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Mitsubishi Electric Comments on 15-Day Language of Proposed Draft 2022 California Energy Code

Additional submitted attachment is included below.

Mitsubishi Electric Comments on 15-Day Language of Proposed Draft 2022 California Energy Code

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Introduction

Mitsubishi Electric US, Inc., Heating and Air Conditioning Division (MEUS HAD), is a leading manufacturer of ductless and Variable Refrigerant Flow (VRF) heat pumps and air conditioning systems. We appreciate the Commission's efforts to mitigate the impacts of buildings on climate change and recognize the importance of rapid mobilization strategies that produce measurable reductions in GHGs over the next thirty years as well as the broader goal to transform California's economy to carbon free and carbon negative alternatives.

While we generally support the Commission's improvements to Title 24, Part 6, we continue to have several concerns related to VRF products and economizer and DOAS requirements. The proposed overlay of economizer or DOAS with bypass requirements on VRF units under 54kbtu and the supporting modeled research do not account for the fact that VRF systems perform particularly well in low-load conditions that overlay economizer run times. We propose an economizer and DOAS bypass exemption for VRF systems under 54kbtu, and an exemption for VRF with heat recovery wherein waste heat from zones calling for cooling is redirected to zones simultaneously calling for heating. This feature alone is known to increase VRF system efficiency in the range of 20% -40%*[1] under such partial and mixed load conditions, precisely when economizers would be in operation.

Additionally, we ask for clarification of terms and requirements included in the 15-Day language which, we believe, will give rise to ambiguity and dissent around interpretation.

Studies on VRF and Economizer Performance Suggest Limited Gains from Combining Them

The CEC 15-day language continues to impose economizer requirements on commercial VRF systems by lowering the requirement threshold from 54kbtu to 33kbtu (Section 140.4 (e)1) on all indoor units. The language in Exception 6 still requires economizer modes of operation for VRF systems paired with either coupled or decoupled DOAS (definition includes DX-DOAS and ERVs that are either separate or connected to primary conditioning system returns or supply plenums). According to the substantially rewritten Section140.4(p), economizer modes or DOAS bypass systems must have flow rates of outside air in a bypass mode of .3cfm/sq. foot (Sect.140.4(p)1).

Imposing economizer or DOAS requirements on VRF increases system costs significantly and threatens to diminish the VRF market. According to a research publication by the Bonneville Power Administration (BPA):

> *"Several studies have shown that economizers seldom save as much energy as they should. In addition, adding economizers to VRF systems, or dedicated ventilation systems may not be cost effective…. Energy modeling performed for the Washington State Energy Code estimated that because a VRF system with heat recovery capability uses about the same amount of energy as a non-VRF system with economizers, there is an exception to the economizer requirement for VRF systems with heat recovery capability. Oregon Energy Code also has an exception to the economizer requirement for VRF systems with heat recovery capability."*[1]

We have estimated conservatively that VRF systems have a 20% efficiency advantage over rooftop systems. A 2017 national study conducted modeling on VRF system efficiencies compared to rooftop units (RTUs) in sixteen US climate zones and concluded the following:

> *"The simulation results show that the VRF systems would save around 15–42% and 18–33% for HVAC site and source energy uses compared to the RTU-VAV systems. In addition, calculated results for annual HVAC cost savings point out that hot and mild climates show higher percentage cost savings for the VRF systems than cold climates mainly due to the differences in electricity and gas use for heating sources."*[2]

Thus, according to this study, average site energy is in the range of 28% and source energy savings in the range of 25% over RTUs with VAV, (variable air volume or variable capacity). A2012 ACEEE review of economizer efficiencies found that:

> *"The Fifth NW Power Plan estimated that in the commercial sector, rooftop heating ventilating and air-conditioning (HVAC) improvements would contribute 16.7% of retrofit savings and economizers provide a large share of that savings (NPCC 2005). Often dubbed "free cooling," the outside air economizer shows great savings potential in theoretical energy simulations. The actual performance has been much less than ideal as discussed in the literature review…. Several field studies have found that more than half of outside air*

economizers are not providing optimal savings, either because dampers or controls have failed, changeover is set incorrectly, or the improper type of controls for the local climate have been installed."[3]*

The current CEC proposal overlays RTU economizer requirements on what is already a class of highly efficient VRF products with fewer failure modes. VRF system efficiency exceed 20%-40% compared to a maximum of 16% efficiency enhancement for RTUs with economizers according to some estimates*[1&3]. Taken together, these factors suggest the proposed VRF economizer requirement is impractical and will not achieve the desired result and may actually cause net efficiency losses especially in the shoulder seasons where simultaneous cooling and heating is more likely to occur. Furthermore, VRF systems offer more diverse zone control and the ability to fully shut off unoccupied zones. This is not an option with central RTU type systems.

We again suggest that the request for a VRF exemption is entirely reasonable and consistent with regulatory precedent in other states. Although CASE Team and staff have suggested that the Economizer Trade Off Table 140.4F provides recognition to higher efficiency rating equipment, this exemption path doesn't substitute for a VRF exemption because the 25% efficiency gains attributable to VRF are not recognized by either the California Energy Code or CBECC, the compliance software.

Requiring Economizers on VRF is Neither Cost-Effective Nor Efficient

Even when VRF systems aren't equipped with heat recovery, a DOAS system attempting to increase VRF system efficiency by operating with direct outside air cooling under evening partial load conditions is attempting to improve VRF efficiencies when they are likely to be idling at their highest system efficiencies. One can compare the power demand of a compressor running at low-load times to the high fan power required to run an economizer during the same conditions and conclude they are at best a wash. The 0.3 CFM/sq.ft. requirement is roughly equal to the ventilation required for high ventilation applications like schools but is roughly double the ASHRAE 62.1 minimum ventilation rate for many other commercial applications. Consequently, there is an inherent energy and cost tradeoff in order to economize for these applications. The compressor is shut off and mechanical cooling ceases, but in order to economize, the large central fans in the DOAS/ERV need to ramp up in order to accommodate the minimum economizer flow rate. The economizer run hours coincide when VRF compressor speeds are generally idling at a minimum and system efficiencies are high.

When VRF heat recovery efficiencies are added to this equation, there is a diminishing return for utilizing economizers when heat recovery is simultaneously moving waste heat from cooling zones to heating zones, whether or not the majority of zones are calling for cooling. In essence, there's an energy trade-off between compressor energy and fan energy and it may amount to a zero-sum gain in terms of energy consumption in many applications.

This is even more likely to weigh against economizers that are now required to have MERV 13 filtration, which can easily result in higher fan power-draw. Actual efficiency of this fan versus compressor power trade-off will vary with several factors such as total length of ventilation ductwork, number of bends in the ducting, filter area, type of fans used, etc. Despite modeling performed on VRF-coupled economizers, they may not prove to be either efficient or cost-effective for most commercial applications (office, hotel, multifamily residential, religious centers, etc.) since this requirement will result in a ventilation system which adds complexity and duct capacity. Oversizing the ventilation system by a factor of two above ASHRAE 62.1 requirements will inherently result in a system with lower operating efficiency for all run hours except the small subset of run hours where it is economizing. Inevitably, the need to double duct and fan capacity for DOAS systems to meet the economizer airflow requirements will add unreasonable cost to most VRF projects.

VRF with Heat Recovery Should be Given Greater Compliance Credit

Although Table 140.4-D (below) offers some economizer exemptions for the improved efficiency of any system with 30% to 70% higher IEER (or COP), it doesn't specifically acknowledge the additional efficiency of VRF with heat recovery estimated to add an additional 20% to 30% system efficiency depending upon climate zone and load conditions. Not to be confused with "heat recovery" in an ERV or HRV, VRF heat recovery is moving "waste" heat from one zone in a VRF system calling for cooling, to another zone in the same system calling for heat and it does so through branch control boxes (valve boxes) that allow the heat to be

TABLE 140.4-D ECONOMIZER TRADE-OFF TABLE FOR COOLING SYSTEMS

Climate Zone	Efficiency Improvement [a]
1	70%
2	65%
3	65%
4	65%
5	70%
6	30%
7	30%
8	30%
9	30%
10	30%
11	30%
12	30%
13	30%
14	30%
15	30%
16	70%

[a] If a unit is rated with an annualized or part-load metric, ~~IPLV, IEER or SEER,~~ then to eliminate the required ~~air or water~~ economizer, only the applicable minimum cooling efficiency of the ~~HVAC~~ unit must be increased by the percentage shown. If the ~~HVAC~~ unit is only rated with a full load metric, ~~such as~~ like EER or COP cooling, then that metric must be increased by the percentage shown. To determine the efficiency required to eliminate the economizer, when the unit equipment efficiency is rated with an energy-input divided by work-output metric, the metric shall first be converted to COP prior to multiplying by the efficiency improvement percentage and then converted back to the rated metric.

moved to other zones in the building through the refrigerant loops without that refrigerant going through the outdoor unit (compressor). These system efficiencies tend to be highest when loads are moderate, similar conditions for when economizers may be operating, and it is unlikely that the efficiencies are cumulative. For this reason, it is important to recognize VRF heat recovery efficiencies by exempting these systems from economizer requirements, otherwise the overlay of requirements create conditions wherein competing system features cancel the measurable efficiency in the field.

Prescriptive Requirements for Space Conditioning Systems by Climate Zone

Under Section 140.4 (a) 2B & F, the energy code 15-day language now requires that only office, financial, library, retail and grocery applications in specified climate zones with cooling capacities less than 65kbtu "must be served by a furnace plus AC system". Given the state's decarbonization mandates, dual-fuel HP systems should be required as these systems have been demonstrated to lower both NOx (up to 98%) and CO2 emissions by as much as 69%*[6]. However, despite possible source energy advantages for DFHPs in these applications, the energy code should allow cold-climate HPs (CCHPs) to fulfill these applications as they are highly efficient down to -20°F. The greening of the grid and a 100% RPS that is expected by 2045 will make the source energy profile of CCHPs competitive.

Partial Electric Baselines as Applied to Specific Climate Zones

We are deeply appreciative that Section 150.1(c)7, sets partial electric baselines with compliance credit (EDR) to highly motivate the specification of heat pumps. However, we continue to question the logic of the climate zones that have been chosen for single family dwellings. It appears that the CEC has set a very low bar for how well they expect the ASHP systems to perform. Section 150.1 (c)7 currently calls for HP space heating (ASHPs) in climate zones 3, 4, 10, 13 and 14. These climate zones were chosen based on cost effectiveness of the systems, <u>but wholesale gas versus ASHP equipment costs posted to the docket by NRDC indicate that ASHP equipment is 15% to 30% cheaper than similar central furnace plus AC systems of the same brand and efficiency.</u> <u>This fact alone would dictate that ASHPs should be required in all jurisdictions that now require ultra-low NOx furnaces and where AC is generally installed in new homes (30%</u>

more expensive that ASHPs) which includes the San Juaquin AQMD and SCAQMD jurisdictions (CZs 6, 7, 8, 9, 10, 11, 12, 13, 14 and 15). Therefore, we recommend that central ASHPs be encouraged in climate zones 3,4,5,6,7,8,9,10,12,13,14,15 and that DFHPs or cold-climate HPs be required in climate zones 1, 2, 11 and 16.

Concerns about Addition of Ambiguous Term in Table 140.4-A

Table 140.4-A requires a fan power deduction when "systems feed a terminal unit with a fan with electrical input power <=1kW". When asked for clarification, a CASE Team staffer responded that *"the term "terminal unit" covers the device at the end of the air distribution system and not the upstream AHU/DOAS/other equipment".* In this context, terminal unit could consist of any type of equipment depending upon system configuration. Two CASE Team staff later agreed on the following interpretation: *"In the example of a coupled DOAS serving fan terminal units, the DOAS fan itself, if it was greater than the 1kW limit, must stay within a power budget as stated. If that DOAS fan (say it is a 3 kW fan), serves fan terminal units and those fan terminal units are smaller than 1 kW (<1kW) then this 0.1 inch deduction takes effect.… If the DOAS fan served fan terminals which were above 1kW, those 1kW fan terminals themselves would have triggered the fan power allowance section of (the) code and the DOAS fan in this instance would not have to take the deduction of 0.1 inches." According to Section 140(c)1, Table 140.4-A only applies to fan systems over 1kW, however, it is not obvious from the current text that DOAS with fan power greater than 1kW must take a fan-power deduction of .1* when the DOAS input power exceeds 1kW but the input power of the terminal units are below 1kW. The simplest clarification would be "Deduction for DOAS systems with >1kW that feed a terminal unit or units with a fan with electrical input power <=1kW", although it is not at all clear what the basis for this deduction is in the research. Why is a DOAS feeding two terminal units of under 1kW not afforded the same power budget as an identical system serving a single terminal unit of the same total capacity? The grounds for the fan-power deduction is not obvious.

Conclusions

Mitsubishi Electric is concerned that rushing to implement economizer requirements on all VRF indoor units under 54kbtu fails to recognize the efficiencies and advantages of VRF systems in their various configurations. Economizer requirements should be limited to packaged systems for which economizers are designed, and it is inherently disadvantageous to overlay this requirement onto VRF multi-split systems. We specifically ask that the CEC consider the same regulations instituted by Oregon and Washington based on their own assessment of the research, and allow an exemption for VRF systems. Proceeding with the 33kbtu requirement as the CEC appears to be doing will very likely reduce the installation and use of these inherently more efficient VRF products in the state, which works against the current strategic electrification initiative aimed at reducing carbon emissions and the intent of this new version of Title 24, Part 6. Thank you for the opportunity to comment and we look forward to working with the Commission to ensure desired efficiency results.

Respectfully,

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Footnotes:

*1 Variable Refrigerant Flow Overview, Bonneville Power Administration, June 2012, Page 3

*2 Evaluation of energy savings potential of variable refrigerant flow (VRF) from variable air volume (VAV) in the U.S. climate locations, Oak Ridge National Lab, Dongsu Kima, Sam J. Coxa, Heejin Cho (Mechanical Engineering, Mississippi State University, Starkville, MS 39759, USA), Piljae Im (Building Technologies Research and Integration Center, Oak Ridge National Laboratory, TN 37831, USA), Published in Science Direct, Energy Reports, May 2017, pg.1

*3 The Premium Economizer: An Idea Whose Time Has Come, ACEEE, Reid Hart, Dan Morehouse, and Will Price, Eugene Water & Electric Board, P. 103