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September 18, 2017

California Energy Commission
Docket Unit, MS-4
Re: Docket No. 17-AAER-06
1516 Ninth Street
Sacramento, California 95814-5512

Re: AHRI Proposal – Title 20 Phase II Pre-Rulemaking – Commercial and Industrial Fans & Blowers *[Docket No. 17-AAER-06]*

Dear CEC Staff:

The attached proposal is submitted in response to the California Energy Commission (CEC) Phase II Pre-Rulemaking Invitation to Submit Proposals notice issued on July 18, 2017 and meeting held on August 1, 2017, regarding minimum efficiency standards for commercial and industrial fans into California's Appliance Efficiency Standards in Title 20 of the California Code of Regulations, Sections 1601 through 1609.

AHRI is the trade association representing manufacturers of heating, cooling, water heating, and refrigeration equipment. More than 300 members strong, AHRI is an internationally recognized advocate for the industry, and develops standards for and certifies the performance of many of the products manufactured by our members. In North America, the annual output of the HVACR industry is worth more than $20 billion. In the United States alone, our members employ approximately 130,000 people, and support some 800,000 dealers, contractors, and technicians. In addition to its activities as a global standards developer, AHRI works closely with other global codes and standards developers as well as utilities to ensure their access to the latest technology and innovation from the HVACR and water heating industry.

AHRI proposes that the CEC limit the scope of the proposed regulation on commercial and industrial fans to stand-alone fans only and exclude from the scope all fans embedded in residential, commercial and industrial HVACR and water heating equipment (Embedded Fans) from any fan standards. Such Embedded Fan standards would save minimal if any energy, would create needless testing and other requirements and would raise costs for consumers with no offsetting energy savings. Virtually all the potential energy savings from Embedded Fans are already covered by other Federal and California standards. Information and data included in this report and corrections to the DOE analysis show that additional standards on Embedded Fans do not meet Energy Commission criteria for significant statewide energy savings or for cost-effectiveness to consumers.

Although AHRI does not dispute that the potential exists for cost-effective, energy saving measures that could be implemented for stand-alone fans, AHRI urges the CEC to exclude all fans embedded in all residential, commercial, and industrial HVACR and water heating equipment from the scope and pursue a stand-alone commercial and industrial fans regulation which, at minimum, preserves all negotiated exclusions and provisions resulting from the Department of Energy (DOE) Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) Commercial and Industrial Fans and Blowers Working Group.

AHRI appreciates the opportunity to provide this proposal. If you have any questions regarding this submission, please do not hesitate to contact me.

Sincerely,

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Proposal Information Template – Commercial and Industrial Fans and Blowers

2017 Appliance Efficiency Standards

Air-Conditioning, Heating, and Refrigeration Institute, September 18, 2017

Contents

Purpose

This document is a report template to be used by researchers who are evaluating proposed changes to the California Energy Commission's (Commission) appliance efficiency regulations (Title 20, California Code Regulations, §§ 1601 – 1608). This proposal specifically covers commercial and industrial fans and blowers, Docket 17-AAER-06, and includes all of the following sections:

- Product/Technology Description
- Overview
- Methodology
- Proposed Standards and Recommendations
- Analysis of Proposal
- References
- Appendices

Product/Technology Description

Commercial and industrial fans and blowers are generally understood to be rotary bladed machines used to convert power to air power; typically consisting of an impeller, a shaft, bearings, a structure or housing, sold in a stand-alone testable configuration and, if included by the manufacturer at the time of sale, transmissions, driver and controls. Primary fan categories include axial cylindrical housed; panel; centrifugal housed airfoil and backward inclined/backward curved, excluding inline and radial; centrifugal housed forward curved; centrifugal unhoused, excluding inline and radial; inline and mixed-flow; radial housed; and power roof ventilators. Many of the above fan types can be embedded into residential, commercial or industrial heating, ventilation, air-conditioning, refrigeration (HVACR) and water heating equipment (Embedded Fans). There is not an adequate test procedure for evaluating the performance of these Embedded Fans and they have a high degree of variation. Further, the performance cannot be compared to stand-alone fans.

Overview

The Air Conditioning Heating and Refrigeration Institute (AHRI) proposes that the California Energy Commission (CEC) limit the scope of the proposed regulation on commercial and industrial fans to stand-alone fans only and exclude from the scope all fans embedded in residential, commercial and industrial heating, ventilation, air-conditioning, refrigeration (HVACR) and water heating equipment (Embedded Fans) from any fan standards. Such Embedded Fan standards would save minimal if any energy, would create needless testing and other requirements and would raise costs for consumers with no offsetting energy savings. Virtually all the potential energy savings from Embedded Fans are already covered by other Federal and California standards. Information and data included in this report and corrections to the DOE analysis show that additional standards on Embedded Fans do not meet Energy Commission criteria for significant statewide energy savings or for cost-effectiveness to consumers.

Although AHRI does not dispute that the potential exists for cost-effective, energy saving measures that could be implemented for stand-alone fans, AHRI urges the CEC to exclude all fans embedded in all residential, commercial, and industrial HVACR and water heating equipment from the scope and pursue a stand-alone commercial and industrial fans regulation which, at minimum, preserves all negotiated exclusions and provisions resulting from the Department of Energy (DOE) Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) Commercial and Industrial Fans and Blowers Working Group.

Table 1: Summary of Proposal

Topic	Description
Description of Standards Proposal/Framework of Roadmap	Embedded HVACR and water heating fans are fans incorporated as components in other equipment. These fans are not independent products. In virtually all cases, the energy associated with Embedded Fans is covered by California appliance and building standards or has been reduced through marketplace actions. Therefore, there is no reason to introduce a separate standard on Embedded Fans.
Technical Feasibility	Incorporating more efficient fans into HVACR and water heating equipment is a complex process requiring retesting and recertification of the product itself for performance, energy consumption, safety, seismic and other factors. There are usually physical limitations on the size of fan that can be used. As a result, manufacturers have already found ways to optimize energy performance and costs of the entire product to end consumers. Adding fan regulations will create unnecessary technical challenges for no actual savings and for significantly increased cost to consumers.
Energy Savings and Demand Reduction	The maximum theoretical energy savings in California for 30 years of equipment shipments would be on the order of 0.1 quads. It is very unlikely that actual savings would reach this level since market forces and incentive programs are promoting the use of variable speed fan drives and other technologies that are already significantly reducing embedded fan energy consumption.
Environmental Impacts and Benefits	Limited to none.
Economic Analysis	Increased product, testing and certification costs for fans with no offsetting economic benefit.
Consumer Acceptance	Commercial HVACR and water heater customers are already implementing advanced fan and drive technologies so that potential energy savings and economic benefits are occurring without additional regulations.

Other Regulatory Considerations	Title 20 and Title 24 standards already regulate the energy of embedded commercial HVACR and water heater fans. Title 24 and Standard 90.1 also provide requirements for stand-alone fans in many applications, potentially negating the need for further regulation under Title 20. LEED certification and the CALGreen Code are among other regulatory and market-based programs encouraging the use of more efficient fans, so that the economically attractive savings opportunities are already occurring. The remaining fan energy savings from a mandatory minimum standard would come at the expense of consumers and installations where more advanced fans do not make economic sense.

Methodology

For this proposal, AHRI adapted the economic and energy savings calculations from the US Department of Energy's commercial and industrial fan rulemaking[1], particularly DOE's Life Cycle Cost and National Impact Analysis models from the third Notice of Data Availability (NODA3). Specific changes and adaptations of the DOE methodology for California are described in the proposal and outlined thoroughly in the appendices. As the DOE rulemaking and analysis covers only fans with motors between one and 150 horsepower, and there is no available information or test method to support an increase in scope, AHRI does not support California pursuing the regulation of fans below one or above 150 horsepower. Due to the difference between the national base case and the more stringent building and appliance efficiency standards in California, AHRI's analysis shows that a stand-alone fans-only standard may be warranted, provided that the regulation completely exempts fans embedded in heating, ventilation, air-conditioning, refrigeration (HVACR) and water heating equipment (Embedded Fans).

Proposed Standards and Recommendations

Consistent with Recommendation 7 in the DOE ASRAC Working Group term sheet, the fan test procedure should generally be based on AMCA 210 (latest version available at the time of publication) for determining fan performance and performance of non-embedded, stand-alone fans.[2] Slightly adapted from the term sheet, the following installation types, in parenthesis after each fan type, will be used for each fan category: (1) axial cylindrical housed (D); (2) panel (A); (3) centrifugal housed airfoil and backward inclined/backward curved, excluding inline and radial (B); (4) centrifugal housed forward curve (B); (5) centrifugal unhoused, excluding inline and radial (A); (6) Inline and mixed-flow (B); (7) Radial housed (D); and (8) Power Roof Ventilators (A). The testable configuration for each equipment class of non-embedded fans shall be defined in the test procedure and include, at a minimum and where appropriate, the following basic parts: an impeller, a

[1] US Department of Energy, Docket EERE-2013-BT-STD-0006

[2] US Department of Energy EERE-2013-BT-STD-0006-0179, (ASRAC Working Group) Recommendation 7

shaft, bearings, and a structure or housing. Calculation of the fan electrical input power (FEP) and fan efficiency index (FEI) should be based on the appropriate AMCA standard for stand-alone fans.

As the vast majority of fans embedded in residential, commercial, and industrial heating, ventilation, air-conditioning, refrigeration (HVACR) and water heating equipment (Embedded Fans) are already covered by California Building Standards (California Title 24 Section 110.2, Tables 110.2-A through K, 120.6 (a and b) and total fan power limit in Section 140.4 (c)) and/or California Appliance Efficiency Standards (Title 20), AHRI proposes that the CEC exempt all Embedded Fans. AHRI further proposes excluding fan blades, impellers, wheels and other components used to repair/replace fans in existing HVACR and water heating equipment (Replacement Embedded Fans). AHRI has no comment on or any position regarding standards for stand-alone fans or fans not embedded in HVACR equipment (except for fan components excluded above).

Proposed Definitions

AHRI proposes that CEC adopt slightly modified definition for stand-alone fan discussed during the DOE ASRAC process[3]:

> Stand-alone fan: a rotary bladed machine used to convert electric power to air power with an energy output limited to 25 kJ/kg of air; typically consisting of an impeller, a shaft, bearings, a structure or housing, sold in a testable configuration and, if included by the manufacturer at the time of sale, transmissions, driver and controls.

In addition, AHRI recommends the following definitions:

- Embedded Fan: A fan included as a component in residential, commercial, or industrial heating, ventilation, air-conditioning, refrigeration (HVACR) or water heating equipment where the fan is:
  - Permanently mounted in the equipment;
  - Used to support heat transfer, combustion, or other mechanisms within the equipment; and
  - Tested as part of equipment certification according to ANSI, ASHRAE, AHRI, DOE or other performance standards; and
  - Labeled for such use if sold as a fan assembly only for use within an exempt product.
- Replacement Embedded Fan:
  - An impeller, blade or wheel sold without a motor, with or without shaft and bearings, designed and marketed as a replacement for an existing part in an Embedded Fan, including cross-reference(s) to the original fan part and a label stating that this part is for replacement purposes only.
  - Complete Embedded Fan assemblies including cross-reference(s) to the original blower part and a label stating that this part is for replacement purposes only.

Proposed Test Procedure, Standard Metrics, Framework or Reporting Requirements

AHRI proposes exempting heating, ventilation, air-conditioning, refrigeration (HVACR) and water heating equipment (Embedded Fans) and Replacement Embedded Fans from minimum efficiency standards.

[3] EERE-2013-BT-STD-0006-0074.xlsx

Therefore, there will be no test procedures or standard metrics for these products. Stand-alone fans should be tested and energy performance should be calculated in accordance with applicable AMCA standards.

Analysis of Proposal

There is very little, if any, energy that will be saved through an energy consumption standard on heating, ventilation, air-conditioning, refrigeration (HVACR) and water heating equipment (Embedded Fans) while there will be costs to end consumers. Therefore, such a standard will have negative economic benefits. Some of the discussions from the DOE process looking at commercial and industrial fans may give the impression of significant energy savings potential on the national level; however, the actual potential from Embedded Fans in California is minimal. The results from the DOE process are misleading or based on incorrect data, inputs and analysis.

As a rule, energy efficiency standards on components in equipment that is subject to energy performance standards, yields little or no additional energy savings. Rather, the component standard merely results in redesigning, and sub-optimizing the piece of equipment itself. For example, a standard on a condenser fan in an air-cooled air-conditioner or chiller will usually result in reconfiguration of coil or other components to maintain the cost and mandated energy efficiency performance of the equipment. Therefore, the burden is to demonstrate that a component standard will result in actual savings.

AHRI estimates that the total theoretical potential energy savings in California for Embedded Fans sold over a 30-year period is on the order of 0.1 quads of energy. In practice, much of this potential has already been captured through market actions such as the adoption of variable speed drives and other technologies not incorporated in the theoretical savings potential calculations. Any further minimum standards will almost certainly come with net life cycle costs to end consumers, especially if this standard applies only in California or in some other sub-segment of the US.

Scope/Framework

Fans embedded in residential, commercial and industrial heating, ventilation, air-conditioning, refrigeration (HVACR) and water heating equipment (Embedded Fans) are used in three classes of products/applications:

1. HVACR and water heating equipment covered by:
    a. Minimum performance standards listed in California Title 20
    b. California Title 24, Section 110.2, Tables 110.2-A through I and Sections 120.6 (a and b)
2. Applications covered by California Title 24
    a. Fans used for ventilation in new construction, additions, and alterations are covered by the fan horsepower limit in Title 24, Section 140.4 (c)
3. Replacement Embedded Fans
    a. Fan blades, impellers, wheels or other impeller parts, including Replacement Embedded Fans, used to repair a fan in existing HVACR and water heating equipment already installed in a building

In the DOE process of considering potential standards for commercial and industrial fans, the Appliance Standards and Rulemaking Federal Advisory Committee *Commercial and Industrial Fans and Blowers Working*

Group (ASRAC Fan Working Group) developed a consensus recommendation that any fan standard apply only to fans between one brake horsepower and 150 air horsepower[4]. AHRI recommends that California adopt this consensus position in any fan standard.

1. HVACR and Water Heating Equipment Where Fan Power is Covered by Equipment Standard

The ASRAC Fan Working Group determined without dissent that fans in 1. a. above should be excluded from any fan standard[5]. Due to more stringent than average national building codes, California should go beyond the ASRAC Fan Working Group on this determination and exclude all fans in all covered products. All fans within covered products are subject to fan limits in California Building Standards.

In addition, California adopts the relevant equipment minimum efficiency standards and other measures from ASHRAE Standard 90.1 into Title 24, in some cases exceeding the requirements of Standard 90.1[6]. These standards add to the equipment with Embedded Fans already covered by Title 20 additional products including:

1) Table 110.2-A Electrically Operated Unitary Air-conditioners and Condensing Units (supply and condenser fans)
   a) Air-cooled both split system and single package with capacities >=760,000 Btu/h
   b) Water-cooled with capacities >=240,000 Btu/h
   c) Evaporatively-cooled with capacities >= 760,000 Btu/h
   d) Condensing Units, air, water and evaporatively-cooled with capacities >=135,000 Btu/h
2) Table 110.2-B Unitary and Applied Heat Pumps (supply and condenser fans)
   a) Air-cooled (cooling mode), both split system and single package with capacities >=240,000 Btu/h
   b) Water-source all types, <135,000 Btu/h
3) Table 110.2-D Water Chilling Packages
   a) Air-cooled, with condenser electrically operated
   b) Air-cooled, without condenser electrically operated (must be paired with a condenser to meet the air-cooled chiller requirements)
4) Table 110.2-G Heat Rejection Equipment
5) Table 110.2-H Electrically Operated Variable Refrigerant Flow (VRF) Air-conditioners
   a) Air-cooled with capacities >=760,000 Btu/h
6) Table 110.2-I Electrically Operated Variable Refrigerant Flow (VRF) Heat Pumps
   a) Air-cooled with capacities >=760,000 Btu/h
7) Mandatory Requirements for Covered Processes
   a) Section 120.6 (a): Refrigerated Warehouses
   b) Section 120.6 (b): Commercial Refrigeration

AHRI recommends that California exclude all fans covered either by Title 20, in Tables 110.2-A through I or in Section 120.6 (a and b) from any separate fan standard. A standard on fans that are embedded components of another product with its own energy efficiency standard will not save energy and are likely to

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[4] ASRAC Working Group, EERE-2013-BT-STD-0006-0179, Recommendation 5

[5] ASRAC Working Group, EERE-2013-BT-STD-0006-0179, Recommendations 2&3

[6] State of California, Building Energy Efficiency Standards, Article 1, Subchapter 2, Section 110.2

increase costs to consumers.

2. Applications Covered by Title 24 Sections 140.4 (c), 140.9 (4) and 140.9(5)

Title 24 Section 140.4 (c) sets a maximum horsepower for all fan systems used in space conditioning (including fans that may also be covered under Title 24 110.2 and Title 20) for new construction, additions and alterations in nonresidential, high-rise residential and hotel/motel buildings. The comprehensive horsepower limitation allows building designers to optimize the costs and benefits of various fan options and duct designs.

Title 24 Section 140.9 (4) requires that the total fan power at design conditions of each fan system must not exceed 27 W/kBtu/h of net sensible cooling capacity.

Title 24 Section 140.9(5) requires unitary air-conditioners with mechanical cooling capacity exceeding 60,000 Btu/h and chilled water fan systems be designed to vary the airflow rate as a function of actual load. In addition, these systems must have controls and/or devices (such as two-speed or variable speed control) that will result in fan motor demand of no more than 50-percent of design wattage at 66-percent of design fan speed.

AHRI recommends that California not adopt any additional minimum standards for Embedded Fans.

3. Replacement Embedded Fans

HVACR and water heating equipment is built, tested and certified around a specific set of components. Changing these components can, and usually does, change the performance of the total equipment. In many cases, such as supply air fans with air flow through gas fired heat exchangers, hot water coils or electric resistance units, there are a variety of safety standards affected by air flow in addition to the standards governing the performance of the equipment. The cost of testing all legacy equipment for some new fan will be cost and resource prohibitive. If a replacement fan is not compliant then, in most cases, an unsafe, engineered-to-fit substitution would be required. Costs, risks, and time required to retest the HVACR and water heating equipment would all be prohibitive. Testing could be impractical if the actual HVACR and water heating equipment is out of production. Manufacturers would be forced to rebuild an out-of-production unit solely for the purpose of testing the new fan. There may be instances where such part substitution makes sense, but that is not a reasonable basis for a broad, minimum standard. AHRI recommends that California not set standards for Replacement Embedded Fans.

Product Efficiency Opportunities

The basic concept behind fan standards is that some portion of fans operate in conditions where an alternative fan would be more efficient either because of the type of fan (e.g. backward curved vs. forward curved centrifugal fans), size of fan, fan speed or other factors. The core question raised by AHRI is whether changing fans embedded in larger systems actually reduces the *system's* energy consumption. The available evidence says that it will not. Second, AHRI will show that the actual potential savings from applications not already covered by other regulations and standards is minimal.

This is best understood by treating each of the major applications for Embedded Fans individually in terms of:

- Technical Feasibility
- Statewide Energy Savings
- Cost Effectiveness
- Other Regulatory Considerations

Assessment of Embedded Fans is more clear when analyzing applications rather than by type of fan since the energy use, costs and constraints are based on the underlying HVACR and water heating equipment and on the use of a fan within the product rather than on the type of fan itself.

These applications include:

- Air-cooled Chillers
- Central Station Air-handling Units and Related Air Distribution Equipment
- Commercial Unitary Air-conditioners and Heat Pumps
- Commercial Boilers or Water Heaters
- Replacement Fans

These applications exclude products covered by Title 20 or Title 24, Section 110.2 (c) where the embedded fans are clearly included in the energy standard for the total product and where there are no additional fans not clearly covered.

AHRI's approach is to:

1. Describe the potential energy savings estimated by DOE in the Energy Conservation Standards for Commercial and Industrial Fans rulemaking (as corrected by AHRI and adjusted to the California market);[7]
2. Assess the market and other constraints to achieving those savings, including market forces that are already achieving the potential;
3. Identify other barriers to substituting fans; and
4. Review the likely consumer economics (as corrected by AHRI and adjusted for California electricity prices)[8]

[7] US Department of Energy, Docket EERE-2013-BT-STD-0006-0192, cif-Noda_3_nia.xlsm. See Methodology Appendix A

[8] US Department of Energy, Docket EERE-2013-BT-STD-0006-0192, cif-Noda_3_lcc.xlsm. See Methodology Appendix B

<u>Applications</u>

1. Air-cooled Chillers

Axial panel or condenser fans in air-cooled refrigeration systems are used to move ambient air over condenser coils. Most of the major air-cooled condenser applications (residential and commercial unitary air-conditioners and heat pumps[9], refrigeration systems, etc.) are covered directly by product-based DOE minimum energy efficiency standards that include the energy of the panel fan. Air-cooled chillers are not covered by DOE and, thus, were considered by DOE in the commercial and industrial fan rulemaking as a potential source of energy savings.

DOE projected that the potential national savings from Panel Fans, including both air-cooled chillers and standalone panel fans, was 1.33 quads over 30 years. However, DOE made somewhat offsetting errors in its inputs on air-cooled chillers and used the incorrect energy savings from the LCC model to project the effects of a standard on OEM Panel Fans used in air-cooled chillers. Corrected for these errors, the total annual national energy savings available from OEM panel fans in air-cooled chillers are 0.08 quads (not including potential savings from approximately 100,000 annual shipments of non-embedded axial fans, applications unknown). The California portion would be approximately 0.01 quad for the embedded air-cooled chiller panel fans over 30 years, again under the DOE assumptions.

1. DOE assumed shipments of 12,759 air-cooled chillers. Based on data from the Current Industrial Reports (CIR), air-cooled chiller shipments averaged 27,000 units from 1994 through 2010 (the last year the report was produced).[10] This is consistent with unpublished shipment data collected by AHRI from its members.
2. DOE assumed 14 panel fans per air-cooled chiller. This would be the equivalent of a 200-ton chiller. The weighted average shipments of air-cooled chillers is under 100 tons, and seven panel fans per chiller is a more reasonable estimate.
3. Implicit annual energy consumption per OEM panel fan in the LCC model is 2,504 to 2,260 kWh/year (from EL0 to EL6), not the 11,563 to 4,002 kWh/year in the NIA, with the LCC consumption transferred to the NIA.
4. California portion assumed at 12%.

However, virtually all air-cooled chillers are sold as integrated units containing both the compressor and the condensing unit.[11] These chillers packages are subject to ASHRAE 90.1 EER and IPLV energy consumption limits, which are included in the equipment portion of California Title 24, Section 110.2-D. Integrated units are optimized to meet the ASHRAE 90.1 standard and any requirement placed on a single component will cause re-optimization (almost always at a higher cost) around a different configuration of compressor, coil, fans, etc. The energy efficiency standards are equipment, not application based (akin to Title 20 standards) and, thus, cover equipment used in both new construction, renovations and as replacements for equipment in existing buildings.

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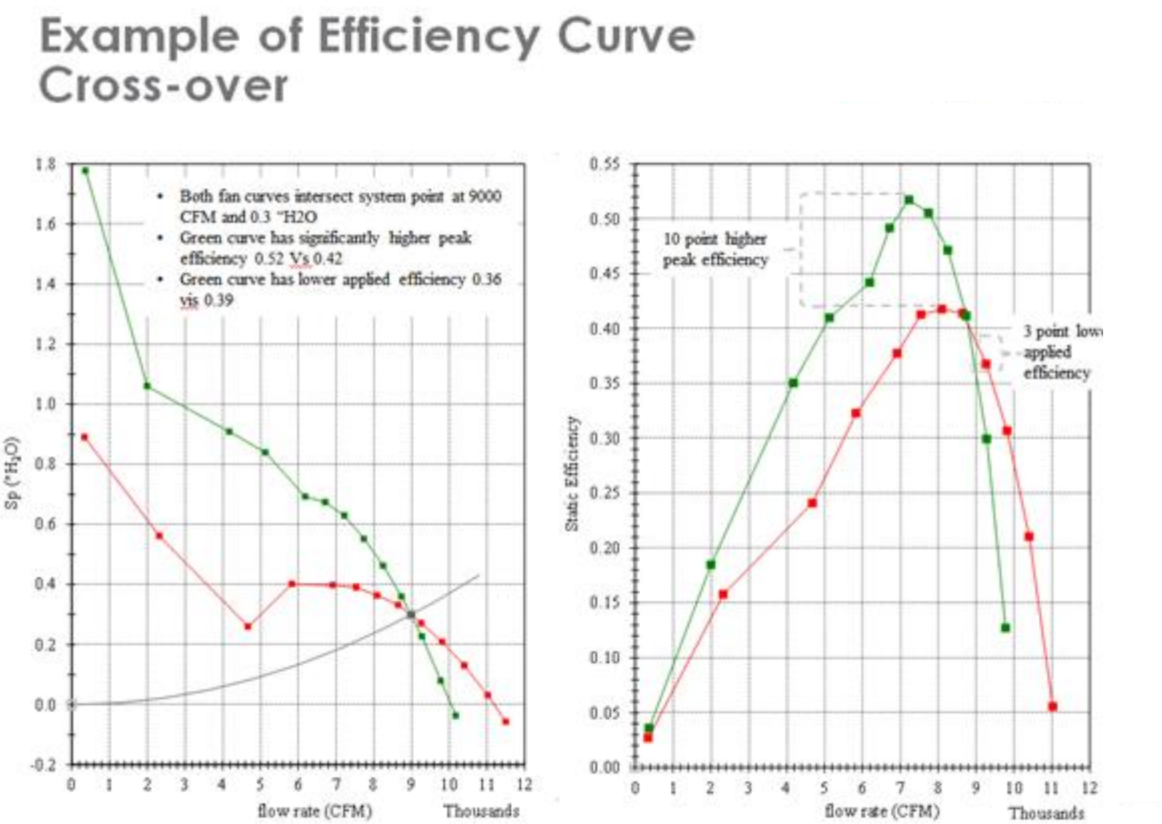
[9] The panel fan in a heat pump's heating mode technically functions as the evaporator fan but is most easily thought of as a condenser fan since it serves as the condenser fan in the cooling mode.

[10] US Census Bureau, Current Industrial Reports, MA35M/MA333M, Refrigeration, Air Conditioning and Warm Air Equipment

[11] AHRI survey of members, unpublished

Further, a “more efficient” fan may not yield a more efficient unit if the fan curve performance does not meet the likely operating conditions. In a specific example, there may be a “higher efficiency” fan that does not work as well as the lower efficiency fan in a specific condenser fan application because of where the fan actually operates. In this case, the red fan offers better performance relative to the green fan, even though the green fan has a peak efficiency well above the red one. The fan operates based on flowrate and static pressure and, in this case, the red fan is the better fan. This is a very specific example that indicates the designer needs to be extremely careful in applying Embedded Fans into a product (Figure 1).

Figure 1: Condenser Fan Operating Characteristics



Source: Courtesy of Ingersoll Rand

As a result, the energy savings from a fan component standard on embedded panel fans in air-cooled chillers is likely to be very close to zero both for individual building owners and for California in total.

Mandating alternative Panel Fans as spare parts in repairs would also be impractical. It is possible to substitute a new condenser fan into an existing air-cooled chiller but that does not necessarily yield any gain in chiller efficiency. Changing the fan may result in a different balance point for the fan/motor. As such it may actually increase the energy consumption because the condenser system is based upon heat exchanger size, heat exchanger pressure drop, system pressure drop and fan energy consumption. A replacement fan with a different efficiency profile may be less efficient at a certain static pressure than the existing design fan. A simple replacement with a fan with higher peak efficiency may not have a higher efficiency at its actual operating point. In addition, there may be size and other constraints on the use of alternative condenser fans.

The economic effects on end consumers of a Panel Fan standard for embedded condenser fans in air-cooled chillers will be an increased per fan cost of $173 (or 10% increase over current price) to the end customer with no expected energy savings and, therefore, no operating cost reduction.[12]

2. Central Station Air-handling Units and Related Air Distribution Equipment

Centrifugal fans are used in central station air-handling units and related distribution equipment to move conditioned air around in a building. The central station air-handling unit passes return air over heating and/or cooling heat exchangers and, as an option, mixes-in outdoor air for ventilation purposes. Central station air-handling units will typically have housed centrifugal fans or unhoused plenum fans for supply air and may or may not have an exhaust/return air fan and economizer option.

DOE estimated that the 30-year national energy savings from supply and exhaust/return air applications in commercial air conditioning equipment not covered by Title 20 would be 0.76 quads for unhoused centrifugal fans and 1.59 quads for housed centrifugal fans. Central station air-handling units make up virtually all the projected savings in unhoused centrifugal fans (Table 2). With the corrections to DOE's assumptions, the actual national savings are likely to be less than 0.6 quads and 0.07 quads in California.

Table 2: Projected National Potential Energy Savings

Type	Application	DOE (30-year Quads)	AHRI (30-year Quads)
Housed Centrifugal	Central Station Air-handling Units	0.67 quads	0.19 quads
	Unitary Exhaust and Return Air	0.92 quads	0.16 quads
	Total	1.59 quads	0.35 quads
Unhoused Centrifugal	Central Station Air-handling Units	0.76 quads	0.23 quads
	Grand Total	2.35 quads	0.58 quads

Source: DOE cif_noda_3nia.xlsm, AHRI from revisions per Appendix A

[12] For LCC methodology, see Appendix B

These are the maximum potential energy savings projected by DOE and do not include any of the effects from market forces or from the fan power limits in Title 24, Section 140.4 (c). The corresponding California potential savings are (Table 3):

Table 3: Projected California Potential Energy Savings

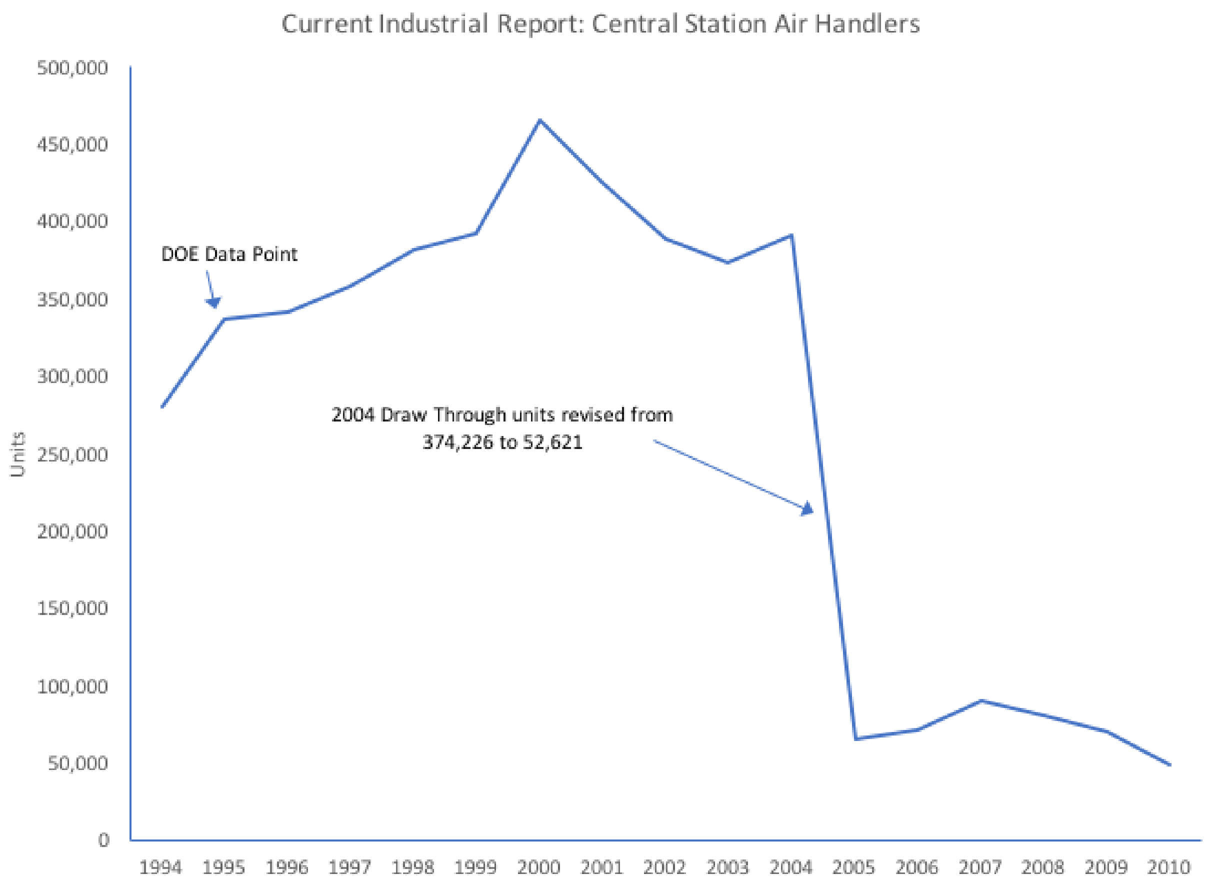
Type	Application	DOE (30-year Quads)	AHRI (30-year Quads)
Housed Centrifugal	Central Station Air-handling Units	0.08 quads	0.02 quads
	Unitary Exhaust and Return Air	0.11 quads	0.02 quads
	Total	0.19 quads	0.04 quads
Unhoused Centrifugal	Central Station Air-handling Units	0.09 quads	0.03 quads
	Grand Total	0.28 quads	0.07 quads

Source: DOE cif_noda_3nia.xlsm, AHRI from revisions per Appendix A

The major reason for the dramatic drop in savings from central station air-handling units is that DOE used old, incorrect data to project the number of central station air-handling units shipped. DOE included in its analysis an estimate that there are 330,402 central station air-handling units shipped.[13] This is based on an Arthur D. Little study (Opportunities for Energy Savings in the Residential and Commercial Sectors with High-Efficiency Electric Motors. December 1999. Prepared for the US Department of Energy by Arthur D. Little, Inc.) which, in turn, relied on data from the US Department of Commerce, Census Bureau, Current Industrial Reports MA35M (CIR) for 1995. Arthur D. Little correctly used the data presented at that time in the CIR. However, there seems to have been a reporting error for product code 35851-13 central station air-handling units (motor driven fan type) – draw through, reported as 315,723 units in 1995, the year referenced by Arthur D. Little. This product category was revised for 2004 and subsequent years in the CIR for 2005, with 2004 shipments for that product code (now 3334151117) reduced from 374,226 to 52,621. The shipments for total central station air-handling units remained in the range of 48,000 to 90,000 units until 2015, when the CIRs were discontinued (Figure 2). AHRI collects but does not make public shipment data for central station air-handling units and the AHRI data is consistent with shipments in the high tens of thousands of units per year.

[13] US Department of Energy, Docket EERE-2013-BT-STD-0006-0192, cif-Noda_3_nia.xlsm, cell H44

Figure 2: Reported US Shipments of Central Station Air-handling Units



Source: US Department of Commerce, Census Bureau, Current Industrial Reports MA35M/MA333M

AHRI data shows a decline in central station air handling units from a peak in 2007 through 2016. Based on the declining trend in shipments and the average of shipments in the CIR from 2004 through 2015, a reasonable estimate of future central station air-handling unit shipments would be approximately 65,000 units per year, nationally.

The revised central station air-handling unit estimate of 0.58 quads nationally and 0.07 quads in California almost certainly overstates the actual potential savings that would occur through a fan standard. Fans used in central station air-handling units are subject to the total fan power limitations of Title 24, Section 104.4 (c) for units used in new construction and renovation. These restrictions put substantial pressure on building designers to limit fan energy use and the effects of these limitations are not adequately captured in the Base Case efficiency assumptions in the DOE models, which are built around national averages where the full effect of the ASHRAE 90.1 standards (implicit in the Title 24 limitations) do not occur.

More importantly, central station air-handling units are used in a building design and construction process that encourages the use of cost effective, higher efficiency solutions. A central station air-handling unit is part of a total (applied) system made up of multiple components (chiller, air handler, air distribution boxes, piping, pumps, ducting, controls) that need to be specified individually and sized to meet the requirements of a specific building. As a practical matter, this design process requires the skills and expertise of professional engineers. Moreover, the California Title 24 Design Review requirement includes the requirement for participation by a professional engineer. Therefore, the expertise to review and optimize fan and other mechanical systems is required in all new nonresidential construction and renovations in California.

In addition, the vast majority of buildings using applied systems are occupied by owners; 73-percent nationally and 82-percent in the Pacific region of buildings with chilled water or other applied cooling systems.[14] The owner/occupants of these buildings have the incentive to make their own assessments of the tradeoffs between first and operating costs. Through the presence of professional engineers and the California design review process, these owner occupants have the necessary technical and economic information to inform those decisions.

Non-regulatory incentives are also playing a major role in promoting more efficient fans and other systems. This includes the LEED and CALGreen processes, which continues to grow as a portion of commercial buildings and where California has been a considerable success story. This process shows the value of non-regulatory incentives and programs for commercial buildings of the type using applied HVAC systems. In addition, International Green Construction Code and ASHARE 189.1, all of which show the effects of market and other regulatory activities on the building industry.

Where there is data available, the results show that owners are making investments in higher efficiency systems. In an AHRI survey of its members, they report that over 75% of central station air-handling units with variable air volume (VAV) systems have fans with variable speed drives. This is an optional advanced, energy saving technology relative to other fan control systems and indicates that market forces are leading to very significant discretionary higher efficiency choices. The energy effects of variable speed drives were also not fully incorporated in the DOE energy analyses, one of many factors overstating the actual savings potential.

Establishing a mandatory minimum fan efficiency standard will distort this market and will principally affect those buildings where higher efficiency systems, for one reason or another, are either not technically appropriate or do not offer lower life cycle costs.

DOE forecasts that centrifugal housed and unhoused fans have favorable economics at a Standards Efficiency Level 5 (EL5) (Table 4):

Table 4: DOE LCC Estimate - Centrifugal Fans – EL5

	LCC Savings	Payback Period	% With Net Cost
Housed Centrifugal	$310	5 years	22.3%
Unhoused Centrifugal	$280	3 years	5.0%

Source: DOE cif_noda_3.xlsm

[14] US Energy Information Agency, Commercial Buildings Energy Consumption Survey, 2012, note, the Pacific region sample starts to get small and the national averages may be more representative

While this is the only data available on fan economics, it is not actually germane to the question of a standard on Embedded Fans in California:

- Considers all fans, not OEM fans,
- Uses an incorrect methodology to estimate per fan costs of engineering, testing and other redesign costs and investments, and
- Uses national, rather than California electricity costs.

Correcting for these factors yields an increase in first costs of 12-percent for unhoused and 68-percent for housed centrifugal fans and negative LCC savings, even at a proxy for California TDV electricity rates (Table 5). There are almost certainly additional mistakes in the allocation of fans by fan type in the NIA and LCC analyses, yielding the significant difference between housed and unhoused centrifugal fan economics. There are no obvious technical or application issues that would lead to these differences. This highlights the complexity and lack of transparency in the DOE analysis. In any event, even before considering the many additional errors in assumptions commented on by AHRI and others in the DOE analysis relating to testing, certification and costs from accommodating proposed larger fan wheels and on the real effects of market forces and Title 24 fan horsepower limits, there is no likely consumer benefit from a component fan standard for embedded fans in central station air-handling units. For example, central station air handling units are tested in-accordance with AHRI 430. To require the fans to be additionally tested in-accordance with AMCA 210 adds additional costs to a customer. There are also costs associated with dynamic and seismic testing.

Table 5: AHRI Corrected LCC Estimate - Centrifugal Fans

	Increased Consumer First Cost	LCC Savings – Average California	LCC Savings – 20% TDV Proxy
Housed Centrifugal	68%	($576)	($473)
Unhoused Centrifugal	12%	($92)	($8)

Source: DOE cif_noda_3.xlsm corrected by AHRI as per Appendix B

In summary, the Title 24 fan horsepower limitations, the California design review process and the market forces result in the use of efficient fans for central station air-handling units. Additional component performance standards will not be cost effective to consumers in general and will mostly target buildings where there is good reason not to use a more efficient fan. The actual energy savings potential is low and the disadvantages to building owners are high.

3. Commercial Unitary Air-conditioners and Heat Pumps

The energy used by supply and condenser (panel) fans in commercial unitary air-conditioners and heat pumps is included in the IEER calculations and these products are covered by Federal standards and California Title 20. As the ASRAC Working Group concluded, it is not appropriate to create a testing and standard framework for covered products.[15] Exhaust and return air fans, however, are not covered by the Title 20 standards.

Exhaust and return air fans are optional equipment used to control pressurization in commercial buildings, especially those with outside air economizers. These outside air systems can use a centrifugal or axial exhaust/return air fans. Specific unit designs are based around either return or exhaust air fans. Both are rarely required.

Commercial unitary equipment falls into two distinct segments: light and heavy commercial. Light commercial systems are generally lower capacity, are used in less complex applications and have or are specified with fewer options. Heavy commercial unitary systems can approach the complexity of applied, chiller systems and are offered with a wider variety of options. In practice, exhaust/return air fans and economizers are commonplace in heavy commercial and have been rare in light commercial equipment.

DOE estimated, in its supporting documents to the ASRAC Working Group, that improving the energy efficiency of exhaust/return air fan systems in rooftop air-conditioners could result in 0.92 quads of energy saved on a national basis.[16] This would translate into 0.11 quads of energy saved in California.[17] However, DOE has not accurately reflected the segmentation between light and heavy commercial equipment and has, thus, overestimated the portion of rooftop air-conditioners with exhaust/return air fans. AHRI has surveyed its members on the percentage of commercial rooftop air-conditioners and heat pumps with exhaust/return air fan systems and reports the percentage of rooftop units with exhaust/return air fans (

[15] ASRAC Working Group, Recommendation 3. California Title 24 110.2 (c) extends the coverage of ASRAC Working Group Appendix B to all Air-cooled Commercial Air-conditioners and Heat Pumps beyond 760,000 Btu/h.

[16] US Department of Energy, Docket EERE-2013-BT-STD-0006-0192, cif-Noda_3-nia.xlsm. See Methodology Appendix A

[17] Based on 12% conversion from US to California, see Methodology Appendix

Table 6):

Table 6: Shipments of Rooftop Units with Exhaust or Return Air Fans

		DOE	AHRI
>=65,000 Btu/h and <135,000 Btu/h	Return	50%	5 to 7%
	Exhaust	0%	
>=135,000 Btu/h and <240,000 Btu/h	Return	50%	7 to 10%
	Exhaust	0%	
>=240,000 Btu/h and <760,000 Btu/h	Return	50%	60 to 75%
	Exhaust	100%	
>=760,000 Btu/h	Return/Exhaust	NA	80 to 90%

Source: AHRI Survey of Manufacturers

Correcting for the proper exhaust/return air fan percentages yields a national 30-year energy savings of 0.16 quads and 0.019 quads in California, with these savings almost exclusively coming from heavy commercial rooftops. The possible energy savings of 0.019 quads is split approximately evenly between units in new construction and replacement units.

As with central station air-handling units, new construction in California is subject to the Section 104.4 (c) fan energy limits as well as the design review processes of Title 24. Heavy commercial rooftop units, also like central station air-handling units, are typically used in more complex buildings with professional engineers involved in the design process. This segment is already adopting more advanced energy savings systems. For example, over 70% of the supply fans in heavy commercial rooftops have variable speed drives, a more expensive and more efficient option. Market forces, other incentives and the fan horsepower requirements are already leading to the use of efficient equipment where it is cost effective. Therefore, the available energy savings that also show consumer benefits are almost certainly less than forecast even by the revised DOE estimates. The 0.009 quads of savings forecast in new construction is likely to be considerably less in practice.

The ease of moving to a different exhaust/return air fan configuration depends upon the overall design for the rooftop unit. For fans inside the basic structural unit, increasing the size of a centrifugal fan wheel would require a redesign and an increase in the size of the fan section of the rooftop unit and, often, of the rooftop unit as a whole. This would add to costs, affect shipping and, in replacement applications, usually result in the added cost of a curb adapter. In addition, any change in the size, configuration or structure of the rooftop unit, or any other tested and certified product would entail retesting for seismic certification.

The user economic analysis for housed centrifugal fans described in Item 2. Central Station Air-handling Units (above) and in Table 5 includes the effects on exhaust/return air fans. It is not possible to disaggregate the DOE LCC analysis to distinguish between various types of housed centrifugal fans. The negative savings in LCC will also apply to exhaust/return air fans in rooftop air-conditioners.

4. Commercial Boilers and Water Heaters

Neither fans embedded in commercial boilers nor commercial waters were recommended by the DOE ASRAC WG to be excluded from the scope of the test procedure and energy conservations, even though the metric for commercial water heaters includes the Embedded Fan's energy. Commercial boilers, on the other hand, are examples of HVACR products with an embedded fan where the fan power is not covered by the product test procedures and efficiency standards. The actual energy savings potential from a standard on the boiler or water heater fan itself are likely to be very small, both to the individual building owner and to California. In addition, the complexity of integrating a new fan system into a boiler or water heater is considerable, raising costs, ultimately passed on to consumers. A more appropriate approach would be to work through the commercial boiler's test standard's consensus process and find a path to incorporate the electrical energy used in a boiler system into the test procedure and the equipment ratings and to exclude fans embedded in commercial water heaters entirely from the California rulemaking.

Fans are used in commercial boilers and water heaters either to create forced draft for high efficiency gas-fired systems or to provide forced draft combustion air for oil or other systems with non-atmospheric burners. As such, the fan is an integral part of the combustion system. The burner and fan configuration affects the combustion efficiency, emissions and safety system of the boiler or water heater. A different fan cannot be introduced into the boiler or water heater without redesign, if there is a size or other physical change, and without significant retesting. This would make substitution of different fans completely impractical as replacement parts and raises the costs and complexity of switching from one fan to another.

The commercial boiler and water heater industries are small, with annual shipments of approximately 20,000 boiler units and under 2,000 hot water supply boilers nationally per year, which limits both the total potential for energy savings and the ability to recover any necessary redesign, testing and certification costs.[18] There is no estimate, at this time, of either the energy used by fans in commercial boilers and commercial water heaters or the potential for energy savings. The fans used in commercial storage water heaters are virtually all under one horsepower. Fans only exceed one horsepower in commercial boilers and hot water supply boilers with capacities exceeding two million Btu/h. For hot water supply boilers, according to the DOE estimates, approximately 12-percent of models exceed two million Btu/h, or approximately 250 boilers per year nationally.[19] The shipments for commercial boilers and hot water supply boilers are somewhat lower than those for air-cooled chillers; commercial boilers have only a single fan, while air-cooled chillers have multiple fans; and panel fans in air-cooled chillers are usually one to two horsepower or more. Therefore, the potential energy savings from any redesign of commercial boiler fans are almost certainly well less than those for air-cooled chillers, probably one-fifth or less since the average air-cooled chiller has seven fans and a

[18] US Department of Energy, Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Packaged Boilers, March 4, 2016, Table 9A.2.2 for commercial boilers. EERE-2014-BT-STD-0042-0040, p.15, AHRI comments on Commercial Water Heaters correcting DOE shipment levels for hot water supply boilers.

[19] US Department of Energy, Technical Support Document: Energy Efficiency Program For Consumer Products and Commercial and Industrial Equipment: Commercial Water Heating Equipment, April 18, 2016, Figure 3.10.26, p.3-29

boiler or water heater has only one. On that assumption, the potential 30-year electricity savings from commercial boiler fans would be on the order of 0.016 quads nationally and 0.0019 quads in California.

Neither AHRI nor DOE has estimated the potential effects on consumer economics. Given the small degree of energy savings and the small shipment volume relative to the significant redesign, testing and certification costs associated with incorporating a new fan, it is highly unlikely that there are significant positive consumer benefits.

Fan energy use in commercial boilers is, thus, a topic that is much better addressed in the context of general test procedures and standards, either through DOE efficiency standards or through the ASHRAE standards consensus process.

5. Replacement Embedded Fans

Replacement fan parts for commercial unitary equipment include supply, return, exhaust and condenser fan blades/wheels, fan motors, fan drives and fan controls. In some cases, the entire fan assembly will need to be replaced. For all practical purposes, these parts and the complete assembly need to be replaced by an identical product with the same performance as the original one. In many instances, these parts are not fully classified as "fans" in the ASRAC definitions. Individual impellers or fan blades are not considered fans.

Constraints on substituting a different fan as a replacement part include:

- Size of the fan housing and other physical factors such as adequacy of the supporting structures
- Performance characteristics of the original fan matched to the application needs
- Testing and certification requirements on the original product:
    - Energy performance
    - Capacity
    - Safety of heating elements under different air flows
    - Structural characteristics under seismic conditions

There are third-party suppliers of replacement fan blades for some condenser (panel) fans. While these exist, they are designed to be direct substitutes and are not intended to change the air flow and efficiency of the original equipment.

Testing and certification are huge issues for replacement parts. One manufacturer estimates that it would take three full years occupying the full capacity of all its testing labs to certify a new fan for performance certification and for safety testing of heating elements across its entire legacy product line. As a result, this manufacturer keeps an inventory of original equipment replacement supply fans for its complete legacy product line or it has arrangements with contract manufacturers to supply legacy fans and fan parts.

There is a potential concern that loose fan parts intended to be used as replacement parts will create a loophole to evade a standard on non-embedded fans. This concern is much more theoretical than real. If someone buys loose parts and fabricates a product for later sale, then that person has created an article of commerce subject to other certification and testing standards. The alternative use, fabricating an air handling unit on site from loose fan parts is a theoretical possibility but has been extremely rare in practice. Virtually all nonresidential buildings without unitary air-conditioners (that would never be field fabricated from parts) are designed and specified by licensed engineers and inspected by California building inspectors. This would be sufficient deterrent to non-compliant field fabricated systems.

The potential opportunity for energy savings from replacement HVACR and water heating fans is not known, even assuming such replacements were practical. AHRI has not assessed the total size of the replacement HVACR and water heating fan parts market and DOE has not estimated the potential energy savings from replacement parts.

To prevent misuse of replacement parts, a more useful approach is to label the parts as “for replacement only” and to leave them otherwise unregulated.

Technical Feasibility

Manufacturers optimize the efficiency of their products by making trade-offs between various options taking into consideration the energy conservation standards for the complete product and the performance required by consumers. Imposing efficiency standards on components narrows the manufacturer’s choices to optimize complete and complex products. It can lead to an overall higher cost without providing any energy saving. This undermines the very principle of the life cycle cost analysis of complete products that regulatory agencies perform to prove that an efficiency standard is technologically feasible and economically justified. Application-based fan regulation will lead to two options if a desired fan is not compliant at the required air flow:

- Replace it with a compliant fan that is typically larger and more expensive; or
- Add static pressure to the application at the required air flow and therefore improve efficiency until compliance occurs but actually consumes more energy.

Such unnecessary regulation will lead to larger fans and larger system size with associated increase in costs and building installation problems as well as greater energy use due to higher static resulting from compliant fan application points.

Statewide Energy Savings

AHRI estimates that the total theoretical potential energy savings in California for Embedded Fans sold over a 30-year period is on the order of 0.1 quads of energy. However, these savings will likely be less for the reasons already stated, such as widespread use of variable speed drives.

Cost-effectiveness

Regulation of Embedded Fans is not cost effective. Corrections to the DOE analysis and narrowing the focus to California yields an increase in first costs of 12-percent for unhoused and 68-percent for housed centrifugal fans and negative LCC savings, even at proxy California TDV electricity rates.

Environmental Impacts/Benefits

There are no environmental benefits of regulating Embedded Fans. An environmental impact of the regulation if Embedded Fans are not excluded, would be replacing entire units, rather than fan components on installed units requiring repair, which stands to generate a large amount of unnecessary waste without any proven energy savings.

Impact on California's Economy

Regulating Embedded Fans would have a significant negative impact on California's small businesses and economy as these consumers would be faced with enormous costs for new HVACR and water heating equipment for both new projects and where replacement fans would no longer be available.

Consumer Utility/Acceptance

This proposal does not address consumer expectancy or the effects the proposal may have on the consumer's behavior.

Manufacturer Supply Chain Timelines

Should California choose to enact a stand-alone fans regulation, AHRI recommends two years from the date of publication of the final rule for manufacturers to list product, and an additional three years for compliance with new standards. This timeline is crucial to enable an entire industry to come into compliance with new test procedures, calculation procedures, listing, labeling, and enforcement.

Other Regulatory Considerations

As there is an active federal rulemaking underway, any California-specific commercial and industrial fans regulation is at risk of federal preemption. Further, many systems that include commercial and industrial fans and blowers are already subject to DOE's energy conservation standards. The energy efficiencies of these systems are determined through product performance rating standards and method of testing standards. Product categories enforced by the federal government are subject to federal standards and are preempted from state regulation. This includes the entire piece of equipment, including all components. Should California proceed with a fans rulemaking, *all* fans in *all* federally regulated products must be clearly and completely excluded.

Conclusion

In summary, regulating fans and blowers embedded in residential, commercial or industrial HVACR and water heating equipment (Embedded Fans) simply does not make sense from a technical or regulatory stand point. Regulation of Embedded Fans is impractical because the standalone performance is different from the fan or blower performance within a system. Further, CEC should not duplicate federal regulations currently under development. However, should CEC decide to proceed, it should propose a limited, more meaningful scope and definition of fan, to enable requirements for which compliance can be applied and performance measured. The regulation should clearly exclude from the scope Embedded Fans in equipment regulated by the federal government and the State of California. The focus should be upon the types of stand-alone fans that are testable as applied and which constitute the majority of the energy consumption in buildings.

References

1. AHRI Comments to DOE on CIFB Rulemaking, EERE-2014-BT-STD-0042-0040
2. State of California, Building Energy Efficiency Standards, Article 1, Subchapter 2, Section 110.2
3. US Census Bureau, Current Industrial Reports, MA35M/MA333M, Refrigeration, Air Conditioning and Warm Air Equipment
4. US Department of Energy, Docket EERE-2013-BT-STD-0006
5. US Department of Energy, Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Packaged Boilers, March 4, 2016
6. US Department of Energy, Technical Support Document: Energy Efficiency Program For Consumer Products and Commercial and Industrial Equipment: Commercial Water Heating Equipment, April 18, 2016
7. US Energy Information Agency, Electric Power Monthly
8. US Energy Information Agency, Commercial Buildings Energy Consumption Survey, 2012
9. Email from Patrick Saxton to Everett Shorey, August 22, 2017:

   Mr. Shorey,

   I'm glad the information has been helpful. At this early stage of the Energy Commission process, I suggest using EIA data for the California specific price of electricity. EIA table 5.6.B Average Price of Electricity to Ultimate Customers by End-Use Sector can be found at https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_06_b.

   The proposal could comment on the use of the EIA data for rates, suggest an alternate set of rates, suggest and explain a composite rate based on the commercial and industrial rates, or some combination of these.

   Best regards,

   Pat

Appendices

Methodology Appendix A: Projecting Fan Energy Scenarios

Methodology Appendix B: Estimating Consumer Costs and Benefits

Spreadsheet: cif_noda_3_lcc AHRI.xlsx

Spreadsheet: cif_noda3_nia - corrected fans AHRI.xlsm

Methodology Appendix A
Projecting Alternative Fan Energy Savings Scenarios

Overview and AHRI Approach

The US Department of Energy, in support of the ASRAC Fan Working Group, (Docket EERE-2013-BT-STD-0006), prepared a National Impact Analysis (NIA) model (Docket EERE-2013-BT-STD-0006-0192). This model is designed to project, among other things, the amount of energy (in source quads) that would be saved from a particular set of engineering options (Energy Levels or ELs). AHRI modified the NIA by changing shipment or other assumptions to test the effects of those assumptions. AHRI left the basic structure of the model constant and did not change future shipment projections, discount rates, future fuel costs or the imported results from the Life Cycle Cost (LCC) model (with the exception of Panel Fans).

AHRI is neither commenting on nor endorsing any of the assumptions in the NIA. It is using the NIA as the basis to provide initial estimates of the possible effects of changes in assumptions.

Changes – NIA Shipments

In order to test the effects of changes in base case shipments, AHRI:

1. Modified sheet "Shipments 2012" for each analyzed product
    a. For Air Cooled Chillers: cells I44:I45, number of units and panel fans per unit
    b. For Central Station Air Handlers: cell H46, number of units shipped
    c. For Commercial Unitary Packaged Air Conditioning and Heating: cells D44:I49, Unit Equipment, Fans per Unit, Percentage Units with Return or Exhaust Fan
2. Recomputed Total Shipments (Cells H8:20 of "Shipments 2012") to reflect changes in assumptions in cells D44:I49 and recomputed percentages by fan type.
3. Transferred the recomputed percentages to sheet "Shipments" Cells E75:81 – PC Market Shares
4. Adjusted the Total Shipments ("Shipments" Cells E65:J65) to reflect the changes in Total Shipments from "Shipments 2012 Cell H20 adjusted by the growth rate from 2012 included in the original model.

Changes – NIA Energy Consumption

NIA Sheet "LCC Inputs"

The "Notes" to this sheet describe the values transferred from the LCC analysis into the NIA. In particular, it describes:

"Energy Consumption:
This table presents the average unit energy consumption in the base-case and in each standards-case considered. For example, based on the LCC sample, in the base-case (i.e. "zero" percent market cut off or EL0), axial cylindrical housed fans meeting EL1 have an average unit energy consumption of 42,982 kWh (THIS MAY CHANGE) per year. In the standards-case EL1, the average unit energy consumption of axial cylindrical housed fans at EL 1 is 22,085 kWh/ year, and there are no more fans at EL0. This is used in the energy savings calculation."

However, the values in these tables do not correspond to the values in the Sheet "LCC Results" of the model cif_NODA_3_lcc.xslm for Retail Price/Total Installed Cost or the implicit energy consumption (First Year Operating Cost divided by average electricity price, even accounting for Monte Carlo differences in those values).

For Panel Fans, cells O32:U38 modified to "OEM, Reference" from the "LCC Results" sheet of the LCC model to reflect that all analyzed Panel Fans are used in OEM applications.

California Adjustment

AHRI assumed that California represents 12% of the total US market. The CEC questioned whether 12% was a correct number. AHRI has no shipment data to support or refute this estimate. The Pacific Census Region contains 16.7% of the commercial building inventory and California is by far the largest state in that region[1]. While building inventory does not equate totally with air conditioner installations, it is a reasonable proxy and 12% is a plausible estimate of California's share of shipments.

[1] US Energy Information Agency, Commercial Buildings Energy Consumption Survey (CBECS), 2012

Methodology Appendix B
Estimating Consumer Costs and Benefits

Overview and AHRI Approach

The US Department of Energy, in support of the ASRAC Fan Working Group, (Docket EERE-2013-BT-STD-0006), prepared a Life Cycle Cost (LCC) model (Docket EERE-2013-BT-STD-0006-0190). The LCC model estimates consumer economics (change in life cycle cost, payback period and % consumers who have negative economics). The calculations take changes in fan costs, grosses them up using estimated markups from manufacturing costs through the distribution channel(s) and estimates the change in the end price to the ultimate consumer. It also estimates potential energy savings over time and discounts that back to a present value of those future savings. The difference between the increased consumer cost and the energy savings represents the change in life cycle cost. AHRI reanalyzed the LCC by considering the effects of fan shipment volumes in the NIA on the amortized costs of fan and OEM conversion costs. AHRI has also made initial estimates of the effects on consumer economics from electricity rates more closely approximating those in California. DOE has not made public the results of the individual Monte Carlo runs, as it has in the past either directly or by providing a model where it is possible to extract those results. Therefore, AHRI is not in a position directly to assess changes in fan technologies or most other input variables.

AHRI is neither commenting on nor endorsing any of the assumptions in the LCC other than those directly referred to in this analysis and AHRI has strongly disagreed with many of its assumptions in the past. It is using the LCC as the basis to provide initial estimates of the possible effects of changes in assumptions.

Changes – Equipment Costs

In assessing the costs of more efficient fans, DOE has recognized that there will be significant costs for fan design, testing, plant conversion and the like. DOE allocates these costs to individual fans by:

- Estimating the total industry-wide costs for fans themselves and also for the OEM (this appears to be a carry-over of the distinction made in DOE's traditional Manufacturer Impact Analysis between costs that are expensed and those that are capitalized)
- Allocating those costs to individual fans by dividing the total industry-wide cost by an estimate of the number of fans produced.

DOE used the number of fans in an AMCA database as the basis for determining the shipments of fans to use as the denominator in allocating total industry-wide costs to individual fans. This is an inadequate approach since the AMCA database is neither comprehensive nor complete. It was not designed to be a proxy for annual shipments. This is particularly an issue since DOE has gone to significant effort to develop actual shipment estimates in the NIA. AHRI has updated the LCC by substituting NIA shipment estimates (corrected by AHRI as described in Appendix A and in the discussions of various HVAC applications). AHRI kept the total industry costs constant as these costs are not volume dependent, rather they are related to the number of manufacturers and the number of fan models.

1. Panel Fans: divided by 180,000 OEM fans vs. 340,000 original NIA
2. Unhoused Centrifugal Fans: divided by 107,000 OEM fans vs. 384,064 original NIA

3. Housed Centrifugal Fans: divided by 50,000 OEM fans vs. 221,684 original NIA

AHRI then multiplied by the incremental markup to reach a revised additional end-user price for an individual fan.

California Electric Rates and TDVs

California analyzes electricity effects using Time Dependent Values (TDVs), which take into account hourly differences in electricity prices and the effects of California climate zones. In general, electricity prices per kWh are higher in California than the national average. Depending on the time of usage, TDV prices may or may not be higher than the average California price. Since Embedded HVAC fans are used in climate control applications that tend to be peak related, a weighted average TDV price for the electricity used by Embedded HVAC Fans will tend to be above the California average.

In principle, it would be possible to compute a weighted average TDV electricity price for Embedded HVAC Fans. In practice, this would be extremely complex, requiring hourly usage patterns by California climate zone and building type. The California Energy Commission has recommended that this analysis is not necessary at this stage in the process of considering fan standards.[2]

In order to capture California effects, AHRI has updated the DOE analysis of estimated end user economics based on:

1. Average California May 2017 commercial electricity prices of $0.1438 per kWh.[3]
2. 20% increase in average California commercial electricity prices to approximate possible TDV pricing.

[2] Email from Patrick Saxton to Everett Shorey, August 21, 2017. "You are correct that docket number 17-AAER-06 is for appliance efficiency regulations and that the TDV metric would not be applicable for any proposals or analysis. The appliance regulations are typically evaluated using site energy and an average California electricity rate"

[3] US Energy Information Agency, Electric Power Monthly, Table 5.6.B