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CA IOU Fans and Blowers Comments 9-28-2018

Additional submitted attachment is included below.

Fans & Blowers

Codes and Standards Enhancement (CASE) Initiative
For PY 2018: Title 20 Standards Development

Comments regarding the Draft Staff Report
Fans & Blowers
17-AAER-06

September 28, 2018

Prepared for:

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1. Background

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (Energy Commission) efforts to update California's Appliance Efficiency Regulations (Title 20) to include new requirements or to upgrade existing requirements for various technologies. The three California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE)– sponsored this effort (herein referred to as the Statewide CASE Team). The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve the energy and water efficiency of various products sold in California. This document is a part of the effort to develop technical and cost-effectiveness information for potential appliance standards. These comments include updated recommendations for inputs to the analysis for commercial and industrial fans and blowers (herein referred to as "fans").

This analysis was based on the same methodology as used in the United States (U.S.) Department of Energy (DOE) Notice of Data Availability (NODA) III analysis, with various changes to the inputs. The updates below include (1) updated shipments estimates based on additional inputs and insights from stakeholders and (2) updated reference to the latest version of AMCA 208, which in turn had an impact on the shipment-weighted average values of unit energy consumption and incremental cost per efficiency level.

In September 2017, the Statewide CASE Team submitted a proposal to the Energy Commission for test procedures and standards for standalone fans with the Air Movement and Control Association International (AMCA), Appliance Standards Awareness Project (ASAP), Northwest Energy Efficiency Alliance (NEEA), Natural Resources Defense Council (NRDC), and American Council for an Energy-Efficient Economy (ACEEE).[1] The Statewide CASE Team also submitted a proposal for embedded fans with ASAP, NEEA, NRDC, and ACEEE.[2] On June 11, 2018 the Energy Commission released their Draft Staff Report and on July 11, 2018 the Statewide CASE team presented at the Energy Commission staff workshop on various topics which are expanded upon in these comments.[3][4]

These comments provide updates and/or clarifications on shipments, incremental cost, and unit energy consumption, which may be useful to the Energy Commission.[5] These comments also provide a proposal on moving forward on the fans rulemaking. Finally, it should be noted that the Statewide CASE Team is also providing separate feedback through the "Joint AMCA/Advocate" comment letter which addresses scope, definitions, test methods, marking and other issues related to stand-alone fans.

[1] http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-06/TN221217_20170918T163210_AMCA_ASAP_NEEA_NRDC_ACEEE_PGE_SDGE_SCE_SoCalGas_Comments_AMCA_a.pdf.

[2] http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-06/TN221220_20170918T163646_ASAP_NEEA_NRDC_ACEEE_PGE_SDGE_SCE_SoCalGas_Comments_Efficiency.pdf.

[3] https://efiling.energy.ca.gov/GetDocument.aspx?tn=224133

[4] https://efiling.energy.ca.gov/GetDocument.aspx?tn=223775

[5] The data source for the revised calculations of UEC and corresponding incremental costs was provided by Lawrence Berkeley National Lab in 2018. The calculations used the same methodology as in the DOE NODA III analysis and revised inputs provided by the Statewide CASE Team to account for updates in shipments and in AMCA 208.

2. Proposal on Two-Phase Rulemaking

The Statewide CASE Team has been engaged with manufacturers and industry organizations on various aspects related to fans and blowers. The Statewide CASE Team has been working with other advocates and AMCA on various issues related to standalone fans and, as mentioned above, has docketed separate comments with AMCA and other efficiency advocates on various issues.

The Statewide CASE Team has also been engaged with various issues related to certain embedded fan product categories and is aware of the various issues that need further attention. The Statewide CASE Team recognizes that most savings from the Draft Staff Report come from stand-alone fans and certain embedded fans, for which we support the Energy Commission pursuing as soon as possible. The Statewide CASE Team also knows from the U.S. DOE NODA III analysis and the Draft Staff Report that the savings from many of the embedded fan categories are cost-effective and technically feasible but may require additional time and effort. Therefore, the Statewide CASE Team supports the Energy Commission considering moving forward with a "two-phase" rulemaking for fans. For the first phase the Statewide CASE Team recommends the Energy Commission pursue the current scope as outlined in the Draft Staff Report except for the embedded fan types shown below which we recommend be pursued in a second phase of the rulemaking.

- Air-cooled water chilling packages
- Air-cooled commercial package air-conditioning and heating equipment with cooling capacity greater than or equal to 65,000 Btu/h [6]
- Air compressors
- Commercial packaged boilers
- Commercial water heaters
- Dedicated outdoor air systems
- Energy recovery ventilators
- Room fan coil units
- Pool heaters
- Water-cooled and evaporatively-cooled commercial package air-conditioning and heating equipment with cooling capacity greater than or equal to 760,000 Btu/h

The Statewide CASE Team looks forward to working with the Energy Commission to pursue cost-effective energy savings from these fan types in phase two of the fans rulemaking.

[6] Specifically, this would include pursuing return and exhaust fans in equipment with cooling capacity between 65,000 and 760,000 Btu/h and pursuing supply, condenser, return, and exhaust fans in equipment with cooling capacity greater than or equal to 760,000 Btu/h.

3. Fan Shipment Updates

The Statewide CASE Team has recommendations for the Energy Commission to consider regarding updates to shipment estimates for embedded fans. These recommendations are based upon reviewing stakeholder feedback to the Energy Commission docket and investigating underlying data sources. All shipments represented in this document represent shipment quantities within the proposed scope of coverage the Statewide CASE Team has previously recommended in the joint proposals for standalone and embedded fans as described above. This scope includes all fans with rated shaft input power greater than or equal to one horsepower, or, for fans without a rated shaft input power, electrical input power greater than or equal to one kilowatt (kW), and fan airpower less than or equal to 150 horsepower.[7]

3.1 Commercial Unitary Air Conditioners and Heat Pumps

Air-Conditioning, Heating and Refrigeration Institute's (AHRI) written comments to the Energy Commission on September 18, 2017, stated that an internal survey of their members was conducted regarding the portion of commercial unitary air conditioners and heat pumps (rooftop units or RTUs) that ship with either return or exhaust fans by size category.[8] The survey showed a significantly lower portion of units with return/exhaust fan compared to the DOE NODA III estimates. See Table 1 for a reproduction of AHRI's survey results along with the DOE NODA III estimates.

Table 1: DOE NODA III and AHRI Estimates of the Portion of Rooftop Unit Shipments with Return or Exhaust Fans

Rooftop unit size	Fan type	DOE NODA III	AHRI
≥65,000 Btu/h[a] 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: Recreated from Table 6 of AHRI Comments on September 18, 2017, AHRI Survey of Manufacturers.
[a] British thermal unit per hour (Btu/h).

On a national basis, AHRI's estimates of rooftop units shipped with return or exhaust fans may be reasonable. However, the California Building Energy Efficiency Standards contain a prescriptive requirement that all cooling air handling units (AHUs) with a design total mechanical cooling capacity greater than 54,000 Btu/h be equipped with an economizer (Title 24, part 6, Section 140.4(e)1). While it is possible to achieve compliance using the performance option instead of the prescriptive requirements (which results in some RTUs not using an economizer), the Statewide

[7] Various exclusions have also been recommended and more information can be found in the joint recommendations the Statewide CASE Team supported on standalone and embedded fans.
[8] http://docketpublic.energy.ca.gov/PublicDocuments/17-AAER-06/TN221201-1_20170918T134628_AHRI_Comment__Proposal__Title_20_II_PreRulemaking__Commercial_a.pdf.

CASE Team believes that a significant majority of rooftop units sold in California contain economizers.

When a heating, ventilation, and air conditioning (HVAC) system operates in economizer mode, the building must have a way to remove air, because otherwise the building will become over-pressurized. The methods to regulate indoor air pressure include either barometric dampers, a return fan with dampers, or a power exhaust fan.[9] The Statewide CASE Team conducted informal conversations with numerous California-based HVAC experts. Based on these conversations, we believe that the portion of rooftop units with return or exhaust fans in AHRI's survey significantly underestimate actual California shipments for the 65,000 to 135,000 Btu/h and 135,000 to 240,000 Btu/h capacity ranges.

The Statewide CASE Team recommends that the Energy Commission use the DOE NODA III estimates for return and exhaust fans for all sizes of commercial RTUs.

3.2 Air-Handling Units

AHRI also suggested that the Energy Commission use significantly lower shipment estimates for air-handlers. AHRI showed that prior to 2005, the Current Industrial Report (CIR) from the U.S. Department of Commerce estimated annual air-handling unit shipments to be on the order of 370,000 units/year, which was used in the NODA III analysis.[10] However, as highlighted by AHRI's comments, this estimate suddenly dropped to the order of 70,000 units/year in 2005 and stayed in this range until the report was discontinued in 2011.

The Statewide CASE Team understands that adjustments were made to the way that the CIR classifies fan-coil units, and that they were reclassified out of the "Central station air-handling units (motor-driven fan-type)" category in the CIR. For reference, the product codes in the reports are: 3334151117 (draw through), 3334151119 (blow through), and 3334151121 (heating and ventilating).

The lower estimate of roughly 70,000 units/year (nationally) does appear to be more in line with what would be expected when looking at other central plant HVAC components, such as chillers and boilers. The CIR reports also publish the economic value of the shipments so cost per unit can be calculated. For the pre-2005 CIR reports, the price/unit for air-handling units was approximately $2,100/unit, and then from 2005 onward approximately $11,000/unit, which is a more reasonable cost for an air-handling unit.

The Statewide CASE Team would like to point out that shipments fluctuate across all heat transfer equipment product codes in the CIR, in some cases significantly, from year to year. Also, of note is that in the year that fan-coil units were apparently reclassified out of the air-handling unit category (2005) of the CIR, no other categories of HVAC equipment increased by several hundred thousand units/year. The Statewide CASE Team has not been able to determine the root cause of this accounting change or what happened to the roughly 300,000 previously classified air-handler unit shipments.

[9] http://www.taylor-engineering.com/Websites/taylorengineering/articles/ASHRAE_Journal_-_Economizer_Relief_Systems.pdf.
[10] https://www.census.gov/programs-surveys/current-industrial-reports.html.

In summary, the Statewide CASE Team recommends that the Energy Commission use a revised estimate on the order of 70,000 units/ year (nationally) for air-handler shipments.

3.3 Air-Cooled Chillers

The Statewide CASE Team also reviewed AHRI's recommendation regarding air-cooled chiller fan shipments. AHRI stated that DOE's original assumption of 14 fans per chiller would correspond to a 200-ton chiller, and that on a shipment weighted basis, the average chiller size is closer to 100 tons. AHRI stated this would then correspond to roughly 7 fans per chiller. AHRI also stated that DOE's estimate of air-cooled chiller shipments in the NODA III of 12,759 units per year is low, and that based on the CIR, the average number of air-cooled chiller shipments from 1994-2010 was closer to 27,000 units per year. With a reduction in the number of fans per unit and an increase in the overall number of units, the total number of panel fans shipped in air-cooled chillers remains roughly the same. The Statewide CASE Team believes these suggested changes from AHRI are reasonable and note that they do not significantly impact the overall shipments of panel fans in air-cooled chillers.

3.4 New Categories of Embedded Fan Equipment Types

The Statewide CASE Team also recommends that the Energy Commission consider adding more equipment types to capture more of the embedded fan market. These equipment types are: dedicated outdoor air systems (DOAS), energy/heat recovery ventilators (ERV/HRV), and fan-coil units (FCU). Confidential data on annual shipments of fans in each of these equipment types was used to provide an aggregated estimate of national fan shipments as shown below in Table 2, and breakouts by fan equipment class as shown in Table 3.

Table 2: Additional Embedded Fan Shipments (National)[a]

	DOAS	ERV/HRV	FCU
Average number of fans per unit	2.33	2.00	1.00
Percentage units with an "in-scope" supply fan	100%	100%	100%
Percentage units with "in-scope" condenser fans	100%	0%	0%
Percentage units with a return fan	0%	0%	0%
Percentage units with an exhaust fan	33%	100%	0%
Additional HVACR[b] fans (across all three equipment)	157,667		

Source: Derived from confidential data on annual shipments

[a] Table represents total U.S. shipments (multiply by 12% to estimate CA shipments) within the proposed scope of proposed standards as described in Section 2.

[b] Heating, ventilation, air conditioning, and refrigeration (HVACR).

Table 3: New Embedded Fan Categories by Fan Equipment Class

Equipment class	Subcategory	DOAS	ERV/HRV	FCU	HVACR fans (across all three equipment types)
Panel	Panel/Propeller (P)	43%	0%	0%	25%
Centrifugal housed	Airfoil (AF)	14%	0%	0%	8%
	Backward Curved (BC)	14%	0%	0%	8%

	Forward Curved (FC)	14%	100%	50%	37%
Centrifugal unhoused	Centrifugal Unhoused	14%	0%	50%	21%
Total		100%	100%	100%	100%

Source: Derived from confidential data on annual shipments

3.5 Shipments Summary

The Statewide CASE Team presents two scenarios for the resulting updated California shipment estimates using the AHRI and DOE NODA III shipment estimates for fans in RTUs. Table 4 and Table 5 show the shipment results using the AHRI and DOE NODA III estimates, respectively, for fans in RTUs, and mirror the tables found in the DOE NODA III analysis. Both tables incorporate the updated shipments for AHUs and air-cooled chillers, based on AHRI's recommendations, as well as the new estimates of shipments of fans in the additional equipment types (DOAS, ERV/HRV, and FCUs). The Statewide CASE Team recommends the Energy Commission use the DOE NODA III shipment estimates in Table 5 5. Additionally, note that within "Standalone fans", the "Mfr_OEM" column refers to standalone fans that are purchased by original equipment manufacturers (OEM).[11]

Table 4: California Shipments of Standalone and Embedded Fans in 2012 (Using AHRI Assumptions for RTUs)

Equipment class	Subcategory	Standalone fans		Embedded fans	Total
		Mfr	Mfr_OEM	OEM	
Axial cylindrical housed	Tube Axial (TA)	1,493	1,327	-	2,820
	Vane Axial (VA)	635	565	70	1,270
Panel	Panel/Propeller (P)	11,722	6,038	22,080	39,840
Centrifugal housed	Airfoil (AF)	2,027	973	2,459	5,459
	Backward Curved (BC)	3,973	1,907	1,703	7,583
	Forward Curved (FC)	1,135	545	10,502	12,182
Centrifugal unhoused	Centrifugal Unhoused	4,680	3,120	9,845	17,645
Inline and mixed flow	Centrifugal Inline (CI)	2,098	182	-	2,280
	Mixed Flow (MF)	828	72	-	900
Radial	Radial	4,100	220	-	4,320
Power roof ventilator	Axial Power Roof Ventilator (APRV)	1,711	89	-	1,800
	Centrifugal Power Roof Ventilator (CPRV)	5,989	311	-	6,300
Total	-	40,391	15,349	46,659	102,399

Source: DOE NODA III and AHRI

[11] https://www.regulations.gov/document?D=EERE-2013-BT-STD-0006-0192.

Table 5: California Shipments of Standalone and Embedded Fans in 2012 (Using DOE NODA III Assumptions for RTUs)

Equipment class	Subcategory	Standalone fans		Embedded fans	Total
		Mfr	Mfr_OEM	OEM	
Axial cylindrical housed	Tube Axial (TA)	1,493	1,327	-	2,820
	Vane Axial (VA)	635	565	70	1,270
Panel	Panel/Propeller (P)	11,722	6,038	22,080	39,840
Centrifugal housed	Airfoil (AF)	2,027	973	2,682	5,682
	Backward Curved (BC)	3,973	1,907	3,463	9,343
	Forward Curved (FC)	1,135	545	21,023	22,703
Centrifugal unhoused	Centrifugal Unhoused	4,680	3,120	9,845	17,645
Inline and mixed flow	Centrifugal Inline (CI)	2,098	182	-	2,280
	Mixed Flow (MF)	828	72	-	900
Radial	Radial	4,100	220	-	4,320
Power roof ventilator	Axial Power Roof Ventilator (APRV)	1,711	89	-	1,800
	Centrifugal Power Roof Ventilator (CPRV)	5,989	311	-	6,300
Total	-	40,391	15,349	59,163	114,903

Source: DOE NODA III and AHRI

4. Unit Energy Consumption Updates

The Statewide CASE Team recommends that the Energy Commission use the following unit energy consumption (UEC) values in their analysis, where the non-qualifying scenario corresponds to setting no standards (EL 0), and the qualifying scenario corresponds to the levels recommended in the joint proposals referenced in Section 0.

These shipment-weighted average UEC values are similar to the DOE NODA III values, but updated to account for a new target reference efficiency for un-ducted fans, new motor and belt efficiency values based on AMCA 208 (which references AMCA 207), and for updated shipment values as described in the previous section.[12] The NODA III LCC analysis had set the EL 3 target efficiency value to 62 percent for un-ducted fans. However, the recently published AMCA standard 208 uses 60 percent for un-ducted fans, which aligns with the AMCA-Advocate Joint Proposal.[13] The results presented in Tables 6 through 8 reflect the 60 percent target reference efficiency.

Table 6: Average Per-Unit Energy Use and Energy Savings for Standalone Fans

Equipment class	Average per-unit electricity Use for non-qualifying scenario (kilowatt-	Average per-unit electricity Use for qualifying	Average per-unit electricity savings (kWh/yr)

[12] As reference, the un-ducted equipment classes include panel fans, centrifugal unhoused fans, and power roof ventilator fans.
[13] https://www.techstreet.com/amca/standards/amca-208-18?product_id=2004773.

	hours per year (kWh/yr))	scenario (kWh/yr)	
Axial cylindrical housed	40,457	39,645	812
Panel fans	10,849	10,246	602
Centrifugal housed	43,198	42,781	418
Centrifugal unhoused	42,648	42,586	62
In-line mixed	16,669	15,369	1,300
Radial	46,117	44,655	1,462
Power roof ventilator	9,023	7,864	1,160
Shipment weighted average	26,363	25,668	694

Source: DOE NODA III and revised inputs as described in section 3 and 4.

Table 7: Average Per-Unit Energy Use and Energy Savings for Embedded Fans

Equipment class	Average per-unit electricity use for non-qualifying scenario (kWh/yr)	Average per-unit electricity use for qualifying scenario (kWh/yr)	Average per-unit electricity Savings (kWh/yr)
Axial cylindrical housed	20,627	19,598	1,030
Panel fans	2,246	2,163	83
Centrifugal housed	5,800	5,567	233
Centrifugal unhoused	15,284	15,204	80
Shipment weighted average	6,069	5,917	153

Source: DOE NODA III and revised inputs as described in section 3 and 4.

Table 8: Average Per-Unit Energy Use and Energy Savings for All Fans

Product class	Average per-unit electricity use for non-qualifying scenario (kWh/yr)	Average per-unit electricity use for qualifying scenario (kWh/yr)	Average per-unit electricity savings (kWh/yr)
Axial cylindrical housed	40,115	39,299	816
Panel fans	6,081	5,766	314
Centrifugal housed	21,341	21,031	310
Centrifugal unhoused	27,382	27,310	72
In-line mixed	16,669	15,369	1,300
Radial	46,117	44,655	1,462
Power roof ventilator	9,023	7,864	1,160
Shipment weighted average	17,580	17,156	424

Source: DOE NODA III and revised inputs as described in section 3 and 4.

5. Incremental Cost Updates

The Statewide CASE Team recommends that the Energy Commission use the following incremental cost values in Tables 9 to 11 in their analysis, where the non-qualifying scenario corresponds to EL 0 and the qualifying scenario corresponds to the levels recommended in the joint proposals referenced in Section 0. Note: for un-ducted fans, the Statewide CASE team used the cost data from the DOE NODA III at EL3 (62 percent target) as a proxy to represent the costs at the qualifying scenario (60 percent target).

Table 9: Average Per-Unit Installed Cost and Incremental Cost for Standalone Fans

Product Class	Average per-unit installed cost for non-qualifying scenario ($/unit)	Average per-unit installed cost for qualifying scenario ($/unit)	Average per-unit incremental installed cost ($/unit)
Axial cylindrical housed	$6,478.09	$6,823.75	$345.65
Panel fans	$1,975.32	$2,035.21	$59.89
Centrifugal housed	$3,018.64	$3,068.46	$49.82
Centrifugal unhoused	$2,931.40	$2,955.25	$23.85
In-line mixed	$3,572.87	$4,263.06	$690.19
Radial	$1,931.19	$2,150.47	$219.28
Power roof ventilator	$3,223.04	$3,817.27	$594.23
Shipment weighted average	$2,900.55	$3,100.06	$199.51

Source: DOE NODA III and revised inputs as described in section 3 and 4.

Table 10: Average Per-Unit Installed Cost and Incremental Cost for Embedded Fans

Product class	Average per-unit installed cost for non-qualifying scenario ($/unit)	Average per-unit installed cost for qualifying scenario ($/unit)	Average per-unit incremental installed cost ($/unit)
Axial cylindrical housed	$7,055.94	$7,494.98	$439.05
Panel fans	$1,567.09	$1,617.91	$50.82
Centrifugal housed	$1,725.75	$1,899.25	$173.50
Centrifugal unhoused	$3,605.12	$3,661.52	$56.40
Shipment weighted average	$1,985.58	$2,094.12	$109.54

Source: DOE NODA III and revised inputs as described in section 3 and 4.

Table 11: Average Per-Unit Installed Cost and Incremental Cost for All Fans

Product class	Average per-unit installed cost for non-qualifying scenario ($/unit)	Average per-unit installed cost for qualifying scenario ($/unit)	Average per-unit incremental installed cost ($/unit)
Axial cylindrical housed	$6,488.07	$6,835.34	$347.27

Panel fans	$1,749.05	$1,803.91	$54.86
Centrifugal housed	$2,263.01	$2,385.12	$122.11
Centrifugal unhoused	$3,307.27	$3,349.28	$42.01
In-line mixed	$3,572.87	$4,263.06	$690.19
Radial	$1,931.19	$2,150.47	$219.28
Power roof ventilator	$3,223.04	$3,817.27	$594.23
Shipment weighted average	$2,487.01	$2,634.175	$147.16

Source: DOE NODA III and revised inputs as described in section 3 and 4.