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Հոկտեմբերի 24-25, Երևան

PUBLIC COUNCIL ON RENEWABLE AND CLEAN ENERGY
Proceedings of the 5th International Renewable and Clean Energy Conference
Yerevan - October 24-25, 2013

ОБЩЕСТВЕННЫЙ СОВЕТ ПО ВОЗОБНОВЛЯЕМЫМ И ЧИСТЫМ ИСТОЧНИКАМ ЭНЕРГИИ
Труды Пятой Международной конференции по возобновляемым и чистым источникам энергии
Ереван - 24-25 октября, 2013

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Երևան, հոկտեմբերի 24 – 25, 2013թ.

ՀԱՄԱԺՈՂՈՎԻ ՆՅՈՒԹԵՐ

PUBLIC COUNCIL ON RENEWABLE ENERGY

The 5th International Renewable and Clean Energy Conference
“The Prospects of Low Carbon Development in Armenia”
Yerevan, October 24 – 25, 2013

CONFERENCE PROCEEDINGS

ОБЩЕСТВЕННЫЙ СОВЕТ ПО ВОЗОБНОВЛЯЕМОЙ ЭНЕРГИИ

5-ая Международная конференция по возобновляемым и чистым источникам энергии
“Перспективы низкоуглеродного развития в Армении”
Ереван – 24 – 25 октября 2013 г.

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Ընդհանուր խմբագրությունը Ս. Շատվորյանի:

The book presents the proceedings of the 5th International Renewable and Clean Energy Conference held in Yerevan on October 24 – 25, 2013.

Chief Editor: S. Shatvoryan

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Под общей редакцией С. Шатворяна.

Խմբագիր՝ Քրիստինե Սիմոնյան
Սրբագրիչ՝ Ալլա Աբրամովա

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Համաժողովը նախաձեռնել և կազմակերպել է Հայաստանի վերականգնվող և մաքուր էներգիայի հասարակական խորհուրդը՝ «Կլիմայի փոփոխության մասին ՄԱԿ-ի շրջանակային կոնվենցիայի ներքո Հայաստանի երրորդ ազգային հաղորդագրության պատրաստման համար նպաստավոր պայմանների ստեղծում» ՄԱԶԾ-ԳԷՖ/00060737 Ծրագրի ֆինանսական աջակցությամբ և ԱՄՆ Պետդեպարտամենտի հասարակայնության հետ կապերի գրասենյակի դրամաշնորհի շրջանակներում: Այս հրատարակության մեջ տեղ գտած կարծիքները, եզրակացությունները և խորհրդատվությունները պատկանում են հեղինակներին և կարող են չհամընկնել ԱՄՆ պետդեպարտամենտի դիրքորոշումների հետ:

The 5th International Renewable and Clean Energy Conference
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5-ая Международная конференция по возобновляемым и чистым источникам энергии.
Ереван, 24 – 25 октября 2013 г.

Конференция инициирована и организована Общественным советом по возобновляемой и чистой энергии Армении, профинансирована совместно программой ПРООН-ГЭФ/00060737 по содействию в подготовке Третьего Национального сообщения Рамочной Конвенции ООН по изменению климата, а также через грант отделения по связям с общественностью Государственного департамента США. Мнения, выводы или рекомендации, выраженные в данной публикации принадлежат авторам и могут не совпадать с точкой зрения Государственного департамента.

Dear Reader,

The Fifth International Renewable and Clean Energy Conference "The Prospects of Low Carbon Development in Armenia" on October 24-25, 2013 collected more than 160 participants and presented about 60 scientific and practical papers.

During the last decade five international conferences were organized by the efforts of the Public Council on Renewable Energy of Armenia to highlight the actual problems and developments in renewable and clean energy and environmental security, technological innovations, development policy of the energy sector in Armenia and the whole world. The Conferences became the major platform for establishment of professional and business contacts and new interdisciplinary relations in the region. Conduction of the Conferences and publication of the proceedings aimed at making available the achievements and experience to the professionals of the sector and also awaring the public of importance of energy saving and protection of the environment. Building of more secure and cleaner environment is the noble duty of every citizen. All those who made the Fifth International Renewable and Clean Energy Conference happen - the organizers and participants – have made their own contribution for addressing the challenges in energy and environment, and we express our deepest gratitude to all of them.

Suren Shatvoryan
Chairman of the Organizing Committee

UDC 536.24

ADDRESSING THE EXPANDING ELECTRICITY USE IN COOLING DATA CENTERS

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Keywords: Data Center Cooling System, Multistage Evaporative Cooling, Semi-Conductor Clean Room Process Cooling Method

New methods and systems to provide evaporative cooling by combining multiple direct and indirect evaporative cooling stages into one multistage evaporative cooling system to achieve cooling media (air or water) temperatures that are much lower than the initial wet bulb temperature of the ambient air have been developed.

Introduction

Some key facts in the **"State of the Data Center 2011"** document from Emerson Network Power and Data Center Dynamics' **"Global Data Center Energy Demand Forecasting"** follows:

- 509,147 Data Centres Worldwide covering 285,831,541 sq ft of space.
- Total Data Center power consumption worldwide in 2011 of around 31 GW and is projected to increase 19% in 2012. This amount if fully utilized would be sufficient to provide energy to all residential households in the United Kingdom, France or Italy.
- Data Centres Worldwide consume approximately 2.5% of the power used worldwide. Approximately 40% of all energy consumed in a Data Center is for cooling or 1% of all the power used worldwide.
- In 2011, mankind created 1.2 trillion GB of Data, equivalent to 75 billion 16 GB ipods. Every person on earth would have 10 ipods.
- In 2011, $53 billion in cyber weekend sales was larger than the entire economy of Bulgaria.
- 845,000,000 active Facebook users on earth at the end of 2011 or 1 in every 8 people on earth. Currently, Facebook has over 1 billion active users.
- Daily Tweets on Twitter in February 2011 averaged 140 million, almost 3X the 50 million average daily Tweets sent in 2010.
- In 2011, every second, 1157 people start watching a YouTube video, that's 1,000,000 videos a day.
- A Server purchased in 2011 has an average of 45X more computing capacity than a similarly configured server installed in 2001.

Technology Summary

Key attributes of the Multistage Evaporative Cooling System:

- Scalable from 10 to over 1000 tons.
- Based on Phoenix AZ Summer Ambient Air Design Conditions for cooling applications are 43.44°C DB and 21.11°C WB, MECS delivers 13.88 °C cool water, 11.66 °C cold air, or both at the same time.
- Simple practical design provides ease of monitoring, control, and maintenance.
- 60 to 80% less power usage / energy savings compared to traditional mechanical refrigeration systems in Data Centres
- NO Compressors and NO Freon
- Process cooling approach leads to NO over sizing of Data Center cooling systems and therefore reduces up front capital requirements by 40% to 60% (over sizing is typically by 150% to 200% when cooling Data Centres with Air (Comfort cooling)).

Multistage Evaporative Cooling System*; United States 6,1538615; Filed September 23, 2011 and converted to the Non-Provisional Patent Application titled:* ***New Advanced Multi-Purpose Multistage Evaporative Cold Water/Cold Air Generating And Supply System****; United States 13624912; Filed September 22, 2012 under accelerated examination rules of USPTO.*

The Inventor has developed new methods and systems that provide evaporative cooling by combining multiple direct and indirect evaporative cooling stages into one multistage evaporative cooling system to achieve cooling media (air or water) temperatures that are much lower than the initial wet bulb temperature of the ambient air.

Key attributes of the Individual Server Enclosure Cooling System:

- Process Cooling Individual Racks with loads up to 35 kW on a Real Time basis

- Process Cooling adjusts cooling in Real Time to meet the actual load of the Server Rack as it varies between 3 kW to over 35 kW
- Provides 21.11 °C to 27.0 °C cool air back to Data Center white space
- Increases Data Center Floor Area and Capacity in White Space by eliminating perimeter CRACs and CRAHs in the Data Center white space
- Eliminates hot aisles and cold aisles
- Restores Lost Rack Capacity of the Data Center due to lack of cooling (cold air flow to individual racks) as rack load densities increase through the individual cooling high load density Racks
- Provides significant energy savings of 60 to 80%
- Eliminates the need for hot aisle / cold aisle containment equipment and systems thereby reducing capital costs
- Eliminates the need for air ducts in the Data Center White Space.
- Can be incorporated into raised floor designs or placed above the Racks over the aisles

Real Time Individual Electronic Enclosure Cooling System; United States 13748088; Filed January 22, 2013 under accelerated examination rules of USPTO.

The Inventor is applying semi-conductor clean room process cooling methods to Data Center / Mission Critical environments providing real time load based process cooling at the Rack or Electronic Enclosure as loads fluctuate between 3 kW and 35 kW. Process cooling the heat loads of Server Racks or Electronic Enclosures eliminates hot isles and cold isles typically found in today's Data Centers by combining the Multistage Evaporative Cooling System (MECS), Real Time Individual Electronic Enclosure Cooling System, or hereinafter, Individual Server Enclosure Cooling System (ISECS), and Real Time Monitoring and Control System (RTMCS).

Temperature Performance of the Real Time Data Center Cooling System

The data in this document are for Phoenix, Arizona, USA consist of excerpts from the full white paper showing temperature performance of the Real Time Data Center Cooling System (RTDCCS) which analyzes temperature performance in four (4) major cities in the United States; i.e. Phoenix, AZ; Newark (Wilmington), DE; Houston, TX; and San Jose, CA.

To begin putting the advantages and benefits of the RTDCCS together for this engineering analysis and perspective, let’s first look at the amount of potential energy savings available to Data Center Owners/Operators by comparing 11 different traditional data center mechanical cooling methods to the RTDCCS. These systems can be ranked from an energy usage standpoint by evaluating the energy required to operate the system in kilowatts (kW) versus the cooling capacity provided in tons of cooling (12,000 BTU/Hr per ton). The table following compares kW per ton of power usage of the Real Time Data Center Cooling System against these competitive systems.

Comparison of Traditional Mechanical Cooling Systems to the RTDCCS. Energy Usage in kW / Ton

Type of Data Center Cooling System	Traditional Mechanical Cooling kW/Ton	RTDCCS kW/Ton	kW/Ton Savings	%Energy Savings
CRAC Cooled System	2.88	0.55	2.33	80.9%
CRAH Cooled System – Chilled Water Based	2.73	0.55	2.18	79.9%
CRAC Cooled System with Containment	2.67	0.55	2.12	79.4%
CRAH Cooled System with Containment	2.54	0.55	1.99	78.3%
Liquid Cooled Racks Unoptimized	2.37	0.55	1.82	76.8%
Liquid Cooled Racks Chilled Water Temps Optimized	1.72	0.55	1.17	68.0%
Liquid Cooled Racks Chilled Water Temps Optimized and Free Cooling Systems	1.39	0.55	0.84	60.4%
Liquid Cooled Racks Chilled Water Temps Optimized and Evaporative Free Cooling Systems	1.21	0.55	0.66	54.5%
Active Liquid Cooled Doors Chilled Water Temps Optimized and Evaporative Free Cooling	1.17	0.55	0.62	53.0%
Passive Liquid Cooled Doors Chilled Water Temps Optimized and Evaporative Free Cooling	0.93	0.55	0.38	40.9%
Pumped Refrigerant Systems	1.74	0.55	1.19	68.4%
Air Side Economizing	1.41	0.55	0.86	61.0%

Summary of Temperature Performance of Real Time Data Center Cooling System Solution

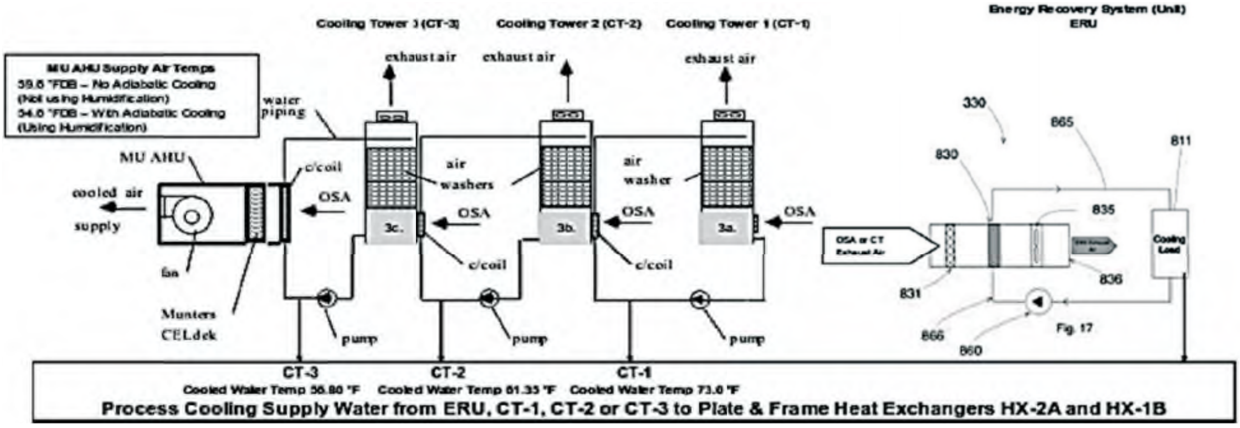
Phoenix AZ

1. ASHRAE published Summer Design Conditions of 4% for cooling applications - Data Center White Space temperature (for the entire compute space) can be maintained at a set point temperature of 17.47 °C completely eliminating hot aisles and cold aisles. No compressors and refrigerants are used in the system. Significant additional energy can be saved by maintaining a set point temperature of 23.88°C in the Data Center White Space.

2. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - Data Center White Space temperature (for the entire compute space) can be maintained at a set point temperature of 20.52 °C in the hottest month of August completely eliminating hot aisles and cold aisles. No compressors and refrigerants are used in the system. Significant additional energy can be saved by maintaining a set point temperature of 23.88 °C in the Data Center White Space.

Note: All temperatures in the graphic shown below are shown in °F. All temperatures in the body of this paper and the graphic at the end of this document have been converted to °C.

Principal Diagram of Multistage Evaporative Cooling System (MECS)
Phoenix, Arizona, USA



Example of Projected Monthly Temperature Performance of the Real Time Data Center Cooling System

The Engineering Analysis in the spreadsheet below estimates mean monthly thermal performance of the Real Time Data Center Cooling System consisting of Multistage Evaporative Cooling System (MECS) generating cold water and the Individual Server Enclosure Cooling Systems (ISECS) for use in process cooling of the Server Racks located in the white space of the Data Center. The analysis is for a data center project that would be located in Phoenix AZ.

This analysis uses the ASHRAE Design Conditions for Phoenix International Airport (PHX) area and the monthly mean dry bulb and wet bulb temperatures for the PHX

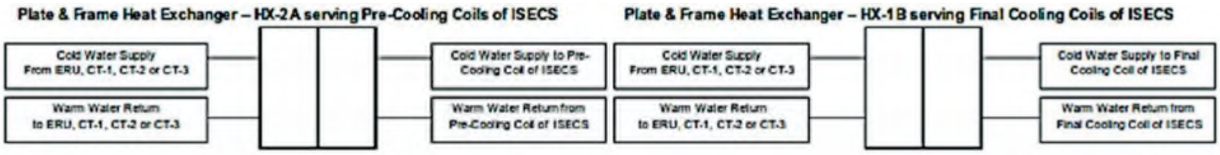
(http://www.weatherexplained.com/Vol-2/2001-Phoenix-Arizona-PHX.html#ixzz2XMUi3IdJ).

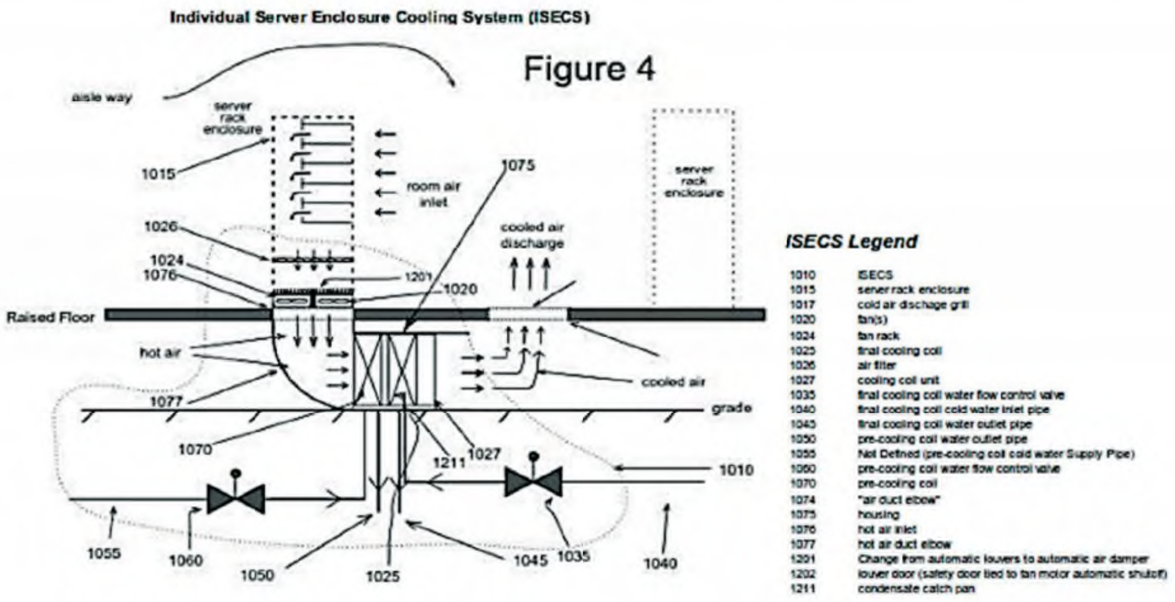
Example Engineering Analysis

Preliminary Assumptions:

- Preliminary assumption - MECS consists of three cooling towers: CT-1, CT-2 and CT-3.
- An assumed approach temperature for all cooling tower CT-1, CT-2 and CT-3 is 1.58 °C.
- An assumed approach temperature for ambient air pre-cooling coils for the mentioned cooling towers is 0.53 °C.
- Humidity and partial temperature control of the Data Centre's White Space should be provided by the building comfort HVAC Systems.
- A combination of the MECS + ISECS provides process sensible cooling of the Data Center Server Racks.
- Each cooling coil in the Fan Coil Unit (Pre-Cooling Coil and Final Cooling Coil) assumes a 0.53 °C approach temperature plus a 0.053 °C adjustment for cooling water heat (temperature) gain (Totalling 0.583 °C).

Principal Diagram of the Real Time Individual Electronic Enclosure Cooling System (or ISECS)





Estimating the temperature performance of the Real Time Data Center Cooling System (MECS + ISECS) for Data Center to be located in city of Phoenix, AZ

Below are calculations for the ASHRAE published Summer Design Conditions of .4% for cooling applications showing the ambient air design dry bulb and wet bulb temperatures for Phoenix AZ (PHX) of 43.44 °CDB and 21.11 °CWB.

Engineering Analysis Assumptions

- DC site Location: Phoenix AZ (PHX)
- Site Elevation: 370 meters (1200 feet)
- OSA summer temperature design conditions for .4%: 43.44 °C DB / 21.11 °C WB
- All Cooling Towers & ERU Approach Temps: 1.58 °C
- All pre-cooling coils for Cooling Tower Approach Temps: 0.53 °C
- Fluid-fluid Plate HX Approach Temps: 0.53 °C
- Pre-cooling coil of FCU Approach Temps: 0.53 °C
- Final cooling coil of FCU Approach Temps: 0.53°C

Design parameters of the OSA are:

- Relative humidity: 12.61%
- Dew point temperature: 8.59 °C
- Humidity ratio: 50.90 gr/lb
- Enthalpy: 34.52 btu/lb
- Specific volume: 15.18 ft^3/lb

Calculation

Estimated temperature of the cold water leaving the Cooling Tower CT-1 and entering the ambient air pre-cooling coils of the cooling tower CT-2 is: 21.11+ 1.58= 22.69 °C

Estimated DB temperature of the pre-cooled ambient air leaving pre-cooling coils of the Cooling Tower CT-2: 22.69 +0.53 = 23.22°C

Estimated parameters of the pre-cooled ambient air entering wet media of the cooling tower CT-2A:

- Dry Bulb temperature: 23.33 °C
- Wet Bulb Temperature: 14.64 °C
- Relative humidity: 38.94%
- Dew point temperature: 8.59°C
- Humidity ratio: 50.90 gr/lb
- Enthalpy: 25.70 btu/lb
- Specific volume: 14.21 ft^3/lb

Estimated temperature of the cold water leaving the Cooling Tower CT-2 and entering the ambient air pre-cooling coils of the cooling tower CT-3 is: 14.64 + 1.58 = 16.22 °C

Estimated DB temperature of the pre-cooled ambient air leaving pre-cooling coils of the Cooling Tower CT-3: 16.22 +0.53 = 16.75 °C

Estimated parameters of the pre-cooled ambient air entering wet media of the cooling tower CT-3:

- Dry Bulb temperature: 16.75 °C
- Wet Bulb Temperature: 12.11 °C
- Relative humidity: 58.31%
- Dew point temperature: 8.59 °C
- Humidity ratio: 50.90 gr./lb.
- Enthalpy: 22.85 btu / lb.
- Specific volume: 13.90 ft^3/lb.

Estimated temperature of the cold water leaving the Cooling Tower CT-3 and entering into primary loop of the liquid-liquid plate and frame HX: 12.11 + 1.58 = 13.69 °C

Estimated temperature of the secondary loop supply cooling water leaving plate and frame HX and entering into the final cooling coils of the FCUs: 13.69 + .53 = 14.22 °C

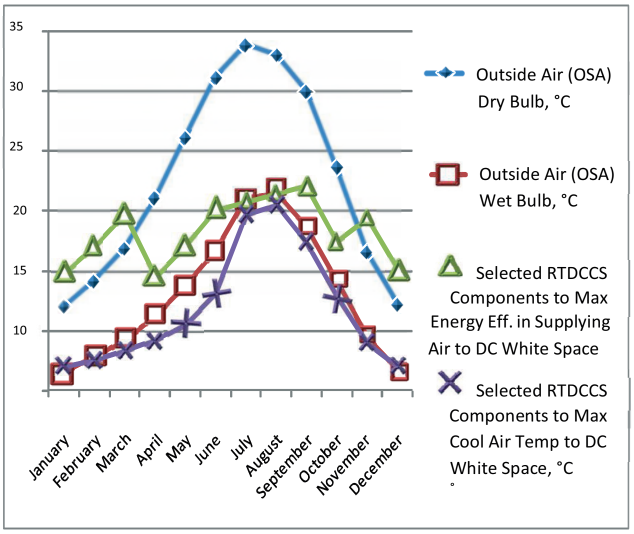
Estimated temperature of the cooled air leaving final cooling coil of the FCU serving and individual electronics enclosure*:

14.22 + 0.58 = 14.80 °C < 27 °C (ASHRAE TC 9.9 Maximum Recommended)

2001 Monthly Mean Dry Bulb and Wet Bulb Temperatures for Phoenix, Arizona, USA (www.weatherexplained.com)

RTDDCS - Data Center White Space Cooling

	Outside Air (OSA) Dry Bulb °C	(OSA) Wet Bulb °C	Selected RTDCCS Components to Max Energy Eff. in Supplying Air to DC White Space °C	Selected RTDCCS Components to Max Cool Air Temp to DC White Space °C
January	12.06	6.61	14.89	7.07
February	14.17	7.83	17.00	7.61
March	16.83	9.22	19.67	8.43
April	21.06	11.28	14.50	9.26
May	26.06	13.72	16.94	10.59
June	31.11	16.67	20.06	13.13
July	33.78	21.11	20.75	19.69
August	32.94	21.39	21.42	20.52
September	29.94	18.72	22.06	17.48
October	23.56	14.11	17.39	12.91
November	16.56	9.44	19.39	8.98
December	12.22	6.67	15.06	7.02



Summary of the Engineering Analysis

The Engineering Analysis conducted below is based on the Real Time Data Center Cooling System and its patent-pending cooling technologies consisting of the Multi-stage Evaporative Cooling System (MECS) combined with the Individual Server Enclosure Cooling System (ISECS), also described herein as Fan Coil Unit (FCU), operating in Phoenix, Arizona, USA, would provide year round required cooling of the Server Racks in the Data Center and returning cold supply air back to the Data Center While Space (See Individual Server Enclosure Cooling System (ISECS) Figure 4). Depending on the ambient conditions, in the majority of cases, the Energy Recovery Unit (ERU) operating alone would be able to satisfy the all cooling needs of the Data Centre's IT Equipment (See attached Engineering Analysis spread sheet document). In some ambient conditions and depending on the customer's set point temperature requirements for the Data Center White Space, Cooling Tower CT-1, Cooling Tower CT-2, and Cooling Tower CT-3 may be operational. The sequence of operations would be CT-1 alone, CT-1 and CT-2, or CT-1, CT-2 and CT-3. All 3 Cooling Towers can be used to provide redundant back up the Energy Recovery Units (ERU 1A and ERU 1B). This analysis results in a very economical and cost effective cooling solution providing significant energy savings as compared to traditional data center mechanical refrigeration systems.

Phoenix Arizona USA Conclusions – RTDCCS Temperature Performance

A Real Time Data Center Cooling System applied to a Data Center in Phoenix AZ can meet ASHRAE TC 9.9 data center white space maximum temperature set point of 27.0 °C or below for both the ASHRAE published ambient air Summer Design Conditions of .4% for cooling applications; and the monthly Mean Temperatures for Phoenix International Airport (PHX) (highest temperature of the process cooled air entering the white space is 22.05°C in September).

Therefore, the RTDCCS can provide a temperature of process cooled air (process cooling of the rack heat loads) entering the white space of between 14.89°C and 22.05°C meeting the guidelines established by ASHRAE TC 9.9. The Real Time Monitoring and Control System can maintain customer desires set point temperatures within the data center white space of customer selected temperature within a±1°C control tolerance.

References

1. The full White Paper on Temperature Performance with complete data and analysis can be viewed by clicking on this link:
http://r4ventures.biz/uploads/White_Paper_-_Preliminary_Temperature_Performance_Evaluation_of_the_Real_Time_Data_Center_Cooling_System_January.pdf
2. The full White Paper on Energy Usage in kW / Ton with complete data and analysis can be viewed by clicking on this link:
http://www.r4ventures.biz/uploads/Real_Time_Data_Center_Cooling_System_Benefits_and_Comparison_to_Traditional_Cooling_Systems_October_2012.pdf

ՀԱՇՎՈՂԱԿԱՆ ԿԵՆՏՐՈՆՆԵՐԻ ՀՈՎԱՑՄԱՆ ՆՊԱՏԱԿՈՎ ԾԱԽՍՎՈՂ ԷԼԵԿՏՐԱԷՆԵՐԳԻԱՅԻ ՔԱՆԱԿԻ ՆՎԱԶԵՑՄԱՆ ԼՈՒԾՈՒՄՆԵՐ

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Առանցքային բառեր. հաշվողական կենտրոն, հովացման համակարգ, բազմաստիճան գոլորշիչ հովացում, կիսահաղորդչային մաքուր սենյակ, սառեցման մեթոդ

RTDCCS համակարգը բաղկացած է նոր բազմաստիճան գոլորշիչային սառեցման համակարգից, որը զուգակցված է էլեկտրոնային սարքավորումների անհատական հովացման համակարգի հետ: Գյուտի մշակումը նպատակ ունի է նվազեցնել հաշվիչ կենտրոնների սարքավորումների հովացման ծախսերը և էլեկտրաէներգիայի սպառումը: Տեխնիկական լուծումը, որի հեղինակն է՝ Մայք Ռեյտբլատը, ներառում է ցածր հզորության կոմպրեսորներ, սակայն չի օգտագործում սառցանյութ և համեմատած ավանդական մեխանիկական հովացման համակարգերի և տեխնոլոգիաների հետ ապահովում է էներգետիկ ծախսերի խնայողություն՝ 60-80%: Այն ամբողջությամբ վերացնում է տաք և սառը հոսանքները, պահպանում է սահմանված ջերմաստիճանը ± 1°C ճշտությամբ: