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Central Fan Integrated Mechanical Ventilation Modeling

Additional submitted attachment is included below.

FIELD CONTROLS
Improving Indoor Environments

February 27, 2018

California Energy Commission
1516 Ninth Street
Sacramento, California 95814

Subject: Comment on Central Fan Integrated Mechanical Ventilation Associated with 2019 Building Energy Efficiency Standards Rulemaking (45 Day Review) to California Code of Regulations, Title 24

Central Fan Integrated Mechanical Ventilation

Summary of Position

Before the 2019 residential energy code goes into effect, it is imperative that Central Fan Integrated systems for mechanical ventilation (CFI) be properly modeled in the performance software. Current CBECC-RES software overstates the incremental energy use of CFI systems by a factor of 4 or more, according to a recent analysis, presented here. While this incremental energy use does not currently disqualify CFI systems from use, since the reference building is also modeled with a CFI system, the addition to the 2019 residential energy code for new construction of prescriptive PV production to offset electric usage is a major change that will make CFI systems cost-prohibitive in the State.

Background

CFI systems offer a significant improvement in indoor air quality (IAQ), relative to the current dominant technology for mechanical ventilation – continuously running bathroom exhaust fans. They bring in a known source of fresh outside air on an intermittent schedule and distribute the fresh air through the main air handling unit and ductwork already present in the home for space conditioning. The quality of the air is better, the distribution of the air is better, and the pressure in the home is positive or neutral, which is preferable to negative pressure created by exhaust ventilation. They can even be wired to provide make-up air when combustion appliances are operating, thus providing protection against backdrafting and avoiding strong neutral pressures in the building. CFI systems are also cost-effective, with an installed cost of under $1,000 per house, since they make use of equipment used for space conditioning that is already present in the house. And the incremental utility costs of operating CFI systems is on the order of $100 per year – a very economical IAQ upgrade in our opinion.

The Problem with CFIs in Today's CBECC-RES software

The current modeling software used in California grossly overstates the energy usage of CFI systems, relative to default mechanical ventilation systems. Our research found that, in Climate Zone 10 as an example, energy use of a CFI-ventilated house was 6,000 kWh and 700 therms overstated, versus an analysis in DoE's BeOpt/Energy Plus simulation engine. In TDV terms, switching the ventilation strategy from exhaust to CFI added 100-266 TDV, an increase of 150-600%, shown in Table 1. ***Put another way, adding a CFI system is the equivalent of adding another 1.5 houses to 6 houses to the model.***

CFI Impact by Climate Zone						
	Exhaust Ventilation		CFI Ventilation			
Climate Zone	TDV Ref	TDV Prop	TDV Ref	TDV Prop	TDV chg	% chg
1	49.72	60.15	303.53	316.14	314	421%
2	36.44	36.47	224.22	222.24	186	409%
3	28.23	34.32	192.76	200.52	172	402%
4	28.91	30.72	185.57	188.63	160	420%
5	26.52	35.28	201.79	221.85	195	454%
6	21.67	19.34	144.29	142.29	121	524%
7	14.24	14.08	114.34	115.33	101	618%
8	20.56	21.74	134.13	132.57	112	415%
9	33.03	32.64	185.65	181.21	148	354%
10	33.34	34.24	199.39	195.73	162	374%
11	64.87	63.99	307.23	303.70	239	273%
12	42.41	45.02	253.89	251.48	209	364%
13	65.90	65.15	300.19	296.81	231	254%
14	62.74	62.67	291.16	289.49	227	262%
15	96.25	91.69	329.27	322.46	226	147%
16	60.07	66.05	292.50	300.20	240	264%

TABLE 1: CBECC-RES results with and without CFI ventilation

For comparison, another widely used energy modeling package, Energy Plus, puts the incremental energy of a CFI system in a similarly constructed house at 1,200 kWh and a savings of 26 therms, more than 80% lower than CBECC-RES, as shown in Tables 2 and 3.

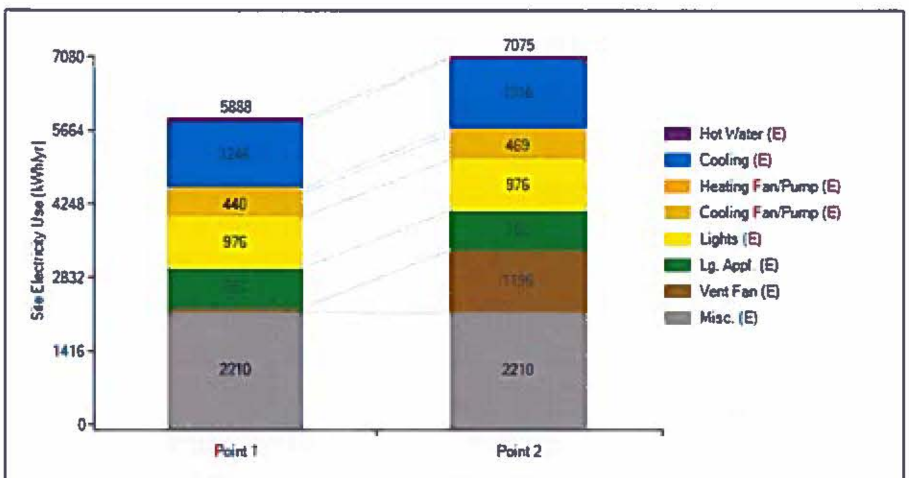

TABLE 2: Energy Plus modeling results of Electric Usage with Exhaust ventilation (Point 1) and CFI supply ventilation (Point 2) in CZ10

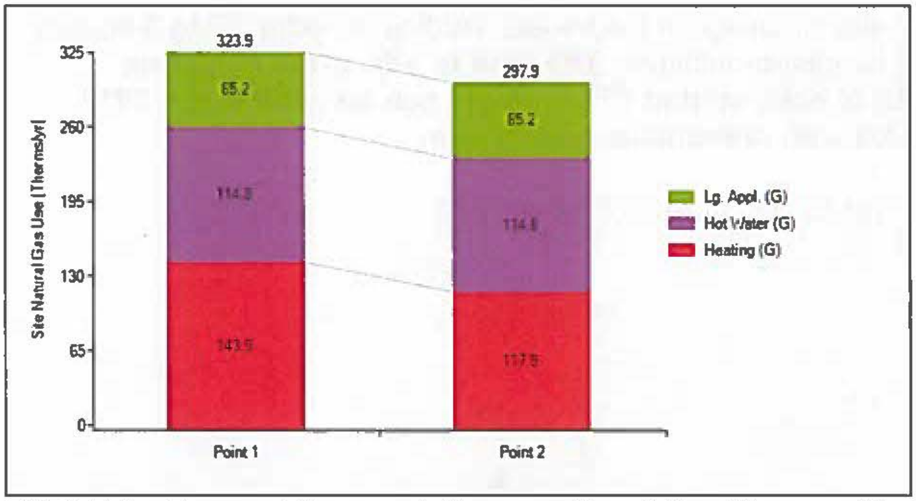

TABLE 3: Energy Plus modeling results of Gas Usage with Exhaust ventilation (Point 1) and CFI supply ventilation (Point 2) in CZ10

Our "real-world" estimates of incremental CFI energy use are lower than both CBECC-RES and Energy Plus. We estimate incremental energy use of roughly 500 kWh in the example used above. Previous research confirms our estimates. Sherman and Walker put the incremental energy usage for switching from exhaust to CFI ventilation between 500-1,000 kWh/year[1], depending on climate zone, all in fan energy, since the outside air brought in by a properly designed CFI system is equal to that of a properly designed exhaust system. In our study, the California Energy Commission's software added 5,000 kWh/year for fan operation alone and an additional 5,000-13,000 kWh/year in cooling and 300-1,200 therms/year in heating, when a CFI system was added to the house. There is a massive discrepancy between real-world expectations and what the software is modeling on an absolute basis. Others have recognized this[2] and recommended changes to the building energy simulation software to accurately model the energy use of CFI systems.

Why the CBECC-RES Software is Overstating CFI Energy Use

By digging through the temporary files, we discovered why the disparity exists between real world and modeled energy use. The software assumes that the CFI system is continuously bringing outside air into the house equal to the full CFM of the air handler fan. This far overstates the amount of outside air ventilation of CFI systems, which drives up the heating and cooling energy demand in the house to bring the outside air to temperature setpoint. Figure 1 shows the CBECC-RES modeled air and energy flows in an example exhaust and CFI house in CZ10. Since the software assumes the same amount of outside air is also brought into the reference building, compliance margin does not suffer significantly in a house with prescriptive standard heating and cooling equipment. Thus, the 2016 code does not place an undue burden on CFI systems for compliance. However, the net-zero code due to go into effect in 2020 will require PV

[1] Sherman, M. and Walker, I. 2007. "Energy Impact of Residential Ventilation Standards in California," LBNL 61282. Lawrence Berkeley National Laboratory, Berkeley, CA. Study found impact of typical central air handler ventilation systems to be over 750 kwh/yr, about that of a standard refrigerator.

[2] Moore, Mike. May 9, 2017 letter to CEC on 2019 pre-rulemaking docket, Docket 17-BSTD-01, Mechanical Ventilation Energy Use

panels to compensate for electric usage in the house. Adding an extra 1.5 to 6 houses worth of PV panels would be cost-prohibitive. **The time to adjust the modeling protocols in CBECC-RES is now, so that CFI systems can be used in the 2019 code cycle to improve IAQ with reasonable energy use.**

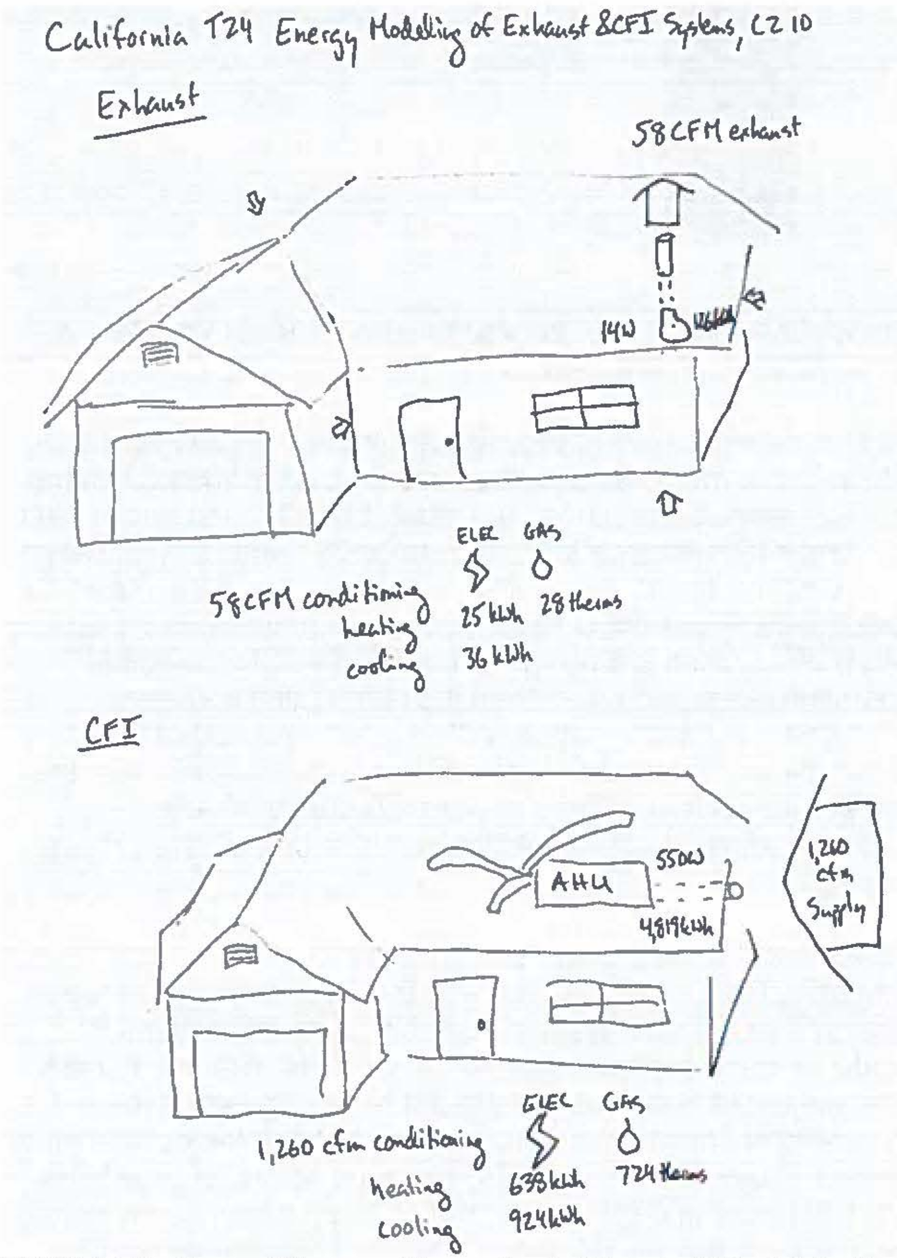

FIGURE 2: Air and Energy Flows in California Title 24 Software, Exhaust & CFI

Suggestions for Adjusting the Modeling Software to Better Reflect Reality
Our research has identified the changes needed to the software. These changes reflect common industry product performance, and are not specific to the authors of this document. We recommend consulting with other manufacturers, such as Honeywell, to confirm that the changes proposed are generic in nature, in keeping with the CEC's long-standing value to allow for an even playing field among vendors. We recommend that the CBECC-RES software better account for:

- Intermittent operation
- Correct % outside air brought in by the air handler
- Controls that time ventilation cycles to coincide with heating and cooling, thus reducing the incremental energy usage associated with CFI systems

CFI systems typically operate the central fan only intermittently, 10 minutes on and 20 minutes off, for instance. This cuts fan and conditioning energy by 2/3, relative to current calculations. The second change needed is the proportion of total fan cfm bringing in outside air. Typical CFI systems are set up to bring 10-20% of total fan cfm in from outside when the damper is opened. Current software assumes 100% is outside air. A properly installed CFI system requires no additional energy to condition outside air than an exhaust system; both are set to meet Title-24 adopted ASHRAE 62.2 cfm rates, and the software should reflect that.
Finally, the software should recognize that CFI systems are computer-controlled to time their operation with heating and cooling cycles, so that the incremental energy use is minimized. We suggest a simple algorithm that manufacturers can comply with (or improve upon), such as:

1) If heating or cooling energy occurs in a given 60 minute period, CFI system will time its operation to coincide, so there is no incremental mechanical ventilation fan energy in the house that hour
2) If no heating or cooling energy occurs in a given 60 minute period, CFI system will operate for 20 or 30 minutes with full operation of the air handling unit at max cfm, bringing in outside air at exactly ASHRAE 62.2 whole-building continuous ventilation cfm rate specified by Title 24.

The effect of making these three changes in the above bulleted list would be to reduce CFI ventilation incremental energy use by 75-85%, depending mostly on climate zone, which would bring the Title 24 modeling impact of CFI systems much closer in line with other software and actual results.

Please let me know if you need additional information.

Sincerely,

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