Appliance Standards Awareness Project
Natural Resources Defense Council

June 16, 2017

California Energy Commission
Docket Unit, MS-4
1516 Ninth Street
Sacramento, CA 95814-5512

RE: Docket No. 17-AAER-06: Commercial and Industrial Fans & Blowers

This letter constitutes the comments of the Appliance Standards Awareness Project (ASAP) and Natural Resources Defense Council (NRDC) on the California Energy Commission's (CEC's) invitation to participate for commercial and industrial fans & blowers. We appreciate the opportunity to provide comments to the Commission.

ASAP is a coalition that includes representatives of efficiency, consumer and environmental groups, utility companies, state government agencies, and others. Working together, the ASAP coalition seeks to advance cost-effective efficiency standards at the national and state levels through technical and policy advocacy and through outreach and education.

NRDC is an international nonprofit environmental organization with more than 1.3 million members and online activists. Since 1970, NRDC's lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC's top institutional priorities are curbing global warming and creating a clean energy future. Energy efficiency is one of the quickest, cleanest, cheapest solutions to global warming and other energy-related problems. Cost-effective energy efficiency standards help to ensure that consumer and commercial products provide the same level of comfort and service using less energy, with benefits for consumers, the environment and the electricity grid.

Overview

We are pleased that CEC is initiating this rulemaking for commercial and industrial fans. Fans are available with a wide range of efficiencies, and some models on the market have very efficient designs. However, the actual efficiency of a fan in the field depends enormously on how it is applied. Therefore, improved fan selection represents a huge opportunity for energy savings for California (and the nation) and energy bill savings for building owners. Over the past several years we and other efficiency advocates have worked with the Air Movement and Control Association (AMCA) to develop an innovative approach for fan efficiency standards that would both drive improved fan design as well as help ensure that fans are appropriately selected in order to reduce power consumption. This approach is based on the concept of efficiency standards applying to the entire certified operating range (i.e. flow and pressure points) of a fan.

The U.S. Department of Energy (DOE) has conducted a significant amount of work over several years towards the development of fan efficiency standards in collaboration with manufacturers, efficiency advocates, and other stakeholders, which we believe provides a good starting point for the CEC rulemaking. In 2011, DOE initiated a rulemaking for commercial and industrial fans with the publication of a proposed determination of coverage.[1] In 2015, DOE convened an Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) working group comprised of representatives of fan, motor, and HVAC manufacturers, consulting engineering firms, utilities, efficiency advocates, and DOE to negotiate test procedures and efficiency standards for fans. Both of our organizations participated in the ASRAC working group. As described below, the working group reached consensus on a number of items related to the scope of coverage, an efficiency metric, and test procedures consistent with the approach for efficiency standards noted above.[2] However, DOE has yet to publish a proposed rule for either test procedures or efficiency standards, and the status of the DOE rulemaking is uncertain. We encourage CEC to leverage the work of DOE and the ASRAC working group to advance potential CEC fan efficiency standards.

Product Definition and Scope

We encourage CEC to leverage the working definitions discussed during the ASRAC working group. The term sheet from the ASRAC working group did not include definitions other than a working definition for "safety fan." However, an interim term sheet discussed by the working group includes working definitions for a number of items including definitions for "fan," various fan components, fan categories, and equipment classes.[3] These working definitions should provide a good starting point for CEC.

We also encourage CEC to adopt the scope of coverage outlined in the term sheet for the ASRAC working group. The working group reached consensus on three broad topics related to the scope of coverage: (1) the horsepower range that would be covered; (2) the fan categories that would be included and excluded; and (3) the treatment of fans embedded in equipment.

As described above, the term sheet for the ASRAC working group outlines an approach for fan efficiency standards based on the entire certified operating range. The working group recommended that test procedures and efficiency standards apply to operating points for which:

- Fan shaft power is equal to or greater than 1 HP; and
- Fan airpower is equal to or less than 150 HP (static airpower for unducted fans; total airpower for ducted fans)[4]

The horsepower range recommended by the working group is very similar to that covered in the recently established DOE efficiency standards for commercial and industrial pumps. The pump standards apply to pumps with shaft powers greater than or equal to 1 HP and less than or equal to 200 HP.[5] For fans, a shaft power of 200 HP is roughly equal to fan airpower of 150 HP. The use of fan airpower (rather than fan shaft power) to define the upper limit of the horsepower

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[1] https://www.regulations.gov/document?D=EERE-2011-BT-DET-0045-0001.
[2] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0179.
[3] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0143. pp. 18-19.
[4] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0179. p. 4.
[5] https://www.ecfr.gov/cgi-bin/text-idx?SID=6a9057ce2e0b62f5670a2f59840ec17e&mc=true&node=se10.3.431_1462&rgn=div8.

range helps avoid a potential situation at the upper end of the horsepower range where one fan would be covered by the standards, while another fan that delivers the same service (i.e. fan airpower) is excluded because it is less efficient and therefore has a shaft power just above the upper limit.

The working group also reached consensus on specific fan categories that would be included and excluded.[6] Table 1 below shows these included and excluded categories.

Table 1. Fan categories included and excluded in the term sheet for the ASRAC working group

Included	Excluded
Axial cylindrical housed	Radial housed unshrouded fans with diameter less than 30 inches or a blade width of less than 3 inches
Panel	Safety fans[7]
Centrifugal housed	Circulating fans
Centrifugal unhoused	Induced flow fans
Inline and mixed flow	Jet fans
Radial housed	Cross flow fans
Power roof ventilators	

The fan categories recommended to be included in the scope of coverage by the working group cover those used in a wide variety of common commercial and industrial applications. The excluded fan categories are fan types that are primarily used in specialty applications and represent a small connected load. For example, induced fans are often used in laboratory exhaust systems, and jet fans are typically used to ventilate tunnels. We also note that commercial and industrial ceiling fans (i.e. circulating fans), which were recommended to be excluded by the working group, are covered by new DOE standards for ceiling fans.[8]

Finally, the working group reached consensus on the treatment of fans embedded in equipment. The working group recommended seven instances where embedded fans would be excluded: those fans embedded in regulated central air conditioners and heat pumps (single-phase, <65,000 Btu/h); regulated commercial air conditioners and heat pumps that are three-phase and <65,000 Btu/h (air-cooled); regulated consumer furnaces; transport refrigeration and fans exclusively powered by internal combustion engines; vacuums; heat rejection equipment;[9] and air curtains. The working group also recommended for exclusion supply and condenser fans that are embedded solely in specific types of regulated equipment for which the DOE efficiency metric captures (at least to some extent) the energy use of these supply and condenser fans.[10] Supply and condenser fans that are also embedded in other types of equipment (i.e. unregulated

[6] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0179. pp. 1-2.
[7] As defined in Appendix D of the term sheet.
[8] Commercial and industrial ceiling fans are referred to in the DOE standards as “large-diameter ceiling fans.” https://www.regulations.gov/document?D=EERE-2012-BT-STD-0045-0150.
[9] As defined on pp. 2-3 of the term sheet.
[10] The specific types of regulated equipment are listed in Appendix B of the term sheet.

equipment) and/or are also sold as standalone fans would be subject to any test procedures and efficiency standards.[11]

The approach for embedded fans recommended by the ASRAC working group accomplishes several things. First, it eliminates a burden on HVAC manufacturers in cases where they are the "manufacturer" of supply and/or condenser fans embedded in their regulated equipment. For example, for a supply fan that is part of a commercial air conditioner or heat pump ≥65,000 Btu/h, in many cases the HVAC manufacturer is not purchasing a supply fan in a "testable configuration"[12] from a fan manufacturer, but may be purchasing just the impeller, for example. In these cases, the HVAC manufacturer would be considered the "manufacturer" of the supply fan, and these particular fans may exist only as part of a commercial air conditioner or heat pump. In these cases, the working group recommendation would mean that these fans would not be subject to any test procedures or efficiency standards.[13]

Second, the approach for embedded fans recommended by the working group would avoid an important potential loophole by specifying that supply and condenser fans that are also embedded in other types of equipment and/or are also sold as standalone fans would be subject to any test procedures and efficiency standards. This avoids the situation, for example, where a fan manufacturer could claim that a given fan they are selling will eventually be embedded in a piece of regulated equipment and therefore is exempt from the standards, which would be very difficult to enforce. The approach outlined in the term sheet ensures that any fan sold as a standalone fan is subject to any test procedures and efficiency standards, regardless of where the fan ultimately ends up.

Third, this approach for embedded fans would achieve savings for fans that are embedded in unregulated equipment, such as air handlers, and would help establish a level playing field for both fan and HVAC manufacturers in regards to fans in unregulated equipment. In particular, fans ultimately embedded in unregulated equipment would be subject to the same requirements regardless of whether the fan manufacturer or the HVAC manufacturer is the "manufacturer" of a given fan.

We continue to support the scope of coverage outlined in the term sheet from the ASRAC working group and believe that this scope of coverage makes sense for initial fan efficiency standards.

Existing Test Procedures and Test Procedures Under Development

As noted above, the ASRAC working group recommended an innovative approach for potential fan efficiency standards based on the concept of standards applying to the entire certified operating range (i.e. flow and pressure points). In the presentation from the May 11, 2017

[11] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0179. pp. 2-4.
[12] The term sheet specified that "testable configuration" would include "at a minimum and where appropriate, the following basic parts: an impeller, a shaft, bearings, and a structure or housing."
[13] Importantly, the working group also agreed that in the future, modifications should be considered for test procedures for regulated equipment containing supply and condenser fans to more fully capture the energy use of these fans.

webinar, CEC requests comment on the merits of fan energy index (FEI) versus fan energy rating (FER).[14] As explained below, we encourage CEC to use FEI as the efficiency metric.

The FER metric was first outlined by DOE in the first notice of data availability (NODA). In the December 10, 2014 NODA, FER was defined as "the weighted average electric input power of a fan over a specified load profile, in horsepower, and measured at a given speed."[15] The NODA also described how an efficiency index (FEI) could be calculated as the ratio of the FER of a fan just meeting the standard to the FER of a given fan. In the analysis for the NODA, DOE used a load profile with three operating points: 100%, 110%, and 115% of the flow at the best efficiency point (BEP). DOE calculated FER of a given fan model at the maximum of a specific set of operating speeds (850 RPM, 1150 RPM, 1750 RPM, and 3550 RPM) included in the fan's operating range. The FER calculation also incorporated motor and transmission losses. We understand that the practical impact of the FER approach outlined in the first NODA would be to limit the rated maximum speed of fans: since the required efficiency (used to calculate FER_{STD}) decreases with flow and pressure, a manufacturer could make a noncompliant fan compliant by reducing the maximum rated operating speed. Reducing the maximum rated operating speed of relatively inefficient fans would achieve energy savings by eliminating some of the most inefficient operating points from the selection range. However, this approach fails to achieve the much greater savings that are possible through an approach addressing the entire certified operating range.

DOE's second NODA (NODA II) continued to refer to an FER metric, but this time based on all operating points.[16] FEI continued to be calculated as the ratio of the electric input power (FER) of a fan just meeting the standard to the FER of a given fan, this time at each fan operating point. Like the approach in the first NODA, the approach in NODA II would also limit the maximum speed of fans since the rated maximum speed could only be as high as that for which at least one operating point meets the standard. However, a metric based on all certified operating points provides the potential for significantly greater savings beyond limiting the maximum rated speed. In particular, a focus on first cost often results in designers and contractors selecting undersized fans that operate at high speeds far from their peak efficiency point (i.e. far to the right of the peak efficiency point), which in turn results in significant wasted energy. As shown in Figure 1 below, with an approach based on all certified operating points, in many cases a portion of operating points far to the right of the peak efficiency point would be noncompliant (the red shaded region in Figure 1). Therefore, this approach would shift a significantly greater portion of fan selections to more-efficient selections compared to an approach that would only reduce maximum rated speed.

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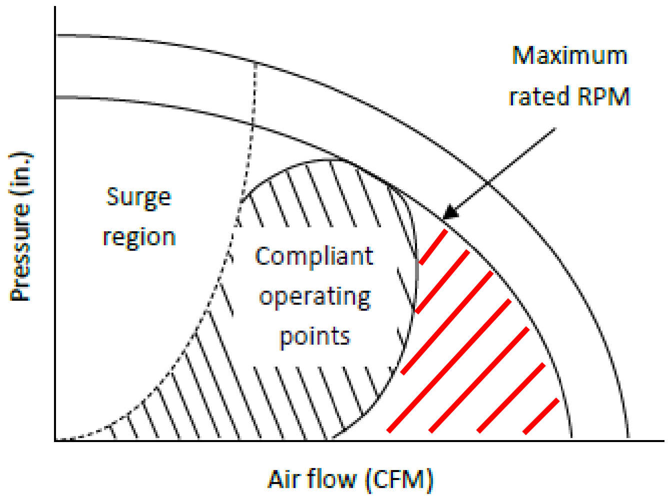
[14] http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-05/TN217523_20170510T135340_Invitation_to_Participate_Presentation.pdf. p. 23.
[15] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0037. p. 73247.
[16] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0062. p. 24843.

Figure 1. Example of the maximum rated speed (RPM) and the compliant operating range of a fan based on an approach for efficiency standards addressing the entire certified operating range



An approach for efficiency standards based on the entire operating range would shift fan selections to models that provide higher efficiency at the customer's actual design point (flow and pressure). Under this approach, manufacturers would also have a market incentive to improve overall fan efficiency through better design in order to be able to market their fans for a wider range of operating points.

The ASRAC working group recommended that the metric used for any DOE standard be the fan electrical input power (FEP) and that the fan energy index (FEI) be allowed for representations.[17] FEP as defined in the working group term sheet is essentially equivalent to FER in NODA II as both metrics represent fan electric input power at a given fan operating point. DOE's third NODA (NODA III) reflected the recommendation of the working group to use FEP as the regulated metric.[18] In our comments on NODA III, we noted that we were open to suggestions from industry to use FEI as the regulated metric.[19] The NODA III notes that FEI allows "for better comparability across all regulated fans."[20] In particular, FEI allows for easily comparing the power consumption of one fan versus another. For example, regardless of the fan type, size, etc., a fan with an FEI of 1.2 at the customer's design point would consume 17% less power than a fan with an FEI of 1.0.[21] We further noted in our comments that we believe that using FEI would retain the intent of the working group term sheet and would not result in any change to compliance rates or energy savings at the different potential efficiency levels.

We also note that AMCA is currently working to develop an industry standard (AMCA 208) for the calculation of FEI. We believe that AMCA 208 (once finalized) along with other AMCA testing and rating standards (notably AMCA 210 and AMCA 207) would provide a good basis

[17] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0179. p. 5.
[18] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0194. p. 75744.
[19] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0205. p. 2.
[20] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0194. p. 75744
[21] (1.2 – 1.0) / 1.2

for a potential CEC test procedure for fans. The ASRAC working group recommended using AMCA 210 as the basis for determining bare-shaft fan performance.[22] The working group term sheet also outlined a methodology for calculating wire-to-air performance, including the specification of default values for motor, transmission, and control losses.[23] The recently finalized AMCA 207 contains slightly different default values than those in the term sheet. In our comments on NODA III, we noted that we are open to suggestions from industry to use the default values in (the now finalized) AMCA 207.[24] We continue to be open to using the default values in AMCA 207 rather than those in the term sheet given the broad support for AMCA 207 among manufacturers and given that we understand that the impact of the choice of default values between those in the term sheet and those in AMCA 207 is relatively minor. In addition, we understand that AMCA 208 will reference AMCA 207, which further suggests that the use of AMCA 207 would make sense as part of a potential CEC test procedure.

Product Lifetime, Per-Unit Energy Savings, and Incremental Cost

We encourage CEC to leverage DOE's analyses, including estimates of product lifetime, per-unit energy savings, and incremental cost. DOE's analyses incorporated input from a broad range of stakeholders including significant input from the ASRAC working group. As part of DOE's NODA III, DOE estimated average fan lifetimes by fan type including estimates for all fans, standalone fans, and embedded fans. DOE noted that these estimates were developed using a variety of sources including an ASHRAE HVAC service life and maintenance database, an industry expert interview, and DOE's analyses for equipment types that include embedded fans.[25] Table 2 below shows these average lifetime estimates, which we believe provide a good basis for CEC's analysis.

Table 2. DOE estimates of average fan lifetimes[26]

Fan type	Average lifetime (years)		
	All fans	Standalone fans	Embedded fans
Axial cylindrical housed	28	29	18
Panel	25	28	21
Centrifugal housed	21	27	18
Centrifugal unhoused	19	27	17
Inline and mixed flow	27	27	n/a
Radial	30	30	n/a
Power roof ventilator	30	30	n/a

The lifecycle cost (LCC) spreadsheet accompanying DOE's NODA III includes estimates of installed cost, first year operating cost, lifetime operating cost, total lifecycle cost (LCC), simple payback period, % of consumers that experience a net cost, and average LCC savings at each

[22] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0179. p. 5.
[23] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0179. pp. 5-9.
[24] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0205. p. 2.
[25] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0190. "Lifetime" tab.
[26] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0190. "Summary by EC" tab.

analyzed efficiency level for each fan category. Table 3 and Table 4 below show DOE's estimates of average LCC savings and simple payback period, respectively, by fan type.

For all fan types, average LCC savings are positive at all efficiency levels, meaning that any additional upfront cost associated with a more-efficient fan is more than paid back over the lifetime of the fan. The simple payback periods for all fan types at all efficiency levels are less than 7 years, compared to average fan lifetimes of 19-30 years as shown in Table 2.

Table 3. DOE estimates of average LCC savings by fan type (2015$)[27]

Efficiency level	Axial cylind. housed	Panel	Centrif. housed	Centrif. unhoused	Inline and mixed flow	Radial	Power roof vent.
1	4,611	2,928	1,289	3,634	2,150	8,182	1,992
2	5,117	2,563	1,213	2,657	2,252	9,664	2,120
3	5,185	2,298	1,577	2,218	2,540	8,374	2,078
4	5,235	2,277	1,692	2,125	2,709	8,997	1,938
5	5,669	2,313	1,484	1,773	2,785	10,145	1,852
6	7,874	2,397	2,641	3,067	3,666	12,209	1,934

Table 4. DOE estimates of simple payback periods by fan type (years)[28]

Efficiency level	Axial cylind. housed	Panel	Centrif. housed	Centrif. unhoused	Inline and mixed flow	Radial	Power roof vent.
1	5.6	1.4	3.9	3.4	6.9	1.6	6.5
2	5.0	1.5	4.0	3.6	6.3	1.3	6.0
3	4.7	1.6	3.2	3.1	5.6	1.4	5.9
4	4.4	1.6	2.9	2.8	5.2	1.3	6.2
5	3.9	1.6	3.4	2.6	5.2	1.3	6.2
6	2.4	1.5	2.2	1.1	4.6	1.3	6.0

DOE's analysis shows that efficiency standards for fans have the potential to provide significant economic savings.

In sum, the innovative approach for fan efficiency standards outlined in the term sheet from the ASRAC working group has the potential to provide very large energy savings and economic savings by both driving improved fan design as well as helping ensure that fans are appropriately selected. We encourage CEC to leverage the work of DOE and the ASRAC working group to advance potential CEC fan efficiency standards.

Thank you for considering these comments. Please do not hesitate to contact us with any questions at jmauer@standardsasap.org or 505-508-2910.

[27] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0190. "Summary by EC" tab. Results for "all" fans. LCC savings for impacted customers (i.e. excluding those who would have purchased a fan at or above a given efficiency level in the base case).
[28] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0190. "Summary by EC" tab. Results for "all" fans.

Sincerely,

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