R4 Ventures LLC

White Paper

Comparison of Real Time Data Center Cooling System First Costs, Energy Usage, PUE and First Costs per Watt versus 8 of the most common systems offered by APC Schneider Electric

Patents

Mike Reytblat – Inventor and Chief Scientist - The first patented system is the Multistage Evaporative Cooling System (MECS). Notice of Allowance was issued by the USPTO in August 2014 on our Advanced Multi-Purpose, Multi-stage Evaporative Cold Water/Cold Air Generating and Supply System US Patent Application Number 13/624912 and a US Patent Number 8,899,061 published on December 2 2014. The second patented system is the Real Time Individual Electronic Enclosure Cooling System (hereinafter Individual Server Enclosure Cooling System or ISECS). Notice of Allowance was issued by the USPTO in August on our Real Time Individual Electronic Enclosure Cooling System – US Patent Application Number 13/748088 and US Patent Number 8,857,204 published on October 14, 2014. A Real Time Data Center Cooling System (RTDCCS) is created by combining ISECS with MECS.

By: Darrell Richardson, CEO and Mike Reytblat, Chief Scientist

R4 Ventures LLC

Please direct questions to Darrell Richardson via phone (602) 509-3355 or email darrell@r4ventures.biz or mike@r4ventures.biz

January 2015

Table of Content

Executive Summary

This White Paper provides a detailed pricing analysis of the R4 Ventures LLC Real Time Data Center Cooling System (RTDCCS) compared to 8 data center cooling solutions provided by APC Schneider Electric based on market research that established the size of the average data center in the United States. The average size data center is as follows:

Average United States Data Center	
Total Number of Average Size Data Centers in the US	18,065
Annual kWh Consumed by the Average Data Center in the US	4,621,958
KW per Average Data Center	527.62
IT KW Cooling Load in Average Data Center	247.98
Average Data Center PUE in the US	2.13
Total Average Data Center Cooling Load W/ RTDCCS Commissioned	354.56
Average Data Center PUE in the US W/ RTDCCS Retrocommissioned	1.43
BTUs / Hr for the Average Data Center	1,062,186
Average DC Installed Mech. Cooling Capacity (Tons of Refrig)	88.52
Average Nunber of 42U Racks in Average Data Center	60
SF of White Space per Rack (Raised Floor)	27.5
SF of White Space in Average Data Center	1,650.00
Average KW per rack	4.13
Parameters Established for Planning and Competive Cost Comparison Purposes	
IT Load in Average Size Data Center in KW per Rack	**4.0**
# of 42U Racks in Average Size Data Center	**60**
Total SF of Average Data Center Used For Planning Purposes	**1,620**

The analysis shows that the price of the RTDCCS for meeting the average size data center shown above for a 4 KW per rack and 60 rack system is a first cost of $1,225,740 and had an annual energy consumption cost of $22,486 and a second set of high density parameters of 12 KW per rack and 20 rack system (same 240 KW IT load) is a first cost of $714,380 and had an annual energy consumption cost of $22,486. The first cost and annual energy consumption would be the same in comparing the RTDCCS against APC's row based high density cooling solution. This was compared to 8 different cooling system solution provided by APC Schneider Electric based on the same data center white space parameters based on 3 different design scenarios.

1. Low Density - Perimeter Cooling based on 4 KW per rack, 60 rack system and a 240 KW IT load.
2. High Density - Perimeter Cooling based on 12 KW per rack, 20 rack system and a 240 KW IT load.
3. High Density - Row Based Cooling based on 12 KW per rack, 20 rack system and a 240 KW IT load.

The APC first costs, annual energy consumption costs, PUE comparison and average cost per watt was developed on APC's own data center cost and data center energy cost calculators developed by APC engineers and available on the internet at http://www.apcmedia.com/salestools/WTOL-7AXSAN/WTOL-7AXSAN_R1_EN.swf and http://www.apcmedia.com/salestools/WTOL-7CMGPL/WTOL-7CMGPL_R3_EN.swf.

The 8 different APC cooling solutions are:

Legend: Perimeter Cooling

APC #1 Perimeter CRAH with Chiller / Tower
APC #2 Perimeter CRAH with VFD Chiller / Tower
APC #3 Perimeter CRAH with Chiller / Dry Cooler
APC #4 Perimeter CRAH with VFD Chiller / Dry Cooler
APC #5 Perimeter CRAH with Packaged Chiller
APC #6 Perimeter CRAC DX Air Cooled
APC #7 Perimeter CRAC DX Glycol Cooled
APC #8 Perimeter CRAC DX Water Cooled

Legend: Row Based Cooling

APC #9 Row Based Cooling CRAH with Chiller / Tower
APC #10 Row Based Cooling CRAH with VFD Chiller / Tower
APC #11 Row Based Cooling CRAH with Chiller / Dry Cooler
APC #12 Row Based Cooling CRAH with VFD Chiller / Dry Cooler
APC #13 Row Based Cooling CRAH with Packaged Chiller
APC #14 Row Based Cooling CRAC DX Air Cooled
APC #15 Row Based Cooling CRAC DX Glycol Cooled
APC #16 Row Based Cooling CRAC DX Water Cooled

All input data is detailed in the attached spreadsheets that allow any reviewer of this document to replicate the results by going on the APC website calculators in inputting the same parameters used by the author. Note: An error was found in

the data center cost calculator and reported and was subsequently acknowledged by APC in APC #6 Perimeter CRAC DX Air Cooled cooling system solution. Therefore, the results data in comparison for APC #6 is not being considered.

The analysis shows that the RTDCCS compares as follows:

- Low Density - Perimeter Cooling comparison
    - First Cost of APC cooling systems range from a high of $1,261, 601 to a low of $815,162 as compared to the RTDCCS first costs of $1,225,740.
    - Annual Energy Cost of the APC cooling systems range a high of $167,678 to a low of $81,250 as compared to the RTDCCS annual energy costs of $22, 486 providing a simple payback in months to recover the initial first cost of the RTDCCS where it has a higher first cost range from a low of 1.11 months to a high of 5.16 months.
    - PUE of the APC cooling systems range from a high of 1.96 to a low of 1.57 as compared the RTDCCS PUE of 1.21.
    - Cooling System First Costs per Watt of the APC cooling systems range from a high of $5.26 to a low of $3.40 as compared to the RTDCCS First Cost per watt of $5.11.
- High Density - Perimeter Cooling comparison
    - First Cost of APC cooling systems range from a high of $1,407,495 to a low of $969,101 as compared to the RTDCCS first costs of $714,380.
    - Annual Energy Cost of the APC cooling systems range a high of $167,678 to a low of $81,250 as compared to the RTDCCS annual energy costs of $22, 486. In all cases, the RTDCCS has a lower first cost than the APC cooling systems and therefore, a simple payback does not apply.
    - PUE of the APC cooling systems range from a high of 1.96 to a low of 1.57 as compared the RTDCCS PUE of 1.21.
    - Cooling System First Costs per Watt of the APC cooling systems range from a high of $5.87 to a low of $4.40 as compared to the RTDCCS First Cost per watt of $2.98.
- High Density – Row Based Cooling comparison
    - First Cost of APC cooling systems range from a high of $1,074, 534 to a low of $611,390 as compared to the RTDCCS first costs of $714,380.
    - Annual Energy Cost of the APC cooling systems range from a high of $90,180 to a low of $52,392 as compared to the RTDCCS annual energy costs of $22, 486 providing a simple payback in months to recover the initial first cost of the RTDCCS where it has a higher first cost range from a low of .77 months to a high of 1.52 months.
    - PUE of the APC cooling systems range from a high of 1.59 to a low of 1.41 as compared the RTDCCS PUE of 1.21.
    - Cooling System First Costs per Watt of the APC cooling systems range from a high of $4.48 to a low of $2.54 as compared to the RTDCCS First Cost per watt of $2.98.

Company Background

R4V Ventures LLC ("R4V") is using research, development, innovative technologies and the earth's abundant natural and renewable resources to provide cooling to commercial and industrial buildings throughout the world. R4V's first technology to be commercialized is the Real Time Data Center Cooling System focused on reducing the cooling costs and electrical usage in data centers worldwide. R4V is applying semi-conductor clean room process cooling methods to data center facilities through patent pending technologies providing significant cooling energy cost savings of 60 to 80% when compared to traditional mechanical cooling systems and technologies and significantly reducing green house gas (GHG) emissions. Data Centers (DCs) currently use 2.5% of the total electricity produced in the United States in the operation of DCs with 40% of this electricity being used for cooling. This equates to 1% of all the electricity produced in the United States.

In addition to data centers, R4V technologies are targeting extremely high energy use markets including process cooling requirements in industrial, manufacturing and food processing applications, high cooling energy using commercial and industrial buildings, natural gas turbine inlet air cooling, and large industrial compressor inlet air cooling. R4V patents, commercializes and brings to market these unique cooling technologies through continued R&D, strategic partnerships, contract manufacturing relationships and engineering knowhow licensing and system distribution relationships.

Technology Summary

Background

R4 Ventures LLC 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 and eliminating hot isles and cold isles by combining the Multistage Evaporative Cooling System (MECS*),* Individual Server Enclosure Cooling System (ISECS), and Real Time Monitoring and Control System (RTMCS).

Multistage Evaporative Cooling System

- Scalable from 10 to over 1000 tons.
- Based on Phoenix AZ Summer Ambient Air Design Conditions for cooling applications are 110.2°FDB and 70°FWB, MECS delivers 57°F cool water, 53°F 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 Centers
- 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 Centers with Air (Comfort cooling))

MULTISTAGE EVAPORATIVE COOLING SYSTEM
United States 6,1538615
Filed September 23, 2011

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

Converted Provision United States Patent Application 6,1538615 to Non Provisional Patent Application. A Utility Patent Application for the Multistage Evaporative Cooling System patent was filed on September 23, 2011. 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. The Inventor has named this cooling system the Multistage Evaporative Cooling System (MECS) This new approach and method of the combined multiple direct and indirect evaporative cooling processes fully complies with all laws of thermodynamics by properly sequencing components and actions to achieve maximum cooling at a minimal energy use. The MECS outperforms conventional refrigeration systems by using at least 60 - 80% less energy to operate. The MECS's resulting output is cold air, cold water, or both.

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 Rack as it varies between 3 KW to over 35 KW
- Provides 70°F to 80.6°F 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
- 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
- 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%

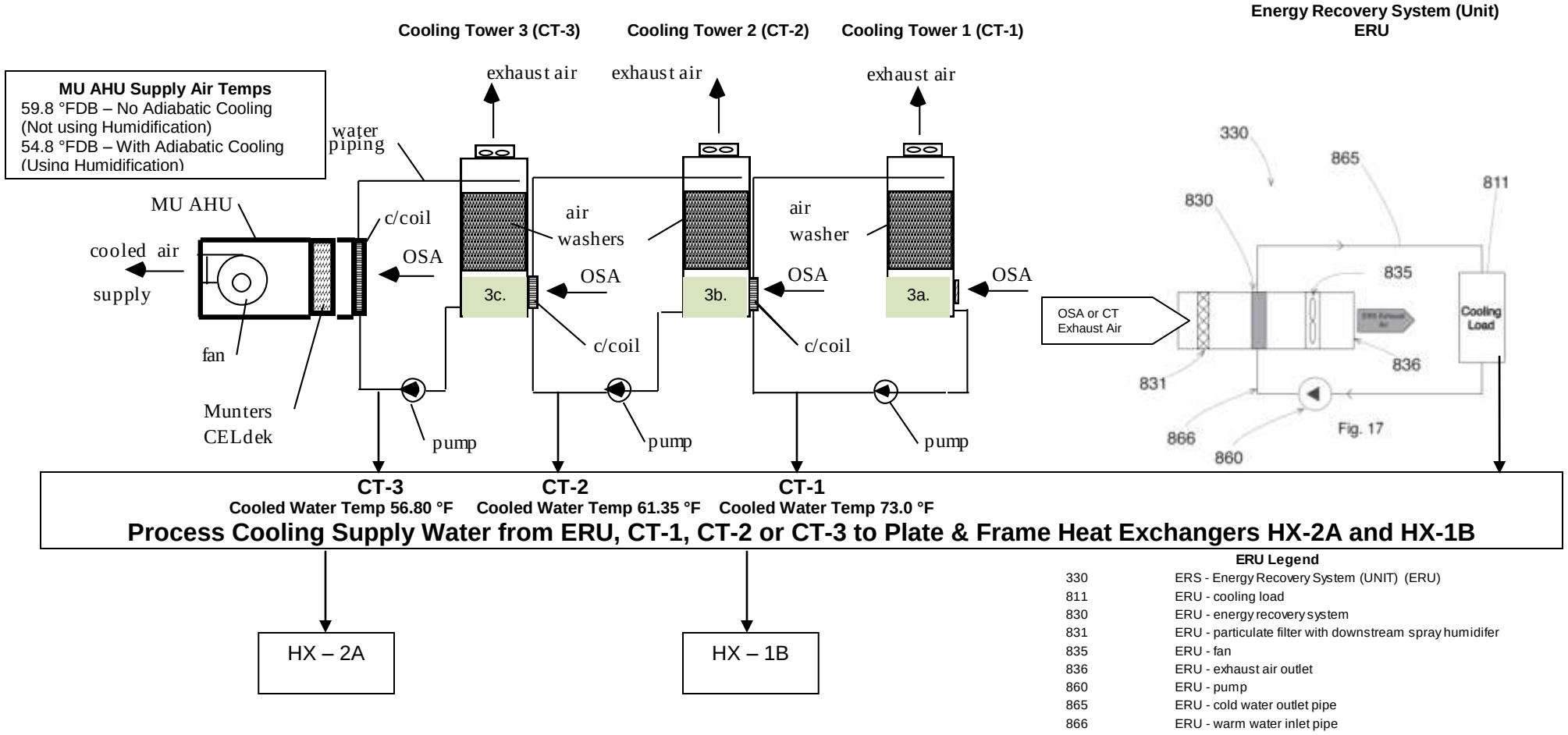
REAL TIME INDIVIDUAL ELECTRONIC ENCLOSURE COOLING SYSTEM
United States 13748088
Filed January 22, 2013 under accelerated examination rules of USPTO

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 50 KW. Process cooling the heat loads of 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). The various ISECS apparatus options (ISECS units) provide for cooling individual server racks or electrical enclosures. These ISECS units maintain target exiting (discharge) air temperatures, i.e. supply air to the Data Center white space, equal to or colder than room temperature within a tolerance of plus or minus 1 or 2 degrees F. The ISECS units employ industrial cooling using the staged cooling towers of the Multistage Evaporative Cooling System (MECS) to evaporatively provide cold water to the ISECS units.

Preliminary Performance Analysis for Phoenix AZ of the Real Time Data Center Cooling System consisting of the Multistage Evaporative Cooling System (MECS - Patent Pending) and the Individual Server Enclosure Cooling System (ISECS - Patent Pending)

Parameters:

1. Phoenix, AZ Summer Ambient Air Design Conditions (ASHRAE .4% for cooling applications Phoenix AZ (PHX) are 110.2 °FDB and 70.0 °FWB for the Energy Recovery System (Unit) or ERU, all three CTs and the Makeup Air Handling Unit (MU AHU)
2. OSA is the inlet air at above design parameters to all stages.
3. Entered Air Conditions entering the Fill at each stage:
    a. CT1 – 110.2°FDB and 70°FWB
    b. CT2 – 74.0°FDB and 58.35°FWB
    c. CT3 – 62.35°FDB and 53.80°FWB
4. Entered Air Conditions to the MU AHU is 110.2 °FDB and 70.0°FWB
5. Entered Air Conditions to the ERU is 110.2 °FDB and 70.0 °FWB



ERU Legend

330	ERS - Energy Recovery System (UNIT) (ERU)
811	ERU - cooling load
830	ERU - energy recovery system
831	ERU - particulate filter with downstream spray humidifer
835	ERU - fan
836	ERU - exhaust air outlet
860	ERU - pump
865	ERU - cold water outlet pipe
866	ERU - warm water inlet pipe

Plate & Frame Heat Exchanger – HX-2A serving Pre-Cooling Coils of ISECS

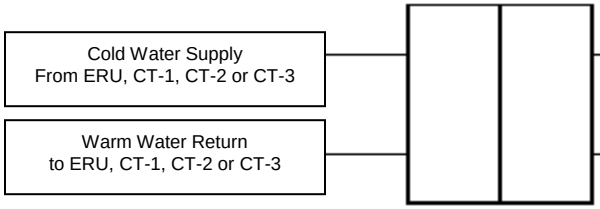
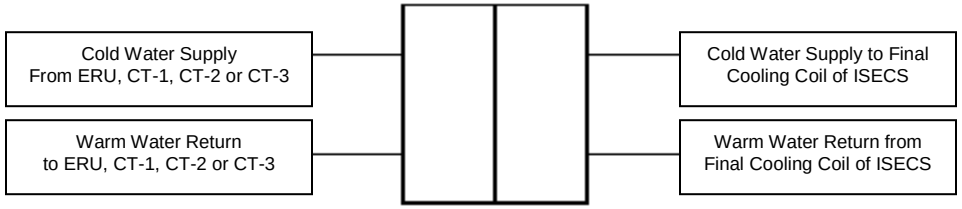
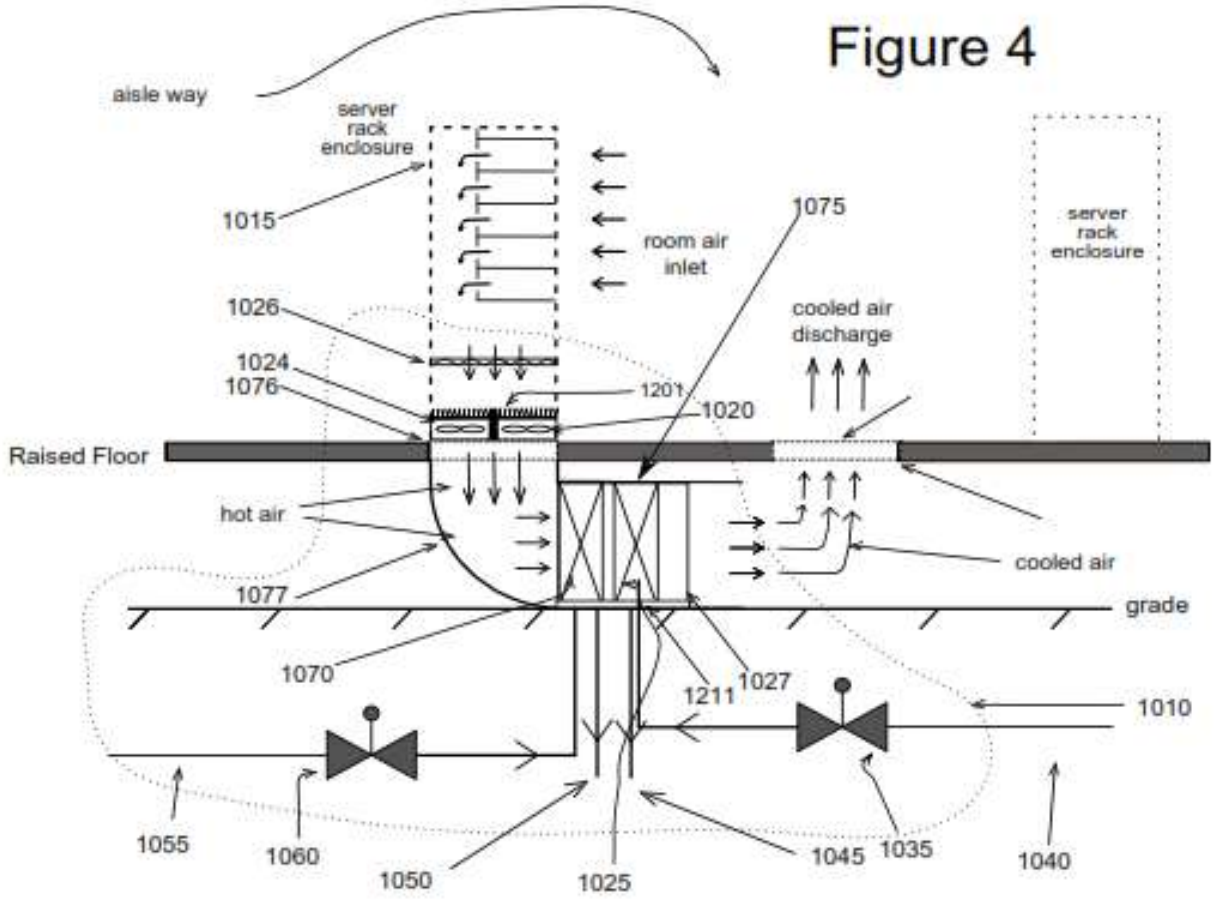


Plate & Frame Heat Exchanger – HX-1B serving Final Cooling Coils of ISECS



Individual Server Enclosure Cooling System (ISECS)



ISECS Legend

1010	ISECS
1015	server rack enclosure
1017	cold air dischage grill
1020	fan(s)
1024	fan rack
1025	final cooling coil
1026	air filter
1027	cooling coil unit
1035	final cooling coil water flow control valve
1040	final cooling coil cold water inlet pipe
1045	final cooling coil water outlet pipe
1050	pre-cooling coil water outlet pipe
1055	Not Defined (pre-cooling coil cold water Supply Pipe)
1060	pre-cooling coil water flow control valve
1070	pre-cooling coil
1074	"air duct elbow"
1075	housing
1076	hot air inlet
1077	hot air duct elbow
1201	Change from automatic louvers to automatic air damper
1202	louver door (safety door tied to fan motor automatic shutoff)
1211	condensate catch pan

Preliminary Temperature Performance Evaluation of New Cooling Technologies consisting of the Multistage Evaporative Cooling System (MECS) alone or combined with the Real Time Electronic Enclosure Cooling System (ISECS) in the Real Time Data Center Cooling System (RTDCCS) for Phoenix, AZ; Newark, DE; Houston, TX; and San Jose, CA.

Note: See separate White Paper for full details of this Temperature Performance Evaluation. The full White Paper will be provided upon written request.

R4 Ventures LLC has evaluated the cooled water and cooled air temperature performance of our **compressor-less … refrigerant-less cooling system technologies** in this White Paper to provide engineering analysis of what temperatures can be attained in four major markets in the United States. The applications evaluated are:

- Data Centers – Real Time Data Center Cooling System (MECS + ISECS)
- Commercial/Industrial Buildings – MECS
- Inlet Air Cooling for Nat Gas Turbines/CHP Systems – MECS
- Process Cooling Water for Industrial & Food Processing Plants - MECS

Real Time Data Center Cooling System (RTDCCS) (Data Center Market) and the Multistage Evaporative Cooling System (MECS) (Commercial/Industrial Buildings, Turbine Inlet Air Cooling, and Process Cooling Water for Industrial & Food Processing Markets) for four (4) major cities in the United States, Phoenix, AZ; Newark (Wilmington), DE; Houston, TX; and San Jose, CA. The RTDCCS consists of patent pending technology including the Multistage Evaporative Cooling System (MECS) which generates cold water (and cold supply air for the above described markets) coupled with the Individual Server Enclosure Cooling System (ISECS) which provides process cooling of the heat load at the rack level based on the ASHRAE Summer Design Conditions for commissioning in a new or retro commissioned Data Centers. This white paper details the cooled water temperature performance of the RTDCCS (MECS + ISECS) in Data Center White Space and the cooled supply air temperature performance of the MECS for the above described markets based on ASHRAE published Summer Design Conditions of .4% for cooling applications, and the monthly Mean Dry Bulb and Wet Bulb Temperatures for each city's closest airport (Phoenix, Wilmington and Houston) and monthly ASHRAE published Summer Design Conditions of .4% for cooling applications (San Jose).

The tables and charts shown in the separate White Paper for each of the cities identified show the temperature performance of the RTDCCS and MECS. The RTDCCS performance is based on, first, the selected and operational components of the RTDCCS based on achieving the **maximum energy efficiency** while meeting the ASHRAE TC 9.9 Maximum Temperature Recommendations and second, the selected and operational components of the RTDCCS based on achieving the **lowest possible temperature** in the Data Center White Space. Excerpt from an APC white paper:

Cooling

The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) TC 9.9 publishes both recommended and allowable operating temperatures for IT equipment. The intent is to provide better guidance to ensure reliability and performance of equipment while maximizing the efficiency of the cooling system. These 2011 *ASHRAE Thermal Guidelines* values for class 1 equipment are provided in **Table 1**.

Table 1

Operating temperature limits per ASHRAE TC9.9

Operating temperature	Temperature range
Recommended	64.4-80.6°F (18-27°C)
Allowable	59-89.6°F (15-32°C)

The MECS tables and charts show the temperature performance based on, first, the selected and operational components of the MECS based on achieving the **maximum energy efficiency** in meeting or approaching the desired comfort space temperatures in commercial and industrial buildings and second, the selected and operational components of the MECS based on achieving the **lowest possible space temperature** in commercial and industrial buildings. The MECS tables and charts designed to supply cold air for Turbine/Compressor Inlet Air applications show the temperature performance based on, first, the selected and operational components of the MECS based on achieving the **maximum**

energy efficiency in meeting or approaching the desired inlet air temperatures of 59 °F (the temperature in which 100% name plate efficiency can be achieved) in natural gas turbine power generation systems and second, the selected and operational components of the MECS based on achieving the **lowest possible inlet air temperature** entering the turbine or compressor.

Summary of Temperature Performance of R4 Ventures LLC's New Cooling Technologies

Data Centers – Real Time Data Center Cooling System (MECS + ISECS)

1. Phoenix AZ
    a. 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 63.45 °F 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 75 °F in the Data Center White Space.
    b. 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 68.94 °F 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 75 °F in the Data Center White Space.
2. Newark DE
    a. 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 75.65 °F 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 77 °F in the Data Center White Space.
    b. 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 75.80 °F in the hottest month of July 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 77 °F in the Data Center White Space.
3. Houston TX
    a. 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 76.16 °F completely eliminating hot aisles and cold aisles. No compressors and refrigerants are used in the system. Additional energy can be saved by maintaining a set point temperature of 79.5 °F in the Data Center White Space.
    b. 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 79.48°F in the hottest months of July and August completely eliminating hot aisles and cold aisles. No compressors and refrigerants are used in the system. Additional energy can be saved by maintaining a set point temperature of 79.5 °F in the Data Center White Space.
4. San Jose CA
    a. 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 61.97 °F 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 75 °F in the Data Center White Space.
    b. 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 67.60 °F in the hottest month of July 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 75 °F in the Data Center White Space.

Comparison of Real Time Data Center Cooling System First Costs, Energy Usage, PUE and First Costs per Watt versus 8 of the most common systems offered by APC Schneider Electric

Real Time Data Center Cooling System Competitive Analysis
Average Sized Low Density and High Density US Data Centers

Prepared by R4 Ventures LLC - Darrell Richardson

Average Size Low Density Data Center
(240 kW, 60 racks at 4 kW per rack, 1620 SF)

Real Time Data Center Cooling System (RTDCCS)	# of Units	$ / Unit	Same Design as APC Inputs Total Selling Price
Multistage Evaporative Cooling Sytem (MECS)	1	$ 423,000	$ 423,000
Individual Server Enclosure Cooling System (ISECS)	60	$ 12,000	$ 720,000
Sub Total including Installation at 32% of Material Cost			$ 1,143,000
Design / Engineering (Same as APC CRAH & CRAC)		5%	$ 29,550
Project Mgmt / Facilities Engineering (Same as APC CRAH & CRAC)		9%	$ 53,190
Total RTDCCS Installed Selling Price			**$ 1,225,740**

Average Size High Density Data Center
(240 kW, 20 racks at 12 kW per rack, 540 SF)

Real Time Data Center Cooling System (RTDCCS)	# of Units	$ / Unit	Same Design as APC Inputs Total Selling Price
Multistage Evaporative Cooling Sytem (MECS)	1	$ 423,000	$ 423,000
Individual Server Enclosure Cooling System (ISECS)	20	$ 12,000	$ 240,000
Sub Total including Installation at 32% of Material Cost			$ 663,000
Design / Engineering (Same as APC CRAH & CRAC)		5%	$ 18,350
Project Mgmt / Facilities Engineering (Same as APC CRAH & CRAC)		9%	$ 33,030
Total RTDCCS Installed Selling Price			**$ 714,380**

Real Time Data Center Cooling System Annual Energy Costs

IT Load kW	Overhead kW	Overhead kW	RTDCCS kW	Total kW	PUE
240	10%	24	25.67	289.67	**1.21**

	kW / Ton	Tons of Cooling	Total kWh	Cost per kWh	Annual Energy Cost
Cooling Tower Pumps and Fans	0.15				
Fan Coils Units	0.14				
	0.29	88.52	224,864.85	$ 0.10	**$ 22,486**

Real Time Data Center Cooling System Cost per IT Load Watt

RTDCCS Cooling System Cost per Watt - 4 kW per rack	$ 1,225,740	240	**$**	**5.11**
RTDCCS Cooling System Cost per Watt - 12 kW per rack	$ 714,380	240	**$**	**2.98**

APC Costs Derived from APC - Schneider Electric's Data Center Capital Cost Calculator

http://www.apcmedia.com/salestools/WTOL-7AXSAN/WTOL-7AXSAN_R1_EN.swf

Legend: Perimeter Cooling

APC #1 Perimeter CRAH with Chiller / Tower
APC #2 Perimeter CRAH with VFD Chiller / Tower
APC #3 Perimeter CRAH with Chiller / Dry Cooler
APC #4 Perimeter CRAH with VFD Chiller / Dry Cooler
APC #5 Perimeter CRAH with Packaged Chiller
APC #6 Perimeter CRAC DX Air Cooled
APC #7 Perimeter CRAC DX Glycol Cooled
APC #8 Perimeter CRAC DX Water Cooled

Legend: Row Based Cooling

APC #9 Row Based Cooling CRAH with Chiller / Tower
APC #10 Row Based Cooling CRAH with VFD Chiller / Tower
APC #11 Row Based Cooling CRAH with Chiller / Dry Cooler
APC #12 Row Based Cooling CRAH with VFD Chiller / Dry Cooler
APC #13 Row Based Cooling CRAH with Packaged Chiller
APC #14 Row Based Cooling CRAC DX Air Cooled
APC #15 Row Based Cooling CRAC DX Glycol Cooled
APC #16 Row Based Cooling CRAC DX Water Cooled

RTDCCS vs. APC Schneider Electric Cooling Systems

Average Size Data Center (240 kW, 60 racks at 4 kW per rack, 1620 SF)

Error in APC Software

Perimeter Cooling System for Low Density Data Center at 4 kW per Rack / 60 Racks

System Cost Comparison

	APC #1	APC #2	APC #3	APC #4	APC #5	APC #6	APC #7	APC #8
APC Schneider Cooling System Costs	$1,248,722	$ 1,261,601	$ 1,142,892	$ 1,155,771	$ 871,729	$ 461,752	$ 815,162	$ 920,992
RTDCCS Total Costs	$ 1,225,740	$ 1,225,740	$ 1,225,740	$ 1,225,740	$ 1,225,740	$ 1,225,740	$ 1,225,740	$ 1,225,740
Difference $	**$ (22,982)**	**$ (35,861)**	**$ 82,848**	**$ 69,969**	**$ 354,011**	**$ 763,988**	**$ 410,578**	**$ 304,748**
Difference %	**-1.8%**	**-2.8%**	**7.2%**	**6.1%**	**40.6%**	**165.5%**	**50.4%**	**33.1%**

Annual Energy Cost Comparision

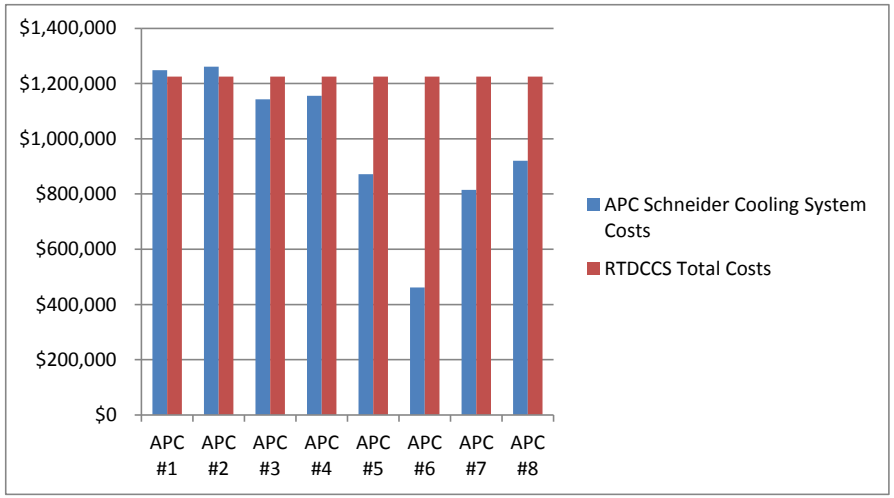
	APC #1	APC #2	APC #3	APC #4	APC #5	APC #6	APC #7	APC #8
APC Schneider Cooling System Energy Costs	$ 89,244	$ 81,250	$ 89,244	$ 85,540	$ 91,120	$ 135,280	$ 167,678	$ 167,678
RTDCCS Total Energy Costs	$ 22,486	$ 22,486	$ 22,486	$ 22,486	$ 22,486	$ 22,486	$ 22,486	$ 22,486
Energy Savings $	**$ 66,758**	**$ 58,764**	**$ 66,758**	**$ 63,054**	**$ 68,634**	**$ 112,794**	**$ 145,192**	**$ 145,192**
Energy Savings %	**74.8%**	**72.3%**	**74.8%**	**73.7%**	**75.3%**	**83.4%**	**86.6%**	**86.6%**
Mths of Energy Savings to cover Add'l Cost of RTDCCS	**(0.34)**	**(0.61)**	**1.24**	**1.11**	**5.16**	**6.77**	**2.83**	**2.10**

PUE Comparison

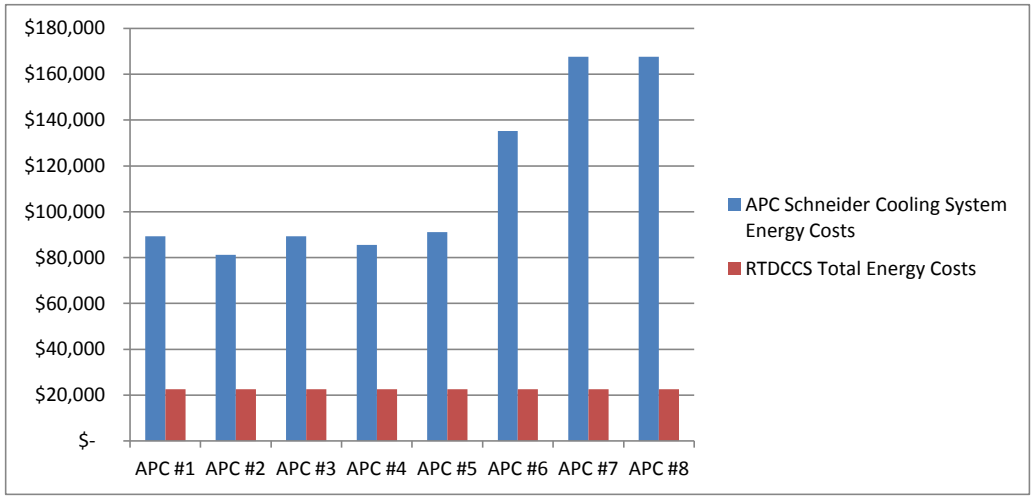
	APC #1	APC #2	APC #3	APC #4	APC #5	APC #6	APC #7	APC #8
APC Schneider Cooling System PUE	1.59	1.59	1.59	1.57	1.59	1.81	1.96	1.96
RTDCCS PUE	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Difference	**0.38**	**0.38**	**0.38**	**0.36**	**0.38**	**0.60**	**0.75**	**0.75**
Difference %	**24.1%**	**24.1%**	**24.1%**	**23.1%**	**24.1%**	**33.3%**	**38.4%**	**38.4%**

Cooling System Cost per Watt

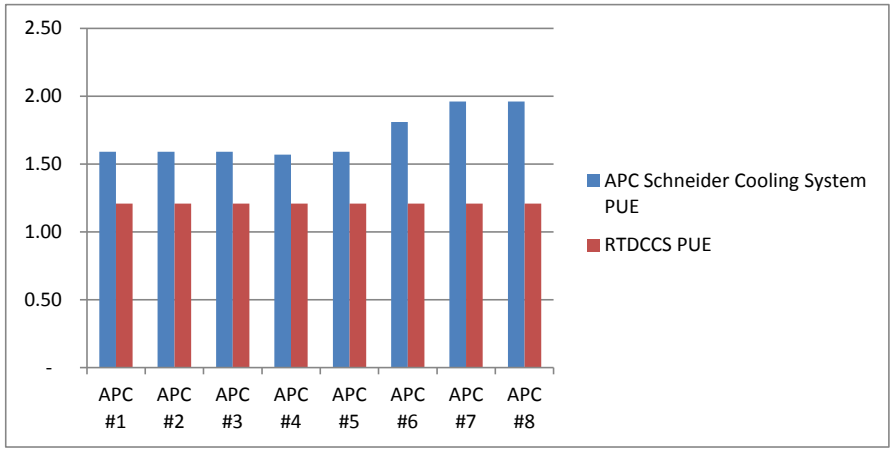
	APC #1	APC #2	APC #3	APC #4	APC #5	APC #6	APC #7	APC #8
APC Schneider Cooling System Cost per Watt	$ 5.19	$5.26	$4.77	$4.80	$3.64	$1.92	$3.40	$3.83
RTDCCS Cost per Watt	$ 5.11	$ 5.11	$ 5.11	$ 5.11	$ 5.11	$ 5.11	$ 5.11	$ 5.11



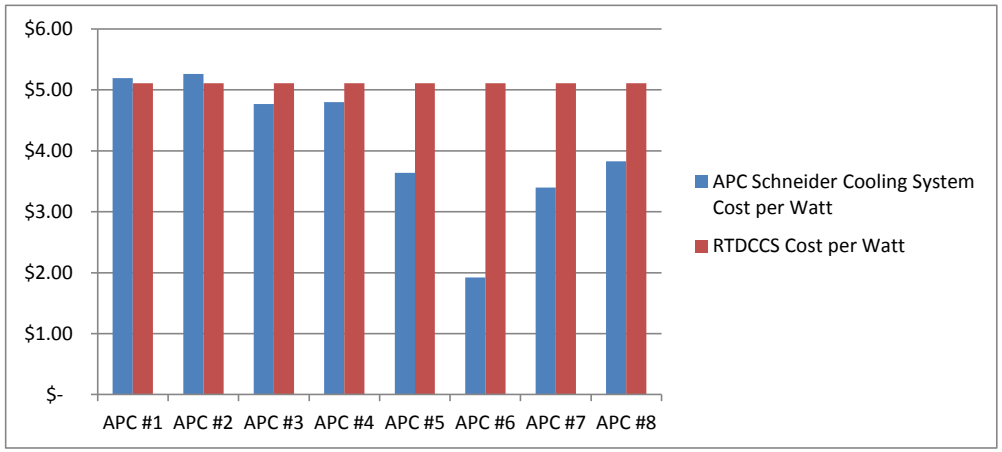
Average Size Data Center Cooling System Costs - 4 kW per Rack: 240 kW IT Load



Average Size Data Center Cooling System Energy Costs - 4 kW per Rack: 240 kW IT Load



Average Size Data Center PUE - 4 kW per Rack: 240 kW IT Load



Average Size Data Center Cooling System Cost per Watt - 4 kW: 240 kW IT Load

Average Size Data Center (240 kW, 20 racks at 12 kW per rack, 540SF)

Error in APC Software

Perimeter Cooling System for High Density Data Center at 12 kW per Rack / 20 Racks

System Cost Comparison

	APC #1	APC #2	APC #3	APC #4	APC #5	APC #6	APC #7	APC #8
APC Schneider Cooling System Costs	$1,394,616	$ 1,407,495	$ 1,288,786	$ 1,301,665	$ 1,017,623	$ 658,646	$ 969,101	$ 1,074,931
RTDCCS Total Costs	$ 714,380	$ 714,380	$ 714,380	$ 714,380	$ 714,380	$ 714,380	$ 714,380	$ 714,380
Difference $	**$ (680,236)**	**$ (693,115)**	**$ (574,406)**	**$ (587,285)**	**$ (303,243)**	**$ 55,734**	**$ (254,721)**	**$ (360,551)**
Difference %	**-48.8%**	**-49.2%**	**-44.6%**	**-45.1%**	**-29.8%**	**8.5%**	**-26.3%**	**-33.5%**

Annual Energy Cost Comparision

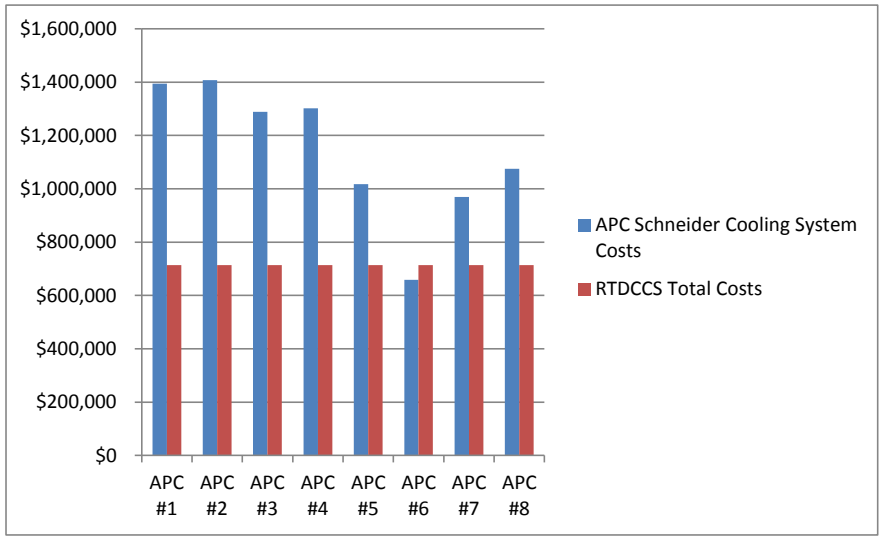
	APC #1	APC #2	APC #3	APC #4	APC #5	APC #6	APC #7	APC #8
APC Schneider Cooling System Energy Costs	$ 89,244	$ 81,250	$ 89,244	$ 85,540	$ 91,120	$ 135,280	$ 167,678	$ 167,678
RTDCCS Total Energy Costs	$ 22,486	$ 22,486	$ 22,486	$ 22,486	$ 22,486	$ 22,486	$ 22,486	$ 22,486
Energy Savings $	**$ 66,758**	**$ 58,764**	**$ 66,758**	**$ 63,054**	**$ 68,634**	**$ 112,794**	**$ 145,192**	**$ 145,192**
Energy Savings %	**74.8%**	**72.3%**	**74.8%**	**73.7%**	**75.3%**	**83.4%**	**86.6%**	**86.6%**
Mths of Energy Savings to cover Add'l Cost of RTDCCS	**(10.19)**	**(11.79)**	**(8.60)**	**(9.31)**	**(4.42)**	**0.49**	**(1.75)**	**(2.48)**

PUE Comparison

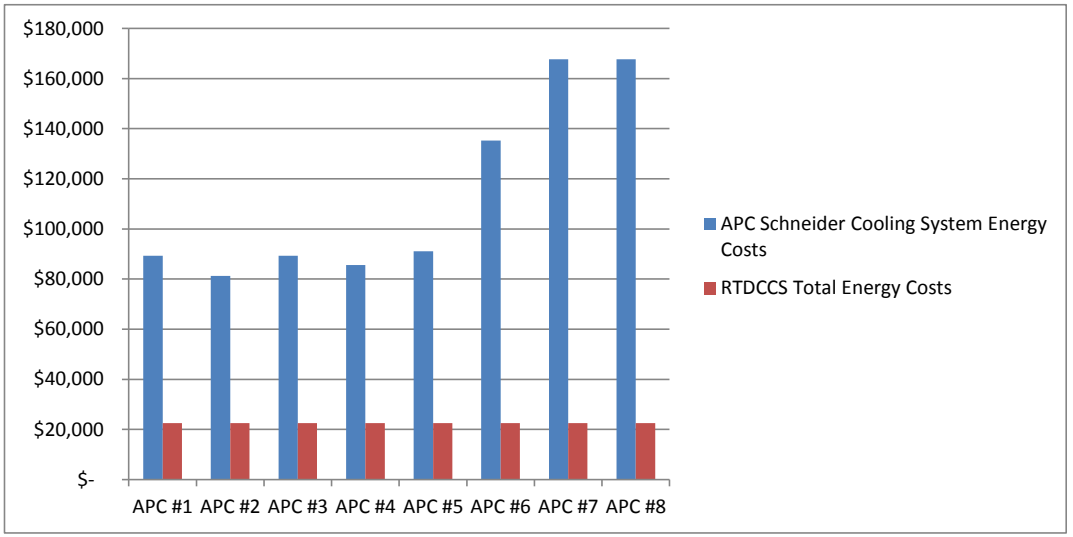
	APC #1	APC #2	APC #3	APC #4	APC #5	APC #6	APC #7	APC #8
APC Schneider Cooling System PUE	1.59	1.59	1.59	1.57	1.59	1.81	1.96	1.96
RTDCCS PUE	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Difference	**0.38**	**0.38**	**0.38**	**0.36**	**0.38**	**0.60**	**0.75**	**0.75**
Difference %	**24.1%**	**24.1%**	**24.1%**	**23.1%**	**24.1%**	**33.3%**	**38.4%**	**38.4%**

Cooling System Cost per Watt

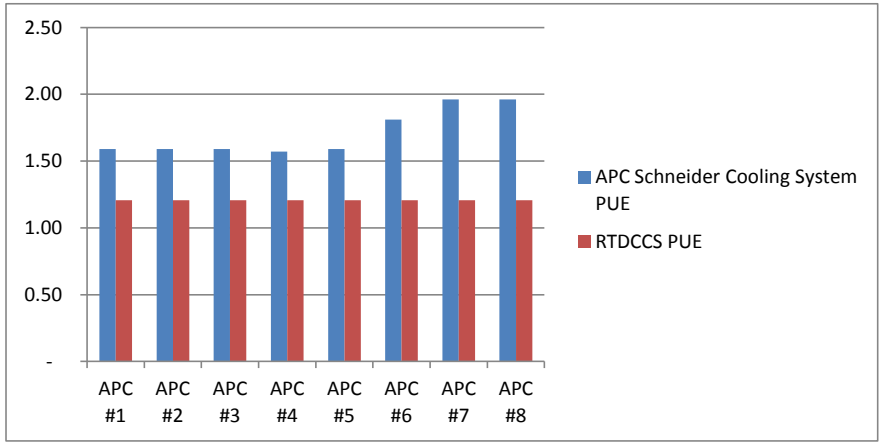
	APC #1	APC #2	APC #3	APC #4	APC #5	APC #6	APC #7	APC #8
APC Schneider Cooling System Cost per Watt	$ 5.81	$ 5.87	$ 5.37	$ 5.41	$ 4.25	$ 2.74	$ 4.04	$ 4.47
RTDCCS Cost per Watt	$ 2.98	$ 2.98	$ 2.98	$ 2.98	$ 2.98	$ 2.98	$ 2.98	$ 2.98



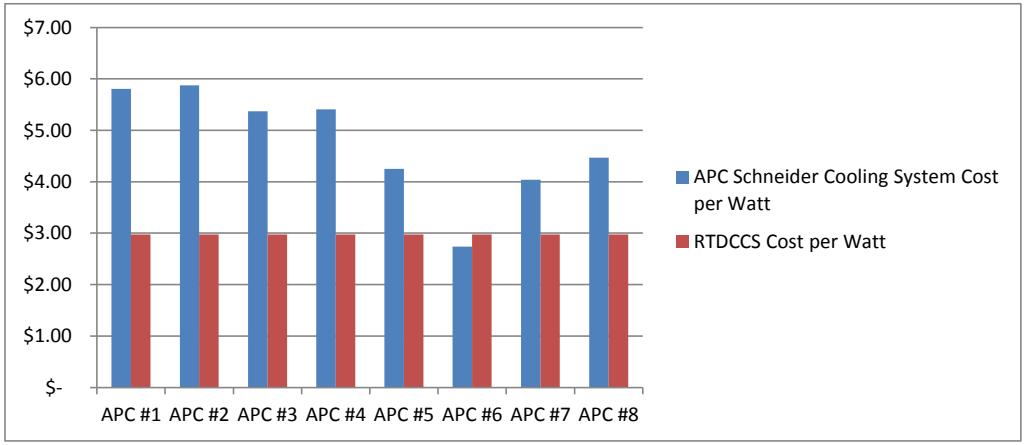
Average Size Data Center Cooling System Costs - 12 kW per Rack: 240 kW IT Load



Average Size Data Center Cooling System Energy Costs - 12 kW per Rack: 240 kW IT Load



Average Size Data Center PUE - 12 kW per Rack: 240 kW IT Load



Average Size Data Center Cooling System Cost per Watt - 12 kW: 240 kW IT Load

APC Schneider Row Based Cooling (In-Row Cooling)

Average Size Data Center (240 kW, 20 racks at 12 kW per rack, 540SF)

Error in APC Software

Row Based Cooling System for High Density Data Center at 12 kW per Rack / 20 Racks

System Cost Comparison

	APC #9	APC #10	APC #11	APC #12	APC #13	APC #14	APC #15	APC #16
APC Schneider Cooling System Costs	$1,061,655	$ 1,074,534	$ 955,825	$ 968,704	$ 684,662	$ 368,529	$ 611,390	$ 717,220
RTDCCS Total Costs	$ 714,380	$ 714,380	$ 714,380	$ 714,380	$ 714,380	$ 714,380	$ 714,380	$ 714,380
Difference $	**$ (347,275)**	**$ (360,154)**	**$ (241,445)**	**$ (254,324)**	**$ 29,718**	**$ 345,851**	**$ 102,990**	**$ (2,840)**
Difference %	**-32.7%**	**-33.5%**	**-25.3%**	**-26.3%**	**4.3%**	**93.8%**	**16.8%**	**-0.4%**

Annual Energy Cost Comparision

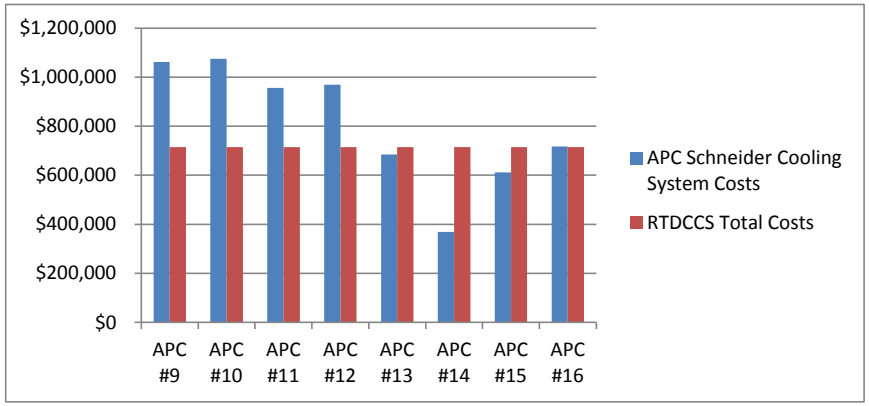
	APC #9	APC #10	APC #11	APC #12	APC #13	APC #14	APC #15	APC #16
APC Schneider Cooling System Energy Costs	$ 59,691	$ 52,392	$ 66,030	$ 56,700	$ 61,305	$ 94,920	$ 90,180	$ 90,180
RTDCCS Total Energy Costs	$ 22,486	$ 22,486	$ 22,486	$ 22,486	$ 22,486	$ 22,486	$ 22,486	$ 22,486
Energy Savings $	**$ 37,205**	**$ 29,906**	**$ 43,544**	**$ 34,214**	**$ 38,819**	**$ 72,434**	**$ 67,694**	**$ 67,694**
Energy Savings %	**62.3%**	**57.1%**	**65.9%**	**60.3%**	**63.3%**	**76.3%**	**75.1%**	**75.1%**
Mths of Energy Savings to cover Add'l Cost of RTDCCS	**(9.33)**	**(12.04)**	**(5.54)**	**(7.43)**	**0.77**	**4.77**	**1.52**	**(0.04)**

PUE Comparison

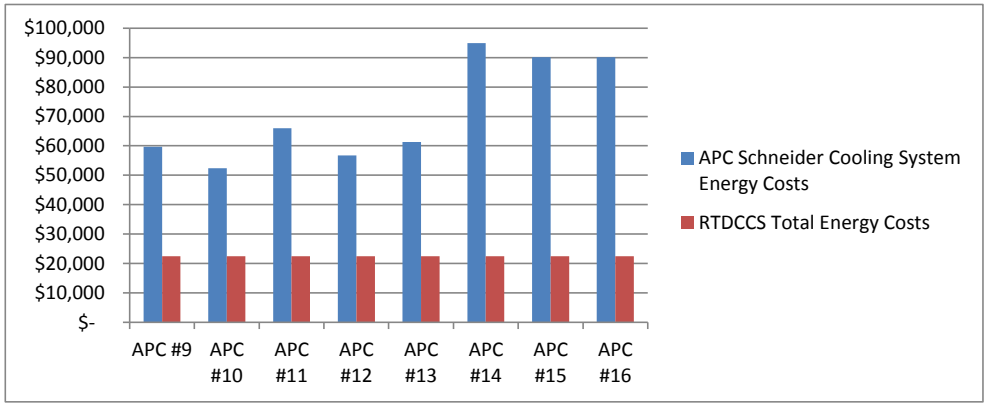
	APC #9	APC #10	APC #11	APC #12	APC #13	APC #14	APC #15	APC #16
APC Schneider Cooling System PUE	1.44	1.41	1.47	1.43	1.45	1.61	1.59	1.59
RTDCCS PUE	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Difference	**0.23**	**0.20**	**0.26**	**0.22**	**0.24**	**0.40**	**0.38**	**0.38**
Difference %	**16.2%**	**14.4%**	**17.9%**	**15.6%**	**16.8%**	**25.0%**	**24.1%**	**24.1%**

Cooling System Cost per Watt

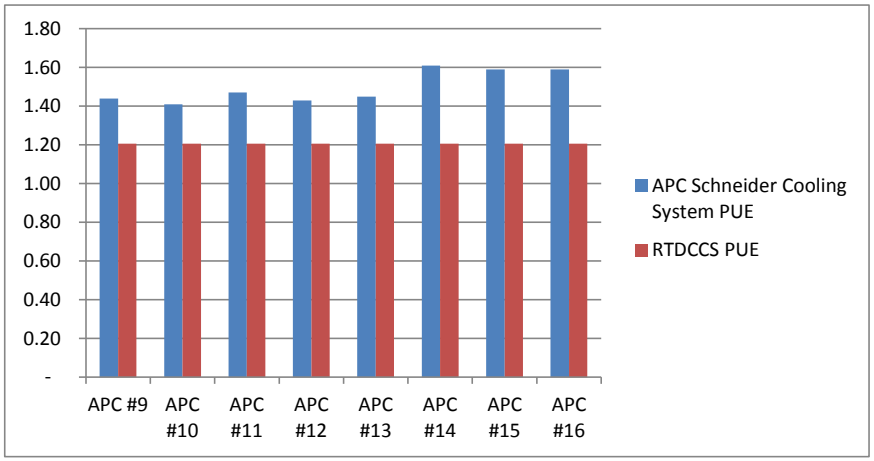
	APC #9	APC #10	APC #11	APC #12	APC #13	APC #14	APC #15	APC #16
APC Schneider Cooling System Cost per Watt	$ 4.43	$ 4.46	$ 3.97	$ 4.04	$ 2.84	$ 1.54	$ 2.54	$ 2.99
RTDCCS Cost per Watt	$ 2.98	$ 2.98	$ 2.98	$ 2.98	$ 2.98	$ 2.98	$ 2.98	$ 2.98



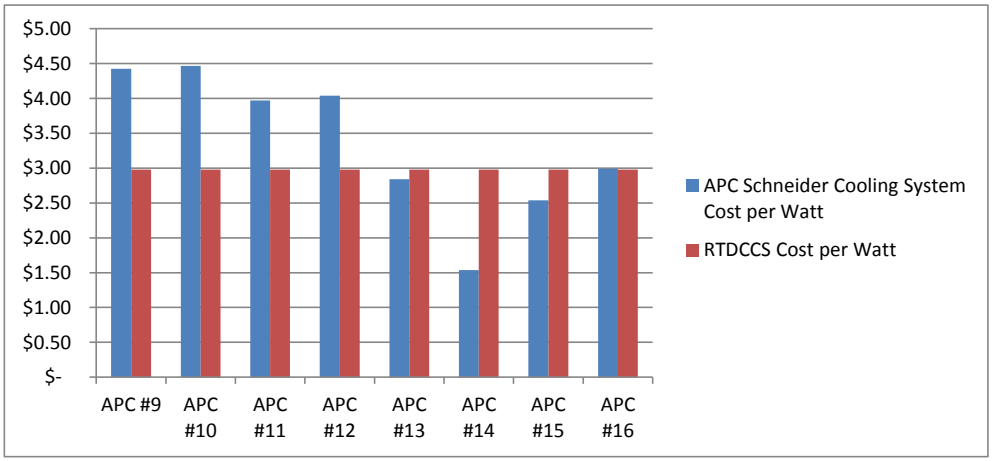
Average Size Data Center In-Row Cooling System Costs - 12 kW per Rack: 240 kW IT Load



Average Size Data Center In-Row Cooling System Energy Costs - 12 kW per Rack: 240 kW IT Load



Average Size Data Center In-Row PUE - 12 kW per Rack: 240 kW IT Load



Average Size Data Center In-Row Cooling System Cost per Watt - 12 kW: 240 kW IT Load

APC Schneider Electric Data Center Cooling System Costs Analysis

Prepared by R4 Ventures LLC - Darrell Richardson

Data Center 1st Costs Derived from APC - Schneider Electric's Data Center Capital Cost Calculator

http://www.apcmedia.com/salestools/WTOL-7AXSAN/WTOL-7AXSAN_R1_EN.swf

Average Size Data Center (240 kW, 60 racks at 4 kW per rack, 1620 SF)

INPUTS

Location - North America United States
Data Center IT Capacity - 240 kw
Average Power Density - 4 kw/Rack
Installation Labor Rate - Typical ($90.00 per hour)
Cooling System - 8 Selections Below
Air Distribution Type - Perimeter Cooling
UPS Architecture - Traditional Non Scalable
Redundancy Levels - No to all

Energy Costs Derived from APC - Schneider Electric's Data Center Efficiency Calculator

http://www.apcmedia.com/salestools/WTOL-7CMGPL/WTOL-7CMGPL_R3_EN.swf

Average Size Data Center (240 kW, 60 racks at 4 kW per rack, 1620 SF)

FIXED INPUTS

Data Center IT Capacity in kW	240
Total IT Load	100%
Electricity Cost	$ 0.10
UPS System	Typical
Power Redundancy	Single Path Power
CRAC / CRAH Redundancy	Single Path CRAC/ CRAH
Heat Rejection Redundancy	Single Path Heat Rejection
Water-side Economizer Time in Hrs/Yr	3,000
Options: Only option selected	
Deep Raised Floor	Checked

	Components Including Installation, Design, Engineering and Project Mgmt Costs — Cooling System $	%	Components with Costs Broken Out — Cooling System $	%	Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
APC #1 Perimeter CRAH with Chiller / Tower	$1,148,722	100.0%	$1,148,722	92.0%	$1,810,000	$7.53			
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)			$100,000	8.0%	$100,000	$0.42			
Total APC #1	$1,148,722		$1,248,722	100.0%	$1,910,000	$7.95	240,372	65.4%	$5.19
Sub System Component Costs									
- CRAH	$389,844	33.9%	$210,516	16.9%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower	$324,248	28.2%	$175,094	14.0%					
- Water Cooled Chiller	$218,940	19.1%	$118,228	9.5%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	10.9%	$67,392	5.4%					
- Heat Rejection Pumps	$90,890	7.9%	$49,081	3.9%					
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)		0.0%	$100,000	8.0%					
Installation	(Reference % only)	32.0%	$367,591	29.4%					
Design / Engineering	(Reference % only)	5.0%	$57,436	4.6%					
Project Management / Facilities Engineering	(Reference % only)	9.0%	$103,385	8.3%					
Total	$1,148,722	100.0%	$1,248,722	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	**Chilled Water**
Chiller	**Chiller with Cooling Tower**
Air Distribution	**Perimeter Cooling**
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	**1.59**
Annual Energy Costs at 240 kW load	**$333,000**
Cooling System Energy Costs %	**26.80%**
Cooling System Energy Costs $	**$89,244**

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #2 Perimeter CRAH with VFD Chiller / Tower	$1,161,601	100.0%	$1,161,601	92.1%	$1,820,000	$7.59			
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)			$100,000	7.9%	$100,000	$0.42			
Total APC #2	$1,161,601		$1,261,601	100.0%	$1,920,000	$8.01	239,789	65.7%	$5.26
Sub System Component Costs									
- CRAH	$389,844	33.6%	$210,516	16.7%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower	$324,248	27.9%	$175,094	13.9%					
- Water Cooled Chiller	$231,819	20.0%	$125,182	9.9%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	10.7%	$67,392	5.3%					
- Heat Rejection Pumps	$90,890	7.8%	$49,081	3.9%					
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)		0.0%	$100,000	7.9%					
Installation	(Reference % only)	32.0%	$371,712	29.5%					
Design / Engineering	(Reference % only)	5.0%	$58,080	4.6%					
Project Management / Facilities Engineering	(Reference % only)	9.0%	$104,544	8.3%					
Total	$1,161,601	100.0%	$1,261,601	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	**Chilled Water**
Chiller	**Chiller with Cooling Tower VFD**
Air Distribution	**Perimeter Cooling**
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	**1.59**
Annual Energy Costs at 240 kW load	**$325,000**
Cooling System Energy Costs %	**25.0%**
Cooling System Energy Costs $	**$81,250**

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #3 Perimeter CRAH with Chiller / Dry Cooler	$1,042,892	100.0%	$1,042,892	91.3%	$1,690,000	$7.05			
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)			$100,000	8.7%	$100,000	$0.42			
Total APC #3	$1,042,892		$1,142,892	100.0%	$1,790,000	$7.47	239,716	63.8%	$4.77
Sub System Component Costs									
- CRAH	$389,844	37.4%	$210,516	18.4%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower	$218,418	20.9%	$117,946	10.3%					
- Water Cooled Chiller	$218,940	21.0%	$118,228	10.3%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	12.0%	$67,392	5.9%					
- Heat Rejection Pumps	$90,890	8.7%	$49,081	4.3%					
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)		0.0%	$100,000	8.7%					
Installation	(Reference % only)	32.0%	$333,725	29.2%					
Design / Engineering	(Reference % only)	5.0%	$52,145	4.6%					
Project Management / Facilities Engineering	(Reference % only)	9.0%	$93,860	8.2%					
Total	$1,042,892	100.0%	$1,142,892	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	**Chilled Water**
Chiller	**Chiller With Dry Cooler**
Air Distribution	**Perimeter Cooling**
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	**1.59**
Annual Energy Costs at 240 kW load	**$333,000**
Cooling System Energy Costs %	**26.80%**
Cooling System Energy Costs $	**$89,244**

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #4 Perimeter CRAH with VFD Chiller / Dry Cooler	$1,055,771	100.0%	$1,055,771	91.3%	$1,710,000	$7.10			
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)			$100,000	8.7%	$100,000	$0.42			
Total APC #4	$1,055,771		$1,155,771	100.0%	$1,810,000	$7.52	240,845	63.9%	$4.80
Sub System Component Costs									
- CRAH	$389,844	36.9%	$210,516	18.2%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower		0.0%	$0	0.0%					
- Air Cooled Chiller	$231,819	22.0%	$125,182	10.8%					
- Dry Cooler	$218,418	20.7%	$117,946	10.2%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	11.8%	$67,392	5.8%					
- Heat Rejection Pumps	$90,890	8.6%	$49,081	4.2%					
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)		0.0%	$100,000	8.7%					
Installation	(Reference % only)	32.0%	$337,847	29.2%					
Design / Engineering	(Reference % only)	5.0%	$52,789	4.6%					
Project Management / Facilities Engineering	(Reference % only)	9.0%	$95,019	8.2%					
Total	$1,055,771	100.0%	$1,155,771	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	Chilled Water
Chiller	Chiller with Dry Cooler VFD
Air Distribution	Perimeter Cooling
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.57
Annual Energy Costs at 240 kW load	$329,000
Cooling System Energy Costs %	26.00%
Cooling System Energy Costs $	$85,540

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #5 Perimeter CRAH with Packaged Chiller	$771,729	100.0%	$771,729	88.5%	$1,390,000	$5.80			
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)			$100,000	11.5%	$100,000	$0.42			
Total APC #5	$771,729		$871,729	100.0%	$1,490,000	$6.22	239,655	58.5%	$3.64
Sub System Component Costs									
- CRAH	$389,844	50.5%	$210,516	24.1%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower		0.0%	$0	0.0%					
- Air Cooled Chiller	$257,085	33.3%	$138,826	15.9%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	16.2%	$67,392	7.7%					
- Heat Rejection Pumps		0.0%	$0	0.0%					
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)		0.0%	$100,000	11.5%					
Installation	(Reference % only)	32.0%	$246,953	28.3%					
Design / Engineering	(Reference % only)	5.0%	$38,586	4.4%					
Project Management / Facilities Engineering	(Reference % only)	9.0%	$69,456	8.0%					
Total	$771,729	100.0%	$871,729	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	Chilled Water
Chiller	Packaged Chiller
Air Distribution	Perimeter Cooling
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.59
Annual Energy Costs at 240 kW load	$335,000
Cooling System Energy Costs %	27.20%
Cooling System Energy Costs $	$91,120

Invalid pricing problem identified highlighted in pink. Reported to APC Schneider Electric and they are working on the problem.

		Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
		Cooling System		Cooling System						
		$	%	$	%					
APC #6 Perimeter CRAC DX Air Cooled		$361,752	100.0%	$361,752	78.3%	$942,000	$3.92			
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)				$100,000	21.7%	$100,000	$0.42			
Total APC #6		$361,752		$461,752	100.0%	$1,042,000	$4.34	240,306	44.3%	$1.92
Sub System Component Costs										
- CRAH			0.0%	$0	0.0%					
- CRAC		$239,760	66.3%	$129,470	28.0%					
- Cooling Tower			0.0%	$0	0.0%					
- Air Cooled Chiller			0.0%	$0	0.0%					
- Dry Cooler			0.0%	$0	0.0%					
- Remote Condensor		$121,992	33.7%	$65,876	14.3%					
- Chilled Water Pumps			0.0%	$0	0.0%					
- Heat Rejection Pumps			0.0%	$0	0.0%					
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)			0.0%	$100,000	21.7%					
Installation	(Reference % only)		32.0%	$115,761	25.1%					
Design / Engineering	(Reference % only)		5.0%	$18,088	3.9%					
Project Management / Facilities Engineering	(Reference % only)		9.0%	$32,558	7.1%					
Total		$361,752	100.0%	$461,752	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	**Air Cooled**
Chiller	**N/A**
Air Distribution	**Perimeter Cooling**
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	**1.81**
Annual Energy Costs at 240 kW load	**$380,000**
Cooling System Energy Costs %	**35.60%**
Cooling System Energy Costs $	**$135,280**

		Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
		Cooling System		Cooling System						
		$	%	$	%					
APC #7 Perimeter CRAC DX Glycol Cooled		$715,162	100.0%	$715,162	87.7%	$1,330,000	$5.54			
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)				$100,000	12.3%	$100,000	$0.42			
Total APC #7		$715,162		$815,162	100.0%	$1,430,000	$5.96	240,072	57.0%	$3.40
Sub System Component Costs										
- CRAH			0.0%	$0	0.0%					
- CRAC		$405,854	56.7%	$219,161	26.9%					
- Cooling Tower			0.0%	$0	0.0%					
- Air Cooled Chiller			0.0%	$0	0.0%					
- Dry Cooler		$218,418	30.5%	$117,946	14.5%					
- Remote Condensor			0.0%	$0	0.0%					
- Chilled Water Pumps			0.0%	$0	0.0%					
- Heat Rejection Pumps		$90,890	12.7%	$49,081	6.0%					
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)			0.0%	$100,000	12.3%					
Installation	(Reference % only)		32.0%	$228,852	28.1%					
Design / Engineering	(Reference % only)		5.0%	$35,758	4.4%					
Project Management / Facilities Engineering	(Reference % only)		9.0%	$64,365	7.9%					
Total		$715,162	100.0%	$815,162	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	**DX - Glycol**
Chiller	**N/A**
Air Distribution	**Perimeter**
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	**1.96**
Annual Energy Costs at 240 kW load	**$413,000**
Cooling System Energy Costs %	**40.60%**
Cooling System Energy Costs $	**$167,678**

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #8 Perimeter CRAC DX Water Cooled	$820,992	100.0%	$820,992	89.1%	$1,450,000	$6.03			
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)			$100,000	10.9%	$100,000	$0.42			
Total APC #8	$820,992		$920,992	100.0%	$1,550,000	$6.45	240,464	59.4%	$3.83
Sub System Component Costs									
- CRAH		0.0%	$0	0.0%					
- CRAC	$405,854	49.4%	$219,161	23.8%					
- Cooling Tower	$324,248	39.5%	$175,094	19.0%					
- Water Cooled Chiller		0.0%	$0	0.0%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps		0.0%	$0	0.0%					
- Heat Rejection Pumps	$90,890	11.1%	$49,081	5.3%					
Estimated Hot Aisle Cold Aisle Containment (Bid from APC Distributor)		0.0%	$100,000	10.9%					
Installation	(Reference % only)	32.0%	$262,717	28.5%					
Design / Engineering	(Reference % only)	5.0%	$41,050	4.5%					
Project Management / Facilities Engineering	(Reference % only)	9.0%	$73,889	8.0%					
Total	$820,992	100.0%	$920,992	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	**No Selection - Using DX - Glycol**
Chiller	**N/A**
Air Distribution	**Perimeter Cooling**
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	**1.96**
Annual Energy Costs at 240 kW load	**$413,000**
Cooling System Energy Costs %	**40.60%**
Cooling System Energy Costs $	**$167,678**

APC Schneider Electric Data Center Cooling System Costs Analysis

Prepared by R4 Ventures LLC - Darrell Richardson

Data Center 1st Costs Derived from APC - Schneider Electric's Data Center Capital Cost Calculator

http://www.apcmedia.com/salestools/WTOL-7AXSAN/WTOL-7AXSAN_R1_EN.swf

Average Size Data Center (240 kW, 60 racks at 4 kW per rack, 1620 SF)

INPUTS

Location - North America United States
Data Center IT Capacity - 240 kw
Average Power Density - 4 kw/Rack
Installation Labor Rate - Typical ($90.00 per hour)
Cooling System - 8 Selections Below
Air Distribution Type - Perimeter Cooling
UPS Architecture - Traditional Non Scalable
Redundancy Levels - No to all

Energy Costs Derived from APC - Schneider Electric's Data Center Efficiency Calculator

http://www.apcmedia.com/salestools/WTOL-7CMGPL/WTOL-7CMGPL_R3_EN.swf

Average Size Data Center (240 kW, 60 racks at 4 kW per rack, 1620 SF)

FIXED INPUTS

Data Center IT Capacity in kW	240
Total IT Load	100%
Electricity Cost	$ 0.10
UPS System	Typical
Power Redundancy	Single Path Power
CRAC / CRAH Redundancy	Single Path CRAC/ CRAH
Heat Rejection Redundancy	Single Path Heat Rejection
Water-side Economizer Time in Hrs/Yr	3,000
Options: Only options selected	
Deep Raised Floor	Checked

	Components Including Installation, Design, Engineering and Project Mgmt Costs — Cooling System $	%	Components with Costs Broken Out — Cooling System $	%	Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
APC #1 Perimeter CRAH with Chiller / Tower	$1,344,616	100.0%	$1,344,616	96.4%	$1,960,000	$8.16			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	3.6%	$50,000	$0.21			
Total APC #1	$1,344,616		$1,394,616	100.0%	$2,010,000	$8.37	240,196	69.4%	$5.81
Sub System Component Costs									
- CRAH	$585,738	43.6%	$316,299	22.7%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower	$324,248	24.1%	$175,094	12.6%					
- Water Cooled Chiller	$218,940	16.3%	$118,228	8.5%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	9.3%	$67,392	4.8%					
- Heat Rejection Pumps	$90,890	6.8%	$49,081	3.5%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	3.6%					
Installation (Reference % only)		32.0%	$430,277	30.9%					
Design / Engineering (Reference % only)		5.0%	$67,231	4.8%					
Project Management / Facilities Engineering (Reference % only)		9.0%	$121,015	8.7%					
Total	$1,344,616	100.0%	$1,394,616	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	**Chilled Water**
Chiller	**Chiller with Cooling Tower**
Air Distribution	**Perimeter Cooling**
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	**1.59**
Annual Energy Costs at 240 kW load	**$333,000**
Cooling System Energy Costs %	**26.80%**
Cooling System Energy Costs $	**$89,244**

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #2 Perimeter CRAH with VFD Chiller / Tower	$1,357,495	100.0%	$1,357,495	96.4%	$1,970,000	$8.22			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	3.6%	$50,000	$0.21			
Total APC #2	$1,357,495		$1,407,495	100.0%	$2,020,000	$8.43	239,659	69.7%	$5.87
Sub System Component Costs									
- CRAH	$585,738	43.1%	$316,299	22.5%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower	$324,248	23.9%	$175,094	12.4%					
- Water Cooled Chiller	$231,819	17.1%	$125,182	8.9%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	9.2%	$67,392	4.8%					
- Heat Rejection Pumps	$90,890	6.7%	$49,081	3.5%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	3.6%					
Installation	(Reference % only)	32.0%	$434,398	30.9%					
Design / Engineering	(Reference % only)	5.0%	$67,875	4.8%					
Project Management / Facilities Engineering	(Reference % only)	9.0%	$122,175	8.7%					
Total	$1,357,495	100.0%	$1,407,495	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	Chilled Water
Chiller	Chiller with Cooling Tower VFD
Air Distribution	Perimeter Cooling
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.59
Annual Energy Costs at 240 kW load	$325,000
Cooling System Energy Costs %	25.0%
Cooling System Energy Costs $	$81,250

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #3 Perimeter CRAH with Chiller / Dry Cooler	$1,238,786	100.0%	$1,238,786	96.1%	$1,840,000	$7.67			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	3.9%	$50,000	$0.21			
Total APC #3	$1,238,786		$1,288,786	100.0%	$1,890,000	$7.88	239,896	68.2%	$5.37
Sub System Component Costs									
- CRAH	$585,738	47.3%	$316,299	24.5%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower		0.0%	$0	0.0%					
- Water Cooled Chiller	$218,940	17.7%	$118,228	9.2%					
- Dry Cooler	$218,418	17.6%	$117,946	9.2%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	10.1%	$67,392	5.2%					
- Heat Rejection Pumps	$90,890	7.3%	$49,081	3.8%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	3.9%					
Installation	(Reference % only)	32.0%	$396,412	30.8%					
Design / Engineering	(Reference % only)	5.0%	$61,939	4.8%					
Project Management / Facilities Engineering	(Reference % only)	9.0%	$111,491	8.7%					
Total	$1,238,786	100.0%	$1,288,786	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	Chilled Water
Chiller	Chiller With Dry Cooler
Air Distribution	Perimeter Cooling
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.59
Annual Energy Costs at 240 kW load	$333,000
Cooling System Energy Costs %	26.80%
Cooling System Energy Costs $	$89,244

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #4 Perimeter CRAH with VFD Chiller / Dry Cooler	$1,251,665	100.0%	$1,251,665	96.2%	$1,860,000	$7.73			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	3.8%	$50,000	$0.21			
Total APC #4	$1,251,665		$1,301,665	100.0%	$1,910,000	$7.94	240,621	68.2%	$5.41
Sub System Component Costs									
- CRAH	$585,738	46.8%	$316,299	24.3%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower		0.0%	$0	0.0%					
- Air Cooled Chiller	$231,819	18.5%	$125,182	9.6%					
- Dry Cooler	$218,418	17.5%	$117,946	9.1%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	10.0%	$67,392	5.2%					
- Heat Rejection Pumps	$90,890	7.3%	$49,081	3.8%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	3.8%					
Installation	(Reference % only)	32.0%	$400,533	30.8%					
Design / Engineering	(Reference % only)	5.0%	$62,583	4.8%					
Project Management / Facilities Engineering	(Reference % only)	9.0%	$112,650	8.7%					
Total	$1,251,665	100.0%	$1,301,665	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	Chilled Water
Chiller	Chiller with Dry Cooler VFD
Air Distribution	Perimeter Cooling
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.57
Annual Energy Costs at 240 kW load	$329,000
Cooling System Energy Costs %	26.00%
Cooling System Energy Costs $	$85,540

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #5 Perimeter CRAH with Packaged Chiller	$967,623	100.0%	$967,623	95.1%	$1,540,000	$6.43			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	4.9%	$50,000	$0.21			
Total APC #5	$967,623		$1,017,623	100.0%	$1,590,000	$6.64	239,502	64.0%	$4.25
Sub System Component Costs									
- CRAH	$585,738	60.5%	$316,299	31.1%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower		0.0%	$0	0.0%					
- Air Cooled Chiller	$257,085	26.6%	$138,826	13.6%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	12.9%	$67,392	6.6%					
- Heat Rejection Pumps		0.0%	$0	0.0%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	4.9%					
Installation	(Reference % only)	32.0%	$309,639	30.4%					
Design / Engineering	(Reference % only)	5.0%	$48,381	4.8%					
Project Management / Facilities Engineering	(Reference % only)	9.0%	$87,086	8.6%					
Total	$967,623	100.0%	$1,017,623	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	Chilled Water
Chiller	Packaged Chiller
Air Distribution	Perimeter Cooling
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.59
Annual Energy Costs at 240 kW load	$335,000
Cooling System Energy Costs %	27.20%
Cooling System Energy Costs $	$91,120

Invalid pricing problem identified highlighted in pink. Reported to APC Schneider Electric and they are working on the problem.

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #6 Perimeter CRAC DX Air Cooled	$608,646	100.0%	$608,646	92.4%	$1,150,000	$4.78			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	7.6%	$50,000	$0.21			
Total APC #6	$608,646		$658,646	100.0%	$1,200,000	$4.99	240,586	54.9%	$2.74
Sub System Component Costs									
- CRAH		0.0%	$0	0.0%					
- CRAC	$450,903	74.1%	$243,488	37.0%					
- Cooling Tower		0.0%	$0	0.0%					
- Air Cooled Chiller		0.0%	$0	0.0%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor	$157,743	25.9%	$85,181	12.9%					
- Chilled Water Pumps		0.0%	$0	0.0%					
- Heat Rejection Pumps		0.0%	$0	0.0%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	7.6%					
Installation (Reference % only)		32.0%	$194,767	29.6%					
Design / Engineering (Reference % only)		5.0%	$30,432	4.6%					
Project Management / Facilities Engineering (Reference % only)		9.0%	$54,778	8.3%					
Total	$608,646	100.0%	$658,646	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	Air Cooled
Chiller	N/A
Air Distribution	Perimeter Cooling
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.81
Annual Energy Costs at 240 kW load	$380,000
Cooling System Energy Costs %	35.60%
Cooling System Energy Costs $	$135,280

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #7 Perimeter CRAC DX Glycol Cooled	$919,101	100.0%	$919,101	94.8%	$1,490,000	$6.21			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	5.2%	$50,000	$0.21			
Total APC #7	$919,101		$969,101	100.0%	$1,540,000	$6.42	239,936	62.9%	$4.04
Sub System Component Costs									
- CRAH		0.0%	$0	0.0%					
- CRAC	$609,793	66.3%	$329,288	34.0%					
- Cooling Tower		0.0%	$0	0.0%					
- Air Cooled Chiller		0.0%	$0	0.0%					
- Dry Cooler	$218,418	23.8%	$117,946	12.2%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps		0.0%	$0	0.0%					
- Heat Rejection Pumps	$90,890	9.9%	$49,081	5.1%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	5.2%					
Installation (Reference % only)		32.0%	$294,112	30.3%					
Design / Engineering (Reference % only)		5.0%	$45,955	4.7%					
Project Management / Facilities Engineering (Reference % only)		9.0%	$82,719	8.5%					
Total	$919,101	100.0%	$969,101	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	DX - Glycol
Chiller	N/A
Air Distribution	Perimeter
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.96
Annual Energy Costs at 240 kW load	$413,000
Cooling System Energy Costs %	40.60%
Cooling System Energy Costs $	$167,678

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #8 Perimeter CRAC DX Water Cooled	$1,024,931	100.0%	$1,024,931	95.3%	$1,610,000	$6.69			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	4.7%	$50,000	$0.21			
Total APC #8	$1,024,931		$1,074,931	100.0%	$1,660,000	$6.90	240,658	64.8%	$4.47
Sub System Component Costs									
- CRAH		0.0%	$0	0.0%					
- CRAC	$609,793	59.5%	$329,288	30.6%					
- Cooling Tower	$324,248	31.6%	$175,094	16.3%					
- Water Cooled Chiller		0.0%	$0	0.0%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps		0.0%	$0	0.0%					
- Heat Rejection Pumps	$90,890	8.9%	$49,081	4.6%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	4.7%					
Installation	(Reference % only)	32.0%	$327,978	30.5%					
Design / Engineering	(Reference % only)	5.0%	$51,247	4.8%					
Project Management / Facilities Engineering	(Reference % only)	9.0%	$92,244	8.6%					
Total	$1,024,931	100.0%	$1,074,931	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	**No Selection - Using DX - Glycol**
Chiller	**N/A**
Air Distribution	**Perimeter Cooling**
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	**1.96**
Annual Energy Costs at 240 kW load	**$413,000**
Cooling System Energy Costs %	**40.60%**
Cooling System Energy Costs $	**$167,678**

APC Schneider Electric Data Center Cooling System Costs Analysis

Prepared by R4 Ventures LLC - Darrell Richardson

Data Center 1st Costs Derived from APC - Schneider Electric's Data Center Capital Cost

http://www.apcmedia.com/salestools/WTOL-7AXSAN/WTOL-7AXSAN_R1_EN.swf

Average Size Data Center (240 kW, 60 racks at 4 kW per rack, 1620 SF)

INPUTS

Location - North America United States
Data Center IT Capacity - 240 kw
Average Power Density - 4 kw/Rack
Installation Labor Rate - Typical ($90.00 per hour)
Cooling System - 8 Selections Below
Air Distribution Type - Perimeter Cooling
UPS Architecture - Traditional Non Scalable
Redundancy Levels - No to all

Energy Costs Derived from APC - Schneider

http://www.apcmedia.com/salestools/WTOL-7CMGPL/WTOL-7CMGPL_R3_EN.swf

Average Size Data Center (240 kW, 60 racks at 4 kW per rack, 1620 SF)

FIXED INPUTS

Data Center IT Capacity in kW		240
Total IT Load		100%
Electricity Cost	$	0.10
UPS System	Typical	
Power Redundancy	Single Path Power	
CRAC / CRAH Redundancy	Single Path CRAC/ CRAH	
Heat Rejection Redundancy	Single Path Heat Rejection	
Water-side Economizer Time in Hrs/Yr		3,000

Options: Only options selected
Coordinated CRAC/CRAH automatically selected
Optimized rack layout automatically selected

	Components Including Installation, Design, Engineering and Project Mgmt Costs — Cooling System $	%	Components with Costs Broken Out — Cooling System $	%	Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
APC #9 Row Based CRAH with Chiller / Tower	$1,011,655	100.0%	$1,011,655	95.3%	$1,590,000	$6.63			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	4.7%	$50,000	$0.21			
Total APC #9	$1,011,655		$1,061,655	100.0%	$1,640,000	$6.84	239,819	64.7%	$4.43
Sub System Component Costs									
- CRAH	$252,777	25.0%	$136,500	12.9%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower	$324,248	32.1%	$175,094	16.5%					
- Water Cooled Chiller	$218,940	21.6%	$118,228	11.1%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	12.3%	$67,392	6.3%					
- Heat Rejection Pumps	$90,890	9.0%	$49,081	4.6%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	4.7%					
Installation (Reference % only)		32.0%	$323,730	30.5%					
Design / Engineering (Reference % only)		5.0%	$50,583	4.8%					
Project Management / Facilities Engineering (Reference % only)		9.0%	$91,049	8.6%					
Total	$1,011,655	100.0%	$1,061,655	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	**Chilled Water**
Chiller	**Chiller with Cooling Tower**
Air Distribution	**Close-coupled cooling (In-Row)**
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	**1.44**
Annual Energy Costs at 240 kW load	**$303,000**
Cooling System Energy Costs %	**19.70%**
Cooling System Energy Costs $	**$59,691**

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #10 Row Based CRAH with VFD Chiller / Tower	$1,024,534	100.0%	$1,024,534	95.3%	$1,610,000	$6.69			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	4.7%	$50,000	$0.21			
Total APC #10	$1,024,534		$1,074,534	100.0%	$1,660,000	$6.90	240,658	64.7%	$4.46
Sub System Component Costs									
- CRAH	$252,777	24.7%	$136,500	12.7%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower	$324,248	31.6%	$175,094	16.3%					
- Water Cooled Chiller	$231,819	22.6%	$125,182	11.6%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	12.2%	$67,392	6.3%					
- Heat Rejection Pumps	$90,890	8.9%	$49,081	4.6%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	4.7%					
Installation (Reference % only)		32.0%	$327,851	30.5%					
Design / Engineering (Reference % only)		5.0%	$51,227	4.8%					
Project Management / Facilities Engineering (Reference % only)		9.0%	$92,208	8.6%					
Total	$1,024,534	100.0%	$1,074,534	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	Chilled Water
Chiller	Chiller with Cooling Tower VFD
Air Distribution	Close-coupled cooling (In-Row)
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.41
Annual Energy Costs at 240 kW load	$296,000
Cooling System Energy Costs %	17.7%
Cooling System Energy Costs $	$52,392

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #11 Row Based CRAH with Chiller / Dry Cooler	$905,825	100.0%	$905,825	94.8%	$1,480,000	$6.15			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	5.2%	$50,000	$0.21			
Total APC #11	$905,825		$955,825	100.0%	$1,530,000	$6.36	240,650	62.5%	$3.97
Sub System Component Costs									
- CRAH	$252,777	27.9%	$136,500	14.3%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower		0.0%	$0	0.0%					
- Water Cooled Chiller	$218,940	24.2%	$118,228	12.4%					
- Dry Cooler	$218,418	24.1%	$117,946	12.3%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	13.8%	$67,392	7.1%					
- Heat Rejection Pumps	$90,890	10.0%	$49,081	5.1%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	5.2%					
Installation (Reference % only)		32.0%	$289,864	30.3%					
Design / Engineering (Reference % only)		5.0%	$45,291	4.7%					
Project Management / Facilities Engineering (Reference % only)		9.0%	$81,524	8.5%					
Total	$905,825	100.0%	$955,825	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	Chilled Water
Chiller	Chiller With Dry Cooler
Air Distribution	Close-coupled cooling (In-Row)
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.47
Annual Energy Costs at 240 kW load	$310,000
Cooling System Energy Costs %	21.30%
Cooling System Energy Costs $	$66,030

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #12 Row Based CRAH with VFD Chiller / Dry Cooler	$918,704	100.0%	$918,704	94.8%	$1,490,000	$6.21			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	5.2%	$50,000	$0.21			
Total APC #12	$918,704		$968,704	100.0%	$1,540,000	$6.42	239,936	62.9%	$4.04
Sub System Component Costs									
- CRAH	$252,777	27.5%	$136,500	14.1%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower		0.0%	$0	0.0%					
- Air Cooled Chiller	$231,819	25.2%	$125,182	12.9%					
- Dry Cooler	$218,418	23.8%	$117,946	12.2%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	13.6%	$67,392	7.0%					
- Heat Rejection Pumps	$90,890	9.9%	$49,081	5.1%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	5.2%					
Installation (Reference % only)		32.0%	$293,985	30.3%					
Design / Engineering (Reference % only)		5.0%	$45,935	4.7%					
Project Management / Facilities Engineering (Reference % only)		9.0%	$82,683	8.5%					
Total	$918,704	100.0%	$968,704	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	Chilled Water
Chiller	Chiller with Dry Cooler VFD
Air Distribution	Close-coupled cooling (In-Row)
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.43
Annual Energy Costs at 240 kW load	$300,000
Cooling System Energy Costs %	18.90%
Cooling System Energy Costs $	$56,700

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #13 Row Based CRAH with Packaged Chiller	$634,662	100.0%	$634,662	92.7%	$1,180,000	$4.90			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	7.3%	$50,000	$0.21			
Total APC #13	$634,662		$684,662	100.0%	$1,230,000	$5.11	240,816	55.7%	$2.84
Sub System Component Costs									
- CRAH	$252,777	39.8%	$136,500	19.9%					
- CRAC		0.0%	$0	0.0%					
- Cooling Tower		0.0%	$0	0.0%					
- Air Cooled Chiller	$257,085	40.5%	$138,826	20.3%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps	$124,800	19.7%	$67,392	9.8%					
- Heat Rejection Pumps		0.0%	$0	0.0%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	7.3%					
Installation (Reference % only)		32.0%	$203,092	29.7%					
Design / Engineering (Reference % only)		5.0%	$31,733	4.6%					
Project Management / Facilities Engineering (Reference % only)		9.0%	$57,120	8.3%					
Total	$634,662	100.0%	$684,662	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	Chilled Water
Chiller	Packaged Chiller
Air Distribution	Close-coupled cooling (In-Row)
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.45
Annual Energy Costs at 240 kW load	$305,000
Cooling System Energy Costs %	20.10%
Cooling System Energy Costs $	$61,305

Invalid pricing problem identified highlighted in pink. Reported to APC Schneider Electric and they are working on the problem.

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #14 Row Based CRAC DX Air Cooled	$318,529	100.0%	$318,529	86.4%	$829,000	$3.46			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	13.6%	$50,000	$0.21			
Total APC #14	$318,529		$368,529	100.0%	$879,000	$3.67	239,595	41.9%	$1.54
Sub System Component Costs									
- CRAH		0.0%	$0	0.0%					
- CRAC	$214,114	67.2%	$115,622	31.4%					
- Cooling Tower		0.0%	$0	0.0%					
- Air Cooled Chiller		0.0%	$0	0.0%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor	$104,415	32.8%	$56,384	15.3%					
- Chilled Water Pumps		0.0%	$0	0.0%					
- Heat Rejection Pumps		0.0%	$0	0.0%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	13.6%					
Installation (Reference % only)		32.0%	$101,929	27.7%					
Design / Engineering (Reference % only)		5.0%	$15,926	4.3%					
Project Management / Facilities Engineering (Reference % only)		9.0%	$28,668	7.8%					
Total	$318,529	100.0%	$368,529	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	Air Cooled
Chiller	N/A
Air Distribution	Close-coupled cooling (In-Row)
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.61
Annual Energy Costs at 240 kW load	$339,000
Cooling System Energy Costs %	28.00%
Cooling System Energy Costs $	$94,920

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #15 Row Based CRAC DX Glycol Cooled	$561,390	100.0%	$561,390	91.8%	$1,100,000	$4.57			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	8.2%	$50,000	$0.21			
Total APC #15	$561,390		$611,390	100.0%	$1,150,000	$4.78	240,700	53.2%	$2.54
Sub System Component Costs									
- CRAH		0.0%	$0	0.0%					
- CRAC	$252,082	44.9%	$136,124	22.3%					
- Cooling Tower		0.0%	$0	0.0%					
- Air Cooled Chiller		0.0%	$0	0.0%					
- Dry Cooler	$218,418	38.9%	$117,946	19.3%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps		0.0%	$0	0.0%					
- Heat Rejection Pumps	$90,890	16.2%	$49,081	8.0%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	8.2%					
Installation (Reference % only)		32.0%	$179,645	29.4%					
Design / Engineering (Reference % only)		5.0%	$28,070	4.6%					
Project Management / Facilities Engineering (Reference % only)		9.0%	$50,525	8.3%					
Total	$561,390	100.0%	$611,390	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	DX - Glycol
Chiller	N/A
Air Distribution	Close-coupled cooling (In-Row)
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	1.59
Annual Energy Costs at 240 kW load	$334,000
Cooling System Energy Costs %	27.00%
Cooling System Energy Costs $	$90,180

	Components Including Installation, Design, Engineering and Project Mgmt Costs		Components with Costs Broken Out		Total System Cost with above Inputs	Total System Cost per watt with above Inputs	Total System Watts	Cooling System as a percent of Total System Costs	Cooling System Cost per watt with above Inputs
	Cooling System		Cooling System						
	$	%	$	%					
APC #16 Row Based CRAC DX Water Cooled	$667,220	100.0%	$667,220	93.0%	$1,210,000	$5.05			
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)			$50,000	7.0%	$50,000	$0.21			
Total APC #16	$667,220		$717,220	100.0%	$1,260,000	$5.26	239,604	56.9%	$2.99
Sub System Component Costs									
- CRAH		0.0%	$0	0.0%					
- CRAC	$252,082	37.8%	$136,124	19.0%					
- Cooling Tower	$324,248	48.6%	$175,094	24.4%					
- Water Cooled Chiller		0.0%	$0	0.0%					
- Dry Cooler		0.0%	$0	0.0%					
- Remote Condensor		0.0%	$0	0.0%					
- Chilled Water Pumps		0.0%	$0	0.0%					
- Heat Rejection Pumps	$90,890	13.6%	$49,081	6.8%					
Estimated Hot Aisle Cold Aisle Containment (50% of Bid from APC Distributor)		0.0%	$50,000	7.0%					
Installation	(Reference % only)	32.0%	$213,510	29.8%					
Design / Engineering	(Reference % only)	5.0%	$33,361	4.7%					
Project Management / Facilities Engineering	(Reference % only)	9.0%	$60,050	8.4%					
Total	$667,220	100.0%	$717,220	100.0%					

Calculated Energy Costs and Results

Variable Inputs

Cooling System	**No Selection - Using DX - Glycol**
Chiller	**N/A**
Air Distribution	**Close-coupled cooling (In-Row)**
Infrastructure Efficiency - PUE Selected	
Cooling Sysfem Costs per Year - Energy Allocation Selected	

Results

PUE	**1.59**
Annual Energy Costs at 240 kW load	**$334,000**
Cooling System Energy Costs %	**27.00%**
Cooling System Energy Costs $	**$90,180**