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Proposal to Include Refrigerant Economizers in The California Energy Commission 2103 Building Energy Efficiency Standards For Residential and Non Residential Buildings Title 24, Part 6

Prepared by:

Emerson Network Power

May 6, 2015

(revised June 9, 2015)

Presented by:

Steven Madara

VP Global Thermal Sales

Purpose

To present and gain approval to include the "refrigerant" based economization system as used in the Liebert DSE product line in the same category as the prescriptive water economization requirement as defined in Section 140.9(a) of CEC Title 24 Energy Code for Computer Rooms (Energy Code). It will be demonstrated through the Exceptional Design Compliance method of modeling that the "refrigerant" economizer solution of the Liebert DSE meets or exceeds the full intent of the Energy Code while additionally not requiring water for economization supporting the recent Emergency Declaration to conserve water in the State of California. It is requested the CEC provide an immediate exception to allow "refrigerant" economizers with the same stipulations as water economizers.

Executive Summary

The Energy Code requires all Data Centers to meet the efficiency requirement of either one of two prescriptive economization methods (outside air economization or water economization) or to demonstrate through the Exceptional Design Compliance method the proposed solution meets or exceeds the energy efficiency of the prescriptive methods. At the time the Energy Code was written, the refrigerant economization method developed by Emerson Network Power and deployed in the Liebert DSE product line was just being released into the market place to meet the high efficiency needs of data center thermal management. Since 2012, over 1500 of the Liebert DSE systems have been installed throughout North America, South America, Europe and Australia, of which 52 systems are installed in California data centers.

The Liebert DSE data center cooling system with pumped refrigerant economization system solves many building design issues for thermal management needs, and meets or exceeds the efficiency of most water economization methods. Specifically, it meets the requirement of full economization at 40 deg F outdoor temperatures and in many cases full economization is achieved in most data centers at outdoor temperatures of 65 deg F or more. Additionally, the system design reduces or eliminates several of the power components associated with water economizers and further eliminates the need for any water in the heat rejection process. A cooling system with a water economizer uses an average of 4.2 million gallons of water per year for a data center with an IT load of 1.2 MW. Approximately, 50 MW of new data center capacity is added in California per year and over half of these sites can effectively use this technology. Other advantages of not utilizing water include, significant reduction in maintenance, chemical treatment, and the risk of bacteria exposure such as Legionella.

The Liebert DSE data center cooling system is described in more detail in the Report Detail section, but consists of an indoor evaporator (CRAC style unit), air cooled condenser and a refrigerant pump package. The system operates like a standard air cooled Direct Expansion (DX) system, but when the

criteria for economization is met, the compressors turn off and a refrigerant pump is turned on to move the refrigerant through the system to reject the heat of the data center. The refrigerant pump power is typically less than 5% of the energy of the compressor but yields the same capacity. Additionally, the control used in the Liebert DSE will allow the unit to go into economization mode automatically when conditions meet the criteria to support the load with economization. This allows 100% of the available temperature hours in the year to be utilized. Lastly, the economization mode is not based on a fixed outdoor temperature or chilled water temperature and operates in economizer mode at much higher outdoor temperatures when the load varies (lower) or the return air conditions increases.

Modeling was completed comparing a water economizer system to the Liebert DSE pumped refrigerant economizer system for all sixteen (16) climate zones in California. The Liebert DSE pump refrigerant economization system utilizes less energy based on the TDV calculation methods for 14 of these 16 climate zones while using no water. An evaluation of the data center locations in California indicate most if not all data centers are located within the 14 climate zones where the energy consumption is lower by a weighted average of 10%. The modeling was completed using the Performance Compliance Approach, as specified in Section 140.1 of the Energy Code, calculation methodology by a third party engineering firm with PE licensure and LEED –AP qualification. Water elimination is equal to approximately 4,274,000 gallons per year for each 1.2 MW of data center load.

Emerson Network Power is requesting that the CEC grant an immediate formal exception to include the use of a pumped refrigerant economization system under the category of the prescriptive water economization requirement with the same stipulations imposed with the water economization method. This will eliminate the multiple and time consuming requests for submission of the Exceptional Calculation Method for each individual data center proposal based on the data presented in this report.

Report Details

Pumped Refrigerant Economizer Technology:

Pumped Refrigerant Economizer technology was developed to provide economization modes of operation similar to water economizers in a DX (compressorized) cooling system for applications where a chilled water thermal system is not practical. For example, in small to middle size data centers up to 2MW-3MW of IT load, the capital cost, operational costs and physical size are not suited for traditional chilled water equipment. The major growth in the data center space is lead by Co-Location companies that are building very efficient data centers. Most of these new data centers are being built in a modular approach in 500kW to 1,600kW building blocks providing reliable redundancy for the customer at the module level. A typical site could grow over time to 5MW to 10MW in total size.

The Liebert DSE cooling system with pumped refrigerant economization consists of an indoor evaporator (CRAC style unit), air cooled condenser and a refrigerant pump package. The system operates like a standard air cooled DX system, but when the criteria for economization is met, the compressors turn off and a refrigerant pump is turned on to move the refrigerant through the system to reject the heat of the data center.

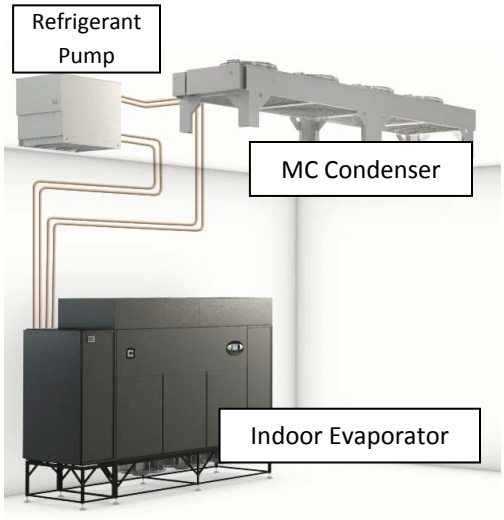


Fig 1 - System Component Layout

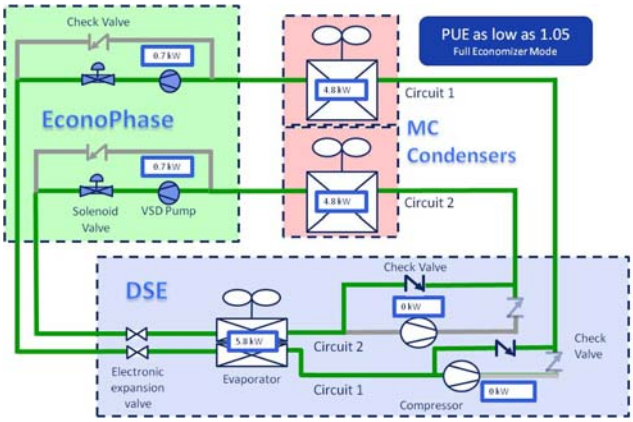


Fig 2 - System Flow Diagram

The efficiency of the system is achieved by using the most efficient system components on the market today and implementing an economizer system that circulates the refrigerant in the system to absorb the heat and then reject the heat outdoors. This unique feature of the design uses the same evaporator and condenser coil and circuit for both the DX and Economization modes requiring less overall fan power as a result of the lower system airside pressure drop. Then when the system goes into economization mode, the refrigerant pump power is typically less than 5% of the energy of the compressor but yields the same capacity. In most systems, there are two refrigerant circuits, providing an opportunity for both full and partial economization modes of operation through a staged operation.

Additionally, when compared to a system with a water economizer, there is no intermediate heat exchanger and one less fluid pump (Water system uses a cooling tower pump and a chilled water circulating pump, Refrigerant system uses one refrigerant pump) to consume less power.

Econo Mode	OD Temp		System 1		System 2		Cond Fan	Evap Fan	Total Power	Mech PUE
	°F	°C	Compr	Pump	Compr	Pump				
Full DX	95	35.0	8.9	0.0	8.9	0.0	4.1	3.5	25.4	1.24
Partial	60	15.6	0.0	0.4	8.9	0.0	2.4	3.5	15.2	1.15
Full	50	10.0	0.0	0.5	0.0	0.5	4.8	3.6	9.4	1.09
Full	40	4.4	0.0	0.6	0.0	0.6	0.5	3.6	5.3	1.05

Fig 3 – Operating Components by Ambient (example DA125 at 80% load/95°F RAT)

The fully integrated control used in the Liebert DSE will allow the unit to go into economization mode automatically when conditions meet the criteria to support the load with economization. This allows 100% of the available temperature hours in the year to be utilized without manual intervention or dead bands of operation. Lastly, the economization mode is not based on a fixed outdoor temperature or chilled water temperature as is typically the case with water economizers (in chilled water systems the economization mode is governed by the leaving chilled water set point regardless of the load). If the load varies (lower) or the return air conditions increase, the system will go into economizer mode at much higher outdoor temperatures. This is shown graphically in Appendix A.

All Liebert DSE performance is tested and certified to the new AHRI 1360 standard for Computer Room cooling equipment. The first listings for the new AHRI section will be published in September 2015.

California Building Codes:

The California 2013 Building Energy Efficiency Standards (Title 24), effective July 1, 2014, for Non Residential buildings (Subchapter 5) in Section 140.0(c) require either the performance compliance approach (energy budgets) in Section 140.1 or the prescriptive compliance approach in Section 140.2 for the Climate Zone in which the building will be located. The prescriptive requirement for Computer Rooms is further defined in Section 140.9 where either integrated air economizers or integrated water economizers are capable of provide 100 percent of the expected system cooling load. For water economizers, this must be met with outside air temperatures of 40°F dry-bulb/35°F wet-bulb conditions and below.

Additionally, containment is required for rooms with design loads exceeding 175 kW per room. For the data center, this typically means you can drive return air temperatures to the cooling system higher than most office environments. It is not uncommon today to see this value exceed 95°F.

Compliance Modeling Method:

Compliance Modeling requirement in section 140.1 is based on the 2013 Time Dependent Valuation (TDV) and was conducted by AlaJor Engineering, Inc (Appendix B).

Exceptional Design Compliance - End Use Summary Comparison – The table shown below is a comparison of the results from the preliminary baseline and proposed models simulated for a project in San Francisco for a 1,190kW (14,000sqft @ 85 w/sqft) Data Center using standard redundancy assumptions (N+2) and conservative return air temperatures (80°F) with containment. The baseline water economizer model was created utilizing the CEC's CBECC-Com (Build 717) and extracting the baseline IDF model that was created. The extracted baseline IDF model was modified and removed the air economizer and added the water economizer. The model was simulated with EnergyPlus and the results extracted to the *Exceptional Design Compliance - End Use Summary Comparison* spreadsheet. The proposed Liebert DSE model was created utilizing the CEC's CBECC-Com (Build 717) and extracting the proposed IDF model that was created. The extracted proposed IDF model was modified and added custom curves for the Liebert DSE equipment that were developed from a regression analysis from data provided for the operation for the Liebert pumped refrigerant system (same source for AHRI ratings). The model was simulated and the results extracted to the *Exceptional Design Compliance - End Use Summary Comparison* spreadsheet. EnergyPlus models for the above are available if required.

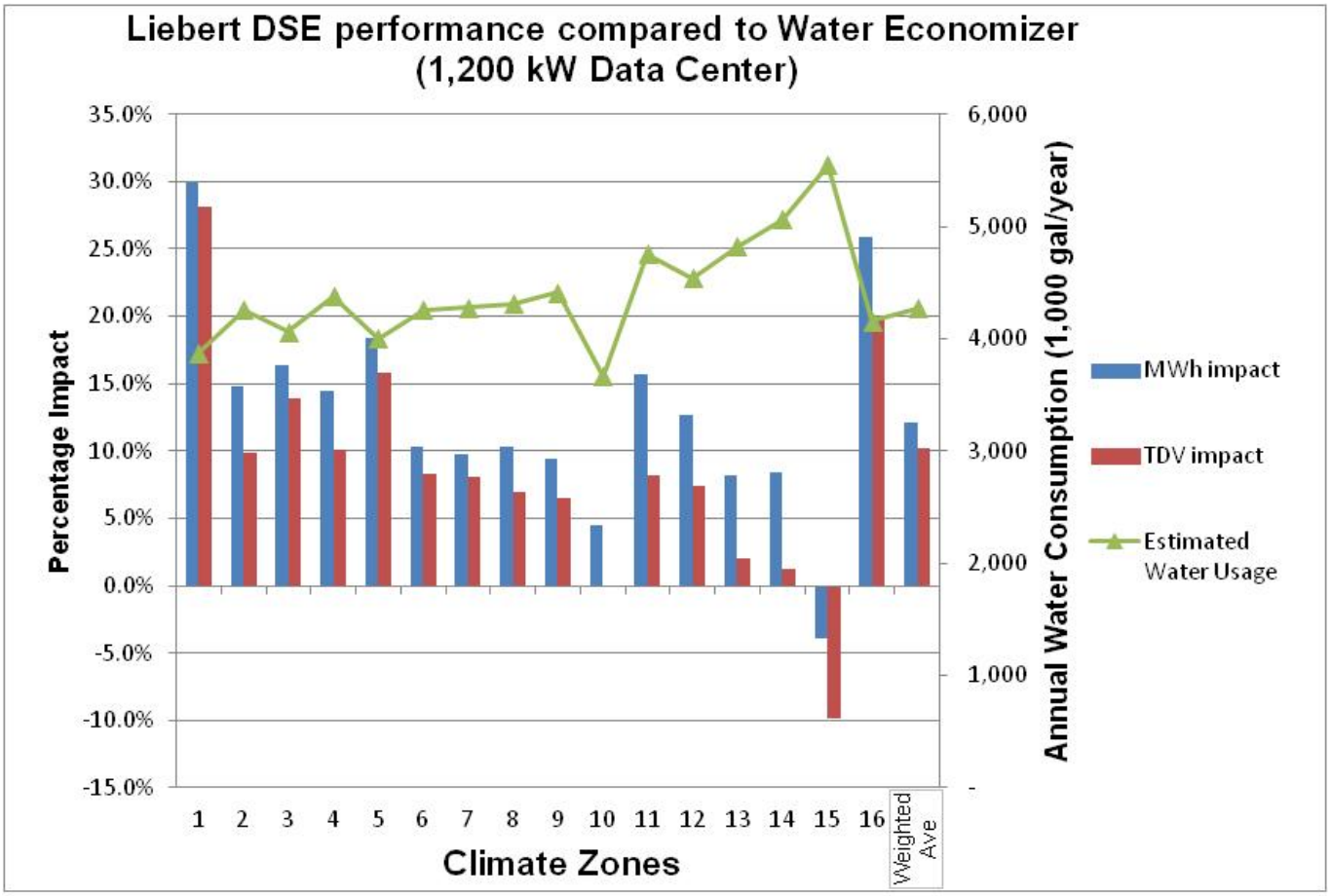
	End Use	Baseline Waterside Economizer				Estimated Water	DSE Proposed Design - Custom Curves				
		GJ	MWh	TDV MJ/m^2	TDV kBtuh/ft^2	Gal / Year	GJ	MWh	TDV MJ/m^2	TDV kBtuh/ft^2	TDV Margin
Climate Zone 3	Space Cooling	3,830.2	1,064.0	14,911.2	1,313.5	-	5,954.5	1,654.1	24,059.0	2,119.3	(805.8)
	Fans	3,197.0	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

The results for this site provide a reduction of the TDV value by 388.1 and an overall reduction of MWh consumed in a year by 364.5. However, the most significant reduction is the elimination of all water consumption equal to 4,063,160 gallons per year.

Compliance Modeling Results:

The modeling for a similar Data Center was conducted for all 16 Climate Zones . The results are summarized below with the details provided in Appendix C. The Industry weight average value is based on the Co-Location data center population distribution across the state of California. The data center distribution for the state is provided in Appendix D. Most of the Co-Location data centers are located in 9 of the 16 Climate Zones and all have favorable reductions in the TDV value by 10% and eliminate on average over 4,274,000 gallons of water per 1.2 MW of data center IT load. It is estimated there will be approximately 50MW of new data load added per year.

Climate Zone	MWh reduction	% MWh reduction	TDV kBtuh/ft^2 reduction	% TDV reduction	Water Reduction (1000gal/year)
Climate Zone 1 - Arcata	-686.8	30.0%	-803.8	28.1%	3,875
Climate Zone 2 - Santa Rosa	-338.1	14.8%	-285.9	9.9%	4,260
Climate Zone 3 - Oakland	-364.5	16.3%	-388.1	13.9%	4,063
Climate Zone 4 - Sunnyvale	-336.5	14.4%	-294.0	10.1%	4,378
Climate Zone 5 - Santa Maria	-426.1	18.4%	-457.0	15.9%	4,003
Climate Zone 6 - Los Angeles	-236.9	10.3%	-234.0	8.3%	4,258
Climate Zone 7 - San Diego	-225.1	9.8%	-235.0	8.1%	4,280
Climate Zone 8 - El Toro	-239.1	10.3%	-198.3	6.9%	4,312
Climate Zone 9 - Pasadena	-217.2	9.4%	-186.7	6.5%	4,414
Climate Zone 10 - Riverside	-101.9	4.5%	1.8	-0.1%	3,664
Climate Zone 11 - Red Bluff	-396.4	15.6%	-259.3	8.1%	4,755
Climate Zone 12 - Sacramento	-296.3	12.7%	-219.2	7.3%	4,541
Climate Zone 13 - Fresno	-190.9	8.1%	-60.4	2.0%	4,822
Climate Zone 14 - China Lake	-204.4	8.4%	-37.6	1.2%	5,061
Climate Zone 15 - El Centro	94.0	-4.0%	291.9	-9.9%	5,551
Climate Zone 16 - Mount Shasta	-632.1	25.9%	-610.1	19.8%	4,154
Average	-299.9	12.8%	-248.5	8.5%	4,399
Industry Weighted Average (per 1.2MW)	-293.0	12.1%	-278.0	10.2%	4,274



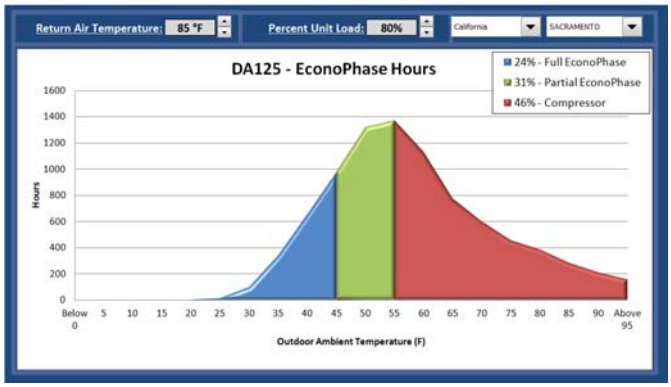
Actions Requested of the CEC:

The use of a “refrigerant” economizer provides significant benefits to the State of California for use in Data Centers. There is on average a 8% reduction (weighted average of 10%) in the TDV energy value but more significantly it eliminates the water requirement for these data centers. The inclusion of a “refrigerant” economizer in the prescriptive compliance method will make the adaption and implementation of this technology on par with water economization evaluations and bypass the burdensome and time consuming process of preparing the Energy Budget for each project.

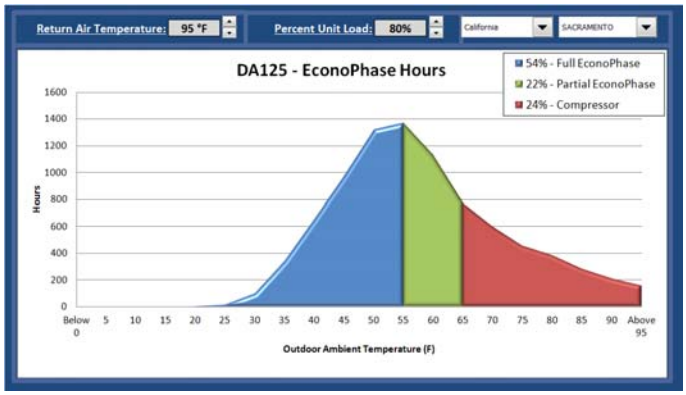
It is requested that the CEC provide an immediate exception to Section 140.9(a) (Prescriptive Requirements for Computer Rooms) with either the modification of 140.9(a)1.B to include integrated refrigerant economizers (or define as a Fluid Economizer) or add a separate definition for a refrigerant economizer.

Appendix A – Liebert DSE Adjustable Economization Criteria for More Economization Hours

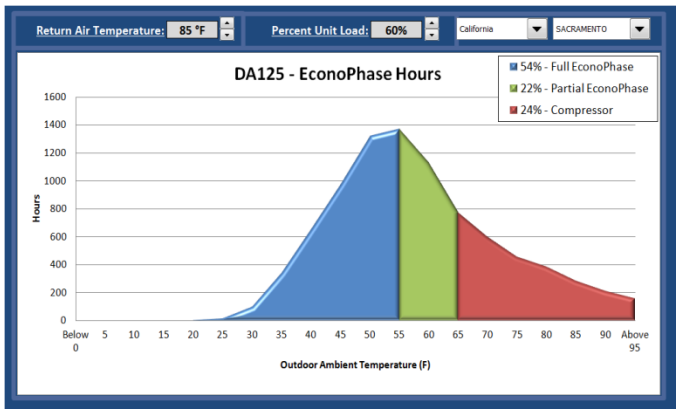
Base Line



Higher Return Air Temperature



Lower Load



Appendix B – AlaJor Engineering, Inc.

Christian Hurd, PE, LEED-AP

AlaJor Engineering, Inc., President

Credentials

Professional Engineer, State of California, State of Virginia, State of Washington, State of Colorado
LEED-AP

Experience

Mr. Hurd has over 19 years of experience in engineering, design and construction projects. Mr. Hurd is responsible for mechanical and plumbing engineering and design and is a specialist in computational fluid dynamics, fluid flow analysis, energy modeling and building information modeling. Projects include mechanical and plumbing design of mission critical data center, telecommunication, industrial, and large commercial facilities

Appendix C – Exceptional Design Compliance Calculations for all 16 Climate Zones

Exceptional Design Compliance - End Use Summary

	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
Climate Zone 1	Space Cooling	3,864.2	1,073.5	15,134.5	1,333.2	-	4,600.9	1,278.1	18,654.5	1,643.2	(310.1)
	Fans	3,417.8	949.5	13,466.8	1,186.3	-	1,025.8	285.0	4,070.7	358.6	827.7
	Lighting	153.6	42.7	644.3	56.8	-	153.6	42.7	644.3	56.8	-
	Pumps	710.8	197.5	2,756.8	242.8	-	-	-	-	-	242.8
	Heat Rejection	105.9	29.4	492.6	43.4	-	-	-	-	-	43.4
	Compliance Total	8,252.5	2,292.5	32,495.0	2,862.4	-	5,780.3	1,605.8	23,369.5	2,058.6	803.8
	Interior Equipment	28,527.8	7,925.0	111,278.5	9,802.2	-	28,527.8	7,925.0	111,278.5	9,802.2	-
	Total	36,780.2	10,217.6	143,773.5	12,664.6	3,875,000	34,308.1	9,530.8	134,648.0	11,860.8	803.8
											PASS

	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
Climate Zone 2	Space Cooling	3,980.9	1,105.9	16,067.3	1,415.3	-	5,287.2	1,468.8	22,778.5	2,006.5	(591.2)
	Fans	3,208.0	891.2	12,647.8	1,114.1	-	1,540.3	427.9	6,122.4	539.3	574.8
	Lighting	153.6	42.7	638.2	56.2	-	153.6	42.7	638.2	56.2	-
	Pumps	682.3	189.5	2,610.8	230.0	-	-	-	-	-	230.0
	Heat Rejection	173.3	48.1	820.4	72.3	-	-	-	-	-	72.3
	Compliance Total	8,198.1	2,277.4	32,784.5	2,887.9	-	6,981.1	1,939.4	29,539.1	2,602.0	285.9
	Interior Equipment	28,527.8	7,925.0	110,541.0	9,737.3	-	28,527.8	7,925.0	110,541.0	9,737.3	-
	Total	36,725.9	10,202.4	143,325.5	12,625.2	4,260,000	35,508.9	9,864.4	140,080.1	12,339.3	285.9
											PASS

	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
Climate Zone 3	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

	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
Climate Zone 4	Space Cooling	4,018.1	1,116.2	15,785.7	1,390.5	-	5,486.1	1,524.0	22,866.6	2,014.3	(623.7)
	Fans	3,344.6	929.1	13,114.5	1,155.2	-	1,543.4	428.8	6,155.6	542.2	613.0
	Lighting	153.6	42.7	631.2	55.6	-	153.6	42.7	631.2	55.6	-
	Pumps	687.0	190.8	2,599.2	229.0	-	-	-	-	-	229.0
	Heat Rejection	191.2	53.1	860.9	75.8	-	-	-	-	-	75.8
	Compliance Total	8,394.5	2,332.0	32,991.5	2,906.1	-	7,183.2	1,995.5	29,653.4	2,612.1	294.0
	Interior Equipment	28,527.8	7,925.0	108,901.1	9,592.8	-	28,527.8	7,925.0	108,901.1	9,592.8	-
	Total	36,922.2	10,257.0	141,892.6	12,498.9	4,378,000	35,710.9	9,920.5	138,554.5	12,204.9	294.0
											PASS

	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
Climate Zone 5	Space Cooling	3,925.0	1,090.4	15,272.3	1,345.3	-	5,101.1	1,417.1	20,742.7	1,827.2	(481.9)
	Fans	3,439.2	955.4	13,586.3	1,196.8	-	1,551.0	430.9	6,158.7	542.5	654.3
	Lighting	153.6	42.7	637.5	56.2	-	153.6	42.7	637.5	56.2	-
	Pumps	684.7	190.2	2,606.5	229.6	-	-	-	-	-	229.6
	Heat Rejection	136.9	38.0	624.3	55.0	-	-	-	-	-	55.0
	Compliance Total	8,339.5	2,316.7	32,726.8	2,882.8	-	6,805.7	1,890.6	27,538.9	2,425.8	457.0
	Interior Equipment	28,527.8	7,925.0	109,418.5	9,638.4	-	28,527.8	7,925.0	109,418.5	9,638.4	-
	Total	36,867.2	10,241.7	142,145.3	12,521.2	4,003,000	35,333.5	9,815.6	136,957.3	12,064.2	457.0
											PASS

Appendix C (con't) – Exceptional Design Compliance Calculations for all 16 Climate Zones

Exceptional Design Compliance - End Use Summary

Climate Zone 6

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	4,008.6	1,113.6	15,547.4	1,369.5	-	5,704.3	1,584.6	22,660.4	1,996.1	(626.6)
Fans	3,135.0	870.9	12,220.7	1,076.5	-	1,542.1	428.4	6,148.6	541.6	534.9
Lighting	153.6	42.7	647.9	57.1	-	153.6	42.7	647.9	57.1	-
Pumps	711.0	197.5	2,685.8	236.6	-	-	-	-	-	236.6
Heat Rejection	244.8	68.0	1,011.3	89.1	-	-	-	-	-	89.1
Compliance Total	8,253.0	2,292.7	32,113.1	2,828.8	-	7,400.0	2,055.7	29,456.9	2,594.8	234.0
Interior Equipment	28,527.8	7,925.0	108,592.0	9,565.6	-	28,527.8	7,925.0	108,592.4	9,565.6	(0.0)
Total	36,780.7	10,217.7	140,705.1	12,394.3	4,258,000	35,927.8	9,980.7	138,049.3	12,160.4	233.9
										PASS

Climate Zone 7

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	4,009.1	1,113.7	15,997.5	1,409.2	-	5,785.8	1,607.3	23,429.2	2,063.8	(654.6)
Fans	3,184.8	884.7	12,632.5	1,112.8	-	1,536.8	426.9	6,235.7	549.3	563.5
Lighting	153.6	42.7	652.1	57.4	-	153.6	42.7	652.1	57.4	-
Pumps	704.3	195.7	2,708.4	238.6	-	-	-	-	-	238.6
Heat Rejection	234.7	65.2	994.4	87.6	-	-	-	-	-	87.6
Compliance Total	8,286.5	2,302.0	32,985.0	2,905.6	-	7,476.2	2,076.9	30,316.9	2,670.5	235.0
Interior Equipment	28,527.8	7,925.0	110,989.4	9,776.8	-	28,527.8	7,925.0	110,989.0	9,776.7	0.0
Total	36,814.3	10,227.0	143,974.4	12,682.3	4,280,000	36,004.0	10,001.9	141,305.9	12,447.3	235.1
										PASS

Climate Zone 8

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	4,061.1	1,128.2	15,992.9	1,408.8	-	5,794.5	1,609.7	23,609.0	2,079.7	(670.9)
Fans	3,215.2	893.2	12,397.5	1,092.1	-	1,535.5	426.6	6,101.8	537.5	554.6
Lighting	153.6	42.7	648.6	57.1	-	153.6	42.7	648.6	57.1	-
Pumps	683.7	189.9	2,593.4	228.4	-	-	-	-	-	228.4
Heat Rejection	230.8	64.1	978.0	86.1	-	-	-	-	-	86.1
Compliance Total	8,344.5	2,318.1	32,610.3	2,872.6	-	7,483.7	2,079.0	30,359.3	2,674.3	198.3
Interior Equipment	28,527.8	7,925.0	109,613.1	9,655.5	-	28,527.8	7,925.0	109,613.1	9,655.5	-
Total	36,872.3	10,243.1	142,223.4	12,528.1	4,312,000	36,011.4	10,004.0	139,972.4	12,329.8	198.3
										PASS

Climate Zone 9

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	4,100.9	1,139.2	16,022.2	1,411.4	-	5,864.5	1,629.2	23,552.3	2,074.7	(663.3)
Fans	3,149.9	875.1	12,120.8	1,067.7	-	1,547.3	429.8	6,159.4	542.6	525.1
Lighting	153.6	42.7	639.3	56.3	-	153.6	42.7	639.3	56.3	-
Pumps	687.8	191.1	2,610.7	230.0	-	-	-	-	-	230.0
Heat Rejection	255.1	70.9	1,077.1	94.9	-	-	-	-	-	94.9
Compliance Total	8,347.5	2,318.9	32,470.2	2,860.2	-	7,565.5	2,101.7	30,351.0	2,673.5	186.7
Interior Equipment	28,527.8	7,925.0	108,035.8	9,516.6	-	28,527.8	7,925.0	108,035.8	9,516.6	-
Total	36,875.2	10,243.9	140,506.0	12,376.8	4,414,000	36,093.2	10,026.7	138,386.8	12,190.1	186.7
										PASS

Climate Zone 10

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	3,811.9	1,059.0	15,430.2	1,359.2	-	6,010.1	1,669.6	25,335.5	2,231.7	(872.5)
Fans	3,378.8	938.6	13,149.0	1,158.3	-	1,562.6	434.1	6,205.0	546.6	611.7
Lighting	153.6	42.7	631.7	55.6	-	153.6	42.7	631.7	55.6	-
Pumps	595.0	165.3	2,222.6	195.8	-	-	-	-	-	195.8
Heat Rejection	154.0	42.8	717.9	63.2	-	-	-	-	-	63.2
Compliance Total	8,093.3	2,248.3	32,151.5	2,832.1	-	7,726.3	2,146.4	32,172.3	2,834.0	(1.8)
Interior Equipment	28,527.8	7,925.0	108,966.3	9,598.6	-	28,527.8	7,925.0	108,966.3	9,598.6	-
Total	36,621.0	10,173.3	141,117.8	12,430.7	3,664,000	36,254.1	10,071.4	141,138.5	12,432.5	(1.8)
										FAIL

Appendix C (con't) – Exceptional Design Compliance Calculations for all 16 Climate Zones

Exceptional Design Compliance - End Use Summary

	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
Climate Zone 11	Space Cooling	4,251.2	1,181.0	17,331.2	1,526.7	-	5,997.4	1,666.1	26,480.9	2,332.6	(806.0)
	Fans	3,873.8	1,076.1	14,856.5	1,308.7	-	1,545.4	429.3	6,144.9	541.3	767.4
	Lighting	153.6	42.7	641.5	56.5	-	153.6	42.7	641.5	56.5	-
	Pumps	649.3	180.4	2,482.5	218.7	-	-	-	-	-	218.7
	Heat Rejection	195.6	54.3	899.1	79.2	-	-	-	-	-	79.2
	Compliance Total	9,123.5	2,534.5	36,210.9	3,189.7	-	7,696.5	2,138.1	33,267.3	2,930.4	259.3
	Interior Equipment	28,527.8	7,925.0	112,214.7	9,884.7	-	28,527.8	7,925.0	112,214.7	9,884.7	-
	Total	37,651.3	10,459.5	148,425.6	13,074.4	4,755,000	36,224.2	10,063.1	145,482.0	12,815.1	259.3
											PASS

	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
Climate Zone 12	Space Cooling	4,055.9	1,126.7	16,515.0	1,454.8	-	5,677.0	1,577.1	24,638.2	2,170.3	(715.6)
	Fans	3,339.8	927.8	13,210.9	1,163.7	-	1,533.4	426.0	6,105.6	537.8	625.9
	Lighting	153.6	42.7	638.3	56.2	-	153.6	42.7	638.3	56.2	-
	Pumps	687.9	191.1	2,612.3	230.1	-	-	-	-	-	230.1
	Heat Rejection	193.4	53.7	893.8	78.7	-	-	-	-	-	78.7
	Compliance Total	8,430.6	2,342.0	33,870.2	2,983.5	-	7,364.1	2,045.7	31,382.1	2,764.4	219.2
	Interior Equipment	28,527.8	7,925.0	111,090.2	9,785.6	-	28,527.8	7,925.0	111,090.2	9,785.6	-
	Total	36,958.4	10,267.0	144,960.4	12,769.2	4,541,000	35,891.8	9,970.7	142,472.2	12,550.0	219.2
											PASS

	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
Climate Zone 13	Space Cooling	4,124.0	1,145.7	16,630.5	1,464.9	-	6,062.8	1,684.2	26,109.6	2,299.9	(835.0)
	Fans	3,281.7	911.6	12,738.0	1,122.1	-	1,544.3	429.0	6,128.2	539.8	582.2
	Lighting	153.6	42.7	639.1	56.3	-	153.6	42.7	639.1	56.3	-
	Pumps	681.5	189.3	2,605.0	229.5	-	-	-	-	-	229.5
	Heat Rejection	207.1	57.5	950.4	83.7	-	-	-	-	-	83.7
	Compliance Total	8,447.9	2,346.8	33,563.0	2,956.5	-	7,760.7	2,155.9	32,876.9	2,896.0	60.4
	Interior Equipment	28,527.8	7,925.0	111,041.5	9,781.4	-	28,527.8	7,925.0	111,041.5	9,781.4	-
	Total	36,975.6	10,271.8	144,604.5	12,737.8	4,822,000	36,288.5	10,080.9	143,918.4	12,677.4	60.4
											PASS

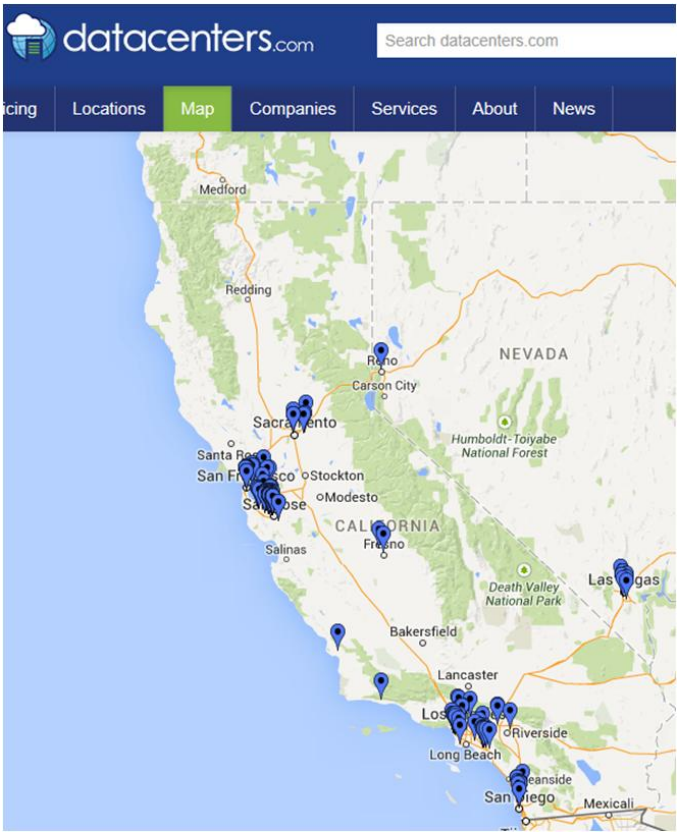
	End Use	Baseline Waterside Economizer				Estimated Water	DSE Proposed Design - Custom Curves				
		GJ	MWh	TDV MJ/m^2	TDV kBtuh/ft^2	Gal / Year	GJ	MWh	TDV MJ/m^2	TDV kBtuh/ft^2	TDV Margin
Climate Zone 14	Space Cooling	4,116.9	1,143.7	16,544.2	1,457.3	-	6,219.7	1,727.8	27,294.9	2,404.3	(947.0)
	Fans	3,675.4	1,021.0	14,411.4	1,269.5	-	1,620.7	450.2	6,390.1	562.9	706.6
	Lighting	153.6	42.7	633.4	55.8	-	153.6	42.7	633.4	55.8	-
	Pumps	656.4	182.4	2,504.9	220.7	-	-	-	-	-	220.7
	Heat Rejection	127.6	35.4	651.0	57.3	-	-	-	-	-	57.3
	Compliance Total	8,729.9	2,425.2	34,744.8	3,060.6	-	7,994.0	2,220.7	34,318.4	3,023.0	37.6
	Interior Equipment	28,527.8	7,925.0	110,968.5	9,774.9	-	28,527.8	7,925.0	110,968.5	9,774.9	-
	Total	37,257.7	10,350.2	145,713.4	12,835.5	5,061,000	36,521.8	10,145.7	145,287.0	12,797.9	37.6
											PASS

	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
Climate Zone 15	Space Cooling	4,420.2	1,227.9	17,886.0	1,575.5	-	7,187.9	1,996.8	30,329.6	2,671.7	(1,096.1)
	Fans	3,003.1	834.3	11,396.6	1,003.9	-	1,515.9	421.1	5,984.1	527.1	476.8
	Lighting	153.6	42.7	633.5	55.8	-	153.6	42.7	633.5	55.8	-
	Pumps	658.2	182.9	2,492.1	219.5	-	-	-	-	-	219.5
	Heat Rejection	283.9	78.9	1,225.3	107.9	-	-	-	-	-	107.9
	Compliance Total	8,519.1	2,366.6	33,633.5	2,962.7	-	8,857.4	2,460.6	36,947.3	3,254.6	(291.9)
	Interior Equipment	28,527.8	7,925.0	110,144.3	9,702.3	-	28,527.8	7,925.0	111,278.5	9,802.2	(99.9)
	Total	37,046.8	10,291.6	143,777.7	12,665.0	5,551,000	37,385.2	10,385.6	148,225.8	13,056.8	(391.8)
											FAIL

Appendix C (con't) – Exceptional Design Compliance Calculations for all 16 Climate Zones

	Exceptional Design Compliance - End Use Summary										
	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
Climate Zone 16	Space Cooling	4,026.8	1,118.6	16,328.6	1,438.3	-	4,668.7	1,297.0	20,711.5	1,824.4	(386.1)
	Fans	3,843.5	1,067.7	14,887.0	1,311.4	-	1,701.7	472.7	6,709.9	591.1	720.3
	Lighting	153.6	42.7	638.8	56.3	-	153.6	42.7	638.8	56.3	-
	Pumps	668.7	185.8	2,536.1	223.4	-	-	-	-	-	223.4
	Heat Rejection	106.8	29.7	595.8	52.5	-	-	-	-	-	52.5
	Compliance Total	8,799.5	2,444.5	34,986.3	3,081.9	-	6,524.1	1,812.4	28,060.1	2,471.7	610.1
	Interior Equipment	28,527.8	7,925.0	110,676.3	9,749.2	-	28,527.8	7,925.0	110,676.9	9,749.2	(0.0)
	Total	37,327.3	10,369.5	145,662.6	12,831.0	4,154,000	35,051.8	9,737.4	138,737.0	12,221.0	610.1
											PASS

Appendix D – California Data Centers (reference - http://www.datacentermap.com/usa/california)



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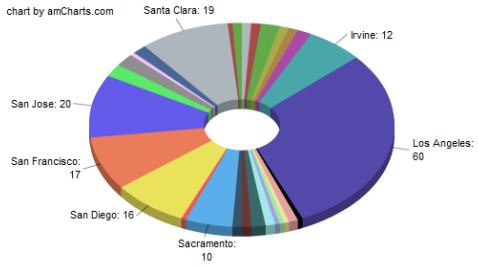

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