DOCKETED

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Project Title:	2019 Title 24, Part 6, Building Energy Efficiency Standards Rulemaking
TN #:	222480
Document Title:	Comment on New Refrigerant Economizer Exception
Description:	Comment on the proposed 2019 Standards by Jeff Stein, Taylor Engineering. Sent electronically be email and docketed by staff.
Filer:	Adrian Ownby
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	2/8/2018 10:53:46 AM
Docketed Date:	2/8/2018

TAYLOR ENGINEERING

To:	CEC
From:	Jeff Stein
Subject:	Comment on New Refrigerant Economizer Exception
Date:	February 7, 2018

Please do not add this proposed new exception to the computer room economizer requirement:

EXCEPTION 5 to Section 140.9(a)1: A computer room located in Climate Zones 1-9, 11-14, and 16 may be served by an integrated pumped refrigerant economizer certified by AHRI using AHRI 1360.

Reasons:

1. A refrigerant economizer is not nearly as efficient as an airside economizer or a waterside economizer.
    a. Figure 1 shows the hours per year in San Jose when each type of economizer is typically in 100% free cooling, no free cooling, and integrated free cooling. For example, a refrigerant economizer can meet 100% of the load only about 8% of the year, compared to 33% for a water economizer and 78% for an air economizer. Clearly the refrigerant economizer is the worst in terms of potential free cooling.
    b. Supply fan: Refrigerant economizer CRAC units and water econ CRAH units have similar components and similar pressure drops but CRAC units have higher minimum fan speeds. So the refrigerant economizer is worse in terms of supply fan energy.
    c. Compressor: Air-cooled DX compressors are not close to the efficiency of water-cooled compressors. For example, see the T-24 limitation on air-cooled chillers. So the refrigerant economizer is worse in terms of compressor energy.
    d. Condenser/Tower Fan: The refrigerant economizer is basically a dry-cooler. A water-side economizer is a wet cooler (cooling tower). Water has far better heat transfer than air. A dry-cooler uses about 5 to 10 times as much fan power as a cooling tower to achieve the same approach. So the refrigerant economizer is worse in terms of condenser/tower fan energy.

e. A water economizer has some CHW/CW pump energy that a refrigerant economizer does not have, but that is in the noise compared to the supply fan, compressor, and condenser/tower fan.

2. There are no truly integrated pumped refrigerant economizers available on the market.

   a. The Liebert DSE has 2 circuits that can be in either compressor mode or economizer pump mode. In partial economizer mode (1 compressor running and one economizer pump running) the DSE loses half of its DX capacity. So to switch from 2 circuits in compressor mode to 1 circuit in economizer the economizer must be able to meet enough of the load that the remaining compressor can meet the rest of the load. The controls must estimate if the economizer can do enough based on the current load, setpoints, and ambient conditions. The controls have to predict if the economizer can meet the load before dropping a compressor and losing 50% of its DX capacity.

   b. Similarly, to go from one circuit on compressor to both circuits on compressor, the economizer must be able to meet the entire load because there are no compressors available. If the controls guess wrong the load could be lost very quickly so they need to be very conservative. Liebert refuses to share their control algorithms with us.

   c. In a best case scenario, the controls would work roughly as shown in Figure 2. This shows that even if the ambient temperature is low enough to enable the economizer, the economizer cannot be enabled if the load is high.

   d. Here is another example of the non-integration: Suppose the OAT is 45 and you are in 100% econ. Then the OAT rises to 46 and you need 98% capacity from the econ and 2% from the DX. To get any capacity from the DX you lose half the economizer so now your DX is doing 50% of the load when a chiller might only do 2% in a water econ.

   e. At best, the Liebert DSE is half way between a fully integrated economizer and a non-integrated economizer.

3. A dry-cooler in series with an air-cooled chiller is more efficient than the Liebert DSE because the dry-cooler can pick up any amount of load without affecting the capacity of the air-cooled chiller, i.e. it is fully integrated. Of course, an a/c chiller + dry-cooler is not nearly as efficient as a water economizer and would not deserve an exception.

4. The economizer requirement is a prescriptive requirement. A refrigerant economizer can use the performance approach. Liebert has claimed that a refrigerant

economizer cannot be properly modeled in the current software so they deserve the prescriptive exception. Unfortunately, there are many systems that cannot be properly modeled but none of them have prescriptive exceptions. VRF, for example, cannot be modeled. But that has not stop hundreds of VRF buildings from using the performance approach. It is very common to use work around and/or exceptional calculation methods that are acceptable to the AHJs. CBECC-Com also allows the user to use a customized EnergyPlus model for the proposed design.

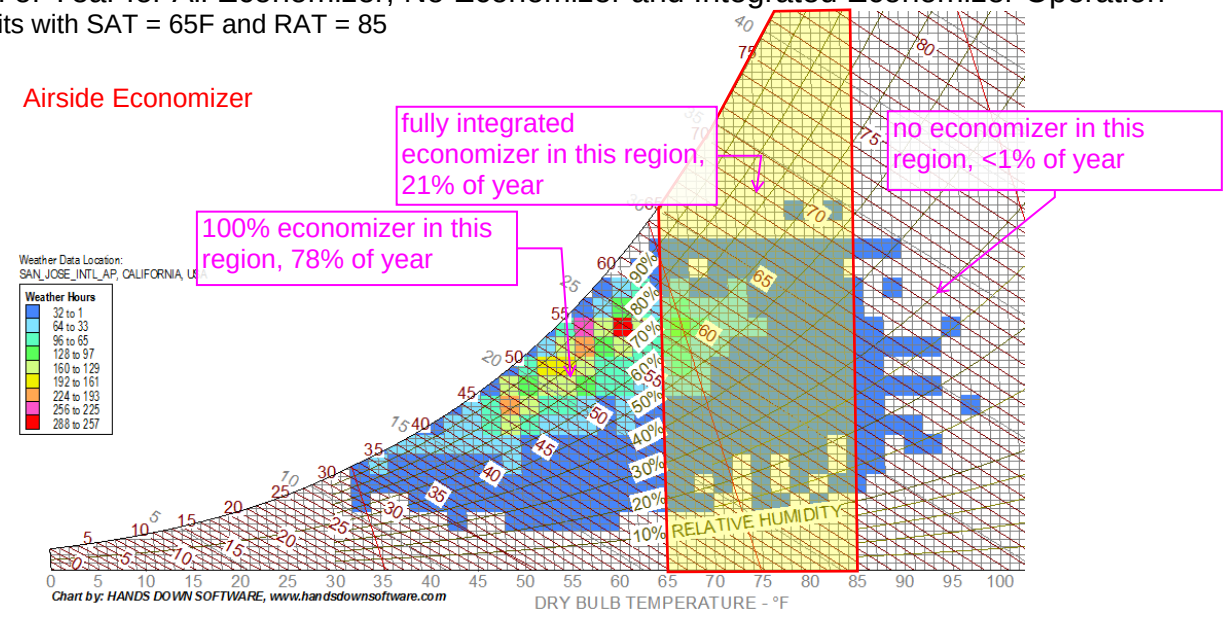
5. I suspect the only reason this is being considered by the CEC is due to a misunderstanding of a poorly worded Taylor Engineering memo in 2015. Shortly before leaving Taylor Engineering, Mark Hydeman reviewed the data Liebert submitted to the CEC for a special exception. Mark later admitted that he only briefly looked at the calibration data for the DX curves and not at the simulation models. When presented with some obvious flaws in the Liebert analysis, Mark agreed that Liebert's analysis was flawed and did not warrant the exception. See attached emails.
6. To qualify for an exception an independent 3rd party should perform the simulations, not Liebert. For example, when JCI and Carrier asked for exceptions to the 300 ton air-cooled chiller limitation, the CEC engaged an independent 3rd party to run the simulations and demonstrate equivalence.
7. The analysis that Liebert submitted was based on their unit which has modulating compressors and variable speed fans that make it more efficient than other CRAC units. This new exception does not capture any of those efficiencies. So Liebert and other manufacturers can now use this exception for systems that are less efficient than the Liebert DSE.
8. This exception does not say anything about the minimum performance of the refrigerant economizer. The airside and waterside economizer requirements say what ambient conditions the economizer must meet the entire load. This new exception allows the refrigerant economizer to be sized to meet the load at any conditions. For example, a refrigerant economizer that couldn't even meet the load at 10°F OA drybulb would still meet this exception.

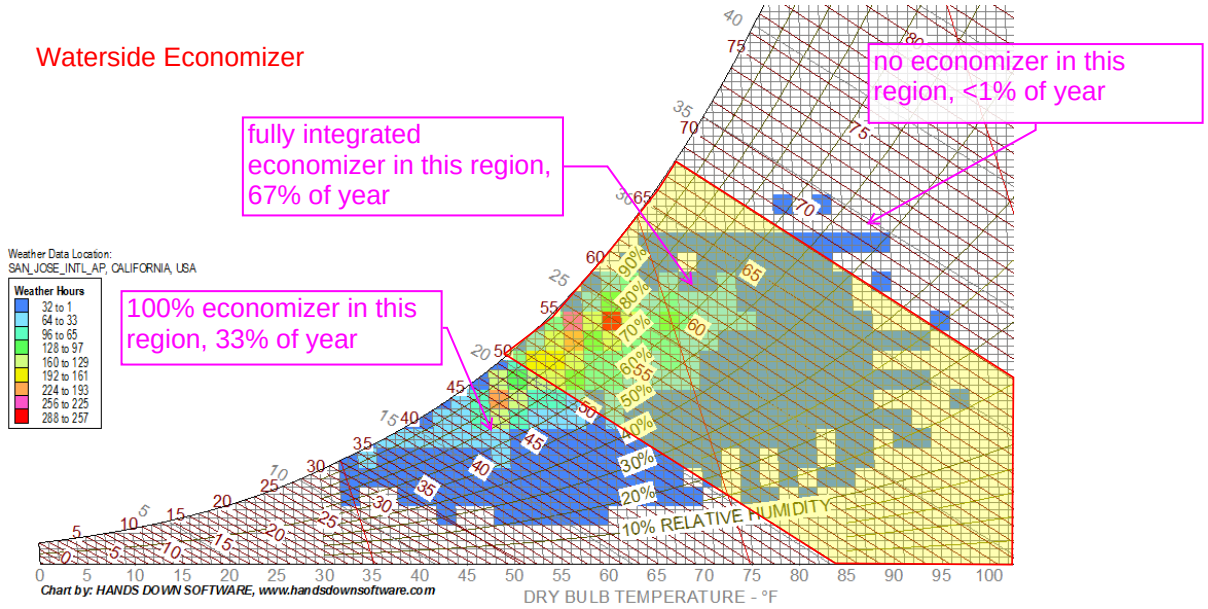
If you do not agree with deleting this exception then at the very least please limit it to small computer rooms. For example:

"EXCEPTION 5 to Section 140.9(a)1: A computer room <u>with a design IT load < 200 KW</u> located in Climate Zones 1-9, 11-14, and 16 may be served by an integrated pumped refrigerant economizer certified by AHRI using AHRI 1360."

Reason: Architectural or business considerations may sometimes dictate that a small/medium computer room be buried deep inside a large office building. Serving such a computer room with an airside or waterside economizer can be relatively difficult and expensive compared to a refrigerant economizer. As the computer room gets bigger the savings of an air/water economizer become greater, making it harder to justify the refrigerant economizer. At a full data center scale, the savings are huge, the architectural consideration are gone, and there is no possible justification for the refrigerant economizer exception. The cost of a performance model is insignificant compared to the lifecycle cost of a data center.

Figure 1. Fraction of Year for All Economizer, No Economizer and Integrated Economizer Operation
For CRAC/CRAH units with SAT = 65F and RAT = 85





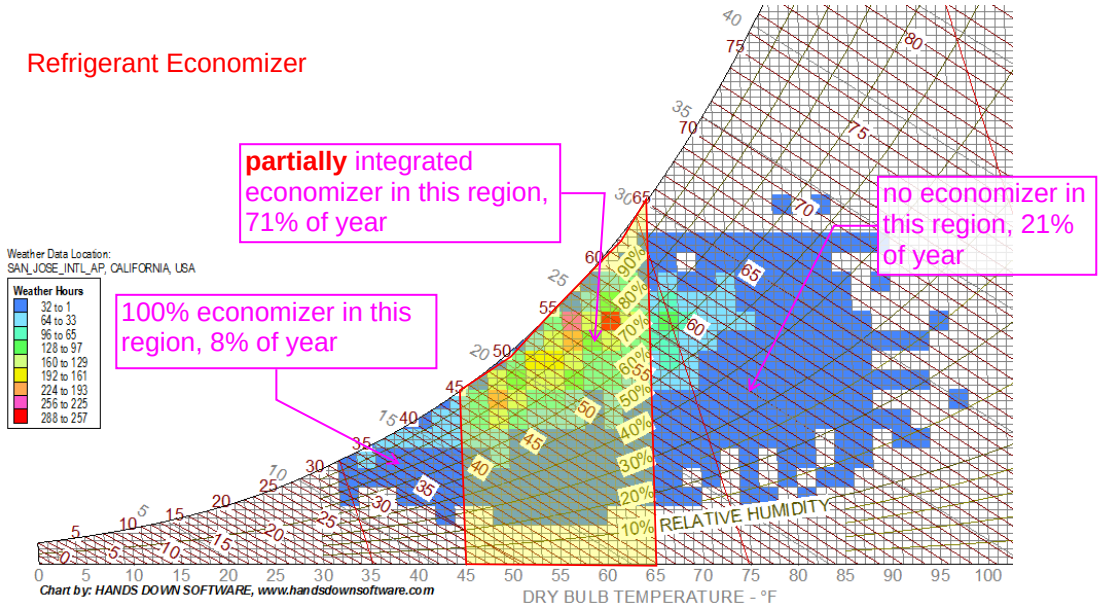
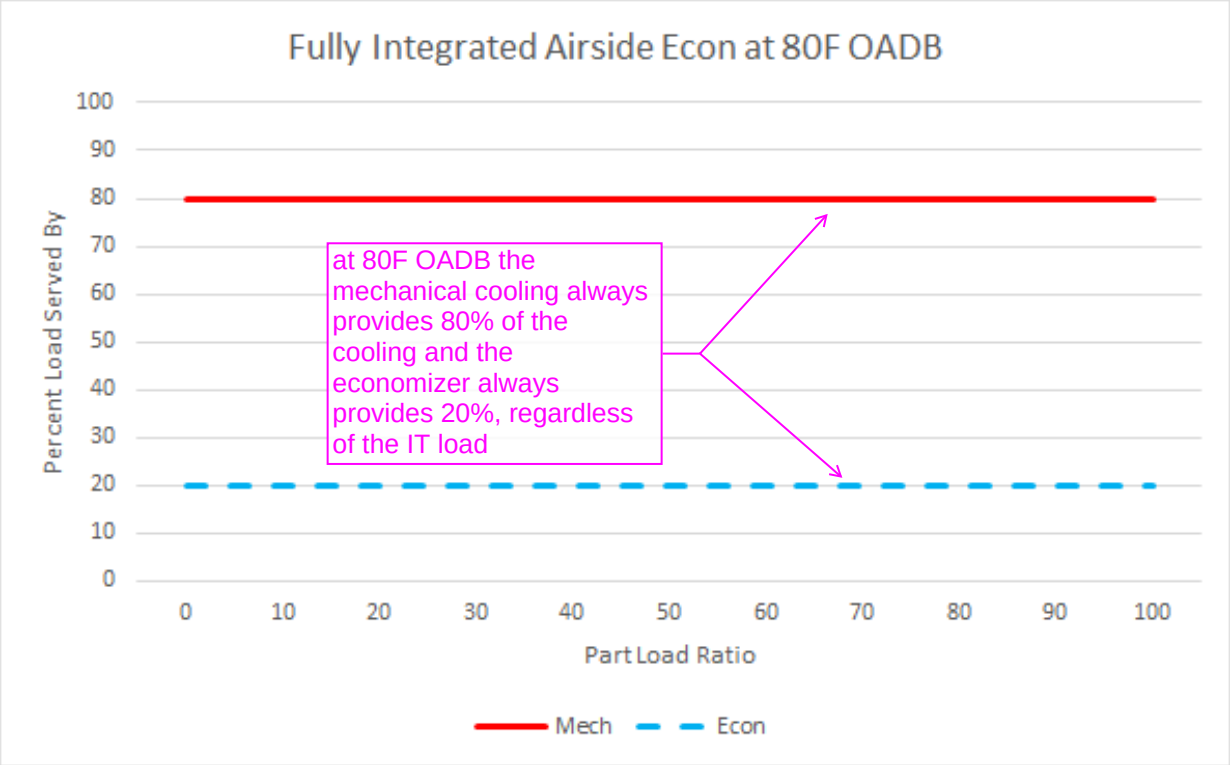
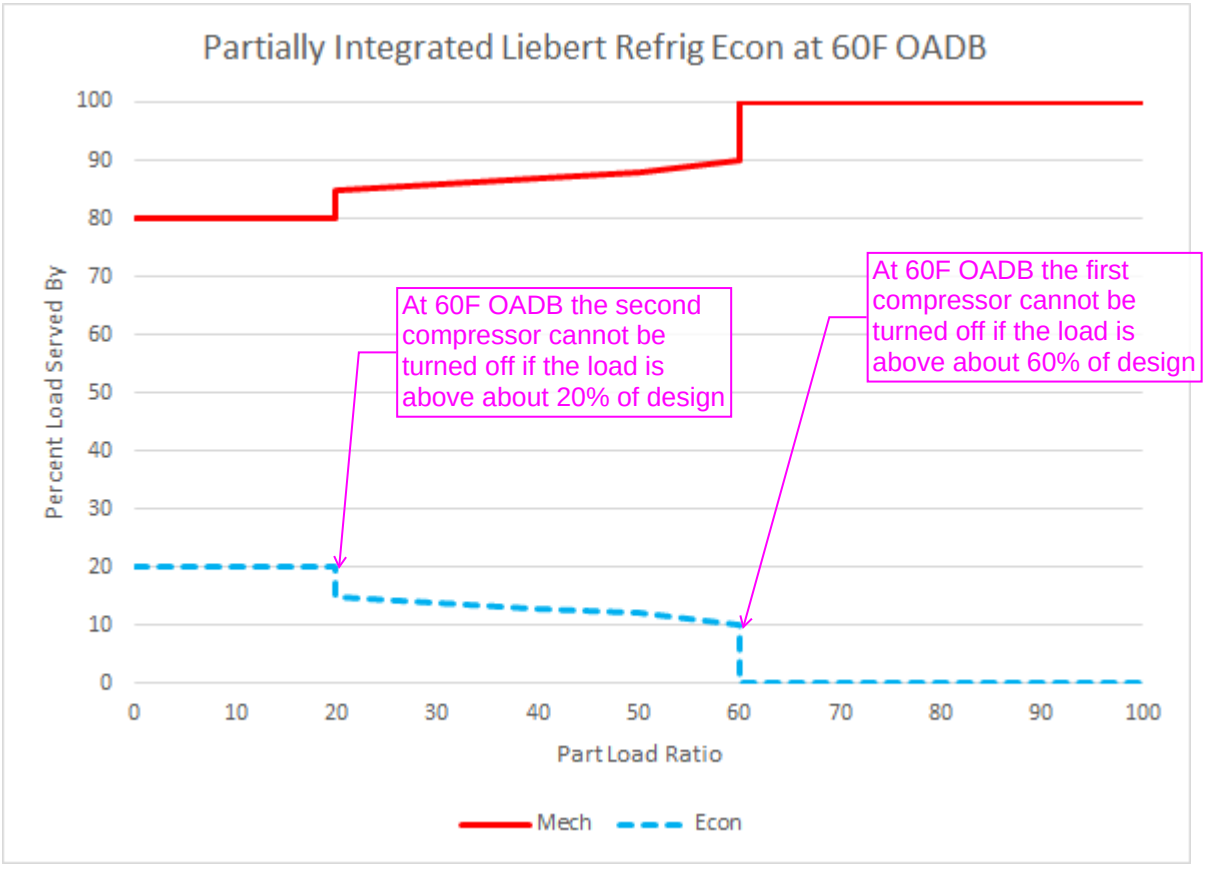


Figure 2. Fully Integrated Economizer vs Partially Integrated Refrigerant Economizer
For CRAC/CRAH units with SAT = 65F and RAT = 85

For an airside economizer the economizer can provide about 20% of the load at about 80F OA drybulb.



At 60F OA drybulb the refrig econ can provide somewhere between 0% and 20% of the load.



Jeff Stein

From: Mark Hydeman <mark.hydeman@continual.net>
Sent: Saturday, October 24, 2015 12:25 PM
To: Jeff Stein; hhauenstein@energy-solution.com; mbh9@pge.com
Cc: set2@pge.com; Steve Taylor
Subject: RE: Compliance Option

Heidi:

I did not catch the issue Jeff uncovered as I was focusing on the calibration of the models and not the compliance software. I plan to add comments on the issues Jeff uncovered with the fan energy as they are indeed relevant and appear to be incorrect. What's the status of our contract?

Mark

From: Jeff Stein [mailto:JStein@taylor-engineering.com]
Sent: Thursday, October 22, 2015 1:27 PM
To: hhauenstein@energy-solution.com; mbh9@pge.com
Cc: set2@pge.com; Steve Taylor <STaylor@taylor-engineering.com>; Mark Hydeman <mark.hydeman@continual.net>
Subject: RE: Compliance Option

Yes I think it makes sense.

-Jeff Stein, jstein@taylor-engineering.com, 510-263-1547

From: hhauenstein@energy-solution.com [mailto:hhauenstein@energy-solution.com]
Sent: Thursday, October 22, 2015 12:04 PM
To: Jeff Stein <JStein@taylor-engineering.com>; mbh9@pge.com
Cc: set2@pge.com; Steve Taylor <STaylor@taylor-engineering.com>; Mark Hydeman <mark.hydeman@continual.net>
Subject: RE: Compliance Option

Jeff and Steve,

PG&E has asked us to work with Mark to get continued support on this effort. Energy Solutions is in the process to set up a subcontract agreement with Continual so Mark can provide input through our existing contract with PG&E.

Let me know if you think it makes sense to set up a call between Taylor, PG&E, Mark and Energy Solutions to coordinate a response to CEC.

Best,

Heidi Hauenstein | o: (510) 482-4420 x219 | m: (970) 390-4607

From: Alatorre, Mark@Energy [mailto:Mark.Alatorre@energy.ca.gov]
Sent: Thursday, October 22, 2015 11:58 AM
To: Jeff Stein; mbh9@pge.com; hhauenstein@energy-solution.com
Cc: set2@pge.com; Steve Taylor
Subject: RE: Compliance Option

Jeff,

Emerson submitted a report to the docket in response to Mark Hydeman's letter. I have attached the report for your convenience.

Regards,
Mark

From: Jeff Stein [mailto:JStein@taylor-engineering.com]
Sent: Friday, October 16, 2015 3:16 PM
To: Hunt, Marshall; Heidi Hauenstein
Cc: Alatorre, Mark@Energy; Tartaglia, Stuart; Steve Taylor
Subject: RE: Compliance Option

Heidi,

What is the status of the refrigerant economizer compliance option? Mark Hydeman submitted comments on 8/10/15 expressing concerns about the lack of scope and clarity of the Emerson data provided for public review. His comments did not indicate that he or Taylor Engineering support the proposed compliance option. Has Emerson provided any of the requested data? Mark is no longer with Taylor Engineering. We share his concerns about the validity of this option. We would like to further investigate the option once the requested data has been provided.

-Jeff Stein, jstein@taylor-engineering.com, 510-263-1547

From: Mark Hydeman
Sent: Wednesday, August 19, 2015 6:43 PM
To: 'Hunt, Marshall' <MBH9@pge.com>; 'Heidi Hauenstein' <hhauenstein@energy-solution.com>
Cc: 'Mark@Energy Alatorre' <Mark.Alatorre@energy.ca.gov>; 'Tartaglia, Stuart' <SET2@pge.com>
Subject: RE: Compliance Option

By the way, I am leaving Taylor Engineering on September 1st 2015. It's been a great 16 years but I needed a change. My new contact information is in my signature block below and my Outlook VCard is attached. This was an amicable parting I have nothing but praise for my ex-Partners at Taylor Engineering.

Mark

Mark Hydeman, P.E., Fellow ASHRAE
Principal, Continual Inc.
584 Castro Street #344
SF CA 94114-2512
(415) 602-9982 mobile/office
(647) 793-1367 fax

mark.hydeman@continual.net
www.continual.net

From: Mark Hydeman
Sent: Wednesday, August 19, 2015 6:30 PM

To: Hunt, Marshall; Heidi Hauenstein
Cc: Mark@Energy Alatorre; Tartaglia, Stuart
Subject: RE: Compliance Option

All I filed the attached document to the Docket and receive confirmation that it was filed correctly. As far as I know the ball is in Emerson's court.

I found my filing on the CEC website here: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=15-MISC-03.

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<< OLE Object: Picture (Device Independent Bitmap) >>
Mark

Mark Hydeman, P.E., Fellow ASHRAE
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584 Castro Street #344
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(415) 602-9982 mobile/office
(647) 793-1367 fax

mark.hydeman@continual.net
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-----Original Message-----
From: Hunt, Marshall [mailto:MBH9@pge.com]
Sent: Thursday, August 06, 2015 4:40 PM
To: Heidi Hauenstein; Mark Hydeman
Cc: Mark@Energy Alatorre
Subject: Fwd: Compliance Option

Please contact Mark and bring him up to date.

Sent from my iPhone

Begin forwarded message:

From: "Alatorre, Mark@Energy" <Mark.Alatorre@energy.ca.gov<mailto:Mark.Alatorre@energy.ca.gov>>
Date: August 6, 2015 at 4:37:42 PM CDT
To: "Hunt, Marshall" <MBH9@pge.com<mailto:MBH9@pge.com>>
Subject: Compliance Option

Hi Marshall,

I wanted to touch bases with you and see if there has been any progress in the review of the refrigerant economizer compliance option. Do you know of any review/analysis being done? If so, can you tell me of any conclusions?

Thank you,
Mark

Jeff Stein

From: Mark Hydeman <mark.hydeman@continual.net>
Sent: Wednesday, October 21, 2015 2:17 PM
To: Jeff Stein; Steve Taylor
Subject: RE: Refrigerant economizers

Jeff:

They claimed to have tested these units in auto using two separate chambers: one each for the indoor and outdoor unit. They quoted ISO standards for the calibration of the chambers and instrumentation. I did not review the EnergyPlus files but they provided them. I did not notice the drop in fan energy nor did I have very much time to review this. I suggest that you add a comment to the docket disclosing your discovery. I agree that the fan energy should be a push.

Mark

From: Jeff Stein [mailto:JStein@taylor-engineering.com]
Sent: Wednesday, October 21, 2015 11:37 AM
To: Mark Hydeman <mark.hydeman@continual.net>; Steve Taylor <STaylor@taylor-engineering.com>
Subject: RE: Refrigerant economizers

Mark,

According to Liebert, CEC granted Liebert the exception.

When you did your review of the Liebert proposal did you notice in their analysis that almost all of the savings come from supply fan savings? They claim an IRC served by a waterside economizer uses 5 times as much fan energy as their CRAC! Supply fan energy for a waterside economizer should be similar or less than fan energy for a CRAC unit and certainly should not be 5 times higher. If we remove the fan energy savings then according to their analysis the CRAC unit is much worse than a waterside economizer in every climate zone.

The model was simulated and the results extracted to the *Exceptional Design Compliance - Summary Comparison* spreadsheet. EnergyPlus models for the above are available if requir

most savings come from fans but there should be no fan savings so it does not pass!

Climate Zone 3	End Use	Baseline Waterside Economizer				Estimated Water	DSE Proposed Design - Custom Curves				
		GJ	MWh	TDV MJ/m^2	TDV kBtuh/ft^2	Gal / Year	GJ	MWh	TDV MJ/m^2	TDV kBtuh/ft^2	TDV Margin
	Space Cooling	3,830.2	1,064.0	14,911.2	1,313.5	-	5,954.5	1,654.1	24,059.0	2,119.3	(805.8)
	Fans	3,197.0	888.1	12,610.2	1,110.8	-	618.9	171.9	2,439.4	214.9	895.9
	Lighting	154.1	42.8	720.9	63.5	-	154.1	42.8	720.9	63.5	-
	Pumps	709.7	197.1	2,717.1	239.3	-	-	-	-	-	239.3
	Heat Rejection	148.5	41.3	665.3	58.6	-	-	-	-	-	58.6
	Compliance Total	8,039.4	2,233.3	31,624.7	2,785.7	-	6,727.4	1,868.9	27,219.3	2,397.7	388.1
	Interior Equipment	28,527.8	7,925.0	109,114.8	9,611.6	-	28,527.8	7,925.0	109,114.8	9,611.6	-
	Total	36,567.2	10,158.4	140,739.6	12,397.4	4,063,160	35,255.1	9,793.9	136,334.1	12,009.3	388.1
											PASS

-Jeff Stein, jstein@taylor-engineering.com, 510-263-1547

From: Mark Hydeman [mailto:mark.hydeman@continual.net]
Sent: Wednesday, September 16, 2015 7:05 PM
To: Steve Taylor <STaylor@taylor-engineering.com>
Cc: Jeff Stein <JStein@taylor-engineering.com>
Subject: Re: Refrigerant economizers

I don't know the status. My review concluded that they did a thorough job of testing the device but a bad job of documenting the test conditions and instrumentation. They did chamber studies to develop the calibration data base of test points.

Mark

Mark Hydeman
via iPhone, please excuse any typos.

On Sep 16, 2015, at 6:59 PM, Steve Taylor <STaylor@taylor-engineering.com> wrote:

> Mark: see attached. Did Liebert's system get approved for California?