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[6450-01-P]

DEPARTMENT OF ENERGY

10 CFR Part 431

[Docket No. EERE-2013-BT-STD-0006]

RIN: 1904-AC55

Energy Conservation Standards for Commercial and Industrial Fans and Blowers: Availability of Provisional Analysis Tools

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

ACTION: Notice of data availability (NODA).

SUMMARY: The U.S. Department of Energy (DOE) has completed a provisional analysis that estimates the potential economic impacts and energy savings that could result from promulgating a regulatory energy conservation standard for commercial and industrial fans and blowers ("fans"). At this time, DOE is not proposing any energy conservation standard for fans. However, it is publishing this analysis so stakeholders can review the analysis results and the underlining assumptions and calculations that might ultimately support a proposed standard. DOE encourages stakeholders to provide any

additional data or information that may improve the analysis. The analysis is now publically available at http://www.regulations.gov/docket?D=EERE-2013-BT-STD-0006

ADDRESSES: The docket, EERE-2013-BT-STD-0006, is available for review at www.regulations.gov, including **Federal Register** notices, comments, and other supporting documents/materials. 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 http://www.regulations.gov/docket?D=EERE-2013-BT-STD-0006. The www.regulations.gov web page contains instructions on how to access all documents in the docket, including public comments.

For further information on how to submit a comment, review other public comments and the docket, or participate in the public meeting, contact the Appliance and Equipment Standards Program staff at (202) 586-6636 or by e-mail: ApplianceStandardsQuestions@ee.doe.gov.

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I. History of Energy Conservation Standards Rulemaking for Commercial and Industrial Fans and Blowers

On June 28, 2011, DOE published a notice of proposed determination of coverage to initiate the energy conservation standards rulemaking for fans, blowers, and fume hoods. 76 FR 37678. Subsequently, DOE published a notice of public meeting and availability of the Framework document for commercial and industrial fans and blowers ("fans") in the Federal Register. 78 FR 7306 (February 1, 2013). In the Framework document, DOE requested feedback from interested parties on many issues, including the engineering analysis, the manufacturer impact analysis (MIA), the life-cycle cost (LCC) and payback period (PBP) analyses, and the national impact analysis (NIA).

On December 10, 2014, DOE published a notice of data availability (December 2014 NODA) that estimated the potential economic impacts and energy savings that could result from promulgating energy conservation standards for fans. 79 FR 73246. The December 2014 NODA comment period was originally scheduled to close on January 26, 2015. However, DOE subsequently published a notice extending the comment period to February 25, 2015, to allow additional time for interested parties to submit comments. 80 FR 1477 (January 12, 2015). The December 2014 NODA analysis used a "wire-to-air" fan electrical input power metric, the fan energy index (FEI), to characterize fan performance. FEI is the ratio of the weighted-average fan electrical input power of a minimally compliant fan to the weighted-average fan electrical input power of a given fan, at three specified operating points. The FEI metric relied on an equation describing fan efficiency as a function of airflow and pressure in order to set the minimum fan efficiency of each considered efficiency level (EL) analyzed in the December 2014 NODA. In October 2014, several representatives of fan manufacturers and energy efficiency advocates[1] (Joint Stakeholders) presented DOE with an alternative metric approach called "Fan Efficiency Ratio," which included a fan efficiency-only metric approach (FER_H) and a wire-to-air metric approach (FER_W).[2] Both the FEI approach,

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[1] The Air Movement and Control Association (AMCA), New York Blower Company, Natural Resources Defense Council (NRDC), the Appliance Standards Awareness Project (ASAP), and the Northwest Energy Efficiency Alliance (NEEA).
[2] Supporting documents from this meeting, including presentation slides are available at: http://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0029.

presented in the December 2014 NODA, and the FER_W approaches relied on an equation to determine required fan efficiency as a function of the fan's airflow and pressure. The main differences between the December 2014 NODA FEI and the FER_W approaches were the form of the equation used for the fan efficiency, and the operating conditions at which the metric was evaluated. While in the December 2014 NODA, the FEI was calculated as a weighted average of the fan performance at three specific operating points, the FER_W was calculated at all manufacturer-declared operating points. On May 1, 2015, based on the additional information received and comments to the December 2014 NODA, DOE published a second NODA (May 2015 NODA) that announced the availability of data from DOE analyses conducted using a modified FEI metric. 80 FR 24841. The modified FEI metric used in the May 2015 NODA is similar to the FER_W metric presented by the Joint Stakeholders.

Concurrent with these efforts, DOE also began a process through the Appliance Standards Rulemaking Federal Advisory Committee (ASRAC) to discuss negotiated energy conservation standards and test procedure for fans.[3] On April 1, 2015, DOE published a notice of intent to establish a negotiated rulemaking Working Group for fans. 80 FR 17359. Twenty-five nominees were selected to serve as members of the Working Group in addition to one member from ASRAC and one DOE representative. Members of the Working Group were selected to ensure all stakeholders' interests and areas of expertise were represented.

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[3] Information on the ASRAC, the commercial and industrial fans Working Group, and meeting dates is available at: http://energy.gov/eere/buildings/appliance-standards-and-rulemaking-federal-advisory-committee.

The Working Group negotiations comprised 16 meetings and three webinars and covered scope, metrics, test procedures, and energy conservation standard levels for fans.[4] The negotiations were initially scheduled to end on August 6, 2015, but the Working Group voted to extend the process by 30 days. The Working Group concluded its negotiations on September 3, 2015, with a consensus vote to approve and publish a term sheet containing recommendations for DOE on scope, energy conservation standards analysis methodology, and the test procedure for fans. The term sheet containing the Working Group recommendations is available in the fans energy conservation standard rulemaking docket.[5] ASRAC subsequently voted to approve the recommendations of the Working Group during the September 24, 2015 webinar meeting.

II. Current Status

Since the negotiations, DOE has revised its analysis to reflect the term sheet recommendations regarding the metric and energy conservation standards. DOE is publishing this NODA to inform stakeholders of the impacts of potential energy conservation standards for fans based on term sheet recommendations and to request feedback on specific issues.

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[4] Details of the negotiation sessions can be found in the public meeting transcripts that are posted to the docket for the energy conservation standard rulemaking at: http://www.regulations.gov/docket?D=EERE-2013-BT-STD-0006

[5] The term sheet, document No. 179, is posted on the docket for the energy conservation standards rulemaking at: http://www.regulations.gov/docket?D=EERE-2013-BT-STD-0006

DOE made several changes to its analysis in preparing this NODA to address the term sheet recommendations as well as other stakeholder concerns expressed during the negotiations. Table II-1 lists the stakeholders who commented on issues addressed in this NODA. These changes and the ensuing results are described in section III below, the accompanying analysis spreadsheets, or both. The most significant changes include

1) the augmentation of the AMCA sales data used in the May 2015 NODA to better account for fans made by companies that incorporate those fans for sale in their own equipment (see section III.G);
2) the augmentation of the AMCA sales data used in the May 2015 NODA to represent additional sales of forward curved fans, which AMCA stated were underrepresented in the original data AMCA provided. (AMCA, Public Meeting Transcript, No. 85 at p. 91); and
3) the inclusion of OEM equipment conversion costs.

At this time, DOE is not proposing any energy conservation standards for fans. DOE may revise the analyses presented in today's NODA based on any new or updated information or data it obtains during the course of the rulemaking. DOE encourages stakeholders to provide any additional data or information that may improve the analysis.

Table II-2 List of Commenters on Energy Conservation Standard Issues Addressed in this NODA

Company or Organization	Abbreviation	Affiliation
ACME Engineering & Manufacturing Corporation	ACME	Manufacturer
AcoustiFLO	AcoustiFLO	Manufacturer
Air-Conditioning, Heating, and Refrigeration Institute	AHRI	Trade Association

Air Movement and Control Association, Inc.	AMCA	Trade Association
Appliance Standards Awareness Program	ASAP	Efficiency Advocate
California Investor-Owned Utilities	CA IOUs	Utilities
ebm-papst, Inc.	ebm-papst	Manufacturer
Flowcare Engineering Inc.	Flowcare	Manufacturer
Greenheck Fan Corporation	Greenheck	Manufacturer
Ingersoll Rand/Trane	Ingersoll Rand/Trane	Manufacturer
Morrison Products	Morrison	Manufacturer
United Technologies/Carrier	United Technologies/Carrier	Manufacturer

III. Summary of the Analyses Performed by DOE

DOE developed provisional analyses of fans in the following areas: (1) engineering; (2) manufacturer impacts; (3) LCC and PBP; and (4) national impacts. The Government Regulatory Impact Model (GRIM), the engineering spreadsheet, the life-cycle cost spreadsheet, and the national impact analysis spreadsheet used in preparing these analyses and their respective results are available at: http://www.regulations.gov/docket?D=EERE-2013-BT-STD-0006. Each individual spreadsheet includes an introduction that provides an overview of the contents of the spreadsheet. These spreadsheets present the various inputs and outputs to the analysis and, where necessary, instructions. Brief descriptions of the calculation of the considered energy conservation standard levels, of the scope, of the provisional analyses, and of the supporting spreadsheet tools are provided below. If DOE proposes energy conservation standards for fans in a future NOPR, then DOE will publish a technical support document

(TSD) containing a detailed written account of the analyses performed in support of the NOPR, which will include updates to the analyses made available in this NODA.

A. Fan Electrical Input Power

Fan energy performance is a critical input in the provisional analyses discussed in this notice. DOE used the fan electrical input power metric (FEP) as recommended by the Working Group to characterize the efficiency levels and represent fan performance. (No. 179, Recommendation #6 at p. 5)[6]

The recommended FEP metric represents the electrical input power of the fan and includes the performance of the motor, and any transmission and/or control if integrated, assembled, or packaged with the fan. The Working Group recommended to require manufacturers to determine the FEP at each manufacturer-declared operating point, at standard air density, where the operating point is characterized by a value of airflow and total pressure for ducted fans and by a value of airflow and static pressure for unducted fans. [7,8] Two methods were recommended by the Working Group for determining the FEP : (1) a fan shaft input power measurement combined with default values to represent the performance of the motor and any transmission and/or control (default value testing method); or (2) a direct measurement of the fan electrical input power (direct testing

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[6] A notation in this form refers to a specific recommendation from the Working Group term sheet, document No. 179.

[7] Ducted fans are: axial cylindrical housed, centrifugal housed, inline and mixed-flow, and radial housed fans. Unducted fans are panel fans, centrifugal unhoused fans, and power roof ventilators. (No. 179, Appendix C at p. 16)

[8] In this document, all pressures refer to standard air densities. Standard air density is defined by a density of 0.075 lb/ft^3, corresponding to air at 68 ºF, 50 percent relative humidity and 406.78 in.wg.

method). The recommended default value testing method provides different sets of calculation algorithms and default values to establish the FEP of a fan depending on its configuration (e.g., bare shaft fan, fan with regulated electric motor, or fan with motor with transmission and/or control). The Working Group also recommended allowing the representation of an index metric, the FEI, to allow for better comparability across all regulated fans. The engineering analysis and conversion cost spreadsheet presents the algorithms and default values used by the default value testing method and calculations of the FEP for both testing methods. (No. 179, Recommendation #9-16 at pp. 6-10)

As noted previously, the FEP of a fan includes the performance of the bare shaft fan and of its drive system.[9] In the December 2014 NODA and the May 2015 NODA, DOE calculated the FEP of a fan that exactly meets a given efficiency level (FEP_{STD}) using a fan efficiency equation and the default values and calculation algorithms of a fan sold with a regulated electric motor and transmission, such as a belt drive. During the negotiations, the Working Group voted to retain this approach and provided further recommendations on how to establish the fan efficiency equation and default values for standalone fans.[10] (No. 179, Recommendation #18 at p. 11)

[9] The drive system includes the motor and any transmission and/or control if integrated, assembled or packaged with the fan.

[10] A standalone fan is a fan that is not exclusively distributed in commerce for incorporation or incorporated in a larger piece of equipment.

Based on this recommendation, and applying the same approach for embedded fans (see Section III.B), this NODA calculates the $FEP_{STD,i}$ of a fan based on the following equation, in kW, at a given operating point i:

$$FEP_{STD,i} = 0.746 \times \left(\frac{Q_i \times P_i}{6343 \times \eta_{STD,i}} \times \frac{1}{\eta_{T,i}} + L_{M,i} \right)$$

Eq. 1

Where:

Q_i = airflow (cfm) at operating point i;

P_i = total pressure for ducted fans, static pressure for unducted fans (in.wg.) at operating point i;

$\eta_{STD,i}$ = standard level fan total efficiency for ducted fans, standard level fan static efficiency for unducted fans at operating point i (percent), calculated in accordance with Eq. 2;

$\eta_{T,i}$ = default transmission efficiency (percent) at operating point i;

$L_{M,i}$ = default electric motor losses (hp) at operating point i;

6343 = conversion factor for I-P units; and

0.746 = hp to kW conversion factor.

The Working Group recommended a fan efficiency equation to use for all fans when calculating FEP_{STD}. (No. 179, Recommendations #19-21 at pp. 11-12) For each efficiency level considered, this NODA uses the equation recommended by the Working Group to determine the fan total efficiency for ducted fans and the fan static efficiency for unducted fans (percent) at a given operating point i (percent):

$$\eta_{STD,i} = \eta_{target} \frac{Q_i \times P_i}{(Q_i + 250)(P_i + 0.4)}$$

Eq. 2

Where:

$\eta_{STD,i}$ = standard level fan total efficiency for ducted fans, standard level fan static efficiency for unducted fans (percent) at operating point i and considered efficiency level;

Q_i= flow (CFM) at operating point i;

P_i = total pressure for ducted fans, static pressure for unducted fans (in.wg.) at operating point i;

η_{target}= constant (percent) used to establish the efficiency level associated with each standards case considered (see section III.E).

The detailed equations and assumptions used to calculate FEP_{STD} are included in the engineering analysis and conversion cost spreadsheet.

In addition, for this NODA, DOE maintained the Working Group recommendation for the FEI calculation, with one modification as follows: DOE calculated the FEI using a reference value of FEP (FEP_{REF}) instead of using a value equal to the first energy conservation standards DOE may set (FEP_{STD}). As a reference value, DOE used the mid-point efficiency level (EL3).

DOE requests feedback on the calculation of the FEP_{STD} and FEI.

B. Scope of the Analysis and Addition of Certain Embedded Fans

In the December 2014 NODA and the May 2015 NODA, DOE analyzed the following fan categories: axial housed fans, axial unhoused fans, centrifugal housed fans, centrifugal unhoused fans, inline and mixed flow fans, radial fans, and power roof ventilators. This NODA analyzes the same fan categories based on the recommendation of the Working Group, but renames axial housed fans as axial cylindrical housed fans and axial unhoused fans as panel fans based on information provided by the Working Group. In addition, based on the discussions of the Working Group, DOE incorporated more embedded fans into its analysis for this NODA. [11] DOE also added more sales of forward curved fans for this NODA, which AMCA stated were under-represented in the original data AMCA provided. (AMCA, Public Meeting Transcript, No. 85 at p. 91) Accordingly, this NODA analyzes the fans listed in Table III-1 with the characteristics discussed in this section and exemptions listed in Table III-2. (No. 179, Recommendation #1-4 at pp. 1-4)

Table III-1: Fan Categories Analyzed

Family	Fan Category	In NODA scope?
Axial	Axial cylindrical housed	Yes*
	Panel	Yes*
	Power Roof Ventilator	Yes*
	Induced flow fans	No
	Safety fan	No
	Circulating fans	No
Centrifugal	Centrifugal housed	Yes*
	Centrifugal unhoused	Yes*
	Radial shrouded	Yes*

	Radial unshrouded	No if impeller is less than 30 inches in diameter or less than 3 inches in blade width.
	Power Roof Ventilator	Yes*
	Induced flow fans	No
	Safety fan	No
	Inline	Yes*
Mixed flow	-	Yes*
Cross flow	-	No

*Excluding embedded fans listed in Table III-2

Table III-2: Embedded Fans Recommended Exemptions

	Equipment Category	
Fans exclusively embedded in:	Single phase central air conditioners and heat pumps with a certified cooling capacity rated less than 65,000 Btu per hour, subject to DOE's energy conservation standard at 10 CFR 430.32(c)	
	Three phase, air-cooled, small commercial packaged air-conditioning and heating equipment with a certified cooling capacity rated less than 65,000 Btu per hour, subject to DOE's energy conservation standard at 10 CFR 431.97(b)	
	Residential furnaces subject to DOE's energy conservation standard at 10 CFR 430.32(y)	
	Transport refrigeration (i.e., Trailer refrigeration, Self-powered truck refrigeration, Vehicle-powered truck refrigeration, Marine/Rail container refrigerant)	
	Vacuums	
	Heat Rejection Equipment	Packaged evaporative open circuit cooling towers
		Evaporative field erected open circuit cooling tower
		Packaged evaporative closed circuit cooling towers
		Evaporative field erected closed circuit cooling tower
		Packaged evaporative condensers
		Field erected evaporative condensers
		Packaged air cooled (dry) coolers
		Field erected air cooled (dry) coolers
		Air cooled steam condensers
		Hybrid (water saving) versions of all of the previously listed equipment that contain both evaporative and air cooled heat exchange sections
	Air curtains	
Supply or Condenser fans, exclusively embedded in:	Air-cooled commercial package air conditioners and heat pumps (CUAC, CUHP) between 5.5 and 63.5 tons regulated by DOE's energy conservation standard at 10 CFR 431.97(b)	
	Water-cooled, evaporatively-cooled, and water-source commercial air conditioners or heat pumps regulated by DOE's energy conservation standard at 10 CFR 431.97(b)	
	Single package vertical air conditioners and heat pumps regulated by DOE's energy conservation standard at 10 CFR 431.97(d)	

	Packaged terminal air conditioners (PTAC) and packaged terminal heat pumps (PTHP) regulated by DOE's energy conservation standard at 10 CFR 431.97(c)
	Computer room air conditioners regulated by DOE's energy conservation standard at 10 CFR 431.97(e)
	Variable refrigerant flow multi-split air conditioners and heat pumps regulated by DOE's energy conservation standard at 10 CFR 431.97(f)

In addition, based on the recommendation of the Working Group, this NODA only considered fans with operating points with a fan shaft input power equal to, or greater than, 1 horsepower and a fan airpower equal to or less than 150 horsepower. (No. 179, Recommendation #5 at p. 4) The horsepower scope limitations are further explained in the engineering analysis and conversion cost spreadsheet.

C. Equipment Classes

When evaluating and establishing energy conservation standards, DOE divides covered equipment into equipment 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)) In the December 2014 and May 2015 NODAs, DOE divided commercial and industrial fans into seven equipment classes based primarily on the direction of the airflow through the fan and other features that impact the energy use and utility of a fan (see Table III-3). In addition, DOE grouped inline and mixed flow fans into a single equipment class and included all power roof ventilators in a single equipment class.

Table III-3: Fan Equipment Classes

Airflow	Fan Category	Feature	Equipment Class
Axial	Axial cylindrical housed	Cylindrical housing	Axial cylindrical housed
	Panel	Orifice panel or ring	Panel
	Power Roof Ventilator	Weather protection housing	Power Roof Ventilator
Centrifugal	Power Roof Ventilator	Weather protection housing	
	Centrifugal housed	Scroll Housing	Centrifugal housed
	Centrifugal unhoused	No Housing	Centrifugal unhoused
	Radial shrouded	Radial impellers and housing (dust/material handling)	Radial housed
	Radial unshrouded		
	Inline	Cabinet or cylindrical Housing	Inline and Mixed Flow
Mixed flow	-	-	

During the negotiations, the Working Group did not come to a consensus regarding the equipment classes and stakeholders provided several suggestions for modifying these equipment classes. (No. 179, Recommendation #30 at p. 19)

ASAP and AMCA, supported by the CA IOUs, recommended grouping all ducted fans into a single equipment class, and all unducted fans in a single equipment class. (ASAP and AMCA, No. 50 at p. 2; CA IOUs, No. 49 at p. 2) Flowcare commented that fans should be classified into three classes: axial fans, centrifugal fans, and mixed flow fans. (Flowcare, No. 46 at p. 6)

Ingersoll Rand/Trane commented that centrifugal housed fans with a forward curved blade design have a distinct utility compared to other centrifugal housed fans (e.g.

backward curved centrifugal housed fans) and should be in a separate equipment class. Ingersoll Rand/Trane commented that forward curved centrifugal housed fans are compact, have a relatively good sound quality, and are most suitable for low-pressure applications, in which they are relatively efficient. (Ingersoll Rand/Trane, No. 153 at p. 5) AHRI provided similar comments. AHRI stated that forward curved centrifugal housed fans require a separate equipment class for the following reasons: (1) their compact sizes compared to backward curved fans providing the same airflow and pressure; (2) their specific applications in low pressure and speed ranges, providing good sound quality; and (3) the European Regulation 327 /2011 considers them separately. (AHRI, No. 129-2 at pp. 1-6)

DOE did not group all fans into only ducted and unducted equipment classes because fans have other unique features that provide different utilities to the customer and, as a result, justify additional equipment classes. However, DOE recognizes that ducted and unducted fans perform differently. For this NODA, the FEP_{std} at each EL is calculated differently for ducted and unducted fans to account for these performance differences. (See section III.A for more details) For this same reason, DOE also did not establish equipment classes based solely on airflow.

With respect to establishing a separate equipment class for forward curved centrifugal housed fans, DOE analyzed a sample of fan selections[12] and found forward curved centrifugal housed fans that meet every efficiency level being analyzed. In

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[12] See description of the fan selection sample in the life cycle analysis section III.F.1.

addition, for small diameter fans, DOE also found an example of a forward curved fan with a small impeller diameter (i.e. less than 6.5 inches) that met all efficiency levels up to EL 5, showing that it is technologically feasible for small forward curved fans to reach high efficiency levels.[13] DOE notes that there may be many more forward curved fans with small impeller diameters at high efficiency levels in the market than its database shows. DOE recognizes that maintaining the utility of small forward curved fans across all operating points is important and requires preserving forward curved fan availability or acceptable non-forward curved fan replacements across sizes and operating points. Based on analysis of the data available, DOE believes small forward curved fans or acceptable non-forward curved replacements would be available up to EL 5 across all current sizes and operating points. DOE therefore believes that more-efficient forward curved centrifugal housed fans could replace inefficient forward curved centrifugal housed fans up to EL 5. In addition, to consider the possibility that an original equipment manufacturer (OEM) might opt to replace a forward curved centrifugal housed fan incorporated in a larger piece of heating, ventilation, air-conditioning, and refrigeration (HVACR) equipment with a backward curved centrifugal housed fan, DOE included the costs of redesigning the HVACR equipment to accommodate a different fan in the standards case fan price calculation. (See section III.F.1 for more details) Therefore, DOE does not believe that forward curved centrifugal housed fans merit a separate equipment class.

[13] See engineering analysis discussion in section III.E for details about the considered efficiency levels

Regarding the application range, DOE agrees with AHRI and Ingersoll Rand/Trane that forward curved centrifugal housed fans are most typically used in low pressure (less than 5.0 in.wg.), low speed applications (between 800 and 1200 rpm). DOE accounted for the specificity of the application range in the metric, which allows calculating the FEP_{STD} of a fan based on a fan efficiency equation that provides lower values at decreased pressure and airflow (see Eq. 2). In other words, the required FEP at a given efficiency level decreases with pressure and airflow in order to account for the fact that fans operating in these ranges are inherently less efficient.

Finally, DOE notes that the latest revision of the European Regulation 327 /2011[14] is considering grouping forward curved centrifugal housed fans with backward curved centrifugal housed fans for fans with an electrical input power greater than 5 kW (equivalent to approximately 6.7 hp). At a given diameter, the European study states that forward curved fans typically output more flow compared to backward bladed fans, which allows them to run relatively slower. This effect is more apparent for smaller diameters and becomes less significant as fan diameter increases. The EU therefore concluded that forward and backward curved centrifugal housed fans of larger sizes (greater than 5 kW of fan electrical input power) could be treated in the same product category with the same minimum efficiencies. For capacities less than 5 kW, the latest revision of the European regulation is considering maintaining forward curved centrifugal housed fans as a separate equipment class. DOE's fan selection analysis found forward

[14] Ecodesign Fan Review, Review Study of Commission Regulation (EU) No 327/2011, Final Report prepared by Van Holsteijn en Kemna B.V. for the European Commission, Directorate-General for Energy. Available at http://www.fanreview.eu/documents.htm (last accessed 02/02/2016).

curved centrifugal housed fans with electrical input power below 5kW that were compliant up to EL 6. Therefore, DOE believes such distinction is not necessary when using the FEP metric. In addition, as previously noted, DOE accounted for the costs of potentially incorporating a larger fan in a larger piece of equipment as part of the OEM equipment conversion costs. Therefore, DOE is not considering applying the distinction made in the European regulation 327/2011 and retains forward curved centrifugal housed fans in the same equipment class as other centrifugal housed fans for this NODA analysis.

AHRI and Bade commented that regulating return fans and exhaust fans requires special consideration because they typically operate at similar flows but lower static pressures compared to supply fans, which inherently affects the fan operating efficiency. (AHRI, No. 158 at pp. 5-6; Bade, No 116 at p.1) Similarly, Ingersoll Rand/Trane commented that using efficient fans in variable-air-volume applications might decrease the capability of the fans to achieve an airflow reduction at lower system requirements, which may increase a building's energy consumption by pushing consumers to constant volume systems or requiring different systems. (Ingersoll Rand/Trane, No. 153 at p. 3) DOE agrees with AHRI and Ingersoll Rand/Trane that fans operating at lower pressures will have a lower efficiency compared to fans of equivalent design operating at higher pressures. To account for this effect and preserve the utility of low-pressure fans, DOE is considering a metric that is a function of the operating pressure, where the required FEP at a given efficiency level is less stringent at lower operating pressures. Consequently, a return or exhaust fan operating at a lower pressure than a supply fan at a given flow would have a lower required FEP at a given efficiency level, which mitigates the disproportionate impacts suggested by AHRI and Ingersoll Rand/Trane.

Based on these comments, DOE maintained the equipment classes used in the May 2015 NODA and presented in Table III-3.

DOE seeks comments on the equipment classes used in this notice, including information on specific sizes or operating points for which forward curved fans would no longer be available at efficiency levels up to EL 5 and whether, at those sizes or operating points, an acceptable non-forward curved fan is available.

D. Compliance Year

For this analysis, DOE assumed a compliance date of five years after publication of a final energy conservation standards rule. (42 U.S.C. 6316(a); 42 U.S.C. 6295(l)(2)) The Working Group did not make any recommendation on the compliance year, and DOE believes that five years would allow fan manufacturers sufficient time to redesign their existing equipment, as necessary, to meet new energy conservation standards. DOE anticipates the final rule to publish in 2017, resulting in a compliance date for the standards of 2022. Stakeholders provided several suggestions for the compliance date.

ebm-papst commented that a three-year compliance period would represent sufficient time. (ebm-papst, No. 45 at p. 2) Morrison commented that even five years may not be enough. (Morrison, No. 51 at p. 9)

Ingersoll Rand/Trane and AHRI commented that, in order to allow OEMs to redesign their existing equipment to use fans of different types or sizes, the compliance date for fans that are components of larger piece of equipment should be delayed. For such fans, Ingersoll Rand/Trane recommended an additional two years and AHRI recommended an additional five years after the compliance date for standalone fans. (Ingersoll Rand/Trane, No. 153 at p. 4; AHRI, No. 158 at p. 9)

In the December 2014 NODA, DOE requested comments on the redesign time per fan model. United Technologies/Carrier stated three years would be too short in terms of compliance period and that it could take 18 to 24 months per fan for an OEM to complete a redesign for an embedded fan and the equipment incorporating the fan. (United Technologies/Carrier, No. 43 at p. 2)

DOE believes that manufacturers will be able to offer fans that are compliant with any energy conservation standards DOE may set before 5 years after publication of a final rule. Many fans are compliant with the highest efficiency levels for at least part of their operating range. Consequently, for many fans, any standard may only require certifying a different operating range rather than redesigning the fan. DOE's analysis estimates that at the most stringent EL (EL 6), 70 percent of current fan selections[15] would not meet the standard but that more than half of these could be replaced by

[15] Based on 2012 data, see section III.G for more details. A fan selection is the combination of a fan model and design point at which it is purchased.

existing compliant substitutes. This means that even at the highest EL, only 33 percent of all fan selections would require a redesigned fan. Therefore, DOE believes that a five-year compliance period is sufficient for fan manufacturers, including OEMs to either redesign their fans and equipment or select compliant, alternative fans. For the analyses in this NODA, DOE assumed a compliance date of five years after the publication of the final rule.

DOE seeks comments on the use a compliance date of five years after the publication of the final rule.

E. Engineering Analysis

The engineering analysis establishes the relationship between the manufacturer production cost (MPC) and efficiency levels of fans. This relationship serves as the basis for calculations performed in the other analysis tools to estimate the costs and benefits to individual consumers, manufacturers, and the Nation.

DOE used the same methodology in the engineering analysis of this NODA as for the December 2014 NODA and the May 2015 NODA. For each fan equipment class, DOE identified existing technology options that could affect efficiency. Next, DOE conducted a screening analysis to review each technology option and decide whether it: (1) is technologically feasible; (2) is practicable to manufacture, install, and service; (3) would adversely affect product utility or product availability; or (4) would have adverse impacts on health and safety. The technology options remaining after the screening analysis consisted of a variety of impeller types and guide vanes. DOE categorized the fan equipment classes into subcategories by the technology options the fans use. DOE then conducted a market-based assessment of the prevalence of each subcategory at each efficiency level analyzed. DOE estimated market prevalence using the sales data provided by AMCA that was within the scope of the analysis and for which there was sufficient information. This NODA, like the May 2015 NODA has fewer subgroups than the December 2014 NODA due to limitations in the sales data provided by AMCA.

For this NODA, DOE augmented the AMCA sales data used in the May 2015 NODA to account for embedded fans made by companies that incorporate those fans for sale in their own equipment (see section III.G) and to represent additional sales of forward curved fans, which AMCA stated were underrepresented in the original data AMCA provided. (AMCA, Public Meeting Transcript, No. 85 at p. 91) The resulting engineering database was analyzed at six efficiency levels (ELs) representing different target efficiencies (η_{target}, see section III.A). In this NODA, efficiency levels were set separately for ducted and unducted fans, based on the recommendation of the working group. (No. 179, Recommendation #18 at pp. 10-11) For ducted fans, the six efficiency levels are calculated using the same six total efficiency targets used in the May 2015 NODA. At each of the analyzed efficiency levels in this NODA, the static efficiency targets used for unducted fans are 0.04 less than the total efficiency target at each respective level. The exact target efficiencies used in this NODA are presented in Table 3 of the "MPC Approach" tab of the engineering analysis and conversion cost spreadsheet.

DOE calculated MPCs at each efficiency level using the same methodology as used in the December 2014 NODA and the May 2015 NODA. The MPCs were derived from product teardowns and publically available product literature and were informed by interviews with manufacturers. DOE calculated the MPCs for fans in each subcategory. DOE used these MPCs to characterize the relationship between MPC and blade or impeller diameter for each subcategory. DOE found that all fan subcategories were represented at all ELs, so DOE did not use subcategory MPC differences to directly represent higher efficiency. DOE found some subcategories to be more prevalent at higher ELs. Therefore, DOE calculated MPCs for each fan equipment class at each efficiency level analyzed by weighting the MPCs of each subcategory within a class by its prevalence at the efficiency level being analyzed.

DOE's preliminary MPC estimates indicate that the changes in MPC as efficiency level increases are small or, in some fan equipment classes, zero. However, DOE is aware that aerodynamic redesigns are a primary method by which manufacturers improve fan performance. These redesigns require manufacturers to make large upfront investments for R&D, testing and prototyping, and purchasing new production equipment. DOE's preliminary findings indicate that the magnitude of these upfront costs are more significant than the difference in MPC of a fan redesigned for efficiency compared to its precursor. For this NODA, DOE included a conversion cost markup in its calculation of the manufacturer selling price (MSP) to account for these conversion costs. These markups and associated MSPs were developed and applied in downstream analyses. They are discussed in section III.F and presented in the LCC spreadsheet.

The main outputs of the fans engineering analysis are the MPCs of each fan equipment class (including material, labor, and overhead) and technology option distributions at each efficiency level analyzed.

F. Manufacturer Impact Analysis

For the MIA, DOE used the Government Regulatory Impact Model (GRIM) to assess the economic impact of potential standards on commercial and industrial fan manufacturers. DOE developed key industry average financial parameters for the GRIM using publicly available data from corporate annual reports along with information received through confidential interviews with manufacturers. These values include average industry tax rate; working capital rate; net property, plant, and equipment rate; selling, general, and administrative expense rate; research and development expense rate; depreciation rate; capital expenditure rate; and manufacturer discount rate.

Additionally, DOE calculated total industry capital and product conversion costs associated with meeting all analyzed efficiency levels. Using a proprietary cost model and feedback received from manufacturers during interviews, DOE first estimated the average industry capital and product conversion costs associated with redesigning a single size of a fan series to meet a specific efficiency level. DOE estimated the costs for all subcategories within each fan equipment class. DOE multiplied these per model conversion costs by the number of models that would be required to be redesigned at each efficiency level to arrive at the total industry conversion costs. The number of models that would be redesigned was calculated using information from the engineering database developed from the AMCA sales database (see section III.E). Additional information on the number of models redesigned is available in the engineering analysis and conversion cost spreadsheet, “Total Fan Conversion Costs” section of the “Database Overview and Use” tab.

The GRIM uses these estimated values in conjunction with inputs from other analyses, including the MPCs from the engineering analysis, the annual shipments by fan equipment class from the NIA, and the fan manufacturer markups for the cost recovery markup scenario from the LCC analysis to model industry annual cash flows from the reference year through the end of the analysis period. The primary quantitative output of this model is the industry net present value (INPV), which DOE calculates as the sum of industry annual cash flows, discounted to the present day using the industry specific weighted average cost of capital, or manufacturer discount rate.

Standards can affect INPV in several ways including requiring upfront investments in manufacturing capital as well as research and development expenses, which increase the cost of production and potentially alter manufacturer markups. DOE expects that manufacturers may lose a portion of INPV due to standards. The potential loss in INPV due to standards is calculated as the difference between INPV in the no-standards case (absent new energy conservation standards) and the INPV in the standards cases (with new energy conservation standards in effect). DOE examines a range of possible impacts on industry by modeling various pricing strategies commercial and industrial fan manufacturers may adopt following the adoption of new energy conservations standards for fans.

In addition to INPV, the MIA also calculates the manufacturer markups, which are applied to the MPCs derived in the engineering analysis, to arrive at the manufacturer selling prices (MSPs) in the no-standards case. In the standards cases manufacturers will incur costs from the redesign of models that do not meet the required FEP at a given efficiency levels. DOE modeled two markup scenarios for the standards cases, a preservation of gross margin markup scenario and a conversion cost pass through markup scenario.

In the preservation of gross margin markup scenario, DOE assumes that manufacturers maintain the same manufacturer markup, as a percentage, in the standards cases as they do in the no-standards case, despite higher levels of investment in the standards cases. This markup scenario represents the lower bound, or worst-case scenario for manufacturers, since manufacturers are not able to pass the conversion costs associated with complying with higher efficiency levels on to their customers. In the fan conversion cost recovery markup scenario, DOE assumes that manufacturers are able to pass on to their customers the fan conversion costs they incur to meet higher efficiency levels. In this markup scenario, manufacturer markups are based on the total manufacturer fan conversion costs and calculated to allow manufacturers to recover their upfront fan conversion costs, in addition to their normal no-standards case markup. DOE calculated the conversion cost pass through markups for each efficiency level by amortizing the conversion costs over the units shipped throughout the analysis period that were redesigned to meet the efficiency level being analyzed. This fan conversion cost pass through markup scenario represents the upper bound, or best-case scenario for manufacturers, since manufacturers are able to pass on to their customers the fan conversion costs associated with complying with higher efficiency levels. For the standards cases, all other downstream analyses use the fan manufacturer markups calculated in the fan conversion costs pass through markup scenario.

DOE requests information on the per-model (size of a fan series) redesign costs presented in the engineering analysis and conversion cost spreadsheet.

DOE requests information on the number of models (sizes of a fan series) that are currently in the scope of the rulemaking nationally.

DOE requests feedback on the quantity of redesigns, methodology, and results used to calculate the total industry conversion costs by equipment class and EL, as presented in the engineering analysis and conversion cost spreadsheet.

DOE requests information on the extent to which product conversion costs and/or capital conversion costs are shared among sizes in a fan series.

DOE requests information on the extent to which product conversion costs and/or capital conversion costs are shared between belt and direct drive fans with the same aerodynamic design.

DOE requests information on the extent to which product conversion costs and/or capital conversion costs are shared between fans of different construction classes of the same aerodynamic design.

1. Impacts on OEMs

Several stakeholders commented that the previous DOE analyses did not take into account the significant costs incurred by manufacturers who incoporate fans into their equipment. Ingersoll Rand/Trane, United Technologies/Carrier, Morrison, AHRI, and Greenheck commented that separate costs to redesign the units in which fans are installed would be incurred due to this regulation. . (Ingersoll Rand/Trane, No. 42 at p. 4; United Technologies/Carrier, No. 43 at p. 4; Morrison, No. 51 at p. 5; AHRI, No. 53 at p. 6; Greenheck, No. 54-A at pp. 4-5) AHRI added that the cost to redesign the units in which fans are installed can be several times greater in terms of both time and money than the cost to redesign the fan itself. (AHRI, No. 53 at p. 7) Morrison and Ingersoll Rand/Trane commented that fans in commercial and industrial building applications are typically housed within other equipment such as air handlers or unitary rooftop units that are sized specifically around the fan. (Morrison, No. 51 at p. 5; Ingersoll Rand/Trane, No. 42 at p. 11) AHRI commented that any change to fan size, operating range, or fan type will increase the OEM production cost, and urged DOE to consider the production cost impact to OEMs as part of the rulemaking. (AHRI, No. 53 at p. 6) Ingersoll Rand/Trane added that this increased cost would affect building owners and could decrease adoption rate by consumers. (Ingersoll Rand/Trane, No. 42 at p. 11)

AHRI also commented that in order to pass a regulation imposing additional costs (testing, implementation, time-frame, spare part availability, re-certification) on OEMs, DOE must consider the costs to these manufacturers and compare them to the potential energy saved, and in order to do so must conduct manufacturer interviews with OEMs. AHRI requested that DOE conduct such interviews and delineate DOE-covered equipment made by OEMs as a separate fan equipment class to assess the costs and relative benefits of a second layer of regulation on currently regulated HVACR equipment and publish a new NODA specifically addressing the impact on OEMs who were excluded from DOE's initial analysis. (AHRI, No. 158 at p. 3)

After careful consideration of these comments and the Working Group discussions, DOE recognizes that its previous analyses did not accurately account for the cost impacts of a fans regulation on all impacted manufacturers. DOE revised its analysis for this NODA to better account for cost impacts on fan manufacturers, especially OEMs. DOE understands that some OEMs manufacture their own fans that they then incorporate in the equipment that they manufacture for sale. As discussed in section III.B, DOE augmented the database it used for this NODA by incorporating fans made by companies that then incorporate those fans for sale in their own equipment (see section III.G). The presence of these fans in the database DOE used for this NODA ensures that its analysis accounts for the impacts on MPC (see section III.E) and conversion costs (see previous discussion in this section) for OEMs that manufacture fans and incorporate them in the equipment that they manufacture for sale. DOE also understands that OEMs that incorporate fans may incur additional conversion costs for their equipment not directly associated with improving the efficiency of the fan. For this NODA, DOE estimated OEM equipment conversion costs and included them in its analysis. DOE conducted interviews with manufacturers of equipment with embedded fans. DOE used information gathered during these interviews in conjunction with its engineering database to estimate OEM equipment conversion costs at each EL. In each fan equipment class, fan models in the engineering database that were representing fans sold by OEMs (whether or not the OEM made the fan) and that needed to be redesigned or reselected were determined to incur OEM equipment conversion costs. The aggregated industry OEM equipment conversion costs are presented in the engineering analysis and conversion cost spreadsheet.

DOE applied OEM equipment conversion costs to all embedded fans in its analysis. For OEMs that manufacture the fans that they incorporate in the equipment they manufacture for sale, DOE added the OEM equipment conversion costs to the fan conversion costs to develop total conversion cost recovery markups at each EL, for each fan equipment class, using the cost recovery markup methodology described in section III.F. For OEMs that incorporate fans that they do not manufacture themselves, the OEM equipment conversion cost is used to develop a cost recovery markup that is applied downstream of the fan conversion cost recovery markup. DOE then used the results as an input to the LCC analysis. Consequently, the cost to consumers of embedded fans, and, in turn, the cost-justification for the analyzed efficiency levels, accounts for both fan and OEM equipment conversion costs in this NODA.

DOE believes the revisions made for this NODA analysis—augmenting DOE’s database to more completely incorporate embedded fans and including OEM equipment conversion costs—better account for the costs and benefits associated with potential energy conservation standards for fans incorporated in larger pieces of equipment and address the concerns of Ingersoll Rand/Trane, United Technologies/Carrier, Morrison, AHRI, and Greenheck.

DOE did not analyze a separate equipment class for embedded fans. DOE believes the revisions to its analysis described previously in this section appropriately account for the costs and benefits associated with embedded fans. However, the LCC spreadsheet published as part of this NODA provides the option to view results by subgroup for embedded fans and standalone fans separately.

DOE requests information on the portion of equipment with embedded fans that would require heat testing for certification with any new energy conservation standards. DOE also requests feedback on the number of embedded fans that would require redesign as presented in the engineering analysis and conversion costs spreadsheet.

G. Life-Cycle Cost and Payback Period Analyses

The LCC and PBP analyses determine the economic impact of potential standards on individual consumers, in the compliance year. The LCC is the total cost of purchasing, installing, and operating a commercial or industrial fan over the course of its lifetime.

DOE determines the LCC by considering: (1) the total installed cost to the consumer (which consists of manufacturer selling price, the conversion costs, distribution channel markups, and sales taxes); (2) the range of fan annual energy consumption as they are used in the field; (3) the fan operating costs; (4) fan lifetime; and (5) a discount rate that reflects the real consumer cost of capital and puts the LCC in present-value terms. The PBP represents the number of years needed to recover the increase in purchase price of higher-efficiency fans through savings in the operating cost. The PBP is calculated by dividing the incremental increase in installed cost of the higher efficiency product, compared to the baseline product, by the annual savings in operating costs.

For each considered standards case corresponding to each efficiency level, DOE measures the change in LCC relative to the no-standards case. The no-standards case is characterized by the distribution of fan efficiencies in the absence of new standards (i.e., what consumers would have purchased in the compliance year in the absence of new standards). In the standards cases, fans with efficiency below the standard levels “roll-up” to the standard level in the compliance year.

To characterize annual fan operating hours, DOE established statistical distributions of consumers of each fan equipment class across sectors and applications, which in turn determined the fan operating hours. Recognizing that several inputs to the determination of consumer LCC and PBP are either variable or uncertain (e.g., annual operating hours, lifetime, discount rate), DOE conducts the LCC and PBP analysis by modeling both the uncertainty and variability in the inputs using Monte Carlo simulations and probability distributions.

In addition to characterizing several of the inputs to the analyses with probability distributions, DOE developed a sample of individual fan selections representative of the market.[16] By developing this sample, DOE was able to perform the LCC and PBP calculations for each fan selection to account for the variability in energy consumption associated with each selection.

The primary outputs of the LCC and PBP analyses are: (1) average LCC in each standards case; (2) average PBPs; (3) average LCC savings at each standards case relative to the no-standards case; and (4) the percentage of consumers that experience a net benefit, have no impact, or have a net cost for each fan equipment class and efficiency level. The average annual energy consumption derived in the LCC analysis is used as an input in the NIA (see section III.H).

[16] A fan selection is a fan model and the fan shaft input power, operating flow, and pressure values for which it was purchased.

In the December 2014 NODA and the May 2015 NODA, DOE developed a sample of individual fan selections (i.e., representative database of fan models including data on the design flow, pressure, and fan shaft input power for which they were purchased, and the drive configuration) using fan sales data provided by AMCA. During the negotiations, AMCA commented that these sales data included some standalone fans purchased by OEMs for incorporation into larger HVACR equipment but was not representative of sales of embedded fans. Specifically, AMCA commented that forward curved centrifugal housed fans, which are very common in HVACR equipment, were under-represented. (AMCA, Public Meeting Transcript, No. 85 at p. 91).

In this NODA, DOE collected additional technical and market information specific to embedded fans and revised the LCC sample to represent both the embedded fan and standalone fan markets. For each fan equipment class, DOE used confidential AMCA sales data for over 57,000 fan selections (with complete performance data), representing over 92,000 units sold, to develop a sample representative of fans sold on the US market. Each row in the sample represents a fan selection. The number of rows was adjusted to match the US market distributions across fan equipment classes, subcategory, fan shaft input power, and drive configuration. DOE adjusted the number of standalone fans in the LCC sample to mirror the actual standalone fan market distributions based on confidential market estimates from AMCA for the U.S standalone fan market. For embedded fans, DOE adjusted the number of fan selections in the LCC sample to reflect the actual embedded fan market distributions based on embedded fan shipments data.[17] As a result, and in line with AMCA's comment, the share of forward curved centrifugal housed fans in the sample increased from 3 percent to 19 percent. Using this sample, DOE was able to perform individual energy use calculations for each row in the sample and account for the variability in energy consumption associated with each fan selection.

The "2012 Shipments" worksheet of the NIA spreadsheet presents the standalone fan market and embedded fan market data used to calibrate the LCC sample. The worksheet includes breakdowns by equipment class, subcategory, as well as the HVACR equipment shipments and estimated number of fans per unit used by DOE to calculate the number of embedded fans. The LCC sample description worksheet in the LCC spreadsheet provides more detailed breakdown of the fan selections by power bins and efficiency levels.

DOE seeks feedback and input on the 2012 standalone fan and embedded fan shipments values, by equipment class and subcategory. Specifically, DOE requests feedback on: (1) the estimated number of fans per HVACR equipment; (2) the distribution of HVACR fans across fan subcategories by fan application; and (3) the share of standalone fans purchased and incorporated in HVACR equipment.

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[17] See description of the LCC sample in the LCC Spreadsheet.

DOE seeks feedback and input on the distribution of fan selections by power bin and subcategory for standalone fans and embedded fans as presented in the "LCC sample Description" worksheet of the LCC spreadsheet.

In the December 2014 NODA and the May 2015 NODA, DOE calculated the FEP of a fan selection in the LCC sample using the default values and calculation algorithms for bare shaft fans. DOE applied this approach because the fan selection data included performance data for fans in bare shaft configurations. In this NODA, in order to establish the FEP of a fan considered in the analysis, DOE retained this approach and used the default values and calculation algorithms for bare shaft fans as recommended by the Working Group. The engineering analysis and conversion cost spreadsheet presents the detailed equations and default values used to calculate the FEP of a given fan model in a bare shaft configuration. In addition, based on the Working Group recommendation, the spreadsheet includes default values and calculation algorithms for other fan configurations such as fans with dynamic continuous controls. (No. 179, Recommendation #12-16 at pp. 7-9)

After the publication of the December 2014 NODA, Morrison and AHRI commented that the operating hours seemed high but did not provide quantified estimates. (Morrison, No. 51 at p. 8; AHRI, No. 53 at p. 13) In the December 2014 and May 2015 NODAs, DOE used industrial plant assessment and Energy Plus building simulation data to estimate fan operating hours, which averaged around 6,500 hours per year. [18] In this NODA, DOE retained the same assumption for the operating hours of standalone fans and developed specific operating hours for embedded fans based on HVAC fan operating hours data which averaged 2,725 hours per year.[19]

DOE seeks feedback and inputs on fan operating hours.

In the December 2014 NODA and the May 2015 NODA, DOE assumed that all fans operated at full design flow and pressure when performing the energy use calculation. AHRI noted that most fans in HVAC equipment do not run at full design speed but at 60 percent of full speed (equivalent to running at 60 percent of design flow). (AHRI, No. 129-1 at p. 2) AHRI additionally provided input on the typical fan load profiles in VAV systems. (AHRI, No. 53 at p. 13) ACME commented that, 50 percent of the time, the actual operating point of a fan is not equal to the design point selection of the fan and has a higher pressure value. ACME added that in some situations, the design

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[18] Database of motor nameplate and field measurement data compiled by the Washington State University Extension Energy Program (WSU) and Applied Proactive Technologies (APT) under contract with the New York State Energy Research and Development Authority (NYSERDA) (2011); Strategic Energy Group (Jan. 2008), Northwest Industrial Motor Database Summary from Regional Technical Forum. Retrieved March 5, 2013 from http://rtf.nwcouncil.org/subcommittees/osumotor/Default.htm; U.S. Department of Energy, Energy Efficiency and Renewable Energy, Building Technologies Office, EnergyPlus Energy Simulation Software (Aug. 2014). Available at http://apps1.eere.energy.gov/buildings/energyplus.

[19] Arthur D. Little, Inc. “Opportunities for Energy Savings in the Residential and Commercial Sectors with High-Efficiency Electric Motors (Final Report),” (Dec. 1999); U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy. Energy Conservation Program for Certain Industrial Equipment: Energy Conservation Standards for Water-Cooled and Evaporatively-Cooled Commercial Packaged Air-Conditioning and Heating Equipment. Final Rule Technical Support Document, Chapter 4 Energy Use Characterization (2012). Available at http://www.regulations.gov/document?D=EERE-2011-BT-STD-0029-0039; [19] U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy. Energy Conservation Program for Certain Industrial Equipment: Energy Conservation Standards for Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment. NOPR Technical Support Document, Chapter 7 Energy Use Analysis (2014). Available at http://www.regulations.gov/document?D=EERE-2013-BT-STD-0007-0027.

point of the fan is not known and the actual operating point of a fan may fall in a region of operation where the fan has a poor efficiency. ACME estimated that this could happen at least 30 percent of the time. In addition, ACME commented that the energy use analysis should account for fans operating in variable air volume (VAV) systems, for which the actual fan operating point is different than the design point. ACME believes that accounting for these situations would reduce the energy savings as calculated in the May 2015 NODA. (ACME, No. 149 at pp. 1-2) For industrial fans, AcoustiFLO stated that most fans operate at their design point. (AcoustiFLO, Public Meeting Transcript, No. 85 at p. 193)

Based on these comments and stakeholder feedback received during negotiations DOE revised its December 2014 and May 2015 NODA analyses to account for part load operation. For the commercial sector, DOE assumed that 80 percent of the fans operated at an airflow that differed from the design flow at least some of the time. DOE based the 80 percent value on results from the EnergyPlus building energy use simulation software[20] that indicated that 80 percent of fans in the commercial sector operate along a variable load profile. To reflect this, DOE developed variable load profiles for 80 percent of the commercial fans based on the information provided by AHRI and the EnergyPlus building energy use simulation. In the case of the industrial sector, in line with the inputs from the stakeholders, DOE assumed about a third of the fans operated outside of the

[20] The EnergyPlus building energy use simulation software is available at http://apps1.eere.energy.gov/buildings/energyplus/.

design flow (30 percent). The load profiles are presented in the "Sectors and Applications" worksheet of the LCC spreadsheet.

DOE seeks feedback and inputs on the fan load profiles used in the energy use calculation and on the percentage of fans used in variable load applications.

In the December 2014 NODA and the May 2015 NODA, DOE estimated the average fan lifetime for standalone fans to be 30 years. AHRI commented that the lifetimes seemed high but did not provide quantified estimates. Morrison commented that the lifetimes seemed high and that fans used in HVAC typically have 12-15 year lifetimes. (AHRI, No. 53 at p. 5, Morrison, No. 51 at p. 8) In this NODA, DOE revised the fan lifetimes to account for the fact that fans in HVACR application may have shorter lifetimes. In line with Morrison's comment, DOE used an average embedded fan lifetime of 17 years based on estimates of HVACR equipment lifetimes, but maintained an average lifetime of 30 years for other fans.[21] The LCC spreadsheet includes more details

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[21] Roth, Kurt, Detlef Westphalen, John Dieckmann, Sephir Hamilton, and William Goetzler. "Energy Consumption Characteristics of Commercial Building HVAC Systems Volume III: Energy Savings Potential." National Technical Information Service (NTIS): U.S. Department of Commerce (July 2002). Available at http://apps1.eere.energy.gov/buildings/publications/pdfs/commercial_initiative/hvac_volume3_final_report.pdf.
U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy. Energy Conservation Program for Certain Industrial Equipment: Energy Conservation Standards for Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment. Life-Cycle Cost Spreadsheet (NOPR) (2014). Available at http://www.regulations.gov/docket?D=EERE-2013-BT-STD-0007.

on the fan lifetime estimates and includes a sensitivity scenario that provides results for an average embedded fan lifetime of 15 years. [22]

DOE seeks feedback and inputs on fan lifetimes.

H. National Impact Analysis

The NIA estimates the national energy savings (NES) and the net present value (NPV) of total consumer costs and savings expected to result from potential new standards at each EL. DOE calculated NES and NPV for each EL as the difference between a no-standards case forecast (without new standards) and the standards case forecast (with standards). Cumulative energy savings are the sum of the annual NES determined for the lifetime of all fans shipped during a 30-year analysis period assumed to start in 2022. Energy savings include the full-fuel cycle energy savings (i.e., the energy needed to extract, process, and deliver primary fuel sources such as coal and natural gas, and the conversion and distribution losses of generating electricity from those fuel sources). The NPV is the sum over time of the discounted net savings each year, which consists of the difference between total energy cost savings and increases in total equipment costs. NPV results are reported for discount rates of 3 and 7 percent.

[22] The sensitivity scenario used a mechanical lifetime of 45,000 hours based on typical annual operating hours of 3000 hours and a lifetime in years of 15. The lifetimes calculates in the LCC may lead to different lifetimes in years due to the variability in applications and associated annual operating hours (i.e. fans operating fewer annual hours may have a longer lifetime).

To calculate the NES and NPV, DOE projected future shipments and efficiency distributions (for each EL) for each potential fan equipment class. DOE recognizes the uncertainty in projecting shipments and electricity prices; as a result, the NIA includes several different scenarios for each. Other inputs to the NIA include the estimated fan lifetime used in the LCC analysis, fan price, average annual energy consumption, and efficiency distributions from the LCC.

IV. Issues on which DOE seeks public comment

DOE is interested in receiving comment on all aspects of this analysis. DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

1. DOE requests feedback on the calculation of the FEP_{STD} and FEI.
2. DOE seeks comments on the equipment classes used in this notice.
3. DOE seeks information on whether there are specific sizes or operating points where forward curved fans would no longer be available at efficiency levels up to EL 5.
4. DOE seeks comments on the use a compliance date of five years after the publication of the final rule.
5. DOE requests information on the per-model (i.e., a single size fan within a fan series) redesign costs presented in the engineering analysis and conversion cost spreadsheet.
6. DOE requests information on the number of models that are currently in the scope of the rulemaking nationally.

7. DOE requests feedback on the quantity of redesigns, methodology, and results used to calculate the total industry conversion costs by equipment class and EL, as presented in the engineering analysis and conversion cost spreadsheet.
8. DOE requests information on the extent to which product conversion costs and/or capital conversion costs are shared among sizes in a fan series.
9. DOE requests information on the extent to which product conversion costs and/or capital conversion costs are shared between belt and direct drive fans with the same aerodynamic design.
10. DOE requests information on the extent to which product conversion costs and/or capital conversion costs are shared between fans of different construction classes of the same aerodynamic design.
11. DOE requests information on the portion of equipment with embedded fans that would require heat testing for certification with any new energy conservation standards.
12. DOE requests feedback on the number of embedded fans that would require redesign presented in the engineering analysis and conversion costs spreadsheet.
13. DOE seeks feedback and input on the 2012 standalone fan and embedded fan shipments values, by equipment class and subcategory. Specifically, DOE requests feedback on: (1) the estimated number of fans per HVACR equipment; (2) the distribution of HVACR fans across fan subcategory by

fan application; and (3) the share of standalone fans purchased and incorporated in HVACR equipment.

14. DOE seeks feedback and input on the distribution of fan selections by power bin and subcategory for standalone fans and embedded fans as presented in the "LCC sample Description" worksheet of the LCC spreadsheet.
15. DOE seeks feedback and inputs on the fan operating hours.
16. DOE seeks feedback and inputs on the fan load profiles used in the energy use calculation and on the percentage of fans used in variable load applications.
17. DOE seeks feedback and inputs on the fan lifetimes.

The purpose of this NODA is to notify industry, manufacturers, consumer groups, efficiency advocates, government agencies, and other stakeholders of the publication of an analysis of potential energy conservation standards for commercial and industrial fans and blowers. Stakeholders should contact DOE for any additional information pertaining to the analyses performed for this NODA.

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Energy Efficiency and Renewable Energy