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Comments on Industry Feedback to Fan Power Budget Submeasure of Air Distribution CASE Report

Additional submitted attachment is included below.

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Comments on Industry Feedback to Fan Power Budget Submeasure of Air Distribution CASE Report

CALIFORNIA STATEWIDE UTILITY CODES AND STANDARDS TEAM

July 28, 2021

1. Introduction

The California Statewide Utility Codes and Standards Enhancement Team (Statewide CASE Team) appreciates the opportunity to participate in the review of the July 14, 2021 Express Terms 2022 Energy Code, Title 24 Parts 1 and 6 (15-Day Express Terms).[1]

The Statewide CASE Team actively supports code-setting bodies in developing and revising building energy codes and standards. The program's objective is to achieve significant energy savings and assist in meeting other energy-related state policy goals through the development of reasonable, responsible, and cost-effective code changes. Three California Investor Owned Utilities – Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison – and two Publicly Owned Utilities – Los Angeles Department of Water and Power and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) – sponsored this effort. The Statewide CASE Team is actively supporting the California Energy Commission (Energy Commission) in updating the California Energy Code (Title 24, Part 6) for the 2022 code update cycle. Through CASE Reports, the Statewide CASE Team has provided the Energy Commission with the technical and cost-effectiveness information required to make informed judgments on proposed standards for promising energy efficiency design practices and technologies.

The Statewide CASE Team encourages the Energy Commission to consider the recommendations presented in this document.

[1]CEC Docket #21-BSTD-01, TN #238837
https://efiling.energy.ca.gov/GetDocument.aspx?tn=238838&DocumentContentId=72242.

2. Summary

Over the last several months, the Statewide CASE Team has been interacting with industry stakeholders to ensure that the Fan Power Budget submeasure to the Air Distribution CASE Report[2] is clearly understood and to respond to industry concerns with certain aspects of the measure. In this memo, the Statewide CASE Team would like to respond to specific industry comments that have been docketed in response to the 45-Day and 15-Day Language.

3. Detailed Responses

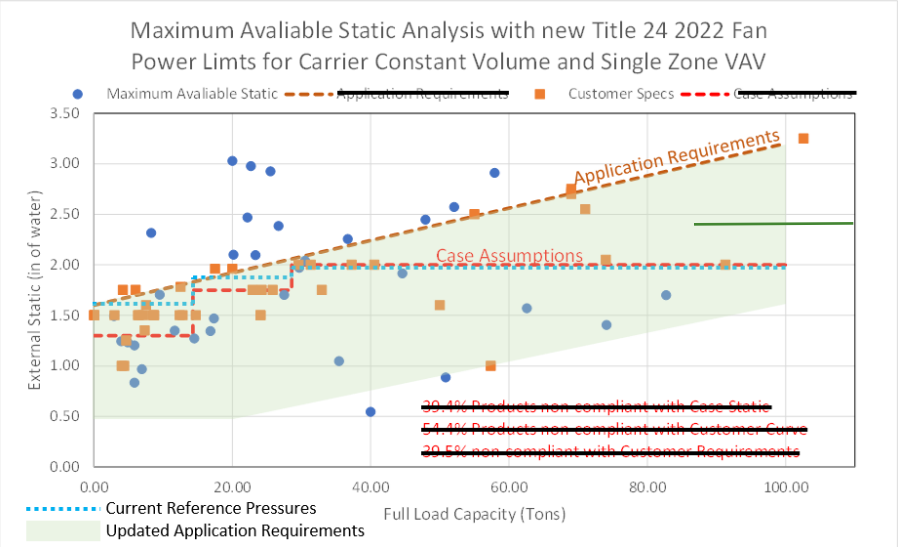
3.1 Limitations to Product Availability

On June 22, 2021, Carrier docketed comments on the Fan Power Budget submeasure, among other topics.[3] The docketed comments were supplemented by additional comments emailed to the Statewide CASE Team and Energy Commission on July 14, 2021. Among other comments, Carrier provided two graphics that attempted to demonstrate the Fan Power Budget submeasure's impact on their product lines. One manufacturer state that entire product lines will have to be removed from the market as a result of this measure and the Statewide CASE Team disagrees with this assertion.

We appreciate the analysis and graphics provided by Carrier. However, we believe that some vital information regarding external static pressures (ESPs) has not been included. Therefore, the Statewide CASE Team has taken the liberty of adding additional clarity to the latest Carrier graphics shared on July 14, 2021. These marked-up graphics for constant air volume/single-zone variable air volume (CAV/SZ-VAV) are shown in Figure 1, and multiple zone variable air volume (MZ-VAV) system types are shown in Figure 2.

[2] https://title24stakeholders.com/wp-content/uploads/2020/09/2022_T24-Final-CASE-Report_Air-Distribution.pdf

[3] Docket 19-BSTD-01, TN # 238418
https://efiling.energy.ca.gov/GetDocument.aspx?tn=238418&DocumentContentId=71720.



Region of customer-selected ESPs

Figure 1: CASE Team Markup of Carrier Graphic Showing Maximum ESP of its Products, Application Requirements, and CASE Assumptions CAV/SZ-VAV Products

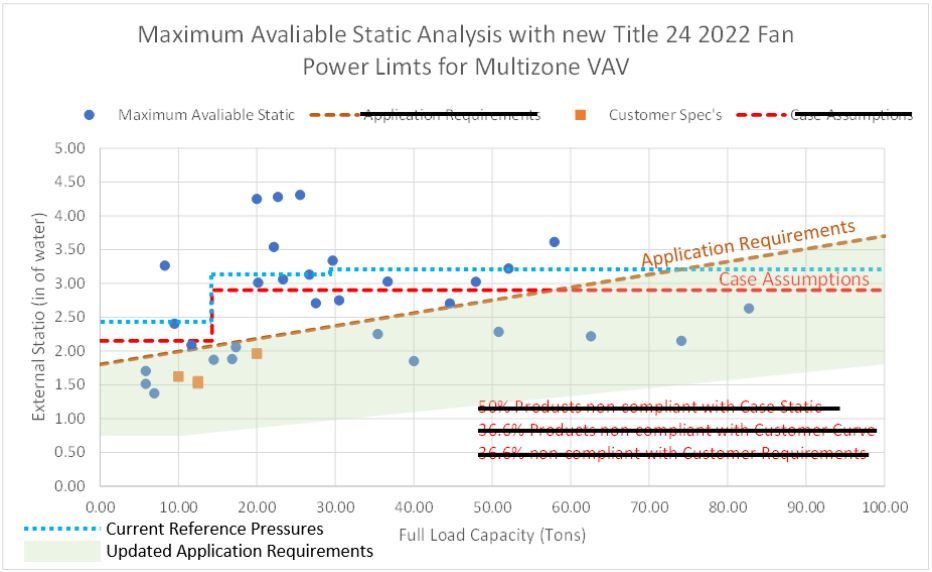


Figure 2: CASE Team Markup of Carrier Graphic Showing Maximum ESP of its Products, Application Requirements, and CASE Assumptions MZ-VAV Products

First, we believe that the ESP "Application Requirements" cannot be well described with the single orange dotted line. Application requirements are much better represented by a region since there are many potential ESP requirements for any system size. Many applications, such as big box retail and schools, typically have short duct lengths with little pressure drop. Carrier's graphic shows many orange squares below its orange dotted lines. The line should be considered as the upper limit of ESP requirements.

Carrier's suggested upper values for ESP are much higher for CAV and SZ-VAV systems than the reference pressures used to calculate the current fan power limits in

both Title 24 and ASHRAE 90.1. The reference values used to calculate the allowed brake horsepower are shown in Figure 3.

Basic Components	VAV System	CV/SZ-VAV System
Return/Exhaust ESP	1.00	0.50
Inlet/Mixed Air Section	0.50	0.50
Outlet Transititon	0.25	0.25
Supply ESP	2.00	1.00
Total	**3.75**	**2.25**

Figure 3: The duct pressure loss values used to calculate the allowed brake horsepower for fan systems for both ASHRAE 90.1-2019 and Title 24-2019. 65% fan efficiency is applied to all systems.

Further, we disagree with showing design ESP requirements (the square orange data points on the graphics) against the new proposed levels. Those design requirements were created by designers not working under the proposed code. Further, we believe that many of these selections are for replacement equipment installed in buildings that may have been designed before fan power limits were in code. The values shown in the graphics representing the CASE assumptions apply to new construction only, and there is a generous additional allowance for replacement equipment that are not included. The primary intent of the Fan Power Budget proposal is to influence designers to create better duct designs. In the CASE Report, we note that the cost justification is based entirely on improved duct design with no change to the equipment fan efficiency or pressure drops.

To further support our position, we point to an analysis docketed by the CA IOUs in response to the United States Department of Energy's request for information regarding energy conservation standards for air-cooled commercial unitary air conditioners and heat pumps from July 2020.[4] The analysis summarizes two survey studies. The comment letter states: "The first compiled field data from a 2011-2017 Test, Adjust, and Balance (TAB) study. The second conducted a permit review of ACUAC/ACUHP projects utilizing the online database *ConstructConnect Insight*,[5] which allows access to

[4] CA IOU comments: https://www.regulations.gov/comment/EERE-2019-BT-STD-0042-0020.

[5] www.constructconnect.com.

mechanical design documentation from most construction projects in the U.S." The summary table from the comments has been reproduced here as Table 1. We want to draw attention to the Median ESP columns for the "TAB Data" and "Permit Review" surveys. The median values are generally significantly lower than Carrier's orange dotted "Application Requirements" lines. It is also essential to understand that the TAB values were collected on existing systems built before the adoption of fan power limits in the jurisdiction, Virginia, in which they were measured. The Permit Review surveys are from an extensive database of construction documents for 2019-2020 buildings that employ rooftop air conditioners.

In addition, although many agree that AHRI 340/360 ESPs are too low, we believe that these values show that industry believes that typical installations have much lower pressures than the maximums described by Carrier.

Table 1: Comparison of AHRI 340/360 ESPs with TAB Study and Permit Review ESPs (Inches of Water Column)

Capacity [kBtu/h]	AHRI 340/360	TAB Data			Permit Review		
	Test ESP	Median ESP	Median ESP Compared to AHRI 340/360	# of Units	Median ESP	Median ESP Compared to AHRI 340/360	# of Units
71 to 105	0.25	0.84	236%	26	0.75	200%	59
106 to 134	0.30	1.16	287%	10	0.88	193%	14
135 to 210	0.35	1.71	387%	20	0.80	129%	33

Regardless of the pressures represented by the orange line, we cannot agree with the description of "non-compliant" for products shown below the line. Those products can be used by the designers at or below the pressures shown. They will not be removed from the market. As we note above, application requirements are a region, not a single line. The Carrier products that fall below the orange dotted line will continue to be available for these lower ESP applications. As a result, the Statewide CASE Team disagrees with the assertion that a given percent of Carrier products will become "non-compliant" from this measure.

Further, the designer may choose to use a lower full-load airflow than the 350 cfm per ton of cooling that assumed in Carrier's analysis. To demonstrate that products will not become "non-compliant" as a result of this measure, the Statewide CASE Team has researched the supply fan performance tables from Carrier's product literature. **Table 2** shows fan performance data for the 40-ton nominal capacity Carrier WeatherMaker unit

with gas heating, model number 48A2D040. The Statewide CASE Team has included markup on the performance table by shading in dark grey the selections that would comply with the proposal for new construction and shading in light grey the additional choices that would comply for equipment replacement. Carrier has noted in conference calls that the vast majority of its sales are for replacement jobs (i.e., alterations), which would qualify for the additional power allowances. It is true that when operated at 14,000 cfm, the unit will only be able to be installed in applications up to 0.4 in. w.c. of ESP for new construction and 1.0 in. w.c. for replacement. However, this product can be configured to operate at a wide range of airflows. At lower airflow, the allowable ESP increases significantly, up to 2" w.c. ESP in new construction and 2.4" w.c. ESP in replacements when operated the airflow used for this product's DOE appliance rating, 10,000 cfm.[6] As the table demonstrates, there are numerous airflow and pressure pairings at which the given model would comply with the proposal. Therefore, the unit will not become "non-compliant" in California due to the Fan Power Budget proposal.

Table 2: Excerpt of Carrier 48A2D040 Supply Fan Performance Data (Vertical Discharge)

Airflow (cfm)	Available ESP (in. w.c.)											
	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2	2.2	2.4
	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	Bhp
10,000	4.89	5.34	5.80	6.26	6.73	7.20	7.67	8.16	8.64	9.14	9.64	10.15
11,000	6.15	6.62	7.11	7.59	8.08	8.58	9.07	9.57	10.08	10.59	11.11	11.63
12,000	7.60	8.09	8.60	9.11	9.63	10.14	10.66	11.18	11.71	12.24	12.77	13.31
13,000	9.24	9.76	10.29	10.83	11.36	11.90	12.44	12.99	13.53	14.08	14.64	15.19
14,000	11.10	11.64	12.19	12.74	13.30	13.87	14.43	15.00	15.57	16.14	16.71	17.28
15,000	13.18	13.74	14.31	14.88	15.46	16.05	16.63	17.22	17.81	18.40	19.00	19.59
16,000	15.49	16.06	16.65	17.24	17.85	18.45	19.06	19.67	20.28	20.89	21.51	22.12
17,000	18.03	18.62	19.23	19.85	20.47	21.09	21.72	22.35	22.98	23.61	24.25	24.89

[6] Rated airflow can be found in the AHRI Database. The AHRI Certified Reference Number for Carrier WeatherMaker model 48A2*040 is 8234386, the certificate can be found at the following URL: https://www.ahridirectory.org/Home/DownloadCertificate?ReferenceId=sUzbLVC3/aFB9wkj0dGAH04Rcakasyq/Ftecn0vsdTvMy5ohebypPTUYlcqkBDVa&ProductTypeId=3401.

18,000	20.82	21.43	22.06	22.69	23.33	23.97	24.62	25.27	25.92	26.58	27.24	27.89
19,000	23.87	24.50	25.14	25.79	26.44	27.11	27.77	28.45	29.12	-		
20,000	27.18	27.82	28.48	29.15	-	-	-	-	-	-		

Source: Carrier Product Data, WeatherMaker Packaged Rooftop Units, 20 to 60 Nominal Tons. https://www.shareddocs.com/hvac/docs/1005/Public/09/48_50A-19PD.pdf, page 71. Shading added by CASE Team.

The Statewide CASE Team would like to point out that the underlying static pressure assumptions have been adjusted since the Final CASE Report was docketed in September 2020. Understandably, stakeholders may have had some issues keeping up with the minor adjustments to the proposal over the past several months. Still, we want to correct the graphics to reflect the latest base pressure assumptions. The reference pressures used to calculate the proposed fan power allowances are shown in blue dotted lines in Figure 1 and Figure 2. In nearly all cases, the new assumptions show greater static ESP than used in the CASE Report. The new static pressure values are shown in tabular form against the values in the CASE Report in 3 for clarity. The changes are due to an additional 0.1" w.c. to the MZ VAV base allowance for all airflow ranges, an extra 0.2" w.c. for all categories from the economizer return damper credit, and a reduction of 0.25" w.c. for CAV/SZ-VAV systems greater than 10,000 cfm.

Table 3: Comparison of Base Supply and Return ESPs from CASE Report to 15-Day Language

Stage of Proposal	MZ VAV System			CAV/SZ-VAV		
	≤5,000 cfm	**>5,000 cfm and ≤10,000 cfm**	**>10,000 cfm**	**≤5,000 cfm**	**>5,000 cfm and ≤10,000 cfm**	**>10,000 cfm**
CASE Report (Sept 2020)	2.15	2.85	2.90	1.40	1.75	2.00
15-Day Language (July 2021)	2.45	3.15	3.20	1.60	1.85	1.95

In summary, the graphics purporting to show a certain percentage of equipment becoming "non-compliant" due to this measure is misleading for several reasons. First, the application requirements cover a much wider range of ESPs than the graphics indicate. Second, the units themselves can be operated at various airflows, and at lower airflows, much more ESP is available. Finally, though understandable, the graphics show outdated underlying static pressures from the CASE Report proposal.

Ultimately, this proposal is not about equipment but instead about driving good building design practice and the need for better duct design. That is why the cost justification in the CASE Report only considered improved duct design and assumed the use of equipment that meets the current fan power limits. We expect the code changes will significantly reduce the need for manufacturers to provide high ESP requirements.

3.2 Efficiency Factor

Both Carrier[7] and AHRI[8] have stated that the Efficiency Factor (EF) of 1.15 should be reduced to 1.0, the mandatory minimum Fan Efficiency Index (FEI) required in Section 120.10. However, EF and FEI cannot be compared. The mandatory FEI is a direct efficiency requirement that applies to fans at their design pressure and airflow. It was created as a backstop to prevent the use of low-efficiency fans that would meet the Fan Power Budget easily when used in fan systems with low ESPs.

The confusion is understandable, as the equations used to calculate the individual fan power allowances are similar to those used in FEI. However, the equations are applied in a very different manner. FEI is applied to a complete fan system, where the total pressure drop of the system is used in the calculation. As system pressure decreases, FEI drives higher efficiency fans. In the tables below, when the EF of 1.15 is applied to the reference pressure drop of each fan power allowance it yields lower individual efficiencies. When they are summed, they do not arrive at a fan efficiency that delivers an FEI of 1.15. Examples of multizone VAV systems with three different airflows are shown below.

Table 4: Comparison of the FEIs of the Least-Efficient Fans Meeting the Power Allowances of Title 24 and the Proposed Fan Power Allowances in a Multizone VAV System at an Airflow of 20,000 CFM

[7] Carrier Corporation rev 2 Comments - Title 24 2022 Building Energy Efficiency 45 Day Review
https://efiling.energy.ca.gov/GetDocument.aspx?tn=238418&DocumentContentId=71720

[8] AHRI Comments – Title 24 - 2022 15-Day Express Terms
https://efiling.energy.ca.gov/GetDocument.aspx?tn=239062&DocumentContentId=72498

	T24-2022	T24-2019
Airflow (cfm)	20,000	20,000
Reference Pressure (in w.c.)	4.80	5.35
BHP Per the FEI equation	25.15	27.81
Allowed Brake Horsepower[1]	22.40	26.00
FEI	1.12	1.07

Note 1: The brake horsepower for the 2022 proposal was calculated by determing the allowed electrical power input, and then calculating the losses for a VFD, motor, and v-belt drive.

Table 5: Comparison of the FEIs of the Least-Efficient Fans Meeting the Power Allowances of Title 24 and the Proposed Fan Power Allowances in a Multizone VAV System at an Airflow of 7,500 CFM

	T24-2022	T24-2019
Airflow (cfm)	7,500	7,500
Reference Pressure (in w.c.)	4.65	5.35
BHP Per the FEI equation	9.35	10.64
Allowed Brake Horsepower[1]	8.61	9.75
FEI	1.09	1.09

Note 1: The brake horsepower for the 2022 proposal was calculated by determing the allowed electrical power input, and then calculating the losses for a VFD, motor, and v-belt drive.

Table 6: Comparison of the FEIs of the Least-Efficient Fans Meeting the Power Allowances of Title 24 and the Proposed Fan Power Allowances in a Multizone VAV System at an Airflow of 3,000 CFM

	T24-2022	T24-2019
Airflow (cfm)	3,000	3,000
Reference Pressure (in w.c.)	3.95	5.35
BHP Per the FEI equation	3.38	4.46
Allowed Brake Horsepower[1]	3.19	3.90
FEI	1.06	1.14

Note 1: The brake horsepower for the 2022 proposal was calculated by determing the allowed electrical power input, and then calculating the losses for a VFD, motor, and v-belt drive.

The tables demonstrate three critical points:

1. The use of EF = 1.15 does not result in reference fans with an FEI = 1.15.
2. The existing method for calculating the fan brake horsepower allowance yields reference FEI's that significantly exceed 1.0.
3. FEI is only of value to determine the appropriate efficiency level of a fan at a given airflow and pressure. Note that in Table 6, the FEI of the higher brake horsepower fan is higher than the lower-power counterpart because the reference pressures are different.

3.3 Definitions of Certain Credits

There appears to be a misunderstanding regarding which credits are available to users in the proposed 2022 Title 24, Part 6Fan Power Budget table. In particular, Carrier's and AHRI's recently docketed comments seem to indicate their belief that certain credits in the return/exhaust/relief table will no longer be available. However, the Statewide CASE Team would like to emphasize that these credits will continue to be available to users should this proposal become adopted. The two credits, in particular, are listed below, along with their definition from the 2019 Nonresidential Compliance Manual (2019 CM).[9] The credits have been converted to an equivalent W/cfm value in the 2022 proposal, but the underlying static pressure values are identical to the 2019 version. Therefore, any analysis comparing the 2019 fan power limits to the 2022 proposal should either include

[9] 2019 Title 24 Part 6 Nonresidential Compliance Manual, Chapter 4, Mechanical Systems: https://www.energy.ca.gov/sites/default/files/2020-05/04_MechanicalSystems.pdf.

or exclude these credits for both the Title 24-2019 baseline and the proposed Title 24-2022 to create a fair comparison.

1) **Return or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms. (0.5 in. w.c.) (2.15 in. w.c. for laboratory and vivarium systems)**

From the 2019 CM:

> The basic input power allowance is based on the assumption that return air passes through an open plenum on its way back to the fan system. For systems where all the return air is ducted back to the return, an additional pressure drop allowance of 0.5 in. w.c. (120 Pa) is allowed. This credit may not be applied for air systems that have a mixture of ducted and nonducted returns.

2) **Return and/or exhaust airflow control devices. (0.5 in. w.c.)**

From the 2019 CM:

> Some types of spaces, such as laboratories, test rooms, and operating rooms, require that an airflow control device be provided at both the supply air delivery point and at the exhaust. The exhaust airflow control device is typically modulated to maintain a negative or positive space pressure relative to surrounding spaces. An additional pressure drop and associated input pow-er adjustment are permitted when this type of device is installed. The credit may be taken when some spaces served by an air handler have exhaust airflow devices and other spaces do not. However, the credit is taken only for the cfm of air that is delivered to spaces with a qualifying exhaust airflow device.

The Statewide CASE Team does believe that our choice not to apply these two allowances is appropriate. The allowances are not used in the ASHRAE 90.1 prototypes used by DOE, nor are they included in the standard (baseline) design in the 2019 Title 24 Nonresidential Alternative Calculation Manual. However, it must be understood that if we had applied the values to both cases in our analysis, the results would have been the same since the same credit would have been given in the baseline and the proposed cases.