Hot Aisle vs. Cold Aisle Containment

Based on APC White Paper #135

and

Liebert White Paper "Focused Cooling Using Cold Aisle Containment".

Presented by:

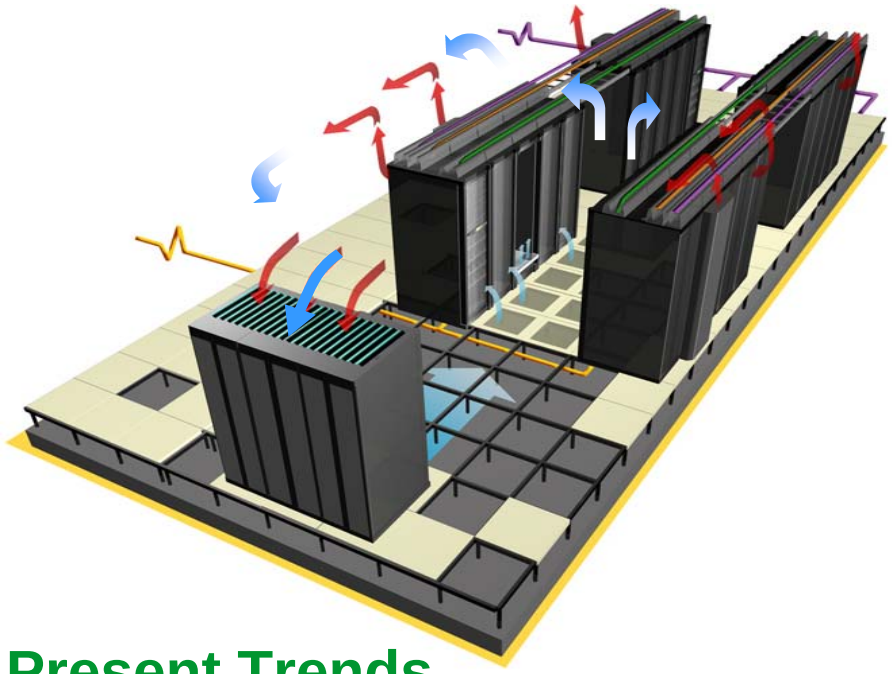
Dave Moody

***APC** by **Schneider Electric** - Senior Applications Engineer*

Introduction

Traditional Data Center Cooling Methods

- Many data center professionals have inherited traditional data centers



Characteristics of Traditional Cooling

- Designed with energy efficiency as a low priority
- Cooling units located at outside perimeter
- Raised floor Supply Air distribution
- Hot air mixes with cold air at A/C unit return and at rack inlets
- Inconsistent hot / cold aisle arrangement
- Oversized power and cooling components
- Low IT rack power densities: 2 - 3 kW

Present Trends

- New emphasis on high efficiency and low carbon emissions
- Row cooling and separation of hot and cold air streams are new technologies to help to remedy the situation

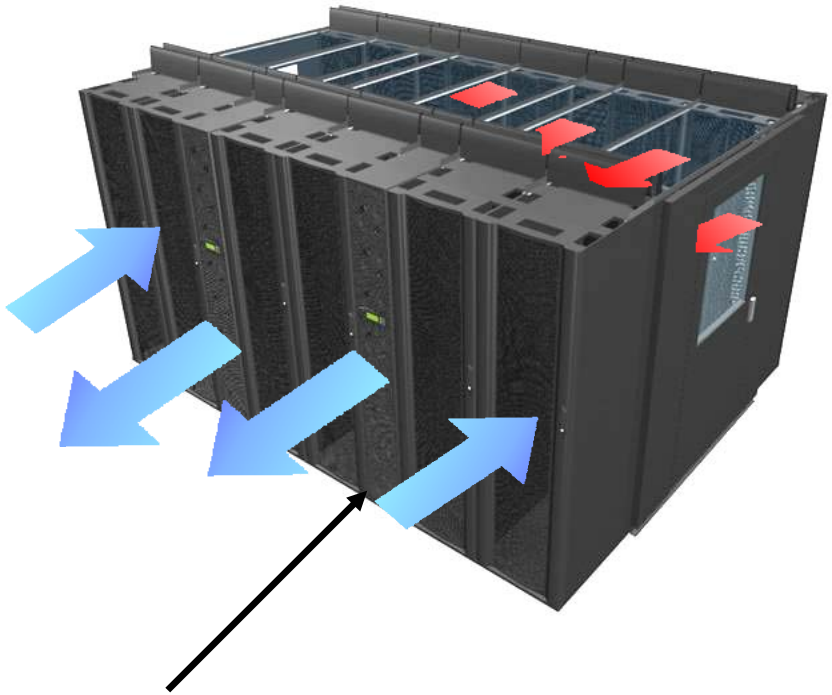
Hot Aisle vs. Cold Aisle Containment System

Both Methodologies prevent Hot and Cold Air streams from mixing

This improves predictability and efficiency of the cooling solution compared to traditional cooling

Hot Aisle contains Hot Air

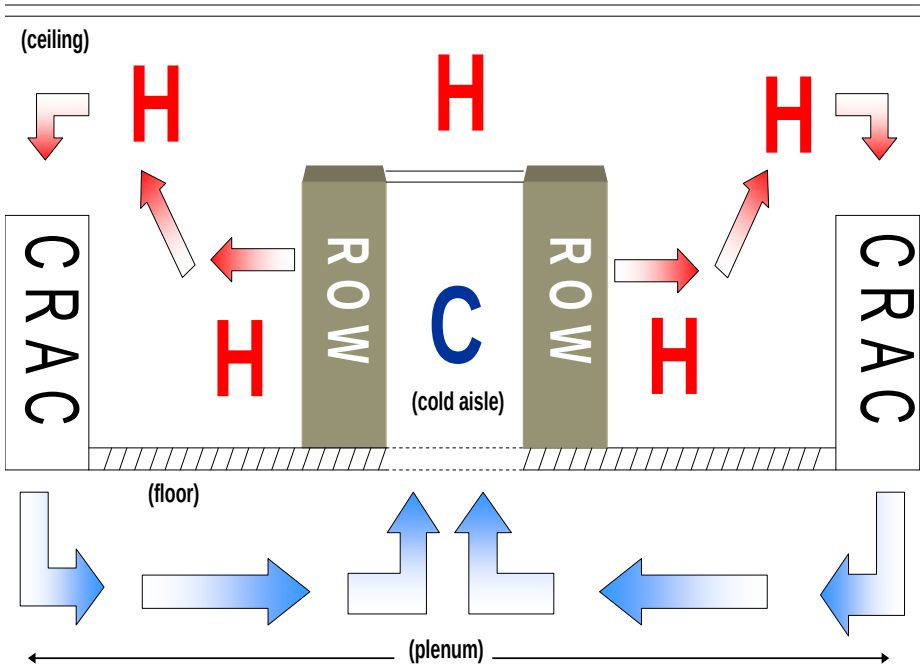
Room operates as Supply air plenum



Row based Cooling Unit

Cold Aisle contains Cold Air

Room operates as Hot air plenum



Perimeter Cooling Units

Hot Aisle vs. Cold Aisle Containment System

Common Characteristics:

- Prevent Hot and Cold air streams from mixing - Local hot spots and re-circulation.
- Cooling system Supply Air Temperatures can be set to a higher value.
- Operation of cooling coils in sensible heat removal range results in reduced humidification and dehumidification costs
- Better overall physical infrastructure utilization that enables right sizing
- May allow reduction in cooling airflow to match actual IT server airflow, reducing fan power.

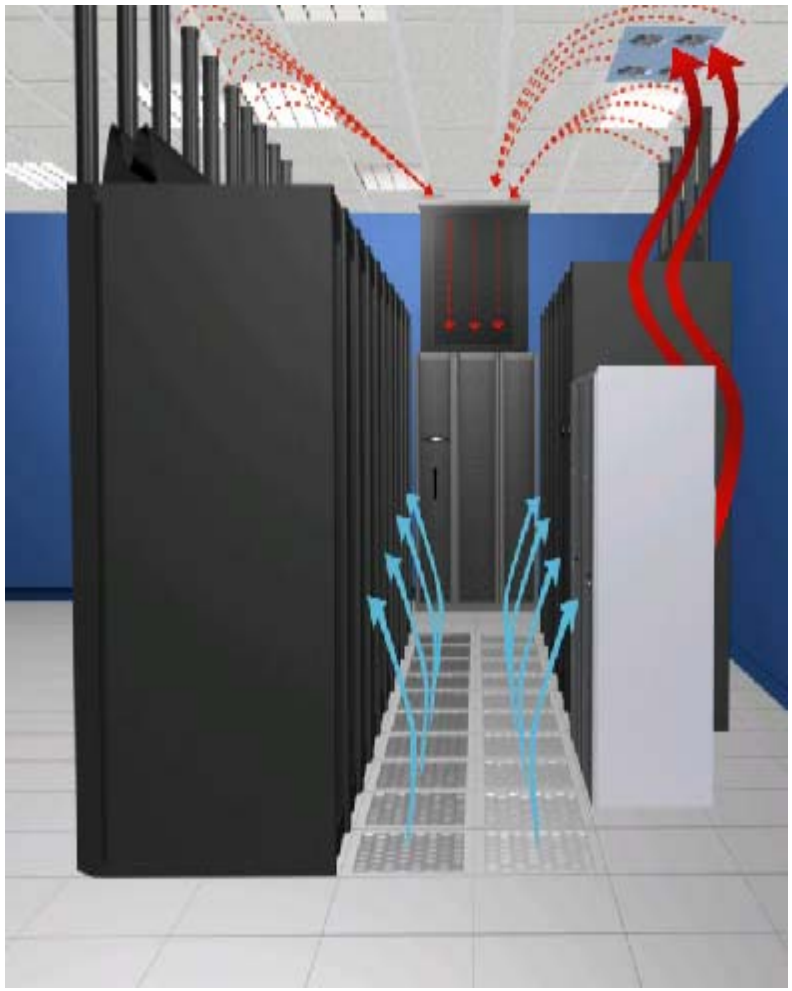
These benefits lead to energy savings and better equipment utilization compared to traditional cooling methods

Individual Rack Cold Aisle Containment

Polar Panel

Individual Rack Perforated Tile

Individual Rack Hot Aisle Containment



Active Duct Return System

Passive Duct Return System

Cold Aisle Containment System (CACS)

CACs Unique Characteristics

- Typically used with traditional perimeter cooling - cold air supplied via raised floor and perforated tiles. As an alternative, CACS is also designed with row based cooling systems.

- The cold aisle air is supplied at server inlet air temps (68 - 75 DEGF)

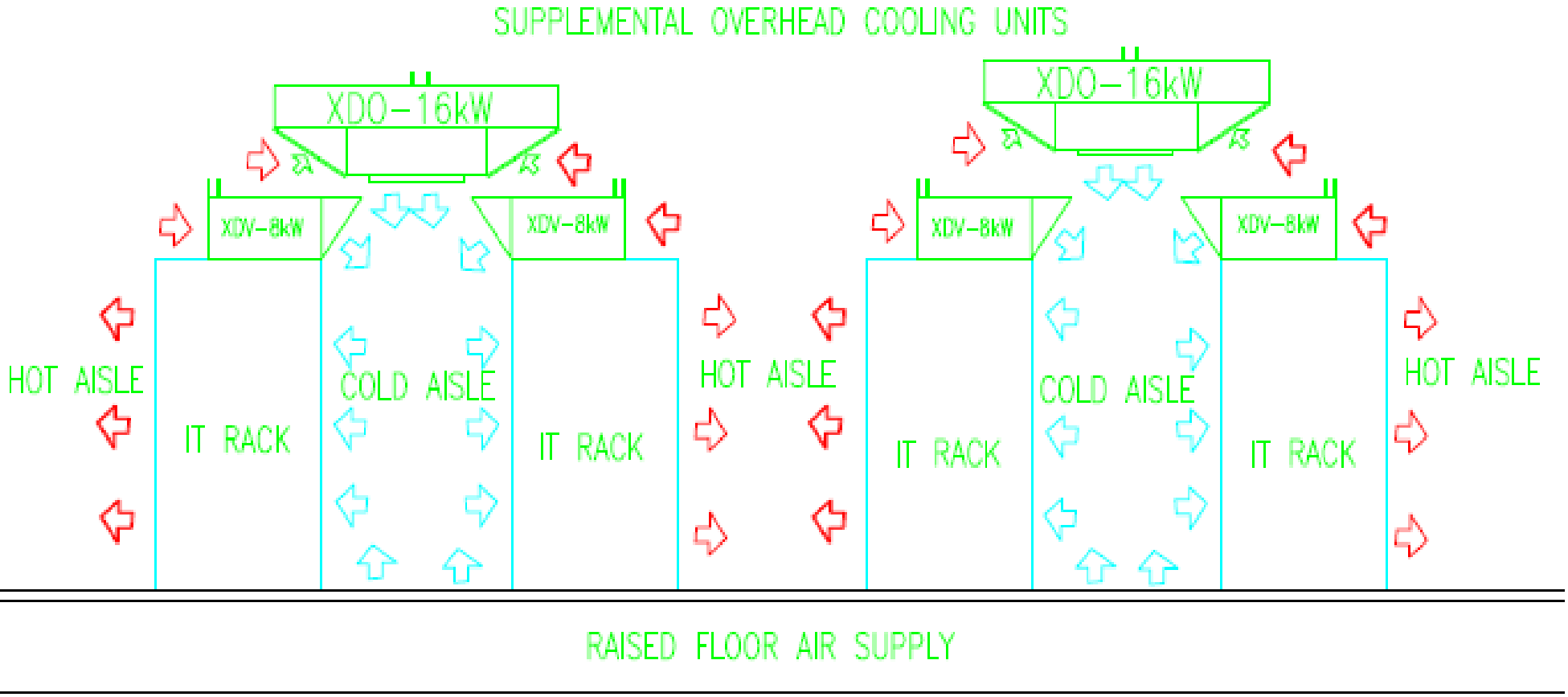
- The rest of the room becomes large, return hot air(80 - 90 DEGF) plenum.

Cold Aisle Containment System (CACS)

Cold Aisle Containment Limitations

- Perimeter Cooling - Longer air paths and higher air pressure resistance result in higher power consumption by fan motors.
- Less than optimum return air temperature (80 - 85 DEGF) provides lower A/C unit cooling capacity.
- Limited power density per rack - limited by the raised floor and perforated tiles airflow capacity, without supplemental cooling.

Cold Aisle Containment with Supplemental Cooling



Cold Aisle Containment with Row based Cooling

Cold Aisle Containment System (CACS)

Cold Aisle Containment Limitations (cont.)

- Predictability – Perimeter systems custom design for variable room and raised floor dimensions.

- Limited ride through during cooling failure - confined to Cold Aisle air volume.

- Room acts as the return air Hot Aisle -

  a. Contradicts perception that data centers should be cool.

  b. Warm air supply for free standing racks and equipment outside of CACS.

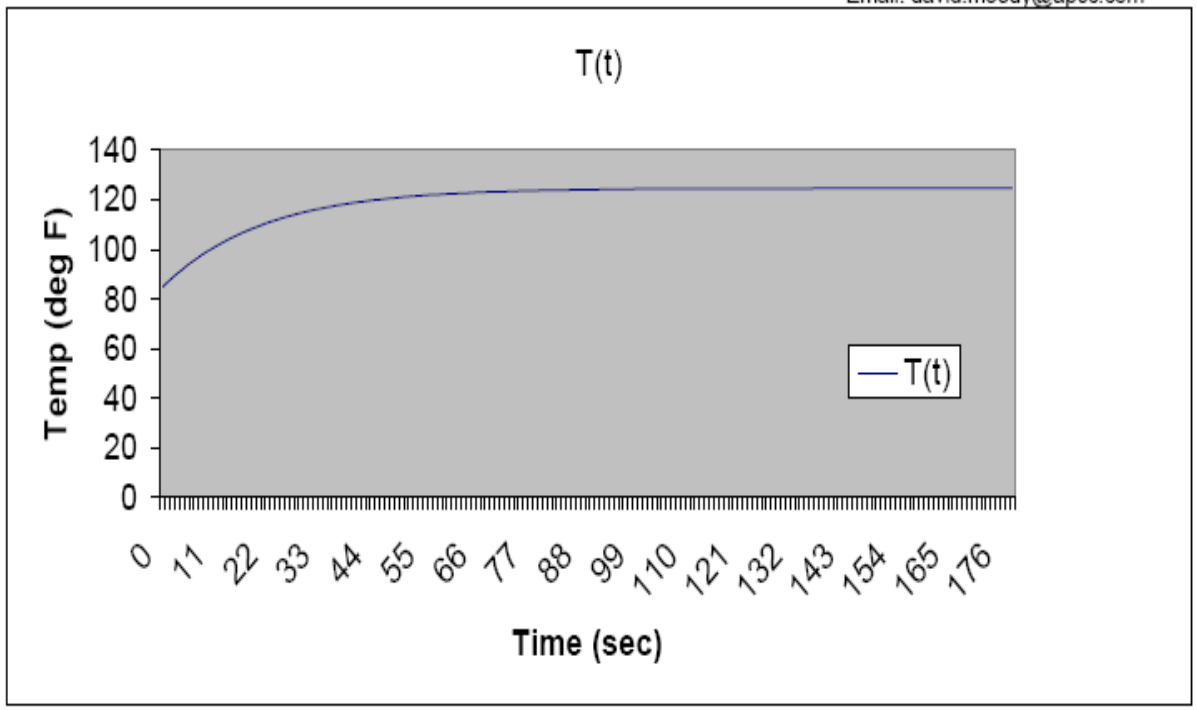
Cold Aisle Containment System (CACS)

Example of limited ride through during cooling failure – confined to Cold Aisle air volume.

Room Temperatrue Rise with no cooling

Ref: AFCOM Ohio
Kevin Dennis TAN Ohio

Date Aug 9, 2009
Dave Moody - APC St. Louis, MO
Tel: 888-576-2208 xt 11428
Email: david.moody@apcc.com



To	85.00	deg F	Initial room temperature
Tin	104.60	deg F	Infiltration air temperature
q(IT)	200.00	kW	IT load
p			
cp			
Q	32,000.00	CFM	IT air flow rate
V	11,200.00	cu. Ft.	Volume of space
t	1	min.	
CFM/kW	160		

Required input data is in yellow

	Length (ft.)	Width (ft.)	Height (ft.)
=>	56	20	10

Temp (DegF)	Time (Sec)
100.05	10
105.28	15
109.40	20
115.21	30
122.45	60
124.18	90

Cold Aisle Containment System (CACS)

Example of limited ride through during cooling failure – confined to Cold Aisle air volume.

Room Temperatrue Rise with no cooling

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Kevin Dennis TAM Ohio

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Email: david.moody@apcc.com

T(t) =	115.20946	deg F	
To	85.00	deg F	Initial room temperature
Tin	104.60	deg F	Infiltration air temperature
q(IT)	200.00	kW	IT load
p			
cp			
Q	32,000.00	CFM	IT air flow rate
V	22,400.00	cu. Ft.	Volume of space
t	1	min.	
CFM/kW	160		

Required input data is in yellow

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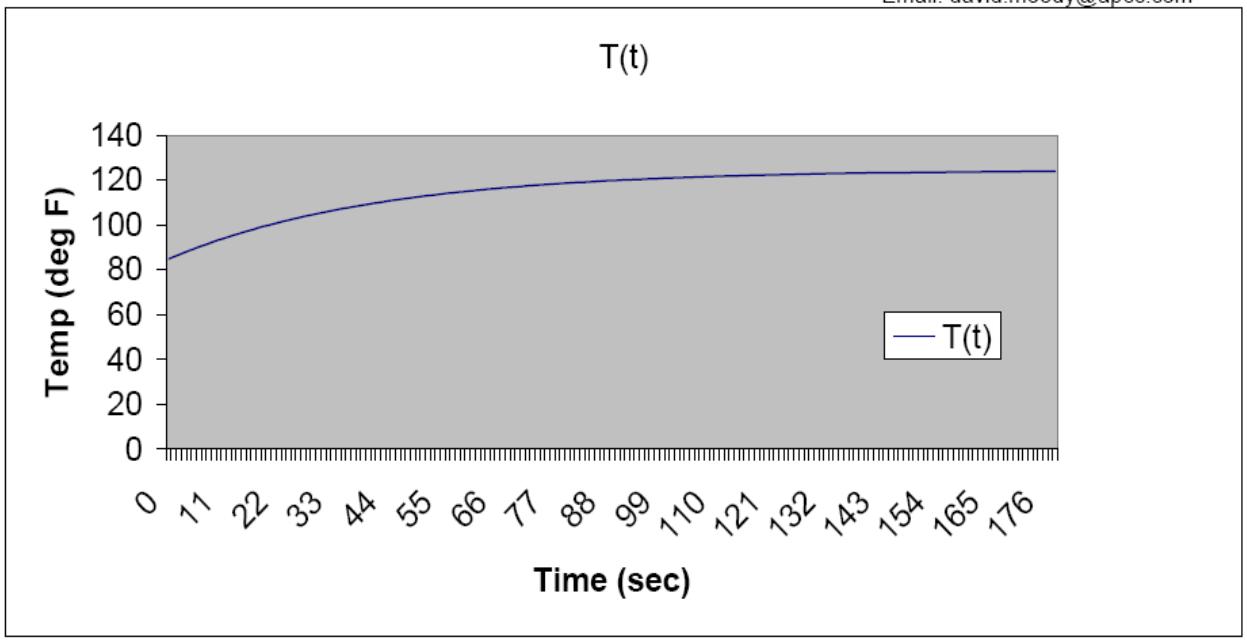

Temp (DegF)	Time (Sec)
89.46	5
93.42	10
96.93	15
100.05	20
105.28	30
115.21	60
120.07	90
122.45	120
123.61	150

Hot Aisle Containment System (HACS)

HACs Unique Characteristics

- Hot Aisle Containment System concept is patented by APC.
- Typically used with Row based cooling - hot air is captured and neutralized via cooling units placed within the row of racks and supplied to cold aisle.
- The rest of the room becomes large, cool supply air plenum, no raised floor or ducting is required.
- Variable Speed fans manage cooling unit airflow to match IT Server airflow.

Hot Aisle Containment System (HACS)

Hot Aisle Containment Advantages

- InRow Cooling is Closed Couple Cooling - short air paths and low air pressure resistance - lower power consumption by fan motors (See White Paper #130).

- Higher return air temperature - provides higher cooling unit capacity and efficiency of the cooling system.

- Supports High power density per rack - all heat is neutralized and there is no airflow limitation with the raised floor and perforated tiles.

Hot Aisle Containment System (HACS)

Hot Aisle Containment Advantages

- HACS with Row based cooling is Predictable solution – independent of room dimensions and raised floor airflow capacity.
- HACS with Perimeter cooling units increases Return Air Temps, for higher A/C unit coil performances, better SHR.
- Higher ride through during cooling failure - significantly larger cold aisle air volume. ***See following Example***
- Room acts as the Cold Aisle in agreement with the perception that data centers should be cold

Hot Aisle Containment System (CACS)

Example of longer ride through during cooling failure – confined to Hot Aisle air volume.

Room Temperatrue Rise with no cooling

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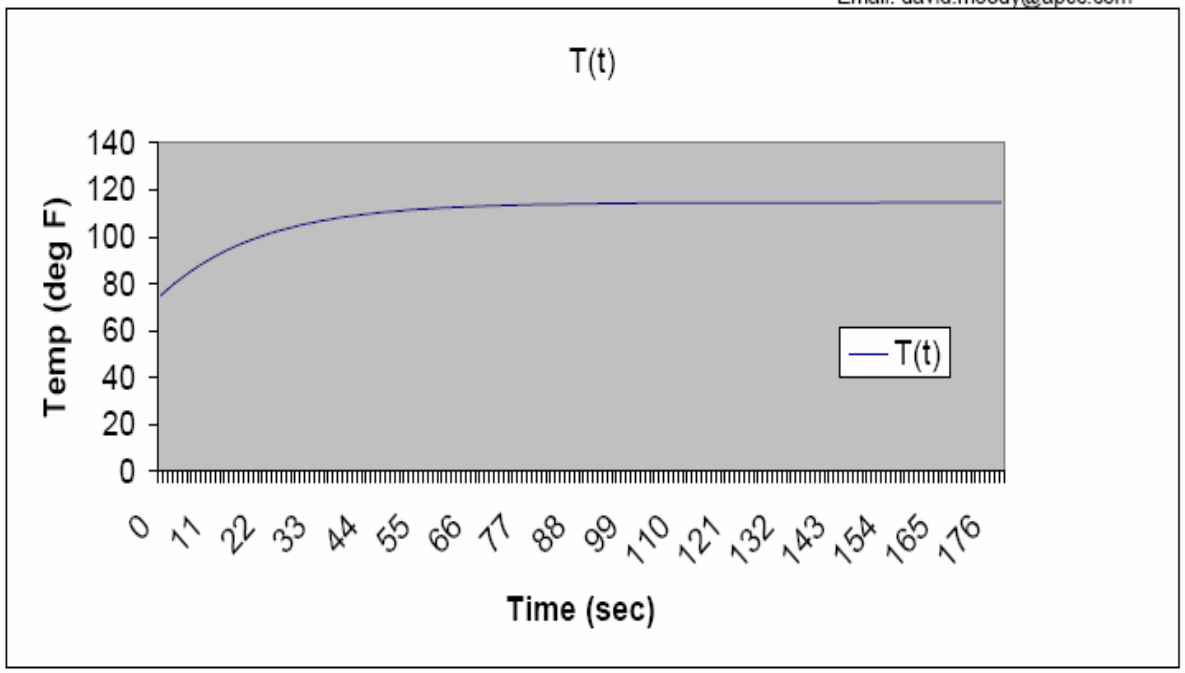

To	75.00	deg F	Initial room temperature
Tin	94.60	deg F	Infiltration air temperature
q(IT)	200.00	kW	IT load
p			
cp			
Q	32,000.00	CFM	IT air flow rate
V	11,200.00	cu. Ft.	Volume of space
t	1	min.	
CFM/kW	160		

Required input data is in yellow

	Length (ft.)	Width (ft.)	Height (ft.)
=>	56	20	10

Temp (DegF)	Time (Sec)
83.42	5
90.05	10
95.28	15
99.40	20
105.21	30
112.45	60
114.18	90
114.60	120
114.70	150
114.73	240

Hot Aisle Containment System (CACS)

Example of longer ride through during cooling failure – confined to Hot Aisle air volume.

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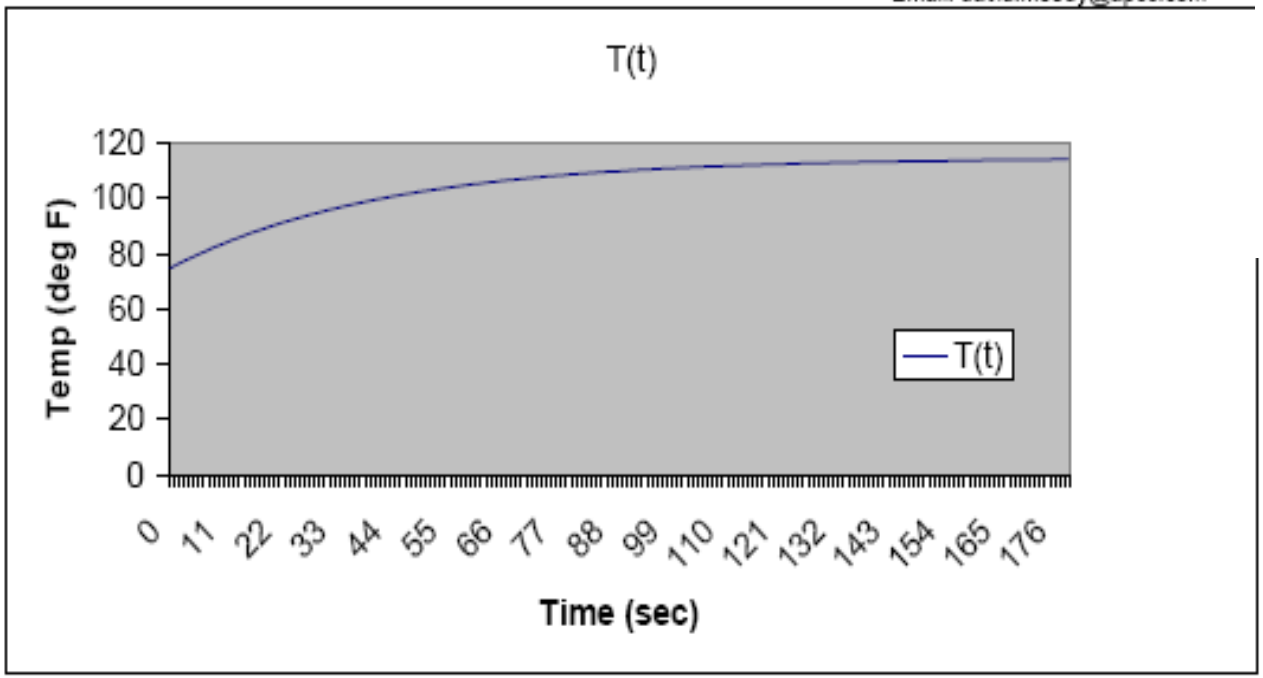
T(t) =	105.20946	deg F	
To	75.00	deg F	Initial room temperature
Tin	94.60	deg F	Infiltration air temperature
q(IT)	200.00	kW	IT load
p			
cp			
Q	32,000.00	CFM	IT air flow rate
V	22,400.00	cu. Ft.	Volume of space
t	1	min.	
CFM/kW	160		

Required input data is in yellow



	Length (ft.)	Width (ft.)	Height (ft.)
=>	56	20	20

Temp (DegF)	Time (Sec)
79.46	5
83.42	10
86.93	15
90.05	20
95.28	30
105.21	60
110.07	90
112.45	120
113.61	150

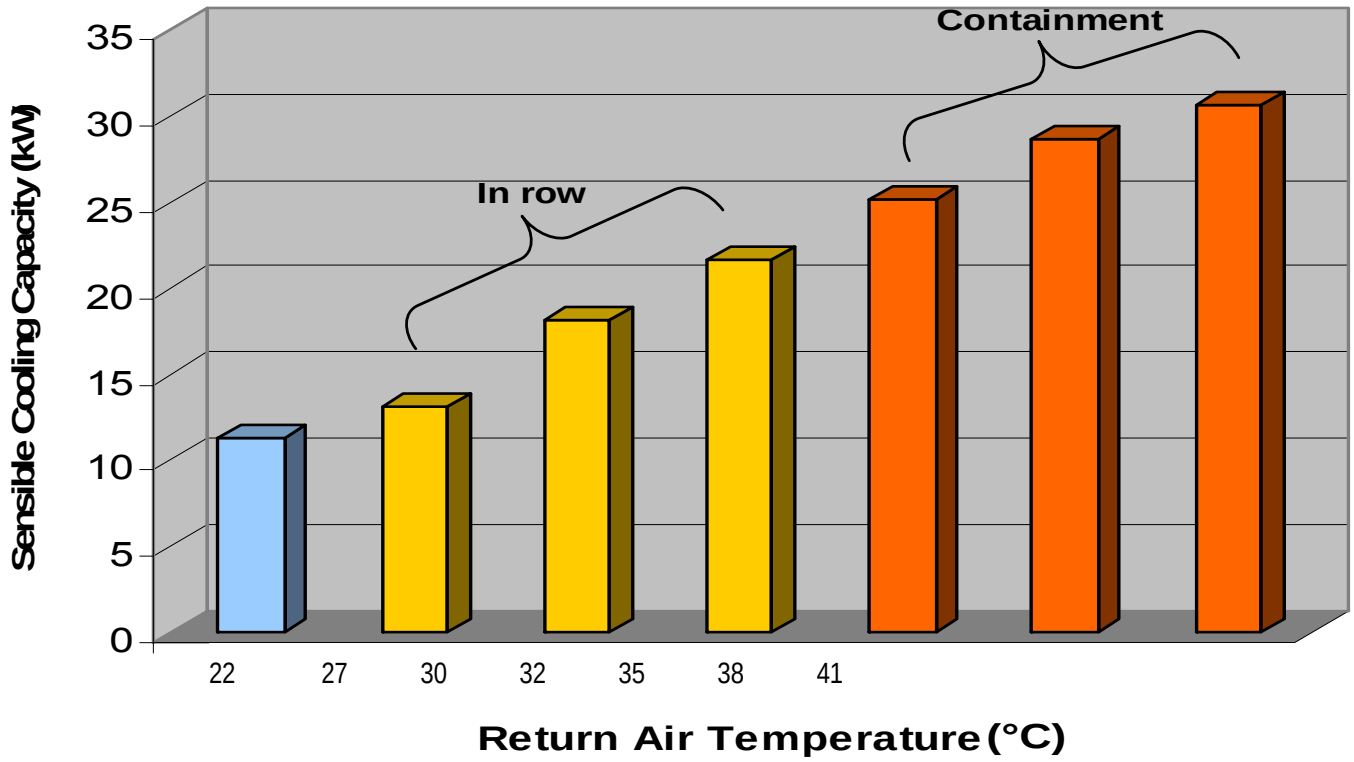
Hot Aisle Containment System (HACS)

Hot Aisle Containment Advantages (cont.)

- Room acts as the Cold Aisle - all room air is within ASHRAE Temp limits - flexible solution that can be deployed with existing architectures.
- Low power consumption and higher potential for using free cooling, economizers and extended period of free cooling.
- Modular & scalable solution due to row based cooling. Additional cooling capacity is added to the HACS in the rows as heat loads increase.

Hot Aisle Containment System (HACS)

Effect of increased return air temperature on sensible cooling capacity



* APC In-row RC model air conditioner

Examples of HACS

Texas Advanced Computing Center, Univ of TX Austin

http://www.tacc.utexas.edu/resources/hpcsystems/#ranger

Examples of HACS

Sun Microsystems Santa Clara, CA Facility

www.sun.com/aboutsun/environment/media/datacenter_tour.xml?intcmp=lnch08_datacenter_tour2

Hot Aisle vs. Cold Aisle Containment System

Fire Suppression Considerations

- Depending upon the location fire detection and/or fire suppression may be required inside the enclosed area of HACS or CACS
- The National Fire Protection Association standard NFPA75 does not state an opinion whether suppression systems (sprinklers or gaseous agents) should be provided in HACS or CACS
- NFPA 75 documents two requirements that could be applied to HACS and CACS (see White Paper #135, page 12 for details)
- HACS have been successfully installed and approved with sprinklers and gaseous agent suppression in many sites

Hot Aisle vs. Cold Aisle Containment System

Energy (Power) Consumption Considerations

- In CW Systems, HACS and CACs may reduce chiller power by reducing Latent Heat removal. Higher CRAC return air temps increase SHR.

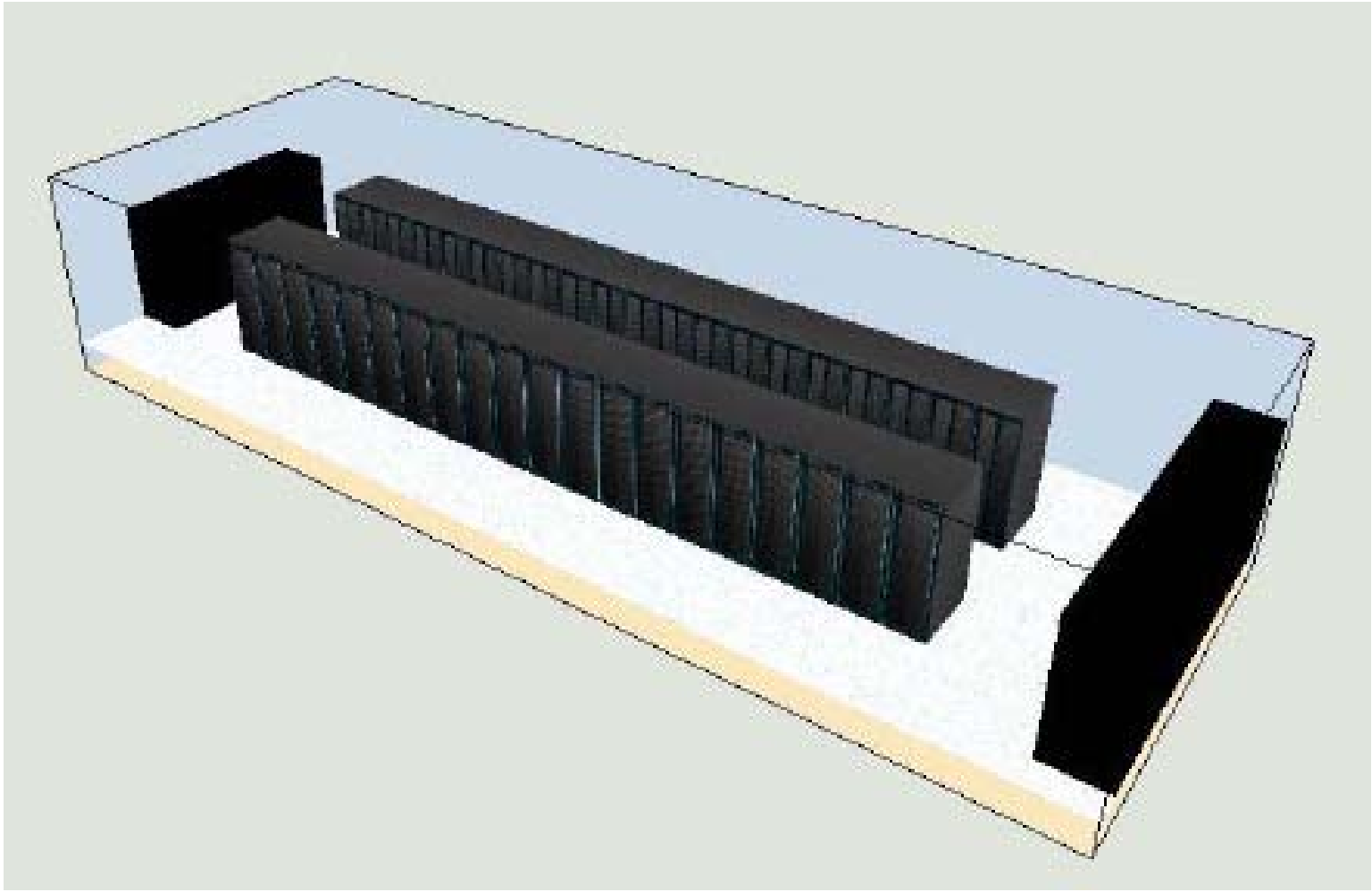
- HACS may permit lower supply air fan power due to factors:
  1. Lower Delta P across InRow cooling units.
  2. Provide match of cooling airflow to IT airflow.

- CACS may permit lower supply air fan power due to factors:
  1. Provide match of cooling airflow to IT airflow, but add airflow for Raised Floor system leakage (20 - 30%).
  2. Floor tiles may require additional air pressure based on required static losses for IT airflow rates.

- Energy Power savings are specific to each site conditions. See example.

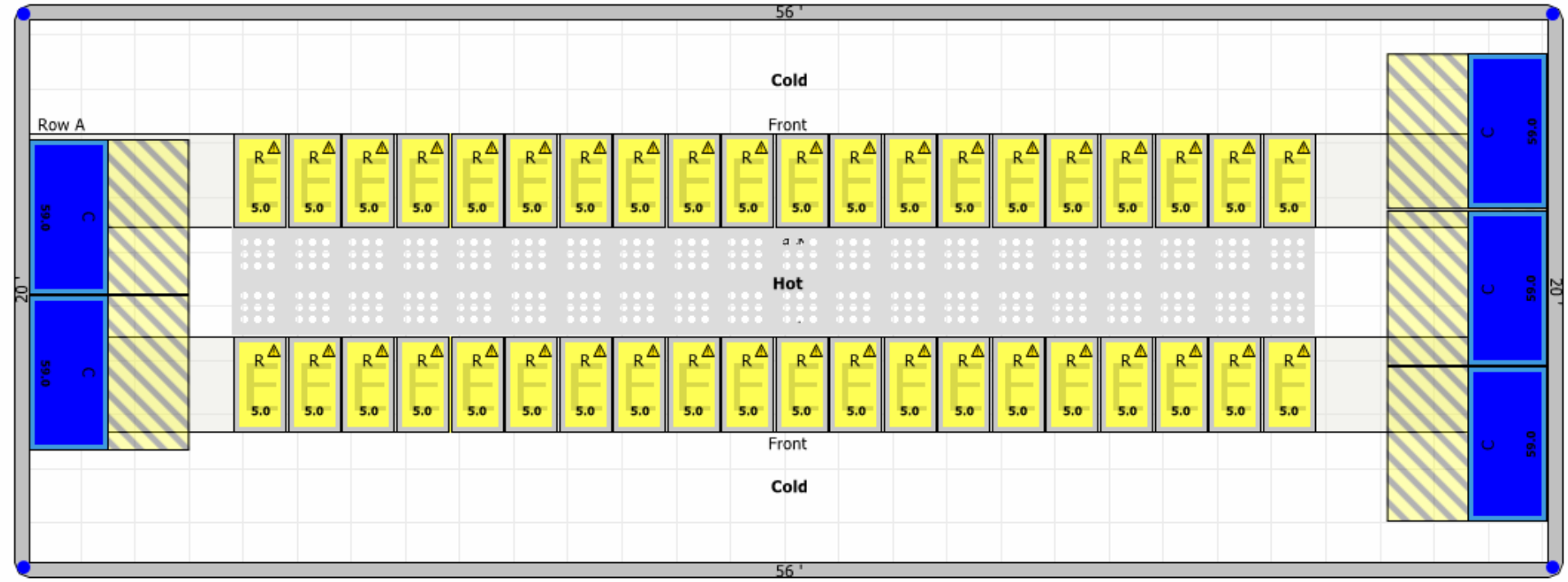
Hot Aisle vs. Cold Aisle Containment System

Example 200 kW Data Center 56 ft. x 20 ft. x 10 ft. = 11,200 Cu. Ft.
40 racks with 5 kW per rack
Perimeter cooling with Chilled Water Downflow CRACS on 18” Raised Floor.



Hot Aisle vs. Cold Aisle Containment System

Example 200 kW Data Center 56 ft. x 20 ft. x 10 ft. = 11,200 Cu. Ft.
40 racks with 5 kW per rack
Perimeter cooling with Chilled Water Downflow CRACS on 18” Raised Floor.
(3), (4) or (5) CRAC Units (depends on unit capacity).



Hot Aisle vs. Cold Aisle Containment System

Example - 200 kW InRoom Data Center:

N Cooling with Model **PCW900** (CW, Downflow, Max. 11,180 CFM per unit.
Total IT Airflow = 200 kW x 160 CFM/kW = 32,000 CFM
Add 20% for raised floor system airflow losses outside cold aisle = 38,400 CFM
Airflow CRAC Quantity = 38,400 / 11,280 = 3.4 units, round up to (4) CRACs.

CRAC Fan HP (full speed) = 7.0 (5.2 kW)
(4) CRACs at full fan speed = 28 HP (20.86 kW)

Supply Airflow per CRAC = 38,400 / 4 units = 9,600 CFM per CRAC
CRAC Fan HP (9,600 CFM) = 4.6 HP (3.42 kW)
(4) CRACs at 9,600 CFM fan speed = 18.4 HP (13.7 kW)

Results 34% Fan Power savings at reduced speed: 5,112 kW-Hr per month
PCW900 Coil capacity at 9,600 CFM = 183.9 MBH (53.8 kW) each
(4) CRACs x 53.8 kW cooling each = 215 kW net sensible cooling

Hot Aisle vs. Cold Aisle Containment System

Example - 200 kW InRoom Data Center:

N Cooling with Model **PCW1500** (CW, Downflow, Max. 17,360 CFM per unit.
Total IT Airflow = 200 kW x 160 CFM/kW = 32,000 CFM
Add 20% for raised floor system airflow losses outside cold aisle = 38,400 CFM
Airflow CRAC Quantity = 38,400 / 17,360 = 2.2 units, round up to (3) CRACs.

CRAC Fan HP (full speed) = 11.5 (8.56 kW)
(3) CRACs at full fan speed = 34.5 HP (25.7 kW)

Supply Airflow per CRAC = 38,400 / 3 units = 12,800 CFM per CRAC
CRAC Fan HP (12,800 CFM) = 4.8 HP (3.58 kW)
(3) CRACs at 12,800 CFM fan speed = 14.4 HP (10.7 kW)

Results 34% Fan Power savings at reduced speed: 10,800 kW-Hr per month
PCW900 Coil capacity at 12,800 CFM = 248.1 MBH (72.6 kW) each
(3) CRACs x 72.6 kW cooling each = 217 kW net sensible cooling

Hot Aisle vs. Cold Aisle Containment System

Energy (Power) Consumption 200 kW InRoom Example Summary:

1. (3) Model PCW1500 use 10.7 kW fan motor power to cool 200 kW data center with Cold aisle containment. . .

2. (4) Model PCW900 use 13.7 kW fan motor power to cool 200 kW data center with Cold aisle containment. . .

Potential energy power savings from 34 to 58%.

Notes: Coil efficiency savings may be reflected in lower CW flow for performance with higher Return Air Temperatures, but standard CRAC unit quantity selections are governed by airflow requirements, not coil cooling capacity.

All CRAC fan HP requirements at 0.15 in. WC Floor pressure.

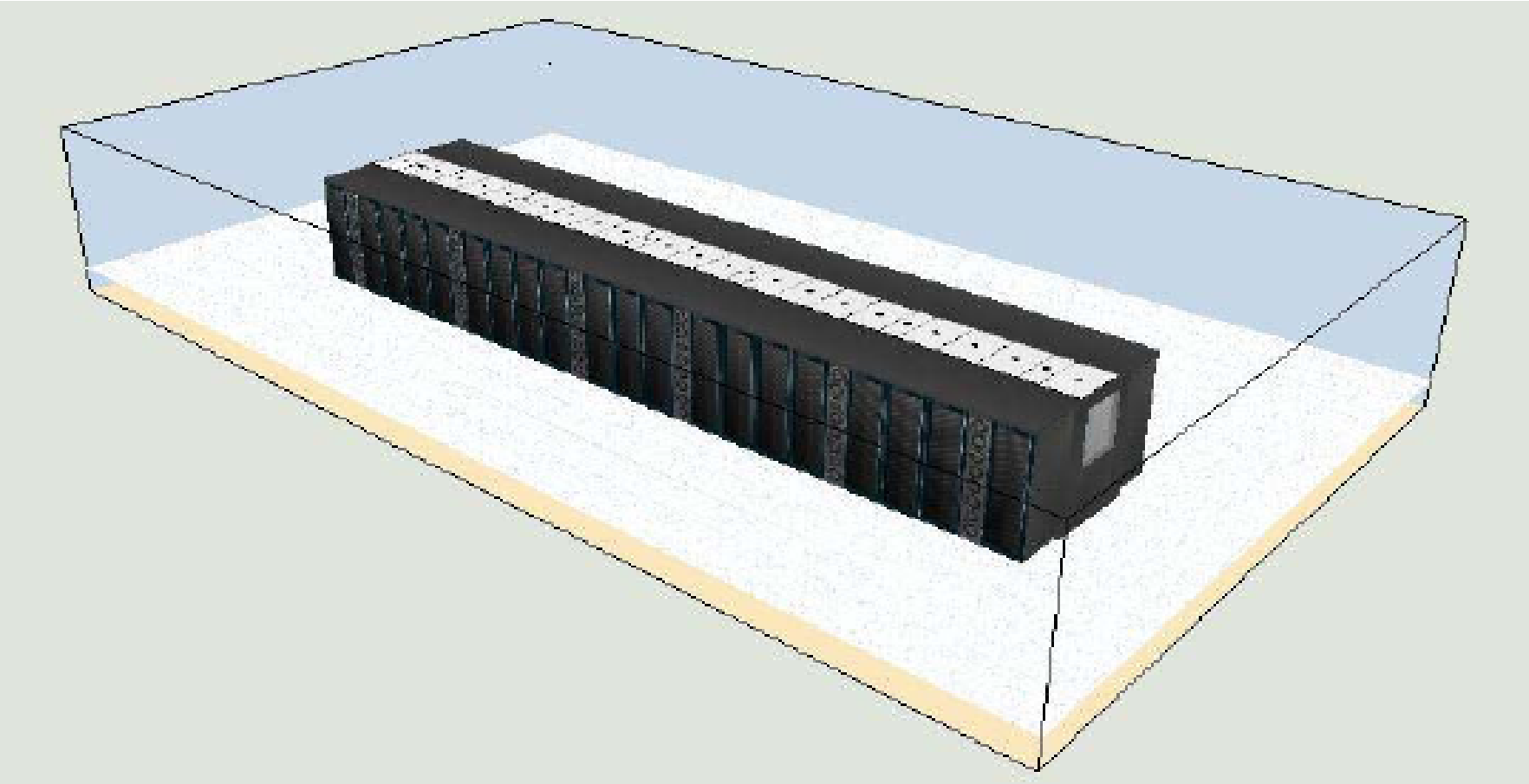
Hot Aisle vs. Cold Aisle Containment System

Example - 200 kW InRow Data Center:

40 racks with 5 kW per rack

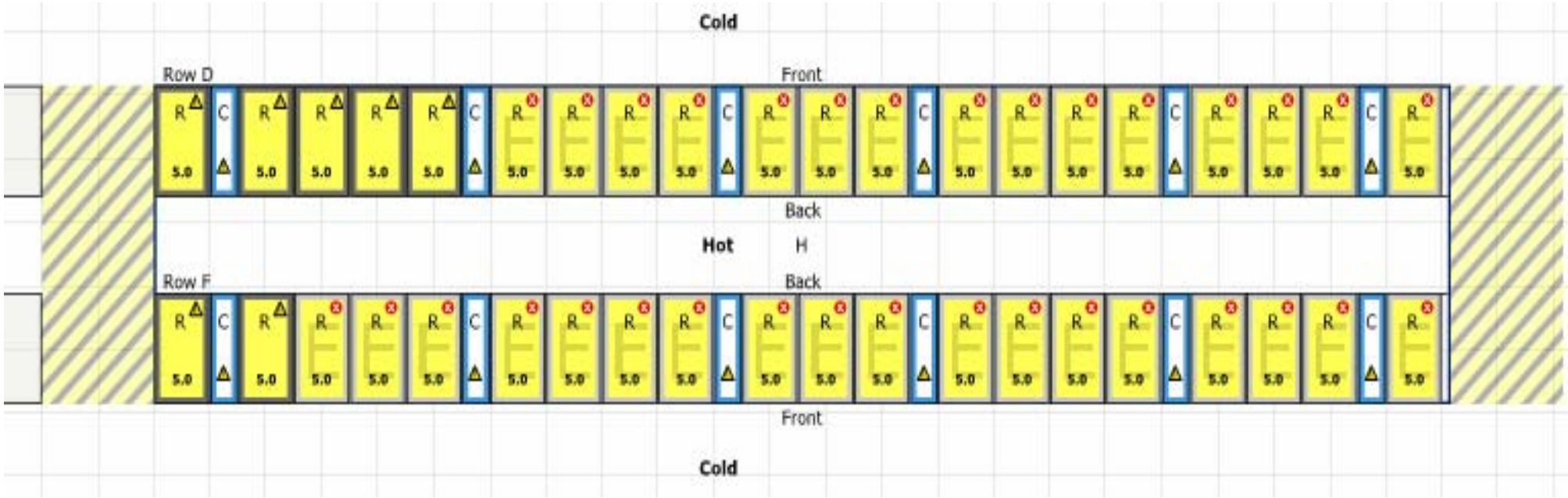
Row Based cooling with Chilled Water IRAH units on hard or raised floor

Hot Aisle Containment System; 200 kW cooling at N Capacity.



Hot Aisle vs. Cold Aisle Containment System

Example - 200 kW InRow Data Center:
(12) Model ACRC100 CW Horizontal Airflow units (IRAH)
Hot Aisle Containment System; 200 kW cooling at N Capacity.



Hot Aisle vs. Cold Aisle Containment System

Example - 200 kW InRow Data Center:

N Cooling with Model **ACRC100** (CW, Horizontal Airflow, Max. 2,900 CFM per unit.
Total IT Airflow = 200 kW x 160 CFM/kW = 32,000 CFM
Airflow IRAH Quantity = 3200 / 2,900 = 11.1 units, round up to (12) IRAH (InRow Air Handler).

IRAH Fan HP (full speed) = 1.1 kW
(12) IRAHs at full fan speed = 13.2 kW

Supply Airflow per IRAH = 32,000 / 12 units = 2,670 CFM per IRAH
IRAH Fan HP (2,670 CFM) = 0.96 kW
(12) IRAHs at 2,760 CFM fan speed = 11.54 kW

Results 12.5% Fan Power savings at reduced speed: 1,195 kW-Hr per month
ACRC100 Coil capacity at 2,670 CFM = 61.5 MBH (18 kW) each
(12) IRAHs x 18 kW cooling each = 216 kW net sensible cooling

Hot Aisle vs. Cold Aisle Containment System

Example - 200 kW Data Center:

Energy (Power) Consumption 200 kW Example Summary:

1. (3) Model PCW1500 use 10.7 kW fan motor power to cool 200 kW data center with Cold aisle containment. . .

2. (4) Model PCW900 use 13.7 kW fan motor power to cool 200 kW data center with Cold aisle containment. . .

3. (12) Model ACRC100 use 11.54 kW fan motor power to cool 200 kW data center with Hot aisle containment. . .

Hot Aisle vs. Cold Aisle Containment System

Characteristic	Cold Aisle Containment	Hot Aisle Containment	Comment
Efficiency improvements	Yes/Maybe	Yes/Maybe	HACS is more efficient than CACS because HACS typically operates at a higher return temperature due to isolation of the return hot air from the rest of the room. Reduced fan power depends on Supply Airflow match to IT Airflow
Ability to increase air supply set point without impacting entire data center	No	Yes	With HACS, cooling set points can be set higher while still maintaining a comfortable room work environment. Increasing CACS cooling set points results in uncomfortably higher data center environment.
Leverages maximum number of potential free cooling days for air side economizer	No	Yes	By preventing mix of hot aisle and cold aisle air, and increasing cooling supply air set point, containment systems allow for increased free cooling days. However, increasing the set point of CACS results in increased room temperatures and increased air system power to exhaust warm room air.
Room neutral solution	No	Yes	A HACS deployment is a “drop-in” room neutral solution. CACS impacts the surrounding data center infrastructure.

Hot Aisle vs. Cold Aisle Containment System

Characteristic	Cold Aisle Containment	Hot Aisle Containment	Comment
Ease of deployment with room cooling	Yes/Maybe	No/Maybe	CACS is preferred when using room level cooling with a free return system which draws its return air from the room. A HACS with perimeter cooling would require return duct work or ceiling plenum.
Ability to scale for high density	No	Yes	CACS is often implemented with raised floor and inefficient fan assisted floor tiles are needed in order to achieve higher density.
Room neutral design	No	Yes	HACS is "room neutral"—it does not impact the outside room temperature in any way. CACS makes the air outside of the contained rows warmer.
Adverse temperature impact on non-racked equipment	Yes	No	With CACS, because the cold aisles are contained, the rest of the data center is allowed to become hot. Equipment outside the contained areas would have to be evaluated for operation at elevated temperatures.

Hot Aisle vs. Cold Aisle Containment System - Summary

- Hot Aisle and Cold Aisle Containment eliminate air mixing and are an improved solution compared to traditional cooling architecture

- Hot Aisle Containment System (HACS) is a more efficient approach than Cold Aisle Containment System (CACS) because the HACS methodology allows for the channeling the IT exhaust air directly into cooling units, avoiding supply/return air losses.

- HACS used with Row based cooling architecture provides closed couple cooling that allows higher cooling coil capacity utilization and efficiency of fewer cooling units.

- HACS can be deployed in an existing data center as a “room neutral” IT zone.

Hot Aisle vs. Cold Aisle Containment System - Summary

- HACS is more flexible, it can be deployed anywhere within the room. It can include only IT equipment in the HACS, with no impact on equipment outside the HACS.

- HACS with Row based cooling is more predictable and scalable solution; it addresses the higher IT density and higher server exhaust air operating temperatures.

- HACS has higher potential for better utilization of free cooling air economizer approaches. IT Hot air is already captive, and only requires active ducting to outside air for economizer.

- HACS has **better ride through capability** when cooling system experiences decrease in capacity.

Hot Aisle vs. Cold Aisle Containment System
- References -

- Emerson-Liebert White Paper *Focused Cooling Using Cold Aisle Containment.*

- APC-Schneider White Paper #135 - *Hot Aisle vs. Cold Aisle Containment.*

- SearchData Center Live Podcast Audio – Media.TechTarget.com
http://media.techtarget.com/audioCast/DATA_CENTER/062409_SDC_WEBISODE2_mixdown.mp3

- Emerson-Liebert CRV - http://www.liebertcrv.com/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Thank you