacturers, as categorized under NAICS code 333413, a business and its affiliates may employ a maximum of 500 employees. These employee thresholds include all employees in a business's parent company and any other subsidiaries. For a discussion of the impacts on the small business manufacturer subgroup, see the Regulatory Flexibility Analysis in section VI.B of this document.

e. Cumulative Regulatory Burden

One aspect of assessing manufacturer burden involves looking at the cumulative impact of multiple DOE standards and the product-specific regulatory actions of other Federal agencies that affect the manufacturers of a covered product or equipment. While any one regulation may not impose a significant burden on manufacturers, the combined effects of several existing or impending regulations may have serious consequences for some manufacturers, groups of manufacturers, or an entire industry. Assessing the impact of a single regulation may overlook this cumulative regulatory burden. In addition to energy conservation standards, other regulations can significantly affect manufacturers' financial operations. Multiple regulations affecting the same manufacturer can strain profits and lead companies to abandon product lines or markets with lower expected future returns than competing products. For these reasons, DOE conducts an analysis of cumulative regulatory burden as part of its rulemakings pertaining to appliance efficiency.

DOE evaluates product-specific regulations that will take effect approximately 3 years before or after the estimated 2028 compliance date of any new and amended energy conservation standards for ceiling fans. This information is presented in Table V.21.

Table V.21 Compliance Dates and Expected Conversion Expenses of Federal Energy Conservation Standards Affecting Ceiling Fan Manufacturers

Federal Energy Conservation Standard	Number of Manufacturers*	Number of Manufacturers Affected by this Rule**	Approx. Standards Year	Industry Conversion Costs (*millions*)	Industry Conversion Costs / Product Revenue***
General Service Lamps† 88 FR 1638 (Jan. 11, 2023)	100+	5	2028	$407 (2022$)	4.5%

* This column presents the total number of manufacturers identified in the energy conservation standard rule contributing to cumulative regulatory burden.
** This column presents the number of manufacturers producing ceiling fans that are also listed as manufacturers in the listed energy conservation standard contributing to cumulative regulatory burden.
*** This column presents industry conversion costs as a percentage of product revenue during the conversion period. Industry conversion costs are the upfront investments manufacturers must make to sell compliant products/equipment. The revenue used for this calculation is the revenue from just the covered product/equipment associated with each row. The conversion period is the time frame over which conversion costs are made and lasts from the publication year of the final rule to the compliance year of the energy conservation standard. The conversion period typically ranges from 3 to 5 years, depending on the rulemaking.
† Indicates a NOPR publications. Values may change on publication of a Final Rule.

In addition to the rulemaking listed in Table V.21, DOE has ongoing rulemakings for other products or equipment that ceiling fan manufacturers produce, including ceiling fan light kits[82] and fans and blowers.[83] If DOE proposes or finalizes any energy

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[82] *www.regulations.gov/docket/EERE-2019-BT-STD-0040.*
[83] *www.regulations.gov/docket/EERE-2022-BT-STD-0002.*

conservation standards for these products or equipment prior to finalizing energy conservation standards for ceiling fans, DOE will include the energy conservation standards for these other products or equipment as part of the cumulative regulatory burden for the ceiling fan final rule.

3. National Impact Analysis

This section presents DOE's estimates of the national energy savings and the NPV of consumer benefits that would result from each of the TSLs considered as potential new or amended standards.

a. Significance of Energy Savings

To estimate the energy savings attributable to potential new or amended standards for ceiling fans, DOE compared their energy consumption under the no-new-standards case to their anticipated energy consumption under each TSL. The savings are measured over the entire lifetime of products purchased in the 30-year period that begins in the first full year of anticipated compliance with new or amended standards (2028–2057). Table V.6 presents DOE's projections of the national energy savings for each TSL considered for ceiling fans. The savings were calculated using the approach described in section IV.H of this document.

Table V.23 Cumulative National Energy Savings for Ceiling Fans; 30 Years of Shipments (2028–2057), in Quadrillion Btu

	Equipment Class	**Trial Standard Level**			
		1	**2**	**3**	**4**
Source National Energy Savings	HSBD	0.00	0.00	0.01	0.04
	Hugger	0.10	0.22	0.25	1.83
	Large Diameter	0.02	0.02	0.02	0.11
	Standard	0.11	0.46	0.61	1.64
	Total	**0.24**	**0.71**	**0.89**	**3.63**
Full-Fuel-Cycle National Energy Savings	HSBD	0.00	0.00	0.01	0.04
	Hugger	0.11	0.22	0.26	1.88
	Large Diameter	0.02	0.02	0.02	0.12
	Standard	0.11	0.48	0.63	1.69
	Total	**0.25**	**0.73**	**0.92**	**3.72**

OMB Circular A-4[84] requires agencies to present analytical results, including separate schedules of the monetized benefits and costs that show the type and timing of benefits and costs. Circular A-4 also directs agencies to consider the variability of key elements underlying the estimates of benefits and costs. For this proposed rulemaking, DOE undertook a sensitivity analysis using 9 years, rather than 30 years, of product shipments. The choice of a 9-year period is a proxy for the timeline in EPCA for the review of certain energy conservation standards and potential revision of and compliance with such revised standards.[85] The review timeframe established in EPCA is generally not synchronized with the product lifetime, product manufacturing cycles, or other factors specific to ceiling fans. Thus, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology. The NES sensitivity analysis results based on a 9-year analytical period are presented in Table V.7. The impacts are counted over the lifetime of ceiling fans purchased in 2028–2036.

Table V.24 Cumulative National Energy Savings for Ceiling Fans; 9 Years of Shipments (2028–2036), in Quadrillion Btu

	Equipment Class	Trial Standard Level			
		1	2	3	4
Source National Energy Savings	HSBD	0.00	0.00	0.00	0.01
	Hugger	0.03	0.06	0.07	0.49
	Large Diameter	0.00	0.00	0.00	0.02
	Standard	0.03	0.12	0.17	0.45
	Total	**0.06**	**0.19**	**0.24**	**0.97**
Full-Fuel-	HSBD	0.00	0.00	0.00	0.01

[84] U.S. Office of Management and Budget. *Circular A-4: Regulatory Analysis*. September 17, 2003. *obamawhitehouse.archives.gov/omb/circulars_a004_a-4* (last accessed January 17, 2023).

[85] EPCA requires DOE to review its standards at least once every 6 years, and requires, for certain products, a 3-year period after any new standard is promulgated before compliance is required, except that in no case may any new standards be required within 6 years of the compliance date of the previous standards. While adding a 6-year review to the 3-year compliance period adds up to 9 years, DOE notes that it may undertake reviews at any time within the 6 year period and that the 3-year compliance date may yield to the 6-year backstop. A 9-year analysis period may not be appropriate given the variability that occurs in the timing of standards reviews and the fact that for some products, the compliance period is 5 years rather than 3 years.

Cycle National Energy Savings	Hugger	0.03	0.06	0.07	0.51
	Large Diameter	0.00	0.00	0.00	0.02
	Standard	0.03	0.13	0.17	0.46
	Total	**0.06**	**0.19**	**0.24**	**0.99**

b. Net Present Value of Consumer Costs and Benefits

DOE estimated the cumulative NPV of the total costs and savings for consumers that would result from the TSLs considered for ceiling fans. In accordance with OMB's guidelines on regulatory analysis,[86] DOE calculated NPV using both a 7-percent and a 3-percent real discount rate. Table V.8 shows the consumer NPV results with impacts counted over the lifetime of products purchased in 2028–2057.

Table V.25 Cumulative Net Present Value of Consumer Benefits for Ceiling Fans; 30 Years of Shipments (2028-2057), billion $2022

Discount Rate	**Equipment Class**	**Trial Standard Level**			
		1	**2**	**3**	**4**
3 %	HSBD	0.01	0.01	0.02	0.13
	Hugger	0.49	1.09	1.33	10.73
	Large Diameter	0.05	0.05	0.05	0.16
	Standard	0.57	2.53	3.55	9.96
	Total	**1.12**	**3.68**	**4.96**	**20.99**
7 %	HSBD	0.00	0.00	0.01	0.05
	Hugger	0.16	0.38	0.47	3.93
	Large Diameter	0.02	0.02	0.02	0.02
	Standard	0.21	0.93	1.34	3.77
	Total	**0.39**	**1.32**	**1.84**	**7.77**

The NPV results based on the aforementioned 9-year analytical period are presented in Table V.9. The impacts are counted over the lifetime of products purchased in 2028–2036. As mentioned previously, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology or decision criteria.

[86] U.S. Office of Management and Budget. *Circular A-4: Regulatory Analysis*. September 17, 2003. *https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4/* (last accessed January 20, 2023).

Table V.26 Cumulative Net Present Value of Consumer Benefits for Ceiling Fans; 9 Years of Shipments (2028–2036), billion $2022

Discount Rate	Equipment Class	Trial Standard Level			
		1	2	3	4
3 %	HSBD	0.00	0.00	0.01	0.04
	Hugger	0.16	0.34	0.42	3.33
	Large Diameter	0.01	0.01	0.01	-0.00
	Standard	0.20	0.85	1.22	3.27
	Total	**0.37**	**1.21**	**1.66**	**6.63**
7 %	HSBD	0.00	0.00	0.00	0.02
	Hugger	0.07	0.15	0.20	1.61
	Large Diameter	0.01	0.01	0.01	-0.02
	Standard	0.10	0.42	0.62	1.65
	Total	**0.17**	**0.58**	**0.83**	**3.26**

The previous results reflect the use of a default trend to estimate the change in price for ceiling fans over the analysis period (see section IV.G of this document). DOE also conducted a sensitivity analysis that considered a scenario in which the price of BLDC fans does not change over the analysis period. The results of this alternative case are presented in appendix 10C of the NOPR TSD.

c. Indirect Impacts on Employment

It is estimated that that amended energy conservation standards for ceiling fans would reduce energy expenditures for consumers of those products, with the resulting net savings being redirected to other forms of economic activity. These expected shifts in spending and economic activity could affect the demand for labor. As described in section IV.N of this document, DOE used an input/output model of the U.S. economy to estimate indirect employment impacts of the TSLs that DOE considered. There are uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Therefore, DOE generated results for near-term timeframes (2028–2032), where these uncertainties are reduced.

The results suggest that the proposed standards would be likely to have a negligible impact on the net demand for labor in the economy. The net change in jobs is so small that it would be imperceptible in national labor statistics and might be offset by other, unanticipated effects on employment. Chapter 16 of the NOPR TSD presents detailed results regarding anticipated indirect employment impacts.

4. Impact on Utility or Performance of Products

As discussed in section IV.C.2 of this document, DOE has tentatively concluded that the standards proposed in this NOPR would not lessen the utility or performance of the ceiling fans under consideration in this rulemaking. Manufacturers of these products currently offer units that meet or exceed the proposed standards.

5. Impact of Any Lessening of Competition

DOE considered any lessening of competition that would be likely to result from new or amended standards. As discussed in section III.F.1.e of this document, the Attorney General determines the impact, if any, of any lessening of competition likely to result from a proposed standard, and transmits such determination in writing to the Secretary, together with an analysis of the nature and extent of such impact. To assist the Attorney General in making this determination, DOE has provided DOJ with copies of this NOPR and the accompanying TSD for review. DOE will consider DOJ's comments on the proposed rule in determining whether to proceed to a final rule. DOE will publish and respond to DOJ's comments in that document. DOE invites comment from the public regarding the competitive impacts that are likely to result from this proposed rule. In addition, stakeholders may also provide comments separately to DOJ regarding these potential impacts. See the **ADDRESSES** section for information to send comments to DOJ.

6. Need of the Nation to Conserve Energy

Enhanced energy efficiency, where economically justified, improves the Nation's energy security, strengthens the economy, and reduces the environmental impacts (costs) of energy production. Reduced electricity demand due to energy conservation standards is also likely to reduce the cost of maintaining the reliability of the electricity system, particularly during peak-load periods. Chapter 15 in the NOPR TSD presents the estimated impacts on electricity generating capacity, relative to the no-new-standards case, for the TSLs that DOE considered in this proposed rulemaking.

Energy conservation resulting from potential energy conservation standards for ceiling fans is expected to yield environmental benefits in the form of reduced emissions of certain air pollutants and greenhouse gases. Table V.10 provides DOE's estimate of cumulative emissions reductions expected to result from the TSLs considered in this rulemaking. The emissions were calculated using the multipliers discussed in section IV.K of this document. DOE reports annual emissions reductions for each TSL in chapter 13 of the NOPR TSD.

Table V.27 Cumulative Emissions Reduction for Ceiling Fans Shipped in 2028-2057

	Trial Standard Level			
	1	**2**	**3**	**4**
Power Sector Emissions				
CO_2 (*million metric tons*)	4.46	13.27	16.75	67.95
CH_4 (*thousand tons*)	0.28	0.82	1.04	4.21
N_2O (*thousand tons*)	0.04	0.11	0.14	0.57
NO_X (*thousand tons*)	1.95	5.80	7.32	29.71
SO_2 (*thousand tons*)	1.18	3.50	4.42	17.94
Hg (*tons*)	0.01	0.02	0.03	0.12
Upstream Emissions				
CO_2 (*million metric tons*)	0.41	1.22	1.54	6.26
CH_4 (*thousand tons*)	37.72	111.08	140.11	568.94
N_2O (*thousand tons*)	0.00	0.01	0.01	0.03
NO_X (*thousand tons*)	6.47	19.04	24.02	97.55
SO_2 (*thousand tons*)	0.02	0.07	0.09	0.37
Hg (*tons*)	0.00	0.00	0.00	0.00
Total FFC Emissions				
CO_2 (*million metric tons*)	4.88	14.49	18.29	74.20
CH_4 (*thousand tons*)	37.99	111.90	141.15	573.15
N_2O (*thousand tons*)	0.04	0.12	0.15	0.60
NO_X (*thousand tons*)	8.41	24.84	31.35	127.26
SO_2 (*thousand tons*)	1.20	3.57	4.51	18.31
Hg (*tons*)	0.01	0.02	0.03	0.12

As part of the analysis for this rulemaking, DOE estimated monetary benefits likely to result from the reduced emissions of CO_2 that DOE estimated for each of the considered TSLs for ceiling fans. Section IV.L of this document discusses the SC-CO_2 values that DOE used. Table V.11 presents the value of CO_2 emissions reduction at each TSL for each of the SC-CO_2 cases. The time-series of annual values is presented for the proposed TSL in chapter 14 of the NOPR TSD.

Table V.28 Present Value of CO_2 Emissions Reduction for Ceiling Fans Shipped in 2028–2057

TSL	SC-CO_2 Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	Million 2022$			
1	46.2	202.0	317.6	612.7
2	137.8	601.3	945.0	1,823.9
3	174.4	760.3	1,194.7	2,306.5
4	707.0	3,083.4	4,844.8	9,353.6

As discussed in section IV.L.2, DOE estimated the climate benefits likely to result from the reduced emissions of methane and N_2O that DOE estimated for each of the considered TSLs for ceiling fans. Table V.12 presents the value of the CH_4 emissions reduction at each TSL, and Table V.13 presents the value of the N_2O emissions reduction at each TSL. The time-series of annual values is presented for the proposed TSL in chapter 14 of the NOPR TSD

Table V.29 Present Value of Methane Emissions Reduction for Ceiling Fans Shipped in 2028 - 2057

TSL	SC-CH_4 Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	Million 2022$			
1	16.6	50.8	71.3	134.3
2	49.1	149.9	210.3	396.3
3	62.1	189.3	265.5	500.5
4	251.9	768.5	1,077.7	2,031.9

Table V.30 Present Value of Nitrous Oxide Emissions Reduction for Ceiling Fans Shipped in 2028-2057

TSL	SC-N_2O Case			
	Discount Rate and Statistics			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
	Million 2022$			
1	0.1	0.6	0.9	1.6
2	0.4	1.8	2.7	4.7
3	0.5	2.2	3.4	5.9
4	2.2	9.0	14.0	24.0

DOE is well aware that scientific and economic knowledge about the contribution of CO_2 and other GHG emissions to changes in the future global climate and the potential resulting damages to the global and U.S. economy continues to evolve rapidly. DOE, together with other Federal agencies, will continue to review methodologies for estimating the monetary value of reductions in CO_2 and other GHG emissions. This ongoing review will consider the comments on this subject that are part of the public record for this and other rulemakings, as well as other methodological assumptions and issues. DOE notes that the proposed standards would be economically justified even without inclusion of monetized benefits of reduced GHG emissions.

DOE also estimated the monetary value of the health benefits associated with NO_X and SO_2 emissions reductions anticipated to result from the considered TSLs for ceiling fans. The dollar-per-ton values that DOE used are discussed in section IV.L of this document. Table V.14 presents the present value for NO_X emissions reduction for each TSL calculated using 7-percent and 3-percent discount rates, and Table V.15 presents similar results for SO_2 emissions reductions. The results in these tables reflect application of EPA's low dollar-per-ton values, which DOE used to be conservative. The time-series of annual values is presented for the proposed TSL in chapter 14 of the NOPR TSD.

Table V.31 Present Value of NO_X Emissions Reduction for Ceiling Fans Shipped in 2028-2057

TSL	3% Discount Rate	7% Discount Rate
	million 2022$	
1	377.0	140.6
2	1,116.6	418.2
3	1,412.1	530.3
4	5,731.3	2,151.1

Table V.32 Present Value of SO_2 Emissions Reduction for Ceiling Fans Shipped in 2028-2057

TSL	3% Discount Rate	7% Discount Rate
	million 2022$	
1	75.8	28.8
2	225.7	86.0
3	285.6	109.2
4	1,158.6	442.4

Not all the public health and environmental benefits from the reduction of greenhouse gases, NOx, and SO_2 are captured in the values above, and additional unquantified benefits from the reductions of those pollutants as well as from the reduction of Hg, direct PM, and other co-pollutants may be significant. DOE has not included monetary benefits of the reduction of Hg emissions because the amount of reduction is very small.

7. Other Factors

The Secretary of Energy, in determining whether a standard is economically justified, may consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6295(o)(2)(B)(i)(VII)) No other factors were considered in this analysis.

8. Summary of Economic Impacts

Table V.16 presents the NPV values that result from adding the estimates of the potential economic benefits resulting from reduced GHG and NO_X and SO_2 emissions to the NPV of consumer benefits calculated for each TSL considered in this rulemaking. The consumer benefits are domestic U.S. monetary savings that occur as a result of purchasing the covered ceiling fans, and are measured for the lifetime of products shipped in 2028-2057. The climate benefits associated with reduced GHG emissions resulting from the adopted standards are global benefits, and are also calculated based on the lifetime of ceiling fans shipped in 2028-2057.

Table V.33 Consumer NPV Combined with Present Value of Climate Benefits and Health Benefits

Category	TSL 1	TSL 2	TSL 3	TSL 4
Using 3% discount rate for Consumer NPV and Health Benefits (billion 2022$)				
5% Average SC-GHG case	1.6	5.2	6.9	28.8
3% Average SC-GHG case	1.8	5.8	7.6	31.7
2.5% Average SC-GHG case	2.0	6.2	8.1	33.8
3% 95th percentile SC-GHG case	2.3	7.3	9.5	39.3
Using 7% discount rate for Consumer NPV and Health Benefits (billion 2022$)				
5% Average SC-GHG case	0.6	2.0	2.7	11.3
3% Average SC-GHG case	0.8	2.6	3.4	14.2
2.5% Average SC-GHG case	0.9	3.0	3.9	16.3
3% 95th percentile SC-GHG case	1.3	4.1	5.3	21.8

C. Conclusion

When considering new or amended energy conservation standards, the standards that DOE adopts for any type (or class) of covered product must be designed to achieve the maximum improvement in energy efficiency that the Secretary determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) In determining whether a standard is economically justified, the Secretary must determine whether the benefits of the standard exceed its burdens by, to the greatest extent practicable, considering the seven statutory factors discussed previously. (42 U.S.C. 6295(o)(2)(B)(i)) The new or amended standard must also result in significant conservation of energy. (42 U.S.C. 6295(o)(3)(B))

For this NOPR, DOE considered the impacts of new and amended standards for ceiling fans at each TSL, beginning with the maximum technologically feasible level, to determine whether that level was economically justified. Where the max-tech level was not justified, DOE then considered the next most efficient level and undertook the same evaluation until it reached the highest efficiency level that is both technologically feasible and economically justified and saves a significant amount of energy.

To aid the reader as DOE discusses the benefits and/or burdens of each TSL, tables in this section present a summary of the results of DOE's quantitative analysis for each TSL. In addition to the quantitative results presented in the tables, DOE also considers other burdens and benefits that affect economic justification. These include the impacts on identifiable subgroups of consumers who may be disproportionately affected by a national standard and impacts on employment.

DOE also notes that the economics literature provides a wide-ranging discussion of how consumers trade off upfront costs and energy savings in the absence of government intervention. Much of this literature attempts to explain why consumers appear to undervalue energy efficiency improvements. There is evidence that consumers undervalue future energy savings as a result of (1) a lack of information, (2) a lack of sufficient salience of the long-term or aggregate benefits, (3) a lack of sufficient savings to warrant delaying or altering purchases, (4) excessive focus on the short term, in the form of inconsistent weighting of future energy cost savings relative to available returns on other investments, (5) computational or other difficulties associated with the evaluation of relevant tradeoffs, and (6) a divergence in incentives (for example, between renters and owners, or builders and purchasers). Having less than perfect foresight and a high degree of uncertainty about the future, consumers may trade off these types of investments at a higher than expected rate between current consumption and uncertain future energy cost savings.

In DOE's current regulatory analysis, potential changes in the benefits and costs of a regulation due to changes in consumer purchase decisions are included in two ways. First, if consumers forego the purchase of a product in the standards case, this decreases sales for product manufacturers, and the impact on manufacturers attributed to lost revenue is included in the MIA. Second, DOE accounts for energy savings attributable only to products actually used by consumers in the standards case; if a standard decreases the number of products purchased by consumers, this decreases the potential energy savings from an energy conservation standard. DOE provides estimates of shipments and changes in the volume of product purchases in chapter 9 of the NOPR TSD. However, DOE's current analysis does not explicitly control for heterogeneity in consumer preferences, preferences across subcategories of products or specific features, or consumer price sensitivity variation according to household income.[87]

While DOE is not prepared at present to provide a fuller quantifiable framework for estimating the benefits and costs of changes in consumer purchase decisions due to an energy conservation standard, DOE is committed to developing a framework that can support empirical quantitative tools for improved assessment of the consumer welfare impacts of appliance standards. DOE has posted a paper that discusses the issue of consumer welfare impacts of appliance energy conservation standards, and potential enhancements to the methodology by which these impacts are defined and estimated in the regulatory process.[88]

DOE welcomes comments on how to more fully assess the potential impact of energy conservation standards on consumer choice and how to quantify this impact in its regulatory analysis in future rulemakings.

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[87] P.C. Reiss and M.W. White. Household Electricity Demand, Revisited. *Review of Economic Studies*. 2005. 72(3): pp. 853–883. doi: *10.1111/0034-6527.00354*.

[88] Sanstad, A.H. *Notes on the Economics of Household Energy Consumption and Technology Choice*. 2010. Lawrence Berkeley National Laboratory. *www1.eere.energy.gov/buildings/appliance_standards/pdfs/consumer_ee_theory.pdf* (last accessed January 27,2023).

1. Benefits and Burdens of TSLs Considered for Ceiling Fan Standards

Table V.34 and Table V.35 summarize the quantitative impacts estimated for each TSL for ceiling fans. The national impacts are measured over the lifetime of ceiling fans purchased in the 30-year period that begins in the anticipated year of compliance with new and amended standards (2028–2057). The energy savings, emissions reductions, and value of emissions reductions refer to full-fuel-cycle results. The efficiency levels contained in each TSL are described in section V.A of this document.

Table V.34 Summary of Analytical Results for Ceiling Fan TSLs: National Impacts

Category	TSL 1	TSL 2	TSL 3	TSL 4
Cumulative FFC National Energy Savings				
Quads	0.25	0.73	0.92	3.72
Cumulative FFC Emissions Reduction				
CO_2 (*million metric tons*)	4.88	14.49	18.29	74.20
CH_4 (*thousand tons*)	37.99	111.90	141.15	573.15
N_2O (*thousand tons*)	0.04	0.12	0.15	0.60
NO_X (*thousand tons*)	8.41	24.84	31.35	127.26
SO_2 (*thousand tons*)	1.20	3.57	4.51	18.31
Hg (*tons*)	0.01	0.02	0.03	0.12
Present Value of Benefits and Costs (*3% discount rate, billion 2022$*)				
Consumer Operating Cost Savings	1.66	5.08	6.43	26.01
Climate Benefits*	0.25	0.75	0.95	3.86
Health Benefits**	0.45	1.34	1.70	6.89
Total Benefits†	2.37	7.17	9.08	36.76
Consumer Incremental Product Costs	0.54	1.39	1.47	5.02
Consumer Net Benefits	1.12	3.68	4.96	20.99
Total Net Benefits	1.82	5.78	7.61	31.74
Present Value of Benefits and Costs (*7% discount rate, billion 2022$*)				
Consumer Operating Cost Savings	0.68	2.09	2.66	10.76
Climate Benefits*	0.25	0.75	0.95	3.86
Health Benefits**	0.17	0.50	0.64	2.59
Total Benefits†	1.11	3.35	4.25	17.21
Consumer Incremental Product Costs	0.29	0.77	0.82	2.99
Consumer Net Benefits	0.39	1.32	1.84	7.77
Total Net Benefits	0.81	2.58	3.43	14.22

Note: This table presents the costs and benefits associated with ceiling fans shipped in 2028−2057. These results include benefits to consumers which accrue after 2057 from the products shipped in 2028−2057.
* Climate benefits are calculated using four different estimates of the SC-CO_2, SC-CH_4 and SC-N_2O. Together, these represent the global SC-GHG. For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3 percent discount rate are shown; however, DOE emphasizes the importance and value of considering the benefits calculated using all four sets of SC-GHG estimates. To monetize the benefits of reducing GHG emissions, this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the IWG.
** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for NO_X and SO_2) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. The health benefits are presented at real discount rates of 3 and 7 percent. See section IV.L of this document for more details.

† Total and net benefits include consumer, climate, and health benefits. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate.

Table V.35 Summary of Analytical Results for Ceiling Fans TSLs: Manufacturer and Consumer Impacts

Category	TSL 1*	TSL 2*	TSL 3*	TSL 4*
Manufacturer Impacts				
Industry NPV (*million 2022$*) (No-new-standards case INPV = 2,329)	2,272 – 2,293	2,244 – 2,298	2,227 – 2,286	2,003 – 2,278
Industry NPV *(% change)*	(2.4) – (1.5)	(3.6) – (1.3)	(4.4) – (1.8)	(14.0) – (2.2)
Consumer Average LCC Savings (2022$)				
Standard	$5.57	$11.25	$16.69	$39.84
Hugger	$2.10	$3.80	$5.14	$28.48
Large-Diameter	$68.20	$68.20	$68.20	($183.40)
High-Speed Belt-Driven	$508.29	$508.29	$663.92	$1,854.94
Consumer Simple PBP (years)				
Standard	5.9	7.0	4.1	4.4
Hugger	7.3	7.5	6.6	5.7
Large-Diameter	5.8	5.8	5.8	11.8
High-Speed Belt-Driven	20.0	2.5	2.1	0.8
Percent of Consumers that Experience a Net Cost				
Standard	17%	38%	36%	34%
Hugger	28%	33%	33%	42%
Large-Diameter	4%	4%	4%	43%
High-Speed Belt-Driven	0%	0%	0%	0%

Parentheses indicate negative (-) values.
* Weighted by shares of each product class in total projected shipments in 2022.

DOE first considered TSL 4, which represents the max-tech efficiency levels for all product classes. TSL 4 would require BLDC motors for all sizes of small diameter ceiling fans, including those sold in both the hugger and standard configuration. For large diameter ceiling fans, the highest level would include permanent magnet direct drive technology or BLDC motors depending on size, while the high-speed belt driven fans would likely include more efficient ECMs and aerodynamic redesign of the fan blades. TSL 4 would save an estimated 3.7 quads of energy, an amount DOE considers significant. Under TSL 4, the NPV of consumer benefit would be $7.8 billion using a discount rate of 7 percent, and $21.0 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 4 are 74 Mt of CO_2, 18 thousand tons of SO_2, 127 thousand tons of NO_X, 0.12 tons of Hg, 573 thousand tons of CH_4, and 0.6 thousand tons of N_2O. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC-GHG at a 3-percent discount rate) at TSL 4 is $3.9 billion. The estimated monetary value of the health benefits from reduced SO_2 and NO_X emissions at TSL 4 is $2.6 billion using a 7-percent discount rate and $6.9 billion using a 3-percent discount rate.

Using a 7-percent discount rate for consumer benefits and costs, health benefits from reduced SO_2 and NO_X emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated total NPV at TSL 4 is $14.2 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 4 is $31.7 billion.

At TSL 4, affected purchasers of standard ceiling fans experience an average LCC savings of $39.84, and those of hugger ceiling fans experience an average LCC savings of $28.48. Average LCC savings for HSBD ceiling fans are $1,855, whereas LDCF purchasers experience a loss of $183.4 (*i.e.*, negative LCC savings). The savings for small diameter ceiling fans are primarily driven by the incorporation of BLDC motors, which is a significantly more-efficient motor technology than what is commonly used today. The simple payback period is 4.4 years for standard ceiling fans, 5.7 years for hugger ceiling fans, 0.8 years for HSBD ceiling fans, and 11.8 years for LDCFs. The fraction of consumers experiencing a net LCC increase is 34 percent for standard ceiling fans, 42 percent for hugger ceiling fans, 0 percent for HSBD ceiling fans, and 43 percent for LDCFs. The fraction of consumers experiencing net costs are attributable mostly to the varied usage associated with ceiling fans.

For small diameter ceiling fans, BLDC motor designs are used in only 7 percent of the market currently. Amongst those shipments with BLDC motors, they are heavily weighted toward ceiling fans greater than 53 inches. For example, BLDC motors are available in over 50 percent of basic models among 60 inch diameter ceiling fans, compared to less than 10 percent of basic models among 44 inch and 52 inch diameter ceiling fans.

Currently, ceiling fans with smaller diameters (such as 44 inches in the standard and hugger configurations) can be purchased for as low as $30 to $50 at major big box stores and online retailers. Consumers purchasing these lower-cost products are likely the consumers who are most sensitive to increases in first cost. At TSL 4, the first cost for these products could increase by approximately 50 to 100 percent as a result of adopting TSL 4. DOE is concerned that, in some cases, the customer may forgo or defer the purchase of a new ceiling fan in the small diameter standard and hugger configuration due to the increase in first cost that would be required to achieve the efficiency levels associated with TSL 4. Further, while low-income consumers of standard and hugger fans experience an overall positive LCC savings of $52.89 and $42.44 respectively, an estimated 21 percent and 27 percent of standard and hugger fan low-income consumers, respectively, experience a net LCC increase. Further, these low-income consumer savings are partially driven by renters who do not purchase the ceiling fan but pay for the electricity consumed by the ceiling fan. If the increase in first cost results in a landlord forgoing the purchase of a ceiling fan, the renters would need to rely on alternative means for comfort conditioning or purchase the ceiling fan themselves. While DOE's research has not found a strong correlation between HVAC (*i.e.*, cooling) usage and ceiling fan usage (i.e., that air-conditioner usage replaces ceiling fan usage, or vice-versa)[89], DOE has acknowledged and applied a price elasticity. However, DOE does not have data to support or refute whether a customer that defers purchasing a ceiling fan due to the increase in first cost would, consequently, increase the use of their HVAC system, room air conditioner, portable air conditioner, or switch to cheaper (and typically less efficient[90]) fan options, such as a box fan.

DOE seeks comment on whether a certain percentage of consumers of small diameter ceiling fans, especially with diameters less than or equal to 53 inches in both the standard and hugger configurations, would defer or forgo purchasing ceiling fans with BLDC motors that achieve TSL 4 efficiency.

DOE also seeks comment on any evidence of consumers substituting one cooling method—*e.g.*, increased HVAC use—for another, *e.g.*, a forgone ceiling fan.

At TSL 4, the projected change in INPV for all ceiling fan manufacturers ranges from a decrease of $325.7 million to a decrease of $50.8 million, which corresponds to decreases of 14.0 percent and 2.2 percent, respectively. DOE estimates that industry must invest $245.5 million to comply with standards set at TSL 4 and that these investments are primarily driven by the number of ceiling fan models that will need to be redesigned at this TSL.

For standard and hugger ceiling fan manufacturers, the projected change in INPV at TSL 4 ranges from a decrease of $274.1 million to a decrease of $39.2 million, which

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[89] Kantner, C.L.S., S.J. Young, S.M. Donovan, and K. Garbesi. *Ceiling Fan and Ceiling Fan Light Kit Use in the U.S.—Results of a Survey on Amazon Mechanical Turk.* 2013. Lawrence Berkeley National Laboratory: Berkeley, CA. Report No. LBNL-6332E. (Last accessed April 12, 2023.) *http://www.escholarship.org/uc/item/3r67c1f9.*

[90] Alternative fan options are generally not subject to efficiency regulations and frequently rely on smaller diameters fans with higher rpms to produce airflow, leading to increased power usage relative to typical ceiling fans.

corresponds to decreases of 18.1 percent and 2.6 percent, respectively. DOE estimates that standard and hugger ceiling fan manufacturers must invest $199.6 million to comply with standards set at TSL 4, which is driven by manufacturers needing to redesign models representing approximately 93 percent of standard and hugger ceiling fan shipments to incorporate a BLDC motor.

Manufacturers currently have engineering designs and tooling equipment for approximately 2,500 standard and hugger ceiling fan models that use AC motors. At TSL 4, all engineering designs and tooling equipment associated with the production of standard and hugger ceiling fans using an AC motor will likely need to be redesigned or redeveloped to incorporate a BLDC motor. Manufacturers will likely need to develop new motor housings for standard and hugger ceiling fan models that use BLDC motors, as well as develop new tooling equipment that is unique to each BLDC motor ceiling fan model. Lastly, manufacturers will need to increase engineering resources to optimize and test the BLDC motor and controls for each newly redesigned standard and hugger ceiling fan model that uses a BLDC motor. These investments, both in engineering resources and in new production equipment, will likely strain manufacturers' limited resources during the three-year compliance period, given the number of standard and hugger ceiling fan models that need to be redesigned during this time period. DOE estimates that in the no-new-standards case, models representing approximately 7 percent of standard and hugger ceiling fan shipments would meet the efficiency levels analyzed at TSL 4. Standard and hugger ceiling fan manufacturers may have to change their component sourcing to ensure sufficient supply of BLDC motors or invest significant capital to manufacture BLDC motors in-house.

DOE seeks comment from stakeholders about whether BLDC motors and BLDC motor controllers are available in the sizes necessary to support the full range of hugger and standard ceiling fans as well as manufacturers' ability to ramp up their sourcing or production of such motors and controllers in the timeframe needed to comply with TSL 4 efficiencies for standard and hugger ceiling fans.

For LDCF manufacturers, the projected change in INPV at TSL 4 ranges from a decrease of $49.8 million to a decrease of $10.1 million, which corresponds to decreases of 6.2 percent and 1.2 percent, respectively. DOE estimates that LDCF manufacturers must invest $43.3 million to comply with standards set at TSL 4. DOE estimates that approximately 48 percent of LDCF shipments would meet the efficiency levels analyzed at TSL 4.

For HSBD ceiling fan manufacturers, the projected change in INPV at TSL 4 ranges from a decrease of $2.0 million to a decrease of $1.8 million, which corresponds to decreases of 75.7 percent and 66.7 percent, respectively. DOE estimates that HSBD ceiling fan manufacturers must invest $2.6 million to comply with standards set at TSL 4. DOE estimates that no HSBD ceiling fan shipments would meet the efficiency levels analyzed at TSL 4.

The Secretary tentatively concludes that at TSL 4 for ceiling fans, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the manufacturing impacts, including the large reduction in INPV for HSBD ceiling fans and the lack of manufacturers currently offering products meeting the efficiency levels required by this TSL for HSBD ceiling fans; the negative LCC benefits for LDCFs with a proposed standard at TSL 4; and the possibility for significant impacts on low-income consumers. As to the final point, the Secretary is concerned that certain (primarily low-income) consumers may decide to forgo purchasing ceiling fans as a result of the increase in first costs. DOE has previously received feedback from manufacturers that consumers may switch to cheaper (and typically less efficient) fan options, such as box fans, or increase use of HVAC systems in the event of significant increases in first costs for ceiling fans because it is a price sensitive market and ceiling fans are not considered a necessity by many consumers.[91] Further, as discussed previously, DOE estimates that, because of price sensitivity, an estimated 10 percent of consumers may exit the market for ceiling fans as a result of the price increases likely at TSL 4.[92] If DOE were to consider the welfare loss from these consumers exiting the market, the costs of a standard set at TSL 4 would be higher still. DOE notes that due to the sensitivity on first cost, a decision not to purchase a ceiling fan is more likely to affect low-income consumers and would impact the low-income economic analysis results presented in this proposed rule for TSL 4. Hence, to ensure accessibility to all consumers, including those with low incomes, the Secretary has tentatively concluded that TSL 4 is not economically justified.

DOE requests comment and data on whether and to what extent an increase in first costs would disproportionately impact low-income consumers.

DOE then considered TSL 3, which represents EL 3 for standard and hugger ceiling fans, EL 3 for HSBD ceiling fans, and EL 1 for LDCFs. TSL 3 would require the use of more-efficient AC motors for standard and hugger ceiling fans less than or equal to 53 inches and BLDC motors for all other standard and hugger ceiling fans, optimized

[91] (ALA, No. 26 at p. 2)
[92] For all other considered TSLs, the fraction of consumers who may exit the market is at most 2 percent based on the demand elasticities used in this NOPR. This is reflective of a smaller increase in average fan purchase price (less than 5 percent) than at TSL 4 (about 20 percent).

designs for each blade span for LDCFs, and ECMs for HSBD ceiling fans. TSL 3 would save an estimated 0.9 quads of energy, an amount DOE considers significant. Under TSL 3, the NPV of consumer benefit would be $1.8 billion using a discount rate of 7 percent, and $5.0 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 3 (for ceiling fans shipped between 2028 and 2057) are 18 Mt of CO_2, 5 thousand tons of SO_2, 31 thousand tons of NO_X, 0.03 tons of Hg, 141 thousand tons of CH_4, and 0.15 thousand tons of N_2O. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC-GHG at a 3-percent discount rate) at TSL 3 is $0.95 billion. The estimated monetary value of the health benefits from reduced SO_2 and NO_X emissions at TSL 3 is $0.6 billion using a 7-percent discount rate and $1.7 billion using a 3-percent discount rate.

Using a 7-percent discount rate for consumer benefits and costs, health benefits from reduced SO_2 and NO_X emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated total NPV at TSL 3 is $3.4 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 3 is $7.6 billion. The estimated total NPV is provided for additional information, but DOE uses the NPV of consumer benefits when determining whether a proposed standard level is economically justified.

At TSL 3, affected purchasers of standard ceiling fans experience an average LCC savings of $16.7, and those of hugger ceiling fans have $5.14 LCC savings. Average LCC savings for HSBD and LDCF ceiling fans are $664 and $68.2, respectively. The simple payback period is 4.1 years for standard ceiling fans, 6.6 years for hugger ceiling fans, 2.1 years for HSBD ceiling fans, and 5.8 years for LDCFs. The fraction of consumers experiencing a net LCC cost is 36 percent for standard ceiling fans, 33 percent for hugger ceiling fans, 0 percent for HSBD ceiling fans, and a 4 percent for LDCFs. In addition, at TSL 3, purchasers of standard and hugger fans spend on average an additional $9.8 and $3.8, respectively, in total installed cost compared to their corresponding baseline (EL 0).

Low-income consumers of standard and hugger fans experience positive LCC savings $21.8 and $8.2, respectively with a 19 percent and 18 percent of standard and hugger fan low-income consumers experiencing a net LCC cost. Further, unlike at TSL 4, DOE expects that low first-cost ceiling fans will remain on the market because compliance with TSL 3 will not require manufacturers to install BLDC motors in the small standard and hugger models that low-income consumers principally rely on. Accordingly, DOE expects that TSL 3 will not result in consumers who are particularly sensitive to purchase price when deciding whether or not to purchase a ceiling fan forgoing the purchase of a ceiling fan altogether.

At TSL 3, the projected change in INPV for all ceiling fan manufacturers ranges from a decrease of $101.3 million to a decrease of $42.6 million, which corresponds to decreases of 4.4 percent and 1.8 percent, respectively. DOE estimates that industry must invest $107.2 million to comply with standards set at TSL 3.

For standard and hugger ceiling fan manufacturers the projected change in INPV at TSL 3 ranges from a decrease of $91.4 million to a decrease of $35.8 million, which corresponds to decreases of 6.0 percent and 2.4 percent, respectively. DOE estimates that standard and hugger ceiling fan manufacturers must invest $93.2 million to comply with standards set at TSL 3. DOE estimates that in the no-new-standards case, models representing approximately 35 percent of standard and hugger ceiling fan shipments would meet or exceed the efficiency levels analyzed at TSL 3. Manufacturers will most likely not use a BLDC motor to meet the efficiency levels required at TSL 3 for standard and hugger ceiling fan models less than or equal to 53 inches. Therefore, any standard or hugger ceiling fan models that will be required to be redesigned will not need to accommodate a BLDC motor. While manufacturers will most likely need to use a BLDC motor to meet the efficiency levels required at TSL 3 for standard and hugger ceiling fan models greater than 53 inches, there are significantly fewer standard and hugger ceiling fan models and shipments greater than 53 inches compared to less than or equal to 53 inches.

For LDCF manufacturers the projected change in INPV at TSL 3 ranges from a decrease of $9.6 million to a decrease of $6.6 million, which corresponds to decreases of 1.2 percent and 0.8 percent, respectively. DOE estimates that LDCF manufacturers must invest $13.4 million to comply with standards set at TSL 3. DOE estimates that approximately 86 percent of LDCF shipments would meet or exceed the efficiency levels analyzed at TSL 3.

For HSBD ceiling fan manufacturers the projected change in INPV at TSL 3 ranges from a decrease of $0.4 million to a decrease of $0.2 million, which corresponds to decreases of 15.3 percent and 6.3 percent, respectively. DOE estimates that HSBD ceiling fan manufacturers must invest $0.5 million to comply with standards set at TSL 3. DOE estimates that approximately 59 percent of HSBD ceiling fan shipments would meet or exceed the efficiency levels analyzed at TSL 3.

After considering the analysis and weighing the benefits and burdens, the Secretary has tentatively concluded that at a standard set at TSL 3 for ceiling fans would be economically justified. At this TSL, the average LCC savings for all product classes is positive. An estimated 36 percent of standard ceiling fans, 33 percent for hugger ceiling fans, 0 percent for HSBD ceiling fans, and 4 percent for LDCFs experience a net cost. The FFC national energy savings are significant and the NPV of consumer benefits is positive using both a 3-percent and 7-percent discount rate. Notably, the benefits to consumers vastly outweigh the cost to manufacturers. Further, the increase in total installed cost is considerably less than TSL 4, and weighted toward larger blade-spans that are more likely to be purchased for features other than only first cost (and thus less likely to burden low-income consumers) and where BLDC motors already make up a significant percentage of basic model designs. TSL3 retains a low-cost entry price point for all standard and hugger ceiling fans less than 53 inches. This ensures that lower-income consumers for whom initial purchase price is the driving factor in purchasing a ceiling fan retain a low-cost option. The projected 2 percent reduction in shipments at TSL 3 (about 0.44 million units), as a result of the increased first costs relative to the no-new-standards case in the compliance year, is considerably less than the projected impact at TSL 4. At TSL 3, the NPV of consumer benefits, even measured at the more conservative discount rate of 7 percent is over 15 times higher than the maximum estimated manufacturers' loss in INPV. The standard levels at TSL 3 are economically justified even without weighing the estimated monetary value of emissions reductions. When those emissions reductions are included – representing $0.95 billion in climate benefits (associated with the average SC-GHG at a 3-percent discount rate), and $ 1.7 billion (using a 3-percent discount rate) or $ 0.6 billion (using a 7-percent discount rate) in health benefits – the rationale becomes stronger still.

TSL 3 includes efficiency levels that require the use of similar technologies for standard and hugger ceiling fans. DOE market research indicates that the current markets offer similar, if not identical designs, for models that differ only in the way they are mounted to the ceiling. For example, DOE has observed that standard ceiling fan models are often sold as a down rod in combination with an otherwise identical hugger ceiling fan model, the combination of which make it a standard ceiling fan. While DOE did not explicitly analyze a TSL that would require TSL 4 efficiency levels for standard ceiling fans and TSL 3 efficiency levels for hugger fans, DOE is strongly considering this alternative combination for the final rule. In that case, DOE would expect the market to begin expanding for BLDC motor technology to support all size ranges of standard ceiling fans, while allowing hugger fans to continue to utilize AC motor technology. This could allow for a more gradual transition and would maintain a low-cost option on the market for hugger ceiling fans, which predominantly service households with lower or standard-size ceiling heights[93]. DOE believes this would help alleviate some of the first cost concerns associated with TSL 4. Even though this hybrid TSL 3 and TSL 4 policy scenario could provide additional benefits, DOE is concerned that manufacturers may respond to the TSL 4 standard ceiling fan efficiency requirements, which essentially require BLDC motor technology, by changing the way they offer ceiling fans for sale. In particular, DOE wonders whether manufacturers would shift to a strategy where they simply offer down rods on hugger ceiling fans that allow for the conversion to standard ceiling fan when installed. This strategy has the potential to significantly decrease the shipments of standard ceiling fans (and the potential benefits from a more efficient proposed standard at TSL 4 efficiency levels for standard fans) by shifting the market to predominantly hugger fans and employing installation alterations to standard ceiling fans

[93] Hugger ceiling fans are installed closer to the ceiling and as such allow for additional head-space below the ceiling fan relative to standards ceiling fans. This makes hugger ceiling fans more likely to be installed in lower ceiling heights than standard ceiling fans.

for the price sensitive part of the market. In such a scenario, the savings associated with this TSL option may never be realized. Down rods are already sold as separate products from most standard and hugger manufacturers to accommodate a variety of ceiling heights. While the current market mostly focuses on large down rods for higher ceiling applications, DOE is concerned that such a market would develop for two to four inch down rods that are common in most standard ceiling fans because the infrastructure for selling down rods directly to consumers already exists today. Therefore, consumers may elect to purchase a hugger fan and a separate two-to-four inch down rod, thereby avoiding purchasing a ceiling fan with a BLDC motor.

DOE seeks comment on this alternative proposed standard level as well as the unintended market consequences and the changes industry would make to the way they bring products to market as a result of standards that require the use of different motor technologies for standard and hugger ceiling fans with small diameters.

As stated, DOE conducts the walk-down analysis to determine the TSL that represents the maximum improvement in energy efficiency that is technologically feasible and economically justified as required under EPCA. The walk-down is not a comparative analysis, as a comparative analysis would result in the maximization of net benefits instead of energy savings that are technologically feasible and economically justified, which would be contrary to the statute. 86 FR 70892, 70908. Although DOE has not conducted a comparative analysis to select the proposed energy conservation standards, DOE notes that for standard and hugger ceiling fans, TSL 3 preserves the low-cost AC motor segment of the ceiling fan market, which permits low-cost consumers to experience minimal increases in first cost, whereas TSL 4 results in a greater increase in first cost for these low-income consumers. TSL 3 also offers higher LCC and lower reduction in INPV than TSL 4 for LDCFs and a considerably lower reduction in INPV for HSBD ceiling fans.

Although DOE considered proposed new and amended standard levels for ceiling fans by grouping the efficiency levels for each product class into TSLs, DOE evaluates all analyzed efficiency levels in its analysis. For standard and hugger ceiling fans, TSL 3 (*i.e.,* the proposed TSL) includes the maximum level of energy savings while preserving lower-cost products on the market for low-income consumers. As previously discussed, setting standards at max-tech for standard and hugger ceiling fans would significantly increase the price of the lowest cost products on the market, reducing shipments (and purchases) by 10 percent, which would disproportionately impact low-income consumers who are most affected by price increases. For LDCFs, TSL 3 represents the highest efficiency level with positive LCC and setting standards above this level would result in negative LCC for consumers. For HSBD ceiling fans, TSL 3 represents the highest efficiency level for which products are currently offered and setting standards at max-tech for these products could result in significant reduction in INPV. Therefore, DOE has concluded that max-tech is not justified.

Table V.36 Proposed Amended Energy Conservation Standards for Ceiling Fans

Equipment Class	**CFM/W**
Standard Ceiling Fans*	D ≤ 53 in.: 0.69 D+53.25 D > 53 in.: 1.31 D +52.08
Hugger Ceiling Fans*	D ≤ 53 in.: 0.56 D+48.75 D > 53 in.: 1.37 D +38.5
Equipment Class	**CFEI**
Large-Diameter Ceiling Fans	1.22 at high speed 1.31 at 40 percent speed or the nearest speed that is not less than 40 percent speed.
High-Speed Belt-Driven Ceiling Fans	1.89 at high speed

* D is the representative value of blade span as determined in accordance with the DOE test procedure at appendix U to subpart B of 10 CFR part 430 and applicable sampling plans.

2. Annualized Benefits and Costs of the Proposed Standards

The benefits and costs of the proposed standards can also be expressed in terms of annualized values. The annualized net benefit is (1) the annualized national economic value (expressed in 2022$) of the benefits from operating products that meet the proposed standards (consisting primarily of operating cost savings from using less energy, minus increases in product purchase costs, and (2) the annualized monetary value of the climate and health benefits from emission reductions.

Table V.20 shows the annualized values for ceiling fans under TSL 3, expressed in 2022$. The results under the primary estimate are as follows.

Using a 7-percent discount rate for consumer benefits and costs and NOx and SO_2 reduction benefits, and a 3-percent discount rate case for GHG social costs, the estimated cost of the proposed standards for ceiling fans is $86.6 million per year in increased equipment costs, while the estimated annual benefits are $281.1 million from reduced equipment operating costs, $54.7 million from GHG reductions, and $67.5 million from reduced NO_X and SO_2 emissions. In this case, the net benefit amounts to $316.74 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated cost of the proposed standards for ceiling fans is $84.6 million per year in increased equipment costs, while the estimated annual benefits are $369.3 million in reduced operating costs, $54.7 million from GHG reductions, and $97.5 million from reduced NO_X and SO_2 emissions. In this case, the net benefit amounts to $436.9 million per year.

Table V.37 Annualized Benefits and Costs of Proposed Energy Conservation Standards for Ceiling Fans (TSL 3)

	Million 2022$/year		
	Primary Estimate	**Low-Net-Benefits Estimate**	**High-Net-Benefits Estimate**
3% discount rate			
Consumer Operating Cost Savings	369.3	343.9	387.6
Climate Benefits*	54.7	52.4	55.5
Health Benefits**	97.5	93.6	98.9
Total Benefits†	521.4	489.9	542.1
Consumer Incremental Product Costs	84.6	85.8	81.3
Net Benefits	436.9	404.1	460.7
7% discount rate			
Consumer Operating Cost Savings	281.1	263.2	294.3
Climate Benefits* (3% discount rate)	54.7	52.4	55.5
Health Benefits**	67.5	65.1	68.5
Total Benefits†	403.3	380.7	418.3
Consumer Incremental Product Costs	86.6	87.7	83.6
Net Benefits	316.7	293.0	334.7

Note: This table presents the costs and benefits associated with ceiling fans shipped in 2028−2057. These results include benefits to consumers which accrue after 2057 from the products shipped in 2028−2057. The Primary, Low Net Benefits, and High Net Benefits Estimates utilize projections of energy prices from the AEO 2023 Reference case, Low Economic Growth case, and High Economic Growth case, respectively. The methods used to derive projected price trends are explained in sections IV.F.1 and IV.H.2 of this document. Note that the Benefits and Costs may not sum to the Net Benefits due to rounding.
* Climate benefits are calculated using four different estimates of the global SC-GHG (see section IV.L of this document). For presentational purposes of this table, the climate benefits associated with the average SC-GHG at a 3 percent discount rate are shown; however, DOE emphasizes the importance and value of considering the benefits calculated using all four sets of SC-GHG estimates. To monetize the benefits of reducing GHG emissions, this analysis uses the interim estimates presented in the Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990 published in February 2021 by the IWG.
** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. *See* section IV.L of this document for more details.
† Total benefits for both the 3-percent and 7-percent cases are presented using the average SC-GHG with 3-percent discount rate.

D. Reporting, Certification, and Sampling Plan

Manufacturers, including importers, must use product-specific certification templates to certify compliance to DOE. For ceiling fans, the certification template reflects the general certification requirements specified at 10 CFR 429.12 and the product-specific requirements specified at 10 CFR 429.32. As discussed in the previous paragraphs, DOE is not proposing to amend the product-specific certification requirements for these products.

VI. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866, 13563, and 14094

Executive Order ("E.O.") 12866, "Regulatory Planning and Review," as supplemented and reaffirmed by E.O. 13563, "Improving Regulation and Regulatory Review, 76 FR 3821 (Jan. 21, 2011) and E.O. 14094, "Modernizing Regulatory Review," 88 FR 21879 (Apr. 11, 2023), requires agencies, to the extent permitted by law, to (1) propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify); (2) tailor regulations to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity); (4) to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt; and (5) identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public. DOE emphasizes as well that E.O. 13563 requires agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. In its guidance, the Office of Information and Regulatory Affairs ("OIRA") in the Office of Management and Budget ("OMB") has emphasized that such techniques may include identifying changing future compliance costs that might result from technological innovation or anticipated behavioral changes. For the reasons stated in the preamble, this proposed regulatory action is consistent with these principles.

Section 6(a) of E.O. 12866 also requires agencies to submit "significant regulatory actions" to OIRA for review. OIRA has determined that this proposed regulatory action constitutes a "significant regulatory action" within the scope of section 3(f)(1) of E.O. 12866. Accordingly, pursuant to section 6(a)(3)(C) of E.O. 12866, DOE has provided to OIRA an assessment, including the underlying analysis, of benefits and costs anticipated from the proposed regulatory action, together with, to the extent feasible, a quantification of those costs; and an assessment, including the underlying analysis, of costs and benefits of potentially effective and reasonably feasible alternatives to the planned regulation, and an explanation why the planned regulatory action is preferable to the identified potential alternatives. These assessments are summarized in this preamble and further detail can be found in the technical support document for this proposed rulemaking.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires preparation of an initial regulatory flexibility analysis ("IRFA") for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by E.O. 13272, "Proper Consideration of Small Entities in Agency Rulemaking," 67 FR 53461 (Aug. 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's website (*energy.gov/gc/office-general-counsel*). DOE has prepared the following IRFA for the products that are the subject of this proposed rulemaking.

For manufacturers of ceiling fans, the SBA has set a size threshold, which defines those entities classified as "small businesses" for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule. (*See* 13 CFR part 121.) The size standards are listed by North American Industry Classification System ("NAICS") code and industry description and are available at *www.sba.gov/document/support-table-size-standards*. Manufacturing of standard and hugger ceiling fans is classified under NAICS 335210, "Small Electrical Appliance Manufacturing." The SBA sets a threshold of 1,500 employees or fewer for an entity to be considered as a small business for this category. Manufacturing of LDCFs and HSBD ceiling fans is classified under NAICS 333413, "Industrial and Commercial Fan and Blower and Air Purification Equipment Manufacturing." The SBA sets a threshold of 500 employees or fewer for an entity to be considered as a small business for this category.

1. Description of Reasons Why Action Is Being Considered

EPCA requires that, not later than 6 years after the issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a NOPR including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6295(m)(1)).

2. Objectives of, and Legal Basis for, Rule

DOE must follow specific statutory criteria for prescribing new or amended standards for covered products, including ceiling fans. Any new or amended standard for a covered product must be designed to achieve the maximum improvement in energy efficiency that the Secretary of Energy determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A) and 42 U.S.C. 6295(o)(3)(B))

3. Description on Estimated Number of Small Entities Regulated

DOE conducted a more focused inquiry of the companies that could be small businesses which manufacture ceiling fans covered by this proposed rulemaking. DOE referenced DOE's publicly available CCD to generate a list of brands associated with covered products, identified the businesses selling each brand using publicly available online information, and referenced D&B Hoovers[94] reports to determine whether they might meet the criteria of a small business. DOE screened out companies that do not offer products covered by this rulemaking, do not meet the definition of a "small business," or are foreign owned and operated.

For ceiling fans, DOE identified 91 companies that manufacture ceiling fans covered by this rulemaking. 61 of these companies are large businesses—with more than 500 total employees if they manufacture LDCF and HSBD or with more than 1,500 total employees if they manufacture standard and hugger ceiling fans—or are foreign-owned

[94] *app.avention.com/login.*

and operated. DOE determined that there were 16 domestic businesses with less than 1,500 total employees that sell standard and hugger ceiling fans covered by this rulemaking, 10 domestic businesses with less than 500 total employees that sell LDCFs covered by this rulemaking, and four domestic businesses with less than 500 total employees that sell HSBD ceiling fans covered by this rulemaking.

Of the 16 domestic businesses that have fewer than 1,500 total employees and manufacture standard and hugger ceiling fans covered by this rulemaking, none of these companies own or maintain domestic production facilities. All 16 of these companies either manufacture their standard and hugger ceiling fans in Asia or out-source their standard and hugger ceiling fans to an original equipment manufacturer ("OEM") located in Asia. Of the 10 domestic businesses with less than 500 total employees that manufacture LDCFs covered by this rulemaking, nine have domestic production facilities. All four domestic businesses with less than 500 total employees that manufacture HSBD ceiling fans covered by this rulemaking have domestic production facilities.

Therefore, DOE did not identify any domestic standard and hugger ceiling fan manufacturers that meet SBA's definition of a small business. DOE identified nine LDCF manufacturers and four HSBD ceiling fan manufacturers that meet SBA's definition of a small business.

DOE requests comment on the number of small businesses identified that meet SBA's definition of a small business and manufacture ceiling fans covered by this proposed rulemaking.

4. Description and Estimate of Compliance Requirements Including Differences in Cost, if Any, for Different Groups of Small Entities

DOE cross-referenced its manufacturer list and brand-to-manufacturer mapping as well as the CCD to create an estimate of the number of models or product families associated with each small entity. DOE further estimated the number of models or product families that would need to be redesigned for each manufacturer, based on the standards proposed in this document. Using the cost estimates previously discussed in section IV.J.2.c of this document, DOE provides estimates of costs for each small business in the following tables for LDCFs and HSBD ceiling fans respectively.

Table VI.1 Small Business Impacts – Large Diameter Ceiling Fans

Small Business	**Estimated Annual Revenue** *(2022$)*	**Total Product Families**	**Estimated Product Families to be Redesigned**	**Estimated Total Conversion Cost** *(2022$)*	**Total Conversion Cost as a Percentage of Compliance-Period Revenue***
Small Business 1	$610,000	10	5	$4,800,000	263.3%
Small Business 2	$795,000	1	1	$960,000	40.3%
Small Business 3	$1,480,000	1	1	$960,000	21.6%
Small Business 4	$19,000,000	5	3	$2,880,000	5.1%
Small Business 5	$21,880,000	2	1	$960,000	1.5%
Small Business 6	$401,000	1	0	-	-
Small Business 7	$244,000	1	0	-	-
Small Business 8	$63,400	2	0	-	-
Small Business 9	$56,000	1	0	-	-

* Compliance period revenue is equal to the “Estimated Annual Revenue” times 3 to account for the 3-year compliance period. Values may not be exact due to rounding.

Table VI.2 Small Business Impacts – High-Speed-Belt-Driven Ceiling Fans

Small Business	**Estimated Annual Revenue** *(2022$)*	**Total Models**	**Estimated Models to be Redesigned**	**Estimated Total Conversion Cost** *(2022$)*	**Total Conversion Cost as a Percentage of Compliance-Period Revenue***
Small Business 1	$930,000	5	3	$233,500	8.4%
Small Business 2	$12,460,000	5	4	$311,400	0.8%
Small Business 3	$5,050,000	1	0	-	-
Small Business 4	$1,440,000	1	0	-	-

* Compliance period revenue is equal to the “Estimated Annual Revenue” times 3 to account for the 3-year compliance period. Values may not be exact due to rounding.

Manufacturers are expected to spread out redesign and retooling costs across the three-year compliance window and, additionally, are expected to prioritize models based on sales volume. Some businesses, particularly those with high conversion costs relative to their annual revenue, may opt to remove models from their product offerings in order to reduce overall conversion costs. Manufacturers may need to seek outside funding to support redesign efforts if internal free cash flows are insufficient. Manufacturers are able to sell non-compliant products produced or imported prior to the compliance date. Additional information about product conversion costs and small business impacts are included in chapter 12 of the NOPR TSD.

DOE requests comment on the estimated and other costs which small manufacturers of ceiling fans may incur if this proposed rulemaking is finalized.

DOE additionally requests comment on whether small businesses would opt to remove models from the market rather than redesign, the basis for which models would be redesigned, and the extent to which this would be the case.

5. Duplication, Overlap, and Conflict with Other Rules and Regulations

DOE is not aware of any other rules or regulations that duplicate, overlap, or conflict with the rule being considered today.

6. Significant Alternatives to the Rule

The discussion in the previous section analyzes impacts on small businesses that would result from DOE's proposed rule, represented by TSL 3. In reviewing alternatives to the proposed rule, DOE examined energy conservation standards set at lower efficiency levels. While TSL 1 and TSL 2 would reduce the impacts on small business manufacturers, it would come at the expense of a large reduction in energy savings. TSL 1 achieves 73 percent lower energy savings compared to the energy savings at TSL 3.

TSL 2 achieves 26 percent lower energy savings compared to the energy savings at TSL 3.

Based on the presented discussion, establishing standards at TSL 3 balances the benefits of the energy savings at TSL 3 with the potential burdens placed on ceiling fan manufacturers, including small business manufacturers. Accordingly, DOE does not propose one of the other TSLs considered in the analysis, or the other policy alternatives examined as part of the regulatory impact analysis and included in chapter 17 of the NOPR TSD.

Additional compliance flexibilities may be available through other means. EPCA provides that a manufacturer whose annual gross revenue from all of its operations does not exceed $8 million may apply for an exemption from all or part of an energy conservation standard for a period not longer than 24 months after the effective date of a final rule establishing the standard. (42 U.S.C. 6295(t)) This exemption, if granted, would effectively extend the compliance window up to five years from the publication of a final rule. Additionally, manufacturers subject to DOE's energy efficiency standards may apply to DOE's Office of Hearings and Appeals for exception relief under certain circumstances. Manufacturers should refer to 10 CFR part 430, subpart E, and 10 CFR part 1003 for additional details.

C. Review Under the Paperwork Reduction Act

Manufacturers of ceiling fans must certify to DOE that their products comply with any applicable energy conservation standards. In certifying compliance, manufacturers must test their products according to the DOE test procedures for ceiling fans, including any amendments adopted for those test procedures. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, including ceiling fans. (*See generally* 10 CFR part 429). The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act ("PRA"). This requirement has been approved by OMB under OMB control number 1910-1400. Public reporting burden for the certification is estimated to average 35 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

D. Review Under the National Environmental Policy Act of 1969

DOE is analyzing this proposed regulation in accordance with the National Environmental Policy Act of 1969 ("NEPA") and DOE's NEPA implementing regulations (10 CFR part 1021). DOE's regulations include a categorical exclusion for rulemakings that establish energy conservation standards for consumer products or industrial equipment. 10 CFR part 1021, subpart D, appendix B5.1. DOE anticipates that this rulemaking qualifies for categorical exclusion B5.1 because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, none of the exceptions identified in categorical exclusion B5.1(b) apply, no extraordinary circumstances exist that require further environmental analysis, and it otherwise meets the requirements for application of a categorical exclusion. *See* 10 CFR 1021.410. DOE will complete its NEPA review before issuing the final rule.

E. Review Under Executive Order 13132

E.O. 13132, "Federalism," 64 FR 43255 (Aug. 10, 1999), imposes certain requirements on Federal agencies formulating and implementing policies or regulations that preempt State law or that have federalism implications. The Executive order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE has examined this proposed rule and has tentatively determined that it would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the products that are the subject of this proposed rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297) Therefore, no further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

With respect to the review of existing regulations and the promulgation of new regulations, section 3(a) of E.O. 12988, "Civil Justice Reform," imposes on Federal agencies the general duty to adhere to the following requirements: (1) eliminate drafting errors and ambiguity, (2) write regulations to minimize litigation, (3) provide a clear legal standard for affected conduct rather than a general standard, and (4) promote simplification and burden reduction. 61 FR 4729 (Feb. 7, 1996). Regarding the review required by section 3(a), section 3(b) of E.O. 12988 specifically requires that executive agencies make every reasonable effort to ensure that the regulation: (1) clearly specifies the preemptive effect, if any, (2) clearly specifies any effect on existing Federal law or regulation, (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction, (4) specifies the retroactive effect, if any, (5) adequately defines key terms, and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires executive agencies to review regulations in light of applicable standards in section 3(a) and section 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this proposed rule meets the relevant standards of E.O. 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 ("UMRA") requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Pub. L. 104-4, section 201 (codified at 2 U.S.C. 1531). For a proposed regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2

U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed "significant intergovernmental mandate," and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect them. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820. DOE's policy statement is also available at *energy.gov/sites/prod/files/gcprod/documents/umra_97.pdf*.

Although this proposed rule does not contain a Federal intergovernmental mandate, it may require expenditures of $100 million or more in any one year by the private sector. Such expenditures may include: (1) investment in research and development and in capital expenditures by ceiling fans manufacturers in the years between the final rule and the compliance date for the new standards and (2) incremental additional expenditures by consumers to purchase higher-efficiency ceiling fans, starting at the compliance date for the applicable standard.

Section 202 of UMRA authorizes a Federal agency to respond to the content requirements of UMRA in any other statement or analysis that accompanies the proposed rule. (2 U.S.C. 1532(c)) The content requirements of section 202(b) of UMRA relevant to a private sector mandate substantially overlap the economic analysis requirements that apply under section 325(o) of EPCA and Executive Order 12866. The **SUPPLEMENTARY INFORMATION** section of this NOPR and the TSD for this proposed rule respond to those requirements.

Under section 205 of UMRA, the Department is obligated to identify and consider a reasonable number of regulatory alternatives before promulgating a rule for which a written statement under section 202 is required. (2 U.S.C. 1535(a)) DOE is required to select from those alternatives the most cost-effective and least burdensome alternative that achieves the objectives of the proposed rule unless DOE publishes an explanation for doing otherwise, or the selection of such an alternative is inconsistent with law. As required by 42 U.S.C. 6295(m), this proposed rule would establish new and amended energy conservation standards for ceiling fans that are designed to achieve the maximum improvement in energy efficiency that DOE has determined to be both technologically feasible and economically justified, as required by 42 U.S.C. 6295(o)(2)(A) and 6295(o)(3)(B). A full discussion of the alternatives considered by DOE is presented in chapter 17 of the TSD for this proposed rule.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105-277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

I. Review Under Executive Order 12630

Pursuant to E.O. 12630, "Governmental Actions and Interference with Constitutionally Protected Property Rights," 53 FR 8859 (Mar. 15, 1988), DOE has determined that this proposed rule would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under the Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516 note) provides for Federal agencies to review most disseminations of information to the public under information quality guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). Pursuant to OMB Memorandum M-19-15, Improving Implementation of the Information Quality Act (April 24, 2019), DOE published updated guidelines which are available at *www.energy.gov/sites/prod/files/2019/12/f70/DOE%20Final%20Updated%20IQA%20Guidelines%20Dec%202019.pdf*. DOE has reviewed this NOPR under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

E.O. 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use," 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OIRA at OMB, a Statement of Energy Effects for any proposed significant energy action. A "significant energy action" is defined as any action by an agency that promulgates or is expected to lead to promulgation of a final rule, and that (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy, or (3) is designated by the Administrator of OIRA as a significant energy action. For any proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

DOE has tentatively concluded that this regulatory action, which proposes new and amended energy conservation standards for ceiling fans, is not a significant energy action because the proposed standards are not likely to have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as such by the Administrator at OIRA. Accordingly, DOE has not prepared a Statement of Energy Effects on this proposed rule.

L. Information Quality

On December 16, 2004, OMB, in consultation with the Office of Science and Technology Policy ("OSTP"), issued its Final Information Quality Bulletin for Peer Review ("the Bulletin"). 70 FR 2664 (Jan. 14, 2005). The Bulletin establishes that certain scientific information shall be peer reviewed by qualified specialists before it is disseminated by the Federal Government, including influential scientific information related to agency regulatory actions. The purpose of the bulletin is to enhance the quality and credibility of the Government's scientific information. Under the Bulletin, the energy conservation standards rulemaking analyses are "influential scientific information," which the Bulletin defines as "scientific information the agency reasonably can determine will have, or does have, a clear and substantial impact on important public policies or private sector decisions." 70 FR 2664, 2667.

In response to OMB's Bulletin, DOE conducted formal peer reviews of the energy conservation standards development process and the analyses that are typically used and has prepared a report describing that peer review.[95] Generation of this report involved a rigorous, formal, and documented evaluation using objective criteria and qualified and independent reviewers to make a judgment as to the technical/scientific/business merit, the actual or anticipated results, and the productivity and management effectiveness of programs and/or projects. Because available data, models, and technological understanding have changed since 2007, DOE has engaged with the National Academy of Sciences to review DOE's analytical methodologies to ascertain whether modifications are needed to improve the Department's analyses. DOE is in the process of evaluating the resulting report.[96]

VII. Public Participation

A. Participation in the Webinar

The time and date of the webinar meeting are listed in the **DATES** section at the beginning of this document. Webinar registration information, participant instructions, and information about the capabilities available to webinar participants will be published on DOE's website: *www.energy.gov/eere/buildings/public-meetings-and-comment-deadlines*. Participants are responsible for ensuring their systems are compatible with the webinar software.

B. Procedure for Submitting Prepared General Statements for Distribution

Any person who has an interest in the topics addressed in this proposed rule, or who is representative of a group or class of persons that has an interest in these issues,

[95] The 2007 "Energy Conservation Standards Rulemaking Peer Review Report" is available at the following website: *energy.gov/eere/buildings/downloads/energy-conservation-standards-rulemaking-peer-review-report-0* (last accessed February 7, 2023).
[96] The report is available at *www.nationalacademies.org/our-work/review-of-methods-for-setting-building-and-equipment-performance-standards.*

may request an opportunity to make an oral presentation at the webinar. Such persons may submit to *ApplianceStandardsQuestions@ee.doe.gov*. Persons who wish to speak should include with their request a computer file in WordPerfect, Microsoft Word, PDF, or text (ASCII) file format that briefly describes the nature of their interest in this proposed rulemaking and the topics they wish to discuss. Such persons should also provide a daytime telephone number where they can be reached.

C. Conduct of the Webinar

DOE will designate a DOE official to preside at the webinar/public meeting and may also use a professional facilitator to aid discussion. The meeting will not be a judicial or evidentiary-type public hearing, but DOE will conduct it in accordance with section 336 of EPCA (42 U.S.C. 6306). A court reporter will be present to record the proceedings and prepare a transcript. DOE reserves the right to schedule the order of presentations and to establish the procedures governing the conduct of the webinar. There shall not be discussion of proprietary information, costs or prices, market share, or other commercial matters regulated by U.S. anti-trust laws. After the webinar and until the end of the comment period, interested parties may submit further comments on the proceedings and any aspect of the proposed rulemaking.

The webinar will be conducted in an informal, conference style. DOE will a general overview of the topics addressed in this proposed rulemaking, allow time for prepared general statements by participants, and encourage all interested parties to share their views on issues affecting this rulemaking. Each participant will be allowed to make a general statement (within time limits determined by DOE), before the discussion of specific topics. DOE will permit, as time permits, other participants to comment briefly on any general statements.

At the end of all prepared statements on a topic, DOE will permit participants to clarify their statements briefly. Participants should be prepared to answer questions by DOE and by other participants concerning these issues. DOE representatives may also ask questions of participants concerning other matters relevant to this rulemaking. The official conducting the webinar/public meeting will accept additional comments or questions from those attending, as time permits. The presiding official will announce any further procedural rules or modification of the above procedures that may be needed for the proper conduct of the webinar.

A transcript of the webinar will be included in the docket, which can be viewed as described in the *Docket* section at the beginning of this proposed rule. In addition, any person may buy a copy of the transcript from the transcribing reporter

D. Submission of Comments

DOE will accept comments, data, and information regarding this proposed rule before or after the public meeting, but no later than the date provided in the **DATES** section at the beginning of this proposed rule. Interested parties may submit comments, data, and other information using any of the methods described in the **ADDRESSES** section at the beginning of this document.

Submitting comments via *www.regulations.gov*. The *www.regulations.gov* webpage will require you to provide your name and contact information. Your contact information will be viewable to DOE Building Technologies staff only. Your contact information will not be publicly viewable except for your first and last names, organization name (if any), and submitter representative name (if any). If your comment is not processed properly because of technical difficulties, DOE will use this information to contact you. If DOE cannot read your comment due to technical difficulties and cannot contact you for clarification, DOE may not be able to consider your comment.

However, your contact information will be publicly viewable if you include it in the comment itself or in any documents attached to your comment. Any information that you do not want to be publicly viewable should not be included in your comment, nor in any document attached to your comment. Otherwise, persons viewing comments will see only first and last names, organization names, correspondence containing comments, and any documents submitted with the comments.

Do not submit to *www.regulations.gov* information for which disclosure is restricted by statute, such as trade secrets and commercial or financial information (hereinafter referred to as Confidential Business Information ("CBI")). Comments submitted through *www.regulations.gov* cannot be claimed as CBI. Comments received through the website will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section.

DOE processes submissions made through *www.regulations.gov* before posting. Normally, comments will be posted within a few days of being submitted. However, if large volumes of comments are being processed simultaneously, your comment may not be viewable for up to several weeks. Please keep the comment tracking number that *www.regulations.gov* provides after you have successfully uploaded your comment.

Submitting comments via email, hand delivery/courier, or postal mail. Comments and documents submitted via email, hand delivery/courier, or postal mail also will be posted to *www.regulations.gov*. If you do not want your personal contact information to be publicly viewable, do not include it in your comment or any accompanying documents. Instead, provide your contact information in a cover letter. Include your first and last names, email address, telephone number, and optional mailing address. The cover letter will not be publicly viewable as long as it does not include any comments.

Include contact information each time you submit comments, data, documents, and other information to DOE. If you submit via postal mail or hand delivery/courier, please provide all items on a CD, if feasible, in which case it is not necessary to submit printed copies. No telefacsimiles ("faxes") will be accepted.

Comments, data, and other information submitted to DOE electronically should be provided in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format. Provide documents that are not secured, that are written in English, and that are free of any defects or viruses. Documents should not contain special characters or any form of encryption and, if possible, they should carry the electronic signature of the author.

Campaign form letters. Please submit campaign form letters by the originating organization in batches of between 50 to 500 form letters per PDF or as one form letter with a list of supporters' names compiled into one or more PDFs. This reduces comment processing and posting time.

Confidential Business Information. Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email two well-marked copies: one copy of the document marked "confidential" including all the information believed to be confidential, and one copy of the document marked "non-confidential" with the information believed to be confidential deleted. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

It is DOE's policy that all comments may be included in the public docket, without change and as received, including any personal information provided in the comments (except information deemed to be exempt from public disclosure).

E. Issues on Which DOE Seeks Comment

Although DOE welcomes comments on any aspect of this proposal, DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

(1) DOE requests comment on its assumption that there are zero products on the market that meet the definition of both ceiling fan and VSD ceiling fan, and its decision not to evaluate amended energy conservation standards for VSD ceiling fans on that basis.

(2) DOE requests comment and data on the distribution of HSBD blade spans.

(3) DOE requests comment and data regarding whether a 50-inch fan is representative of an HSBD ceiling fan.

(4) DOE requests comment on the difference in airflow and power consumption between fans at baseline efficiency and higher efficiency levels while still using an AC motor.

(5) DOE requests data as to the average airflow of HSBD ceiling fans and the range of airflows available.

(6) DOE requests comment and data regarding its tentative determination that energy conservation standards for LDCF standby power would be met by

removing consumer features from the default controller, and that this would likely not result in energy savings.

(7) DOE requests comment and data on the primary factors that govern LDCF controller purchasing decisions.

(8) DOE requests comment and data on the gross margin trends for household durables relevant to ceiling fans that experienced an increase in the cost of goods sold.

(9) DOE requests comment and data as to whether the assumed operating hours and operating speeds are appropriate for HSBD ceiling fans.

(10) DOE requests comment and data on the impact on air-conditioning or heating equipment use from the adoption of more stringent efficiency standards on ceiling fans.

(11) DOE requests comment and data on its assumption that installation costs do not vary by efficiency level for a given product class.

(12) DOE requests comment and data on its lifetime methodology and estimated survival probability distribution for ceiling fans. DOE also requests comment and data as to whether HSBD ceiling fans have a different lifetime than other ceiling fans.

(13) DOE seeks comment on the potential market response to a disparity in standards for standard and hugger product classes, including but not limited to the potential for product switching. Specifically, DOE seeks comment and data as to how the market would respond to a standard requiring BLDC motors for standard ceiling fans but not for hugger ceiling fans.

(14) DOE requests comment on the long-term implications of supply chain disruption on the microchip and semiconductor cost components of affected ceiling fans.

(15) DOE requests comment on its price learning assumption and methodology, including but not limited to data supporting existing or alternative price trends for fans with BLDC motors.

(16) DOE requests comment on its shipment projection methodology and assumptions, including the demand function and associated elasticities for ceiling fans used in the analysis.

(17) DOE requests comment on the presence and size of a direct rebound effect for ceiling fans.

(18) DOE welcomes comment on how it may account for energy prices faced by low income households.

(19) DOE requests comment and data on the overall methodology used for the consumer subgroup analysis.

(20) DOE requests comment on the estimated potential domestic employment impacts on ceiling fan manufacturers presented in this NOPR. Specifically, DOE requests comment on the assumption that almost all standard and hugger ceiling fans are manufactured abroad and any energy conservation standards would not have a significant impact on domestic employment for standard and hugger ceiling fan manufacturers; on the domestic employment impacts shown in for LDCF manufacturers; and on the assumption that while most HSBD ceiling fans are manufactured domestically, due to the extremely low annual shipment volumes, any energy conservation standards would not have a significant impact on domestic employment.

(21) DOE requests comment on the potential manufacturing capacity constraints placed on ceiling fan manufacturers (including any potential supply chain issues) at any of the TSLs presented in this NOPR.

(22) DOE welcomes comments on how to more fully assess the potential impact of energy conservation standards on consumer choice and how to quantify this impact in its regulatory analysis in future rulemakings.

(23) DOE seeks comment on whether a certain percentage of consumers of small diameter ceiling fans, especially with diameters less than or equal to 53 inches in both the standard and hugger configurations, would defer or forgo purchasing ceiling fans with BLDC motors that achieve TSL 4 efficiency.

(24) DOE also seeks comment on any evidence of consumers substituting one cooling method—*e.g.*, increased HVAC use—for another, *e.g.*, a forgone ceiling fan.

(25) DOE seeks comment from stakeholders about whether BLDC motors and BLDC motor controllers are available in the sizes necessary to support the full range of hugger and standard ceiling fans as well as manufacturers' ability to ramp up their sourcing or production of such motors and controllers in the timeframe needed to comply with TSL 4 efficiencies for standard and hugger ceiling fans.

(26) DOE requests comment and data on whether and to what extent an increase in first costs would disproportionately impact low-income consumers.

(27) DOE seeks comment on this alternative proposed standard level as well as the unintended market consequences and the changes industry would make to the way they bring products to market as a result of standards that require the use of different motor technologies for standard and hugger ceiling fans with small diameters.

(28) DOE requests comment on the number of small businesses identified that manufacture ceiling fans covered by this proposed rulemaking.

(29) DOE requests comment on the estimated and potentially un-estimated costs which small manufacturers of ceiling fans may incur if this proposed rulemaking is finalized.

(30) DOE request comment on whether small businesses would opt to remove models from the market rather than redesign, the basis for which models would be redesigned, and the extent to which this would be the case.

(31) DOE requests comments on impacts to domestic small businesses.

(32) DOE additionally requests comments on TSL 4, including the benefits and costs borne by low-income consumers.

(33) Additionally, DOE welcomes comments on other issues relevant to the conduct of this rulemaking that may not specifically be identified in this document.

VIII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this notice of proposed rulemaking and announcement of public meeting.

List of Subjects in 10 CFR Part 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Intergovernmental relations, Small businesses.

Signing Authority

This document of the Department of Energy was signed on June 9, 2023, by Francisco Alejandro Moreno, Acting Assistant Secretary for Energy Efficiency and Renewable Energy, pursuant to delegated authority from the Secretary of Energy. That document with the original signature and date is maintained by DOE. For administrative purposes only, and in compliance with requirements of the Office of the Federal Register, the undersigned DOE Federal Register Liaison Officer has been authorized to sign and submit the document in electronic format for publication, as an official document of the Department of Energy. This administrative process in no way alters the legal effect of this document upon publication in the *Federal Register*.

Signed in Washington, DC, on June 13, 2023.

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Treena V. Garrett
Federal Register Liaison Officer,
U.S. Department of Energy

For the reasons set forth in the preamble, DOE proposes to amend part 430 of chapter II, subchapter D, of title 10 of the Code of Federal Regulations, as set forth below:

PART 430 - ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

1. The authority citation for part 430 continues to read as follows:

Authority: 42 U.S.C. 6291-6309; 28 U.S.C. 2461 note.

2. Amend §430.32 by revising paragraph (s)(2) to read as follows:

§430.32 Energy and water conservation standards and their compliance dates.

* * * * *

(s) * * *

(2)(i) Ceiling fans manufactured on or after January 21, 2020 and before [*Date 3 years after date of publication of the final rule in the Federal Register*] shall meet the requirements shown in the table:

Product Class as defined in Appendix U	Minimum Efficiency (CFM/W)*
Very small-diameter (VSD)	$D \leq 12$ in.: 21 $D > 12$ in.: 3.16 D -17.04
Standard	0.65 D + 38.03
Hugger	0.29 D + 34.46
High-speed small-diameter (HSSD)	4.16 D + 0.02

* D is the ceiling fan's blade span, in inches, as determined in appendix U of this part.

(ii) Ceiling fans manufactured on or after [*Date 3 years after date of publication of the final rule in the Federal Register*] shall meet the requirements shown in the table:

Product Class as defined in Appendix U	Minimum Efficiency (CFM/W)*
Very small-diameter (VSD)	$D \leq 12$ in.: 21 $D > 12$ in.: 3.16 D -17.04
Standard	$D \leq 53$ in.: 0.69 D+53.25 $D > 53$ in.: 1.31 D +52.08

Product Class as defined in Appendix U	Minimum Efficiency (CFM/W)*
Hugger	$D \leq 53$ in.: $0.56\,D+48.75$ $D > 53$ in.: $1.37\,D+38.5$
High-speed small-diameter (HSSD)	$4.16\,D + 0.02$

* D is the ceiling fan's blade span, in inches, as determined in appendix U of this part.

(iii) Large-diameter ceiling fans, as defined in appendix U to subpart B of this part, manufactured on or after January 21, 2020 and before [*Date 3 years after date of publication of the final rule in the Federal Register*], shall have a CFEI greater than or equal to –

(A) 1.00 at high speed; and

(B) 1.31 at 40 percent speed or the nearest speed that is not less than 40 percent speed.

(iv) Large-diameter ceiling fans, as defined in appendix U to subpart B of this part, manufactured on or after [*Date 3 years after date of publication of the final rule in the Federal Register*], shall have a CFEI greater than or equal to –

(A) 1.22 at high speed; and

(B) 1.31 at 40 percent speed or the nearest speed that is not less than 40 percent speed.

(v) High-speed belt-driven ceiling fans, as defined in appendix U to subpart B of this part, manufactured on or after [*Date 3 years after date of publication of the final rule in the Federal Register*], shall have a CFEI greater than or equal to –

(A) 1.89 at high speed.

(vi) The provisions in paragraph (s)(2)(i) through (v) of this section apply to ceiling fans except:

(A) Ceiling fans where the plane of rotation of a ceiling fan's blades is not less than or equal to 45 degrees from horizontal, or cannot be adjusted based on the manufacturer's specifications to be less than or equal to 45 degrees from horizontal;

(B) Centrifugal ceiling fans, as defined in appendix U of this part;

(C) Belt-driven ceiling fans other than high-speed belt-driven ceiling fans, as defined in appendix U of this part;

(D) Oscillating ceiling fans, as defined in appendix U of this part; and

(E) Highly-decorative ceiling fans, as defined in appendix U of this part.

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