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2019 Cost-effectiveness Study: Low-Rise Multifamily Residential New Construction Addendum – Passive House Equivalency Analysis for 2019 Energy Efficiency Ordinances

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1 Introduction

This addendum presents results from analysis of energy efficiency packages that meet minimum Passive House requirements as a potential approach to meeting 2019 local energy efficiency ordinances. The analysis scope is limited to newly constructed low-rise multifamily projects and is based upon the CEC multifamily 8-unit prototype design. The analysis was a collaborative effort between Passive House California (PHCA) and the Statewide Reach Codes Team. The PHCA team provided defined energy efficiency measure packages from the Passive House Planning Package (PHPP) for each climate zone that reflect the minimum requirements to meet the Passive House standard. The Reach Codes team completed energy modeling for each package using the certified version of the 2019 CBECC-Res compliance software for both mixed fuel (gas space heating, water heating, cooking and clothes drying) and all-electric prototypes to determine if buildings that meet Passive House requirements will also comply with proposed local energy efficiency ordinances.

This analysis builds upon the results of the 2019 Cost-effectiveness Study: Low-Rise Residential New Construction (Statewide Reach Codes Team, 2019) conducted for the California Statewide Codes and Standards Program and last modified August 1, 2019, which evaluated compliance packages across all sixteen California climate zones. Reference this report for additional details on methodology and results.

2 Methodology and Assumptions

Table *1* below shows a breakdown of the building specifications modeled for each climate zone. The highlighted cells in the table indicate where measures differ from either the Title 24, Part 6 prescriptive requirements as listed in Table 150.1-B of the 2019 Building Energy Efficiency Standards (California Energy Commission, 2018a) or the Standard Design in CBECC-Res as defined by the 2019 Residential Alternative Calculation Method Reference Manual (California Energy Commission, 2018b). Values highlighted in green reflect measures that are more stringent than the Standard Design reflected in 2019 prescriptive requirements, whereas values highlighted in orange reflect measures that are less stringent than the Standard Design. Values highlighted in blue reflect additional measures required, in addition to meeting minimum Passive House requirements, to meet the EDR Margins for the efficiency packages identified in the 2019 Cost-effectiveness study (Statewide Reach Codes Team, 2019). See the Results & Discussion section for further details.

Some modeling adjustments were made in CBECC-Res to be able to better evaluate Passive House characteristics as described below.

1. Infiltration: The maximum allowable infiltration for Passive House certified projects is 0.6 air changes per hour at 50 Pascals (ACH50). CBECC-Res does not allow credit for reduced infiltration in multifamily buildings and applies a default assumption in the model of 7 ACH50. The Reach Code Team used a research mode in CBECC-Res to be able to model 0.6 ACH50 for this analysis by adjusting the effective leakage area multipliers for the walls and ceiling to reflect a 92% reduction (0.6 ACH50 vs 7 ACH50).
2. Heat Recovery Ventilation (HRV): Most HRVs installed in Passive House certified projects operate with a bypass mode where the heat exchanger is bypassed during the summer when outdoor air conditions are cooler than the thermostat setpoint. This credit was included in the PHPP modeling. While CBECC-Res can model HRVs, it is not able to model this strategy. To estimate the energy impact, the Reach Code Team conducted two simulations, one with an HRV with the proposed heat exchanger effectiveness (70%) and another with an HRV with 0% effectiveness. The second run represents the cooling impact if the bypass mode were engaged throughout the entire summer. Cooling TDV energy use applied in the EDR Margin calculation was determined to be the lower of that from either the 0% or the 70% effectiveness run.

The Reach Code Team reviewed the Home Ventilating Institute's (HVI's) current list of certified equipment and determined that 1 Watt/cfm and 70% effectiveness was a good average representation of the products available. These also align with the values that were used in the PHPP modeling. The impact of 0.5 Watt/cfm and 75% effectiveness was investigated in the mild climates and because the same fan efficacy is applied to the basecase the impact on compliance was minimal.

3. Duct Leakage: Research from a prior study on high performance attics included measured data from 20 homes with ducts located in an unvented attic (PG&E 2015). For these 20 homes, the average total duct leakage to outside was below 25 cfm for all homes and average duct leakage to outside was 0.7% of total system airflow. Most Passive House certified projects do not have vented attics, therefore it is expected that duct leakage in a Passive House will be similar or better than the results from these 20 homes, particularly since total house leakage must be tested to not exceed 0.6 ACH50. It is assumed that duct leakage to outside is 1% of total system airflow for this analysis.

4. Attic Design: The attic insulation levels modeled for Climate Zones 2, 4, and 8-16 are lower than what is assumed for the Standard in CBECC-Res. PHPP modeling used prescriptive Option C, which allows for lower levels of attic insulation if ducts are located within the conditioned space. Prescriptive Option B requires higher levels of attic insulation (and a high performance attic in some climate zones) but allows for ducts to be located in an unvented attic. However, in CBECC-Res the Standard for multifamily buildings assumes Option B in addition to ducts in conditioned space which results in an energy penalty for the Passive House design.

   Most Passive House certified projects do not have a vented attic space, but rather incorporate either a sealed attic with ducts in conditioned space or no attic at all and ductless heat pumps. The Reach Code Team compared the modeled impacts an unvented attic with R-30 insulation at the roof level with a vented attic with R-30 at the ceiling. In both cases ducts are located within conditioned space. Performance between these two cases was very similar based on CBECC-Res results.

Refer to the 2019 Cost-effectiveness Study: Low-Rise Residential New Construction (Statewide Reach Codes Team, 2019) for further details.

Table 1 – Modeled Building Specifications by Climate Zone

CZ	Duct[1]	Infiltration[2]	Wall	Attic[1]	Roof	Glazing (U-factor/SHGC)	Slab[3]	DHW	HVAC	HRV[4]
1	DCS, 1% leakage	QII + 0.6 ACH50	R-21 + R-8	Code Min (R-38)	Code Min (Std roof)	0.15/0.35 (Std Design = 0.30/0.35)	R-20, 4ft edge ins.	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
2	DCS, 1% leakage	QII + 0.6 ACH50	R-21 + R-8	R-30 + Radiant Barrier (Std Design = R-38 + RB)	Code Min (Std roof)	0.25/0.25 (Std Design = 0.30/0.23)	R-10, 4ft edge ins.	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
3	DCS, 1% leakage	QII + 0.6 ACH50	Code Min (R-21 + R-4)	Code Min (R-30 + RB)	Code Min (Std roof)	Code Min (0.30/0.35)	Code Min (uninsulated)	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
4	DCS, 1% leakage	QII + 0.6 ACH50	Code Min (R-21 + R-4)	R-30 + Radiant Barrier (Std Design = R-38 + R-19)	Code Min (Std roof)	Code Min (0.30/0.23)	Code Min (uninsulated)	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
5	DCS, 1% leakage	QII + 0.6 ACH50	Code Min (R-21 + R-4)	Code Min (R-30 + RB)	Code Min (Std roof)	Code Min (0.30/0.35)	Code Min (uninsulated)	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
6	DCS, 1% leakage	QII + 0.6 ACH50	Code Min (R-15 + R-4)	Code Min (R-30 + RB)	Code Min (Std roof)	Code Min (0.30/0.23)	Code Min (uninsulated)	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
7	DCS, 1% leakage	QII + 0.6 ACH50	Code Min (R-15 + R-4)	Code Min (R-30 + RB)	Code Min (Std roof)	Code Min (0.30/0.23)	Code Min (uninsulated)	Basic compact distribution credit	Code Min	1 W/cfm, 70% effect., free cooling bypass
8	DCS, 1% leakage	QII + 0.6 ACH50	Code Min (R-21 + R-4)	R-30 + Radiant Barrier (Std Design = R-38 + R-19)	0.20 solar reflectance cool roof	Code Min (0.30/0.23)	Code Min (uninsulated)	Enhanced compact distribution credit	Code Min	1 W/cfm, 70% effect., free cooling bypass
9	DCS, 1% leakage	QII + 0.6 ACH50	Code Min (R-21 + R-4)	R-30 + Radiant Barrier (Std Design = R-38 + R-19)	Code Min (Std roof)	Code Min (0.30/0.23)	Code Min (uninsulated)	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
10	DCS, 1% leakage	QII + 0.6 ACH50	Code Min (R-21 + R-4)	R-30 + Radiant Barrier (Std Design = R-38 + R-13)	Code Min (Cool roof)	Code Min (0.30/0.23)	Code Min (uninsulated)	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
11	DCS, 1% leakage	QII + 0.6 ACH50	R-21 + R-8	R-42 + Radiant Barrier (Std Design = R-38 + R-19)	Code Min (Cool roof)	Code Min (0.30/0.23)	R-20, 4ft edge ins.	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
12	DCS, 1% leakage	QII + 0.6 ACH50	R-21 + R-8	R-42 + Radiant Barrier (Std Design = R-38 + R-19)	Code Min (Cool roof)	Code Min (0.30/0.23)	R-20, 4ft edge ins.	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
13	DCS, 1% leakage	QII + 0.6 ACH50	R-21 + R-12	R-38 + Radiant Barrier (Std Design = R-38 + R-19)	Code Min (Cool roof)	0.30/0.15 + 2ft overhangs (Std Design = 0.30/0.23)	R-20, 4ft edge ins.	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
14	DCS, 1% leakage	QII + 0.6 ACH50	Code Min (R-21 + R-4)	R-38 + Radiant Barrier (Std Design = R-38 + R-19)	Code Min (Cool roof)	Code Min (0.30/0.23)	Code Min (uninsulated)	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
15	DCS, 1% leakage	QII + 0.6 ACH50	R-21 + R-16	R-46 + Radiant Barrier (Std Design = R-38 + R-19)	Code Min (Cool roof)	0.12/0.12 + 3ft overhangs (Std Design = 0.30/0.23)	R-20, 4ft edge ins.	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass
16	DCS, 1% leakage	QII + 0.6 ACH50	R-21 + R-16	R-38 (Std Design = R-38 + R-13)	Code Min (Std roof)	0.18/0.50 + 3ft overhangs (Std Design = 0.30/0.35)	Code Min (R-7, 16in edge ins.)	Code Min	Code Min	1 W/cfm, 70% effect., free cooling bypass

[1]PHPP modeling used prescriptive Option C, this results in a penalty in CBECC-Res because Option B (high performance attic) is assumed in the Standard Design in addition to ducts in conditioned space. DCS signifies ducts in conditioned space; RB signifies radiant barrier.

[2]Reduced infiltration for multifamily buildings cannot be modeled as a compliance credit. 0.6 ACH50 was evaluated using a research mode of CBECC-Res. QII is prescriptive in all climate zones except 7.

[3]CBECC can only model edge insulation, max R-20 & 4ft depth. BEopt modeling was done to correlate under slab insulation with perimeter insulation.

[4]Standard Design is balanced ventilation 1 W/cfm and no heat recovery. % value is recovery effectiveness percentage of the HRV system. The impact of a free cooling bypass cannot be directly evaluated in CBECC-Res and was estimated.

Highlighted Cells: Green = More stringent than base (2019 T-24 Standard design); Orange = Less stringent than base; Blue = Required in addition to PH to meet ordinance

3 Results & Discussion

Results are summarized by comparing the final Energy Design Rating (EDR) Margin of each Passive House run to the EDR Margin targets that were determined in the statewide report. Table 2 summarizes the calculated EDR Margin for each of the climate zones broken down by fuel type and compared to the targets as identified in the 2019 reach code cost-effectiveness report. In almost all cases, the EDR Margins achieved by the Passive House designs exceed the EDR Margin targets, and in most cases, the Passive House EDR Margin is significantly higher than the target EDR Margins defined in the report.

Table 2 – EDR Margin Comparison of 2019 Reach Code Target vs. Passive House Model

	Mixed Fuel EDR Margin		All-Electric EDR Margin	
Climate Zone	**2019 Reach Code Targets**	**Passive House Model**	**2019 Reach Code Targets**	**Passive House Model**
1 - Arcata	2.0	10.0	3.0	11.1
2 – Santa Rosa	1.5	5.6	1.5	7.4
3 - Oakland	0.5	3.6	0.0	3.6
4 – San Jose	1.0	3.2	1.0	4.0
5 – Santa Maria	0.5	3.5	0.5	4.0
6 – Torrance	1.0	1.5	1.0	2.8
7 – San Diego	0.5	0.5	0.5	1.3
8 – Fullerton	1.0	1.0	1.0	1.4
9 – Burbank	1.5	1.6	1.5	2.6
10 – Riverside	1.5	2.2	1.5	3.5
11 – Red Bluff	2.5	6.4	3.5	8.2
12 – Sacramento	1.5	5.2	2.5	6.3
13 – Fresno	3.0	8.2	3.0	8.8
14 – Palmdale	3.0	6.0	3.5	7.1
15 – Palm Springs	4.0	11.5	4.0	11.8
16 – Blue Canyon	2.0	9.8	3.0	13.8

The exceptions are the mixed fuel cases in Climate Zones 7 and 8 (highlighted in Table 2), which fall short of the cost effective non-preempted efficiency packages developed in the 2019 reach code cost-effectiveness report. Meeting reach code targets are more challenging in mild climates. To meet the reach code targets for mixed fuel in Climate Zone 7, Passive House buildings would need to prescriptively require the basic compact water heating distribution credit. Mixed fuel buildings in Climate Zone 8 would need to prescriptively require expanded compact water heating credit (with verified 0.6 compactness factor) and a cool roof with minimum 0.20 solar reflectance in addition to meeting Passive House certification (see *Table 1*). All-electric buildings do not need to include the additional prescriptive measures to meet the reach code target requirements in these climates.

4 References

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