DEPARTMENT OF ENERGY

10 CFR Part 430

[Docket Number EERE–2012–BT–STD–0045]

RIN 1904–AD28

Energy Conservation Program: Energy Conservation Standards for Ceiling Fans

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

ACTION: Final rule.

SUMMARY: The Energy Policy and Conservation Act of 1975 (EPCA), as amended, 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 save a significant amount of energy. In this final rule, DOE amends the energy conservation standards for ceiling fans. It has determined that the amended energy conservation standards for these products would result in significant conservation of energy, and are technologically feasible and economically justified.

DATES: The effective date of this rule is March 20, 2017. Compliance with the amended standards established for ceiling fans in this final rule is required on and after January 21, 2020.

ADDRESSES: The docket for this rulemaking, which includes **Federal Register** notices, public meeting attendee lists and transcripts, 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.

A link to the docket web page can be found at *https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=5*. The docket web page contains instructions on how to access all documents, including public comments, in the docket.

For further information on how to review the docket, contact Ms. Lucy deButts at: (202) 287–1604 or by e-mail: *ApplianceStandardsQuestions@ee.doe.gov*.

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SUPPLEMENTARY INFORMATION:

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I. Synopsis of the Final Rule

Title III, Part B [1] of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Public Law 94–163 (42 U.S.C. 6291–6309), established the Energy Conservation Program for Consumer Products Other Than Automobiles.[2] These products include ceiling fans, which are the subject of this 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 significant conservation of energy. (42 U.S.C. 6295(o)(3)(B))

In accordance with these and other statutory provisions discussed in this document, DOE is adopting amended energy conservation standards for ceiling fans. The amended standards, which are expressed for each product class as the minimum allowable efficiency in terms of cubic feet per minute per watt (CFM/W), as a function of ceiling fan diameter in inches, are shown in Table I.1. These standards would apply to all ceiling fans listed in Table I.1 and manufactured in, or imported into, the United States on and after January 21, 2020.

TABLE I.1—ENERGY CONSERVATION STANDARDS FOR CEILING FANS

[Compliance starting January 21, 2020]

Product class	Minimum efficiency equation CFM/W *
Very Small-Diameter (VSD).	D ≤ 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
Large Diameter	0.91 D − 30.00

* D is the ceiling fan's blade span, in inches, as determined in Appendix U.

A. Benefits and Costs to Consumers

Table I.2 presents DOE's evaluation of the economic impacts of the adopted 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 13.8 years for all product classes (see section IV.F.5).

TABLE I.2—IMPACTS OF AMENDED ENERGY CONSERVATION STANDARDS ON CONSUMERS OF CEILING FANS

Product class	Average LCC savings * (2015$)	Simple payback period (years)
Standard	25.78	1.7
Hugger	21.50	1.8
Very Small-Diameter	4.29	9.3
High-Speed Small-Diameter	19.80	6.9
Large-Diameter	128.90	4.1

* The calculation excludes consumers with zero LCC savings (no impact).

DOE's analysis of the impacts of the adopted 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 reference year through the terminal year of the analysis period (2016–2049). Using a real discount rate of 7.4 percent, DOE estimates that the INPV for manufacturers of ceiling fans in the case without amended standards is $1,211.6 million in 2015$. Under the adopted standards, DOE expects that manufacturers may lose up to 9.9 percent of this INPV, which is approximately $119.4 million.

DOE's analysis of the impacts of the adopted standards on manufacturers is described in section IV.J of this document.

C. National Benefits and Costs [4]

DOE's analyses indicate that the adopted energy conservation standards for ceiling fans would save a significant amount of energy. Relative to the case without amended standards (referred to as the ''no-new-standards case''), the lifetime energy savings for ceiling fans

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

[2] All references to EPCA in this document refer to the statute as amended through the Energy Efficiency Improvement Act of 2015, Public Law 114–11 (April 30, 2015).

[3] The average LCC savings 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 standards (see section IV.F.7). The simple PBP, which is designed to compare specific ceiling fan efficiency levels, is measured relative to the baseline product (see section IV.C), which corresponds to the least efficient model available to purchase.

[4] All monetary values in this document are expressed in 2015 dollars and, where appropriate, are discounted to 2016 unless explicitly stated otherwise.

purchased in the 30-year period that begins in the anticipated first full year of compliance with the amended standards (2020–2049), amount to 2.008 quadrillion British thermal units (Btu), or quads.[5] This represents a total energy savings of 26 percent across all product classes relative to the energy use of these products in the no-new-standards case.

The cumulative net present value (NPV) of total consumer costs and savings of the standards for ceiling fans ranges from $4.488 billion (at a 7-percent discount rate) to $12.123 billion (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 2020–2049.

In addition, the standards for ceiling fans are projected to yield significant environmental benefits. DOE estimates that the standards would result in cumulative greenhouse gas emission reductions (over the same period as for energy savings) of 120.2 million metric tons (Mt)[6] of carbon dioxide (CO_2), 64.0 thousand tons of sulfur dioxide (SO_2), 222.6 thousand tons of nitrogen oxides (NO_X), 530.1 thousand tons of methane (CH_4), 1.3 thousand tons of nitrous oxide (N_2O), and 0.2 tons of mercury (Hg).[7] The cumulative reduction in CO_2 emissions through 2030 amounts to 18.2 Mt, which is equivalent to the emissions resulting from the annual electricity use of more than 1.9 million homes.

The value of the CO_2 reductions is calculated using a range of values per metric ton (t) of CO_2 (otherwise known as the ''Social Cost of Carbon'', or SCC) developed by a Federal interagency working group.[8] The derivation of the SCC values is discussed in section IV.L. Using discount rates appropriate for each set of SCC values, DOE estimates that the net present monetary value of the CO_2 emissions reduction (not including CO_2 equivalent emissions of other gases with global warming potential) is between $0.8 billion and $11.7 billion, with a value of $3.8 billion using the SCC central value case represented by $40.6/metric ton (t) in 2015. DOE also estimates that the present monetary value of the NO_X emissions reduction to be $0.2 billion at a 7-percent discount rate, and $0.4 billion at a 3-percent discount rate.[9] DOE is investigating appropriate valuation of the reduction in other emissions, and did not include any values for other emissions in this rulemaking.

Table I.3 summarizes the economic benefits and costs expected to result from the adopted standards for ceiling fans.

TABLE I.3—SELECTED CATEGORIES OF ECONOMIC BENEFITS AND COSTS OF AMENDED ENERGY CONSERVATION STANDARDS FOR CEILING FANS *

Category	Present value (billion 2015$)	Discount rate (%)
Benefits		
Consumer Operating Cost Savings	7.0	7
	16.5	3
CO_2 Reduction (using mean SCC at 5% discount rate) **	0.8	5
CO_2 Reduction (using mean SCC at 3% discount rate) **	3.8	3
CO_2 Reduction (using mean SCC at 2.5% discount rate) **	6.1	2.5
CO_2 Reduction (using 95th percentile SCC at 3% discount rate) **	11.7	3
NO_X Reduction †	0.2	7
	0.4	3
Total Benefits ‡	11.0	7
	20.7	3
Costs		
Consumer Incremental Installed Costs	2.5	7
	4.4	3

[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.

[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 2015* (*AEO 2015*).

[8] United States Government-Interagency Working Group on Social Cost of Carbon. *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* May 2013. Revised July 2015. Available at *https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf.*

[9] DOE estimated the monetized value of NO_X emissions reductions associated with electricity savings using benefit per ton estimates from the *Regulatory Impact Analysis for the Clean Power Plan Final Rule,* published in August 2015 by EPA's Office of Air Quality Planning and Standards. Available at *www.epa.gov/cleanpowerplan/clean-power-plan-final-rule-regulatory-impact-analysis.* See section IV.L.2 for further discussion. *On February 9, 2016, the U.S. Supreme Court stayed the rule implementing the Clean Power Plan* pending disposition of the applicants' petitions for review in the United States Court of Appeals for the District of Columbia Circuit and disposition of the applicants' petition for a writ of certiorari, if such writ is sought. *Chamber of Commerce, et al.* v. *EPA, et al.,* Order in Pending Case, available at *http://www.chamberlitigation.com/sites/default/files/scotus/files/2016/SCOTUS%20Order%20Granting%20U.S.%20Chamber%2C%20et%20al.%20Stay%20Application%20—%20States%20of%20West%20Virginia%2C%20Texas%2C%20et%20al.%20v.%20EPA%20%28ESPS%29.pdf* (last visited June 22, 2016). Pending the outcome of that litigation, DOE continues to use the benefit-per-ton estimates established in the Regulatory Impact Analysis for the Clean Power Plan. To be conservative, DOE is primarily using a national benefit-per-ton estimate for NO_X emitted from the Electricity Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski *et al.* 2009). If the benefit-per-ton estimates were based on the Six Cities study (Lepuele *et al.* 2011), the values would be nearly two-and-a-half times larger.

TABLE I.3—SELECTED CATEGORIES OF ECONOMIC BENEFITS AND COSTS OF AMENDED ENERGY CONSERVATION STANDARDS FOR CEILING FANS *—Continued

Category	Present value (billion 2015$)	Discount rate (%)
Total Net Benefits		
Including CO_2 and NO_X Reduction Monetized Value ‡	8.5	7
	16.3	3

* This table presents the costs and benefits associated with ceiling fans shipped in 2020–2049. These results include benefits to consumers which accrue after 2049 from the products purchased in 2020–2049. The incremental installed costs include incremental equipment cost as well as installation costs. The CO_2 reduction benefits are global benefits due to actions that occur nationally.

** The interagency group selected four sets of SCC values for use in regulatory analyses. Three sets of values are based on the average SCC from the integrated assessment models, at discount rates of 5 percent, 3 percent, and 2.5 percent. For example, for 2015 emissions, these values are $12.4/t, $40.6/t, and $63.2/t, in 2015$, respectively. The fourth set ($118/t in 2015$ for 2015 emissions), which represents the 95th percentile of the SCC distribution calculated using a 3-percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. The SCC values are emission year specific. See section IV.L.1 for more details.

† DOE estimated the monetized value of NO_X emissions reductions associated with electricity savings using benefit per ton estimates from the *Regulatory Impact Analysis for the Clean Power Plan Final Rule,* published in August 2015 by EPA's Office of Air Quality Planning and Standards. (Available at *www.epa.gov/cleanpowerplan/clean-power-plan-final-rule-regulatory-impact-analysis.*) See section IV.L.2 for further discussion. To be conservative, DOE is primarily using a national benefit-per-ton estimate for NO_X emitted from the Electricity Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski *et al.* 2009). If the benefit-per-ton estimates were based on the Six Cities study (Lepuele *et al.* 2011), the values would be nearly two-and-a-half times larger.

‡ Total Benefits for both the 3-percent and 7-percent cases are presented using only the average SCC with 3-percent discount rate.

The benefits and costs of the adopted standards, for ceiling fans sold in 2020–2049, can also be expressed in terms of annualized values. The monetary values for the total annualized net benefits are the sum of (1) the national economic value of the benefits in reduced consumer operating costs, minus (2) the increases in product purchase prices and installation costs, plus (3) the value of the benefits of CO_2 and NO_X 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. The national operating cost savings is measured for the lifetime of ceiling fans shipped in 2020–2049. The CO_2 reduction is a benefit that accrues globally due to decreased domestic energy consumption that is expected to result from this rule. Because CO_2 emissions have a very long residence time in the atmosphere, the SCC values in future years reflect future CO_2-emissions impacts that continue beyond 2100.

Estimates of annualized benefits and costs of the adopted standards are shown in Table I.4. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction, (for which DOE used a 3-percent discount rate along with the SCC series that has a value of $40.6/t in 2015),[11] the estimated annualized cost of the standards in this rule is $245.1 million per year in increased equipment costs, while the estimated annualized benefits are $688.1 million in reduced equipment operating costs, $214.1 million in CO_2 reductions, and $15.1 million in reduced NO_X emissions. In this case, the annualized net benefit amounts to $672.2 million per year. Using a 3-percent discount rate for all benefits and costs and the SCC series has a value of $40.6/t in 2015, the estimated cost of the standards is $243.2 million per year in increased equipment costs, while the estimated annualized benefits are $919.0 million in reduced operating costs, $214.1 million in CO_2 reductions, and $21.5 million in reduced NO_X emissions. In this case, the annualized net benefit amounts to $911.4 million per year.

TABLE I.4—SELECTED CATEGORIES OF ANNUALIZED BENEFITS AND COSTS OF AMENDED STANDARDS FOR CEILING FANS *

	Discount rate	Primary estimate	Low-net-benefits estimate	High-net-benefits estimate
		(million 2015$/year)		
Benefits				
Consumer Operating Cost Savings	7%	688.1	579.7	793.5
	3%	919.0	764.2	1081.9
CO_2 Reduction (using mean SCC at 5% discount rate) **	5%	62.8	53.7	71.0
CO_2 Reduction (using mean SCC at 3% discount rate) **	3%	214.1	182.2	242.6
CO_2 Reduction (using mean SCC at 2.5% discount rate) **	2.5%	314.2	267.2	356.3
CO_2 Reduction (using 95th percentile SCC at 3% discount rate) **.	3%	652.7	555.4	739.8
NO_X Reduction †	7%	15.1	13.1	38.1
	3%	21.5	18.4	55.3
Total Benefits ‡	7% plus CO_2 range	766 to 1,356	647 to 1,148	903 to 1,571

[10] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2016, 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 (*e.g.,* 2020 or 2030), and then discounted the present value from each year to 2016. The calculation uses discount rates of 3 and 7 percent for all costs and benefits except for the value of CO_2 reductions, for which DOE used case-specific discount rates, as shown in Table I.3. 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.

[11] DOE used a 3-percent discount rate because the SCC values for the series used in the calculation were derived using a 3-percent discount rate (see section IV.L).

TABLE I.4—SELECTED CATEGORIES OF ANNUALIZED BENEFITS AND COSTS OF AMENDED STANDARDS FOR CEILING FANS *—Continued

	Discount rate	Primary estimate	Low-net-benefits estimate	High-net-benefits estimate
		(million 2015$/year)		
	7%	917.3	775.0	1,074.2
	3% plus CO_2 range	1,003 to 1,593	836 to 1,338	1,208 to 1,877
	3%	1,154.6	964.8	1,379.9
Costs ***				
Consumer Incremental Product Costs	7%	245.1	288.1	272.8
	3%	243.2	298.7	273.7
Net Benefits				
Total ‡	7% plus CO_2 range	521 to 1,111	358 to 860	630 to 1,299
	7%	672.2	487.0	801.4
	3% plus CO_2 range	760 to 1,350	538 to 1,039	935 to 1,603
	3%	911.4	666.1	1,106.2

* This table presents the annualized costs and benefits associated with ceiling fans shipped in 2020–2049. These results include benefits to consumers which accrue after 2049 from the ceiling fans purchased from 2020–2049. The incremental installed costs include incremental equipment cost as well as installation costs. The CO_2 reduction benefits are global benefits due to actions that occur nationally. The Primary Estimate assumes the Reference case electricity prices and housing starts from AEO 2015 and decreasing product prices for ceiling fans with DC motors, due to price trend on the electronics components. The Low Benefits Estimate uses the Low Economic Growth electricity prices and housing starts from AEO 2015 and no price trend for ceiling fans with DC motors. The High Benefits Estimate uses the High Economic Growth electricity prices and housing starts from AEO 2015 and the same product price decrease for ceiling fans with DC motors as in the Primary Estimate. The methods used to derive projected price trends are explained in section IV.G.4. Note that the Benefits and Costs may not sum to the Net Benefits due to rounding.

** The CO_2 reduction benefits are calculated using 4 different sets of SCC values. The first three use the average SCC calculated using 5-percent, 3-percent, and 2.5-percent discount rates, respectively. The fourth represents the 95th percentile of the SCC distribution calculated using a 3-percent discount rate. The SCC values are emission year specific. See section IV.L.1 for more details.

† DOE estimated the monetized value of NO_X emissions reductions associated with electricity savings using benefit per ton estimates from the *Regulatory Impact Analysis for the Clean Power Plan Final Rule,* published in August 2015 by EPA's Office of Air Quality Planning and Standards. (Available at *www.epa.gov/cleanpowerplan/clean-power-plan-final-rule-regulatory-impact-analysis.*) See section IV.L.2 for further discussion. For the Primary Estimate and Low Net Benefits Estimate, DOE used national benefit-per-ton estimates for NO_X emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski *et al.* 2009). For the High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele *et al.* 2011); these are nearly two-and-a-half times larger than those from the ACS study.

‡ Total Benefits for both the 3-percent and 7-percent cases are presented using only the average SCC with 3-percent discount rate. In the rows labeled "7% plus CO_2 range" and "3% plus CO_2 range," the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

*** For certain assumed design options (*e.g.,* fan optimization) that are included at the selected standard level, DOE estimated no incremental costs to consumers, but did estimate a one-time industry conversion cost to manufacturers to make their products compliant with the selected standards that are not reflected in the Consumer Incremental Product Costs. The one-time industry conversion cost to manufacturers of these design options contribute to a loss in industry net present value of $4.8 million, which is equivalent to an annualized cost of $0.4 million/year at a 7.4-percent discount rate over the analysis period.

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

D. Conclusion

Based on the analyses culminating in this final rule, DOE found the benefits to the nation of the standards (energy savings, consumer LCC savings, positive NPV of consumer benefit, and emission reductions) outweigh the burdens (loss of INPV and LCC increases for some users of these products). DOE has concluded that the standards in this final rule represent the maximum improvement in energy efficiency that is technologically feasible and economically justified, and would result in significant conservation of energy.

II. Introduction

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

A. Authority

Title III, Part B of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Public Law 94–163 (42 U.S.C. 6291, *et seq.*) established the Energy Conservation Program for Consumer Products Other Than Automobiles, a program covering most major household appliances (collectively referred to as "covered products"), which includes the ceiling fans that are the subject of this rulemaking. (42 U.S.C. 6295(ff)) EPCA, as amended, prescribes energy conservation standards for these products and authorizes DOE to consider energy efficiency or energy use standards for the electricity used by ceiling fans to circulate air in a room. *Id.*

Under 42 U.S.C. 6295(m), DOE must periodically review its already established energy conservation standards for a covered product. Under this requirement, the next review that DOE would need to conduct must occur no later than 6 years from the issuance of any final rule establishing or amending a standard for a covered product. 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 including new proposed energy conservation standards. (42 U.S.C. 6295(m))

Pursuant to EPCA, DOE's energy conservation program for covered products consists essentially of four parts: (1) Testing, (2) labeling, (3) the establishment of Federal energy conservation standards, and (4) certification and enforcement procedures. The Federal Trade Commission (FTC) is primarily responsible for labeling, and DOE implements the remainder of the program. 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 (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 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, 10 CFR 430.23(w) and 10 CFR 429.32.

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 is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A) and (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, as codified, 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, as codified, 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 products 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 such a 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))

Federal energy conservation requirements generally supersede State laws or 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 42 U.S.C. 6297(d)).

EPCA also requires that for any final rule for new or amended energy conservation standards promulgated after July 1, 2010, DOE must 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)) The amended standards DOE is adopting in this final rule incorporate standby mode and off mode energy use into a single standard.

B. Background

1. Current Standards

The Energy Policy and Conservation Act of 1975 (EPCA) defined and established design standards for ceiling fans. EPCA defined a ''ceiling fan'' as ''a nonportable device that is suspended from a ceiling for circulating air via the rotation of fan blades.'' (42 U.S.C. 6291(49)) In a final rule technical amendment published in the on October 18, 2005, DOE codified the statutorily-prescribed design standards for ceiling fans. 70 FR 60407, 60413. These standards are set forth in DOE's regulations at 10 CFR 430.32(s), and require all ceiling fans manufactured on or after January 1, 2007, to have the following features:

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) and (6))

2. History of Standards Rulemaking for Ceiling Fans

EPCA established energy conservation standards for ceiling fans as described in Section II.B.1 and authorized DOE to consider, if the requirements of 42 U.S.C. 6295(o) and (p) are met, establishing energy efficiency or energy use standards for the electricity used by ceiling fans to circulate air in a room. (42 U.S.C. 6295(ff))

As noted in section II.B.1, DOE codified the statutorily-prescribed design standards for ceiling fans in the CFR at 10 CFR 430.32(s). 70 FR 60407, 60413 (Oct. 18, 2005). DOE also adopted test procedures for ceiling fans at 10 CFR part 430, subpart B, appendix U and 10 CFR 430.23(w). 71 FR 71340, 71366–67 (Dec. 8, 2006). Sampling and certification requirements for ceiling fans are set forth at 10 CFR 429.32.

On March 15, 2013, DOE published a notice announcing the availability of the framework document, ''Energy Conservation Standards Rulemaking Framework Document for Ceiling Fans and Ceiling Fan Light Kits,'' [12] and a public meeting to discuss the proposed analytical framework for the energy conservation standards rulemaking. 78 FR 16643. DOE held the public meeting for the framework document on March 22, 2013,[13] to present the framework document, describe the analyses DOE planned to conduct during the rulemaking, seek comments from interested parties on these subjects, and inform them about and facilitate their involvement in the rulemaking.

On September 29, 2014, DOE published the preliminary analysis for the ceiling fan energy conservation standards rulemaking. 79 FR 58290. DOE posted the preliminary analysis, as well as the complete preliminary technical support document (TSD), on its website.[14] DOE held a public meeting on November 19, 2014, to present the preliminary analysis, which included presenting preliminary results for the engineering and downstream economic analyses, seek comments from interested parties on these subjects, and facilitate interested parties' involvement in the rulemaking.

On January 13, 2016, DOE published a notice of proposed rulemaking (NOPR) for the ceiling fans energy conservation standards rulemaking (ceiling fans NOPR). 81 FR 1688. DOE posted the ceiling fans NOPR analysis, as well as the complete NOPR TSD on its Web site.[15] DOE held a public meeting on February 3, 2016 to present the ceiling fans NOPR, which included the engineering analysis, downstream economic analyses, manufacturer impact analysis, and proposed standards. In the public meeting, DOE also sought comments from interested parties on these subjects, and facilitated interested parties' involvement in the rulemaking. At the public meeting, and during the comment period, DOE received comments that helped DOE identify issues and refine the analyses presented in the ceiling fans NOPR for this final rule. The key changes since the ceiling fans NOPR were the following: (1) The engineering analysis was updated based on additional test data, and (2) the efficiency distribution in the no-new-standards case for the standard and hugger product classes was updated with significantly more market share at the lower efficiency levels based on comments from manufacturers.

This final rule responds to issues raised by commenters in response to the framework document, preliminary analysis, and NOPR.

III. General Discussion

DOE developed this proposal after considering comments, data, and information from interested parties that represent a variety of interests. The following section provides general discussion of the final standards rule; section IV addresses the issues raised by these commenters.

A. Product Classes and Scope of Coverage

1. Scope of Coverage

EPCA defines a ''ceiling fan'' as ''a nonportable device that is suspended from a ceiling for circulating air via the rotation of fan blades.'' (42 U.S.C. 6291(49))

DOE previously interpreted the definition of a ceiling fan such that it excluded certain types of ceiling fans commonly referred to as hugger fans. 71 FR 71343 (Dec. 8, 2006). Hugger ceiling fans are typically understood to be set flush to the ceiling (*e.g.,* mounted without a downrod). The previous interpretation exempted hugger fans from standards on the basis that they are set flush to the ceiling. However, in the test procedure final rule for ceiling fan light kits, DOE reinterpreted the definition of a ceiling fan to include hugger fans, and clarified that the definition also included ceiling fans capable of producing large volumes of airflow. 80 FR 80209 (Dec. 24, 2015).

The changes in interpretation of the ceiling fan definition discussed above resulted in the applicability of the design standards set forth in EPCA at 42 U.S.C. 6295(ff)(1) to these fan types as of January 25, 2016. DOE research indicates that all ceiling fans currently on the market, including hugger ceiling fans and ceiling fans that produce a large volume of airflow, appear to meet the EPCA design standards. Compliance with requirements related to the ceiling fan reinterpretation was discussed in the Ceiling Fan Light Kit test procedure final rule. 80 FR 80209 (Dec. 24, 2015) Specifically, DOE will not assert civil penalty authority for violations of the applicable standards arising as a result of the reinterpretation of the ceiling fan definition before June 26, 2017.

DOE is also establishing efficiency standards for these fan types, which include hugger ceiling fans and ceiling fans that produce a large volume of airflow, in this ceiling fans final rule. Compliance with those standards, as discussed in the **DATES** section, is January 21, 2020.

Additionally, in the ceiling fan test procedure final rule, DOE provided clarification on those ceiling fans that are not subject to the test procedure. 81 FR 48620 (July 25, 2016). The test procedures do not apply to belt-driven ceiling fans, centrifugal ceiling fans, oscillating ceiling fans, or ceiling fans whose blades' plane of rotation cannot be within 45 degrees of horizontal. American Lighting Association (ALA) requested that DOE clarify that if the plane of rotation is not within 45 degrees of horizontal, the ceiling fan is not subject to DOE's proposed efficiency standards, certification requirements or labeling requirements. (ALA, No. 137 at p. 4) DOE confirms that it is not establishing performance standards for ceiling fans whose blades' plane of rotation cannot be within 45 degrees of horizontal in this final rule. The design standards set forth in EPCA at 42 U.S.C.

[12] The energy conservation standards final rule for ceiling fan light kits was published on January 6, 2016. 81 FR 580.

[13] The framework document is available at *regulations.gov* under docket number EERE–2012–BT–STD–0045–0001.

[14] The preliminary analysis, preliminary TSD, and preliminary analysis public meeting information are available at *regulations.gov* under docket number EERE–2012–BT–STD–0045–0066.

[15] The NOPR analysis, NOPR TSD and NOPR public meeting information are available at *regulations.gov* under docket number EERE–2012–BT–STD–0045–0130.

6295(ff) remain applicable to these fans and manufacturers must certify compliance with those design standards to DOE.

In summary, this DOE final rule is not establishing performance standards for belt-driven ceiling fans, centrifugal ceiling fans, oscillating ceiling fans, or ceiling fans whose blades' plane of rotation cannot be within 45 degrees of horizontal. DOE is also not establishing performance standards for highly decorative fans. Manufacturers must continue to submit certification reports to DOE for such fans with respect to the statutory design standards. Both DOE and manufacturers would determine whether a fan met the definition of a highly decorative fan using the final test procedure, though manufacturers would not be required to submit the supporting information, including any test data that supports their highly decorative classification as part of their certification submission to DOE. In addition, manufacturers would be required to test highly-decorative fans according to the test procedure established in the test procedure final rule to make representations of the energy efficiency of such fans (*e.g.,* for the EnergyGuide label)).

2. Product Classes

When 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 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. (42 U.S.C. 6295(q))

Currently there are no product classes for ceiling fans, because the previous final rule for ceiling fans published on October 18, 2005 set design standards, but did not establish product classes. 70 FR 60407. In the ceiling fans NOPR, DOE proposed seven product classes and their associated definitions, which included highly-decorative, belt-driven, very small-diameter, hugger, standard, high-speed small-diameter and large-diameter fans. 81 FR 1688 (January 13, 2016). Chapter 3 of the TSD provides additional discussion on the establishment of these product classes pursuant to 42 U.S.C. 6295(q). In the ceiling fans test procedure final rule, DOE finalized the definitions for these types of ceiling fans. 81 FR 48620 (July 25, 2016). In this final rule, DOE is finalizing all seven product classes proposed in the ceiling fans NOPR. For further details on product classes, see section IV.A.1 of this rulemaking.

B. 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. (42 U.S.C. 6293, 6295(s)) Similarly, DOE must use these test procedures to determine compliance with its energy conservation standards. (42 U.S.C. 6295(s)) As noted, the test procedures for ceiling fans are provided in 10 CFR 430.23(w) and appendix U to subpart B of 10 CFR part 430. DOE published a NOPR to amend the ceiling fan test procedures on October 17, 2014, 79 FR 62521, and published a supplemental NOPR (SNOPR) on June 3, 2015. 80 FR 31487. DOE finalized the test procedure on July 25, 2016. 81 FR 48620.

With respect to the process of establishing test procedures and standards for a given product, DOE notes that, while not legally obligated to do so, it generally follows the approach laid out in guidance found in 10 CFR part 430, subpart C, Appendix A (Procedures, Interpretations and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products). That guidance provides, among other things, that DOE issues final, modified test procedures for a given product prior to publication of the NOPR proposing energy conservation standards for that product. While DOE strives to follow the procedural steps outlined in its guidance, there may be circumstances in which it may be necessary or appropriate to deviate from it. In such instances, the guidance indicates that DOE will provide notice and an explanation for the deviation. Accordingly, DOE has provided notices while it continued to develop the final test procedure for ceiling fans. DOE received comments regarding test methods for ceiling fans for which the plane of rotation of the ceiling fan's blades cannot be within 45 degrees of horizontal, high-volume small-diameter ceiling fans and ceiling fans with blade spans greater than seven feet leading to modification to test methods proposed in the NOPR. (79 FR 62521 (October 17, 2014)). DOE also received comments regarding the variability of results from the test procedures proposed in the SNOPR (80 FR 31487 (June 3, 2015)), based on testing conducted by manufacturers. Lastly, DOE conducted a thorough review of all available test data, including additional test data supplied by manufacturers, to identify opportunities to decrease testing variation.

DOE attempted to issue the final test procedure prior to the NOPR proposing energy conservation standards. However, additional time to address comments received on the NOPR and SNOPR lead to modification of the test procedure, which caused deviations from the guidance provided in 10 CFR part 430, subpart C, Appendix A.

Currently no energy efficiency performance standards exist for ceiling fans, just design standards for certain ceiling fans. In this final rule, DOE is setting energy efficiency performance standards in terms of a minimum efficiency equation established in the test procedure final rule. 81 FR 48620 (July 25, 2016). The test procedure final rule established test procedures for an integrated efficiency metric measured in cubic feet per minute per watt (CFM/W) that is applicable to all ceiling fans for which DOE establishes energy conservation standards in this final rule.

In the July 2016 test procedure final rule, DOE: (1) Specified new test procedures for large-diameter ceiling fans, multi-mount ceiling fans, ceiling fans with multiple fan heads, and ceiling fans where the airflow is not directed vertically, and (2) adopted the following changes to the current test procedure: (a) Low-speed small-diameter ceiling fans must be tested at high and low speeds; (b) high-speed small-diameter ceiling fans must be tested at high speed only; (c) large-diameter ceiling fans must be tested at up to five speeds; (d) a test cylinder is not to be used during testing; (e) fans that can be mounted at more than one height are to be mounted in the configuration that minimizes the distance between the fan blades and the ceiling; (f) any heater installed with a ceiling fan is to be switched off during testing; (g) small-diameter ceiling fans must be mounted directly to the real ceiling; (h) the allowable measurement tolerance for air velocity sensors is ± 5%; (i) the allowable mounting distance tolerance for air velocity sensors is ± 1/16''; (j) the air delivery room must be at 70 F ± 5 F during testing; (k) air delivery room doors and air conditioning vents must be closed and forced-air conditioning equipment turned off during testing; (l) low speed small diameter and HSSD fans capable of operating with single- and multi-phase power be tested with single-phase power, and large diameter fans capable of operating with single- and multi-phase power be tested with multi-phase power; (m) the supply voltage must be 120 V if the ceiling fan's minimum rated voltage is 120 V or the lowest rated voltage range contains 120 V; 240 V if the ceiling fan's minimum rated voltage is 240 V or the lowest rated voltage range contains 240 V; the ceiling fan's minimum rated voltage (if a voltage range is not given) or the mean of the lowest rated voltage range, in all other cases; (n) measurement axes shall be perpendicular to test room walls; and (o) measurement stabilization requirements shall be met for a valid test (*i.e.,* average air velocity readings in each axis for each sensor are within 5% and average electrical power measurement in each axis for each sensor are within 1%). DOE also determined that belt-driven ceiling fans, centrifugal ceiling fans, oscillating ceiling fans, and ceiling fans for which the plane of rotation of the fan blades cannot be within 45 degrees of horizontal are not subject to the ceiling fan test procedure. Manufacturers of highly decorative ceiling fans must use the test procedure as described in section III.A.1.

C. 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. 10 CFR part 430, subpart C, appendix A, section 4(a)(4)(i)

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; and (3) adverse impacts on health or safety. 10 CFR part 430, subpart C, appendix A, section 4(a)(4)(ii)–(iv) Additionally, it is DOE policy not to include in its analysis any proprietary technology that is a unique pathway to achieving a certain efficiency level. Section IV.B of this notice 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 rulemaking. For further details on the screening analysis for this rulemaking, see section IV.B of this notice and chapter 4 of the final rule 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 final rule TSD.

D. 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 any amended standards (2020–2049).[16] The savings are measured over the entire lifetime of products purchased in the 30-year analysis 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) spreadsheet models to estimate national energy savings (NES) from potential amended standards for ceiling fans. The NIA spreadsheet model (described in section IV.H of this rulemaking) calculates energy savings in terms of site energy, which is the energy directly consumed by products at the locations where they are used. Based on the site energy, DOE calculates NES in terms of primary energy savings at the site or at power plants, and also in terms of full-fuel-cycle (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.[17] DOE's approach is based on the calculation of an FFC 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 rulemaking.

2. Significance of Savings

To adopt 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)) Although the term ''significant'' is not defined in the Act, the U.S. Court of Appeals, for the District of Columbia Circuit in *Natural Resources Defense Council* v. *Herrington,* 768 F.2d 1355, 1373 (D.C. Cir. 1985), indicated that Congress intended ''significant'' energy savings in the context of EPCA to be savings that are not ''genuinely trivial.'' The energy savings for all the TSLs considered in this rulemaking, which range from 0.807 quads to 3.738 quads, are nontrivial, and, therefore, DOE considers them ''significant'' within the meaning of section 325 of EPCA.

E. Economic Justification

1. Specific Criteria

As noted above, EPCA provides seven factors to be evaluated in determining whether a potential energy conservation standard is economically justified. (42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII)) The following sections discuss how DOE has addressed each of those seven factors in this rulemaking.

a. Economic Impact on Manufacturers and Consumers

In determining the impacts of a potential amended standard on manufacturers, DOE conducts a manufacturer impact analysis (MIA), as discussed in section IV.J. 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

[16] DOE also presents a sensitivity analysis that considers impacts for products shipped in a 9-year period.

[17] The FFC metric is discussed in DOE's statement of policy and notice of policy amendment. 76 FR 51282 (August 18, 2011), as amended at 77 FR 49701 (Aug. 17, 2012).

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 payback period (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 economic impacts applicable to a particular rulemaking. DOE also evaluates the LCC impacts of potential standards on identifiable subgroups of consumers that may be affected disproportionately by a national 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 cost (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 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 amended standards. DOE's LCC and PBP analysis is discussed in further detail in section IV.F.

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 IV.H, DOE uses the NIA spreadsheet models 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 adopted in this final rule would not reduce the utility or performance of the products under consideration in this 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 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 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)) To assist the Department of Justice (DOJ) in making such a determination, DOE transmitted copies of its proposed rule and the NOPR TSD to the Attorney General for review, with a request that the DOJ provide its determination on this issue. In its assessment letter responding to DOE, DOJ concluded that the proposed energy conservation standards for ceiling fans are unlikely to have a significant adverse impact on competition. DOE is publishing the Attorney General's assessment at the end of this final rule.

f. Need for National Energy Conservation

DOE also considers the need for national energy 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 adopted standards may 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.

The adopted standards also 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; the emissions impacts are reported in section V.B.6 of this rulemaking. DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section IV.L. To date, this accounting for environmental benefits has not had a decisive impact on the outcome of any standards rulemaking, which is also the case for today's final rule.

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 interested parties submit any relevant information regarding economic justification that does not fit into the other categories described above, 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 effect potential amended 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 IV.F.8 of this final 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 also responds to comments received on its analyses in this section.

DOE used several analytical tools to estimate the impact of the standards considered in this document. The first tool is a spreadsheet that calculates the LCC savings and PBP of amended energy conservation standards (the Life-Cycle Cost Analysis spreadsheet). The national impacts analysis uses a second spreadsheet set that provides shipments forecasts and calculates national energy savings and net present value of total consumer costs and savings expected to result from potential energy conservation standards (the National Impact Analysis spreadsheet). 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: *https://www.regulations.gov/#!docketDetail;D=EERE-2012-BT-STD-0045*. Additionally, DOE used output from the latest version of EIA's *Annual Energy Outlook* (*AEO*), a widely known energy forecast 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) 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. See chapter 3 of the final rule TSD for further discussion of the market and technology assessment.

DOE received several comments regarding product classes, and the technology options DOE identified that can improve the efficiency of ceiling fans. The comments are discussed in the following sections.

1. Product Classes

DOE divides covered products into classes by: (a) The type of energy used by the product; (b) the capacity of the product; or (c) other performance-related features that justify different standard levels, considering the consumer utility of the feature and other relevant factors. (42 U.S.C. 6295(q))

In the ceiling fans NOPR, DOE proposed seven product classes based on the capacity of the product and other performance-related features that justify a different standard, considering the utility to the consumer. 81 FR 1688. The product classes include: Highly-decorative, belt-driven, very-small-diameter, hugger, standard, high-speed small-diameter and large-diameter ceiling fans. DOE also proposed definitions for these product classes in the ceiling fan energy conservation standard proposed rule. In the ceiling fan test procedure final rule, DOE finalized the definitions for the following types of ceiling fans: highly-decorative, belt-driven, very-small-diameter, hugger, standard, high speed small-diameter and large-diameter ceiling fans. DOE responded to any comments received in response to the ceiling fans NOPR regarding the definitions for these type of ceiling fans in the test procedure final rule. 81 FR 48620 (July 25, 2016).

In this final rule, DOE finalizes the product classes proposed in the ceiling fans NOPR for the energy conservation standards. DOE received several comments to the ceiling fans NOPR regarding the product classes that were proposed. Westinghouse stated that they agree and appreciate the minor changes made to the product class structure, and that the changes make a big difference, particularly regarding safety. (Westinghouse, Public Meeting Transcript, No. 133 at p. 21) ALA commented that they agreed in general with the product class structure proposed in the NOPR. (ALA, No. 137 at p. 4) BAS stated that they are generally supportive of the product class structure. (BAS, No. 138 at p. 2) However, BAS expressed concern that the product classes may be too complex, in particular, comparing the standard fans to HSSD fans. The two different methods of tests may provide some confusion to end users. Specifically, BAS was concerned that HSSD ceiling fans will be tested at one speed, while standard ceiling fans will be tested at two speeds (BAS, Public Meeting Transcript, No. 133 at p. 22) (BAS, No. 138 at p. 2)

DOE finds that HSSD ceiling fans provide different utility to the consumer than standard ceiling fans. HSSD ceiling fans generally operate at much higher speeds (in terms of RPM) than standard ceiling fans, and are installed in commercial applications. HSSD ceiling fans are available in a blade span range similar to standard ceiling fans, but an HSSD fan typically provides more airflow at a given blade span because it runs at much higher RPMs. Additionally, DOE observed that HSSD ceiling fans are generally used in commercial buildings whereas standard fans are installed in residential buildings. Therefore, HSSD and standard ceiling fans provide distinct utility to different end-users and are not market substitutes. As a result, establishing separate product classes and differing test methods should not provide confusion to end-users.

Also, in general, the product class structure was developed to follow the Underwriters Laboratory (UL) ceiling fan existing safety standards (UL Standard 507–1999, ''UL Standard for Safety for Electric Fans'' (UL 507)).[18] The UL 507 standard uses both blade thickness and maximum tip speed to differentiate fans, such that ceiling fans are safe for use in applications where

[18] Underwriters Laboratories Inc. UL Standard for Safety for Electric Fans, UL 507. 1999. Northbrook, IL. *http://www.comm-2000.com/ProductDetail.aspx?UniqueKey=8782.*

the distance between the fans blades and the floor is 10 feet or less. While standard ceiling fans are used in locations where blades are typically within 10 feet of the floor, HSSD ceiling fans are not and do not have to comply with the UL 507 standard. A product class structure that is consistent with UL 507 provides a method to differentiate standard and HSSD ceiling fans, while still ensuring that the safety standards are in place. Simplifying the product class structure without using the UL507 standard could result in safety issues.

In summary, HSSD ceiling fans provide a different utility to consumers compared to standard fans, and that warrants a separate product class for these ceiling fans. Therefore, in this final rule, DOE continues to define separate product classes for HSSD and standard ceiling fans.

For the reasons discussed above, DOE finalizes the seven product classes proposed in the ceiling fans NOPR in this final rule. The product classes finalized in this final rule are: Highly-decorative, belt-driven, very-small-diameter, hugger, standard, high-speed small-diameter and large-diameter ceiling fans.

In the ceiling fans NOPR, DOE did not propose standards for ceiling fans in the highly-decorative fan and belt-driven ceiling fan product classes. EPCA requires DOE to consider exempting, or setting different standards for, certain product classes for which the ''primary standards'' are not technically feasible or economically justified. EPCA also requires DOE to consider establishing separate exempted product classes for highly-decorative fans for which air movement performance is a secondary design feature. (42 U.S.C.6295(ff)(6)(B)(i)–(ii)) DOE did not have data to determine whether standards for belt-driven ceiling fans were technically feasible and economically justified due to the limited number of basic models for belt-driven ceiling fans. DOE did not receive any comments regarding these product classes and has not received any additional data to analyze potential standards for belt-driven ceiling fans. As a result, in this final rule, DOE does not set any standards for highly-decorative and belt-driven ceiling fans.

DOE is also not establishing performance standards for centrifugal ceiling fans, oscillating ceiling fans, or ceiling fans whose blades' plane of rotation cannot be within 45 degrees of horizontal fans. In the ceiling fan test procedure final rule, DOE stated that those ceiling fans are also not subject to the test procedure. 81 FR 48620 (July 25, 2016).

2. Technology Options

In the NOPR market and technology assessment, DOE identified technology options that would improve the efficiency of ceiling fans, as measured by the DOE test procedure. These technology options fall into four main categories: (1) More efficient motors, which include larger direct-drive single phase induction motors, three-phase induction motors, geared brushless DC motors, gearless brushless DC motors, and brushless DC motors, and; (2) more efficient blades, which include curved blades, airfoil blades, twisted blades, beveled blades, blade attachments, alternative blade materials; (3) ceiling fan controls, which include occupancy sensors; and (4) fan optimization.

DOE received no comments in opposition to the technology options proposed in the ceiling fans NOPR. However, DOE did receive comments regarding including an additional technology option specific to large-diameter ceiling fans. BAS requested that an additional efficiency level be added to represent a large diameter fan using a premium AC motor instead of a three-phased geared brushless DC motor. BAS stated that premium AC motors are almost as efficient as permanent magnet motors. (BAS, Public Meeting Transcript, No. 133 at pp. 35–36)

In response to BAS's comment, and for the reasons discussed in section IV.C.3, DOE added premium AC motor as an additional technology option in this final rule to account for the costs and benefits of premium AC motors used in ceiling fans in DOE's analysis. Further discussion regarding how DOE implemented this technology option in the analysis is provided in chapter 5 of the TSD.

In the absence of adverse comments, DOE analyzed the same technology options from the ceiling fans NOPR, as well as the premium AC motor technology option specific to large-diameter ceiling fans, in this final rule. Table IV.1 provides the list of technology options considered in the analysis and their descriptions. The screening analysis, which is discussed in the next section, provides further discussion on which of these technology options DOE retained as design options for the engineering analysis.

TABLE IV.1—TECHNOLOGY OPTIONS AND DESCRIPTIONS

Technology option	Description
Fan optimization	This represents increasing the efficiency of a fan by adjusting existing fan design features. These adjustments could include changing blade pitch, fine-tuning motor RPM, and/or changing internal motor characteristics.
	The material, mass, and design/assembly of the motor lamination stack will have an impact on efficiency (via reducing eddy current losses, for example). Similarly, the material, diameter, length, configuration, etc. of the wire in the motor will influence electrical resistance losses inside motor as well as the overall efficiency of the motor.
More efficient motors:	
Larger direct drive single-phase induction motors.	This represents increasing the mass and/or choosing steel with better energy efficiency characteristics for the stator and rotor stack, improving the lamination design, increasing the cross section and/or length of the copper wiring inside the motor.
Three-phase induction motors	Three-phase induction motors have lower thermal energy losses than the single-phase motors typically found in residential line-power applications. They also have a more even torque on the rotor resulting in a more efficient rotation and less motor ''hum.''
	However, three-phase power is extremely uncommon in residential applications. For most residences, these types of motors require electronic drive systems that convert single-phase power into a three-phase power supply.
Brushless DC motor	In residential applications, brushless DC motors typically consist of a permanent magnet synchronous AC motor that is driven by a multi-pole electronic drive system. Similar to DC motors, brushless DC motors typically achieve better efficiency than standard AC motors because they too have no rotor energy losses.

TABLE IV.1—TECHNOLOGY OPTIONS AND DESCRIPTIONS—Continued

Technology option	Description
Geared Brushless DC motor	Brushless DC motor fans with geared motors have fan blades attached to the motor via a geared mechanism, which allows the fan blades to rotate at a different speed from the motor.
Premium AC motor	Premium AC motors are NEMA Premium® motors that are highly energy efficient electric motors. A motor can be marketed as a NEMA Premium motor if it meets or exceeds a set of minimum full-load efficiency levels.[19] Such NEMA motors are available in integral horsepower capacities (*i.e.,* 1 hp+).
Gearless Brushless DC motor	Fans with a brushless DC motor that drive the fan blades directly without the use of a geared mechanism.
More efficient blades:	
Curved blades	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.
Airfoil blades	Airfoil blades use curved surfaces to improve aerodynamics, but the thickness is not uniform and the top and bottom surfaces do not follow the same path from leading edge to trailing edge. Airfoil blades typically do not operate as efficiently in reverse, potentially impacting consumer utility on models where reverse flow was an option.
Twisted blades	Twisted blades reduce aerodynamic drag and improve efficiency by decreasing the blade pitch or twist from where the blade attaches to the motor casing to the blade tip.
Blade attachments	Blade attachments refer to upswept blade tips or other components that can be fastened to a fan blade to potentially increase airflow or reduce drag.
Beveled blades	Beveled 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.
Alternative blade materials	Use of alternative materials could enable more complex and efficient blade shapes (plywood vs. MDF vs. injection-molded resin, for example).
Ceiling fan controls:	
Occupancy sensors	Occupancy sensors use technologies that detect the presence of people through movement, body heat, or other means. Ceiling fans used with an occupancy sensor could power down if they sense that a room is unoccupied.
Wind and Temperature Sensors	Wind and temperature sensors detect temperature changes in the surrounding space, or potential wind speed reductions below certain thresholds. Ceiling fans could potentially adjust fan speed based on the wind and temperature in the space the ceiling fan is located when coupled with these sensors.

B. Screening Analysis

DOE uses the following four 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 working prototypes will not be considered further.

(2) *Practicability to manufacture, install, and service.* If it is determined that mass production and reliable installation and servicing of a technology in commercial products 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 or product availability.* If it is determined that a technology would have significant adverse impact on the utility of the product to significant subgroups of consumers or would 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) *Adverse impacts on health or safety.* If it is determined that a technology would have significant adverse impacts on health or safety, it will not be considered further.

10 CFR part 430, subpart C, appendix A, 4(a)(4) and 5(b)

In sum, if DOE determines that a technology, or a combination of technologies, fails to meet one or more of the above four criteria, DOE will exclude it from further consideration in the engineering analysis. The reasons for eliminating any technology are discussed below. 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.

Westinghouse agreed in general with the screened in and screened out technologies, and said they appreciated that DOE considered a significant amount of stakeholder feedback. (Westinghouse, Public Meeting Transcript, No. 133 at p. 46) With the exception of brushless DC motors, ALA agreed with DOE's screening analysis for hugger and standard ceiling fans. (ALA, No. 137 at p. 6) The discussion regarding retaining brushless DC motors as a technology option is provided in section IV.B.2.

1. Screened-Out Technologies

In the ceiling fans NOPR, DOE screened out the following technologies: (1) For standard, hugger and VSD ceiling fans: Three-phase induction motors, occupancy sensors, and blade design elements including airfoil blades, beveled blades, twisted blades, blade attachments, and alternative blade materials; (2) For HSSD ceiling fans: Larger direct-drive single-phase induction motors, three-phase induction motors, twisted blades, blade attachments, alternative blade materials, and occupancy sensors; (3) For large-diameter ceiling fans: Larger direct-drive single-phase induction motors, beveled blades, twisted blades, blade attachments, alternative blade materials, and occupancy sensors. 81 FR 1688, (January 13, 2016).

DOE received several comments regarding the screened-out technologies, specifically occupancy sensors, and wind and temperature sensors. ALA supported screening out occupancy sensors from DOE's analysis. According to ALA, while this technology has the potential to reduce consumer ceiling fan usage, occupancy sensors would be

[19] NEMA Premium Motors Information Page: *https://www.nema.org/Policy/Energy/Efficiency/Pages/NEMA-Premium-Motors.aspx.*

problematic for ceiling fans in bedrooms. (ALA, No. 137 at p. 7) BAS stated that in the Lawrence Berkeley National Laboratory (LBNL) study cited by DOE in the TSD, more than 50 percent of surveyed people indicated there is a ceiling fan operating in an empty room at least half of the time. BAS believes that adding occupancy sensors to those ceiling fans would dramatically reduce the annual energy use of the fan. (BAS, No. 138 at p. 6)

DOE acknowledges that occupancy sensors have the potential to save energy by reducing the number of ceiling fan operating hours. However, available data was insufficient for DOE to evaluate any potential tradeoff between consumer utility and the energy savings of reduced operating hours. DOE also researched the option of introducing occupancy sensors in ceiling fans. DOE did not find data to show that occupancy sensor can be installed reliably market-wide. Therefore, in this final rule, DOE continues to screen out occupancy sensors because DOE cannot satisfactorily evaluate the energy savings potential, technological feasibility and impact on consumer utility of implementing sensors or schedule controls.

In terms of wind and temperature sensors, Center for the Built Environment (CBE) commented that additional research is needed to demonstrate to what degree integrated temperature and wind sensors in a ceiling fan may save energy with current commercial building controls, or standard thermostats found in most homes. (CBE, No. 143 at p. 1) ALA agreed with DOE's decision to not include wind or temperature sensors as technology options. ALA stated they are not aware of any ceiling fans or working prototypes that include integrated wind or temperature sensors, or any data that would indicate that these products could lead to energy savings in real world applications. (ALA, No. 137 at p. 6) BAS stated that many large diameter fan manufacturers offer some sort of speed control based on space temperature (Big Ass Fans' SmartSense). (BAS, No. 138 at pp. 4–5)

Similar to occupancy sensors, DOE acknowledges that wind and temperature sensors have the potential to save energy by reducing the number of ceiling fan operating hours. As BAS stated, there are large-diameter manufacturers that offer some sort of speed control based on space temperature. However, available data is insufficient for DOE to evaluate any potential tradeoff between consumer utility and the energy savings of reduced operating hours based on implementing controls. DOE also did not find data to show that wind and temperature sensors can be installed reliably market-wide. Therefore, for this final rule, DOE continues to screen out wind and temperature sensors for all ceiling fans because DOE cannot satisfactorily evaluate the energy savings potential, technological feasibility and impact on consumer utility of implementing wind and temperature sensors.

In the absence of any adverse comments regarding the technology options that were screened out in the NOPR, DOE continues to screen-out the same technology options from the NOPR in this final rule. Specifically, DOE screened out the following technologies in this final rule—(1) For standard, hugger and VSD ceiling fans: Three-phase induction motors, and blade design elements including airfoil blades, beveled blades, twisted blades, blade attachments, and alternative blade materials, and occupancy, wind and temperature sensors; (2) For HSSD ceiling fans: More efficient direct-drive single-phase induction motors, three-phase induction motors, twisted blades, blade attachments, alternative blade materials, and occupancy, wind and temperature sensors; (3) For large-diameter ceiling fans: More efficient direct-drive single-phase induction motors, beveled blades, twisted blades, blade attachments, alternative blade materials, and occupancy, wind and temperature sensors.

2. Remaining Technologies

In the ceiling fans NOPR, DOE retained the following technology options—(1) For standard, hugger and VSD ceiling fans: Fan optimization, larger direct-drive single-phase induction motor and brushless DC motors; (2) For HSSD ceiling fans: fan optimization, curved blades, airfoil blades and brushless DC motors; (3) For large-diameter ceiling fans: Fan optimization, airfoil blades, geared brushless DC motors and gearless brushless DC motors. 81 FR 1688 (January 13, 2016).

DOE received several comments regarding the retained technology options. For fan optimization, Westinghouse commented that there are always a few changes that can be made to fans to optimize fans, but not all of the options can be made or it will result in a completely different product. (Westinghouse, Public Meeting Transcript, No. 133 at p. 48) DOE recognizes Westinghouse's concern that making changes to a ceiling fan to improve performance may result in what the industry or consumer would consider a different fan model. DOE defined ''fan optimization'' for its analysis as adjusting existing design features. These adjustments include adjusting blade pitch, fine-tuning motor rpm, and changing internal motor characteristics. DOE does not expect any of these adjustments to require significant changes to the appearance, materials, or outputs of the fan. Consequently, the optimized fan should look and feel almost identical to the non-optimized version of the same fan, only consume less energy.

Regal requested that DC motors be referred to as ''brushless DC motors'' instead of just ''DC motors'' in the standard. (Regal, Public Meeting Transcript, No. 133 at p. 52) DOE agrees with Regal and recognizes that ''brushless DC motors'' is a more accurate technical descriptor for these motors. As such, DOE refers to these motors as ''brushless DC motors'' throughout this final rule notice and accompanying TSD.

For brushless DC motors in standard and hugger ceiling fans, ALA commented that they are concerned about the technological feasibility of DC motors due to concerns about their reliability and their incompatibility with existing wall-mounted controls. (ALA, No. 137 at p. 6) Appliance Standards Awareness Project (ASAP), Alliance to Save Energy (ASE), American Council for an Energy-Efficient Economy (ACEEE), Natural Resources Defense Council (NRDC), and Northwest Energy Efficiency Alliance (herein knows as ''Advocates'') claimed they were unaware of any data indicating any reliability issues associated with DC motors for ceiling fans. (Advocates, No. 142 at p. 4)

DOE has observed that several ceiling fan manufacturers offer small-diameter ceiling fans that use brushless DC motors, and that these fans are some of the most efficient small-diameter ceiling fans on the market. DOE does acknowledge, however, that brushless DC motors are a relatively new technology. Consequently, most small diameter ceiling fans that use brushless DC motors that are currently installed in the field are early in their expected lifespan and, in turn, any reliability issues may become apparent as these fans age. Nevertheless, their availability in the market indicates to DOE that brushless DC motors meet the screening criteria of technological feasibility, practicability to manufacture, install, and service, and no significant impacts on utility (including reliability and product availability). Consequently, DOE screened in brushless DC motors for this final rule for standard and hugger fans. DOE accounted for differences in reliability between brushless DC and AC motors in the life cycle cost analyses. In addition, the energy conservation standard efficiency level adopted in this final rule (see section V.C.1 for discussion on TSLs) is consistent with performance achieved by standard and hugger ceiling fans that use larger direct-drive single-phase induction motors. As a result, any issues, if they exist, with the use of brushless DC motors in standard and hugger ceiling fans, should not be influenced by this rule.

For brushless DC motors in VSD ceiling fans, ALA objected to screening in this technology option. ALA stated they are not aware of any brushless DC motor VSD fans on the market, or currently in development, that would provide an acceptable substitute for the functionality of AC motors in VSD fans. (ALA, No. 137 at p. 6) Pacific Gas and Electric Company (PG&E), Southern California Gas Company (SCGC), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE), and Arizona Public Service (APS) (herein known as California Investor Owned Utilities, or CA IOUs), on the other hand, commented that they continue to support the inclusion of brushless DC motor technology for all product classes, including VSD ceiling fans. CA IOUs also identified several VSD models that use brushless DC motors, including Vaxcel F1008, Fanimation MAD3255, and Sunpentown SF–1691C. In addition, CA IOUs stated that several pedestal and desk fans that are similar in technology, utility, and physical dimensions to VSD ceiling fans use brushless DC motors. (CA IOUs, No. 144 at p. 2)

DOE's understanding from manufacturer interviews is that brushless DC motors in VSD ceiling fans could be technologically feasible, as brushless DC motors are used in traditional standard and hugger ceiling fans. DOE reviewed the list provided by CA IOUs regarding VSD ceiling fans with brushless DC motors that are available in the market. The Fanimation MAD 3255 ceiling fan model specifications on the Fanimation website states that the smallest diameter for the model is 44-inches;[20] therefore, this fan is not a VSD ceiling fan. The Vaxcel F0018 and the Sunpentown SF–1619C, however, are VSD ceiling fans that have a brushless DC motor. Therefore, DOE confirms that there are VSD ceiling fan in the market with brushless DC motors. DOE also did some online research regarding pedestal and desk fans that use brushless DC motors, and observed that there are several models available in the market at blade spans 18 inches or less. Desk fans and pedestal fans are similar in utility compared to VSD ceiling fans because they generally provide consumers with targeted airflow, and can be used to provide air to smaller spaces. However, more importantly, these fans have similar physical characteristics to VSD ceiling fans in terms of fan design; the fans typically have similar blade spans, similar airflows, and similar design (*e.g.,* axial blades and a single motor). Additionally, desk fans and VSD fans have similar size constraints for the motor housing. Because DOE has observed that brushless DC motors are commercially available in VSD ceiling fans, and in desk and pedestal fans, DOE concludes that brushless DC motor is practicable to manufacture, install, and service that does not have significant adverse impacts on utility (including reliability and product availability). Therefore, in this final rule, DOE continues to retain brushless DC motors as a technology option for VSD ceiling fans. In addition, the energy conservation standard efficiency level adopted in this final rule (see section V.C.1 for discussion on TSLs) is consistent with performance achieved by VSD ceiling fans that use larger direct-drive single-phase induction motors. As a result, any issues, if they exist, with the use of brushless DC motors in VSD ceiling fans, should not be influenced by this rule.

For the large-diameter product class, BAS requested that an additional efficiency level be added with a premium AC motor instead of the three-phased geared brushless DC motor. (BAS, Public Meeting Transcript, No. 133 at p. 35) DOE acknowledges that for large-diameter ceiling fans, premium AC motors and three-phase geared motors are readily available in the market. Therefore, DOE retained both technology options in the screening analysis because they meet the four screening criteria for this final rule.

Through a review of each technology, DOE concludes that all of the other identified technologies listed in this section meet all four screening criteria to be examined further as design options in DOE's final rule analysis. In summary, DOE retained the following technology options: (1) For standard, hugger and VSD ceiling fans: Fan optimization, larger direct-drive single-phase induction motors and brushless DC motors; (2) For HSSD ceiling fans: Fan optimization, curved blades, airfoil blades and brushless DC motors; (3) For large-diameter ceiling fans: Fan optimization, airfoil blades, premium AC motors, geared brushless DC motors and gearless brushless DC motors.

DOE determined that these technology options are technologically feasible because they are being 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). For additional details, see chapter 4 of the final rule TSD.

C. Engineering Analysis

In the engineering analysis, DOE establishes the relationship between the manufacturer production cost (MPC) and improved ceiling fan efficiency. This relationship serves as the basis for cost-benefit calculations for individual consumers, manufacturers, and the Nation.

In this final rule, for small-diameter ceiling fans (VSD, Standard, Hugger and HSSD ceiling fans), DOE performed its analysis in terms of incremental increases in efficiency due to the implementation of selected design options. DOE selected representative sizes, and for each size, DOE identified a baseline efficiency as a reference point from which to measure changes resulting from each design option. For large-diameter ceiling fans, DOE performed its analysis based on a representative data set of ceiling fan performance data. DOE determined efficiency as observed in the representative dataset by best-fitting lines to the data for fans that incorporate each design option analyzed. Efficiency for all ceiling fans is represented in terms of the metric finalized in the test procedure. 81 FR 48620 (July 25, 2016).

For both small and large-diameter ceiling fans, MPCs for each successive design option are based on reverse-engineering, which includes product teardowns and a bottom-up manufacturing cost assessment. The estimated MPCs also include the costs of controls. DOE then developed the relationship between MPC and ceiling fan efficiency; this relationship is referred to as a cost-efficiency curve. The efficiency ranges from that of the least-efficient ceiling fan sold today (*i.e.,* the baseline) to the maximum-technologically feasible (max-tech) efficiency level.

The following is a summary of the method DOE used to determine the

[20] *http://www.fanimation.com/products/index.php/louvre.html.*

cost-efficiency relationship for ceiling fans:

- Perform airflow and power consumption tests on a representative sample of ceiling fans in each product class.
- Develop a detailed BOM for the tested ceiling fans through product teardowns, and construct a ceiling fan cost model.

DOE used a combination of test data, data from spec sheets, the cost model, and feedback from manufacturers to calculate the incremental increase in efficiency and cost increase from baseline to max-tech. Further details can be found in chapter 5 of the TSD.

1. Standard and Hugger Ceiling Fans

In the ceiling fans NOPR, DOE combined the cost-efficiency curves of flat-blade fans and unconventional-blade fans in the standard and hugger product classes to create an aggregate curve for all standard ceiling fans and all hugger ceiling fans. DOE used the following design options to create the curves: Fan optimization, larger direct drive motors, and brushless DC motors. DOE used the maximum efficiency of the unconventional-blade fans as the max-tech for the aggregate curve to ensure that all types of ceiling fans, including designs with unconventional-blades, can achieve the max-tech level of efficiency. DOE received several comments on the engineering analysis specific to the standard and hugger product classes.

Advocates commented that the energy savings associated with EL 4 for standard and hugger fans are likely to be significantly greater than shown in the analysis. They stated that it looks like the analysis is assuming that the power consumption of a flat-blade fan incorporating a DC motor would be equivalent to that of an unconventional-blade fan with a DC motor. In practice, it seems very unlikely that flat-blade fans with DC motors would not significantly exceed the efficiency levels given that DOE's analysis shows that a flat-blade fan with a DC motor is 30% more efficient than an unconventional-blade fan with a DC motor. (Advocates, No. 142 at p. 4)

For the NOPR, because DOE set the max-tech efficiency for standard and hugger ceiling fan product classes as the max-tech efficiency for unconventional-blade fans, DOE also set the power consumption at max-tech as the max-tech power consumption for unconventional-blade fans to match the max-tech efficiency. DOE acknowledges that to comply with the EL 4 efficiency for both flat blade fans and unconventional-blade fans, manufacturers are likely to employ brushless DC motors. Therefore, at the max-tech efficiency, there is potential for energy savings for the flat-blade fans. For this final rule, DOE adjusted the power consumption at max-tech to include the potential energy savings from the flat-blade fans. DOE used the same weighting between flat and unconventional blade fans at max tech (*i.e.,* unconventional blade fans make up about 2 percent of the market, while flat blade fans are about 98 percent of the market) as at all the other efficiency levels.

In the engineering analysis for standard and hugger ceiling fans, DOE used an aggregate cost-efficiency curve for flat and unconventional blade fans, as opposed to defining two separate product classes, because fans with flat blades and fans with unconventional blades are functionally indistinguishable. Both fan types move air via the rotation of fan blades, improve comfort by this air movement, and can be used in similar spaces (unlike the distinction between standard and hugger fans, where the former cannot be used in rooms with low ceilings). Further, because flat blade and unconventional blade fans on the market appear to operate within the same CFM range, they have the same product capacity. Therefore, when setting the max-tech for the standard and hugger ceiling fan product classes, DOE set it at the max-tech efficiency for unconventional-blade fans, because this ensures that even at max-tech, all types of ceiling fans, including designs with unconventional blades, can achieve this level of efficiency.

Advocates also stated that the costs associated with EL4 for standard and hugger fans are likely to be lower than shown in the analysis, but did not provide supporting data for this statement. (Advocates, No. 142 at p. 4) As described in section IV.C, DOE reverse engineered several ceiling fans at EL4 (with brushless DC motors) to determine the MPC for that EL. To investigate the Advocates' claims, DOE reverse engineered several more brushless DC motor fans, and revisited the cost model to review the costs used in the NOPR. Based on the review, DOE corroborated the costs presented in the NOPR, rather than lower costs. Absent any additional cost data, DOE continues to use the MPC results from the NOPR for EL4 for standard and hugger fans in this final rule.

In summary, in this final rule, DOE continues to use the combined cost-efficiency curves of flat-blade fans and unconventional-blade fans in the standard and hugger product classes to create an aggregate curve for all standard ceiling fans and all hugger ceiling fans.

Since the NOPR, DOE received additional test data for hugger and standard fans from manufacturers, which was used in the analysis for the final rule. The additional test data was used to update some of the efficiency deltas (*i.e.,* the difference in efficiency for a particular design option) in the analysis. Additionally, the test data informed the conversion factors used to convert efficiencies from ENERGY STAR test method, to efficiencies based on testing small-diameter ceiling fans using the test method in the July 2016 test procedure final rule (*i.e.,* mounting fans directly to the real ceiling). Based on the new test data, DOE increased the conversion factors since the NOPR. DOE then used these conversion factors to determine the efficiency results for the engineering analysis. Further details on the updates to the conversion factor is provided in Chapter 5 of the TSD.

2. VSD and HSSD Ceiling Fans

For the NOPR analysis, DOE was not aware of unconventional blade and flat blade fan variations for VSD and HSSD fans, so DOE did not use an aggregate curve approach for these ceiling fans. DOE used the same design option approach as standard and hugger ceiling fans to determine cost-efficiency relationships for all representative sizes in both VSD and HSSD product classes. DOE used the following design options for VSD ceiling fans to create the curves: Fan optimization, larger direct drive single-phase induction motors, and brushless DC motors. DOE used the following design options for HSSD ceiling fans to create the curves: Fan optimization, curved blades, airfoil blades and brushless DC motors.

DOE did not receive any specific comments on the engineering approach used for the VSD product class. However, DOE received several comments specific to the HSSD engineering analysis. Westinghouse commented that they were concerned with the additive approach used in calculating cost differences for the HSSD efficiency levels. They stated that the approach may not be fully calculating or capturing what the true cost increase will be. (Westinghouse, Public Meeting Transcript, No. 133 at p. 92)

DOE interprets Westinghouse's comment to mean that the full cost for the ELs with multiple design options is not being captured in the engineering analysis. As described in section IV.C, DOE developed the manufacturer production costs based on actual product teardowns. When actual torn down models were not available for certain design options, DOE estimated costs based on materials and manufacturing processes necessary for each design option, and by using input from manufacturers. DOE performed this analysis through a catalog teardown, which uses published manufacturer product literature and supplementary component data to estimate the costs of major physical differences between the catalog teardown unit and a similar physical teardown unit. Some efficiency levels are consistent with performance of ceiling fans that use multiple design options, such as fan optimization and larger direct-drive single-phase induction motors. When determining the MPCs for efficiency levels that incorporate several design options, DOE's engineering analysis incorporates the costs of all design options included in that efficiency level (*i.e.,* the additive approach) added to the baseline MPC. The result, therefore, includes all of the production costs associated with manufacturing a baseline fan and all the incremental costs of adding or substituting technology options to improve efficiency. Westinghouse did not identify specific costs not captured by DOE's analysis, or provide information to support a contention that the additive approach does not fully calculate or capture the actual cost increase. Absent additional information, DOE concludes that its MPC estimates capture all manufacturing costs applicable to the efficiency levels analyzed. See chapter 5 of the final rule TSD for further discussion on the HSSD ceiling fan engineering analysis, which includes details about the costs included in DOE's MPC estimates. DOE did increase the conversion costs for all ceiling fans as part of the MIA. See section IV.J.2.a for further discussion on manufacturer conversion costs.

Westinghouse also asked if DOE had considered reordering the HSSD efficiency levels to have EL3 with DC motor and with flat metal blade followed by EL4 with DC motor and airfoil blades instead of adding the airfoil blades in EL3 and DC motor in EL4. Westinghouse commented that this is different from hugger and standard fans, where the motor options are what drive the cost. They stated that the airfoil blade is a high cost adder with not the same payback as a motor upgrade would be. (Westinghouse, Public Meeting Transcript, No. 133 at p. 113) Fanimation agreed with Westinghouse's comments. (Fanimation, Public Meeting Transcript, No. 133 at pp. 113–114) ALA commented that they are skeptical of DOE's estimate of the net benefits that DC motor-based fan provide to consumers, and generally believe that DC motor-based ceiling fan efficiency standards, like DOE's proposed TSL 4-based standard for HSSD fans, are not technologically feasible. Additionally, ALA stated that DOE's proposed max-tech standard is not economically justified because it relies upon the airfoil blade design option, which is not economically justified. ALA stated that if DOE declines to adopt a standard at EL 3 or below for HSSD fans, DOE should consider adopting a standard for HSSD fans based on an efficiency level that corresponds to the fan optimization and DC motor design options, without the use of curved blades or airfoil blades. (ALA, No. 137, pp. 2–3)

Pursuant to EPCA, DOE must adopt standards that achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) To do this, DOE first establishes TSLs by combining specific efficiency levels for each of the product classes analyzed. Higher TSLs generally consist of a combination of higher efficiency levels for each product class, and the highest TSL generally represents the max-tech efficiency level for all product classes. Therefore, higher TSLs typically represent higher potential energy savings. (See section V.A for more details on TSLs chosen for this rulemaking). DOE then considers the impacts of amended standards for ceiling fans at each TSL beginning with the maximum technologically feasible level, to determine whether that level is economically justified. Where the max-tech level is not justified, DOE then ''walks down'' to the next most efficient level and conducts 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.

For this final rule, TSLs 4 and 5 correspond to the max-tech efficiency level for HSSD ceiling fans.[21] Therefore, when DOE performed a walk-down from TSL 5 and determined that TSL 4 would result in the maximum improvement in energy efficiency that was technologically feasible and economically justified (see section V.C.1), the efficiency level for HSSD ceiling fans still corresponded to the max-tech EL for HSSD ceiling fans.

[21] For HSSD ceiling fans, the max-tech efficiency level analyzed included fan optimization, airfoil blades and a brushless DC motor as design options on a baseline fan.

Because TSL 4 is justified, EPCA prohibits DOE from considering TSL 3, which included a lower efficiency level for HSSD ceiling fans (EL 3, which included only airfoil blades and fan optimization as design options on a baseline fan). Thus, the change to the order of the efficiency levels for HSSD ceiling fans suggested by Westinghouse would not change the results of DOE's walkdown analysis. Therefore, DOE has not analyzed an alternate EL3 with a brushless DC motor and with flat metal blades in this final rule.

Since the NOPR, DOE received additional test data for hugger and standard fans from manufacturers that was used in the analysis for the final rule. The additional test data was used to update some of the efficiency deltas in the analysis. Because some of the VSD and HSSD efficiency deltas are dependent on the standard and hugger analysis, the engineering results for VSD and HSSD analyses were updated accordingly. Further details on the engineering analysis is provided in Chapter 5 of the TSD.

3. Large-Diameter Ceiling Fans

In the NOPR, DOE used a combination of the reverse-engineering and design option approach for the large-diameter ceiling fan engineering analysis. DOE relied on test data and feedback from manufacturers to determine energy ELs to analyze. DOE estimated baseline ceiling fan efficiencies based on test data for large-diameter ceiling fans at intermediate ELs adjusted by efficiency deltas. After establishing the baseline efficiency for large-diameter ceiling fans, DOE applied efficiency deltas associated with each design option to the baseline to calculate the efficiency consistent with performance of large-diameter ceiling fans that use each design option from baseline to max-tech. In DOE's analysis, efficiency deltas are estimated differences in ceiling fan efficiency based on comparing performance of ceiling fans that use different technology options, but are otherwise identical. This analysis resulted in an efficiency curve, as a function of ceiling fan diameter, for each efficiency level.

During the NOPR public meeting, BAS requested that an additional efficiency level be added to represent large-diameter ceiling fans that use a premium AC motor instead of a three-phased geared brushless DC motor, and stated that the premium AC motors are almost as efficient as permanent magnet motors. (BAS, Public Meeting Transcript, No. 133 at pp. 35–36)

DOE received test data from BAS that included ceiling fans using premium AC motors. After evaluating the data, DOE confirmed BAS's assertions that large-diameter ceiling fans that use premium AC motors have comparable efficiencies to those that use geared brushless DC motors. In addition, DOE conducted a teardown analysis, which estimated that ceiling fans with a premium AC motor have lower MPC than ceiling fans with a geared brushless DC motor. Therefore, DOE expects that manufacturers would use the lower-cost premium AC motors instead of geared brushless DC motors to meet a standard that is consistent with the performance of ceiling fans that use either of these technologies. Consequently, DOE replaced the geared brushless DC motor design option with premium AC motors for EL 3 in this analysis to reflect this expectation.

In addition to the test data for fans with premium AC motors, DOE also received additional test data from BAS for the other efficiency levels analyzed in the analysis. With this data, DOE's database of large-diameter fan performance includes 87 ceiling fans at EL 2, EL 3 and EL 4, comprising of ceiling fans from six different manufacturers, and with blade spans of 8, 10, 12, 14, 16, 18, 20 and 24 feet. Due to the large number of ceiling fans, the range of efficiency levels, and the variety of manufacturers, DOE determined that this dataset is representative of the EL 2, EL 3 and EL 4 large-diameter ceiling fans in the market.

A representative dataset allowed DOE to shift from the design option approach used in the NOPR (*i.e.,* evaluating technology pairs to determine efficiency deltas associated with each design option) to an efficiency-level approach (*i.e.,* representing efficiency as observed in the representative dataset by using best-fit lines for each technology option analyzed). In its dataset, DOE observed a broad range of efficiencies in ceiling fans with a gearless brushless DC motor and airfoil blades (*i.e.,* max-tech), and a narrow range of efficiencies in ceiling fans either with airfoil blades (*i.e.,* EL 2) or with a premium AC motor and airfoil blades (*i.e.,* EL3). This change in methodology also updated the engineering results for the large-diameter analysis. Further discussion regarding the efficiency-level approach and the engineering results for large-diameter ceiling fans is provided in chapter 5 of the TSD.

During the NOPR public meeting, BAS recommended that efficiencies be gauged using a CFM/W curve as a function of airflow for each diameter. This would essentially require a CFM per watt standard equation as a function of airflow at every diameter available. (BAS, Public Meeting Transcript, No. 133 at p. 39) In written comments, BAS stated that the fundamental assumption that all ceiling fans of the same diameter move the same amount of air is untrue, allows inefficient low airflow products to remain on the market, and creates an upper limit to ceiling fan performance at each diameter. (BAS, No. 138 at p. 12) BAS further urged DOE to consider a metric that will not eliminate high efficiency, high utility ceiling fans from the market. BAS recommended that an efficiency metric based on ceiling fan diameter and maximum airflow be used to provide energy savings across all airflows and diameters, while still allowing the continued development of high utility products. (BAS, No. 138 at p. 15) In this discussion, DOE understood BAS' use of the phrase ''high utility ceiling fans'' to mean ceiling fans with high maximum airflows. The Advocates also encouraged DOE to consider standards for large-diameter ceiling fans that take both diameter and airflow into account. According to the Advocates, by taking only diameter into account in establishing ELs for large-diameter ceiling fans, the standards may have little impact on ceiling fans that deliver relatively low airflow rates, while simultaneously prohibiting ceiling fans of the same diameter that deliver higher airflow rates than those assumed in the analysis. (Advocates, No. 142 at pp. 1–2)

DOE's understanding of both BAS and Advocates concern is that an efficiency standard only based on diameter only could disproportionally impact ceiling fans that deliver higher airflows, compared to those that deliver lower airflows. To investigate this further, DOE analyzed the test data provided by BAS, in addition to DOE's own test data of large-diameter ceiling fans.

DOE began its analysis by confirming that the relationship between diameter and ceiling fan efficiency is an appropriate basis for an energy efficiency standard. DOE plotted a best fit line between diameter and efficiency of all the ceiling fans at max-tech and observed a R^2 correlation of 0.51 between diameter and efficiency. DOE conducted a similar exercise for ceiling fans at EL 2 and EL 3. At these ELs, however, DOE observed a narrower range of efficiencies at each diameter, which resulted in better R^2 correlations of 0.87 and 0.97 for EL 2 and EL 3, respectively, compared to max-tech. Therefore, the greater variation in max-tech test data suggests that the variation in efficiency with airflow is much greater for ceiling fans with gearless brushless DC motors than those with AC motors. DOE realizes that the data for EL 4 ceiling fans is more scattered meaning that not all ceiling fans produce the same amount of airflow and that airflow has a direct effect on the efficiency of ceiling fans. However, for EL 2 and EL 3, the tight range of efficiency and airflow data at EL 2 and EL 3 suggests that the slope from the best fit line is a good representation of the relationship between efficiency and diameter.

For this final rule, the energy conservation standard efficiency level adopted is consistent with performance achieved by large-diameter ceiling fans with EL 3 characteristics. See section V.C.1 for discussion on TSLs. Therefore, DOE believes that the relationship between diameter and efficiency is an appropriate basis for an energy efficiency standard. However, based on the data, DOE did observe that there were some high airflow ceiling fans that might be disproportionally disadvantaged based on a standard using the best fit line. Therefore, to preserve consumer utility that require ceiling fans with high airflow, DOE decreased the y-intercept of the best fit equations, while maintaining the slopes. DOE aimed to preserve consumer utility by maintaining the maximum airflow produced at each diameter, or identify a close alternative, by shifting the equation downwards.

For each of the eight diameters analyzed (ranging from 8–24 feet), DOE identified the ceiling fan with the maximum tested airflow from all efficiency levels. At two of the eight diameters, a ceiling fan at EL 2 produces the largest airflow, and at the other six diameters, a ceiling fan at EL 3 produces the maximum airflow. At three of the eight diameters, the fan with the highest airflow achieves the efficiency level established in this final rule.

For the other five diameters, where the highest airflow ceiling fan does not meet the established standard level, DOE identified the ceiling fan with the highest airflow that achieves the standard level and compared it to the ceiling fan with the maximum airflow at that diameter. DOE calculated the percentage of maximum airflow for these ceiling fans to determine whether the EL 3 standard is still achievable with an EL 3 ceiling fan, without eliminating ceiling fans with high maximum airflows. DOE further investigated any diameter where the maximum airflow ceiling fan did not achieve the standard level, in order to see if the maximum airflow or a close alternative could be achieved. At two of the remaining five diameters, the ceiling fan with the highest airflow that achieved the standard level produced 99 percent of the airflow recorded for the ceiling fan with the maximum airflow. At two other diameters, the ceiling fans that meet the standard produced 90 percent of airflow of the highest airflow ceiling fan. For the last diameter, the highest airflow of a ceiling fan achieving the standard was 85 percent of the ceiling fan with the maximum airflow. The lower percentages at the three diameters may be a representation of smaller sample size, and not an outcome of the stringency of the standard.

For the reasons mentioned, DOE believes that the high efficiency, high airflow ceiling fans will not be eliminated from the market when using the shifted best fit equation. Therefore, DOE continued with the methodology outlined in the NOPR by adopting a standard equation that is only a function of diameter, and not airflow.

BAS commented that the repair costs should be separated for the geared and gearless versions for DC motors used in the large-diameter analysis. BAS stated that the gearless DC motor will take more hours to service than the geared motor because the entire fan assembly has to be removed to repair the gearless motor. (BAS, Public Meeting Transcript, No. 133 at p. 99) BAS also stated that efficiency losses resulting from gearboxes are generally less than 5 percent, not 20 percent. (BAS, Public Meeting Transcript, No. 133 at p. 31)

In the final rule, DOE replaced the geared brushless DC motor with the premium AC motor for efficiency level 3. Therefore, these comments do not affect the large-diameter analysis in the final rule.

4. Reducing Fan Speed To Improve Efficiency

In the NOPR analysis, DOE had requested comments on what an acceptable reduction of fan speed may be to improve ceiling fan efficiency such that it does not affect consumer utility for each of the proposed product classes. DOE received several comments regarding this topic.

CBE stated that, based on CBE laboratory tests, at least one ceiling fan tested is more efficient at lower speed. However, limiting the maximum air speed would not satisfy human comfort at higher temperatures. CBE suggested that one way to avoid this may be setting a limit for the maximum air speed for a ceiling fan, while requiring that the energy efficiency standard be met as well. (CBE, No. 143 at p. 1) BAS commented that a decrease of 50% in airflow nets an approximate gain of 220% on efficiency, but would result in a dramatic reduction in cooling effect and consumer utility. BAS stated that the impact of the reduced performance will likely not be known to the consumer because there are no guidelines, equations or standards that allow consumers to translate CFM into cooling effect. BAS felt this would be especially true if the labeling requirements do not prominently display the maximum CFM of the fan. (BAS, No. 138 at p. 7) ALA stated they do not believe that reducing fan speeds available to a consumer is a viable way to improve efficiency because reducing fan speed directly impairs consumer utility. ALA therefore agreed with DOE's statement in the NOPR, that ''manufacturers will not reduce airflow to levels that are unacceptable when other cost-justified pathways to compliance are available.'' (ALA, No. 137 at p. 7) CA IOUs asked whether companies may simply reduce their fans' RPMs in order to meet the efficiency standard, and ASAP suggested that in such a case, consumers may run their fans at higher speeds, thereby reducing the energy savings from the standard. (CA IOUs, Public Meeting Transcript, No. 133 at p. 159; ASAP, Public Meeting Transcript, No. 133 at pp. 154–155) Westinghouse responded by suggesting that manufacturers that try to meet the standard by reducing the utility (*i.e.,* airflow) of their fans would lose business. (Westinghouse, Public Meeting Transcript, No. 133 at pp. 155–156) In addition, Westinghouse noted that if a manufacturer tried to make an obsolete product simply to meet the standard, demand for the product would wane over time and competition would publicize how that manufacturer's products are lacking in performance. (Westinghouse, Public Meeting Transcript, No. 133 at pp. 158–159)

DOE understands that slowing down a fan can significantly reduce energy consumption. However, DOE also recognizes that airflow, which diminishes at lower fan speeds, factors heavily into consumer utility. DOE observes that the airflow produced by commercially available fans of the same diameter varies. While DOE interprets this to mean that some variation in airflow at a given diameter is acceptable to the market and does not represent a reduction in utility, DOE did not include slowing down the fan as a design option to avoid setting standards that may result in reduced utility. Leaving out reducing fan speed as a design option ensures that manufacturers can meet the level adopted by this final rule in a cost-justified manner without reducing fan speed. While manufacturers may opt to do so, it is unlikely that many will due to the market pressures identified by Westinghouse. In addition, the FTC is primarily responsible for labeling, and issued amendments to the ceiling fan label for all ceiling fans except large-diameter and HSSD ceiling fans on September 15, 2016. 81 FR 63634. The ceiling fan label includes a prominent display of the CFM based on typical use of a ceiling fan. The FTC is planning to seek comments on the need for, and content of, fan labels for large-diameter and HSSD ceiling fans in a separate notice. 81 FR 63634, 63637.

5. Standard Level Equations

In the ceiling fans NOPR, DOE proposed best-fit linear standard level equations in terms of ceiling fan diameter, based on the efficiency results for the representative sizes analyzed for each product classes. The linear standard level equations were established so that the proposed minimum efficiencies could be calculated for all ceiling fan diameters within a product class. DOE received a comment regarding the standard level equations proposed.

In general, ALA commented that DOE should, in adopting final efficiency standards for ceiling fans, clarify that the efficiency equation found in the table in proposed 10 CFR § 430.32(s)(2) represents minimum ceiling fan efficiency. (ALA, No. 137 at p. 3) DOE appreciates the comment from ALA, and has updated references to the standard level equations in this final rule to clarify that it represents minimum ceiling fan efficiency.

In this final rule, DOE continues to develop standard level equations based on diameter for all product classes. As discussed in the ceiling fans NOPR, DOE believes that blade diameter is a better proxy for utility than airflow. The size of a fan determines the cooling area, impacts room aesthetics, and determines if a fan physically fits into a room. Literature published by manufacturers clearly indicates that blade span is an important criterion for consumer fan selection. Manufacturers include sizing guides in published product literature to instruct consumers on how to properly size a fan for a given room size. These fan sizing guides specify the affected square footage of a room based on fan blade diameter. DOE did not find such guides for other ceiling fan characteristics such as airflow.

Therefore, based on the updates to the engineering analyses described in sections IV.C.1 through IV.C.3 for all product classes, DOE also updated the best-fit linear standard level equations.

DOE is not aware of commercially available VSD fan models below 12 inches in diameter. However, extending a best-fit linear equation below 12 inches for VSD would result in minimum ceiling fan efficiency standards below 0 CFM/Watt at near 0 inch diameters. In this final rule, DOE is continuing to use a best-fit linear equation for VSD fans 12 inches in diameter and above (the range in which all known commercially-available VSD models currently exist). However, DOE is extending the minimum ceiling fan efficiency required at 12 inches to all VSD fans below 12 inches in diameter to avoid standards 0 CFM/Watt and below for any VSD models that may exist in this range.

D. Markups Analysis

The markups analysis develops appropriate markups (*e.g.,* manufacturer markups, retailer markups, distributor markups, contractor markups) in the distribution chain and sales taxes to convert the MPC 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, the markups are multipliers that are applied to the purchase cost to cover business costs and profit margin.

DOE characterized four distribution channels to describe how standard, hugger and VSD ceiling fans pass from manufacturers to consumers. These four distribution channels can be characterized as follows:

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

DOE developed separate markups for home improvement centers that have their in-store label ceiling fans and for those that sell independent-label ceiling fans. As indicated in the market assessment, two of the top three ceiling fan brands in the market are the in-store brands for two home improvement centers. These home improvement centers therefore serve as both in-store brand manufacturers and home improvement centers that carry both store-brand and independent-brand ceiling fans. For in-store label ceiling fans, DOE developed an overall markup that encompasses the margins for manufacturing as well as selling the product. For the independent-label ceiling fans sold through home centers, separate markups were developed for the brand manufacturer and for the home improvement centers which serve only as a retailer.

For large-diameter and HSSD ceiling fans, the two distribution channels that DOE considered can be characterized as follows:

Manufacturer → Dealer → Customer
Manufacturer → In-house Dealer → Customer

The second distribution channel for large-diameter and HSSD ceiling fans is a direct sale channel where the manufacturer sells the product directly to a customer through its in-house dealer. DOE assumed the markup for in-house dealers is the same as the conventional dealer markup; therefore, the overall markup for these two distribution channels is the same.

To account for manufacturers' non-production costs and profit margin, DOE applied the manufacturer markup to the full MPC derived in the engineering analysis. The resulting manufacturing selling price (MSP) is the price at which the manufacturer can recover all production and non-production costs and earn a profit. To meet new or amended energy conservation standards, manufacturers typically introduce design changes to their product lines, which increase manufacturer production costs. As production costs increase, manufacturers typically incur additional overhead.

To calculate the manufacturer markups, DOE reviewed 10–K reports [22] submitted to the U.S. Securities and Exchange Commission (SEC) by publicly-owned ceiling fan companies. The financial figures necessary for calculating the manufacturer markup are net sales, costs of sales, and gross profit. Few ceiling fan manufacturing companies are publicly owned, and most of the publicly-owned ceiling fan manufacturing companies are subsidiaries of more diversified parent companies, so the financial information summarized may not be exclusively for the ceiling fan portion of their business and can also include financial information from other product sectors. DOE discussed the manufacturer markup with manufacturers during interviews, and used product specific feedback on market share, markups and cost structure from manufacturers to adjust the manufacturer markup calculated through review of SEC 10–K reports.

To develop markups for the market participants involved in the distribution of ceiling fans, DOE utilized several sources, including: (1) The SEC 10–K reports and U.S. Census Bureau's annual retail trade survey for building material and supplier dealer industry [23] (to develop home improvement center markups); (2) the U.S. Census Bureau's annual wholesale trade report for electrical and electronic appliance, television, and radio set merchant wholesaler industry [24] (to develop wholesaler markups); (3) 2014 RSMeans Electrical Cost Data [25] (to develop contractor markups); and (4) the SEC 10–K reports (to develop dealer markups).

To develop the markups when home centers serve as both brand manufacturer and retailer, DOE relied upon input from an industry expert.[26]

For each of the market participants, DOE developed baseline and incremental markups based on the product markups at each step in the distribution chain. The baseline markup relates the change in the MSP of baseline models to the change in the consumer purchase price. The incremental markup relates the change in the MSP of higher-efficiency models (the incremental cost increase) to the change in the consumer purchase price.

In addition to the markups, DOE derived state and local taxes from data provided by the Sales Tax Clearinghouse.[27] These data represent weighted average taxes that include county and city rates. DOE derived shipment-weighted average tax values for each region considered in the analysis.

Chapter 6 of the final rule TSD provides details on DOE's development of markups for ceiling fans.

E. Energy Use Analysis

The purpose of the energy use analysis is to determine the annual energy consumption of ceiling fans at different efficiency levels in

[22] U.S. Securities and Exchange Commission, Annual 10–K Reports (various years between 2007 and 2013), available at *http://sec.gov.*

[23] U.S. Census Bureau. *2012 Annual Retail Trade Survey.* Building Material and Supplier Dealer. 2012 (Last Accessed April 22, 2015) *http://www.census.gov/retail/arts/historic_releases.html.*

[24] U.S. Bureau of the Census. *2012 Annual Wholesale Trade Report, NAICS 423620: Electrical and Electronic Appliance, Television and Radio Set Merchant Wholesaler.* 2012. Washington, DC. (Last Accessed April 22, 2015) *http://www.census.gov/wholesale/index.html.*

[25] RS Means Company Inc. *Electrical Cost Data: 36th Annual Edition.* 2014. Kingston, MA.

[26] Mehta, V. Independent ceiling fan industry consultant. Personal communication. E-mail to Colleen Kantner, LBNL. November 24, 2013.

[27] Sales Tax Clearinghouse Inc., State Sales Tax Rates Along with Combined Average City and County Rates (2014) available at *http://thestc.com/STrates.stm* (last accessed May 27, 2014).

representative U.S. homes and commercial buildings, and to assess the energy savings potential of increased ceiling fan efficiency. To develop annual energy use estimates, DOE multiplied ceiling fan input power by the number of hours of use (HOU) per year. The energy use analysis estimates the range of operating hours 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 that DOE performed, particularly assessments of the energy savings and the savings in consumer operating costs that could result from adoption of amended standards.

1. Inputs for Standard, Hugger, and VSD Ceiling Fans

a. Sample of Purchasers

As in the NOPR analysis, DOE has included only residential applications in the energy use analysis of standard, hugger, and VSD ceiling fans. DOE used the Energy Information Administration (EIA) 2009 Residential Energy Consumption Survey (RECS) [28] 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 12,083 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, hugger, and VSD 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, hugger, and VSD product classes.

b. Operating Hours

As in the NOPR analysis, DOE used data from an LBNL study [29] 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. 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 NOPR analyses, DOE estimated that the average fraction of time that standard, hugger, and VSD ceiling fans were operated at each speed was equal to the simple average of the fractions reported by the LBNL survey and an AcuPOLL [30] survey submitted by ALA in response to the ceiling fan test procedure NOPR. This average yields an estimate of 33 percent of time spent in active mode on high speed, 38 percent on medium speed, and 29 percent on low speed. In written comments received in response to the NOPR, Westinghouse and ALA indicated agreement with these estimated average hours of use for standard, hugger, and VSD ceiling fans. (Westinghouse, Public Meeting Transcript, No. 133 at p. 79; ALA, No. 137 at p. 8)

For the final rule, DOE refined the NOPR approach by accounting for a distribution in operating hours spent at each speed.[31] Specifically, for each sampled household, 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. Since 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.

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. These values are shown in chapter 5 of the final rule TSD. DOE estimated that all ceiling fans with brushless DC motors expend standby power, and that 7 percent of standard, hugger, and VSD 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, hugger, and VSD product classes, based on testing conducted in association with developing the engineering analysis.

BAS commented that the percentage energy savings for ceiling fans with occupancy sensors will be similar to that of lighting systems with occupancy sensors and that this similarity could be used to estimate savings from ceiling fans with occupancy sensors. (BAS, No. 138 at p. 5) DOE acknowledges that occupancy sensors have the potential to have an impact on the energy consumption of ceiling fans. However, available data is insufficient for DOE to determine what impact occupancy sensors may have on energy use in practice. In the absence of supporting data or evidence to substantiate energy savings, DOE does not believe it is appropriate to assume ceiling fans and lighting systems to have similar percentage energy savings. Furthermore, occupancy sensors have been screened out of the final rule analysis (see section IV.B.1), and it is unclear if fans with occupancy sensors will make up a non-negligible portion of the market in the future, especially in the residential sector.

The CA IOUs indicated that many hugger, standard, and VSD ceiling fans with brushless DC motors have six speeds, not three speeds. Therefore, the CA IOUs recommended that DOE consider incorporating the advantages of six-speed ceiling fans by averaging the performance characteristics at the lowest two speeds, the middle two speeds, and the highest two speeds as proxies for the currently-proposed low-speed setting, middle-speed setting, and high-speed setting, respectively. (CA IOUs, No. 144 at p. 3) As previously mentioned, in the energy use analysis, DOE used the power consumption estimates developed for each representative fan in the engineering analysis. In the engineering analysis, power consumption estimates at high, medium, and low speed were developed based on the test method set forth in the test procedure final rule (CITE). Consistent with the test procedure final rule, testing was conducted at the lowest and highest speed for fans for with brushless DC motors. Testing was not conducted at the other four fan

[28] U.S. Department of Energy–Energy Information Administration. *2009 RECS Survey Data.* (Last accessed May 3, 2016.) *http://www.eia.gov/consumption/residential/data/2009/.*

[29] 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. *http://www.escholarship.org/uc/item/3r67c1f9.*

[30] AcuPOLL® Precision Research, Inc. *Survey of Consumer Ceiling Fan Usage and Operations.* 2014.

[31] For the final rule, DOE used a distribution of operating hours at each speed, rather than an average, to better represent the distribution of impacts on a sample of 10,000 households. The average time at each speed from the distribution is unchanged from average value used in the NOPR analysis.

speeds. Power consumption at medium speed for such fans was estimated based on scaling the power consumption at the middle speed setting from representative fans with three speeds. The specific distribution of time between the six fan speeds commonly had by DC-motor fans is unknown, but DOE concludes that the current approach should be a representative estimate of overall energy use for DC-motor ceiling fans.

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

a. Sample of Purchasers

As in the NOPR analysis, DOE has included only commercial and industrial applications in the energy use analysis of large-diameter and HSSD ceiling fans. Although some large-diameter and HSSD fans are used in residential applications, they represent a very small portion of the total market for large-diameter and HSSD ceiling fans. Similar to standard, hugger, and VSD ceiling fans, DOE developed a sample of 10,000 fans to represent the range of large-diameter and HSSD ceiling fan energy use. The sample captured variations in operating hours.

b. Operating Hours

In the NOPR analysis, DOE used feedback from manufacturers to estimate total hours of operation for HSSD ceiling fans. Manufacturers suggested a range of possible hours of operation, depending on industry and application, with 12 hours per day as a representative value. To represent a range of possible operating hours around this representative value, 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 HSSD fans. DOE also used manufacturer feedback to determine the proportion of operating time spent at each speed, estimating that, on average, HSSD fans spend approximately 10 percent of the time at high or low speed, and the rest of their time (approximately 80 percent) at a medium speed.

Westinghouse and ALA agreed with the average hours of use estimate for HSSD fans in the NOPR analysis, and no stakeholders expressed disagreement. (Westinghouse, Public Meeting Transcript, No. 133 at p. 79; ALA, No. 137 at p. 8) Accordingly, DOE assumed for this final rule that HSSD fans operate for 12 hours a day on average when conducting analysis for the final rule, and has maintained its assumptions regarding the operating hours distribution.

In the energy conservation standards NOPR analysis, DOE's estimate of the daily total hours of operation for large-diameter fans was consistent with total hours of operation estimate from the test procedure SNOPR. (80 FR 31487 (Jun. 3, 2015)) In the test procedure SNOPR, to weight the performance results of the ceiling fans at each of the five speeds, DOE took a simple average of the total daily hours-of-use estimate of 18 hours per day provided by MacroAir and an example of the fraction of time spent at each speed from BAS that DOE assumed implicitly agreed with the 12 hours per day estimate from the October 2014 test procedure NOPR, which yielded an average value of 15 hours per day. Id. BAS took issue with DOE's assumption and, therefore, disagreed with DOE's estimate of 15 hours of use per day (BAS, No. 138 at p. 6)

To estimate the energy consumption of large-diameter ceiling fans, DOE must make an estimate of average operating hours for such fans. Based on the available data on daily operating hours, for the final rule DOE estimated 12 hours of use per day in active mode for large-diameter ceiling fans, consistent with the hours of use estimate for HSSD fans, which are also used in commercial and industrial applications, and also consistent with estimate from the test procedure final rule (CITE).

In the NOPR analysis, DOE also modeled the fraction of time spent at each of five speeds by large-diameter ceiling fans in an approach aligned with the ceiling fans test procedure SNOPR, which proposed to test all large-diameter ceiling fans at maximum speed, 80% speed, 60% speed, 40% speed, and 20% speed. 80 FR 31487 (June 3, 2015). Taking the average of manufacturer inputs yielded the following hours of use distribution for the NOPR analysis: 1.8 hours at maximum speed, 3.5 hours at 80% speed, 3.6 hours at 60% speed, 2 hours at 40% speed, and 4.1 hours at 20% speed. BAS clarified that the input on distribution of time at different speeds was intended as an example and not as an estimate to be used in calculations. (BAS, No. 138 at p. 8) BAS further commented that there is insufficient data to assign operating hours or estimate percentages of operation. (BAS, Public Meeting Transcript, No. 133 at pp. 83–84) BAS recommended against the use of an average of two sets of operating hours in deriving operating hours for large-diameter ceiling fans and recommended measuring at high speed only or using a metric that includes equal weighting at the five proposed operating speeds. (BAS, No. 138 at p. 6)

For the final rule, based on lack of available data to suggest otherwise, DOE gave equal weighting to each of the five speeds from the test procedure, consistent with BAS's suggestion and consistent with the approach in the test procedure final rule. (CITE)

c. Power Consumption at Each Speed and Standby

For the large-diameter ceiling fan product class, the power consumption for a given representative fan was determined 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, as detailed in chapter 5 of the final rule TSD.

For the HSSD ceiling fan product class, as in the NOPR analysis, DOE determined power consumption at high speed for each representative fan in the engineering analysis. To estimate the power consumption at medium speed, DOE multiplied the high-speed power by the average ratio between high-speed power and medium-speed power in the standard, hugger, and VSD fans engineering analysis. DOE used the same approach for low-speed power, using the average ratio between high-speed power and low-speed power from the standard, hugger, and VSD fans engineering analysis.

As in the NOPR analysis, in this final rule DOE considered all HSSD fans at the efficiency levels with a brushless DC motor to have standby power, assuming a remote control was included for all such fans. DOE estimated 0.7 watts as the standby power value for all representative fans in the HSSD product class. Because these fans also have standby power as a result of a remote control receiver, this is the same value used for standard, hugger and VSD fans, as discussed in section IV.E.1.c.

DOE also considered large-diameter fans to have standby power, because available information indicated that the majority of large-diameter ceiling fans in the market use a variable-frequency drive and/or are operated by remote control, which consumes standby power. The standby power for large-diameter ceiling fans was estimated to be 7 watts in the engineering analysis (see chapter 5 of the final rule TSD).

For HSSD and large-diameter ceiling fans with standby power consumption, DOE assumed that all hours not spent in active mode were in standby mode.

3. Impact on Air Conditioning or Heating Equipment Use

DOE did not account for any interaction between ceiling fans and air conditioning or heating equipment in the NOPR analyses. In DOE's estimation it appeared 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 due to an amended energy conservation 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.

ASAP, et al. and the CA IOUs agree that the interaction between ceiling fan and air conditioning use would be negligible on a national level. (ASAP, et al., No. 142 at p. 5) The CA IOUs also agreed with DOE's decision not to include the air conditioning interaction in its analyses for this rule, based on the lack of available data. (CA IOUs, No. 144 at p. 2) ALA suggested that DOE's proposed ceiling fan efficiency standards could result in increased air conditioning use, because many ceiling fan consumers already have air conditioning units—which provide substitutionary cooling at no additional cost—and will therefore be more price sensitive to the price of ceiling fans. (ALA, No. 137 at p. 8) BAS pointed out that shipments projections do not directly reflect the possibility of consumers increasing their air conditioning set point and using the ceiling fan at high speeds. (BAS, Public Meeting Transcript, No. 133 at pp. 77–78)

As noted in the NOPR, DOE agrees that ceiling fans have the theoretical 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, hugger, and VSD fans of less than 1% under the adopted 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. DOE did not account for such interaction in the final rule analyses.

The Center for the Built Environment at the University of California, Berkeley (CBE) agreed with DOE that a modest increase in ceiling fan price is unlikely to increase air conditioning use, but suggested that DOE conduct analyses on the building level rather than only considering ceiling fan cost savings. (CBE, No. 143 at p. 2) BAS cited three projects using building automation systems to vary ceiling fan speed that resulted in a reduction or elimination of air conditioning use. (BAS, No. 138 at p. 10) It was reported in one of the projects cited by BAS that the use of ceiling fans in a school can provide up to 4 °F of ''additional effective'' or ''perceived'' cooling. In the other two projects, the use of ceiling fans resulted in expanded temperature ranges in buildings, such as from a 72 °F to 75 °F range to a 68 °F to 82 °F range.

While DOE appreciates the provision of quantifiable outcomes, it is not clear if and how such cooling translates to applications beyond the specific cases cited, which may not be representative of ceiling fan usage in general. Moreover, as discussed previously, the interaction between ceiling fan use and air conditioning use is unlikely to be significantly different in the case of amended standards than it would be in the no-new-standards case. Customers who would purchase ceiling fans as a cost-effective substitute are for air-conditioning or heating equipment are free to do so regardless of whether there is any amended standard.

F. Life-Cycle Cost and Payback Period Analysis

DOE conducts LCC and PBP analyses to evaluate the economic impacts on individual consumers of potential energy conservation standards. 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 uses the following two metrics to measure consumer impacts:

- The LCC (life-cycle cost) 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 (payback period) 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.

DOE calculated the LCC and PBP for each considered efficiency level for a nationally representative consumer sample for each of the product classes. DOE developed consumer samples that account for variation in factors such as geographic location. Two types of consumer samples were created: one for the standard, hugger and VSD group of fans and another for the HSSD and large-diameter group. This was done to capture the variability in energy consumption, discount rates and energy prices associated with the different groups of ceiling fans.

For VSD, hugger, and standard ceiling fans, DOE created a sample in a manner similar to that outlined in section IV.E.1. Due to a lack of data on the location of HSSD and large- diameter fans, DOE assumed that the geographic distribution of HSSD and large-diameter fan purchasers is similar to that of standard, hugger, and VSD ceiling fan purchasers. Therefore, DOE chose the location of HSSD and large-diameter fan purchasers according to the geographic distribution of households in RECS. For each consumer in the sample used for HSSD and large-diameter fans, DOE determined the energy consumption of ceiling fans and the appropriate electricity price for the location and sector.

The calculation of the total installed cost includes MPCs, manufacturer markups, retailer and distributor markups, and sales taxes. Installation costs were assumed not to 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, repair and maintenance costs, 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.

The computer model DOE uses to calculate the LCC and PBP 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. The model calculated the LCC and PBP for products at each efficiency level for a sample of 10,000 consumers per simulation run.

DOE calculated the LCC and PBP for all consumers as if each were to purchase a new product in the expected first full year of compliance with amended standards. The final rule is expected to publish in late 2016, with a compliance date in late 2019. For this final rule, DOE analyzes LCC results for 2020, the first full year of compliance with final rule.

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 and its appendices of the final rule TSD.

TABLE IV.2—SUMMARY OF INPUTS AND METHODS FOR THE LCC AND PBP ANALYSES *

Inputs	Source/method
Purchase Price	DOE estimated the purchase price of ceiling fans (CF) by combining the different cost components along the production, import, distribution and retail chain. DOE further used a price trend to project prices of CF with brushless DC motors to the compliance year.
Sales Tax	Derived 2020 population-weighted-average tax values for each reportable domain based on Census population projections and sales tax data from Sales Tax Clearinghouse.
Energy Use	Derived in the energy use analysis, and takes into account variations in factors such as operating hours. Variation in geographic location is taken into account for certain product classes.
Energy Prices	Electricity: Based on 2014 marginal electricity price data from the Edison Electric Institute. Variability: Electricity prices vary by season, U.S. region, and baseline electricity consumption level.
Energy Price Trends	Based on *AEO 2015* price forecasts.
Product Lifetime	Derived a mean ceiling fan life time of 13.8 years from a best-fit model based on the Weibull distribution.
Discount Rates	Approach involves identifying all possible debt or asset classes that might be used to purchase the considered appliances, or might be affected indirectly. Primary data source was the Federal Reserve Board's Survey of Consumer Finances.
Efficiency Distribution	Current efficiency distribution for standard and hugger ceiling fans is based on feedback from manufacturers. Current efficiency distribution for VSD, HSSD and large-diameter ceiling fans is based on online model counts. Efficiency distribution for the compliance year is estimated by the market-share module of shipments model. See chapter 9 of the final rule TSD for details.
Assumed Compliance Date	2019.**

* References for the data sources mentioned in this table are provided in the sections following the table and in chapter 8 of the final rule TSD.
** The compliance date was assumed to be in late 2019, so the LCC analysis was conducted for 2020, the first full year of compliance.

1. Purchase Price

DOE estimates the purchase price by combining manufacturing and production cost, manufacturer markups, tariffs, import costs, retail markups, and sales tax. Section IV.D provides the details of the markups analysis.

DOE used a price trend to account for changes in the incremental brushless DC motor price that are expected to occur between the time for which DOE has data for brushless DC motor prices (2014) and the first full year after the assumed compliance date of the rulemaking (2020). DOE estimated a 6 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.[32] This rate is applied only to the incremental cost between a brushless DC motor and an AC motor and not to the price of the entire ceiling fan. For details on the price trend analysis, see section IV.G.

DOE applied sales tax, which varies by geographic location, to the total product cost. DOE collected sales tax data from the Sales Tax Clearinghouse[33] and used population projections from the Census bureau[34] to develop population-weighted-average sales tax values for each state in 2020.

In the final rule analyses, as in the NOPR analysis, DOE assumed that installation costs are the same regardless of efficiency level and do not affect the LCC or PBP. Westinghouse, ALA, and BAS agreed that installation costs are not based on efficiency level of fan technology. (Westinghouse, Public Meeting Transcript, No. 133 at p. 96; ALA, No. 137 at p. 8; BAS, No. 138 at p. 10)

Lutron estimated that, conservatively, there are approximately 20 million ceiling fan speed controls installed in the U.S. that generally work well with AC-motor ceiling fans. Because controls for DC-motor ceiling fans are more complicated, requiring brushless DC motors for standard, hugger, and VSD ceiling fans would unintentionally force consumers with high-cost, integrated control systems (*i.e.,* control systems intended to control ceiling fan operation in addition to other appliances) to replace those controls systems, which is expensive and would remove energy savings potential. (Lutron, No. 141 at p. 2)

Regarding the estimate of 20 million installed speed controls for ceiling fans with AC motors, DOE notes that brushless DC-motor ceiling fans are assumed to be sold with a remote control and that the cost of the associated control is included in DOE's analyses. Therefore, consumer ability to control fan speed is preserved for ceiling fans with brushless DC motors. Regarding high-cost integrated control systems, DOE acknowledges that there may be a higher installation cost for consumers who purchase a DC-motor ceiling fan and need to upgrade from an existing integrated control system that only works with AC-motor ceiling fans to an integrated control system that works with DC-motor ceiling fans; however it is unclear what fraction of AC-motor standard, hugger, and VSD ceiling fans are currently operated by high-cost integrated control systems. DOE's best estimate is that this fraction

[32] PCU334413334413.

[33] *https://thestc.com/STRates.stm.* Last accessed May 7th 2015.

[34] U.S. Census Bureau, Population Division, Interim State Population Projections, 2005. Table A1: Interim Projections of the Total Population for the United States and States: April 1, 2000 to July 1, 2030.

is negligibly small.[35] Furthermore, DOE notes that the standard adopted for standard, hugger, and VSD ceiling fans by this final rule does not require the usage of DC-motor ceiling fans.

The CA IOUs suggested that DOE remove the remote control cost from the installed cost, as the remote control is not an essential component for a ceiling fan. Alternatively, if DOE decides to include the cost of remote controls, the CA IOUs encourage DOE to consider adding the cost for wall mount controls for AC ceiling fans. (CA IOUs, No. 144 at p. 4)

DOE clarifies that in the final rule analysis, the cost of the basic means of control has been accounted for in the engineering analysis at all efficiency levels for all product classes (see section IV.C). For standard, hugger and VSD fans with an AC motor, the means of control are assumed to be electromechanical, *e.g., a* pull chain or wall-mounted controls, as the vast majority of AC-motor ceiling fans are operated with these types of controls. For fans with a brushless DC motor, the means of control is assumed to be a remote control, as the vast majority of ceiling fans with a brushless DC motor are operated by remote control. Chapter 5 of the final TSD provides more detail on the assumptions and costs regarding the means of control. In the case of standard, hugger and VSD fans, DOE will continue to estimate, as in the NOPR analysis, that 7 percent of fans with AC motors are operated with a remote control, which is accounted for separately when calculating the purchase price.

2. Electricity Prices

In the final rule analysis, as in the NOPR analysis, DOE used average electricity prices to characterize energy costs associated with the baseline efficiency level and marginal electricity prices to characterize incremental energy costs associated with the other efficiency levels considered. Marginal electricity prices are used to characterize incremental energy costs because they capture more accurately the small, incremental cost or savings associated with a change in energy use relative to the consumer's bill in the reference case, and may provide a better representation of consumer costs than average electricity prices. In the LCC analysis, the marginal electricity prices vary by season, region, and baseline household electricity consumption level. DOE estimated these prices using data published with the Edison Electric Institute (EEI) Typical Bills and Average Rates reports for summer and winter 2014.[36] DOE assigned seasonal marginal prices to each LCC sample based on the location and the baseline monthly electricity consumption for an average summer or winter month associated with that sample. DOE approximated the electricity prices for the industrial sector using the commercial sector prices. This approximation was made as the type of industrial facility that uses ceiling fans typically occupies a regular building, rather than a heavy industrial complex. For a detailed discussion of the development of electricity prices, see appendix 8B of the final rule TSD.

3. Electricity Price Trends

To arrive at average and marginal electricity prices in future years, DOE multiplied the average and marginal electricity prices in the reference year (2014) by the forecast of annual residential or commercial electricity price changes for each Census division from EIA's *AEO 2015,* which has an end year of 2040.[37] To estimate the trends after 2040, DOE used the average rate of change during 2025–2040.

For each fan purchase sampled, DOE applied the projection for the Census division in which the purchase was located. The AEO electricity price trends do not distinguish between marginal and average prices, so DOE used the *AEO 2015* trends for the marginal prices. DOE reviewed the EEI data for the years 2007 to 2014 and determined that there is no systematic difference in the trends for marginal vs. average electricity prices in the data.

DOE used the electricity price trends associated with the AEO Reference case scenarios for the nine Census divisions. The Reference case is a business-as-usual estimate, given expected market, demographic, and technological trends. DOE also included prices from AEO high-growth and AEO low-growth scenarios in the analysis. The high- and low-growth cases show the projected effects of alternative economic growth assumptions on energy markets.

4. Repair Costs

In the NOPR analysis, DOE used information on repairs and installation from manufacturer interviews to estimate the cost to consumers of repairing a ceiling fan. DOE also assumed that 2.5 percent and 9 percent of AC-motor and DC-motor ceiling fans incurred repair costs, respectively. DOE based these assumptions on repair rate estimates provided by a ceiling fan technical expert.[38]

CA IOUs and ASAP commented that the repair rate for brushless DC motors in ceiling fans may actually be lower than the repair rate for AC motors. (CA IOUs, Public Meeting Transcript, No. 133 at p. 98; ASAP, Public Meeting Transcript, No. 133 at p. 98) The CA IOUs and ASAP disagreed with the repair cost increase for brushless DC motor ceiling fans due to a lack of supporting data, and ASAP further noted that this may have caused the economic results presented in the NOPR to be underestimated. (CA IOUs, No. 144 at p. 5; ASAP, Public Meeting Transcript, No. 133 at pp. 12–13; ASAP, No. 142 at p. 4)

DOE reexamined this issue and found no suitable data with which to update its assumption that the excess rate of failure for brushless DC motors, above the repair rate for AC motors, is 6.5 percent of purchases. Because brushless DC motors incorporate electronics that AC motors do not have, the reliability of AC motors is likely to exceed brushless DC motors. Hence, DOE has continued to use the same assumptions in the final rule analyses.

5. 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 standard, hugger, and VSD ceiling fan stock in 2012 was available from the LBNL study.[39] By combining data from the LBNL study with historic data on standard, hugger, and VSD ceiling fan shipments from NPD, ENERGY STAR and Appliance Magazine (see chapter 3 for more information on historical shipments), DOE estimated the percentage of appliances of a given age that are still in operation. This survival function, which DOE assumed has the form of a cumulative Weibull distribution,[40] provides a mean of 13.8 years and a

[35] In the aforementioned LBNL study, only 1 percent of ceiling fan owners indicated that their ceiling fans were operated via means other than pull chain/chord, wall switch (on-off only), wall control (on-off and variable speed control, and remote control (battery operated). Integrated controls such as the ones mentioned here are assumed to fall into the ''other'' category.

[36] Edison Electric Institute. *Typical Bills and Average Rates Report.* Winter 2014 published April 2014, Summer 2014 published October 2014. See *http://www.eei.org/resourcesandmedia/products/Pages/Products.aspx.*

[37] U.S. Department of Energy-Energy Information Administration, *Annual Energy Outlook 2015 with Projections to 2040* (Available at: <*http://www.eia.gov/forecasts/aeo/*>).

[38] Mehta, V. Personal communication. E-mail to Mohan Ganeshalingam, LBNL. January 14, 2014.

[39] Kantner, *et al.* (2013), *op. cit.*

[40] Weibull distributions are commonly used to model appliance lifetimes.

median of 13.0 years for ceiling fan lifetime and is the same distribution employed in the preliminary and NOPR analyses. Shipment data were available only for standard, hugger, and VSD ceiling fans, so DOE assumed the survival probability function of large-diameter and HSSD ceiling fans is the same as that for standard, hugger, and VSD ceiling fans.

Westinghouse and ALA agreed with the ceiling fan survival function used by DOE in the NOPR analysis, but Westinghouse commented that commercial building ''turning'' (i.e., where a building is repurposed for a new business) can shorten the service life of commercial fans. (Westinghouse, Public Meeting Transcript, No. 133 at p. 101; ALA, No. 137 at p. 8) CA IOUs added that there is qualitative online information suggesting that ceiling fans with brushless DC motors last longer than ceiling fans with AC motors. (CA IOUs, Public Meeting Transcript, No. 133 at p. 102) The CA IOUs also indicated that DC-motor ceiling fans may last longer than AC-motor ceiling fans, and that consumers are less likely to discard DC-motor ceiling fans prior to the end of their useful life when compared to AC-motor ceiling fans. (CA IOUs, No. 144 at p. 3) BAS added that the average lifetime for large-diameter fans is on the order of 15–20 years, with a large spread in the distribution of expected lifetimes. (BAS, No. 138 at p. 11) Finally, HKC commented that the service life of ceiling fans can be shortened by changing design trends. (HKC, Public Meeting Transcript, No. 133 at pp. 103–104)

DOE acknowledges that ceiling fans that use different technologies and belong to product classes may have different technical lifetimes. However, in its analyses, DOE considers the service lifetime of ceiling fans, including the types of effects mentioned by HKC and Westinghouse. The survival function used in the NOPR and final rule analyses inherently incorporates factors other than product failure, such as home renovation rates or design trend changes, by virtue of its derivation from the actual age distribution of installed ceiling fans in the stock. Therefore, the technical possibility of ceiling fans with brushless DC motors lasting longer than ceiling fans with AC motors should not significantly alter the survival function.

With respect to large-diameter ceiling fans, given that the general survival function DOE used results in and a median lifetime of 13 years and an average lifetime of 13.8 years—which does not drastically differ from the average lifetime suggested by BAS—and that DOE is unaware of any data to support an increase in average lifetime for large-diameter ceiling fans, in this final rule DOE used the same survival function proposed in the NOPR for all product classes.

6. Discount Rates

In calculating the LCC, DOE applies discount rates appropriate to consumers to estimate the present value of future operating costs. To identify appropriate discount rates for purchasers, DOE estimated the percentage of HSSD and large-diameter fan purchasers in the commercial and industrial sectors. For HSSD fans, DOE estimated the ratio in floor space between likely building types where a fan would be installed in commercial settings to that in industrial settings. Manufacturer interviews informed DOE of the likely locations of CF installations. Floor space estimates by building type were taken from the 2010 U.S. Lighting Market Characterization,[41] which extrapolates estimates for commercial floor space from the 2003 Commercial Buildings Energy Consumption Survey (CBECS) and industrial floor space from the 2006 Manufacturing Energy Consumption Survey (MECS) to 2010 values using measured growth trends. The ratio suggests that 80 percent of HSSD installations are in the commercial sector and 20 percent are in the industrial sector. For large-diameter fans, DOE used manufacturer feedback about common applications for these fans. DOE estimated that 20 percent of large-diameter ceiling fan installations are in the commercial sector and 80 percent are in the industrial sector.

For residential consumers, DOE estimated a distribution of discount rates for ceiling fans based on consumer financing costs and opportunity cost of funds related to appliance energy cost savings and maintenance costs. First, DOE identified all relevant household debt or asset classes 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 Survey of Consumer Finances[42] (SCF) for 1995, 1998, 2001, 2004, 2007, 2010 and 2013. 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 amended standards would take effect. DOE assigned each sample household, based on its income group, 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 4.4 percent. See chapter 8 of the final rule TSD for further details on the development of residential discount rates.

To establish discount rates for commercial and industrial users, DOE estimated the cost of capital for companies that purchase ceiling fans. The weighted average cost of capital is commonly used 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 their cost of capital is the weighted average of the cost to the firm of equity and debt financing, as estimated from financial data for publicly traded firms in the sectors that purchase ceiling fans. For this analysis, DOE used Damodaran online[43] as the source of information about company debt and equity financing. The average rate across all types of companies, weighted by the shares of each type, is 5.0 percent. See chapter 8 of the final rule TSD for further details on the development of commercial and industrial sector discount rates.

7. Efficiency and Blade Span Distribution in the No-New-Standards Case

To estimate the share of consumers that would be affected by a potential energy conservation standard at a particular efficiency level, DOE's LCC analysis considered the projected distribution (market shares) of product efficiencies in the no-new-standards case (*i.e.,* the case without new efficiency performance standards).

Shipments data for ceiling fans disaggregated by efficiency level are not available, so it is not possible to derive the current shipments-weighted efficiency distribution. Instead, for the NOPR analysis, DOE developed the current efficiency market share distributions for the standard, hugger, and VSD product classes using online data from a ceiling fan retailer[44] and data obtained from in-store visits of major retailers. Ceiling fan models were

[41] Navigant Consulting, Inc. *Final Report: 2010 U.S. Lighting Market Characterization.* January 2012. (Last Accessed May 7, 2016.) *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf.*

[42] Board of Governors of the Federal Reserve System. Survey of Consumer Finances. 1995, 1998, 2001, 2004, 2007, 2010 and 2013. (Last accessed May 7, 2016.) *http://www.federalreserve.gov/econresdata/scf/scfindex.htm.*

[43] Damodaran, A. *Cost of Capital by Sector.* January 2014. (Last accessed May 7, 2016.) *http://people.stern.nyu.edu/adamodar/New_Home_Page/datafile/wacc.htm.*

[44] *http://www.hansenwholesale.com/.*

binned according to their efficiency to arrive at the current distributions. To estimate the efficiency distributions in 2019, DOE applied a consumer-choice model sensitive only to the first cost of options representative of each efficiency level given by the engineering analysis.

Westinghouse commented at the NOPR public meeting that the fraction of hugger fans currently estimated to meet EL 3 appeared to be too high. Westinghouse and ALA also commented that model counts of ceiling fans are not representative of market share. (Westinghouse, Public Meeting Transcript, No. 133 at p. 107–110; ALA, No. 139 at pp. 2–3) ALA estimated that approximately 70 percent of standard and hugger ceiling fan models do not meet the standard level proposed in the NOPR based on test results of sample products, and added that higher sales-volume ceiling fan models are less likely to meet that standard than lower sales-volume models. For certain manufacturers, ALA estimated that over 90 percent of shipments would not comply with the proposed standards (ALA, No. 139 at pp. 2–3)

DOE understands that model counts are not necessarily representative of market share. With respect to the estimate that 90 percent of shipments would not comply with the proposed standards for certain manufacturers, DOE notes that any given manufacturer's efficiency distribution may differ from the efficiency distribution of the entire market. For the 70 percent of standard and hugger sample products that did not meet the proposed standard level based on recent testing results, it is unclear how representative these sample products are of the entire ceiling fan market without corresponding shipments data. However, in the absence of a shipments-weighted efficiency distribution, for this final rule DOE has adopted an updated 2015 efficiency distribution with 70 percent of shipments of standard and hugger ceiling fans below the proposed standard level in the NOPR. Because no market share distribution was suggested by ALA amongst the three efficiency levels below the proposed standard level, market shares were assumed to be split evenly between EL0, EL1, and EL2. The efficiency distribution for 2020 was then projected using the consumer-choice model described in section IV.G.3.

No comments were received regarding the efficiency distribution for VSD ceiling fans, so DOE has maintained its approach from the NOPR analysis for the VSD product class.

For HSSD and large-diameter ceiling fans, DOE developed the current efficiency distributions using model counts available on HSSD and large-diameter fan manufacturer websites. DOE assumed the current distribution observed in 2015 would also be representative of the efficiency distribution in 2020.

The estimated market shares for the no-new-standards case for all ceiling fans are shown in Table IV.3. See chapter 8 of the final rule TSD for further information on the derivation of the efficiency distributions.

TABLE IV.3.—MARKET EFFICIENCY DISTRIBUTION FOR THE NO-NEW-STANDARDS CASE IN 2020

Product class	EL 0 (%)	EL 1 (%)	EL 2 (%)	EL 3 (%)	EL 4 (%)	Total * (%)
Standard	22.7	22.7	22.7	28.9	3.1	100
Hugger	22.6	22.6	22.6	28.8	3.4	100
VSD	4.1	0.0	96.0	0.0	....	100
HSSD	44.7	44.7	0.0	2.7	8.0	100
Large-Diameter	5.1	5.1	58.3	14.1	17.3	100

* Rows may not sum to 100% due to rounding.

DOE also developed size distributions within each product class to determine the likelihood that a given purchaser would select each of the representative fan sizes from the engineering analysis. For the NOPR, DOE estimated the distribution of diameters for standard, hugger, HSSD and large-diameter ceiling fans using the distribution of models currently seen on the market. In particular, DOE estimated that the current market share for 36-inch and 56-inch HSSD ceiling fans are 7 percent and 93 percent, respectively. A limited pool of available VSD fan models indicated a rough split of market share between the two representative blade spans, so DOE assumed that the VSD market was evenly split between the two blade spans.

Westinghouse agreed with the proposed market shares for 36″ and 56″ high-speed small-diameter ceiling fans in the NOPR, as well as the market shares by diameter for hugger, standard, and very-small diameter low-volume ceiling fans. (Westinghouse, Public Meeting Transcript, No. 133 at p. 91, 117) In the absence of additional data or comments to support an alternative approach, DOE retained the same methodology for the final rule analysis to estimate the blade span distribution for all the product classes. DOE estimated the blade span distribution by using the distribution of models currently seen on the market for the final rule. Table IV.4 presents the blade span distribution of each of the product classes. (For the NIA, DOE assumed that blade size distribution remains constant over the years considered in the analysis.)

TABLE IV.4.—BLADE SPAN DISTRIBUTION

Product class	Standard			Hugger		VSD		HSSD		Large-Diameter		
Blade Span (inches)	44	52	60	44	52	13	16	36	56	96	144	240
Market Share (%)	21.1	72.5	6.5	46.2	53.8	50.0	50.0	7.0	93.0	22.0	27.0	51.0

8. Payback Period Analysis

The payback period is the amount of time it takes the consumer to recover the additional installed cost of more-efficient products, compared to baseline products, through energy cost savings. Payback periods are expressed in years. 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. The PBP calculation uses the same inputs as the LCC analysis, except that discount rates are not needed.

EPCA, as amended, 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 forecast for the year in which compliance with the amended standards would be required.

G. Shipments Analysis

DOE uses projections of product shipments to calculate the national impacts of potential amended energy conservation standards on energy use, NPV, and future manufacturer cash flows. Historical shipments data are used to build up an equipment stock, and to calibrate the shipments model to project shipments over the course of the analysis period based on the estimated future demand for ceiling fans. Details of the shipments analysis are described in chapter 9 of the final rule TSD.

The shipments model projects total shipments and market-share efficiency distributions in each year of the 30-year analysis period for the no-new-standards case and each of the standards cases, calibrated using historical shipments. This final rule is expected to publish in late 2016 with a compliance date in late 2019. DOE begins its shipments analysis for the final rule in 2020, the first full year of compliance, and extends over 30 years until 2049. The shipments model consists of three main components: (1) A shipments demand model that determines the total demand for new ceiling fans in each year of the analysis period, (2) a stock model that tracks the age distribution of the stock over the analysis period, and (3) a model that determines the market shares of purchased ceiling fans across efficiency levels. For standard, hugger, and VSD ceiling fans, DOE used a consumer-choice model sensitive to ceiling fan first cost to estimate market shares across efficiency level. For HSSD and large-diameter ceiling fans, DOE used a roll-up approach to estimate the efficiency distribution in each standards case.

1. Shipments Demand Model

DOE used historical shipment data of hugger, standard, and VSD fans from Appliance Magazine's Statistical Review from 1991 to 2006,[45] data from ENERGY STAR annual reports from 2003 to 2013,[46] and data purchased from NPD Research group from 2007–2011.[47] Figure 9.3.1 in Chapter 9 of this final rule TSD displays the historical time series used for DOE's shipments analysis.

As the data were not disaggregated by product class, DOE estimated the relative split between standard, hugger, and VSD product classes. In the NOPR analysis, DOE used online and in-store ceiling fan data and applied a price-weighting approach based on market share data as a function of retail price for ceiling fans collected by the NPD Group from 2007 to 2011. These data inform the price-weighting scheme, which apportions more market share to ceiling fans with lower first costs. DOE calculated 48.7 percent and 51.3 percent current market shares for hugger and standard ceiling fans, respectively. DOE's calculation assumed that multi-mount ceiling fan installations are split 27 percent/73 percent as hugger and standard ceiling fans, respectively.

Westinghouse agreed with DOE's estimates for the market split between standard, hugger, and VSD ceiling fans in the NOPR analyses. (Westinghouse, Public Meeting Transcript, No. 133 at p. 91, 117) DOE retains this methodology for estimating market share by product class for the final rule.

DOE's estimate for HSSD historical shipments is based on scaling historical shipments of standard, hugger, and VSD ceiling fans using a scaling factor estimated from feedback from manufacturer interviews. DOE's estimate for large-diameter fans is based on matching a linear shipments trend to an estimate of 2013 installed stock assuming large-diameter fans were introduced to the market in 2000.

Shipments for standard, hugger, and VSD ceiling fans are calculated for the residential sector. Shipments for HSSD and large-diameter fans are calculated for the commercial and industrial sectors. As all of the inputs used in the downstream analyses are the same for both sectors, DOE does not distinguish between shipments to the commercial or industrial sector.

The ceiling fan shipments demand model considers four market segments that affect the net demand for total shipments: replacements for retired stock, additions due to new building construction, additions due to expanding demand in existing buildings, and reductions due to building demolitions, which erodes demand from replacements and existing buildings.

2. Stock-Accounting Model

The stock accounting model tracks the age (vintage) distribution of the installed ceiling fan stock. The age distribution of the stock impacts both the national energy savings (NES) and NPV calculations, because the operating costs for any year depend on the age distribution of the stock. Older, less efficient units may have higher operating costs, while newer, more efficient units have lower operating costs. The stock accounting model is initialized using historical shipments data and accounts for additions to the stock (*i.e.,* shipments) and retirements. The age distribution of the stock in 2012 is estimated using results from a recent survey of ceiling fan owners.[48] The stock age distribution is updated for subsequent years using projected shipments and retirements determined by the stock age distribution and a product retirement function.

3. Market-Share Projections

The consumer-choice model used for standard, hugger, and VSD ceiling fans estimates the market shares of purchases in each year in the analysis period for each efficiency level presented in the engineering analysis. DOE assumed that each of these product classes provides a specific utility and consumers do not choose between options in different product classes. The consumer-choice module selects which ceiling fans are purchased within a product class in any given year based on consumer sensitivity to first cost, as well as on the ceiling fan options available, which were determined in the engineering analysis. Deviations from purely cost-driven behavior are accounted for using factors found by calibrating the model to observed historical data.

Westinghouse agreed with DOE's NOPR assumption that consumers of standard, hugger, and VSD ceiling fans

[45] Appliance® Statistical Review, Annual Report, *Appliance Magazine* (1991–2006).

[46] United States Environmental Protection Agency, *ENERGY STAR® and Other Climate Protection Partnerships: Annual Report* (2003–2013).

[47] NPD Group, 2007–2011.

[48] Kantner, *et al.* (2013), *op. cit.*

are most sensitive to first cost. (Westinghouse, Public Meeting Transcript, No. 133 at p. 123) DOE maintains this assumption for the consumer-choice model in the final rule.

In the NOPR analysis, DOE assumed the no-new-standards case efficiency distribution for HSSD and large-diameter ceiling fans remained fixed at the estimated 2015 efficiency distribution over the shipments analysis period. In the standards cases, market shares for those levels that do not meet the standard roll up to the standard level, and shares above the standard level are unchanged. In the NOPR analysis, DOE assumed no product class switching between the HSSD and large-diameter product classes.

Westinghouse and BAS agreed with the roll-up approach DOE used in its NOPR analysis, but BAS added that large-diameter ceiling fan manufacturers are likely to meet the minimum efficiency by reducing the utility of their fans (i.e., by reducing the maximum airflow). (Westinghouse, Public Meeting Transcript, No. 133 at pp. 123–124; BAS, Public Meeting Transcript, No. 133 at p. 126)

For this final rule, DOE continues to use the roll-up approach for HSSD and large-diameter ceiling fans. As discussed in section IV.C.3, DOE adjusted the efficiency equation associated with the considered standard levels to ensure that high airflow ceiling fans would be preserved under the standard level in this final rule.

4. Price Trend

The consumer-choice model uses ceiling fan prices, which change over time in some cases. There is considerable evidence of learning-by-doing lowering the cost of new technologies along with increases in production of the new technology. The concept behind this empirical phenomenon is that as the new technology is produced in greater numbers, employees and firms will find ways to lower costs. Brushless DC motors are a relatively new technology for use in ceiling fans, and thus DOE expects price declines. Given the absence of data on cumulative shipments of brushless DC motors, DOE models learning lowering costs, and thus prices, with time. In the NOPR analysis, DOE adopted a price decline rate of 6 percent applied to the incremental (not total) cost associated with a brushless DC motor, based on information from a technical expert for standard, hugger, and VSD ceiling fans.[49] ASAP agreed with DOE's approach to apply price learning only to the electronic component of brushless DC motors, as opposed to applying price learning to the entire product. (ASAP, Public Meeting Transcript, No. 133 at p. 122) DOE continues to use this methodology for applying price trends to brushless DC motors in this final rule.

5. Impact of a Standard on Shipments

DOE assumes that any increase in the average price of a ceiling fan due to a standard would result in a decrease in shipments. For this final rule analysis, DOE uses a relative price elasticity of demand of -0.34, which is the value DOE has typically used for residential appliances.

DOE notes that an increase in the price of ceiling fan light kits due to the adopted ceiling fan light kit standard will also impact the shipments of ceiling fans sold with ceiling fan light kits. The ceiling fan final rule analysis included the impact on ceiling fan shipments from the estimated ceiling fan light kit price change due to the adopted ceiling fan light kit standard. (81 FR 580 (Jan. 6, 2016)) The impact from a ceiling fan light kit standard to ceiling fan shipments is applied to both the no ceiling fan standards case and the ceiling fan standards case shipments.

H. National Impact Analysis

The NIA assesses the national energy savings (NES) and the net present value (NPV) from a national perspective of total consumer costs and savings that would be expected to result from new or amended standards at specific efficiency levels. (''Consumer'' in this context refers to consumers of the product being regulated.) DOE calculates the NES and NPV based on projections of annual product shipments, along with the annual energy consumption, total installed cost, and repair costs. For the final rule analysis, DOE projected the energy savings, operating cost savings, product costs, and NPV of consumer benefits over the lifetime of ceiling fans shipped from 2020 through 2049, beginning with the first full year of compliance with a potential standard.

DOE evaluates the impacts of new and amended standards by comparing a case without such standards with standards-case projections. The no-new-standards case projection characterizes energy use and consumer costs for each product class in the absence of new or amended energy conservation standards. For this projection, DOE considers historical trends in efficiency and various forces that are likely to affect the mix of efficiencies over time. DOE compares the no-new-standards case with projections characterizing the market for each product class if DOE adopted new or amended standards at specific energy efficiency levels (*i.e.,* the TSLs or standards cases) for that class. For the standards cases, DOE considers how a given standard would likely affect the market shares of products with efficiencies greater than the standard when ceiling fans that do not meet the TSL being analyzed are excluded as options available to the consumer.

DOE uses a spreadsheet model to calculate the energy savings and the national consumer costs and savings from each TSL. Interested parties can review DOE's analyses by changing various input quantities within the spreadsheet. The NIA spreadsheet model uses typical values (as opposed to probability distributions) as inputs.

Table IV.5 summarizes the inputs and methods DOE used for the NIA analysis for the final rule. Discussion of these inputs and methods follows the table. See chapter 10 of the final rule TSD for further details.

TABLE IV.5—SUMMARY OF INPUTS AND METHODS FOR THE NATIONAL IMPACT ANALYSIS

Inputs	Method
Shipments	Annual shipments from shipments model.
Assumed Compliance Date of Standard	2019.*
No Standard-Case Forecasted Efficacies	Estimated by market-share module of shipments model.
Standards-Case Forecasted Efficacies	Estimated by market-share module of shipments model.

[49] Mehta, V. Personal communication. E-mail to Mohan Ganeshalingam, LBNL. January 14, 2014.

TABLE IV.5—SUMMARY OF INPUTS AND METHODS FOR THE NATIONAL IMPACT ANALYSIS—Continued

Inputs	Method
Annual Energy Consumption per Unit	Annual weighted-average values are a function of energy use at each EL.
Total Installed Cost per Unit	Annual weighted-average values are a function of cost at each EL. Incorporates projection of future product prices based on historical data.
Annual Energy Cost per Unit	Annual weighted-average values as a function of the annual energy consumption per unit and energy prices.
Repair and Maintenance Cost per Unit	DC motor fans have a 6.5% higher failure rate compared to AC motor fans.
Energy Prices	*AEO 2015* forecasts (to 2040) and extrapolation thereafter.
Energy Site-to-Primary and FFC Conversion	A time-series conversion factor based on *AEO 2015.*
Discount Rate	Three and seven percent.
Present Year	2016.

* The compliance date was assumed to be in late 2019, so the shipments analysis was conducted for products shipped from 2020–2049, beginning with the first full year of compliance.

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 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 product (by vintage or age) by the unit energy consumption (also by vintage). DOE calculated annual NES based on the difference in national energy consumption for the no-new-standards case and for the case where a standard is set at each TSL. 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 2015.* Cumulative energy savings are the sum of the NES for each year over the timeframe of the analysis.

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 full-fuel-cycle (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 approach used for deriving FFC measures of energy use and emissions is described in appendix 10B of the final rule TSD.

The rebound effect accounts for increased usage of an appliance by consumers after the implementation of a standard, reducing the energy savings attributed to a standard. DOE generally accounts for the direct rebound effect in its estimates of the national energy savings when available data suggest consumers may increase product usage in the event of a standard which acts to decrease the average power associated with the product. In the case of ceiling fans, DOE found no data pertaining to a rebound effect associated with more efficient products and also received comments in response to the Framework document from ALA indicating that they did not believe a rebound effect due to a ceiling fan standard was likely. (ALA, No 39, at pg. 39) In this final rule, DOE assumes no rebound effect in its reference scenario. Nevertheless, DOE performed a sensitivity scenario assuming a rebound of 3-percent to examine the implications of rebound. The rebound sensitivity reduces national energy savings at each TSL by 3 percent without impacting NPV results. The full results of this sensitivity analysis can be found in appendix 10C of this final rule TSD. The rebound effect explored in this sensitivity analysis can reduce expected savings in energy costs to consumers in the standards case.

[50] For more information on NEMS, refer to *The National Energy Modeling System: An Overview 2009,* DOE/EIA–0581(2009), October 2009. Available at *http://www.eia.gov/forecasts/aeo/index.cfm.*

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 savings, 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 forecast period.

The operating cost savings are primarily energy cost savings, which are calculated using the estimated energy savings in each year and the projected price of electricity. To estimate electricity prices in future years, DOE multiplied the average regional energy prices by the forecast of annual national-average residential energy price changes in the Reference case from *AEO 2015,* which has an end year of 2040. To estimate price trends after 2040, DOE used the average annual rate of change in prices from 2020 through 2040. As part of the NIA, DOE also analyzed scenarios that used inputs from the *AEO 2015* Low Economic Growth and High Economic Growth cases. NIA results based on these cases are presented in appendix 10C of the final rule TSD.

DOE estimated the range of potential impacts of amended standards by considering four sensitivity scenarios: a high-benefit scenario, a low-benefit scenario, and a scenario that includes a 3-percent rebound effect. In the high benefits scenario, DOE used the *AEO 2015* high economic growth case estimates for new housing starts and electricity prices along with its reference price trend for DC motor fans. As discussed in section IV.G.4, price trend is only applied to the price premium between a DC motor and a direct drive AC motor. In the low benefits scenario, DOE used the low economic growth *AEO 2015* estimates for housing starts and electricity prices, along with no price trend. In the 3-percent rebound scenario, DOE assumed that there would be increased ceiling fan usage due to the decreased operating cost savings associated with a standard. As noted previously, DOE assumes any operating cost incurred by increased usage due to the rebound effect is offset by the economic value associated with that increased usage. The NIA results based on these alternative scenarios are presented in appendix 10C of the final rule TSD.

In calculating the NPV, DOE multiplies the net savings in future years by a discount factor to determine their present value. For this final rule, 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 final rule, DOE analyzed the impacts of the considered standard levels on low-income households and small businesses that purchase ceiling fans. DOE used the LCC and PBP spreadsheet model to estimate the impacts of the considered efficiency levels on these subgroups.

DOE calculated the LCC and PBP results for standard, hugger, and VSD fans based on a sample of low-income households or consumers who were identified in the RECS 2009 survey as being at or below the ''poverty line.'' The poverty line varies with household size, head of household age, and family income.

In the case of the HSSD and large-diameter fans, DOE conducted a subgroup analysis based on small businesses that purchase ceiling fans by applying the small company discount rate distributions for each sector in the LCC and PBP calculation, instead of the discount rate associated with the entire industry.

Chapter 11 in the final rule TSD describes the consumer subgroup analysis.

J. Manufacturer Impact Analysis

1. Overview

DOE conducted an MIA for ceiling fans to estimate the financial impact of amended standards on manufacturers of ceiling fans. The MIA has both quantitative and qualitative aspects. The quantitative part of the MIA relies on the GRIM, an industry cash-flow model customized for the ceiling fans covered in this rulemaking. The key GRIM inputs are data on the industry cost structure, MPCs, shipments, and assumptions about manufacturer markups, and conversion costs. The key MIA output is INPV. DOE used the GRIM to calculate cash flows using standard accounting principles and to compare changes in INPV between the no-new-standards case and various TSLs (the standards cases). The difference in INPV between the no-new-standards case and the standards cases represents the financial impact of amended energy conservation standards on ceiling fan manufacturers. Different sets of assumptions (scenarios) produce different INPV results. The qualitative part of the MIA addresses factors such as manufacturing capacity; characteristics of, and impacts on, any particular subgroup of manufacturers, including small manufacturers; and impacts on competition.

DOE conducted the MIA for this rulemaking in three phases. In the first phase, DOE prepared an industry characterization based on the market and technology assessment, preliminary manufacturer interviews, and publicly available information. In the second phase, DOE estimated industry cash flows in the GRIM using industry financial parameters derived in the first phase and the shipments derived in the shipment analysis. In the third phase, DOE conducted interviews with a variety of ceiling fan manufacturers that account for more than 30 percent of domestic ceiling fan sales covered by this rulemaking. During these interviews, DOE discussed engineering, manufacturing, procurement, and financial topics specific to each company, and obtained each manufacturer's view of the ceiling fan industry as a whole. The interviews provided information that DOE used to evaluate the impacts of amended standards on manufacturers' cash flows, manufacturing capacities, and direct domestic manufacturing employment levels. See section V.B.2.b of this final rule for the discussion on the estimated changes in the number of domestic employees involved in manufacturing ceiling fans covered by standards.

During the third phase, DOE used the results of the industry characterization analysis in the first phase and feedback from manufacturer interviews to group manufacturers that exhibit similar production and cost structure characteristics. DOE identified one manufacturer subgroup for a separate impact analysis; small businesses. DOE determined that ceiling fan manufacturing falls under the North American Industry Classification System (NAICS) code 335210, small electrical appliance manufacturing. The U.S. Small Business Administration (SBA) defines a small business as having less than 1,500 total employees for manufacturing operating under this NAICS code. This threshold includes all employees in a business' parent company and any other subsidiaries. Based on this classification, DOE identified six domestic ceiling fan businesses that manufacturer ceiling fans in the United States and qualify as small businesses per the SBA threshold. DOE analyzed the impact on the small business subgroup in the complete MIA, which is presented in chapter 12 of the final rule TSD, and in the Regulatory Flexibility analysis required by the Regulatory Flexibility Act, 5 U.S.C. 601, et. seq., presented in section VI.B of this final rule.

2. GRIM Analysis and Key Inputs

DOE uses the GRIM to quantify the changes in cash flows over time due to amended energy conservation standards. These changes in cash flows result in either a higher or lower INPV for the standards case compared to the no-new-standards case. The GRIM uses standard annual cash-flow analysis that incorporates MPCs, manufacturer

[51] United States Office of Management and Budget. *Circular A–4: Regulatory Analysis.* September 17, 2003. Section E. Available at *www.whitehouse.gov/omb/memoranda/m03-21.html.*

markups, shipments, and industry financial information as inputs. It then models changes in MPCs, investments, and manufacturer margins that may result from analyzed amended energy conservation standards. The GRIM uses these inputs to calculate a series of annual cash flows beginning with the reference year of the analysis, 2016, and continuing to the terminal year of the analysis, 2049. DOE computes INPV by summing the stream of annual discounted cash flows during the analysis period. DOE used a real discount rate of 7.4 percent for ceiling fan manufacturers. This is the same discount rate used in the NOPR analysis. Many of the GRIM inputs come from the engineering analysis, the shipment analysis, manufacturer interviews, and other research conducted during the MIA. The major GRIM inputs are described in detail in the following sections.

a. Capital and Product Conversion Costs

DOE expects amended ceiling fan energy conservation standards to cause manufacturers to incur conversion costs by bringing their tooling and product designs into compliance with amended standards. For the MIA, DOE classified these conversion costs into two major groups: (1) Capital conversion costs and (2) product conversion costs. Capital conversion costs are investments in property, plant, and equipment necessary to adapt or change existing tooling equipment so new product designs can be fabricated and assembled. Product conversion costs are investments in research, development, testing, marketing, certification, and other non-capitalized costs necessary to make product designs comply with amended standards.

ALA commented that DOE underestimated conversion costs due to an understated percentage of shipments that will meet the standard in the compliance year (ALA, No. 139, p. 2–4). ALA maintains that conversion costs would be doubled had DOE used the efficiency distribution estimated by ALA.

For the final rule, DOE revised the shipment efficiency distribution in the shipment analysis for standard and hugger ceiling fans based on feedback from ALA. The MIA used the shipment efficiency distribution when calculating the industry conversion costs. Conversion costs significantly increased from the NOPR to the final rule due to these changes in the efficiency distribution.

ALA went on to comment that conversion costs are further understated due to their exclusion of additional financing costs that could be incurred by some manufacturers to purchase manufacturing equipment needed to produce ceiling fans that comply with the standard (ALA, No. 139, p. 4). Also, Westinghouse commented that they were concerned DOE's analysis may not be fully calculating or capturing what the true cost increase for manufacturers will be. (Westinghouse, Public Meeting Transcript, No. 133 at p. 92)

DOE increased the per model capital and product conversion costs associated with converting a failing ceiling fan model into a compliant model, based on ALA and Westinghouse's comments. This per model conversion cost increase resulted in higher overall conversion costs from the NOPR to the final rule. This increase in per model conversion costs was in addition to the increase in the number of models needed to be converted due to the changes in the efficiency distribution previously described.

b. Manufacturer Production Costs

Manufacturing a more efficient product is typically more expensive than manufacturing a lower efficient product due to the use of more complex components, which are typically more costly than less efficient components. The increases in the MPCs of the analyzed products can affect the revenues, gross margins, and cash flow of the industry, making these product costs key inputs for the GRIM and the MIA.

In the MIA, DOE used the MPCs calculated in the engineering analysis, as described in section IV.C and further detailed in chapter 5 of the final rule TSD. To calculate MPCs for ceiling fans. DOE updated the MPCs used in the NOPR analysis based on manufacturer feedback for the final rule analysis. The MIA used these updated MPCs for the final rule analysis.

c. Shipment Scenarios

INPV, which is the key GRIM output, depends on industry revenue, which depends on the quantity and prices of ceiling fans shipped in each year of the analysis period. Industry revenue calculations require forecasts of: (1) Total annual shipment volume of ceiling fans; (2) the distribution of shipments across the product class (because prices vary by product class); and, (3) the distribution of shipments across ELs (because prices vary with ceiling fan efficiency).

DOE modeled the no-new-standards case ceiling fan shipments and the growth of ceiling fan shipments using replacement shipments of failed ceiling fan units, new construction starts as projected by *AEO 2015,* and the number of additions to existing buildings due to expanding demand throughout the analysis period taking into account demolitions in the housing stock.

DOE updated the initial 2015 efficiency distribution for the final rule analysis for standard and hugger fans based on feedback from manufacturers. To estimate the distribution of shipments across ELs over the analysis period for standard, hugger, and VSD ceiling fans, a consumer-choice model was used to project consumer purchases based on consumer sensitivity to first cost. For HSSD and large-diameter ceiling fans, a roll-up approach was used, in which consumers who would have purchased ceiling fans that fail to meet the new standards in the no-new-standards case purchase the least efficient, compliant ceiling fans in the standards cases. Consumers that would have purchased compliant ceiling fans in the no-new-standards case continue to purchase the exact same ceiling fans in the standards cases.

For all ceiling fans, DOE also included price elasticity in the shipments analysis for all standards cases. When price elasticity is included in the shipment analysis, the total number of ceiling fans declines as the average price of a ceiling fan increases due to standards. For a complete description of the shipments, see the shipments analysis discussion in section IV.G of this final rule.

d. Markup Scenarios

As discussed in section IV.J.2.b, the MPCs for ceiling fans are the manufacturers' costs for those units. These costs include materials, labor, depreciation, and overhead, which are collectively referred to as the cost of goods sold (COGS). The MSP is the price received by ceiling fan manufacturers from the first sale, typically to a distributor, regardless of the downstream distribution channel through which the ceiling fans are ultimately sold. The MSP is not the cost the end-user pays for ceiling fans, because there are typically multiple sales along the distribution chain and various markups applied to each sale. The MSP equals the MPC multiplied by the manufacturer markup. The manufacturer markup covers all the ceiling fan manufacturer's non-production costs (*i.e.,* selling, general, and administrative expenses [SG&A]; research and development [R&D]; interest) as well as profit. Total industry revenue for ceiling fan manufacturers equals the MSPs at each efficiency level multiplied by the number of shipments at that efficiency level.

Modifying these manufacturer markups in the standards cases yields a different set of impacts on ceiling fan manufacturers than in the no-new-standards case. For the MIA, DOE modeled three standards case markup scenarios for ceiling fans to represent the uncertainty regarding the potential impacts on prices and profitability for ceiling fan manufacturers following the implementation of amended standards. The three scenarios are: (1) A preservation of gross margin markup scenario; (2) a preservation of operating profit markup scenario; and (3) a two-tiered markup scenario. Each scenario leads to different manufacturer markup values, which, when applied to the inputted MPCs, result in varying revenue and cash-flow impacts on ceiling fan manufacturers.

The manufacturer markups for the preservation of operating profit and two-tiered markup scenarios depend on the efficiency distribution of shipments calculated in the shipment analysis. Therefore, the manufacturer markups for the preservation of operating profit and two-tiered markup scenarios are slightly different in the final rule that those in the NOPR analysis.

3. Discussion of Comments

Only ALA and Westinghouse commented on the assumptions and results of the NOPR MIA. These comments addressed the capital and product conversion costs and are addressed in section IV.J.2.a. No further comments on the NOPR were submitted regarding the MIA.

4. Manufacturer Interviews

DOE conducted additional interviews with manufacturers following the preliminary analysis as part of the NOPR analysis. DOE outlined the key issues for ceiling fan manufacturers in the NOPR. 81 FR 1689 (January 13, 2016). DOE considered the information received during these interviews in the development of the NOPR and this final rule. DOE did not receive any comments regarding the key issues described in the NOPR analysis.

a. Shift to Air Conditioning

Several manufacturers stated that ceiling fan energy conservation standards could cause residential consumers to forgo the purchase of a ceiling fan in lieu of an air conditioner due to the price increase, or could cause residential ceiling fan owners to run their air conditioners more frequently instead of using their ceiling fan. Manufacturers assert that if residential consumers instead use their air conditioner to cool their homes, this could result in more energy use, as ceiling fans tend to be more efficient at cooling rooms than air conditioners.

Manufacturers also stated that overly stringent ceiling fan standards could force manufacturers to reduce the aesthetic quality of some ceiling fans to comply with energy conservation standards. This could cause some residential consumers to forgo the purchase of these ceiling fans because the aesthetic appearance of ceiling fans is an important factor when residential consumers purchase ceiling fans. Manufacturers claim this reduction in aesthetic quality could again result in more energy use, because residential consumers who do not purchase ceiling fans would need to use air conditioners to cool their homes. DOE addresses this issue in section IV.E.3 of this final rule.

b. Testing Burden

Manufacturers are concerned about the additional testing burden associated with complying with amended energy conservation standards. Most manufacturers use third-party testing facilities for testing and reporting purposes, which can be expensive. Manufacturers stated that ceiling fan standards would significantly increase the amount that they already invest in testing each year. DOE includes the additional testing and certification costs that manufacturers must make due to standards as part of the MIA. DOE calculates the total industry conversion costs for manufacturers, which includes the additional testing and certification costs of complying with amended standards. These conversion costs impact the INPV at each TSL. Industry cash flow analysis results are discussed in detail in section V.B.2.a.

c. Utility of Brushless and Gearless DC Motors for Residential Consumers

Manufacturers stated that amended energy conservation standards that required the use of brushless DC motors in residential ceiling fans would limit the overall utility of the fan and increase maintenance costs. Manufacturers claim that brushless DC motors require significantly more maintenance and have a higher warranty factor compared to ceiling fans with AC motors. Additionally, ceiling fans with brushless DC motors require the use of a handheld remote, which manufacturers claim is not preferred by many residential consumers. Therefore, manufacturers stated any ceiling fan standard that required the use of a brushless DC motor would significantly reduce the overall utility of ceiling fans to residential consumers.

For the HSSD and large-diameter product classes, which are expected to represent less than three percent of all covered ceiling fan shipments in 2020, manufacturers stated that the use of brushless DC motors in HSSD ceiling fans and gearless DC motors in large-diameter ceiling fans will not significantly impact consumer utility. HSSD and large-diameter ceiling fans are typically used in commercial and industrial applications as opposed to in residential applications. Most manufacturers indicated that commercial and industrial consumers do not dislike using a handheld remote that is required when operating a ceiling fan with a brushless or gearless DC motor, and in some applications it is preferable. Also, these commercial and industrial consumers tend to be better equipped to respond to the increased maintenance costs associated with owning and operating ceiling fans with brushless or gearless DC motors because these consumers are more likely to repair their own products and equipment than residential consumers are.

DOE conducted a screening analysis as part of this final rule analysis and concluded that brushless or gearless DC motors should be considered as a viable technology for all respective product classes of covered ceiling fans for the engineering analysis. See section IV.B of this final rule for a detailed discussion of the screening analysis. Additionally, DOE did include the additional repair costs of ceiling fans using brushless or gearless DC motors as part of the LCC analysis. See section IV.F.4 for a complete description of the repair cost assumptions of brushless and gearless DC motors.

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 all species due to ''upstream'' activities in the fuel production chain. These upstream activities consist of extraction, processing, and transporting fuels to the site of combustion. The associated emissions are referred to as upstream emissions.

The analysis of power sector emissions uses marginal emissions factors that were derived from data in *AEO 2015,* as described in section IV.M.

Details of the methodology are described in the appendices to chapters 13 and 15 of the final rule TSD.

Combustion emissions of CH_4 and N_2O are estimated using emissions intensity factors published by the EPA-GHG Emissions Factors Hub.[52] The FFC upstream emissions are estimated based on the methodology described in chapter 15 of the final rule TSD. The upstream emissions include both emissions from fuel combustion during extraction, processing, and transportation of fuel, and ''fugitive'' emissions (direct leakage to the atmosphere) of CH_4 and CO_2.

The emissions intensity factors are expressed in terms of physical units per MWh or MMBtu of site energy savings. Total emissions reductions are estimated using the energy savings calculated in the national impact analysis.

For CH_4 and N_2O, DOE calculated emissions reduction in tons and also in terms of units of carbon dioxide equivalent (CO_2eq). Gases are converted to CO_2eq by multiplying each ton of gas by the gas' global warming potential (GWP) over a 100-year time horizon. Based on the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,[53] DOE used GWP values of 28 for CH_4 and 265 for N_2O.

The *AEO* incorporates the projected impacts of existing air quality regulations on emissions. *AEO 2015* generally represents current legislation and environmental regulations, including recent government actions, for which implementing regulations were available as of [October 31, 2014]. DOE's estimation of impacts accounts for the presence of the emissions control programs discussed in the following paragraphs.

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 28 eastern States and D.C. were also limited under the Clean Air Interstate Rule (CAIR). 70 FR 25162 (May 12, 2005). CAIR created an allowance-based trading program that operates along with the Title IV program. In 2008, CAIR was remanded to EPA by the U.S. Court of Appeals for the District of Columbia Circuit, but it remained in effect.[54] In 2011, EPA issued a replacement for CAIR, the Cross-State Air Pollution Rule (CSAPR). 76 FR 48208 (Aug. 8, 2011). On August 21, 2012, the D.C. Circuit issued a decision to vacate CSAPR,[55] and the court ordered EPA to continue administering CAIR. On April 29, 2014, the U.S. Supreme Court reversed the judgment of the D.C. Circuit and remanded the case for further proceedings consistent with the Supreme Court's opinion.[56] On October 23, 2014, the D.C. Circuit lifted the stay of CSAPR.[57] Pursuant to this action, CSAPR went into effect (and CAIR ceased to be in effect) as of January 1, 2015.

EIA was not able to incorporate CSAPR into *AEO 2015,* so it assumes implementation of CAIR. Although DOE's analysis used emissions factors that assume that CAIR, not CSAPR, is the regulation in force, the difference between CAIR and CSAPR is not significant for the purpose of DOE's analysis of emissions impacts from energy conservation standards.

The attainment of emissions caps is typically flexible among EGUs and is enforced through the use of emissions allowances and tradable permits. 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 any regulated EGU. In past rulemakings, DOE recognized that there was uncertainty about the effects of efficiency standards on SO_2 emissions covered by the existing cap-and-trade system, but it concluded that negligible reductions in power sector SO_2 emissions would occur as a result of standards.

Beginning in 2016, however, SO_2 emissions will fall as a result of the Mercury and Air Toxics Standards (MATS) for power plants. 77 FR 9304 (Feb. 16, 2012). In the MATS rule, EPA established a standard for hydrogen chloride as a surrogate for acid gas hazardous air pollutants (HAP), and also established a standard for SO_2 (a non-HAP acid gas) as an alternative equivalent surrogate standard for acid gas HAP. The same controls are used to reduce HAP and non-HAP acid gas; thus, SO_2 emissions will be reduced as a result of the control technologies installed on coal-fired power plants to comply with the MATS requirements for acid gas. *AEO 2015* assumes that, in order to continue operating, coal plants must have either flue gas desulfurization or dry sorbent injection systems installed by 2016. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions. Under the MATS, emissions will be far below the cap established by CAIR, so 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 any regulated EGU.[58] Therefore, DOE believes that energy conservation standards will generally reduce SO_2 emissions in 2016 and beyond.

CAIR established a cap on NO_X emissions in 28 eastern States and the District of Columbia.[59] Energy conservation standards are expected to have little effect on NO_X emissions in those States covered by CAIR because excess NO_X emissions allowances resulting from the lower electricity demand could be used to permit offsetting increases in NO_X emissions from other facilities. However, standards would be expected to reduce NO_X emissions in the States not affected by the caps, so DOE estimated NO_X emissions reductions from the standards

[52] Available at *www2.epa.gov/climateleadership/center-corporate-climate-leadership-ghg-emission-factors-hub.*

[53] Intergovernmental Panel on Climate Change. Anthropogenic and Natural Radiative Forcing. In *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Chapter 8. 2013. Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley, Editors. Cambridge University Press: Cambridge, United Kingdom and New York, NY, USA.

[54] See *North Carolina* v. *EPA,* 550 F.3d 1176 (D.C. Cir. 2008); *North Carolina* v. *EPA,* 531 F.3d 896 (D.C. Cir. 2008).

[55] See *EME Homer City Generation, LP* v. *EPA,* 696 F.3d 7, 38 (D.C. Cir. 2012), *cert. granted,* 81 U.S.L.W. 3567, 81 U.S.L.W. 3696, 81 U.S.L.W. 3702 (U.S. June 24, 2013) (No. 12–1182).

[56] See *EPA* v. *EME Homer City Generation,* 134 S. Ct. 1584, 1610 (U.S. 2014). The Supreme Court held in part that EPA's methodology for quantifying emissions that must be eliminated in certain States due to their impacts in other downwind States was based on a permissible, workable, and equitable interpretation of the Clean Air Act provision that provides statutory authority for CSAPR.

[57] See *Georgia* v. *EPA,* Order (D.C. Cir. filed October 23, 2014) (No. 11–1302).

[58] DOE notes that the Supreme Court remanded EPA's 2012 rule regarding national emission standards for hazardous air pollutants from certain electric utility steam generating units. See *Michigan* v. *EPA* (Case No. 14–46, 2015). DOE has tentatively determined that the remand of the MATS rule does not change the assumptions regarding the impact of energy efficiency standards on SO_2 emissions. Further, while the remand of the MATS rule may have an impact on the overall amount of mercury emitted by power plants, it does not change the impact of the energy efficiency standards on mercury emissions. DOE will continue to monitor developments related to this case and respond to them as appropriate.

[59] CSAPR also applies to NO_X and it supersedes the regulation of NO_X under CAIR. As stated previously, the current analysis assumes that CAIR, not CSAPR, is the regulation in force. The difference between CAIR and CSAPR with regard to DOE's analysis of NO_X emissions is slight.

considered in this final rule for these States.

The MATS limit mercury emissions from power plants, but they do not include emissions caps and, as such, DOE's energy conservation standards would likely reduce Hg emissions. DOE estimated mercury emissions reduction using emissions factors based on *AEO 2015,* which incorporates the MATS.

L. Monetizing Carbon Dioxide and Other Emissions Impacts

As part of the development of this rule, DOE considered the estimated monetary benefits from the reduced emissions of CO_2 and NO_X expected to result from each of the TSLs considered. 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 forecast period for each TSL. This section summarizes the basis for the monetary values used for of CO_2 and NO_X emissions and presents the values considered in this final rule.

For this final rule, DOE relied on a set of values for the social cost of carbon (SCC) that was developed by a Federal interagency process. The basis for these values is summarized in the next section, and a more detailed description of the methodologies used is provided as an appendix to chapter 14 of the final rule TSD.

1. Social Cost of Carbon

The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) climate-change-related changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services. Estimates of the SCC are provided in dollars per metric ton of CO_2. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in CO_2 emissions, while a global SCC value is meant to reflect the value of damages worldwide.

Under section 1(b)(6) of Executive Order 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), agencies must, to the extent permitted by law, ''assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs.'' The purpose of the SCC estimates presented here is to allow agencies to incorporate the monetized social benefits of reducing CO_2 emissions into cost-benefit analyses of regulatory actions. The estimates are presented with an acknowledgement of the many uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts.

As part of the interagency process that developed these SCC estimates, technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key model inputs and assumptions. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures. In this way, key uncertainties and model differences transparently and consistently inform the range of SCC estimates used in the rulemaking process.

a. Monetizing Carbon Dioxide Emissions

When attempting to assess the incremental economic impacts of CO_2 emissions, the analyst faces a number of challenges. A report from the National Research Council [60] points out that any assessment will suffer from uncertainty, speculation, and lack of information about (1) future emissions of GHGs, (2) the effects of past and future emissions on the climate system, (3) the impact of changes in climate on the physical and biological environment, and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise questions of science, economics, and ethics and should be viewed as provisional.

Despite the limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing CO_2 emissions. The agency can estimate the benefits from reduced (or costs from increased) emissions in any future year by multiplying the change in emissions in that year by the SCC values appropriate for that year. The NPV of the benefits can then be calculated by multiplying each of these future benefits by an appropriate discount factor and summing across all affected years.

It is important to emphasize that the interagency group is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. In the meantime, the interagency group will continue to explore the issues raised by this analysis and consider public comments as part of the ongoing interagency process.

b. Development of Social Cost of Carbon Values

In 2009, an interagency process was initiated to offer a preliminary assessment of how best to quantify the benefits from reducing carbon dioxide emissions. To ensure consistency in how benefits are evaluated across Federal agencies, the Administration sought to develop a transparent and defensible method, specifically designed for the rulemaking process, to quantify avoided climate change damages from reduced CO_2 emissions. The interagency group did not undertake any original analysis. Instead, it combined SCC estimates from the existing literature to use as interim values until a more comprehensive analysis could be conducted. The outcome of the preliminary assessment by the interagency group was a set of five interim values: Global SCC estimates for 2007 (in 2006$) of $55, $33, $19, $10, and $5 per metric ton of CO_2. These interim values represented the first sustained interagency effort within the U.S. government to develop an SCC for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules.

c. Current Approach and Key Assumptions

After the release of the interim values, the interagency group reconvened on a regular basis to generate improved SCC estimates. Specially, the group considered public comments and further explored the technical literature in relevant fields. The interagency group relied on three integrated assessment models commonly used to estimate the SCC: The FUND, DICE, and PAGE models. These models are frequently cited in the peer-reviewed literature and were used in the last assessment of the Intergovernmental Panel on Climate Change (IPCC). Each model was given equal weight in the SCC values that were developed.

Each model takes a slightly different approach to model how changes in emissions result in changes in economic damages. A key objective of the interagency process was to enable a consistent exploration of the three models, while respecting the different approaches to quantifying damages

[60] National Research Council. *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use.* 2009. National Academies Press: Washington, DC.

taken by the key modelers in the field. An extensive review of the literature was conducted to select three sets of input parameters for these models: Climate sensitivity, socio-economic and emissions trajectories, and discount rates. A probability distribution for climate sensitivity was specified as an input into all three models. In addition, the interagency group used a range of scenarios for the socio-economic parameters and a range of values for the discount rate. All other model features were left unchanged, relying on the model developers' best estimates and judgments.

In 2010, the interagency group selected four sets of SCC values for use in regulatory analyses. Three sets of values are based on the average SCC from the three integrated assessment models, at discount rates of 2.5, 3, and 5 percent. The fourth set, which represents the 95th percentile SCC estimate across all three models at a 3-percent discount rate, was included to represent higher-than-expected impacts from climate change further out in the tails of the SCC distribution. The values grow in real terms over time. Additionally, the interagency group determined that a range of values from 7 percent to 23 percent should be used to adjust the global SCC to calculate domestic effects,[61] although preference is given to consideration of the global benefits of reducing CO_2 emissions. Table IV.6 presents the values in the 2010 interagency group report,[62] which is reproduced in appendix 14A of the final rule TSD.

TABLE IV.6—ANNUAL SCC VALUES FROM 2010 INTERAGENCY REPORT, 2010–2050

[2007$ per metric ton CO_2]

Year	Discount rate			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

The SCC values used for this document were generated using the most recent versions of the three integrated assessment models that have been published in the peer-reviewed literature, as described in the 2013 update from the interagency working group (revised July 2015).[63] Table IV.7 shows the updated sets of SCC estimates from the latest interagency update in 5-year increments from 2010 through 2050. The full set of annual SCC estimates from 2010 through 2050 is reported in appendix 14B of the final rule TSD. The central value that emerges is the average SCC across models at the 3-percent discount rate. However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the interagency group emphasizes the importance of including all four sets of SCC values.

TABLE IV.7—ANNUAL SCC VALUES FROM 2013 INTERAGENCY UPDATE (REVISED JULY 2015), 2010–2050

[2007$ per metric ton CO_2]

Year	Discount rate			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

[61] It is recognized that this calculation for domestic values is approximate, provisional, and highly speculative. There is no *a priori* reason why domestic benefits should be a constant fraction of net global damages over time.

[62] United States Government-Interagency Working Group on Social Cost of Carbon. *Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* February 2010. *https://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.*

[63] United States Government-Interagency Working Group on Social Cost of Carbon. *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* May 2013. Revised July 2015. *https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf.*

It is important to recognize that a number of key uncertainties remain, and that current SCC estimates should be treated as provisional and revisable because they will evolve with improved scientific and economic understanding. The interagency group also recognizes that the existing models are imperfect and incomplete. The National Research Council report mentioned previously points out that there is tension between the goal of producing quantified estimates of the economic damages from an incremental ton of carbon and the limits of existing efforts to model these effects. There are a number of analytical challenges that are being addressed by the research community, including research programs housed in many of the Federal agencies participating in the interagency process to estimate the SCC. The interagency group intends to periodically review and reconsider those estimates to reflect increasing knowledge of the science and economics of climate impacts, as well as improvements in modeling.[64]

In summary, in considering the potential global benefits resulting from reduced CO_2 emissions, DOE used the values from the 2013 interagency report (revised July 2015), adjusted to 2015$ using the implicit price deflator for gross domestic product (GDP) from the Bureau of Economic Analysis. For each of the four sets of SCC cases specified, the values for emissions in 2015 were $12.4, $40.6, $63.2, and $118 per metric ton avoided (values expressed in 2015$). DOE derived values after 2050 based on the trend in 2010–2050 in each of the four cases.

DOE multiplied the CO_2 emissions reduction estimated for each year by the SCC value for that year in each of the four cases. 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 SCC values in each case.

2. Social Cost of Other Air Pollutants

As noted previously, DOE has estimated how the considered energy conservation standards would reduce site NO_X emissions nationwide and decrease power sector NO_X emissions in those 22 States not affected by the CAIR.

DOE estimated the monetized value of NO_X emissions reductions from electricity generation using benefit per ton estimates from the *Regulatory Impact Analysis for the Clean Power Plan Final Rule,* published in August 2015 by EPA's Office of Air Quality Planning and Standards.[65] The report includes high and low values for NO_X (as $PM_{2.5}$) for 2020, 2025, and 2030 using discount rates of 3 percent and 7 percent; these values are presented in appendix 14C of the final rule TSD. DOE primarily relied on the low estimates to be conservative.[66] DOE assigned values for 2021–2024 and 2026–2029 using, respectively, the values for 2020 and 2025. DOE assigned values after 2030 using the value for 2030. DOE developed values specific to the end-use category for ceiling fans using a method described in appendix 14C of the final rule TSD.

DOE multiplied the 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.

DOE is evaluating appropriate monetization of avoided SO_2 and Hg emissions in energy conservation standards rulemakings. DOE has not included monetization of those emissions in the current analysis.

M. Utility Impact Analysis

The utility impact analysis estimates several effects on the electric power generation industry that would result from the adoption of new or amended energy conservation standards. The utility impact analysis estimates the changes in installed electrical capacity and generation that would result for each TSL. The analysis is based on published output from the NEMS associated with *AEO 2015.* 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. DOE uses published side cases to estimate the marginal impacts of reduced energy demand on the utility sector. These marginal factors are estimated based on the changes to electricity sector generation, installed capacity, fuel consumption and emissions in the *AEO* Reference case and various side cases. Details of the methodology are provided in the appendices to chapters 13 and 15 of the final rule TSD.

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 new or amended energy conservation standards.

N. Employment Impact Analysis

DOE considers employment impacts in the domestic economy as one factor in selecting a 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 end users on energy, (2) reduced spending on new energy supply by the utility industry, (3) increased consumer spending on new products to which the new standards apply, 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

[64] In November 2013, OMB announced a new opportunity for public comment on the interagency technical support document underlying the revised SCC estimates. 78 FR 70586. In July 2015 OMB published a detailed summary and formal response to the many comments that were received: This is available at *https://www.whitehouse.gov/blog/2015/07/02/estimating-benefits-carbon-dioxide-emissions-reductions.* It also stated its intention to seek independent expert advice on opportunities to improve the estimates, including many of the approaches suggested by commenters.

[65] Available at *www.epa.gov/cleanpowerplan/clean-power-plan-final-rule-regulatory-impact-analysis.* See Tables 4A–3, 4A–4, and 4A–5 in the report. The U.S. Supreme Court has stayed the rule implementing the Clean Power Plan until the current litigation against it concludes. *Chamber of Commerce, et al.* v. *EPA, et al.,* Order in Pending Case, 577 U.S. ____ (2016). However, the benefit-per-ton estimates established in the Regulatory Impact Analysis for the Clean Power Plan are based on scientific studies that remain valid irrespective of the legal status of the Clean Power Plan.

[66] For the monetized NO_X benefits associated with $PM_{2.5}$, the related benefits are primarily based on an estimate of premature mortality derived from the ACS study (Krewski *et al.* 2009), which is the lower of the two EPA central tendencies. Using the lower value is more conservative when making the policy decision concerning whether a particular standard level is economically justified. [Include this explanation the first time/previous times where these two cites are referenced.] If the benefit-per-ton estimates were based on the Six Cities study (Lepuele *et al.* 2012), the values would be nearly two-and-a-half times larger. (See chapter 14 of the final rule TSD for citations for the studies mentioned above.)

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.[67] 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 final rule using an input/output model of the U.S. economy called Impact of Sector Energy Technologies version 3.1.1 (ImSET).[68] 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.

DOE notes that ImSET is not a general equilibrium forecasting model, and understands 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 generated results for near-term timeframes (2020 and 2025), where these uncertainties are reduced. For more details on the employment impact analysis, see chapter 16 of the final rule 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 adopting in this final rule. Additional details regarding DOE's analyses are contained in the final rule TSD supporting this rulemaking.

A. Trial Standard Levels

In the NOPR analysis, DOE had six TSLs with TSL 6 corresponding to maximum technologically feasible (max tech) efficiency level, TSL 5 corresponding to maximum NPV (at a 7 percent discount rate), and TSL 4 corresponding to maximum NPV (at a 7 percent discount rate) with positive LCC savings. For the final rule, DOE now has five TSLs with TSL 5 corresponding to both max tech and maximum NPV, and TSL 4 corresponding to maximum NPV with an AC motor for all product classes other than HSSD fans, and maximum NPV for HSSD fans. The criteria for TSLs 1–3 remains unchanged.

The TSLs for the final rule were developed by combining specific efficiency levels for each of the product classes analyzed by DOE. DOE presents the results for the TSLs in this document, while the results for all efficiency levels that DOE analyzed are in the final rule TSD.

Table V.1 presents the TSLs and the corresponding efficiency levels for ceiling fans. TSL 5 represents the max-tech energy efficiency for all product classes.

TSL 4 corresponds to maximum NPV with an AC motor for all product classes other than HSSD fans, and maximum NPV for HSSD fans. In addition, at this TSL, less than 50 percent of consumers experience a net cost, and large-diameter ceiling fans that provide high levels of airflow are not disproportionally impacted. Specifically, for large-diameter ceiling fans, while max-tech provides LCC savings and NPV that are both positive, max-tech has potential unintended consequence of disproportionately impacting large diameter fans that provide high levels of airflow. DOE does not have enough data to be certain that large-diameter ceiling fans at the current max CFM levels offered on the market at all diameters can meet the max-tech level, even when using brushless DC motors. Therefore, if large-diameter ceiling fans that provide the highest levels of airflow in today's market cannot meet the max tech level even when using brushless DC motors, these fans could be unintentionally eliminated from the market, diminishing product availability and utility.

TSL 3 corresponds to the highest efficiency level that can be met with a standard (AC) motor for all product classes. TSL 2 corresponds to the fan-optimization design-option efficiency level. TSL 1 corresponds to the first non-baseline efficiency level (i.e., EL 1).

TABLE V.1—TRIAL STANDARD LEVELS FOR CEILING FANS

	VSD	Hugger	Standard	HSSD	Large-diameter
TSL 1	EL 1	EL 1	EL 1	EL 1	EL 1
TSL 2	EL 1	EL 2	EL 2	EL 1	EL 1
TSL 3	EL 2	EL 3	EL 3	EL 3	EL 3
TSL 4	EL 2	EL 3	EL 3	EL 4	EL 3
TSL 5	EL 3	EL 4	EL 4	EL 4	EL 4

[67] 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 *http://www.bea.gov/scb/pdf/regional/perinc/meth/rims2.pdf.*

[68] J.M. Roop, M.J. Scott, and R.W. Schultz. *ImSET 3.1: Impact of Sector Energy Technologies.* 2009. Pacific Northwest National Laboratory: Richland, WA. PNNL–18412. Available at *www.pnl.gov/main/publications/external/technical_reports/PNNL-18412.pdf.*

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Consumers

DOE analyzed the economic impacts on ceiling fans consumers by looking at the effects potential amended standards at each TSL would have on the LCC and PBP. DOE also examined the impacts of potential standards on consumer subgroups. These analyses are discussed below.

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 final rule TSD provides detailed information on the LCC and PBP analyses.

Table V.2 through Table V.11 show the LCC and PBP results for the TSL efficiency levels 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, the impacts are measured relative to the efficiency distribution in the in the no-new-standards case in the compliance year (see section IV.F.7 of this notice). 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 EL 0 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.

TABLE V.2—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR STANDARD FANS

EL	Average costs (2015$)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost	LCC		
0	113.49	16.99	190.29	303.79	....	13.8
1	113.49	12.75	144.06	257.55	0.0	13.8
2	113.49	11.48	130.20	243.70	0.0	13.8
3	124.95	10.33	117.58	242.53	1.7	13.8
4	158.01	5.86	75.92	233.93	4.0	13.8

Note: The results for each EL represent the average result if 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 EFFICIENCY DISTRIBUTION FOR STANDARD FANS

EL	Life-cycle cost savings	
	Percent of consumers that experience net cost	Average LCC savings * (2015$)
	....	....
1	0.0	46.61
2	0.0	37.20
3	27.5	25.78
4	50.4	26.80

* The calculation excludes consumers with zero LCC savings (no impact).

TABLE V.4—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR HUGGER FANS

EL	Average costs (2015$)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost	LCC		
0	100.39	15.05	168.74	269.13	....	13.8
1	100.39	11.30	127.78	228.17	0.0	13.8
2	100.39	10.17	115.51	215.90	0.0	13.8
3	110.63	9.24	105.27	215.90	1.8	13.8
4	139.90	5.52	71.83	211.73	4.1	13.8

Note: The results for each EL represent the average result if 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 EFFICIENCY DISTRIBUTION FOR HUGGER FANS

EL	Life-cycle cost savings	
	Percent of consumers that experience net cost	Average LCC savings* (2015$)
1	0.0	39.02
2	0.0	31.75
3	27.8	21.50
4	51.4	19.20

* The calculation excludes consumers with zero LCC savings (no impact).

TABLE V.6—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR VSD FANS

EL	Average costs (2015$)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost	LCC		
0	268.25	14.12	158.25	426.50		13.8
1	268.25	12.72	142.90	411.15	0.0	13.8
2	289.30	11.87	133.65	422.95	9.3	13.8
3	352.51	7.82	96.53	449.04	13.4	13.8

Note: The results for each EL represent the average result if 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 EFFICIENCY DISTRIBUTION FOR VSD FANS

EL	Life-cycle cost savings	
	Percent of consumers that experience net cost	Average LCC savings* (2015$)
1	0.0	16.10
2	2.1	4.29
3	75.8	−25.94

* The calculation excludes consumers with zero LCC savings (no impact).

TABLE V.8—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR HSSD FANS

EL	Average costs (2015$)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost	LCC		
0	145.28	20.27	204.44	349.72		13.8
1	145.28	18.24	184.24	329.52	0.0	13.8
2	169.20	17.05	172.35	341.55	7.4	13.8
3	177.92	16.92	177.65	355.56	9.8	13.8
4	227.81	8.38	92.49	320.30	6.9	13.8

Note: The results for each EL represent the average result if 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 EFFICIENCY DISTRIBUTION FOR HSSD FANS

EL	Life-cycle cost savings	
	Percent of consumers that experience net cost	Average LCC savings * (2015$)
1	0.0	20.17
2	58.8	−1.90
3	70.0	−15.81
4	38.7	19.80

* The calculation excludes consumers with zero LCC savings (no impact).

TABLE V.10.—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR LARGE-DIAMETER FANS

EL	Average costs (2015$)				Simple payback (years)	Average lifetime (years)
	Installed cost	First year's operating cost	Lifetime operating cost	LCC		
0	4119.72	292.21	2921.38	7041.10		13.8
1	4119.72	262.99	2632.90	6752.62	0.0	13.8
2	4261.44	239.08	2396.87	6658.31	2.7	13.8
3	4458.32	210.14	2110.93	6569.25	4.1	13.8
4	4706.71	156.42	1624.11	6330.82	4.3	13.8

Note: The results for each EL represent the average result if all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

TABLE V.11—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE EFFICIENCY DISTRIBUTION FOR LARGE-DIAMETER FANS

EL	Life-cycle cost savings	
	Percent of consumers that experience net cost	Average LCC savings * (2015$)
1	0.0	291.52
2	1.0	247.21
3	23.3	128.90
4	16.2	347.93

* The calculation excludes consumers with zero LCC savings (no impact).

DOE conducted a sensitivity analysis to determine the potential impacts to consumers for a scenario in which manufacturers increase their manufacturer selling price in order to pass through to consumers their conversion costs at TSL 1 and TSL 2. At TSL 1 and TSL 2, DOE estimates no incremental installed costs to consumers because the assumed design options (*e.g.,* fan optimization) implemented at those levels would not result in incremental MPC or differences in installation costs based on manufacturer interviews. However, DOE estimates that manufacturers will incur conversion costs at TSL 1 and TSL 2 to make their products compliant. To provide a high estimate of the potential cost impacts on consumers, DOE passed through these product conversion costs at TSL 1 and TSL 2 to the higher TSL levels and presents the results in appendix 8.E of the TSD. For this sensitivity, the LCC savings are positive and the PBPs are less than the lifetime of the products for each product class at the chosen TSL level.

b. Consumer Subgroup Analysis

In the consumer subgroup analysis, DOE estimated the impact of the considered TSLs on low-income households and small businesses. Table V.12 through

Table V.16 compare the average LCC savings and PBP at each efficiency level for the two consumer subgroups, along with the average LCC savings for the entire sample for all the product classes. For standard, hugger, and VSD ceiling fans, the average LCC savings and PBP for low-income households at the considered efficiency levels are not substantially different from the averages for all households. For HSSD and large-diameter ceiling fans, the average savings and PBP for small businesses at the considered efficiency levels show moderate differences from the averages for all businesses, but the differences are not significant enough to recommend a different standard level be adopted. Chapter 11 of the final rule TSD presents the complete LCC and PBP results for the subgroups.

TABLE V.12—COMPARISON OF LCC SAVINGS AND PBP FOR LOW-INCOME HOUSEHOLDS AND ALL HOUSEHOLDS FOR STANDARD FANS

EL	Average LCC savings * (2015$)		Simple payback period (years)	
	All	Low-income	All	Low-income
....	....	....	....	....
1	46.61	42.26	0.0	0.0
2	37.20	34.65	0.0	0.0
3	25.78	23.73	1.7	1.7
4	26.80	24.99	4.0	4.0

* The calculation excludes consumers with zero LCC savings (no impact).

TABLE V.13—COMPARISON OF LCC SAVINGS AND PBP FOR LOW-INCOME HOUSEHOLDS AND ALL HOUSEHOLDS FOR HUGGER FANS

EL	Average LCC savings * (2015$)		Simple payback period (years)	
	All	Low-income	All	Low-income
....	....	....	....	....
1	39.02	40.04	0.0	0.0
2	31.75	33.22	0.0	0.0
3	21.50	22.49	1.8	1.8
4	19.20	19.56	4.1	4.2

* The calculation excludes consumers with zero LCC savings (no impact).

TABLE V.14—COMPARISON OF LCC SAVINGS AND PBP FOR LOW-INCOME HOUSEHOLDS AND ALL HOUSEHOLDS FOR VSD FANS

EL	Average LCC savings * (2015$)		Simple payback period (years)	
	All	Low-income	All	Low-income
....	....	....	....	....
1	16.10	16.90	0.0	0.0
2	4.29	5.99	9.3	9.5
3	−25.94	−27.10	13.4	13.6

* The calculation excludes consumers with zero LCC savings (no impact).

TABLE V.15—COMPARISON OF LCC SAVINGS AND PBP FOR SMALL BUSINESSES AND ALL BUILDINGS FOR HSSD FANS

EL	Average LCC savings * (2015$)		Simple payback period (years)	
	All	Small businesses	All	Small businesses
....	....	....	....	....
1	20.17	17.49	0.0	0.0
2	−1.90	−4.96	7.4	7.4
3	−15.81	−18.39	9.8	9.7
4	19.80	6.08	6.9	6.9

* The calculation excludes consumers with zero LCC savings (no impact).

TABLE V.16—COMPARISON OF LCC SAVINGS AND PBP FOR SMALL BUSINESSES AND ALL BUILDINGS FOR LARGE-DIAMETER FANS

EL	Average LCC savings * (2015$)		Simple payback period (years)	
	All	Small businesses	All	Small businesses
....	....	....	....	....
1	291.52	250.66	0.0	0.0
2	247.21	191.28	2.7	2.6
3	128.90	80.70	4.1	4.1
4	347.93	254.52	4.3	4.3

* The calculation excludes consumers with zero LCC savings (no impact).

c. Rebuttable Presumption Payback

As discussed in section IV.F.8, 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 procedures for ceiling fans. In contrast, the PBPs presented in section V.B.1.a were calculated using distributions that reflect the range of energy use in the field.

Table V.17 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 this rule 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 evaluate the economic justification for a potential standard level, thereby supporting or rebutting the results of any preliminary determination of economic justification.

TABLE V.17—REBUTTABLE PRESUMPTION PAYBACK PERIOD RESULTS

EL	Standard	Hugger	VSD	HSSD	Large-diameter
1	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	9.4	3.5	2.9
3	1.5	1.5	12.6	4.2	4.5
4	3.2	3.3		3.2	4.7

2. Economic Impacts on Manufacturers

DOE performed an MIA to estimate the impact of amended energy conservation standards on manufacturers of ceiling fans. This section describes the expected impacts on manufacturers at each TSL. Chapter 12 of the final rule TSD explains the analysis in further detail.

a. Industry Cash Flow Analysis Results

Table V.18 through Table V.20 present the financial impacts, represented by changes in INPV, of amended standards on ceiling fan manufacturers as well as the conversion costs that DOE estimates ceiling fan manufacturers would incur at each TSL. To evaluate the range of cash-flow impacts on the ceiling fan industry, DOE modeled three manufacturer markup scenarios that correspond to the range of anticipated market responses to amended standards. Each scenario results in a unique set of cash flows and corresponding industry values at each TSL.

In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case and each TSL in the standards cases. INPV is calculated by summing the discounted cash flows from the reference year (2016) through the end of the analysis period (2049). INPV values vary by the manufacturer markup scenario modeled to produce them. DOE believes that these manufacturer markup scenarios are most likely to capture the range of impacts on ceiling fan manufacturers as a result of the amended energy conservation standards. The results also discuss the difference in cash flows between the no-new-standards case and the standards cases in the year before the compliance date of amended standards. This difference in cash flow represents the size of the required conversion costs at each TSL relative to the cash flow generated by the ceiling fan industry in the absence of amended energy conservation standards.

To assess the upper (less severe) bound on the range of potential impacts on ceiling fan manufacturers, DOE modeled a preservation of gross margin, or flat, markup scenario. This scenario assumes that in the standards cases, manufacturers would be able to pass along the higher production costs required for more efficient products to their consumers. Specifically, the industry would be able to maintain its average no-new-standards case gross margin (as a percentage of revenue) despite the higher product costs in the standards cases. In general, the larger the product price increases, the less likely manufacturers are to achieve the cash flow from operations calculated in this manufacturer markup scenario because it is less likely that manufacturers would be able to fully mark up these larger cost increases.

To assess the lower (more severe) bound on the range of potential impacts on ceiling fan manufacturers, DOE modeled two additional manufacturer markup scenarios; a preservation of operating profit markup scenario and a two-tiered markup scenario. In the preservation of operating profit markup scenario manufacturers are not able to yield additional operating profit from higher production costs and the investments that are required to comply with amended ceiling fan energy conservation standards, but instead are only able to maintain the same operating profit in the standards cases that was earned in the no-new-standards case. This scenario represents a potential lower bound on the range of impacts on manufacturers because manufacturers are only able to maintain the operating profit that they would have earned in the no-new-standards case despite higher production costs and investments. Manufacturers must therefore, reduce margins as a result of this manufacturer markup scenario, which reduces profitability.

DOE also modeled a two-tiered markup scenario as a potential lower (more severe) bound on the range of potential impacts on ceiling fan manufacturers. In this manufacturer markup scenario, manufacturers have two tiers of markups that are differentiated, in part, by efficiency level. The higher efficiency tiers typically earn premiums (for the manufacturer) over the baseline efficiency tier. Several manufacturers suggested that amended standards would lead to a reduction in premium markups and reduce the profitability of higher efficiency products. During the MIA interviews, manufacturers provided information on the range of typical efficiency levels in those tiers and the change in profitability at each level. DOE used this information to estimate markups for ceiling fans under a two-tiered pricing strategy in the no-new-standards case. In the standards cases, DOE modeled the situation in which standards result in less product differentiation, compression of the markup tiers, and an overall reduction in profitability.

TABLE V.18—MANUFACTURER IMPACT ANALYSIS FOR CEILING FANS—PRESERVATION OF GROSS MARGIN MARKUP SCENARIO

	Units	No-new-standards case	Trial standard levels				
			1	2	3	4	5
INPV	2015$ millions	1,211.6	1,214.6	1,227.2	1,213.2	1,206.8	1,265.3
Change in INPV	2015$ millions		3.0	15.6	1.6	(4.8)	53.8
	%		0.2	1.3	0.1	(0.4)	4.4
Product Conversion Costs	2015$ millions		5.1	9.4	31.7	33.2	46.5
Capital Conversion Costs	2015$ millions		7.1	13.1	63.0	66.7	109.5
Total Conversion Costs	2015$ millions		12.3	22.5	94.7	99.9	155.9

TABLE V.19—MANUFACTURER IMPACT ANALYSIS FOR CEILING FANS—PRESERVATION OF OPERATING PROFIT MARKUP SCENARIO

	Units	No-new-standards case	Trial standard levels				
			1	2	3	4	5
INPV	2015$ millions	1,211.6	1,200.8	1,188.6	1,107.9	1,092.1	926.7
Change in INPV	2015$ millions		(10.7)	(23.0)	(103.7)	(119.4)	(284.8)
	%		(0.9)	(1.9)	(8.6)	(9.9)	(23.5)
Product Conversion Costs	2015$ millions		5.1	9.4	31.7	33.2	46.5
Capital Conversion Costs	2015$ millions		7.1	13.1	63.0	66.7	109.5
Total Conversion Costs	2015$ millions		12.3	22.5	94.7	99.9	155.9

TABLE V.20—MANUFACTURER IMPACT ANALYSIS FOR CEILING FANS—TWO-TIERED MARKUP SCENARIO

	Units	No-new-standards case	Trial standard levels				
			1	2	3	4	5
INPV	2015$ millions	1,211.6	1,232.8	1,275.8	1,123.8	1,116.6	1,164.2
Change in INPV	2015$ millions		21.2	64.3	(87.7)	(95.0)	(47.3)
	%		1.8	5.3	(7.2)	(7.8)	(3.9)
Product Conversion Costs	2015$ millions		5.1	9.4	31.7	33.2	46.5
Capital Conversion Costs	2015$ millions		7.1	13.1	63.0	66.7	109.5
Total Conversion Costs	2015$ millions		12.3	22.5	94.7	99.9	155.9

TSL 1 sets the efficiency level at EL 1 for all ceiling fans. At TSL 1, DOE estimates that impacts on INPV range from −$10.7 million to $21.2 million, or changes in INPV of −0.9 percent to 1.8 percent. At TSL 1, industry free cash flow (operating cash flow minus capital expenditures) is expected to decrease by approximately 6.3 percent to $69.9 million, compared to the no-new-standards case value of $74.6 million in 2019, the year leading up to the standards.

Percentage impacts on INPV are slightly negative to slightly positive at TSL 1. DOE estimates that 77 percent of standard and hugger ceiling fan shipments, 96 percent of VSD ceiling fan shipments, 55 percent of HSSD ceiling fan shipments, and 95 percent of large-diameter ceiling fan shipments would meet or exceed the efficiency levels required at TSL 1.

DOE expects conversion costs to be small at TSL 1 because most of the ceiling fan shipments, on a total volume basis, already meet or exceed the efficiency levels required at TSL 1. DOE estimates that ceiling fan manufacturers will incur a total of $12.3 million in conversion costs at TSL 1 based on estimates for product conversion costs and capital conversion costs. DOE estimates that ceiling fan manufacturers will incur $5.1 million in product conversion costs as they must develop and redesign any ceiling fan models that do not meet the efficiency levels required at TSL 1. DOE estimates that manufacturers will incur $7.1 million in capital conversion costs at TSL 1, as ceiling fan manufacturers most likely will need to purchase new tooling for any redesigned models.

At TSL 1, the shipment-weighted average MPC for all ceiling fans increases by approximately 1.5 percent relative to the no-new-standards case shipment-weighted average MPC for all ceiling fans in 2020, the year of compliance for amended ceiling fan energy conservation standards. In the preservation of gross margin markup scenario, manufacturers are able to fully pass on this slight cost increase to consumers. The slight increase in the shipment-weighted average MPC for all ceiling fans outweighs the $12.3 million in conversion costs, causing a slightly positive change in INPV at TSL 1 under the preservation of gross margin markup scenario.

Under the preservation of operating profit markup scenario, manufacturers earn the same operating profit as would be earned in the no-new-standards case, but manufacturers do not earn additional profit from their investments. The average manufacturer markup for both the preservation of operating profit and two-tiered markup scenarios is calculated by averaging the ceiling fan industry manufacturer markup, for all ceiling fan product classes in aggregate, from the year of compliance (2020) until the terminal year (2049). In this scenario, the 1.5 percent increase in the shipment-weighted average MPC for all ceiling fans results in a slight reduction in average manufacturer markup, from 1.370 in the no-new-standards case to 1.368 at TSL1. The slight reduction in average manufacturer markup and $12.3 million in conversion costs causes a slightly negative change in INPV at TSL 1 under the preservation of operating profit markup scenario.

Under the two-tiered markup scenario, where manufacturers earn different markups for more efficient products, the average manufacturer markup increases from 1.370 in the no-new-standards case to 1.373 at TSL 1 as more shipments are purchased at the higher markup efficiency tiers. The increase in the average manufacturer markup and the increase in the shipment-weighted average MPC for all ceiling fans outweigh the $12.3 million in conversion costs, causing a slightly positive change in INPV at TSL 1 under the two-tiered markup scenario.

TSL 2 sets the efficiency level at EL 1 for VSD, HSSD, and large-diameter ceiling fans and EL 2 for standard and hugger ceiling fans. At TSL 2, DOE estimates that impacts on INPV range from −$23.0 million to $64.3 million, or changes in INPV of −1.9 percent to 5.3 percent. At this TSL, industry free cash flow is estimated to decrease by approximately 11.5 percent to $66.0 million, compared to the no-new-standards case value of $74.6 million in 2019.

Percentage impacts on INPV range from slightly negative to slightly positive at TSL 2. DOE projects that in 2020, 55 percent of standard and hugger ceiling fan shipments, 96 percent of VSD ceiling fan shipments, 55 percent of HSSD ceiling fan shipments, and 95 percent of large-diameter ceiling fan shipments would meet or exceed the efficiency levels required at TSL 2.

DOE expects conversion costs to be moderate at TSL 2 because most of the ceiling fan shipments, on a total volume basis, currently meet or exceed the efficiency levels analyzed at TSL 2. DOE estimates that manufacturers will incur a total of $22.5 million in conversion costs at TSL 2. DOE estimates that manufacturers will incur $9.4 million in product conversion costs at TSL 2 as manufacturers must develop and redesign any ceiling fan models that do not meet the efficiency levels required at TSL 2. Capital conversion costs are estimated to be $13.1 million at TSL 2. Capital conversion costs at TSL 2 are driven by investments in tooling needed to further optimize standard and hugger ceiling fans to meet the efficiency levels required at TSL 2.

At TSL 2, the shipment-weighted average MPC for all ceiling fans increases by approximately 4.2 percent relative to the no-new-standards case shipment-weighted average MPC for all ceiling fans in 2020. In the preservation of gross margin markup scenario, manufacturers are able to recover their $22.5 million in conversion costs over the course of the analysis period through the increase in the shipment-weighted MPC for all ceiling fans, causing a slightly positive change in INPV at TSL 2 under the preservation of gross margin markup scenario.

Under the preservation of operating profit markup scenario, the 4.2 percent increase in the shipment-weighted average MPC for all ceiling fans results in a slight reduction in the average manufacturer markup, from 1.370 in the no-new-standards case to 1.365 at TSL 2. The slight reduction in the average manufacturer markup and $22.5 million in conversion costs cause a slightly negative change in INPV at TSL 2 under the preservation of operating profit scenario.

Under the two-tiered markup scenario, the average manufacturer markup increases from 1.370 in the no-new-standards case to 1.377 at TSL 2 as more shipments are purchased at the higher markup efficiency tiers. The increase in the average manufacturer markup and the increase in the shipment-weighted average MPC for all ceiling fans outweigh the $22.5 million in conversion costs, causing a slightly positive change in INPV at TSL 2 under the two-tiered markup scenario.

TSL 3 sets the efficiency level at EL 2 for VSD ceiling fans and EL 3 for standard, hugger, HSSD, and large-diameter ceiling fans. At TSL 3, DOE estimates that impacts on INPV range from −$103.7 million to $1.6 million, or changes in INPV of −8.6 percent to 0.1 percent. At this level, industry free cash flow is estimated to decrease by approximately 50.1 percent to $37.2 million, compared to the no-new-standards case value of $74.6 million in 2019.

Percentage impacts on INPV range from moderately negative to slightly positive at TSL 3. DOE projects that in 2020, 32 percent of standard and hugger ceiling fan shipments, 96 percent of VSD ceiling fan shipments, 11 percent of HSSD ceiling fan shipments, and 31 percent of large-diameter ceiling fan shipments would meet or exceed the efficiency levels analyzed at TSL 3.

DOE expects higher conversion costs at TSL 3 than at lower TSLs because manufacturers will be required to redesign and retest a significant portion of their ceiling fan models that do not meet the efficiency levels required at this TSL. DOE estimates that manufacturers will incur $31.7 million in product conversion costs at TSL 3 as manufacturers must research, develop, and redesign numerous ceiling fan models to meet the efficiency levels required at TSL 3. Capital conversion costs are estimated to be $63.0 million at TSL 3. Capital conversion costs at TSL 3 are driven by retooling costs associated with producing redesigned standard, hugger, and VSD ceiling fans with larger direct drive motors; HSSD ceiling fans with air foil blades; and large-diameter ceiling fans with premium AC motors and airfoil blades.

At TSL 3, the shipment-weighted average MPC increases by approximately 11.5 percent for all ceiling fans relative to the no-new-standards case MPC in 2020. In the preservation of gross margin markup scenario, manufacturers are able to recover their $94.7 million in conversion costs through the moderate increase in MPC over the course of the analysis period causing a slightly positive change in INPV at TSL 3 under the preservation of gross margin markup scenario.

Under the preservation of operating profit markup, the 11.5 percent MPC increase for all ceiling fans results in a reduction in manufacturer markup after the compliance year, from 1.370 in the no-new-standards case to 1.356 at TSL 3. This reduction in manufacturer markup and $94.7 million in conversion costs incurred by manufacturers cause a moderately negative change in INPV at TSL 3 under the preservation of operating profit scenario.

Under the two-tiered markup scenario, the average manufacturer markup decreases from 1.370 in the no-new-standards case to 1.359 at TSL 3. At TSL 3 under the two-tiered markup scenario, manufacturers reduce their markups on their more efficient shipments, as these premium products are no longer able to earn higher markups as they become the baseline due to standards. The decrease in the average manufacturer markup and the $94.7 million in conversion costs incurred by manufacturers outweighs the moderate increase in the shipment-weighted average MPC for all ceiling fans, causing a moderately negative change in INPV at TSL 3 under the two-tiered markup scenario.

TSL 4 sets the efficiency level at EL 2 for VSD ceiling fans; EL 3 for standard, hugger, and large-diameter ceiling fans; and EL 4 for HSSD ceiling fans. At TSL 4, DOE estimates impacts on INPV range from −$119.4 million to −$4.8 million, or decreases in INPV of −9.9 percent to −0.4 percent. At this level, industry free cash flow is estimated to decrease by approximately 52.9 percent to $35.1 million, compared to the no-new-standards case value of $74.6 million in 2019.

Percentage impacts on INPV range from moderately negative to slightly negative at TSL 4. DOE projects that in 2020, 32 percent of standard and hugger ceiling fan shipments, 96 percent of VSD ceiling fan shipments, 8 percent of HSSD ceiling fan shipments, and 31 percent of large-diameter ceiling fan shipments would meet or exceed efficiency levels analyzed at TSL 4.

For TSL 4, DOE concluded that manufacturers would likely use DC motors in the HSSD ceiling fan product class. DOE estimates that manufacturers will incur a total of $99.9 million in conversion costs at TSL 4. DOE estimates that manufacturers will incur $33.2 million in product conversion costs at TSL 4 as manufacturers must research, develop, and redesign numerous ceiling fan models to meet the efficiency levels required at TSL 4. Capital conversion costs are estimated to be $66.7 million at TSL 4. Capital conversion costs at TSL 4 are driven by retooling costs associated with producing redesigned standard, hugger, and VSD ceiling fans with larger direct drive motors; HSSD ceiling fans with DC motors and airfoil blades; and large-diameter ceiling fans with premium AC motors and airfoil blades.

At TSL 4, the shipment-weighted average MPC for all ceiling fans increases by approximately 12.8 percent relative to the no-new-standards case shipment-weighted average MPC for all ceiling fans in 2020. In the preservation of gross margin markup scenario, manufacturers are not able to recover their $99.9 million in conversion costs over the course of the analysis period through the moderate increase in the shipment-weighted average MPC for all ceiling fans, causing a slightly negative change in INPV at TSL 4 under the preservation of gross margin markup scenario.

Under the preservation of operating profit markup scenario, the 12.8 percent increase in the shipment-weighted average MPC for all ceiling fans results in a reduction of the average manufacturer markup, from 1.370 in the no-new-standards case to 1.355 at TSL 4. The reduction of the average manufacturer markup and $99.9 million in conversion costs cause a moderately negative change in INPV at TSL 4 under the preservation of operating profit scenario.

Under the two-tiered markup scenario, the increase in the shipment-weighted average MPC for all ceiling fans results in a reduction of the average manufacturer markup, from 1.370 in the no-new-standards case to 1.359 at TSL 4. At TSL 4 under the two-tiered markup scenario, manufacturers reduce their markups on their more efficient shipments, as these premium products are no longer able to earn higher markups as they become the baseline due to standards. The decrease in the average manufacturer markup and the $99.9 million in conversion costs outweigh the increase in the shipment-weighted average MPC for all ceiling fans, causing a moderately negative change in INPV at TSL 4 under the two-tiered markup scenario.

TSL 5 represents max-tech for all ceiling fan product classes. This TSL sets the efficiency level at EL 3 for VSD ceiling fans and EL 4 for standard, hugger, HSSD, and large-diameter ceiling fans. At TSL 5, DOE estimates that impacts on INPV range from −$284.8 million to $53.8 million, or changes in INPV of −23.5 percent to 4.4 percent. At this level, industry free cash flow is estimated to decrease by approximately 83.4 percent to $12.4 million, compared to the no-new-standards case value of $74.6 million in 2019.

Percentage impacts on INPV range from significantly negative to slightly positive at TSL 5. DOE projects that in 2020, 3 percent of standard ceiling fan shipments, 4 percent of hugger ceiling fan shipments, no VSD ceiling fan shipments, 8 percent of HSSD ceiling fan shipments, and 17 percent of large-diameter ceiling fan shipments would meet the efficiency levels analyzed at TSL 5.

DOE estimates that manufacturers will incur a total of $155.9 million in conversion costs at TSL 5. DOE estimates that manufacturer will incur $46.5 million in product conversion costs at TSL 5 as manufacturers must research, develop, and redesign the vast majority of their ceiling fan models to meet the efficiency levels required at TSL 5. Capital conversion costs are estimated to be $109.5 million at TSL 5, driven by retooling costs associated with producing redesigned, max-tech standard, hugger, and VSD ceiling fans with DC motors; and HSSD and large-diameter ceiling fans with DC motors and airfoil blades.

At TSL 5, the shipment-weighted average MPC for all ceiling fans significantly increases by approximately 45.1 percent relative to the no-new-standards case shipment-weighted average MPC for all ceiling fans in 2020. In the preservation of gross margin markup scenario, manufacturers are able to recover their $155.9 million in conversion costs over the course of the analysis period through the significant increase in the shipment-weighted average MPC for all ceiling fans, causing a positive change in INPV at TSL 5 under the preservation of gross margin markup scenario.

Under the preservation of operating profit markup scenario, the 45.1 percent increase in the shipment-weighted MPC for all ceiling fans results in a reduction of the average manufacturer markup, from 1.370 in the no-new-standards case to 1.332 at TSL 5. The reduction of the average manufacturer markup and $155.9 million in conversion costs cause a significantly negative change in INPV at TSL 5 under the preservation of operating profit markup scenario.

Under the two-tiered markup scenario, the 45.1 percent increase in the shipment-weighted average MPC for all ceiling fans results in a reduction of the average manufacturer markup, from 1.370 in the no-new-standards case to 1.359 at TSL 5. At TSL 5 under the two-tiered markup scenario, manufacturers reduce their markups on their more efficient shipments, as these premium products are no longer able to earn higher markups as they become the baseline due to standards. The decrease in the average manufacturer markup and $155.9 million in conversion costs outweigh the increase in the shipment-weighted average MPC for all ceiling fans, causing a slightly negative change in INPV at TSL 5 under the two-tiered markup scenario.

b. Impacts on Employment

DOE quantitatively assessed the impacts of amended energy conservation standards on direct employment in the ceiling fan industry. DOE used the GRIM to estimate the domestic labor expenditures and number of domestic production workers in the no-new-standards case and at each TSL from 2016 to 2049. DOE used statistical data from the U.S. Census Bureau's 2014 Annual Survey of Manufacturers, the results of the engineering analysis, and interviews with manufacturers to determine the inputs necessary to calculate industry-wide labor expenditures and domestic employment levels. Labor expenditures involved with the manufacturing of the product are a function of the labor intensity of the product, the sales volume, and an assumption that wages remain fixed in real terms over time.

In the GRIM, DOE used the labor content of ceiling fans and the MPCs to estimate the annual labor expenditures in the industry. DOE used Census data and interviews with manufacturers to estimate the portion of the total labor expenditures that is attributable to domestic labor.

The production worker estimates in this section only cover workers up to the line-supervisor level directly involved in fabricating and assembling a product within a manufacturing facility. Workers performing services that are closely associated with production operations, such as material handing with a forklift, are also included as production labor. DOE's estimates account for production workers who manufacture only the specific products covered by this rulemaking.

Table V.21 represents the potential impacts the amended standards could have on domestic production employment. The upper bound of the results estimates the maximum change in the number of production workers that could occur after compliance with amended energy conservation standards when assuming that manufacturers continue to produce the same scope of covered products in the same production facilities. It also assumes that domestic production does not shift to lower labor-cost countries. Because there is a real risk of manufacturers evaluating sourcing and production facility location decisions in response to amended energy conservation standards, the lower bound of the employment results estimate the maximum decrease in domestic production workers in the industry if some or all existing production was moved outside of the United States. While the results present a range of estimates, the following sections also include qualitative discussions of the employment impacts at the various TSLs. Finally, the domestic production employment impacts shown are independent of the employment impacts from the broader U.S. economy, documented in chapter 17 of the final rule TSD.

DOE estimates that in the absence of amended energy conservation standards, there would be approximately 33 domestic production workers involved in manufacturing ceiling fans in 2020. Table V.21 presents the range of potential impacts of amended energy conservation standards on U.S. production workers in the ceiling fan industry.

TABLE V.21—POTENTIAL CHANGES IN THE TOTAL NUMBER OF DOMESTIC CEILING FAN PRODUCTION WORKERS IN 2020

	No-new-standards case	Trial standard level				
		1	2	3	4	5
Total Number of Domestic Production Workers in 2020 (without changes in production locations)	33	33	33	32	32	28
Potential Changes in Domestic Production Workers in 2020 *	....	0–(33)	0–(33)	(1)–(33)	(1)–(33)	(5)–(33)

* DOE presents a range of potential employment impacts. Numbers in parentheses indicate negative numbers.

At the upper end of the employment impact range, DOE expects there to be slight or no negative impacts on domestic production employment at each of the TSLs. Slight negative impacts on domestic production employment at higher TSLs are driven by the reduction in total ceiling fan shipments. DOE included price elasticity as part of the shipments analysis, so as the average price of ceiling fans increases due to amended standards, fewer ceiling fans would be sold. Therefore, the amount of labor associated with these fewer shipments also decreases. It is important to note that while the average total MPC increases for more efficient ceiling fans, the increase in MPC is almost entirely attributed to the increase in the material costs used to produce more efficient fans. The amount of labor associated with producing more efficient ceiling fans remains virtually the same even as the total MPC of a ceiling fan increases at higher efficiency levels.

At the lower end of the range, DOE models a situation where all domestic employment associated with ceiling fan production moves abroad as a result of energy conservation standards. The majority of manufacturers that have domestic production produce large-diameter ceiling fans. Moving production of large-diameter fans abroad would result in significantly high shipping costs. Based on the prohibitive shipping costs and manufacturer feedback, DOE does not expect the impacts on domestic production employment to approach the lower bound at any TSL.

At TSL 4, the TSL adopted in today's final rule, DOE concludes that, based on the shipment analysis, manufacturer interviews, and the results of the direct domestic employment analysis, manufacturers could face a slight negative impact on domestic production employment due to a slight reduction in overall ceiling fan shipments in 2020.

c. Impacts on Manufacturing Capacity

Ceiling fan manufacturers stated that they anticipate manufacturing capacity constraints if all ceiling fans are required to use DC motors to comply with the amended energy conservation standards. DOE learned during interviews that manufacturers primarily source motors for ceiling fans from either ceiling fan original equipment manufacturers or directly from motor manufacturers and then insert them into their ceiling fan models. During interviews, manufacturers stated that demand for DC motors may outpace supply if DC motors are required for all ceiling fans to comply with amended standards. Manufacturers expressed concern during interviews that currently only a few ceiling fan shipments incorporate DC motors, and there would be major sourcing concerns if all ceiling fan were required to use DC motors.

Manufacturers would most likely meet the standard required at TSL 4 for the HSSD ceiling fans by using DC motors, HSSD ceiling fans only account for less than 3 percent of all ceiling fan shipments. Therefore, DOE does not anticipate a manufacturer capacity constraint on the supply of DC motors for this small portion of the overall ceiling fan market. DOE expects that the motor manufacturers that supply ceiling fan manufacturers with DC motors would be able to increase production of DC motors in the 3 years from the publication of the final rule to the compliance date of the final rule to meet demand for ceiling fans that require DC motors due to amended standards. DOE does not anticipate any significant impact on the manufacturing capacity as a result of the adopted amended energy conservation standards in this final rule. See section V.C.1 for more details on the standard adopted in this rulemaking.

d. Impacts on Subgroups of Manufacturers

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 product manufacturers, and manufacturers exhibiting cost structures substantially different from the industry average could be affected disproportionately. DOE identified only one manufacturer subgroup that required a separate analysis in the MIA; small businesses. DOE analyzes the impacts on small businesses in a separate analysis in section VI.B. DOE did not identify any other adversely impacted manufacturer subgroups for ceiling fans for this rulemaking based on the results of the industry characterization.

e. Cumulative Regulatory Burden

While any one regulation may not impose a significant burden on manufacturers, the combined effects of recent 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. 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 a cumulative regulatory burden analysis as part of its rulemaking for ceiling fans.

DOE identified a number of requirements, in addition to amended energy conservation standards for ceiling fans, that ceiling fan manufacturers will face for products they manufacture approximately three years leading up to and three years following the compliance date of these amended standards. The following section addresses key related concerns that manufacturers raised during interviews regarding cumulative regulatory burden.

Manufacturers raised concerns about existing regulations and certifications separate from DOE's energy conservation standards that ceiling fan manufacturers must meet. These include California Title 20, which has the same energy conservation standards to DOE's existing ceiling fan standards, but requires an additional certification, and California Air Resources Board Standards limiting the amount of formaldehyde in composite wood used to make fan blades, among others.

DOE discusses these and other requirements in chapter 12 of the final rule TSD, which lists the estimated compliance costs of those requirements when available. In considering the cumulative regulatory burden, DOE evaluates the timing of regulations that affect the same product, because the coincident requirements could strain financial resources in the same profit center and consequently affect capacity. DOE also identified the ceiling fan light kit standards rulemaking as a source of additional cumulative regulatory burden on ceiling fan manufacturers.

DOE has published a final rule pertaining to energy conservation standards for ceiling fan light kits. 81 FR 581 The ceiling fan light kit standard affects the majority of ceiling fan manufacturers and will require manufacturers impacted by both standards to make investments to bring both ceiling fan light kits and ceiling fans into compliance during the same time period. Additionally, redesigned ceiling fan light kits could potentially require adjustments to ceiling fan redesigns that are separate from those potentially required by the amended ceiling fan rule.

In addition to the amended energy conservation standards on ceiling fans, several other existing and pending Federal regulations may apply to other products produced by ceiling fan manufacturers. DOE acknowledges that each regulation can affect a manufacturer's financial operations. Multiple regulations affecting the same manufacturer can strain manufacturers' profit and possibly cause them to exit particular markets. Table V.22 presents other DOE energy conservation standards that could also affect ceiling fan manufacturers in the three years leading up to and after the compliance date of amended energy conservation standards for these products.

TABLE V.22—OTHER DOE REGULATIONS POTENTIALLY AFFECTING CEILING FAN MANUFACTURERS

Regulation	Number of manufacturers *	Approximate compliance date	Estimated industry total conversion expenses	Annual industry revenue	Number of manufacturers from today's rule affected **
Electric Motors, 79 FR 30933 (May 29, 2014)	7	2016	$84.6 million (2013$)	$3,880 million (2013$)	1
General Service Fluorescent Lamps, 80 FR 4042 (January 26, 2015).	47	2018	$26.6 million (2013$)	$2,820 million (2013$)	1
Ceiling Fan Light Kits, 81 FR 580 (January 6, 2016)	67	2019	$18.9 million (2014$)	$310 million (2014$)	53
Commercial Industrial Fans and Blowers †	† 242	† 2019	TBD †	TBD †	† 8
General Service Lamps, 81 FR 14528 (NOPR) March 17, 2016 †.	† 142	† 2020	$509.0 million (2014$) †	1,903 million (2014$) †	† 1

* The number of manufacturers listed in the final rule for the energy conservation standard that is contributing to cumulative regulatory burden
** The number of manufacturers producing ceiling fans that are affected by the listed energy conservation standards
† The final rule for this energy conservation standard has not been published.

DOE did not receive any data on other regulatory costs that affect the industry modeled in the cash-flow analysis.

3. National Impact Analysis

a. Significance of Energy Savings

To estimate the energy savings attributable to potential 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 amended standards (2020–2049). Table V.23 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.1 of this notice.

TABLE V.23—CUMULATIVE NATIONAL ENERGY SAVINGS FOR CEILING FANS; 30 YEARS OF SHIPMENTS

[2020–2049]

	Trial standard level				
	1	2	3	4	5
	Quads				
Primary energy	0.772	1.205	1.760	1.921	3.577
FFC energy	0.807	1.260	1.839	2.008	3.738

OMB Circular A–4 [69] 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 rulemaking, DOE undertook a sensitivity analysis using nine, 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.[70] 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.24. The impacts are counted over the lifetime of ceiling fans purchased in 2020–2028.

TABLE V.24—CUMULATIVE NATIONAL ENERGY SAVINGS FOR CEILING FANS; 9 YEARS OF SHIPMENTS

[2020–2028]

	Trial standard level				
	1	2	3	4	5
	quads				
Primary energy	0.221	0.332	0.465	0.510	1.068
FFC energy	0.231	0.347	0.486	0.533	1.116

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,[71] DOE calculated NPV using both a 7-percent and a 3-percent real discount rate. Table V.25 shows the consumer NPV results with impacts counted over the lifetime of products purchased in 2020–2049.

TABLE V.25—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR CEILING FANS; 30 YEARS OF SHIPMENTS

[2020–2049]

Discount rate	Trial standard level (billion 2015$)				
	1	2	3	4	5
3 percent	6.464	9.286	11.389	12.123	21.006
7 percent	2.700	3.744	4.228	4.488	7.454

The NPV results based on the aforementioned 9-year analytical period are presented in Table V.26. The impacts are counted over the lifetime of products purchased in 2020–2028. 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.

[69] U.S. Office of Management and Budget. *Circular A–4: Regulatory Analysis.* September 17, 2003. *www.whitehouse.gov/omb/circulars_a004_a-4/.*

[70] Section 325(m) of 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.

[71] U.S. Office of Management and Budget. *Circular A–4: Regulatory Analysis.* September 17, 2003. *www.whitehouse.gov/omb/circulars_a004_a-4/.*

TABLE V.26—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR CEILING FANS; 9 YEARS OF SHIPMENTS
[2020–2028]

Discount rate	Trial standard level (billion 2015$)				
	1	2	3	4	5
3 percent	2.302	3.165	3.556	3.752	6.298
7 percent	1.312	1.753	1.814	1.904	2.895

The above 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 one scenario with no price decline. The results of these alternative cases are presented in appendix 10C of the NOPR TSD.

c. Indirect Impacts on Employment

DOE expects energy conservation standards for ceiling fans to reduce energy bills 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 in this rulemaking. DOE understands that 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 (2020–2025), where these uncertainties are reduced.

The results suggest that the adopted standards are 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 final rule TSD presents detailed results regarding anticipated indirect employment impacts.

4. Impact on Utility or Performance of Products

Based on testing and teardowns conducted in support of this rule as discussed in section IV.C of this notice, DOE has concluded that the standards adopted in this final rule would not reduce 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 adopted 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.E.1.e, the Attorney General of the United States (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 in writing 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. To assist the Attorney General in making this determination, DOE provided the Department of Justice (DOJ) with copies of the NOPR and the TSD for review. In its assessment letter responding to DOE, DOJ concluded that the proposed energy conservation standards for ceiling fans are unlikely to have a significant adverse impact on competition. DOE is publishing the Attorney General's assessment at the end of this final rule.

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. As a measure of this reduced demand, chapter 15 in the final rule TSD presents the estimated reduction in generating capacity, relative to the no-new-standards case, for the TSLs that DOE considered in this rulemaking.

Energy conservation resulting from amended standards for ceiling fans is expected to yield environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases. Table V.27 provides DOE's estimate of cumulative emissions reductions expected to result from the TSLs considered in this rulemaking. The table includes both power sector emissions and upstream emissions. The emissions were calculated using the multipliers discussed in section IV.K. DOE reports annual emissions reductions for each TSL in chapter 13 of the final rule TSD.

TABLE V.27—CUMULATIVE EMISSIONS REDUCTION FOR CEILING FANS SHIPPED IN 2020–2049

	Trial standard level				
	1	2	3	4	5
Power Sector Emissions					
CO_2 (*million metric tons*)	45.79	71.38	104.07	113.66	212.43
SO_2 (*thousand tons*)	25.38	39.50	57.48	62.75	117.87
NO_X (*thousand tons*)	51.65	80.54	117.49	128.34	239.51
Hg (*tons*)	0.09	0.15	0.21	0.23	0.44
CH_4 (*thousand tons*)	3.67	5.71	8.31	9.08	17.03
N_2O (*thousand tons*)	0.52	0.81	1.17	1.28	2.40

TABLE V.27—CUMULATIVE EMISSIONS REDUCTION FOR CEILING FANS SHIPPED IN 2020–2049—Continued

	Trial standard level				
	1	2	3	4	5
Upstream Emissions					
CO_2 (*million metric tons*)	2.64	4.12	6.02	6.58	12.23
SO_2 (*thousand tons*)	0.49	0.76	1.11	1.22	2.26
NO_X (*thousand tons*)	37.87	59.12	86.36	94.31	175.36
Hg (*tons*)	0.00	0.00	0.00	0.00	0.00
CH_4 (*thousand tons*)	209.18	326.60	477.10	521.03	968.66
N_2O (*thousand tons*)	0.02	0.04	0.06	0.06	0.11
Total FFC Emissions					
CO_2 (*million metric tons*)	48.43	75.50	110.09	120.24	224.66
SO_2 (*thousand tons*)	25.87	40.26	58.59	63.97	120.13
NO_X (*thousand tons*)	89.51	139.66	203.85	222.65	414.87
Hg (*tons*)	0.10	0.15	0.22	0.24	0.44
CH_4 (*thousand tons*)	212.85	332.31	485.41	530.11	985.69
CH_4 (*thousand tons CO_2eq*) *	5959.68	9304.79	13591.50	14843.04	27599.41
N_2O (*thousand tons*)	0.54	0.84	1.23	1.34	2.51
N_2O (*thousand tons CO_2eq*) *	143.43	223.33	325.12	354.94	665.94

* CO_2eq is the quantity of CO_2 that would have the same global warming potential (GWP).
Negative values refer to an increase in emissions.

As part of the analysis for this rule, DOE estimated monetary benefits likely to result from the reduced emissions of CO_2 and NO_X that DOE estimated for each of the considered TSLs for ceiling fans. As discussed in section IV.L of this document, for CO_2, DOE used the most recent values for the SCC developed by an interagency process. The four sets of SCC values for CO_2 emissions reductions in 2015 resulting from that process (expressed in 2015$) are represented by $12.4/t (the average value from a distribution that uses a 5-percent discount rate), $40.6/t (the average value from a distribution that uses a 3-percent discount rate), $63.2/t (the average value from a distribution that uses a 2.5-percent discount rate), and $118/t (the 95th-percentile value from a distribution that uses a 3-percent discount rate). The values for later years are higher due to increasing damages (public health, economic, and environmental) as the projected magnitude of climate change increases.

Table V.28 presents the global value of CO_2 emissions reductions at each TSL. For each of the four cases, DOE calculated a present value of the stream of annual values using the same discount rate as was used in the studies upon which the dollar-per-ton values are based. DOE calculated domestic values as a range from 7 percent to 23 percent of the global values; these results are presented in chapter 14 of the final rule TSD.

TABLE V.28—ESTIMATES OF GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR PRODUCTS SHIPPED IN 2020–2049

TSL	SCC case *			
	5% discount rate, average	3% discount rate, average	2.5% discount rate, average	3% discount rate, 95th percentile
	Million 2015$			
Power Sector Emissions				
1	321.5	1472.2	2338.6	4486.8
2	498.5	2287.8	3635.9	6973.5
3	722.5	3324.3	5286.2	10134.5
4	789.6	3632.1	5775.3	11072.8
5	1500.9	6854.9	10882.2	20887.5
Upstream Emissions				
1	18.2	84.1	133.9	256.6
2	28.3	131.0	208.5	399.5
3	41.2	190.7	303.7	581.7
4	45.0	208.3	331.8	635.5
5	85.0	391.1	621.8	1192.4
Total FFC Emissions				
1	339.8	1556.4	2472.5	4743.4
2	526.8	2418.8	3844.4	7373.0
3	763.6	3515.0	5589.9	10716.3

TABLE V.28—ESTIMATES OF GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR PRODUCTS SHIPPED IN 2020–2049—Continued

TSL	SCC case *			
	5% discount rate, average	3% discount rate, average	2.5% discount rate, average	3% discount rate, 95th percentile
	Million 2015$			
4	834.6	3840.4	6107.1	11708.4
5	1585.9	7246.0	11503.9	22079.9

* For each of the four cases, the corresponding SCC value for emissions in 2015 is $12.4, $40.6, $63.2, and $118 per metric ton (2015$). The values are for CO_2 only (*i.e.,* not CO_{2eq} of other greenhouse gases).

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 world economy continues to evolve rapidly. Thus, any value placed on reduced CO_2 emissions in this rulemaking is subject to change. DOE, together with other Federal agencies, will continue to review various 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. However, consistent with DOE's legal obligations, and taking into account the uncertainty involved with this particular issue, DOE has included in this rule the most recent values and analyses resulting from the interagency review process.

DOE also estimated the cumulative monetary value of the economic benefits associated with NO_X 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.29 presents the cumulative present values for NO_X emissions for each TSL calculated using 7-percent and 3-percent discount rates. This table presents values that use the low dollar-per-ton values, which reflect DOE's primary estimate. Results that reflect the range of NO_X dollar-per-ton values are presented in Table V.31.

TABLE V.29—ESTIMATES OF PRESENT VALUE OF NO_X EMISSIONS REDUCTION FOR CEILING FANS SHIPPED IN 2020–2049 *

TSL	3% discount rate	7% discount rate
	Million 2015$	
Power Sector Emissions		
1	86.2	35.2
2	133.4	54.0
3	193.7	77.6
4	213.4	85.6
5	404.6	166.6
Upstream Emissions		
1	69.9	27.9
2	108.5	43.0
3	157.5	61.7
4	172.1	67.5
5	326.3	131.4
Total FFC Emissions		
1	156.1	63.1
2	241.9	96.9
3	351.2	139.4
4	385.5	153.1
5	730.9	297.9

* Results are based on the low benefit-per-ton values.

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 National Economic Impacts

The NPV of the monetized benefits associated with emissions reductions can be viewed as a complement to the NPV of the consumer savings calculated for each TSL considered in this rulemaking. Table V.30 presents the NPV values that result from adding the estimates of the potential economic benefits resulting from reduced CO_2 and

NO_X emissions in each of four valuation scenarios to the NPV of consumer savings calculated for each TSL considered in this rulemaking, at both a 7-percent and 3-percent discount rate. The CO_2 values used in the columns of each table correspond to the 2015 values in the four sets of SCC values discussed above.

TABLE V.30—NET PRESENT VALUE OF CONSUMER SAVINGS COMBINED WITH PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS

TSL	Consumer NPV at 3% discount rate added with:			
	SCC case $12.4/t and 3% low NO_X values	SCC case $40.6/t and 3% low NO_X values	SCC case $63.2/t and 3% low NO_X values	SCC case $118/t and 3% low NO_X values
	Billion 2015$			
1	6.960	8.177	9.093	11.364
2	10.055	11.947	13.372	16.901
3	12.502	15.254	17.329	22.455
4	13.343	16.349	18.615	24.217
5	23.323	28.983	33.241	43.817
TSL	Consumer NPV at 7% discount rate added with:			
	SCC case $12.4/t and 7% low NO_X values	SCC case $40.6/t and 7% low NO_X values	SCC case $63.2/t and 7% low NO_X values	SCC case $118/t and 7% low NO_X values
1	3.103	4.320	5.236	7.507
2	4.367	6.259	7.685	11.213
3	5.131	7.882	9.957	15.083
4	5.475	8.481	10.748	16.349
5	9.338	14.998	19.256	29.832

Note: The SCC case values represent the global SCC in 2015, in 2015$ per metric ton (t), for each case.

In considering the above results, two issues are relevant. First, the national operating cost savings are domestic U.S. monetary savings that occur as a result of market transactions, while the value of CO_2 reductions is based on a global value. Second, the assessments of operating cost savings and the SCC are performed with different methods that use different time frames for analysis. The national operating cost savings is measured for the lifetime of products shipped in 2020–2049. Because CO_2 emissions have a very long residence time in the atmosphere,[72] the SCC values in future years reflect future climate-related impacts that continue beyond 2100.

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 final rule, DOE considered the impacts of 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 (or appear to do so) 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

[72] The atmospheric lifetime of CO_2 is estimated of the order of 30–95 years. Jacobson, M.Z. Correction to ''Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming.'' *J. Geophys. Res.* 2005. 110: D14105. doi: 10.1029/2005JD005888.

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 regulatory option 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 final rule 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.[73]

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.[74] 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.

1. Benefits and Burdens of TSLs Considered for Ceiling Fan Standards

Table V.31 and Table V.32 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 first full year of compliance with amended standards (2020–2049). 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 notice.

TABLE V.31—SUMMARY OF ANALYTICAL RESULTS FOR CEILING FANS TSLS: NATIONAL IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
Cumulative FFC National Energy Savings (quads)					
quads	0.807	1.260	1.839	2.008	3.738.
NPV of Consumer Costs and Benefits (billion 2015$)					
3% discount rate	6.464	9.286	11.388	12.123	21.006.
7% discount rate	2.700	3.744	4.228	4.488	7.454.
Cumulative FFC Emissions Reduction (Total FFC Emission)					
CO_2 (*million metric tons*)	48.43	75.50	110.09	120.24	224.66.
SO_2 (*thousand tons*)	25.87	40.26	58.59	63.97	120.13.
NO_X (*thousand tons*)	89.51	139.66	203.85	222.65	414.87.
Hg (*tons*)	0.10	0.15	0.22	0.24	0.44.
CH_4 (*thousand tons*)	212.85	332.31	485.41	530.11	985.69.
CH_4 (*thousand tons CO_2eq*) *	5,959.68	9,304.79	13,591.50	14,843.04	27,599.41.
N_2O (*thousand tons*)	0.54	0.84	1.23	1.34	2.51.
N_2O (*thousand tons CO_2eq*) *	143.43	223.33	325.12	354.94	665.94.
Value of Emissions Reduction (Total FFC Emissions)					
CO_2 (*billion 2015$*) **	0.340 to 4.743	0.527 to 7.373	0.764 to 10.716	0.835 to 11.708	1.586 to 22.080.
NO_X—3% discount rate (*million 2015$*)	156.1 to 355.9	241.9 to 551.6	351.2 to 800.7	385.5 to 878.9	730.9 to 1,666.3.
NO_X—7% discount rate (*million 2015$*)	63.1 to 142.2	96.9 to 218.5	139.4 to 314.2	153.1 to 345.3	297.9 to 671.8.

Parentheses indicate negative (−) values.
* CO_2eq is the quantity of CO_2 that would have the same global warming potential (GWP).
** Range of the economic value of CO_2 reductions is based on estimates of the global benefit of reduced CO_2 emissions.

TABLE V.32—SUMMARY OF ANALYTICAL RESULTS FOR CEILING FANS TSLS: MANUFACTURER AND CONSUMER IMPACTS

Category	TSL 1 *	TSL 2 *	TSL 3 *	TSL 4 *	TSL 5 *
Manufacturer Impacts					
Industry NPV (*million 2015$*) (No-new-standards case INPV = 1,211.6)	1,200.8–1,232.8	1,188.6–1,275.8	1,107.9–1,213.2	1,092.1–1,206.8	926.7 to 1,265.3.
Industry NPV (*% change*)	(0.9)–1.8	(1.9)–5.3	(8.6)–0.1	(9.9)–(0.4)	(23.5) to 4.4.
Consumer Average LCC Savings ** (2015$)					
Standard	46.61	37.20	25.78	25.78	26.80.
Hugger	39.01	31.75	21.50	21.50	19.20.
Very Small-Diameter	16.10	16.10	4.29	4.29	(25.94).
High-Speed Small-Diameter	20.17	20.17	(15.81)	19.80	19.80.
Large-Diameter	291.52	291.52	128.90	128.90	347.93.
Consumer Simple PBP * (years)**					
Standard	0.0	0.0	1.7	1.7	4.0.

[73] 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.

[74] Sanstad, A.H. *Notes on the Economics of Household Energy Consumption and Technology Choice.* 2010. Lawrence Berkeley National Laboratory. *https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/consumer_ee_theory.pdf.*

TABLE V.32—SUMMARY OF ANALYTICAL RESULTS FOR CEILING FANS TSLS: MANUFACTURER AND CONSUMER IMPACTS—Continued

Category	TSL 1 *	TSL 2 *	TSL 3 *	TSL 4 *	TSL 5 *
Hugger	0.0	0.0	1.8	1.8	4.1.
Very Small-Diameter	0.0	0.0	9.3	9.3	13.4.
High-Speed Small-Diameter	0.0	0.0	9.8	6.9	6.9.
Large-Diameter	0.0	0.0	4.1	4.1	4.3.
Percent of Consumers that Experience a Net Cost					
Standard	0.0	0.0	27.5	27.5	50.4.
Hugger	0.0	0.0	27.8	27.8	51.4.
Very Small-Diameter	0.0	0.0	2.1	2.1	75.8.
High-Speed Small-Diameter	0.0	0.0	70.0	38.7	38.7.
Large-Diameter	0.0	0.0	23.3	23.3	16.2.

* Parentheses indicate negative (−) values. The entry "n.a." means not applicable because there is no change in the standard at certain TSLs.
** The calculation excludes consumers with zero LCC savings (no impact).
*** Simple PBP results are calculated assuming that all consumers use products at that efficiency level.
The PBP is measured relative to the baseline product.

DOE first considered TSL 5, which represents the max-tech efficiency levels. TSL 5 would save 3.738 quads of energy, an amount DOE considers significant. Under TSL 5, the NPV of consumer benefit would be $7.454 billion using a discount rate of 7 percent, and $21.006 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 5 are 224.66 Mt of CO_2, 120.13 thousand tons of SO_2, 414.87 thousand tons of NO_X, 0.44 ton of Hg, 985.69 thousand tons of CH_4, and 2.51 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 5 ranges from $1.586 billion to $22.080 billion.

At TSL 5, the average LCC impact for affected consumers is a cost of $25.94 for VSD ceiling fans and a savings of $19.20, $26.80, $19.80, and $347.93 for hugger, standard, HSSD and large-diameter ceiling fans, respectively. The simple payback period is 13.4 years for VSD ceiling fans, 4.1 years for hugger ceiling fans, 4.0 years for standard ceiling fans, 6.9 years for HSSD ceiling fans, and 4.3 years for large-diameter ceiling fans. The fraction of consumers experiencing a net LCC cost is 76 percent for VSD ceiling fans, 51 percent for hugger ceiling fans, 50 percent for standard ceiling fans, 39 percent for HSSD ceiling fans, and 16 percent for large-diameter ceiling fans.

At TSL 5, the projected change in INPV ranges from a decrease of $284.8 million to an increase of $53.8 million, which represents a decrease of 23.5 percent and an increase of 4.4 percent.

At TSL 5, the corresponding efficiency levels for all product classes are the max-tech efficiency levels. Specifically for the VSD, hugger, and standard ceiling fan product classes, the percentages of consumers that experience net cost are greater than 50 percent. Additionally, specific to the VSD ceiling fan product class, the average LCC savings in 2015$ for all consumers, and affected consumers relative to no standards case is negative. Manufacturers may experience a loss in INPV of up to 23.5 percent.

The Secretary concludes that at TSL 5, 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 percentage of consumers that experience net cost for the VSD, hugger, and standard ceiling fan product classes, the negative average LCC savings for the VSD ceiling fan product class, and the potential reduction in manufacturer industry value. Consequently, the Secretary has tentatively concluded that TSL 5 is not economically justified.

DOE then considered TSL 4, which corresponds to the maximum NPV with an AC motor for all product classes other than HSSD fans, and maximum NPV for HSSD fans. At this TSL, less than 50 percent of consumers experience a net cost, and large-diameter ceiling fans that provide high levels of airflow are not disproportionally impacted. TSL 4 would save 2.008 quads of energy, an amount DOE considers significant. Under TSL 4, the NPV of consumer benefit would be $4.488 billion using a discount rate of 7 percent, and $12.123 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 4 are 120.24 Mt of CO_2, 63.97 thousand tons of SO_2, 222.65 thousand tons of NO_X, 0.24 ton of Hg, 530.11 thousand tons of CH_4, and 1.34 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 4 ranges from $0.835 billion to $11.708 billion.

At TSL 4, the average LCC impact for affected consumers is a savings of $4.29 for VSD ceiling fans, $21.50 for hugger ceiling fans, $25.78 for standard ceiling fans, $19.80 for HSSD ceiling fans, and $128.90 for large-diameter ceiling fans. The simple payback period is 9.3 years for VSD ceiling fans, 1.8 years for hugger ceiling fans, 1.7 years for standard ceiling fans, 6.9 years for HSSD ceiling fans, and 4.1 years for large-diameter ceiling fans. The fraction of consumers experiencing a net LCC cost is 2 percent for VSD ceiling fans, 28 percent for hugger ceiling fans, 27 percent for standard ceiling fans, 39 percent for HSSD ceiling fans, and 23 percent for large-diameter ceiling fans.

At TSL 4, the projected change in INPV ranges from decreases of $119.4 million to $4.8 million, which represent decreases of 9.9 percent and 0.4 percent, respectively.

For TSL 4, the efficiency levels for each product class correspond to the following: max-tech for HSSD ceiling fan product class, EL 3 for the hugger, standard, and large-diameter ceiling fan product classes, and EL 2 for the very-small diameter ceiling fan product class. Within large-diameter ceiling fans, TSL 4 does not disproportionately impact fans that provide high levels of airflow. At TSL 4, the average LCC savings in 2015$ are positive for all product classes. Also, the fraction of consumers that experience net savings at TSL 4 is greater than the fraction of consumers that experience a net cost. Manufacturers may experience a loss in INPV of up to 9.9 percent.

After considering the analysis and weighing the benefits and burdens, the Secretary has concluded that at TSL 4 for ceiling fans, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, the estimated monetary value of the emissions reductions, and positive average LCC savings would outweigh the negative impacts on some consumers and on manufacturers, including the conversion costs that could result in a reduction in INPV for manufacturers. Accordingly, the Secretary has concluded that TSL 4 would offer the maximum improvement in efficiency that is technologically feasible and economically justified, and would result in the significant conservation of energy.

Therefore, based on the above considerations, DOE adopts the energy conservation standards for ceiling fans at TSL 4. The amended energy conservation standards for ceiling fans, which are expressed as minimum CFM/W, are shown in Table V.33.

TABLE V.33—AMENDED ENERGY CONSERVATION STANDARDS FOR CEILING FANS

Product class	Minimum efficiency equation (CFM/W)*
Very Small-Diameter (VSD).	D ≤ 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
Large Diameter	0.91 D − 30.00

*D is the ceiling fan's blade span, in inches, as determined in Appendix U.

2. Summary of Annualized Benefits and Costs of the Adopted Standards

The benefits and costs of the adopted standards can also be expressed in terms of annualized values. The annualized net benefit is the sum of (1) the annualized national economic value (expressed in 2015$) of the benefits from operating products that meet the adopted 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 benefits of CO_2 and NO_X emission reductions.[75]

Table V.34 shows the annualized values for ceiling fans under TSL 4, expressed in 2015$. The results under the primary estimate are as follows.

Using a 7-percent discount rate for benefits and costs other than CO_2 reductions (for which DOE used a 3-percent discount rate along with the average SCC series corresponding to a value of $40.6/t in 2015 (2015$)), the estimated cost of the adopted standards for ceiling fans is $245.1 million per year in increased equipment costs, while the estimated benefits are $688.1 million per year in reduced equipment operating costs, $214.1 million per year in CO_2 reductions, and $15.1 million per year in reduced NO_X emissions. In this case, the net benefit amounts to $672.2 million per year.

Using a 3-percent discount rate for all benefits and costs and the average SCC series corresponding to a value of $40.6/t in 2015 (in 2015$), the estimated cost of the adopted standards for ceiling fans is $243.2 million per year in increased equipment costs, while the estimated annual benefits are $919.0 million in reduced operating costs, $214.1 million in CO_2 reductions, and $21.5 million in reduced NO_X emissions. In this case, the net benefit amounts to $911.4 million per year.

TABLE V.34—SELECTED CATEGORIES OF ANNUALIZED BENEFITS AND COSTS OF ADOPTED STANDARDS (TSL 4) FOR CEILING FANS

	Discount rate	Primary estimate	Low-net-benefits estimate	High-net-benefits estimate
		Million 2015$/year		
Benefits				
Consumer Operating Cost Savings	7%	688.1	579.7	793.5.
	3%	919.0	764.2	1081.9.
CO_2 Reduction (using mean SCC at 5% discount rate) **	5%	62.8	53.7	71.0.
CO_2 Reduction (using mean SCC at 3% discount rate) **	3%	214.1	182.2	242.6.
CO_2 Reduction (using mean SCC at 2.5% discount rate) **	2.5%	314.2	267.2	356.3.
CO_2 Reduction (using 95th percentile SCC at 3% discount rate) **.	3%	652.7	555.4	739.8.
NO_X Reduction †	7%	15.1	13.1	38.1.
	3%	21.5	18.4	55.3.
Total Benefits ‡	7% plus CO_2 range	766 to 1,356	647 to 1,148	903 to 1,571.
	7%	917.3	775.0	1,074.2.
	3% plus CO_2 range	1,003 to 1,593	836 to 1,338	1,208 to 1,877.
	3%	1,154.6	964.8	1,379.9.
Costs ***				
Consumer Incremental Product Costs	7%	245.1	288.1	272.8.
	3%	243.2	298.7	273.7.
Net Benefits				
Total ‡	7% plus CO_2 range	521 to 1,111	358 to 860	630 to 1,299.
	7%	672.2	487.0	801.4.
	3% plus CO_2 range	760 to 1,350	538 to 1,039	935 to 1,603.

[75] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2014, 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 (2020, 2030, *etc.*), and then discounted the present value from each year to 2015. The calculation uses discount rates of 3 and 7 percent for all costs and benefits except for the value of CO_2 reductions, for which DOE used case-specific discount rates. 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.

TABLE V.34—SELECTED CATEGORIES OF ANNUALIZED BENEFITS AND COSTS OF ADOPTED STANDARDS (TSL 4) FOR CEILING FANS—Continued

	Discount rate	Primary estimate	Low-net-benefits estimate	High-net-benefits estimate
	3%	911.4	666.1	1,106.2.

* This table presents the annualized costs and benefits associated with ceiling fans shipped in 2020–2049. These results include benefits to consumers which accrue after 2049 from the ceiling fans purchased from 2020–2049. The incremental installed costs include incremental equipment cost as well as installation costs. The CO_2 reduction benefits are global benefits due to actions that occur nationally. The Primary Estimate assumes the Reference case electricity prices and housing starts from AEO 2015 and decreasing product prices for ceiling fans with DC motors, due to price trend on the electronics components. The Low Benefits Estimate uses the Low Economic Growth electricity prices and housing starts from AEO 2015 and no price trend for ceiling fans with DC motors. The High Benefits Estimate uses the High Economic Growth electricity prices and housing starts from AEO 2015 and the same product price decrease for ceiling fans with DC motors as in the Primary Estimate. The methods used to derive projected price trends are explained in section IV.G.4. Note that the Benefits and Costs may not sum to the Net Benefits due to rounding.

** The CO_2 reduction benefits are calculated using 4 different sets of SCC values. The first three use the average SCC calculated using 5-percent, 3-percent, and 2.5-percent discount rates, respectively. The fourth represents the 95th percentile of the SCC distribution calculated using a 3-percent discount rate. The SCC values are emission year specific. See section IV.L.1 for more details.

† DOE estimated the monetized value of NO_X emissions reductions associated with electricity savings using benefit per ton estimates from the *Regulatory Impact Analysis for the Clean Power Plan Final Rule,* published in August 2015 by EPA's Office of Air Quality Planning and Standards. (Available at *www.epa.gov/cleanpowerplan/clean-power-plan-final-rule-regulatory-impact-analysis.)* See section IV.L.2 for further discussion. For the Primary Estimate and Low Net Benefits Estimate, DOE used national benefit-per-ton estimates for NO_X emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski *et al.* 2009). For the High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele *et al.* 2011); these are nearly two-and-a-half times larger than those from the ACS study.

‡ Total Benefits for both the 3-percent and 7-percent cases are presented using only the average SCC with 3-percent discount rate. In the rows labeled "7% plus CO_2 range" and "3% plus CO_2 range," the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

*** For certain assumed design options (e.g. fan optimization) that are included at the selected standard level, DOE estimated no incremental costs to consumers, but did estimate a one-time industry conversion cost to manufacturers to make their products compliant with the selected standards that are not reflected in the Consumer Incremental Product Costs. The one-time industry conversion cost to manufacturers of these design options contribute to a loss in industry net present value of $4.8 million, which is equivalent to an annualized cost of $0.4 million/year at a 7.4-percent discount rate over the analysis period.

VI. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866 and 13563

Section 1(b)(1) of Executive Order 12866, "Regulatory Planning and Review," 58 FR 51735 (Oct. 4, 1993), requires each agency to identify the problem that it intends to address, including, where applicable, the failures of private markets or public institutions that warrant new agency action, as well as to assess the significance of that problem. The problems that the adopted standards for ceiling fans are intended to address are as follows:

(1) Insufficient information and the high costs of gathering and analyzing relevant information leads some consumers to miss opportunities to make cost-effective investments in energy efficiency.

(2) In some cases the benefits of more efficient equipment are not realized due to misaligned incentives between purchasers and users. An example of such a case is when the equipment purchase decision is made by a building contractor or building owner who does not pay the energy costs.

(3) There are external benefits resulting from improved energy efficiency of appliances that are not captured by the users of such equipment. These benefits include externalities related to public health, environmental protection and national energy security that are not reflected in energy prices, such as reduced emissions of air pollutants and greenhouse gases that impact human health and global warming. DOE attempts to qualify some of the external benefits through use of social cost of carbon values.

The Administrator of the Office of Information and Regulatory Affairs (OIRA) in the OMB has determined that the regulatory action in this document is a significant regulatory action under section (3)(f) of Executive Order 12866. Accordingly, pursuant to section 6(a)(3)(B) of the Order, DOE has provided to OIRA: (i) The text of the draft regulatory action, together with a reasonably detailed description of the need for the regulatory action and an explanation of how the regulatory action will meet that need; and (ii) an assessment of the potential costs and benefits of the regulatory action, including an explanation of the manner in which the regulatory action is consistent with a statutory mandate. DOE has included these documents in the rulemaking record.

In addition, the Administrator of OIRA has determined that the regulatory action is an "economically" significant regulatory action under section (3)(f)(1) of Executive Order 12866. Accordingly, pursuant to section 6(a)(3)(C) of the Order, DOE has provided to OIRA an assessment, including the underlying analysis, of benefits and costs anticipated from the 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 can be found in the technical support document for this rulemaking.

DOE has also reviewed this regulation pursuant to Executive Order 13563, issued on January 18, 2011. 76 FR 3281, Jan. 21, 2011. EO 13563 is supplemental to and explicitly reaffirms the principles, structures, and definitions governing regulatory review established in Executive Order 12866. To the extent permitted by law, agencies are required by Executive Order 13563 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 Executive Order 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, OIRA 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, DOE believes that this final rule is consistent with these principles, including the requirement that, to the extent permitted by law, benefits justify costs.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires preparation of a final regulatory flexibility analysis (FRFA) for any final rule where the agency was first required by law to publish a proposed rule for public comment. As required by Executive Order 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 (*http://energy.gov/gc/office-general-counsel*). DOE has prepared the following FRFA for the products that are the subject of this rulemaking.

1. Need for, and Objectives of, the Rule

A description of the need for, and objectives of, this rule is set forth elsewhere in the preamble and not repeated here.

2. Significant Comments in Response to the IRFA

DOE did not receive comments in response to the IRFA. Comments on the economic impacts of amended standards are addressed in section IV.J.2.a and section IV.J.3 and did not result in significant changes to the FRFA.

3. Comments Filed by the Chief Counsel for Advocacy

The SBA's Chief Counsel for Advocacy did not submit comments on this rulemaking.

4. Description and Estimate of the Number of Small Entities Affected

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 available at: *https://www.sba.gov/sites/default/files/files/Size_Standards_Table.pdf*. Ceiling fan manufacturing is classified under NAICS code 335210, ''Small Electrical Appliance Manufacturing.'' The SBA sets a threshold of 1,500 employees or less for an entity to be considered as a small business for this category.

To estimate the number of companies that manufacture ceiling fans covered by this rulemaking, DOE conducted a market survey using publicly available information. DOE first attempted to identify all ceiling fan manufacturers by researching industry trade associations (*e.g.,* ALA [76]), information from previous rulemakings, individual company websites, and SBA's database. DOE then attempted to gather information on the location and number of employees to see if these companies met SBA's definition of a small business for each potential ceiling fan manufacturer by reaching out directly to those potential small businesses and using market research tools (*e.g., www.hoovers.com*, *www.manta.com*, *glassdoor.com*, *www.linkedin.com*, *etc.*). DOE also asked interested parties and industry representatives if they were aware of any small businesses during manufacturer interviews and DOE public meetings. DOE used information from these sources to create a list of companies that manufacture or sell ceiling fans and would be affected by this rulemaking.

For ceiling fans, DOE identified 66 companies that sell ceiling fans covered by this rulemaking. 25 of these companies are large businesses with more than 1,500 total employees or are foreign-owned and operated. DOE determined that of the remaining 41 companies with less than 1,500 employees, only six companies are small businesses that maintain domestic production facilities.

5. Description of Compliance Requirements

There are six small domestic ceiling fan manufacturers identified. Four small businesses manufacture HSSD ceiling fans and three small businesses manufacture large-diameter ceiling fans (one of these small businesses manufactures both HSSD and large-diameter ceiling fans and are therefore counted in each of these small business counts). To estimate conversion costs for small manufacturers, DOE multiplied an estimate of the number of platforms that would need to be redesigned at TSL 4 by the per-platform conversion cost estimated for the respective type of conversion cost, efficiency level, and product class for each manufacturer. Additionally, DOE obtained company revenue information from publicly available databases such as Hoovers [77] and Manta.[78]

Leveraging these assumptions, DOE estimated total conversion costs and conversion costs relative to small ceiling fan manufacturers' annual revenues. DOE presents the estimated total conversion costs incurred by small domestic ceiling fan manufacturers at TSL 4 in Table VI.1.

[76] ALA. Membership Directory and Buyer's Guide 2015. Last Accessed June 9, 2015. *http://www.lightrays-digital.com/lightrays/2015_membership_directory#pg1*.

[77] *www.hoovers.com.*

[78] *www.manta.com.*

TABLE VI.1—CONVERSION COSTS FOR SMALL CEILING FAN MANUFACTURERS AT THE ADOPTED TRIAL STANDARD LEVEL
[TSL 4]

Product conversion costs (2015$ millions)	Capital conversion costs (2015$ millions)	Total conversion costs (2015$ millions)	Average total conversion costs as a percentage of annual revenue
$0.7	$1.6	$2.3	2.6

There are four small manufacturers that make HSSD fans. For one of these small manufacturers, their entire HSSD product offerings use DC motors and they should be able to meet the HSSD standard without any modifications to their product offerings. For the other three HSSD small manufacturer, two only offer one HSSD ceiling fan and one only offers five HSSD ceiling fans. These small manufacturers primarily sell commercial, industrial, and/or agricultural fans not covered by this rulemaking. DOE does not believe that HSSD ceiling fan sales significantly contribute to these companies' revenue. HSSD small manufacturers either make compliant HSSD ceiling fans or these HSSD ceiling fans do not comprise a significant portion of their company's revenue. If these manufacturers decide not to invest in making compliant HSSD ceiling fans, DOE does not believe their revenue will be significantly reduced.

There are three small manufacturers that make large-diameter fans. Two of these small manufacturers primarily make ceiling fans that have DC motors and exceed the efficiency levels required for large-diameter ceiling fans at the adopted standard. The last small manufacturer has eight large-diameter ceiling fans that would have to be converted to comply with the adopted standards for this product class. This would require replacing the motor on these eight large-diameter ceiling fans with a more efficient AC motor.

6. Significant Alternatives Considered and Steps Taken To Minimize Significant Economic Impacts on Small Entities

The discussion in section VI.B.5 analyzes impacts on small businesses that would result from DOE's adopted final rule, TSL 4. In reviewing alternatives to the adopted rule, DOE examined energy conservation standards set at higher and lower efficiency levels; TSL 1, TSL 2, TSL 3, and TSL 5.

DOE considered TSL 5, but determined that the 86 percent increase in the energy savings and 66 percent increase in NPV compared to TSL 4 did not justify the total industry conversion costs of $155.9 million, the potential loss of up to 23.5 percent of INPV, and increased burden on small manufacturers.

DOE also considered TSLs lower than the TSL adopted. At TSL 1, the energy savings was reduced by 60 percent and consumer NPV was reduced by 40 percent compared to TSL 4. At TSL 2, the energy savings was reduced by 37 percent and consumer NPV was reduced by 17 percent compared to TSL 4. At TSL 3, the energy savings was reduced by 8 percent and consumer NPV was reduced by 6 percent compared to TSL 4. DOE concludes that establishing standards at TSL 4 balances the benefits of the energy savings and consumer NPV with the potential burdens placed on ceiling fan manufacturers, including small businesses. Accordingly, DOE is declining to adopt one of the other TSLs, or the other policy alternatives detailed as part of the regulatory impacts analysis included in chapter 17 of the final rule TSD.

Additional compliance flexibilities may be available through other means. For example, individual manufacturers may petition for a waiver of the applicable test procedure (see 10 CFR 430.27). Further, 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. Additionally, Section 504 of the Department of Energy Organization Act, 42 U.S.C. 7194, provides authority for the Secretary to adjust a rule issued under EPCA in order to prevent ''special hardship, inequity, or unfair distribution of burdens'' that may be imposed on that manufacturer as a result of such rule. 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. 76 FR 12422 (March 7, 2011); 80 FR 5099 (Jan. 30, 2015). 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 30 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

Pursuant to the National Environmental Policy Act (NEPA) of 1969, DOE has determined that the rule fits within the category of actions included in Categorical Exclusion (CX) B5.1 and otherwise meets the requirements for application of a CX. (See 10 CFR part 1021, App. B, B5.1(b); 1021.410(b) and App. B, B(1)–(5).) The rule fits within this category of actions because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, and for which none of the exceptions identified in CX B5.1(b) apply. Therefore, DOE has made a CX determination for this rulemaking, and DOE does not need to prepare an Environmental Assessment or Environmental Impact Statement for this rule. DOE's CX determination for this rule is available at *http://energy.gov/nepa/categorical-exclusion-cx-determinations-cx.*

E. Review Under Executive Order 13132

Executive Order 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 rule and has 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 final 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 Executive Order 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 Executive Order 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 final rule meets the relevant standards of Executive Order 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. Public Law 104–4, sec. 201 (codified at 2 U.S.C. 1531). For a 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 ''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 *http://energy.gov/sites/prod/files/gcprod/documents/umra_97.pdf*.

DOE has concluded that this final rule 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 final 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 document and chapter 17 of the TSD for this final 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 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(d), (f), and (o), 6313(e), and 6316(a), In accordance with the statutory provisions discussed in this document, this final rule establishes 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. A full discussion of the alternatives considered by DOE is presented in chapter 17 of the TSD for this final 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 Executive Order 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights,'' 53 FR 8859 (March 18, 1988), DOE has determined that this 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). DOE has reviewed this final rule 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

Executive Order 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 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 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 concluded that this regulatory action, which sets forth amended energy conservation standards for ceiling fans, is not a significant energy action because the 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 final rule.

L. Review Under the Information Quality Bulletin for Peer Review

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.'' Id at FR 2667.

In response to OMB's Bulletin, DOE conducted formal in-progress peer reviews of the energy conservation standards development process and analyses and has prepared a Peer Review Report pertaining to the energy conservation standards rulemaking analyses. 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. The ''Energy Conservation Standards Rulemaking Peer Review Report'' dated February 2007 has been disseminated and is available at the following Web site: *www.energy.gov/eere/buildings/peer-review*.

M. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this rule prior to its effective date. The report will state that it has been determined that the rule is a ''major rule'' as defined by 5 U.S.C. 804(2).

VII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this final rule.

List of Subjects in 10 CFR Part 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Intergovernmental relations, Reporting and recordkeeping requirements, and Small businesses.

Issued in Washington, DC, on November 21, 2016.

David J. Friedman,

Acting Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, DOE amends 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. Section 430.32 is amended by:

■ a. Redesignating paragraphs (s)(2), (3), (4) and (5) as (s)(3), (4), (5) and (6), respectively; and

■ b. Adding a new 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 shall meet the requirements shown in the table:

Product class as defined in Appendix U	Minimum efficiency (CFM/W)[1]
Very small-diameter (VSD).	D ≤ 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
Large-diameter	0.91 D − 30.00

[1] D is the ceiling fan's blade span, in inches, as determined in Appendix U of this part.

(ii) The provisions in this appendix 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, 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.

* * * * *

Note: The following letter will not appear in the Code of Federal Regulations.

U.S. DEPARTMENT OF JUSTICE

Antitrust Division:
William J. Baer,
Assistant Attorney General, Main Justice Building, 950 Pennsylvania Avenue NW., Washington, DC 20530–0001, (202) 514–2401/(202) 616–2645 (Fax).

March 21, 2016

Anne Harkavy,

Deputy General Counsel for Litigation, Regulation and Enforcement U.S. Department of Energy, Washington, DC 20585.

Dear Deputy General Counsel Harkavy:

I am responding to your January 21, 2016, letter seeking the views of the Attorney General about the potential impact on competition of proposed energy conservation standards for ceiling fans.

Your request was submitted under Section 325(o)(2)(B)(i)(V) of the Energy Policy and Conservation Act, as amended, 42 U.S.C. 6295(o)(2)(B)(i)(V), which requires the Attorney General to make a determination of the impact of any lessening of competition that is likely to result from the imposition of proposed energy conservation standards. The Attorney General's responsibility for responding to requests from other departments about the effect of a program on competition has been delegated to the Assistant Attorney General for the Antitrust Division in 28 CFR 0.40(g).

In conducting its analysis, the Antitrust Division examines whether a proposed standard may lessen competition, for example, by substantially limiting consumer choice or increasing industry concentration. A lessening of competition could result in higher prices to consumers.

We have reviewed the proposed standards contained in the Notice of Proposed Rulemaking (81 FR. 1688, January 13, 2016) and the related Technical Support Document. We have also reviewed supplementary information submitted to the Attorney General by the Department of Energy, as well as materials presented at the public meeting held on the proposed standards on February 3, 2016, and have conducted interviews with industry representatives.

Based on the information currently available, we do not believe that the proposed energy conservation standards for ceiling fans are likely to have a significant adverse effect on competition. Our opinion is subject to some uncertainty, in part because manufacturers indicated to us that they cannot reliably determine which of their products will be able to comply with the new standards. The manufacturers understand that a new test procedure will likely be used to determine ceiling fan efficiency performance, and believe that there is insufficient test data using this new test procedure for the manufacturers to be able to predict their ceiling fans' compliance with the proposed standards, particularly in the popular ''Standard'' and ''Hugger'' categories.

Sincerely,

William J. Baer

[FR Doc. 2017–00474 Filed 1–18–17; 8:45 am]

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