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On Proposal Information on Commercial & Industrial Fans & Blowers

Additional submitted attachment is included below.

Proposal Information Template –

Docket Number 17-AAER-06, Commercial & Industrial Fans & Blowers

2017 Appliance Efficiency Standards

Michael L. Wolf, Greenheck Group, 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 report specifically covers Commercial & Industrial Fans & Blowers.

[Please keep the description brief. The proposal shall include all of the following sections, as described in this template:

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

Product/Technology Description

Fans and Blowers use a power-driven rotating impeller to move air. The impeller does work on the air, imparting to it both static and kinetic energy, which vary depending on the fan type[1]. Refer to Chapter 21 of the 2016 ASHRAE Handbook on HVAC Systems and Equipment for a complete overview of the products and technologies as part of the proposals the Subject regulation. From a regulatory perspective, the fans described above are often referred to as "stand alone fans".

Equipment that performs heating, cooling, humidification and/or dehumidification processes often incorporates one of more fans to operate. Examples include air conditioning equipment, furnaces, air handlers, make-up-air equipment, energy recovery equipment, and boilers. Again, refer to the 2016 ASHRAE Handbook on HVAC Systems and Equipment for a more complete overview of the products and technologies. From a regulatory perspective, fans used in the equipment described above are often referred to as "embedded fans".

Overview

When considering a regulation to reduce energy for commercial and industrial fans and blowers, it is important to consider that the end consumer (i.e. building owner or facility manager) often has little knowledge or influence over the buying decision for the product. In the case of commercial and industrial fans and blowers the key stakeholders include:

1. **Owners**
    - Establish building needs and end use objectives.
2. **Architects and Design Engineers**
    - Develop designs and specifications to meet project objectives and compliance with building and energy codes. Energy consumption may or may not be an important consideration of the project.
3. **General Contractors and Sub-Contractors**
    - Work to purchase and install equipment and components that meet specifications of the architect and design engineer. Contractors are usually responsible for assuring equipment, components and installation comply with building and energy code requirements.
4. **Manufacturers**
    - Work to design and manufacture equipment and components that minimize energy consumption in a cost-effective manner and create a preference for their products in the market.

Regulation that can leverage the needs of these stakeholders from the top down will ultimately drive maximum energy savings.

When considering the market dynamic described above the best way to maximize energy savings for commercial and industrial fans and blowers is to focus first on the overall system that the fan is being used (i.e. building) and then the equipment in the system (e.g. air-conditioner, air handler, furnace) and finally down to the product (e.g. fan or blower) in the equipment &/or system.

This proposal draws from personal experience and company insights. This proposal is also intended to build on, and provide additional insight as it relates to work and proposals from:

1. Air Movement and Control Association (AMCA)
2. Air Conditioning Heating and Refrigeration Institutes (AHRI)
3. Appliance Standards Awareness Project (ASAP)
4. Northwest Energy Efficiency Alliance (NEEA)
5. Natural Resources Defense Council (NRDC)
6. Energy Solutions (representing CA Utilities)
7. U.S. Department of Energy (DOE) Appliance Standards Regulatory Advisory Committee (ASRAC)

Table 1: Summary of Proposal

Topic	Description
Description of Standards Proposal/Framework of Roadmap	See items 1 through 3 below.

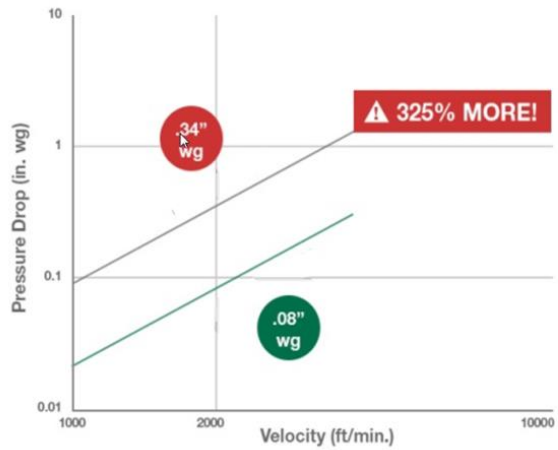
Technical Feasibility	See items 1 through 3 below. This proposal will create regulatory requirements that will leverage natural market behavior to reduce fan power consumption through better fan application and selection as well as improve product designs by manufacturers.
Energy Savings and Demand Reduction	We have conducted analysis at a national level and have the ability to conduct a more focused analysis on products that have shipped into CA. We will be glad to provide further details upon request and under the protection of a Confidentiality Agreement.
Environmental Impacts and Benefits	I am not aware of any environmental impact either positive or negative resulting from the proposed regulation.
Economic Analysis	We have conducted a preliminary analysis at a national level and have the ability to conduct a more focused analysis on products that have shipped into CA. We will be glad to provide further details upon request and under the protection of a Confidentiality Agreement.
Consumer Acceptance	I expect this regulation to meet with general acceptance in the market place. As with all regulation of this type, I expect products that comply with the regulation will be larger and more expensive than product typically being used today.
Other Regulatory Considerations	This regulation will relate closely to ASHRAE 90.1, 189.1, IECC and IgCC. This regulation may also be harmonized with CEC Title 24. I anticipate that future DOE regulation may ultimately pre-empt this regulation.

When considering regulation that will drive a reduction of energy for commercial and industrial fans and blowers, regulatory proposals need to prioritize and assure harmonization of regulatory requirements as follows:

1. ***Regulation of Ventilation Systems (e.g. ASHRAE 90.1, IECC, CEC Title 24)***

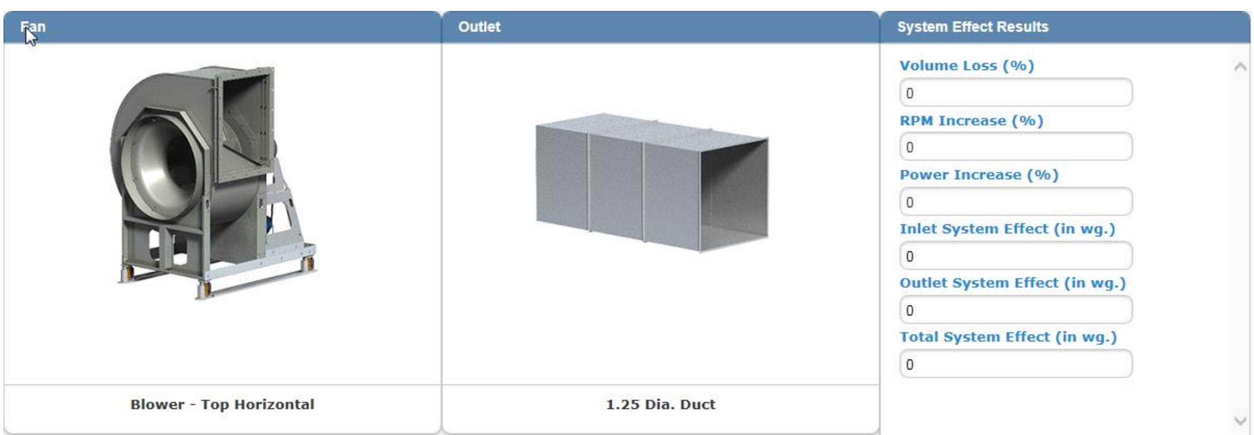
   Energy Codes such as CEC Title 24, the ICC International Energy Conservation Code (IECC) and Energy Standards such as ASHRAE 90.1, are examples of regulations that establish requirements for HVAC energy usage in non-residential buildings. These regulatory requirements are the most effective mechanism to drive energy conservation because they drive positive and collaborative behavior by everyone who may impact power consumption. This includes the building owner, building designer and manufacturer.

As it relates to reducing fan energy, consider that many ventilation designs do not accurately account for the pressure drop of components such as grilles, dampers and louvers. The graph below shows the comparable pressure drop of two dampers of the same size and airflow.



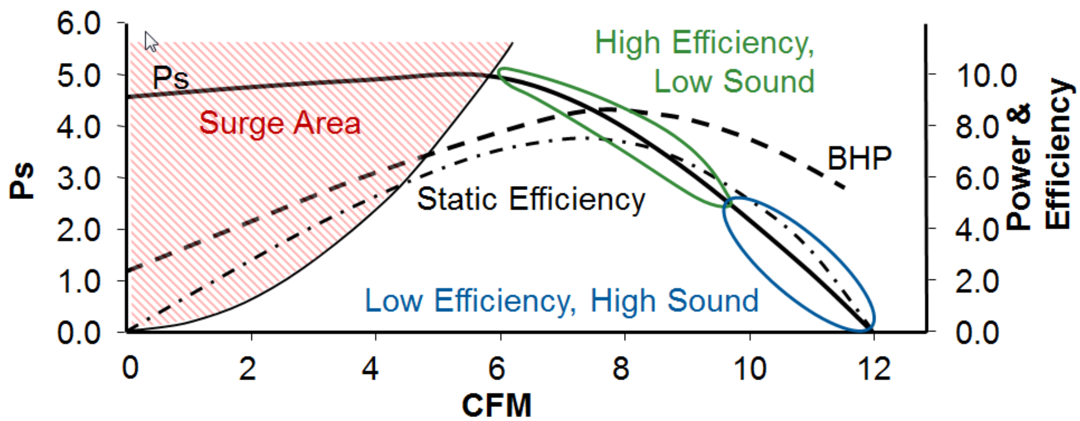
It is intuitive that a damper with 325% more pressure drop will result in a significant increase in fan power consumption. Failure to accurately account for the pressure drop of specific components, such as dampers, will be compensated for in the fan selection. The result will be a fan that is under-optimized for the application and will likely require significantly more power consumption than necessary to meet the airflow requirements of the system.

Fan inlet and outlet conditions can also significantly increase pressure drop and are often not accounted for in the system design and/or fan installation. The diagrams below demonstrate the impact elbows on the inlet and outlet of a centrifugal blower can have on a fan's energy consumption.



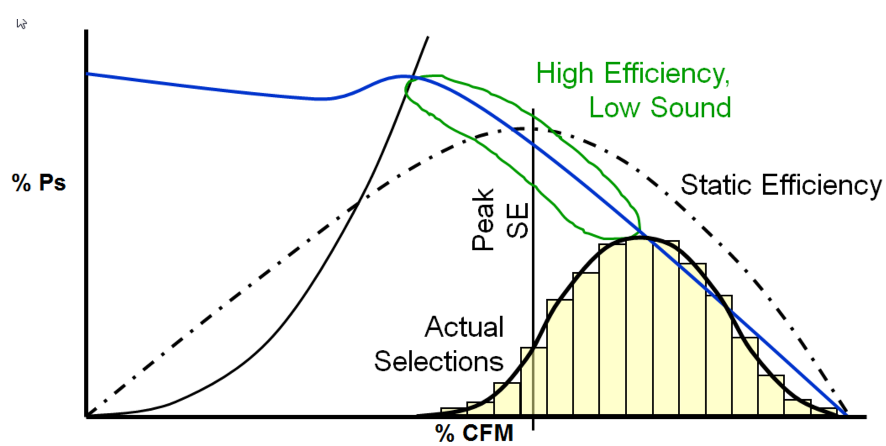
In this example, adding an elbow to the inlet of the fan and replacing the straight duct on the discharge of the fan with an elbow increases the Pressure Drop (i.e. Total System Effect) by 1 in. wg. and the fan power consumption by 18%. (ref. Greenheck System Effect Simulator - https://ses.greenheck.com/)

To further demonstrate how pressure drop impacts fan design and selection consider the representative fan curve below.



Note that fans are never selected in the "Surge Area" of a fan curve and most manufacturers do not publish performance or allow software selections in this portion of the performance curve. The reason is that fan performance is often not stable in this area of the curve (i.e. flow and pressure will fluctuate dramatically causing the fan to "surge"). When a fan is in "surge," it will often fail to meet performance requirements of the system, possibly cause damage to ventilation system components (e.g. such as duct work) and may ultimately lead to a mechanical failure of the fan. As a result, selections are made to the right of the "Surge Area."

Fans will use the least amount of energy and generally run quieter when the operating point (airflow and pressure drop) is in the "High Efficiency, Low Sound" portion of the fan curve. However, if pressure drop and/or system effect is not accurately accounted for the fan may be at risk of operating in the "Surge Area" after installation. To account for this, fan selections are often made in the "Low Efficiency, High Sound" portion of the fan curve (see tan bars in the graph to the right). The Fan Energy Index (FEI) being proposed later in this document will eliminate or limit selection points in the "Low Efficiency, High Sound" portion of the fan curve in much the same way selection points are limited in the "Surge Area"



portion of the fan curve. This metric will require design engineers to be more diligent in accounting for pressure drop of components and the inlet and outlet conditions of the fan and encourage manufacturers to supply products that minimize power consumption at the design duty point.

The items above can be further enforced as part of the energy code (e.g. Title 24) compliance process. For example, fan power requirements established by Title 20 need to be evaluated as part of the Title 24 plan review process before issuing a building permit. This will help assure items such as pressure drop and system effect are accounted for as part of the system design. This can be complimented as part of the final commissioning process before issuing a certificate of occupancy.

2. ***Regulation of Heating, Air-conditioning, Refrigeration and Ventilation Equipment (e.g. DOE regulated equipment, CEC Title 20 regulated equipment) – relates to embedded fans.***

Fans are often incorporated (embedded) by original equipment manufacturers (OEMs) in products designed to heat, condition, ventilate and/or create pressurization. To maximize equipment efficiency and minimize power consumption it is best to consider fan power as part of the overall power consumption of the equipment the fan is embedded into. Energy consumption of fans embedded in equipment will also be impacted by the same pressure drop and system effect issues described in the previous section. As such, the best way to account for these items and minimize embedded fan energy consumption is to evaluate the fan as part of the overall equipment power consumption.

Exhaust air energy recovery devices are prime examples of HVAC equipment that can consume higher amounts of fan energy while at the same time reducing the overall energy consumption of the equipment. For example, adding an air-to-air energy recovery device to a 2,100 cfm DX-DOAS unit will increase the overall fan power by 342%, but during typical operation in dehumidification season the unit will use approximately 22% less energy than a unit without the air-to-air energy recovery device (see table below).

	Without Energy Recovery	With Energy Recovery
Supply Fan Shaft Power (Bhp)	0.22	0.80
Exhaust Fan Shaft Power (Bhp)	0.15*	0.82
Total Fan Shaft Power (Bhp)	0.37	1.62
Total Fan Electrical Input Power (kW)	**0.33**	**1.46**
Compressor Full Load Power (kW)	14.0	7.4
Dehumidification Season Power Consumption(kW-h)**	**17,770**	**13,922**

** Typically in this configuration the DX-DOAS unit does not include the system exhaust fan, but an exhaust fan or other airflow control device will be required for space pressurization. Fan shaft power was estimated using a 50% static efficient selection at the AHRI-920 rated duct pressure.*
*** Operation was assumed to be 12 hours a day, 5 days a week based on an average DX-DOAS*

season length. Design conditions used were from AHRI Standard 920. Includes fans, energy wheel, compressor, and control power.

The point of this example is not to imply that regulation of a fan will discourage, or prevent the use of energy efficient equipment. The point is that evaluating the fan as part of the overall power consumption and energy saving capability of a piece of equipment will generate much, much more energy savings than regulation of the individual fan.

3. Regulation of Individual Fans (e.g. subject of this document, DOE CIFB Term Sheet[2], EU327)

Regulating individual fans in a way that drives energy savings while minimizing regulatory loop holes, preventing unintended consequences and is easy to assimilate by the market is a challenge. Many of these challenges have been vetted over the past several years. First as part of developing fan energy regulation language in ASHRAE 90.1 and still further as part of the DOE ASRAC Working Group Term Sheet recommendations regarding the DOE Commercial and Industrial Fan & Blower rule. Members of the Air Movement and Control Association (AMCA) have been, and continue to be at the forefront of this effort.

I propose the CEC look to leverage the specific work of AMCA with regard to a test standard and metric for establishing regulatory requirements for standalone fans. AMCA has moved forward with developing a certified ratings program (CRP) for the Fan Energy Index (FEI) referenced in the DOE ASRAC CIFB Term Sheet.

The FEI metric is unique and much more complex than many other regulatory metrics. While most other metrics establish a regulatory requirement for only one or a limited number of operating points, FEI evaluates fan energy consumption over a range of operating points for flow and pressure. While FEI is unique to other regulatory metrics, it is a practical metric for fans based on the following:

1. FEI will limit fan power based on the fan's range of operation.
   - Not simply the BEST point of operation.
2. FEI will leverage natural market dynamics to help drive energy savings.
   - System designers can specify FEI levels to meet specific energy consumption objectives.
   - System Regulations such as CEC Title 24, ASHRAE 90.1, et al can establish minimum FEI levels across a multitude of fan categories and applications.
3. FEI is a good comparison of relative energy consumption across all fan categories and applications.
   - This will help facilitate adoption in the market.
4. FEI can be used to incent/rebate "stretch" metrics.
   - While energy standards, codes and regulations can establish minimum efficiency levels for FEI, utilities and other energy advocate groups can establish incentive programs that exceed the minimum regulatory requirements.
5. FEI can be used with ALL fans.
   - Existing metrics, such as the Fan Efficiency Grade (FEG) metric in ASHRAE 90.1, are limited and require exceptions for many types of fans and applications.

Methodology

This proposal is in general support of the joint proposal by AMCA/ASAP/NEEA and NRDC for Standalone fans and the AHRI proposal with regard to Embedded fans.

Proposed Standards and Recommendations

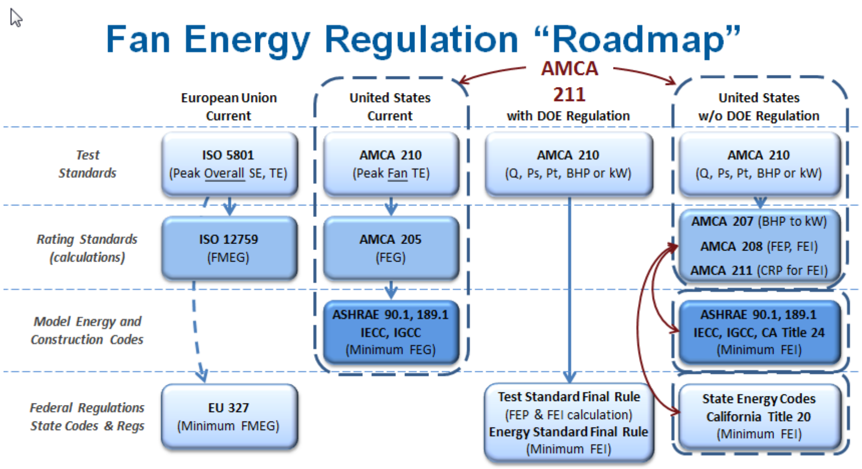
Given the opportunity to improve equipment efficiency by including embedded fan power into the regulation and energy consumption of the equipment, my proposal is segmented into independent proposals for Stand along and Embedded fans.

Standalone Fans

As applicable, I propose using the most current versions of standards and publications below as a basis for the Subject regulation as it applies to standalone fans:

1. AMCA Standard 210.
2. AMCA Standard 207.
3. AMCA Standard 208.
4. AMCA Publication 211.

These standards and publications are largely based on recommendations put forward in the DOE ASRAC Term Sheet[3] and as shown below are designed to support harmonization of appliance regulations and building code regulation both domestically and internationally.



Embedded Fans

As applicable, I propose consideration of one of the following:

1. Exemption of Fans embedded in equipment that incorporates heat exchanger technology.

2. Separate regulation for equipment that incorporates heat exchanger technology such that fan energy is evaluated and regulated as part of the requirements for the equipment.
3. Regulation of fan energy as part of the requirements in CEC Title 24 or other applicable energy code (e.g. ASHRAE 90.1, IECC et al).

Proposed Definitions

Standalone Fans - Reference:

1. AMCA Standard 210.
2. AMCA Standard 207.
3. AMCA Standard 208.
4. AMCA Publication 211.
5. 2016 ASHRAE Handbook – HVAC Systems & Equipment

Embedded Fans - Reference:

1. DOE Equipment Regulation
2. ASHRAE 90.1
3. CEC Title 20
4. CEC Title 24

Proposed Test Procedure

Standalone Fans - Reference:

1. AMCA Standard 210.
2. AMCA Standard 207.
3. AMCA Standard 208.
4. AMCA Publication 211.

Embedded Fans – Reference - To be determined (tbd)

Proposed Standard Metrics

Standalone Fans - Reference:

1. AMCA Standard 208.
2. AMCA Publication 211.

Embedded Fans – Reference - To be determined (tbd)

Proposed Framework

Standalone Fans – Reference - AMCA, ASAP, NEEA, NRDC joint proposal.

Embedded Fans – Reference - To be determined (tbd)

Proposed Reporting Requirements

Standalone Fans – Reference - AMCA, ASAP, NEEA, NRDC joint proposal.

Embedded Fans – Reference - To be determined (tbd)

Analysis of Proposal

Efficiency Levels and Compliance Windows need further evaluation based on:

1. Ability of manufacturers to utilize existing data used for compliance with industry performance certification such as AMCA CRP[3] and BESS[4] to meet Subject regulation.
2. A reasonable balance between energy savings and non-compliance levels.
    a. Recommend updating DOE NODA 3 specific to California with more current information from manufacturers.

Scope/Framework

Standalone Fans – Reference - AMCA, ASAP, NEEA, NRDC joint proposal.

Embedded Fans – Reference - To be determined (tbd)

Product Efficiency Opportunities

Standalone Fans – Reference - AMCA, ASAP, NEEA, NRDC joint proposal.

Embedded Fans – Reference - To be determined (tbd)

Technical Feasibility

Standalone Fans – Reference - AMCA, ASAP, NEEA, NRDC joint proposal.

Embedded Fans – Reference - To be determined (tbd)

Statewide Energy Savings

I have not evaluated this item. I propose a reasonable balance between energy savings and non-compliance levels. As stated above, I recommend updating DOE NODA 3 specific to California with more current information from manufacturers.

Cost-effectiveness

I have not evaluated this item. I propose a reasonable balance between energy savings and non-compliance levels. As stated above, I recommend updating DOE NODA 3 specific to California with more current information from manufacturers.

Environmental Impacts/Benefits

I have not evaluated this item.

Impact on California's Economy

I have not evaluated this item.

Consumer Utility/Acceptance

Standalone Fans – Reference - AMCA, ASAP, NEEA, NRDC joint proposal.

Embedded Fans – Reference - To be determined (tbd)

Manufacturer Supply Chain Timelines

Standalone Fans – Reference - AMCA, ASAP, NEEA, NRDC joint proposal.

Embedded Fans – Reference – AHRI proposal.

Also consider that Supply Chain Timelines for compliance ultimately depend on:

1. Ability of manufacturers to meet CEC regulatory requirements by utilizing data used for compliance with existing industry performance certification programs such as AMCA CRP[3] and BESS[4] Agricultural Ventilation Fans.
2. A reasonable balance between energy savings and non-compliance levels.
   a. Recommend updating DOE NODA 3 specific to California with more current information from manufacturers.

Other Regulatory Considerations

Standalone Fans – Reference - AMCA, ASAP, NEEA, NRDC joint proposal.

Embedded Fans – Reference – AHRI proposal.

Test Lab Certification - Given the unique characteristics required for accurate and repeatable testing of fans, I recommend the CEC require processes and procedures at least as rigorous as those required by the AMCA Lab Accreditation program[5]

Conclusion

Standalone Fans – Reference - AMCA, ASAP, NEEA, NRDC joint proposal.

Embedded Fans – Reference – AHRI proposal.

References

1. 2016 ASHRAE Handbook on HVAC Systems and Equipment.
2. U.S. Department of Energy. 2015. Appliance Standards Regulatory Advisory Committee: Commercial and Industrial Fans and Blowers: Term Sheet. Washington, DC: DOE. www.regulations.gov/document?D=EERE-2013-BT-STD-0179
3. AMCA Certified Rating Program
   a. http://www.amca.org/certified-listed/cpsearch.php
   b. http://www.amca.org/UserFiles/file/English%20White%20Paper%20FINAL%20rev7-26-06.pdf
4. University of IL, Biological and Structural Systems (BESS) Labs - http://bess.illinois.edu/index2.htm
5. AMCA Laboratory Accreditation Program - http://www.amca.org/pdf/accreditationsteps.pdf