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*** THIS DOCUMENT SUPERSEDES TN 224825 ***

Additional submitted attachment is included below.

September 28, 2018

Mr. Alejandro Galdamez
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814-5512

RE: ***CIFB Title 20 Proposed Reg. DOCKET: 17-AAER-06, Commercial and Industrial Fans & Blowers (CIFB)***

The following comments are in response to the California Energy Commission (CEC) Draft Staff Report titled "Analysis of Efficiency Standards and Test Procedures for Commercial and Industrial Fans and Blowers", June 2018 | Publication Number CEC-400-2018-014-SD.

Greenheck supports CEC's recommendation regarding the Fan Energy Index (FEI).

The FEI proposed for the CEC CIFB T20 regulation is uniquely applicable to fans for several reasons.

1. FEI is easy to understand – FEI has a universal meaning across multiple fan types and has a universal meaning at any fan power. For example, at a given duty point, a fan with an FEI of 1.0 will consume 50% more power than a fan with an FEI of 1.5 (1.5/1.0-1). This holds true for a 1kW fan, a 5kW fan, a 100kW fan and so on. The same is true regardless of fan type (axial fan, centrifugal fan, power roof ventilator, or some other type of fan). FEI will be easy for the market to understand and apply to virtually any fan application.

2. FEI is applicable to energy standards and codes – FEI lends itself to use in energy standards such as ASHRAE 90.1, national energy codes such as IECC, and state energy codes such as CEC Title 24. ASHRAE 90.1 is already in the final review process to adopt FEI requirements into the 2019 standard; more on this below. I anticipate IECC and T24 will incorporate FEI language into their next review cycles consistent with 90.1 addendum ao. The adoption of FEI for CEC T20 CIFB rule will add rigor to building standards and code requirements targeted at reducing fan energy consumption.

3. FEI leverages natural market dynamics – FEI will reinforce the commercial building construction process to reduce fan energy consumption. When designing a ventilation system for a commercial building, the simplicity of FEI will allow consumers (i.e. building owners, contractors, and engineers) to be more informed about the energy consumption for their specific fan application. A more informed consumer will make better fan selections. For example, FEI will provide specifying engineers an easy to understand single number reference to limit the power consumption for any given fan duty point. By including the fan FEI on the building equipment schedule engineers will

establish a minimum baseline for fan power consumption. Owners and engineers can establish an FEI to meet minimum regulatory and code requirements or they can increase the FEI based on tradeoffs between first cost and lifetime building operation costs. Based on the building design FEI requirements established by the owner and engineer, contractors will be compelled to only supply fans that meet the minimum FEI specified by the owner/engineer. In this way, FEI will ensure a level playing field during the bid process for the building.

From a regulatory perspective, FEI will make it easy for code officials to verify compliance to local, state and national codes during plan review and during final commissioning. During plan review, requiring FEI on engineering design documents (this will need to be done in energy codes such as T24, IECC, etc.) will allow code officials to easily verify that the FEI for a given fan meets minimum code and regulatory requirements. During the building commissioning code officials can easily check the FEI on the fan label to verify compliance with code and regulatory requirements.

Finally, as FEI becomes more widely adopted, manufacturers will work to improve fan designs and offer the market more options to minimize fan power consumption at the performance ranges being specified by consumers.

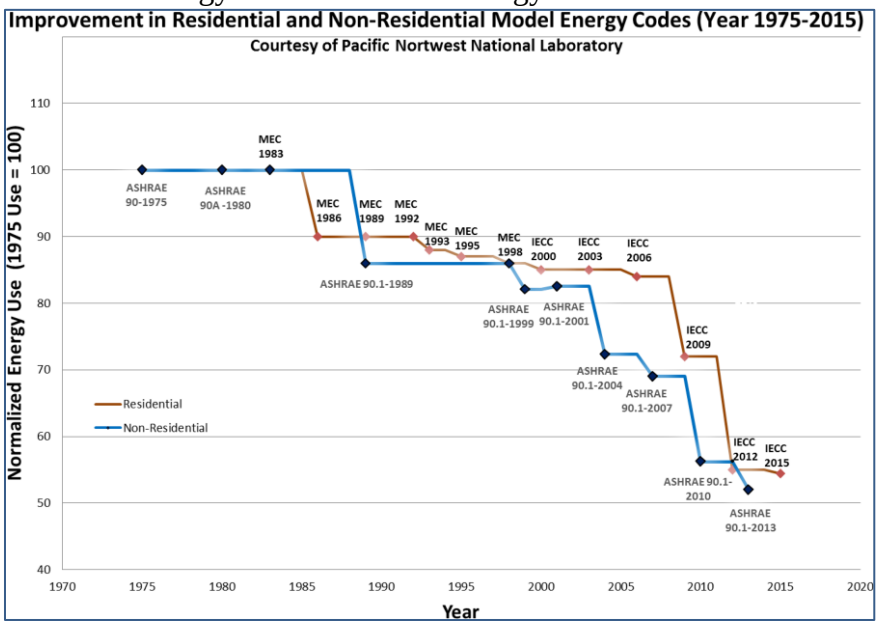
While much of what I've just covered is already being done in the market, FEI will be useful to reinforce this behavior, bring more awareness to the power consumption of commercial and industrial fans and ultimately reduce energy consumption in a cost effective and practical manner.

4. <u>FEI is applicable to incentive programs</u> – The simplicity of FEI will provide the market with a single number methodology easily applied to incentive programs that promote "above code" fan energy limits.

Greenheck recommends T20 CIFB Regulation harmonization with Building Energy Codes

Studies show that building system energy standards, such as ASHRAE 90.1, and energy codes, such as the IECC, are effective regulatory tools for driving significant energy reduction in commercial buildings (ref. Fig. 2).

Energy Code & Related Energy Use Reduction

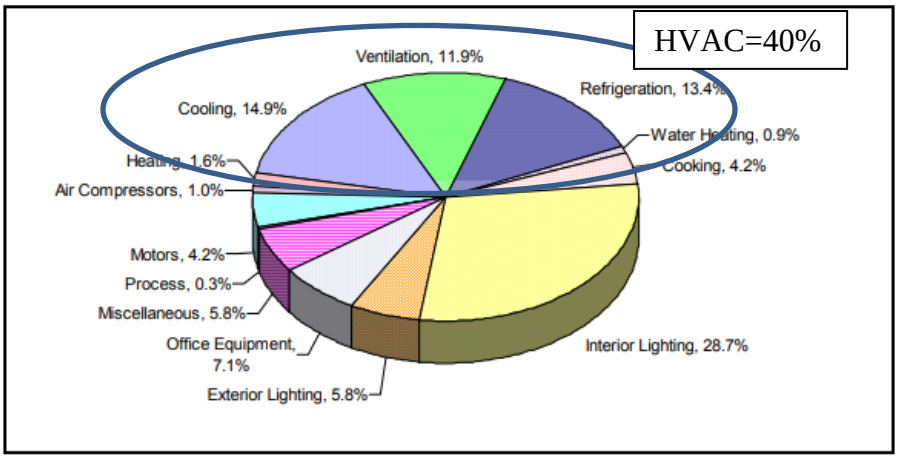


Ref: http://solarenergyengineering.asmedigitalcollection.asme.org/article.aspx?articleid=2565042

Figure 2

Studies further show that the significant energy savings related to the model energy codes is the result of a holistic approach to energy reduction that focuses first on building systems. These systems include "Lighting Systems", "Heating, Ventilating and Air-Conditioning (HVAC) Systems", etc. As it relates to HVAC systems, the CEC California End Use Survey shows that HVAC systems account for approximately 40% of the electricity usage in commercial buildings (ref. Fig. 3).

Commercial Building Electric Usage by End Use



Ref: http://www.energy.ca.gov/2006publications/CEC-400-2006-005/CEC-400-2006-005.PDF

Figure 3

Further, building energy codes typically prioritize HVAC energy regulatory requirements first on the overall HVAC system, then on major equipment efficiency and finally on individual component efficiency. With regard to reducing energy consumption of major equipment, ASHRAE 90.1, IECC, T24, et al incorporate efficiency limits on a wide range of defined HVAC equipment. For purposes of these comments I will refer to this equipment as "regulated equipment". Examples of "regulated equipment" from ASHRAE 90.1 include:

1. "Electrically Operated Unitary Air Conditioners and *Condensing Units*"
2. "Electrically Operated Unitary and Applied Heat Pumps"
3. "Water-Chilling Packages"
4. "Electrically Operated *Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps*, *Single-Package Vertical Air Conditioners, Single-Package Vertical Heat Pumps, Room Air Conditioners*, and *Room Air Conditioner* Heat Pumps"
5. "Warm-Air Furnaces and Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces, and Unit Heaters"
6. "Gas- and Oil-Fired *Boilers*"
7. "Performance Requirements for Heat-Rejection *Equipment*"
8. "Heat Transfer *Equipment*"
9. "Electrically Operated Variable-Refrigerant-Flow Air Conditioners"
10. "Electrically Operated Variable-Refrigerant-Flow and Applied Heat Pumps"
11. "Air Conditioners and *Condensing Units* Serving *Computer Rooms*"
12. "Commercial Refrigerators and Freezers"
13. "Commercial Refrigeration"
14. "Vapor-Compression-Based *Indoor Pool Dehumidifiers*"
15. "Electrically Operated *DX-DOAS Units*, Single-Package and Remote Condenser, without *Energy* Recovery"
16. "Electrically Operated *DX-DOAS Units*, Single-Package and Remote Condenser, with *Energy* Recovery"

ASHRAE 90.1 continues to expand on the list of regulated equipment as an effective way to reduce energy consumption in buildings. For example, the DOAS equipment listed as items 15 and 16 above is the most recent addition to this list and is in process to be regulated by DOE. The DOE efficiency regulations typically account fan energy consumption in the equipment. The DOE DOAS regulation is accounting for fan energy as follows:

1. Fans included in DX-DOAS ISMRE rating:

Without Exhaust Air Energy	Units with Exhaust Air Energy Recovery
Fan Energy Included in Metric(s)	
Supply Fans & Condensing Fans	Supply Fans, Condensing Fans, and Relief/Exhaust Fan
Fan Energy Not Included in the Metric	
Relief/Exhaust Fan*	-

*In many cases the relief/exhaust fan is a standalone fan, but some manufacturers offer it as an option.

2. External Fan Statics - External static pressures are being evaluated to reflect actual application pressure requirements based on rated airflow and fan type (supply or exhaust).
3. Filtration – Minimum MERV 8 filters on the supply side. This aligns with minimum filtration requirements for typical ventilation codes.
4. Exhaust air energy recovery devices - The devices must be installed during tests to adequately capture the fan energy associated with the device at the equipment's rated airflow.

At a component level, ASHRAE 90.1 includes energy requirements for fans. A proposal to include FEI in 90.1 is currently under review by the ASHRAE 90.1 Standing Standards Project Committee (SSPC). The proposal, addendum AO, is in the final review phase with anticipated adoption into ASHRAE 90.1-2019. CEC can benefit from, and expedite fan energy savings in California by harmonizing the CEC T20 CIFB regulation with ASHRAE 90.1 (paying special attention to addendum AO) and CEC T24.

Effectively harmonizing the CEC T20 CIFB regulation with existing building energy standards such as CEC T24, ASHRAE 90.1, IECC, et al will add rigor to fan regulation that will help drive a reduction in fan energy in California and establish a model for other states and regulatory agencies looking to reduce fan energy through regulation.

Greenheck recommends CEC work with AMCA to finalize the T20 CIFB Rule

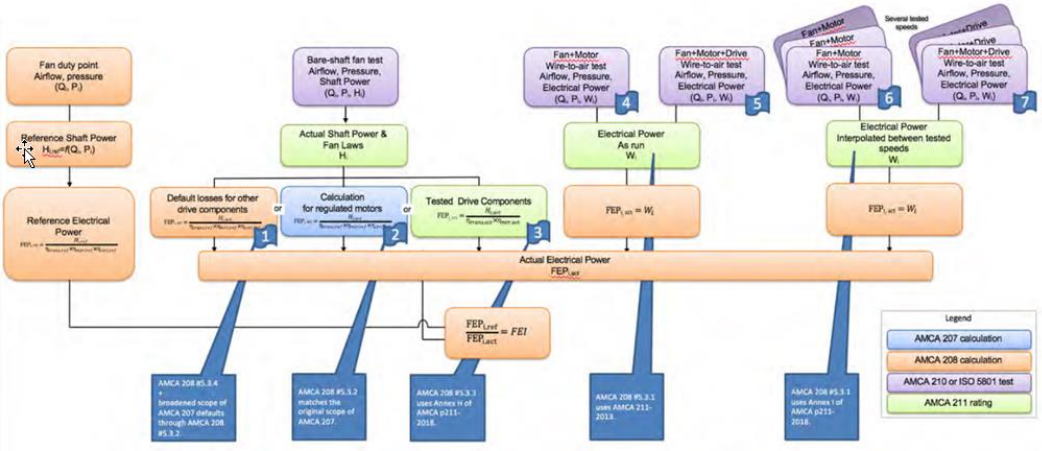
The Air Movement and Control Association International (AMCA) has a history of working with manufacturers and regulatory bodies to adapt their standards and certification programs to help ensure regulations are practical and achieve the desired results in the market. To ensure FEI will maximize energy savings related to fans, *we recommend CEC work closely with AMCA to clearly define the test procedure, compliance requirements, performance representation, etc. necessary for the FEI "performance map."* In developing a Certified Ratings Program (CRP) for FEI, AMCA has given careful consideration to several items that will be critical to the successful implementation of the CEC T20 CIFB regulation. Examples include:

1. FEI is new to the industry – The AMCA FEI test procedure and certified ratings program referenced in the staff report are new to the industry and will need to be adapted to meet the regulatory requirements of CEC T20. The development of the AMCA test procedure and CRP for FEI was done with an eye towards an eventual DOE regulation. AMCA has also worked to harmonize the FEI test procedures and CRP in a manner that will not disrupt existing AMCA programs. As a result of the previous DOE related efforts and the goal to sustain currently effective AMCA certified rating programs, there are several AMCA standards and documents that ultimately define FEI. See Figure 1 to understand the situation better.

   To ensure compatibility with the CEC T20 regulatory process AMCA is now working to combine the various standards and publications shown in Figure 1 into a single document supportive of the anticipated CEC T20 regulation. AMCA's years of experience in administering its CRP for fan performance will ensure the CEC T20 CIFB test

procedures, reporting requirements, label requirements and related issues pertaining to the T20 regulation are implemented in a practical, cost-effective and enforceable manner.

FEI "Roadmap"



Ref: AMCA Fan Regulation Committee

Figure 1

2. FEI is unlike any other regulatory metric - Typical appliance regulatory test procedures and metrics define compliance based on a single point of operation. This single point of operation is seldom how the equipment is applied in real life applications. FEI is much more robust than typical appliance regulatory metrics in that it defines a compliant "performance map" that is applicable to actual fan installations. This creates unique challenges and opportunities regarding data reporting and enforcement. CEC will likely be able to leverage AMCA CRP requirements related to reporting and enforcement of FEI.

3. FEI encompasses "wire to air" performance testing and verification - The AMCA test standards and related CRP referenced in the staff report have been used for years to effectively and accurately measure and verify performance and power consumption of commercial and industrial fans. The existing CRP data for most fans is largely based on manufacturers' "shaft to air" fan performance. ANSI/AMCA Standard 208-18 includes standardized methods to determine FEI wire to air performance from shaft to air performance based on load-dependent drive losses for all fan drive options. Examples include the accounting for drive losses, motor efficiencies and control efficiencies. More specifically, ANSI/AMCA Standard 208-18 provides a method to develop FEI ratings from existing product testing and performance data (legacy data) on fans using motors regulated by DOE. However, for motors not regulated by DOE (e.g. EC motors), AMCA's work is ongoing to define and develop acceptable efficiency ratings and/or test procedures for unregulated motors. A standard method for establishing efficiencies for unregulated motors will provide manufacturers the ability to develop FEI performance for fans with unregulated motors in the same manner as regulated motors. In the absence of an acceptable efficiency testing/rating methodology for unregulated motors, manufacturers will be required to test every fan and motor combination independently.

Both options will take considerable time and it is questionable how much of this work can be accomplished within one year of the regulation being complete.

With regard to "control efficiencies", such as variable frequency drives, the Air-Conditioning and Refrigeration Institute (AHRI) Standard 1210/1211, Performance Rating of Variable Frequency Drives, may be applicable to the fan regulation. As with unregulated motors, AMCA is working to address this issue as part of their CRP for FEI.

Working with AMCA provide the CEC assurance that the wire to air FEI metric is developed in manner that ensures repeatability and applicability to all electrical components between the fan shaft and the electrical input power to the fan.

4. Challenges regarding use of "legacy data" to establish FEI values – As explained previously, existing product testing and performance data (legacy data) is based largely on shaft to air testing and ratings. Given that FEI is a wire to air metric, FEI will require specific ratings for every fan, motor and drive combination. This will need careful consideration as it relates to how manufacturers record products in the CEC MAEDBS.

   AMCA standards currently allow manufacturers to test fans in various configurations depending on how the fan is typically applied in the market. For example, some fans can be tested in either a ducted or non-ducted configuration. Based on feedback during the DOE rulemaking process, DOE test configurations are fixed as part of the regulation and manufacturers are not allowed to "choose" a test configuration. If CEC requirements are defined as strictly as DOE's, it is likely that many manufacturers will need to retest some, maybe all, products to the regulatory defined test configuration. The time required to conduct testing for configurations that are not part of a manufacturer's legacy data will need to be considered when CEC establishes a regulatory compliance date.

5. Compliance verification test tolerances – Fan testing tolerances are not covered in the draft staff report, however they should be considered. It is my understanding that appliances covered under Title 20 must exceed the regulatory efficiency requirements during any verification testing. In order to ensure the appliance exceeds the published efficiency levels during verification testing, efficiency ratings are usually de-rated from original test results. Since FEI defines a compliant performance map, and since verification testing can be done at any duty point on this performance map, with results compared to published ratings (as opposed to a fixed level), *Greenheck recommends that CEC use verification performance tolerances consistent with the AMCA Certified Ratings Program*.

   AMCA's Certified Ratings Program allows published ratings to be developed directly from laboratory tests, without any de-rating of performance. In the check test process, AMCA requires the verification test results to be within a certain tolerance of the published ratings. These tolerances include the effect of both measurement uncertainty and manufacturing tolerances. In taking this approach, participants in the Certified Ratings Program are assured to be on a level playing field with products that are not part of the AMCA Certified Ratings Program (i.e. "non-certified products"). Since

California's Appliance Efficiency Regulations will apply only to fans sold in California, we believe a similar approach should be used for the CEC T20 CIFB rule. FEI is designed to encourage efficient product selection and there will be a serious erosion of benefits if the performance of fans sold in California requires de-rating while the same products sold outside of California do not. In addition, fan manufacturers may be discouraged from selling fans in California if doing so will require a performance de-rate compared to manufacturers selling fans in other states. *As such, Greenheck recommends that CEC use verification performance tolerances consistent with the AMCA Certified Ratings Program.*

Greenheck recommends a two-phase implementation for the T20 CIFB Rule.

Greenheck recommends CEC consider a two-phase implementation for the T20 CIFB regulation. The objective being to implement regulation on products that maximize energy savings and allow further evaluation of more complex issues related to equipment with embedded fans. We believe the following may be reasonable:

- Phase 1: All fans within the scope of ASHRAE 90.1 addendum AO and fans that are tested outside of the equipment (e.g. fully custom air handlers, etc.) and fans embedded in equipment listed as outside of the scope of T20.
- Phase 2: Evaluation regarding regulating fans and equipment outside the scope of Phase 1.

There are significantly more savings associated with stand-alone fans - The CEC Staff report identifies regulatory savings for stand-alone and embedded fans as follows:

	Stand-Alone Fans	Embedded Fans
First Year Savings (GWh)	49.5	24
Savings after Stock Turnover (GWh/yr)	1424.4	429

Based on this information:

- First year savings for a stand-alone fan regulation is more than 100% (49.5/24-1) greater than comparative savings on embedded fans
- Savings after stock turnover is over 200% (1424.4/429-1) greater for stand-alone fans than embedded fans

Developing an effective regulation for stand-alone fans will generate significant savings in a timely manner and allow the industry to develop a better understanding of FEI that will be beneficial in a phase two rule making for equipment with embedded fans.

Regulating equipment is more effective than regulating "embedded fans" – As demonstrated in previous sections, regulation of equipment that includes embedded fans is an effective way to reduce energy consumption. That said, regulation of fans embedded in equipment is a complex issue and is best accomplished as part of a regulation for the equipment's defined purpose. This allows fan energy to be evaluated against other components in the equipment to achieve the overall best efficiency and lowest energy consumption for the equipment's application. Because equipment utility and design are so diverse, these standards must be unique to the equipment's intended function. In addition, applying a stand-alone fan regulation to fans embedded in equipment minimizes the potential equipment energy savings, and in some cases will result in an

increase in energy consumption in the equipment &/or the building (ref. comments from Ingersoll Rand, Lochinvar, et al).

Greenheck manufactures several lines of "unregulated" equipment that are candidates for regulation. These include:

1. Energy Recovery Ventilators; ref:
   - http://www.greenheck.com/products/air-conditioning/energy-recovery-ventilators/preconditioners
2. Make-up Air Units; ref:
   - http://www.greenheck.com/products/air-conditioning/make-up-air
3. Small Air Handler and Fan Coil Units; ref:
   - http://www.greenheck.com/products/air-conditioning/indoor-air-handling-units
4. Custom Air Handling Equipment; ref:
   - http://www.innoventair.com/Products-Applications/Custom-Air-Handling
5. Desiccant Dehumidification Equipment; ref:
   - http://www.innoventair.com/Products-Applications/Desiccant-Dehumidification
6. Pool Dehumidification Equipment; ref:
   - http://www.innoventair.com/Products-Applications/Pool-Dehumidification
7. DOAS Equipment (soon to be regulated by DOE); ref:
   - http://www.greenheck.com/en/products/air-conditioning/dedicated-outdoor-air-systems

Greenheck recommends adding the equipment classes above as exclusions to the phase one fan regulation. Furthermore, to maximize energy savings and avoid potential unintended consequences resulting from applying stand-alone fan requirements to equipment designed for functions other than ventilation, *Greenheck recommends regulation of the equipment classes listed above be addressed as phase two of the regulatory process for fans.* To further develop this recommendation, Greenheck is prepared to share additional sales, cost numbers, etc. with CEC.

Regarding a phase two regulation on equipment with embedded fans, we recommend consideration of existing test standards specifically applicable to fans embedded in equipment. Examples include:

1. AHRI 430 – Performance Rating of Central Station Air-handling Unit Supply Fans.
2. AMCA 211 – Product Rating Manual for Fan Air Performance; Section 19, Requirements for Energy Recovery Ventilators/Heat Recovery Ventilators.

Industry trends are towards HVAC systems that reduce equipment with embedded fans – Commercial HVAC systems are trending away from variable air volume (VAV) systems that utilize fans to move air around a building. The market is increasing the use of variable refrigerant flow (VRF) systems that consume less fan energy. Reference studies below:

1. 2018 Hindawi Research Article – Comparison Evaluations for VRF and RTU Systems Performance on Flexible Research Platform.
   - Energy savings range from 27% to 51% for a VRF compared to a VAV system.
   - https://www.hindawi.com/journals/ace/2018/7867128/

2. 2017 ScienceDirect Report – Evaluation of energy savings potential of VRF from VAV in the U.S. Climate locations.
   - Energy savings range from 15% to 42% for a VRF compared to a VAV system.
   - https://www.sciencedirect.com/science/article/pii/S2352484717300562
3. 2017 MAXIMIZE Report – Global VRS System Market – Industry Analysis and Forecast.
   - Global VRF system market size is projected to grow at an 11.9% CAGR from 2016 to 2024.
   - https://www.maximizemarketresearch.com/market-report/global-vrf-system-market/8412/

Studies such as these indicate a market trend towards equipment that reduces the use of fans. As such, there is a good chance that the staff report savings estimates for embedded fans will go down over time. This serves as another reason to address stand-alone fans first and equipment with embedded fans as a separate phase of the regulation.

Testing requirements for embedded fans - For fans embedded in equipment not currently regulated by the DOE (unregulated equipment), it is likely that little, or no, "legacy" data exists that can be used to establish FEI values. Fans embedded in unregulated equipment will require "new" testing to establish an FEI performance map. This testing will be timely, costly and in many cases will lead to a redesign of the equipment that the fan is embedded into. Testing and related equipment redesigns will, in most cases, require more than a year to implement. As such, CEC can achieve energy savings faster by focusing first on a regulation for stand-alone fans followed by a regulation on equipment with embedded fans. To further develop this rationale, Greenheck is prepared to share additional sales, cost numbers, etc. with CEC.

Concluding Remarks

Greenheck very much appreciates the opportunity to comment and contribute to the CEC T20 Draft Staff Report dated June 2018 on the rule making for Centrifugal and Industrial Fans and Blowers. In summary:

1. Greenheck is supportive of the CEC effort to reduce fan energy consumption through the T20 CIFB regulatory process.
2. Greenheck is prepared to work with CEC, AMCA, energy advocates and others to assure the T20 CIFB rule will reduce energy in a manner that leverages existing test standards and market practices.
3. Greenheck recommends CEC to harmonize the T20 CIFB rule with existing building energy standards; especially CEC T24, ASHRAE 90.0 and IECC.
4. To assure a timely implementation and maximize energy savings related to equipment with embedded fans, Greenheck recommends a two-phase approach to implementing CEC T20 CIFB regulation: phase one for stand-alone fans and phase two for equipment with embedded fans. Greenheck is prepared to share data in confidence to further this discussion.

Thank you.

Commenter Credentials:

With nearly 33 years of experience with the Greenheck Group, a leading manufacturer of HVAC equipment and having held positions in engineering, sales, marketing, software development, and general management, I have a solid foundation for understanding the impact regulations can have on a business and a market. In addition, I am active in the development of test standards and codes with industry trade associations including ASHRAE, AMCA, AHRI, UL, NFPA, ICC, and others and participated on the U.S. Department of Energy's Working Group responsible for developing recommendations on Commercial and Industrial Fan Energy Regulation. I am also a U.S. Secretary of Energy appointee to Department of Energy's Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC).

The Greenheck Group is comprised of a number of brands including Greenheck, Unison Comfort Technologies, Innovent, Valent, Precision Coils, Accurex, and Airolite. Headquartered in Schofield, WI, **Greenheck has offices and manufacturing facilities in California**, Wisconsin, Kentucky, Tennessee, North Carolina, Mexico, and India. In the coming year we will be expanding our manufacturing footprint to include Oklahoma. Greenheck employs nearly 4,000 people worldwide, including over 3,500 in the United States. With over 70 years of family ownership, Greenheck is a worldwide leader in the manufacture of air-movement, conditioning and control equipment, systems and services. Greenheck's extensive product offering includes commercial fans and industrial blowers, laboratory exhaust systems, dedicated outdoor air systems, energy recovery ventilators, air handling equipment, make-up air equipment, and kitchen ventilation systems. Related products include air-control dampers, fire and smoke control dampers, heating and cooling coils as well as architectural and mechanical louvers. Greenheck equipment is used in all types of commercial, institutional, and industrial buildings and applications ranging from comfort ventilation to industrial processes.

Industry Associations

Greenheck engineers are active with many government and industry organizations working to establish performance standards and application guidance related to HVAC systems and products. Examples include:

- United States Department of Energy (DOE)
- International Standards Organization (ISO)
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
- Air Movement & Control Association (AMCA)
- Air-Conditioning, Heating, & Refrigeration Institute (AHRI)
- International Code Council (ICC)
- California Energy Commission (CEC)

Greenheck's involvement with the aforementioned groups is largely focused on development of standards, regulations and programs that result in energy efficient HVAC systems as well as practical selection and application of energy efficient products manufactured for these systems. Greenheck is continuously working with these organizations and other industry members to provide constructive, consistent and substantial insight regarding industry standards and regulations.

Greenheck appreciates the opportunity to support this regulatory effort and is prepared to provide additional details regarding historical data and the potential impact the regulation will have on the market.

Respectfully Submitted,

Mike

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