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Comments on Nonresidential MZ Heat Pump Baseline Proposal

Additional submitted attachment is included below.

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To:	California Energy Commission
From:	Taylor Engineers
Subject:	Docket Number: 24-BSTD-01 15-Day Language
Date:	September 5, 2024

Taylor Engineers is grateful that the Energy Commission has taken the time to meet with a range of concerned stakeholders and has carefully considered feedback in revising the draft 15-day language for the multi-zone heat pump baseline in 140.4(a)3. In particular, the Staff Memo has ultimately acknowledged that the proposed FPFC system is generally not cost effective in most applications when compared to the existing baseline system. The current draft language provides more flexibility in system selection by adding the dual fan dual duct system, which can be a very efficient and cost-effective all-electric HVAC system for some applications, and by providing an exception for buildings larger than 150,000 ft^2 or greater than 5 stories. Taylor Engineers is strongly supportive of energy efficient and appropriate solutions for decarbonizing buildings and HVAC systems. We are appreciative of the opportunity to collaborate with the Energy Commission to advance Title 24 Part 6 and look forward to continuing to collaborate in future cycles.

Nevertheless, Taylor Engineers does have some concerns about the cost effectiveness analysis based on the proposed VRF system type for the medium office building (MOB) and small school prototypes. We believe that the determination of cost effectiveness is incorrect, compared to the existing baseline system type, based on our review of the detailed cost calculations. Our revisions and corrections to the calculations result in higher first costs, higher maintenance costs, and higher replacement costs for VRF over the 30 year period, and benefit to cost ratios (BCR) of less than 1.0 for both protypes and in nearly all climates.

For example, for the medium office building (many of the same concerns apply to the small school):

- The MOB has an area of 53,628 sf. The baseline system assumes 60 VAV boxes at $3245/ea installed and ~900 sf/zone, which is a reasonable average zone size. The proposed system assumes 30 VRF fan coils at $2056/ea installed. That unit cost is far too low, it cannot be lower than that for a VAV box, and there is no reason that the number of VRF fan coils should be less than the number of VAV zones. In our suggested revisions, we increase the number of VRF fan coils to 60 and increased the cost of VRF fan coils to $4000/ea installed. This also doesn't yet include costs for VRF branch controllers and power connections to each fan coil.
- The VRF model assumes condensate piping costs at $317/ton. A contractor suggested $2500/zone for condensate piping, not including condensate pumps.
- The analysis assumes a 20 year lifespan for VRF. We shortened to 15 years, which may still be generous. We heard an anecdote from one building where 10% of the units are failing per year already after 8 years. The spreadsheet analysis did not include replacement costs for zone level equipment, so we added these for VAV boxes and VRF fan coils. Because of the shorter lifespan and higher unit costs, this is a major increase in differential replacement costs for the VRF system type.
- Maintenance costs were included for 30 VAV boxes, but not for VRF fan coils. We set the quantities for both to 60, and added the link to the maintenance costs for fan coils. This is a large cost differential because of all of the required fan coil filter changeouts. In practice, there's very little annual maintenance done on VAV boxes, whereas changing out fan coil filters is likely even higher than the assumed $180/yr because the required MERV-13 filters would generally only last about 3 months in these applications. This results in a large differential increase in maintenance costs for the VRF system type.
- The VRF model assumes $1500/ton for refrigerant piping in CZ3, which works out roughly to $4.4/ft2 and seems very low. We had a 2020 cost estimate that worked out to $13/ft2. We have not included this in our suggested revisions.
- Demand controlled ventilation (DCV) is a mandatory requirement for spaces with high occupant densities, such as classrooms and conference rooms, even for DOAS systems. To implement this, an additional damper

is required for each DCV zone but these costs are also omitted from the VRF system. We have not included this in our suggested revisions, but this is particularly costly for the small school.

Further, VRF system costs are widely expected to increase in 2026 as new refrigerant restrictions go into effect, requiring the use of mildly flammable A2L refrigerants, changes to VRF product lines, and additions of refrigerant detectors and automatic shutoff valves. These costs do not appear to be factored into the analysis. Lastly, there have been longstanding concerns that VRF rated efficiencies are vastly overstated based on AHRI rating conditions. Recent research into VRF system performance led to significant changes to AHRI 1230-2023, which has only recently led to new, lower efficiency ratings for VRF equipment. We have seen average reductions in EER of 16% from one manufacturer based on the new AHRI 1230 standard.

Screenshots summarizing our noted corrections to the cost effectiveness calculations for the medium office building and small school are included below.

Medium Office VRF/DOAS Cost-Effectiveness

added replacement cost for VAV boxes

	CZ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Base Case	Baseline First Cost	$1,549,694	$1,596,678	$1,594,542	$1,605,220	$1,581,728	$1,600,949	$1,605,220	$1,614,513	$1,612,378	$1,623,056	$1,620,920	$1,596,678	$1,609,492	$1,635,870	$1,640,141	$1,665,769
	Replacement Cost	$268,486	$293,361	$292,230	$297,884	$285,446	$295,623	$297,884	$302,822	$301,692	$307,345	$306,215	$293,361	$300,145	$314,129	$316,391	$329,959
	Maintenance Cost	$74,697	$74,697	$74,697	$74,697	$74,697	$74,697	$74,697	$74,697	$74,697	$74,697	$74,697	$74,697	$74,697	$74,697	$74,697	$74,697
	Total	$1,892,877	$1,964,736	$1,961,470	$1,977,802	$1,941,872	$1,971,269	$1,977,802	$1,992,033	$1,988,767	$2,005,099	$2,001,832	$1,964,736	$1,984,334	$2,024,697	$2,031,229	$2,070,425
VRF/DOAS	Proposed First Cost	$1,729,097	$1,834,690	$1,830,500	$1,851,451	$1,805,358	$1,843,070	$1,851,451	$1,868,212	$1,864,022	$1,884,973	$1,880,783	$1,834,690	$1,859,831	$1,910,115	$1,918,495	$1,968,778
	Replacement Cost	$418,216	$456,238	$454,510	$463,152	$444,140	$459,695	$463,152	$470,065	$468,336	$476,978	$475,250	$456,238	$466,608	$487,348	$490,804	$511,544
	Maintenance Cost	$236,205	$236,205	$236,205	$236,205	$236,205	$236,205	$236,205	$236,205	$236,205	$236,205	$236,205	$236,205	$236,205	$236,205	$236,205	$236,205
	Total	$2,383,518	$2,527,133	$2,521,215	$2,550,807	$2,485,704	$2,538,970	$2,550,807	$2,574,482	$2,568,563	$2,598,156	$2,592,237	$2,527,133	$2,562,645	$2,633,667	$2,645,504	$2,716,527
Cost-Effectiveness	Incremental Cost	$9.15	$10.49	$10.44	$10.68	$10.14	$10.59	$10.68	$10.86	$10.81	$11.06	$11.01	$10.49	$10.78	$11.36	$11.45	$12.05
	AGIC Avoided Cost	$0.43	$0.43	$0.43	$0.43	$0.43	$0.17	$0.18	$0.18	$0.17	$0.17	$0.43	$0.18	$0.43	$0.17	$0.43	$0.43
	Net Incremental Cost	$8.72	$10.05	$10.01	$10.25	$9.71	$10.41	$10.51	$10.68	$10.64	$10.89	$10.58	$10.31	$10.35	$11.18	$11.02	$11.62
	LSC Energy Model Savings	$2.44	$4.15	$0.22	$7.23	$0.56	$0.82	$4.25	$5.17	$5.84	$5.59	$10.28	$6.07	$9.04	$9.64	$12.97	$5.91
	BCR, Medium Office LCC'	**0.28**	**0.41**	**0.02**	**0.71**	**0.06**	**0.08**	**0.40**	**0.48**	**0.55**	**0.51**	**0.97**	**0.59**	**0.87**	**0.86**	**1.18**	**0.51**

Savings from avoided gas hookup are included here for baseline, but there is no accounting for additional electrical costs for 60 VRF fan coils

Added maintenance costs for VRF indoor units.

Added replacement costs for VRF indoor units. Fixed formula reference for ERV replacement costs.

Was hardcoded at 30 zones, corrected to reference 60 zones

Small School VRF/DOAS Cost-Effectiveness

	CZ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Base	Baseline First Cost	$744,155	$755,869	$749,690	$758,206	$752,857	$753,796	$748,587	$757,874	$757,214	$758,581	$759,831	$750,431	$751,825	$759,783	$761,884	$759,522
	Replacement Cost	$82,251	$88,724	$85,292	$89,966	$87,153	$87,746	$84,874	$89,901	$89,559	$90,302	$90,932	$85,780	$86,598	$90,820	$92,235	$90,635
	Maintenance Cost	$53,096	$53,096	$53,096	$53,096	$53,096	$53,096	$53,096	$53,096	$53,096	$53,096	$53,096	$53,096	$53,096	$53,096	$53,096	$53,096
	Total	$879,502	$897,688	$888,077	$901,268	$893,105	$894,638	$886,556	$900,870	$899,869	$901,978	$903,859	$889,306	$891,519	$903,699	$907,215	$903,252
VRF/DOAS	Baseline First Cost	$807,829	$874,412	$839,298	$883,631	$836,658	$857,190	$870,515	$882,960	$865,906	$872,066	$882,457	$852,330	$866,702	$875,879	$912,502	$874,077
	Replacement Cost	$135,477	$151,994	$143,283	$154,281	$142,628	$147,722	$151,027	$154,115	$149,884	$151,412	$153,990	$146,516	$150,081	$152,358	$161,443	$151,911
	Maintenance Cost	$103,365	$103,365	$103,365	$103,365	$103,365	$103,365	$103,365	$103,365	$103,365	$103,365	$103,365	$103,365	$103,365	$103,365	$103,365	$103,365
	Total	$1,046,670	$1,129,771	$1,085,946	$1,141,277	$1,082,651	$1,108,277	$1,124,907	$1,140,440	$1,119,155	$1,126,842	$1,139,812	$1,102,210	$1,120,148	$1,131,602	$1,177,310	$1,129,353
Cost-Effectiveness	Incremental Cost	$167,168	$232,083	$197,869	$240,009	$189,546	$213,639	$238,352	$239,569	$219,286	$224,865	$235,954	$212,904	$228,629	$227,902	$270,095	$226,101
	Incremental Cost / SF	$6.85	$9.51	$8.11	$9.84	$7.77	$8.75	$9.77	$9.82	$8.99	$9.21	$9.67	$8.72	$9.37	$9.34	$11.07	$9.27
	LSC Energy Model Savings	$3.72	$2.48	$1.37	$4.85	$1.31	$0.74	$0.35	$3.34	$3.32	$4.69	$7.52	$4.82	$6.66	$7.14	$9.56	$2.78
	BCR, Small School LCC	**0.54**	**0.26**	**0.17**	**0.49**	**0.17**	**0.08**	**0.04**	**0.34**	**0.37**	**0.51**	**0.78**	**0.55**	**0.71**	**0.76**	**0.86**	**0.30**

Removed discount of 20% applied to DOAS replacement cost. Formula was also incorrectly pointing to VAV replacement discount