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IES Narrative

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Matrix Narrative for Failing Cases

Four categories have been detected leading to the noted fails on the Appendix 3B sheet. This matrix identifies which model number matches which category and the following pages give a detailed explanation of the IES response for that category.

	Category			
Test No.	Thermal Energy Storage Loop	~2% Deviation in TDV Energy for Daylight Tests	<1% Deviation	Other
0418406	✓			
0418506	✓			
0408516			✓	
0418806			✓	
0418906			✓	
1013906				✓
0404207		✓		
0404307		✓		
0404407		✓		
0506007		✓		

Test Fail: Thermal Energy Storage Loop

- CEC Comment: Higher TDV Energy in the TES model than the Baserun model.

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IES Response:

The TES model in IESVE has a Water-to-water heat exchanger (WWHX) that transfers heat between the TES loop and the ChWL (see Figure 1 below). This heat exchanger is permanently coupled with the TES tank to avoid any potential mixing of water/glycol with water only; thus maintaining the heat transfer properties of water in the Chilled Water Loop. The WWHX has a non-zero approach temperature. i.e., there will always be a temperature drop in the WWHX. To account for this temperature drop, when the chiller is cooling the building, the chiller leaving water temperature needs to be lower than the required ChWL supply temperature (44°F) because it must first overcome the inefficiency of the WWHX.

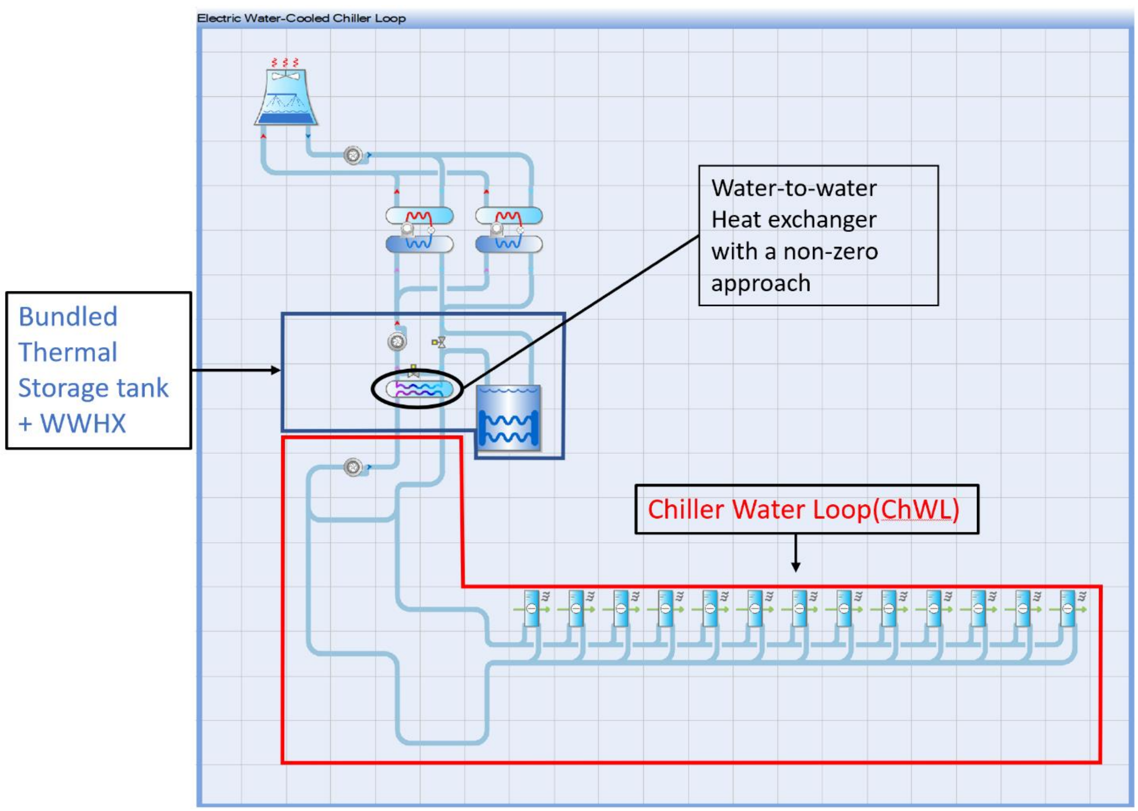

Figure 1: IESVE TES loop and ChWL

However, the baseline model (400006) does not have a WWHX. As a result, the chiller water leaving temperature is 44°F.

Since the chillers in the TES model has to cool the water to a lower temperature (to account for the temperature drop in the WWHX) the chillers consume more energy than the baseline chiller. This has therefore been reflected in the TDV of the model. Figures below show the TDV of the baseline chiller

(400006) and the TDV of the TES chiller (418506) during a week in the non-TES operating month (Figure 2) and a week in TES operating month (Figure 3).

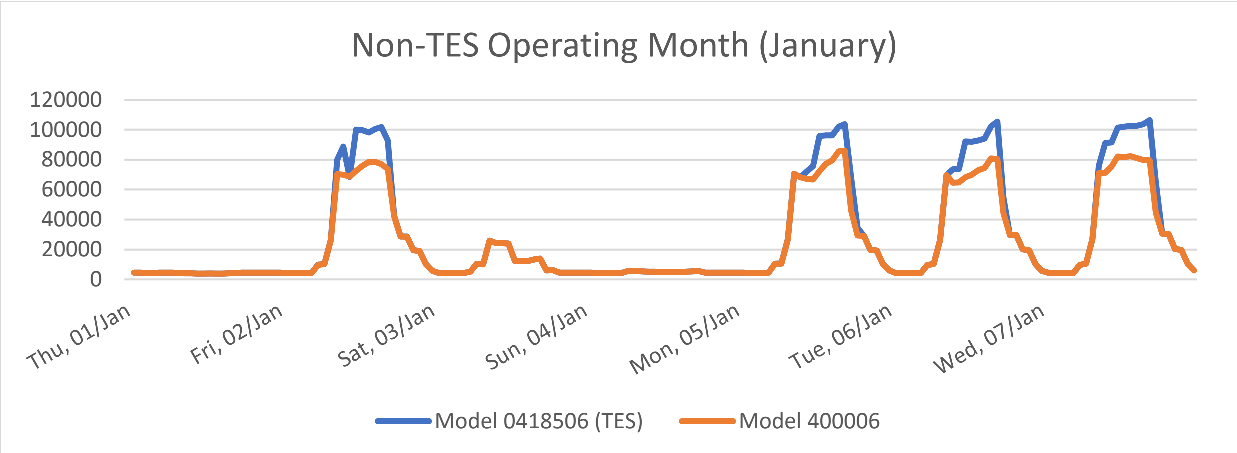

Figure 2: TDV Energy of baseline (0400006) and TES (0418506) model in January (non-TES operating month)

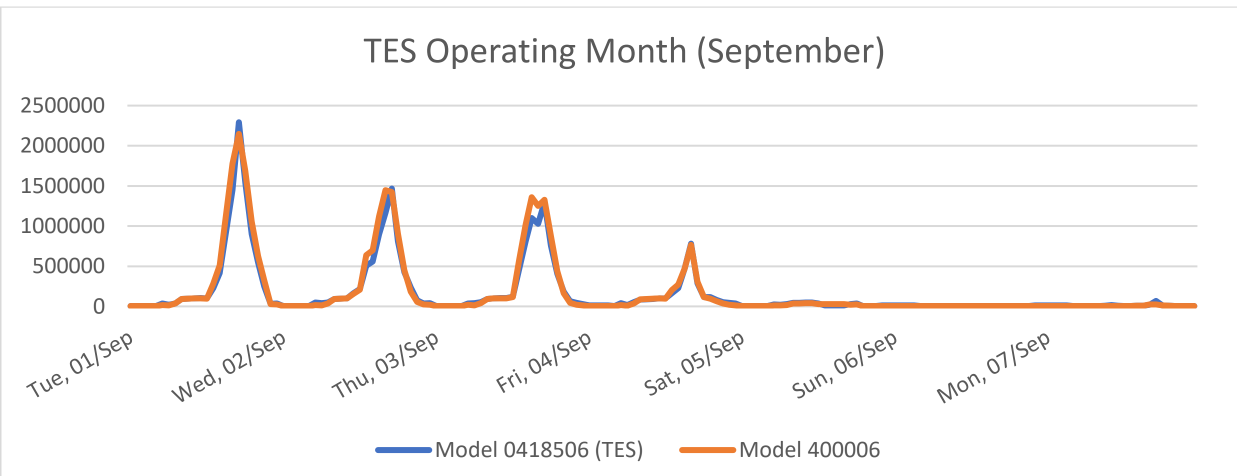

Figure 3: TDV Energy of baseline and proposed model in September (TES operating month)

Observations:

1) During the period when the TES is not operating (Figure 2), the TES TDV Energy (blue line) is higher than the baseline TDV (Orange line). We believe this is because the TES system has to cool the water to a lower temperature to account for the temperature drop in the WWHX.

2) During the TES operation period (Figure 3), we can see that the TDV Energy of the TES model (blue line) is lower than the TDV Energy of the baseline model. i.e. it’s operating as expected.

Conclusion:

WWHX (no bypass), in the TES model 0418506, is causing a year-round inefficiency, especially during periods where the TES is not operational, because the WWHX cannot be bypassed. Baseline model 400006 has no WWHX; therefore the baseline is not penalized for the inherently inefficient WWHX.

Test Fail: ~2% Deviation in TDV Energy for Daylight Tests

- CEC Comment: Higher TDV Energy in the Daylight Test model than the Baserun model

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IES Response:

The deviation in TDV Energy when applying daylight-sensitive tests 0404207, 0404307 and 0404407 between CBECC-Com and IESVE result in a comparative percentage deviation of 2.14%, 2.67% and 2.06% respectively. While these small ~**2%** differences are negligible, the directional change is causing a fail.

Test Case	Annual TDV EUI (excludes Receptacle, Process, Process Ltg)		Percentage Deviation from Baserun 0400007	
	(kBtu/sqft)		(%)	
	CBECC-Com	IESVE	CBECC-Com	IESVE
0400007-OffLrg-Baserun	93.36	81.89		
0404207-OffLrg-Cont.DimHighVT	93.14	83.42	**+0.23%**	**-1.87%**
0404307-OffLrg-StepDim	92.70	83.47	**+0.71%**	**-1.93%**
0404407-OffLrg-StepDimHighVT	93.21	83.41	**+0.16%**	**-1.86%**

Table 1: Percentage Impact of Daylight Controls between CBECC-Com and IESVE

It is worth noting that the deviation for both IESVE and EnergyPlus sees directional consistency for Lighting Energy as shown in Table 2. Therefore, the intermittent and interzonal dynamic of these daylight tests are having other consequences, while are negligible, does influence the pass/fail outcome.

Test Case	Interior Lighting (kBtu/sqft)		Percentage Deviation from Baserun 0400007	
	(kBtu/sqft)		(%)	
	CBECC-Com	IESVE	CBECC-Com	IESVE
0400007-OffLrg-Baserun	4.00	3.82		
0404207-OffLrg-Cont.DimHighVT	3.97	3.81	**+0.60%**	**+0.09%**
0404307-OffLrg-StepDim	3.93	3.81	**+1.78%**	**+0.05%**
0404407-OffLrg-StepDimHighVT	3.93	3.81	**+1.788%**	**+0.14%**

Table 2: Directional Consistency for Daylight Tests between CBECC-Com and IESVE

It is also worth noting that the deviation in lighting energy with these daylighting ECM strategies are for a very deep-plan building. i.e. very low fractional results are anticipated. However, the fractional differences can likely be attributed to oversimplification methods in the CBECC-Com model, which does not model over 50% of the building. CBECC-Com simplifies the simulation by using floor multipliers, which is inaccurately accounting for the full energy-balance dynamics in over 50% of the building, bypasses requirements of ASHRAE Standard 140, as demonstrated visually in Figure 4.

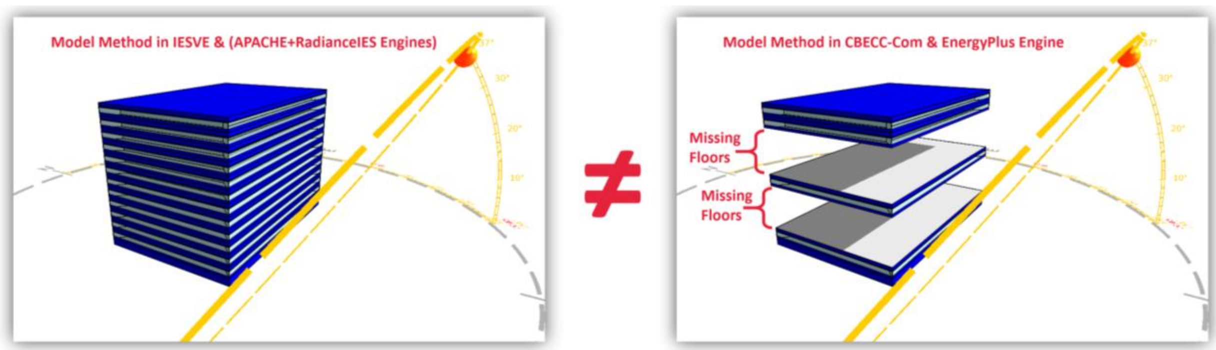

Figure 4: Different Model Methods using in IESVE and CBECC-Com

A previous peer-reviewed ASHRAE research paper[1] has stated that using floor multipliers in building energy models will result in a … :

> "*magnitude of underestimation is dependent on climate zone, with more noticeable effects in milder climates. Buildings in these climates, due to their mild outdoor conditions, are more sensitive to changes within the building. Likewise, the effects of thermal mass that are lost when simplifying a model with floor multipliers are more significant.*".

The "0400007-OffLrg-Baserun" model is located in San Diego, a temperate climate, and Figure 5 shows the change in daylight strategy occurring during the morning setpoint changeover period when the building simultaneously becomes occupied.

[1] "Intelligent Simplification: Consequences of Grouping Floors with Identical Thermal Blocks"; Megan Tosh, Nathan Kegel; 2015 ASHRAE Energy Modeling Conference

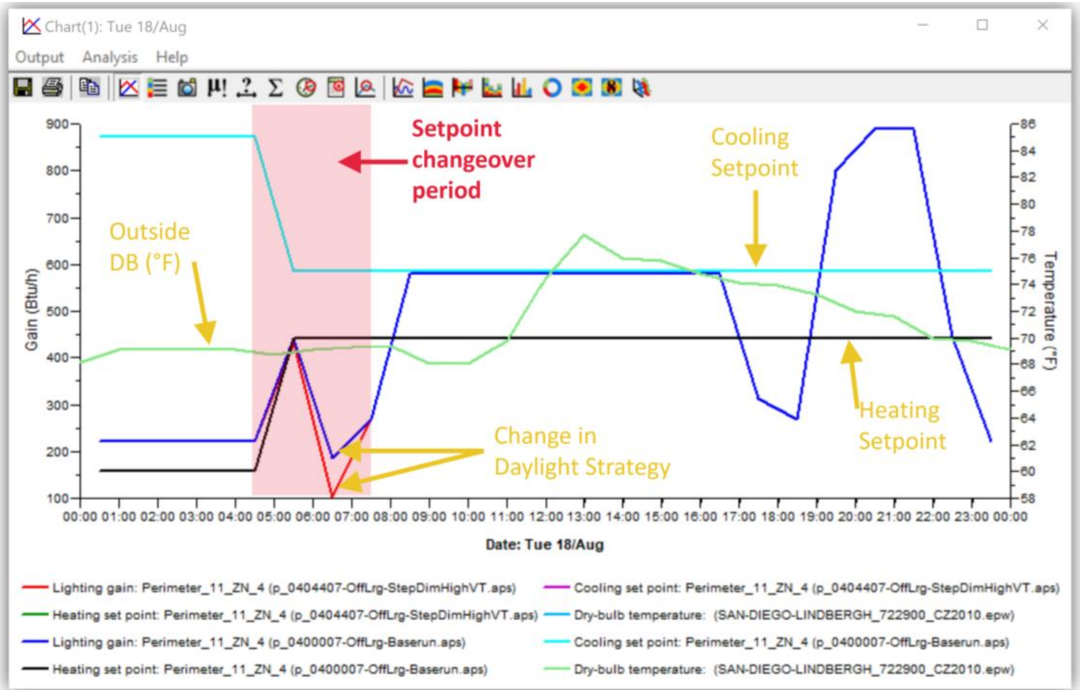

Figure 5: Change in Lighting Heat Gain (and Energy) during the morning setpoint changeover period

Tosh and Kegel's research also noted that:

"*Whether the loss of accuracy when using floor multipliers is worth the time savings during modeling depends on the project and model. A 2% discrepancy in annual energy cost is significant when modeling energy savings for projects pursuing LEED certification. It is significant when calibrating a model of an operating building to evaluate potential savings. When evaluating acceptable limits of error, a 2% discrepancy can be problematic.* "

In terms of the thermal mass effect in this temperate climate for daylight-sensitive tests 0400007, 0404207, 0404307 and 0404407 models, it is apparent that the 2% discrepancy is realized again in the CEC spreadsheet. Figure 6 shows the thermal mass 'changeover' from source to sink for all 48 perimeter rooms with daylighting. Note the rate of internal conduction is different for all spaces; i.e. all floors and spaces should be modeled to account for the thermal mass of the building and sub-hourly heating & cooling demands. The building is highly sensitive during this period, for a small % change tolerance.

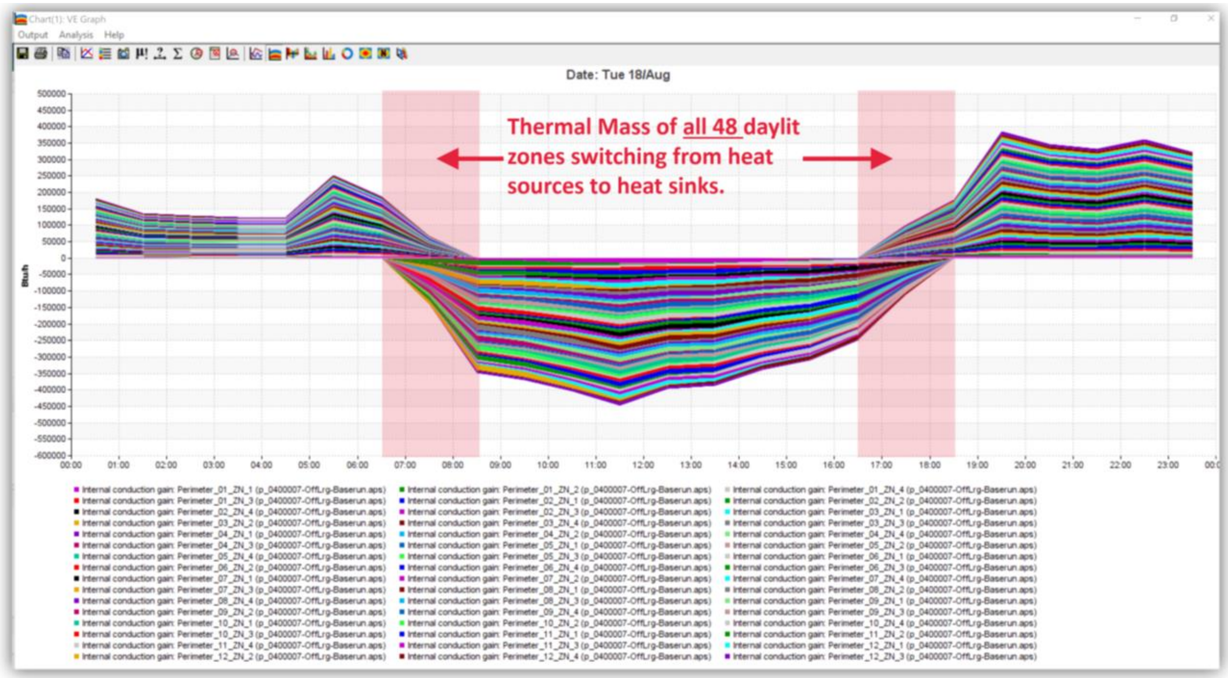

Figure 6: Thermal Mass 'Changeover' for 48 daylit zones.

ANSI/ASHRAE Standard 140: Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs" clearly states that:

> *"for the building thermal envelope and fabric load test cases of Section 5.2, the basic comparative test cases test the ability of the programs to model such combined effects as thermal mass, direct solar gain windows, window-shading devices, internally generated heat, infiltration, sunspaces, and deadband and setback thermostat control. "*

CBECC-Com & EnergyPlus reference models are not operating within the limits of ASHRAE Standard 140 by excluding the combined effects of thermal mass and direct solar gain windows. This is not an equal comparison between CBECC-Com and IESVE. We request that the negligible ~2% TDV Energy difference result in a Pass for IESVE Software. For future CASE studies, we recommend that the CEC ceases the inaccurate use of floor multipliers.

> *tests can be accommodated within the current title purpose and scope of Standard 140, and additional research on this topic is recommended, as discussed in Informative Annex B23.*
>
> *Of the current set of Class I test cases, four test suites were initially developed by the National Renewable Energy Laboratory (NREL) with the International Energy Agency (IEA), and one test suite was developed by Natural Resources Canada, also in collaboration with the IEA (see Annex B23, Section B23.1 for reference citations).*
>
> *For the building thermal envelope and fabric load test cases of Section 5.2, the basic comparative test cases (Sections 5.2.1 and 5.2.2) test the ability of the programs to model such combined effects as thermal mass, direct solar gain windows, window-shading devices, internally generated heat, infiltration, sunspaces, and deadband and setback thermostat control. The in-depth comparative test cases (Section 5.2.3) facilitate diagnosis by allowing excitation of specific heat transfer mechanisms. The ground-coupled slab analytical verification tests of*

Figure 7: ANSI/ASHRAE Standard 140 Excerpt requiring thermal mass & direct solar gain windows

Finally, it is worth nothing that, due to the very fine margins being considered, the dynamic reaction of the building across the day. The figure below shows the hourly change in sensible load for the baseline (0400007) and variant (04040207) for a south facing room across a summer day. Note the very fine differences which, when totaled for the building, can lead to a marginal swing in either direction.

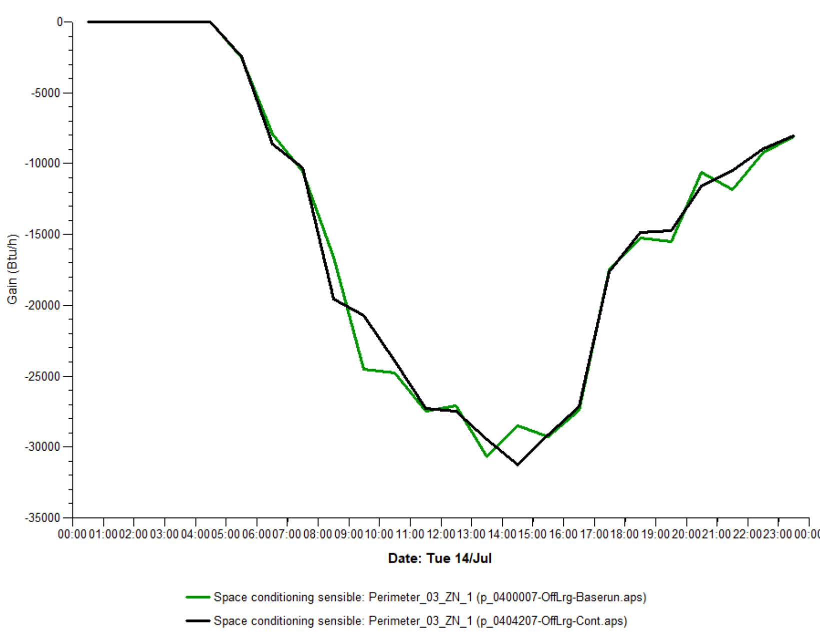

Figure 8: Sensible load variation in a south facing room for a large office baseline (0400007) & variant (04040207)

Test Fail: Other

- CEC Comment: The 1013906-RetlStrp-EvapCooler TDV Energy is moving in the opposite direction to CBECC

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IES Response:

For this model IES is showing a slight increase in TDV (0.98%) versus a negative for CBECC. This is due to a small increase in heating energy (8%) and the relative contribution that heating makes in this model.

This can be explained by some additional heating energy required during the morning heat up. The contribution of the direct evaporative cooling means that temperature presented to the heating coil can be a lower temperature. See below for a psychrometric chart showing the condition of the air presented to a coil (LGStore1) at 7.30 on Feb 11th. The resulting conditions means that the dry bulb temperature is 53.11 DegF. In the baseline system this condition at the exact same time is 60.55 DegF.

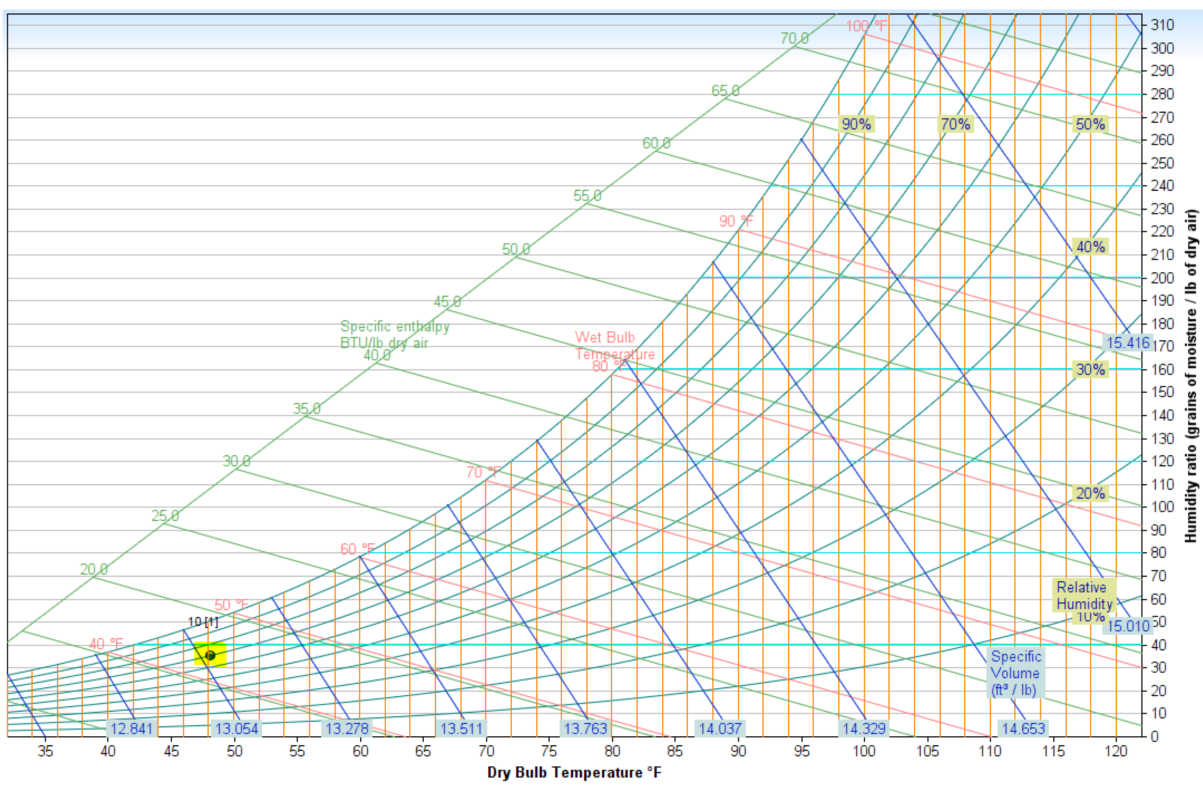

Figure 9: Psychrometric chart showing the condition of the air presented to the heating coil for LGStore 1 at 7.30 on the 11th Feb

Test Fail: <1% Deviation

- CEC Comment: The following models are showing a fail:
  - 0408516-OffLrg-HVACChWdeltaT
  - 0418906-OffLrg-TES-StoTnkVol

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IES Response:

These models are failing due to a less than 1% movement in the opposite direction to CBECC, which is also showing a less than 1% movement. Because of the very tight margins we ask that these be considered as a pass.

	CBECC	IES
0408516-OffLrg-HVACChWdeltaT	-0.9554%	+0.464%
0418806-OffLrg-TES-StoTnkRval	+0.564%	0.00%

In the following model the difference shown by IES is greater than 1%, however as the CBECC model difference is so minute, we would also ask that this be considered a pass.

0418906-OffLrg-TES-StoTnkVol	-0.007%	+1.627%

General: Models not included

The following models are not included in the IES VE Title 24 2019 sensitivity tests:

- 0519515-RetlMed-HPWtrHtrSplitTnkCprsrIns – The VE does not model internal compressors
- 0418606-OffLrg-TES-StoTnkShp – The VE does not model storage tank shape
- 0418706-OffLrg-TES-StoTnkLoc – The VE does not model storage tank location
- 1014315-RetlStrp-WSHP – The VE does not contain the Title 24 WSHP curves
- 1014506-RetlStrp-WSHP – The VE does not contain the Title 24 WSHP curves