Core4 Systems, Inc.
PO Box 5823
Napa, CA 94581
Phone: +1 (707) 255-1623
jmccullum@core4sys.com

Case Study

By:

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PO Box 5823
Napa, CA 94581
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jmccullum@core4sys.com

Sonic.net Case Study

Executive Summary

Sonic.net is a progressive Internet/co-location data center located in Santa Rosa, Calif. The data center facility is approximately 5400 square feet and originally was environmentally controlled by three, 30-ton Liebert CRAC units and one, five-ton portable unit. However, the facility had maxed out its existing cooling solution and required a retrofit to support additional capacity for new customers with higher density loads.

The Liebert equipment, ranging from 2-4 years old, had reheat, humidity control and dehumidification. Due to some unique changes in the operation of the original Liebert units (Sonic.net disconnected the dehumidification heaters on all units and set up the controls to ensure that no units would fight another's operation) the facility was operating with reasonable efficiency.

After a thorough evaluation, Core4 Systems recommended a system designed to improve all of the basic issues that existed within Sonic.net's data center. The system chosen was sized (with larger piping, valves, condensers, and component space) to expand from the original load of 158kW to a facility load of 700kW of computer load or 200 tons.

Upon installation the computer load was increased from 158kW to 208kW within the first 60 days and continued to increase monthly as new customers came online. The load is expected to meet 100 tons within its first year or operation. Sonic.net expects to expand its current occupancy to 100 tons, or 100 percent, within the second year, eventually quadrupling their existing load. The original operational conditions of the facility averaged 158kW Computer & Light Load and a 112kW Cooling Load which equates to a ration of 1.41 to 1 Server to Cooling Energy and a PUE of 1.86.

Core4 at Sonic.net

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ROI Measurement

To properly evaluate ROI from this project, savings have been projected from the measurements of the Core4 System and compared with the Liebert specification sheets at an n+1 and a designed load of 351kW or 100 tons. This allows for a true representation of the saving vs. a CRAC installation without any inefficiency of deployment added to the calculations. All of the measurements have been independently evaluated by kW Engineering and PG&E's High Tech Solutions personnel.

The following descriptions are broken down to each component of the Core4 Solution to best describe how we achieved such dramatic savings.

The Sonic.net Data Center, Santa Rosa, Calif.

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Core4 System Bin Analysis

This section shows the air cooled Liebert System's efficiency at various dry bulb temperature hours in 5°f increments vs. the Core4 System at the same temperatures in wet-bulb temperature hours. As can be seen on the chart, the Liebert System efficiency doesn't change much. This is because it runs at minimum head pressures of 100°F (manufactures set point). These head pressures are factory set and designed around the units with a 10°F (25 PSIG) differential or with a speed control operating the head pressure at 225 PSIG or 100°F. The Liebert System condenser design TD is 25°f off of dry bulb temperature. The Core4 system is a floating head pressure system (reduced compression) and the system varies based on ambient conditions. The Bin Analysis Summary table shows the Core4 System efficiency at wet-bulb temperatures, in 5°f increments. The Core4 System runs off of wet-bulb conditions instead of dry-bulb conditions. It is designed to run at 8°F off of wet bulb temperature.

This project is installed in Santa Rosa California and the BIN temperature / hours were provided by Lawrence Berkeley National Labs (LBNL).

Core4		Liebert
Wet Bulb	**Hours**	**Dry Bulb**
72.5°F	67	96.6°F
67.5°F	456	88.8°F
62.5°F	894	78.1°F
57.5°F	1484	66.2°F
52.5°F	1980	57.9°F
47.5°F	1477	51.7°F
42.5°F	1236	45.4°F
37.5°F	661	38.6°F
32.5°F	390	32.9°F
27.5°F	111	28.2°F
22.5°F	4	24.8°F

Bin Analysis Summary

Core4 System 2N performance vs. Liebert System N+1 performance is based on 100 tons or 351kw room load. The ratings below are a reflection of the equipment's efficiency, not the systems efficiency, as the equipments efficiency does not demonstrate savings from indirect energy use. As you will begin to notice any cooling system applied to a load has inefficiencies that presents itself in the form of an increase room load. These are known as indirect inefficiencies and are not represented on this chart. The true efficiency of the systems is represented at the bottom of the Total Savings chart on page 9 of this review.

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Core 4 (Measured) kW per ton	Wet Bulb Hours	Dry Bulb Hours	Liebert (listed) kW per ton
.85	0	8	2.13
.83	67	48	1.98
.82	456	126	1.84
.75	894	227	1.71
.63	1484	284	1.58
.52	1980	389	1.47
.51	1477	463	1.34
.26	2402	7215	1.23

Compressor kW Energy Usage

Core4 (Carlyle) Compressor EER / kW per ton vs. Liebert (Carlyle) Compressors EER/ kW per ton. The increase in the compressors EER can be directly related to two system conditions, a 12°F increase in suction temperature and a 26°-66°F decrease in condensing temperature. The Core4 Compressor operates with floating head pressures or Reduced Compression™ and the Liebert units are designed to operate with a fixed head pressure.

Most systems and compressor manufactures don't openly design for a reduced compression system design of this magnitude. Our system design and components have been selected for these parameters and the manufactures have approved of our application of their components within the Core 4 overall design.

Reduced Compression™ EER / kW per ton	Wet Bulb Hours	Dry Bulb Hours	Liebert EER / kW per ton
24.6 / .48	0	8	8.7 / 1.37
27.4 / .43	67	48	9.1 / 1.31
30.8 / .38	456	126	9.8 / 1.22
34.8 / .34	894	227	10.6 / 1.13
39.8 / .30	1484	284	11.5 / 1.04
46.1 / .26	1980	389	12.5 / .96
54.2 / .22	1477	463	13.6 / .88
MTS Cooling / Compressor Free	2402	7215	14.1 / .85

This table shows the difference in annual kWs comparing both compressor systems in operation.

Manufacture	# of Comp	average kW per Ton	Total Tons	Hours Yearly	Total Annual kW
Liebert Carlyle	6	.92	100	8760	805,920
Core4 Carlyle	2	.28	100	8760	245,280

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Condenser kW Energy Usage

The Core4 System is designed with two condensers and two circuits. Each condenser is designed to handle 200 tons (for future load) at an 8°F approach. The Core4 System will run both condensers at less than 50 tons at an 8°F approach. The Core4 fans are VFD driven to the exact load at an 8°F approach.

Core4 Condenser Fan kW vs. Existing Liebert Condenser Fan kW- water cooled vs. air cooled. Our system is designed around the evaporative cooled condensers heat rejection capabilities. This equates to closer approaches, but more kW to maintain low approaches. We penalize our system with an 8°F approach, but it pays back in reduced compressor kW.

The Liebert Condensers are sized for a 25°F Temperature Difference (approach) off of dry bulb and the fans operate on demand.

Condenser kW Summary Table - Core4 vs. Liebert

Manufactures	# of Condensers	# of Pumps	# of Fan Motors	Total Horsepower	Total Annual kW
Core 4 Condenser	2	2 - 5HP	2- 10HP	35hp Part Load pumps 100% Yearly- fans 45% Maximum VFD yearly	<78,840
Liebert Condenser	4	0	12 - ¾ HP	9hp Part Load 80% Yearly	29,623

The chart above shows the total condenser kW. Reduced Compression requires that the condensers operate more often and increase in kWh under low ambient conditions.

Refrigerant Pump kW Energy Usage

The refrigerant pump estimated performance table shows this pump was selected for a future system capacity addition. Each pump will be capable of pumping 44 GPM (100 Tons) at design conditions which is twice the flow rate required. Each pump will be VFD controlled to match the current load. This table also shows that Liebert units do not have a refrigerant pump so they incur no kWh associated to a pump.

Pump	kW	Hours	# of Pumps	Total kW
Teikuko Pump	.93	5400	2	10,044

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MTS Cooling™ with Scavenger Coil Cooling™ Energy Savings

MTS Cooling with Scavenger Coil (SC) Cooling are forms of refrigerant side economizing. MTS is a full time compressor free cooling and SC is a part time free cooling.

MTS Cooling is designed to allow compressor free cooling 1,800 hours per year in Santa Rosa. The refrigerant exiting the evaporator goes straight to the condenser, rather than to the compressors. After a delay the control systems shuts down the compressors. MTS Cooling reduces the compressors total hours of operation. This cooling does not increase or reduce any other systems components energy use.

Wet Bulb Temp	Hours	Tons Saved	Compressor kW per ton	Coil Active	Total kWh Saved
< 40°F	1800	25	.22	4	39,600

SC Cooling is Core4's form of part time economizing designed to remove heat from the air prior to the air entering the main cooling coil. SC Cooling operates off of a differential between the indoor room temperature and the outdoor wet-bulb temperature. When the room temperature is 13°F above the outdoor wet-bulb temperature, SC Cooling activates. As SC Cooling activates and the operation differential increases, the work being performed by free cooling increases and the work being done by the compressors decrease. Thus the compressors perform less of the total tons. The total tons is converted into kW's by multiplying the compressor kW per ton at that given wet-bulb, by the number of hours it operates at those conditions. This results in a total saved kWh.

Wet-bulb Temperature	Hours	Tons Saved	Compressor kW per ton	Coils Active	Total kWh Saved
55	893	3	0.43	4	4607.88
53	744	6	0.43	4	7678.08
51	840	8	0.38	4	10214.4
49	840	9.8	0.36	4	11854.08
47	733	11	0.34	4	10965.68
45	733	13	0.32	4	12197.12
43	618	13	0.3	4	9640.8
41	618	13	0.26	4	8355.36
		Total kW Saved			75513.4

Cooling Fan Energy Usage

The Core4 System saves energy by designing the air handlers at a 47°F Coil / 68°F RAT / 57°F SAT 50percent Return Air RH at 25 tons a piece at 15,000 CFM each to total the 100 ton load. The performance of our fan system is based on dry coil methodology, reducing the airside pressure drop and specially designed fans. The Liebert System requires 5 indoor fans

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running to provide N+1 Redundancy. Each Core4 AHU is capable of providing 100 percent more CFM and controlled by a VFD on each unit.

Direct Energy Usage Below is a chart showing the direct kWh associated with each air handler units fan system.

Fan System	CFM	kW	Hours	# of Fans	Total kW
Liebert	15,000	6.92	8760	5 Units	303,096
Core4 System	15,000	3.13	8760	4 Units	108,624

Indirect Energy Usage The chart below shows the energy in the form of heat being rejected into the room by the fan motor and the energy needed to remove that heat by the cooling system. Similar to servers, fan energy is a measurement of heat being rejected into the room.

Fan System	kW Total	BTUH Waste Heat / Tons	System Efficiency	Annual kW
Liebert	34.6	118,005 / 9.8	1.86	154,526
Core4 System	12.5	42,650 / 3.5	.40	12,453

Moisture Removal Energy Usage

Liebert specification charts show us that more than 13% of the capacity of this unit is removed in the form of latent heat or moisture removal at perfect conditions and more under ASHREA standard data center design. Due to the design and operation conditions, Liebert units need to remove moisture to function properly. Moisture is then added back into the environment by the use of humidifiers. The Core4 System utilizes a dry coil design and does not remove moisture. The Liebert uses 16 tons of cooling per hour at 100 tons just condensing water out of the air, only for humidifiers to put it back. Our system wastes minimal energy and performs most of its cooling sensibly. This table shows the wasted energy used in removing moisture.

System	Latent Heat Removed by the coils	Total Tons Hours	kW per ton for cooling totally connected	Total kW Hourly	Annual kW	Tonnage Reduced
Liebert Systems	164,000 BTUH	13.6	1.91	25.8	226,350	
Core4 System	4,200 BTUH	.35	.36	.10	876	13.25

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Moisture Replacement Energy Usage

The standard Liebert system removes moisture in the form of latent heat. With our high coil temperatures and unique design our systems are relegated to removing a low portion of latent heat. This means that our design does not need to add moisture for eventual removal. The chart below is an estimation of the energy required to control the data centers humidity. CRAC Manufactures states that the unit removes an estimated .089lbs to .207lbs of moisture per minute for 1000 CFM at 72°f / 45-60 percent RH during normal operation this water must be replaced. Most manufacturers use a standard heat generated evaporation method of replacing the moisture.

System	Latent Heat Removed by the coils	Total CFM	Total Pound of water removed per year	Manufacture kW per pound of water to Humidify	Humidifier kW Annually	Total kW Ave. for humidifier
Liebert Systems	164,000 BTUH	60,000	210,502 - 498,596	.43	90,516 - 214,396	152,456
Core4 System	4,200 BTUH	60,000	32,350	.43	13,422	13,422

Sonic.net Facility Potential Total Energy Usage &Savings

As can be seen in the table below the total potential savings for this system exceed 1,360,484 kW with MTS Cooling. At .12 cents a kW the total annual savings could exceed $163,258. The facilities savings are based on the original 100 ton load. The price for this system was $518,000, it received a $142,000 Utility Rebate. The ROI is expected to be 2-3 years based on the 100 ton package. Sonic.net purchased an upgraded unit (with the capability and core components already installed) to be able to expand to 200 tons at an additional price of $120,000.

The kW per ton ratings listed at the bottom of the table are an evaluation of the systems fully connected performance, kWh divided by the tonnage, divided by the total hours of operation and reflect both direct and indirect efficiency.

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Total kW Energy Usage & Savings from Sonic.net's 100 Ton System.

The table below shows the energy used by each unit to perform each task. Each task is then totaled in the right column to show the total energy saved or spent by a typical Core4 installation as compared to a perfect n+1 CRAC Installation. The line at the bottom states total systems efficiency in kW per ton for 100 tons. The Liebert CRAC system performed at 1.91kW total system connected efficiency (which includes all direct and indirect energy usage) if you compare that to the Core4 System at .40kW per ton (also includes all direct and indirect energy usage) you will see an 79 percent increase in the facilities cooling efficiency or an 79% decrease in the facilities energy usage.

System Core	Core4 System kWh	Leibert System kWh	Core4 kWh Savings
Compressor	245,280	805,920	560,640
Condenser	78,840	29,623	-49,217
Refrigerant Pump	10,044	0	-10,044
Evap Fans	108,624	303,096	194,472
Fan Heat Removal	12,453	154,526	142,073
Humidity Removal	876	226,350	225,474
Humidty Replacement	13,422	152,456	139,034
Scavenger Savings	-75,513	0	75,513
MTS Savings	-39,600	0	39,600
Estimated kW	354,426	1,671,971	1,317,545
System kW Per Ton	0.40	1.91	

Core4 Savings by Area

The Pie Chart below shows where the Core4 System saves its energy. Each percentage is a reflection of the overall system efficiency and cannot be specifically targeted for individual savings.

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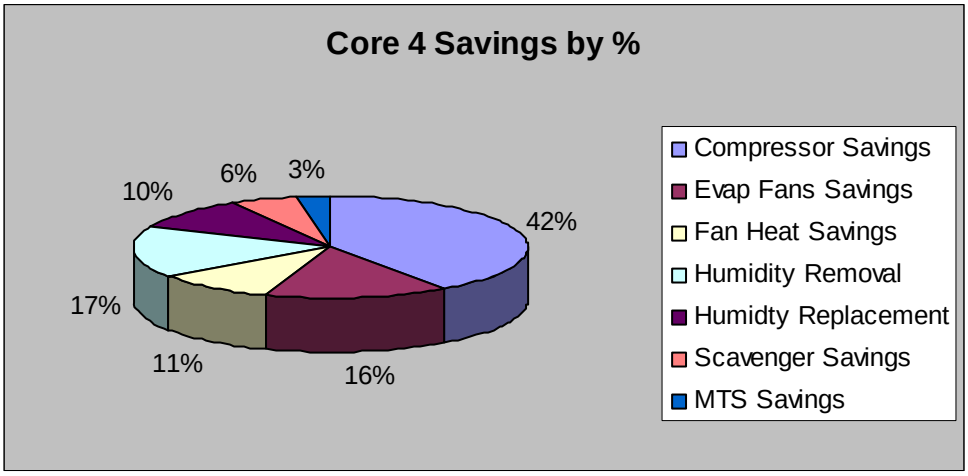

Core4 Extrapolated Savings Based on Cooling Load

The following table shows the potential savings associated with this installation based on total tons of operation. The table shows 60/80/100 tons and 300/1000 tons. Although the system's efficiency is based on the 100 ton load, each tonnage is a representation of the efficiency at 100 tons multiplied by the ton/hours. This chart does not show any increase or decrease in efficiency due to running out of the tonnage parameters. Most total efficiencies will change dependant of the installation and load.

System	60 Tons	80 tons	100 Tons	300 Tons	1000 Tons
CRAC	$120,382	$160,509	$200,637	$601,910	$2,006,365
Core4	$25,519	$34,025	$42,531	$127,593	$425,311
Yearly Savings	$94,863	$126,484	$158,105	$474,316	$1,581,054
Monthly Savings	$7,905	$10,540	$13,175	$39,526	$131,755

Core4 System kW vs. Data Center kW Performance Ratio

On the following two pages the graphs show the Core4 Systems performance ratio for the warmer months of April and May 2008. In the chart you will notice the straight thick red line. This line is the average of LBNL report on energy usage in the data centers (table included below).

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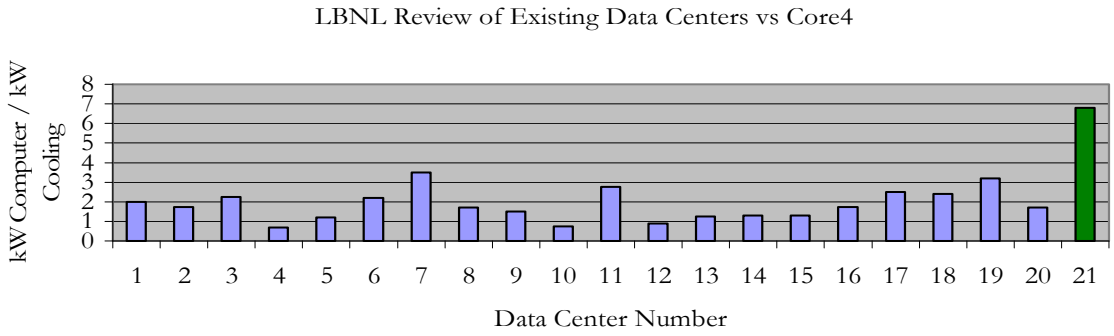

The ratio is a comparison of the energy and heat generated in the data centers by light and computers vs. the energy needed to remove the heat. Next you will notice the Core4 red line, this lines position varies on time of day. What you will notice is that the LBNL line is a ratio of 1.68 to 1 and the Core4 line averages 5.97 to 1 during the warm summer months and is more efficient during the winter months. On the following chart the Data Center #21 is the Core4 Installation.

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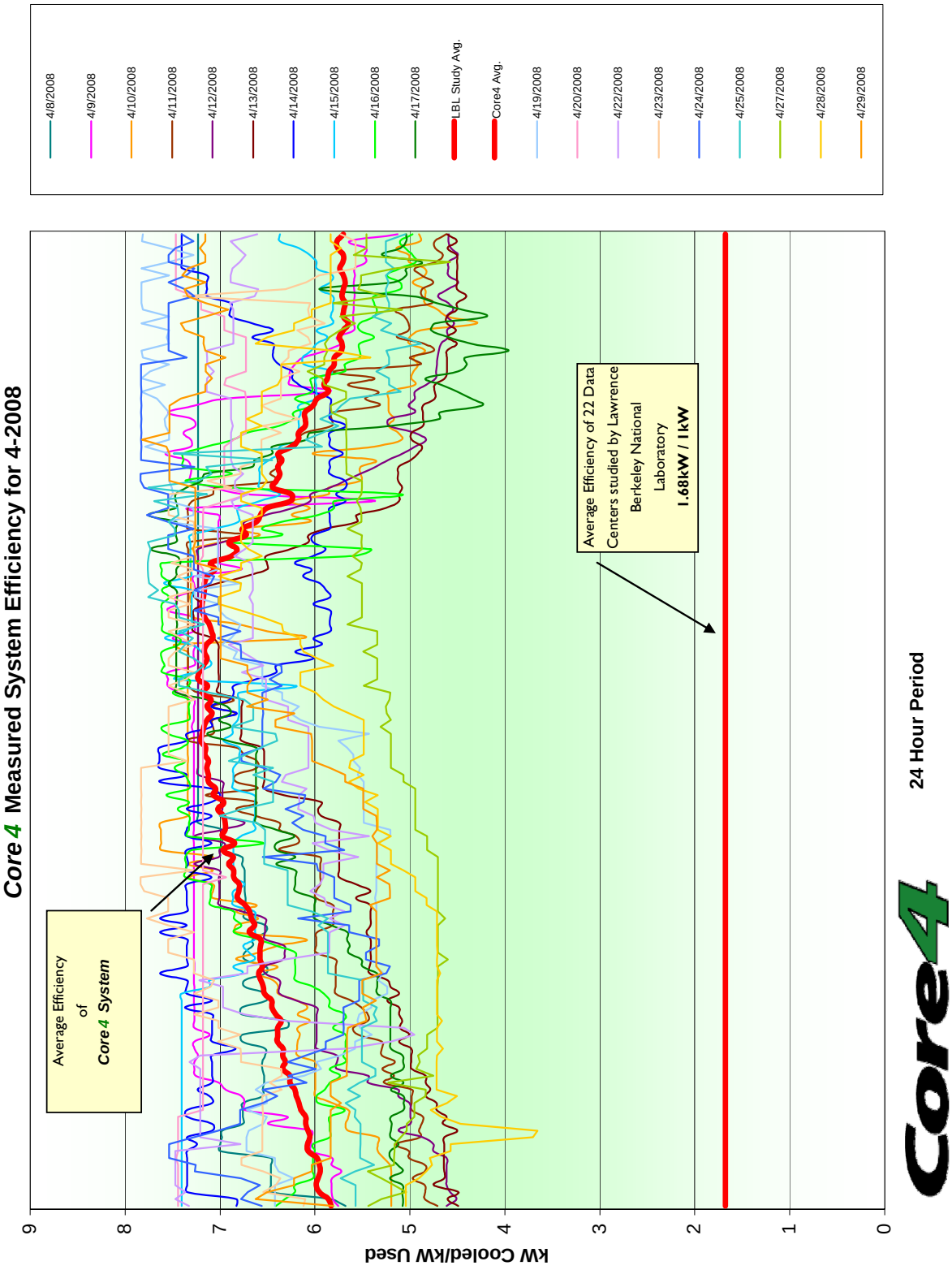

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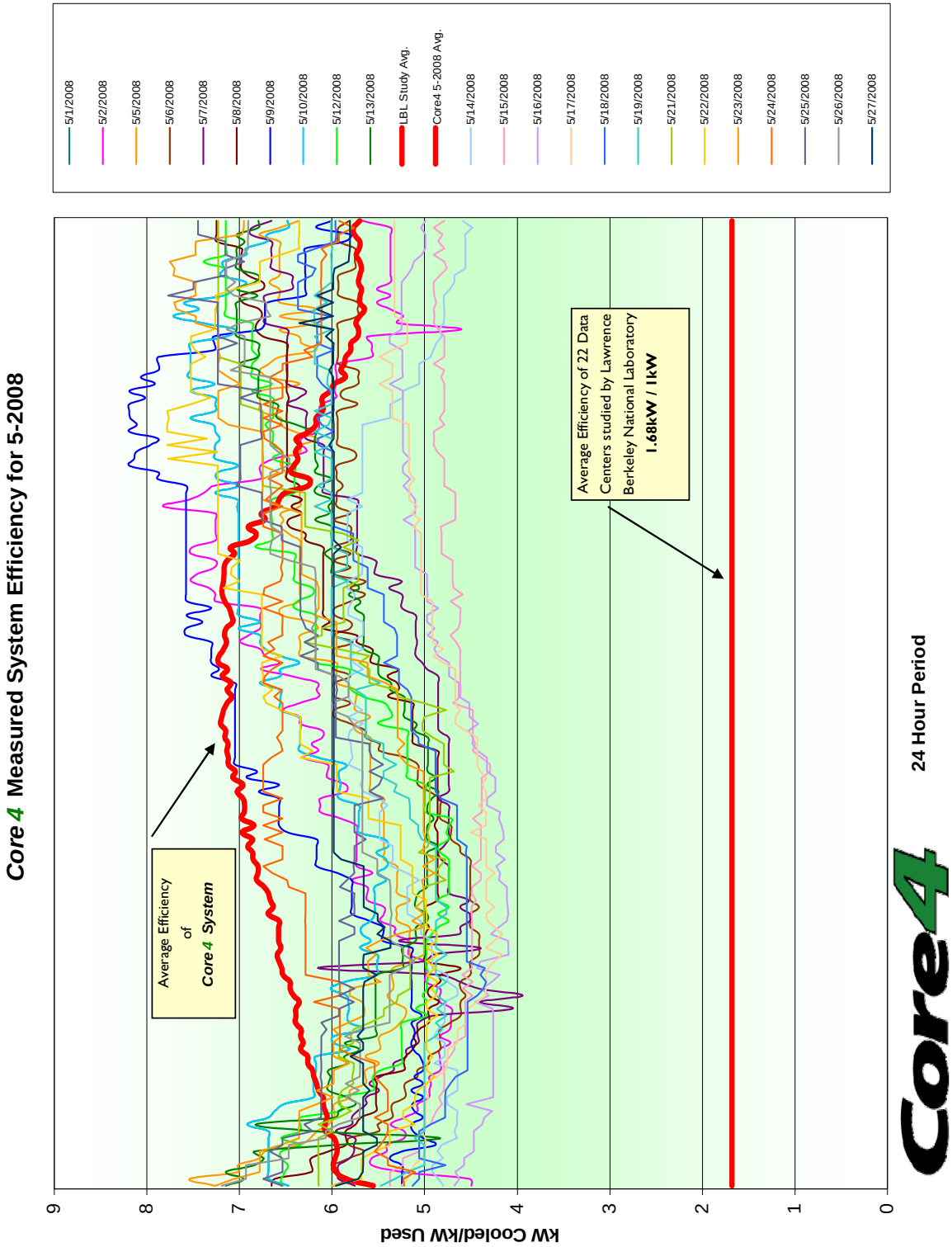

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Comparison of the Core4 System vs. Chiller Systems Efficiency.

Some may ask how the Core4 System performs against a built-up chiller system. This chart, also provided by LBNL, shows the total connected efficiency of the chilled water plants which were surveyed in the Data Center Efficiency report. What is important to evaluate here is that chiller plants aren't that much more efficient than Air Cooled CRAC units. Typical Liebert's average is 1.91 kW per ton, the chiller systems below average is 1.69 kW per ton not including any indirect inefficiency which equates to an 11% efficiency improvement. The Core4 System averages .40kW per ton total connected efficiency, which is 79 percent better than Liebert's and 76 percent better than the chiller systems evaluated. This chart just reiterates how efficient a well designed Core4 solution can be.