Task Force	Task Force, Chair	Members
Data Center – Cooling	Mr Raghuveer Singh, Vertiv Energy Pvt Ltd	• Mr Shankar KM, STT GDC • Mr PC Lohia, Reliance • Mr B Rajput, NIC • Mr Angela Barboza, Rittal • Mr Punit Desai, Infosys • Mr Mario Dias, NetApp • Mr Shubhabrata Sengupta, CtrlS • Mr Gopi Ravi, Stulz

A Joint Initiative to

"Enhance Energy Efficiency in Indian Data Centers"

by

CII-Indian Green Building Council (IGBC) and

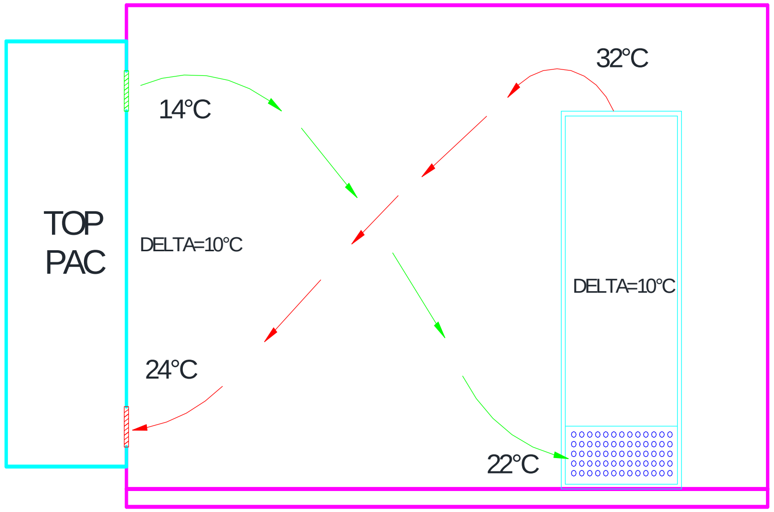
Lawrence Berkeley National Laboratory (LBNL), U.S. Department of Energy

CRAC Equipment Efficiency

Measure Type	ECBC Compliant	ECBC+ & Level II	SuperECBC & Level III
CRAC Equipment Efficiency	✓ Minimum Net Sensible Coefficient of Performance (SCOP) value of 2.5 for both Downflow & Upflow. ECBC Reference (Section 5.2.2.4)	Recommended for Level II ✓ Minimum Net Sensible Coefficient of Performance (SCOP) value of 3.0 for both Downflow & Upflow.*	Recommended for Level III ✓ Minimum Net Sensible Coefficient of Performance (SCOP) value of 3.5 for both Downflow & Upflow.*
Comments on CRAC Equipment Efficiency	**Comments on the ECBC Compliant:** ✓ 2.5 NSCOP (Net Sensible Coefficient of performance) is achievable for upflow and downflow ✓ Refer AHRI 1360/1361 for the design operating condition	**Comments on the ECBC+:** ✓ 2.9 NSCOP (Net Sensible Coefficient of performance) is achievable for upflow and downflow (with fan above floor) ✓ 3 NSCOP is achievable with fan under floor (min 600mm clear false floor height) ✓ Refer AHRI 1360/1361 for design inputs **Group recommendations:** ✓ We recommend only downflow CRAC for the ECBE+ & superECBC ✓ We propose minimum 600mm clear false floor height ✓ We propose to use higher return air temperature (RAT) of 34 deg.C or above. because ASHRAE has increased supply air range limit ✓ We recommend to use CRAC with Fan under the floor	**Comments on the superECBC:** ✓ 3.1 NSCOP (Net Sensible Coefficient of performance) is achievable for upflow and downflow (with fan above floor) ✓ 3.2 NSCOP is achievable with fan under floor (min 600mm clear false floor height) ✓ Refer AHRI 1360/1361 for design inputs **Group recommendations:** ✓ We recommend only downflow Units for the ECBE+ & superECBC ✓ We propose to use higher return air temperature (RAT) of 38 deg.C RAT or above ✓ At higher RAT, we can achieve NSCOP higher than 3.5 ✓ We recommend to use CRAC with Fan under the floor

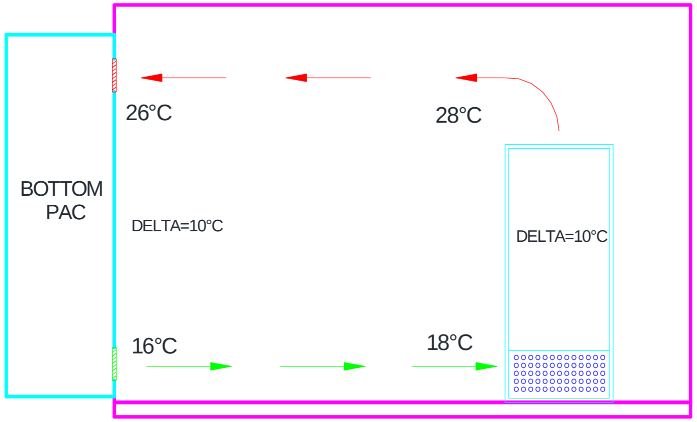
CRAC Equipment Efficiency – why Top Discharge Units are not recommended by Data Centre cooling Group

TOP DISCHARGE PAC



AMB 33°C 70%RH
DEWPOINT = 26.94°C

BOTTOM DISCHARGE PAC



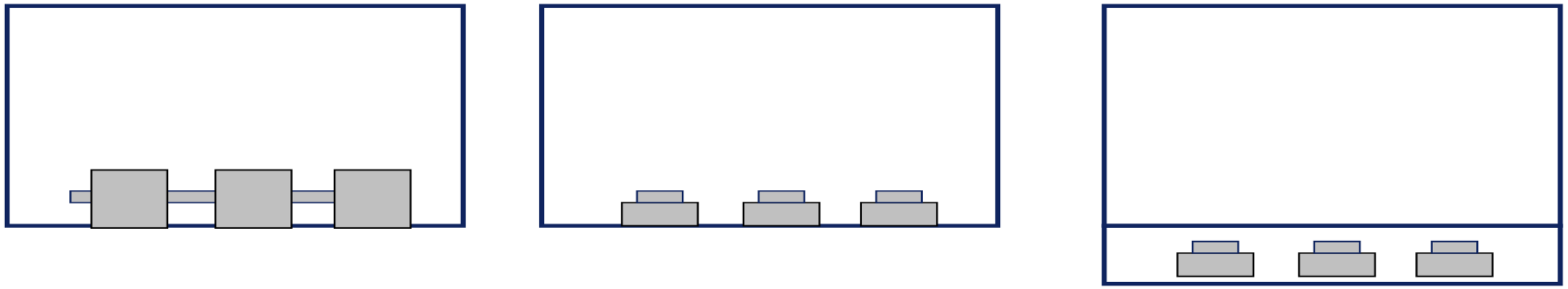
AMB 33°C 70%RH
DEWPOINT = 26.94°C

Inefficiency of Top throw PAC vs Bottom throw PAC

CRAC Equipment Efficiency – why CRAC with Fan under the floor is recommended by Data Centre cooling Group

Fan Systems – Energy Analysis Based on Test at ETL (Independent Lab)

Blower System 'A' | Blower System 'B' | Blower System 'C'



Blower System 'A'

- Qty (3) Centrifugal Blowers
- Belt-driven, common shaft
- 16,300 CFM
- 8.6 kw
- approx $5,800 annual operating cost @$0.08/kwhr

Blower System 'B'

- Qty (3) Motorized Impellers
- Direct-drive
- 16,400 CFM
- 6.9 kw
- approx $4,800 annual operating cost @$0.08/kwhr
- 4-year payback

Blower System 'C'

- Qty (3) Motorized Impellers underfloor
- Direct-drive
- 16,400 CFM
- 5.5 kw
- approx $3,800 annual operating cost @$0.08/kwhr
- 2.5 year payback

Air Management

Measure Type	ECBC Compliant	ECBC+ & Level II	SuperECBC & Level III
Air Management	-NONE-	**Recommended for Level II** ✓ Hot & Cold Aisles* ✓ Include air barriers such that there is no significant air path for hot IT discharge air to recirculate back to the IT inlets without passing through a cooling system.* ✓ Target IT inlet temperature shall be no more than 6˚C higher than the cooling system supply temperature. * ✓ Provide variable fan speed to minimize excess airflow. No more than 30% extra supply air relative to IT airflow. *	**Recommended for Level III** ✓ Target IT inlet temperature shall be no more than 3˚C higher than the cooling system supply temperature.* ✓ Provide variable fan speed to minimize excess air-flow. No more than 15% extra supply air relative to IT airflow.*

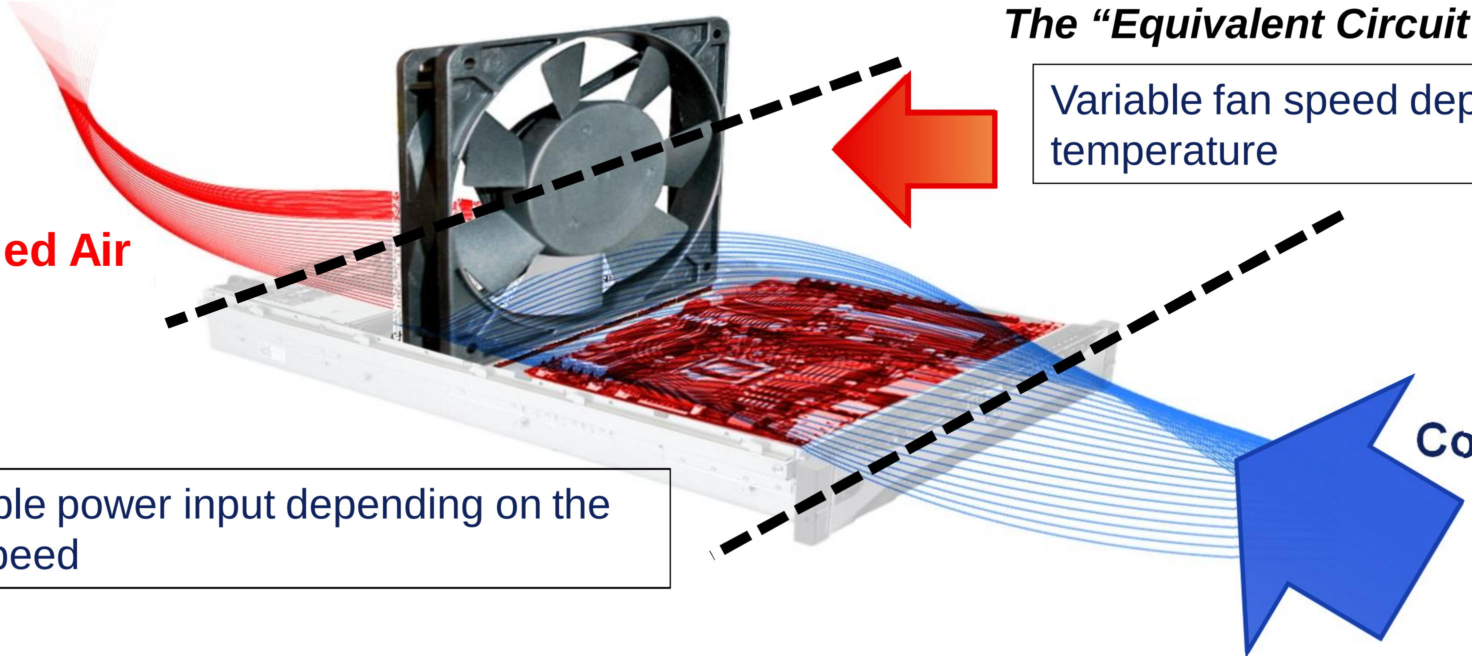
Air Management - Everything Starts from the Server

…When IT Works, IT Makes Heat

The "Equivalent Circuit"

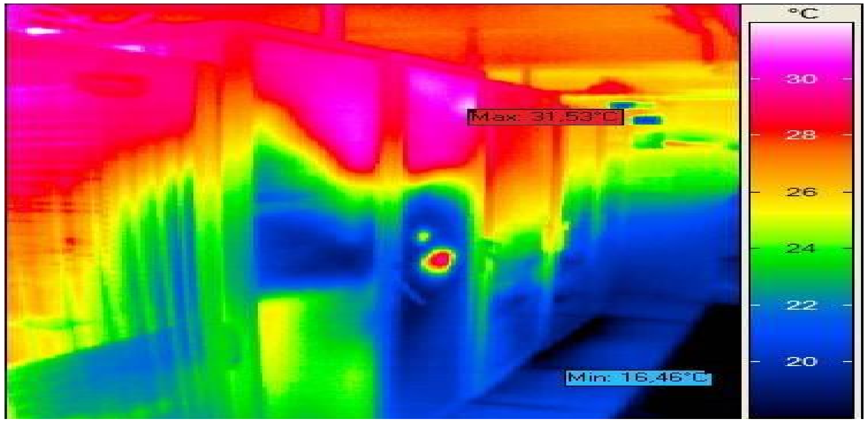
Variable fan speed depending on inlet temperature

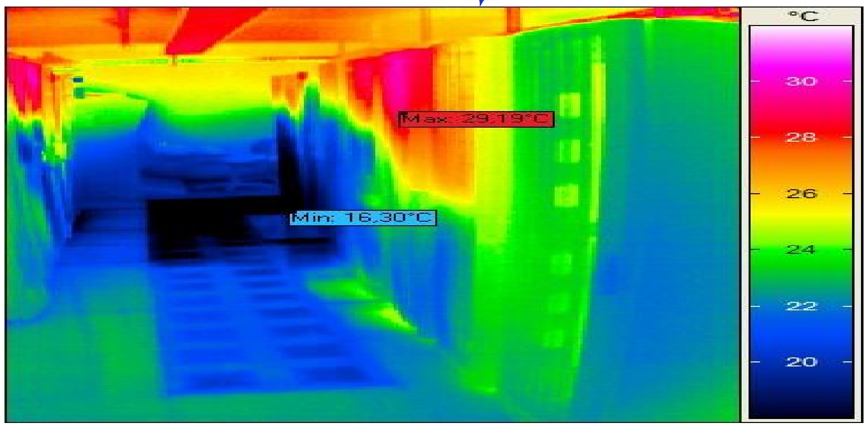
Hot Discharged Air



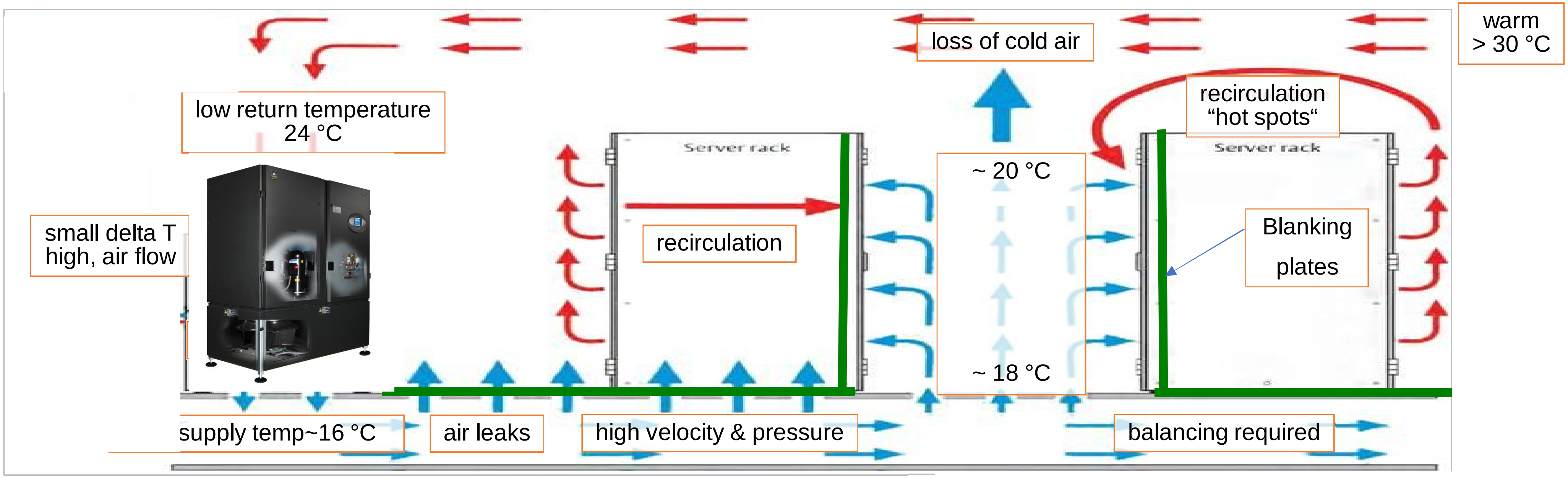
Cold Supply Air

Variable power input depending on the fan speed



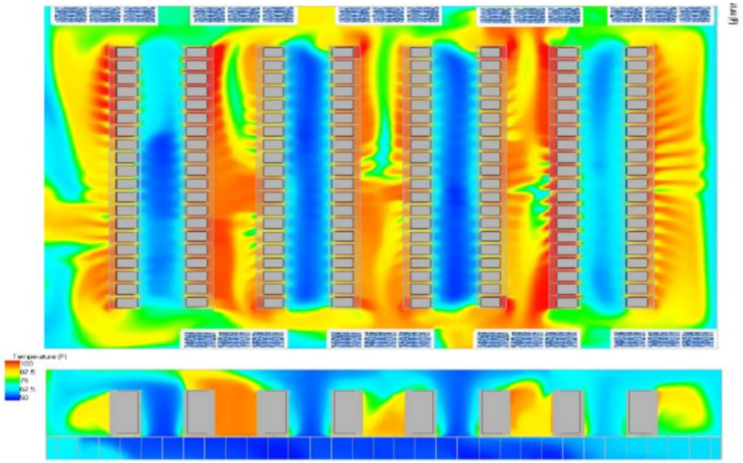


Air Management: ECBC+

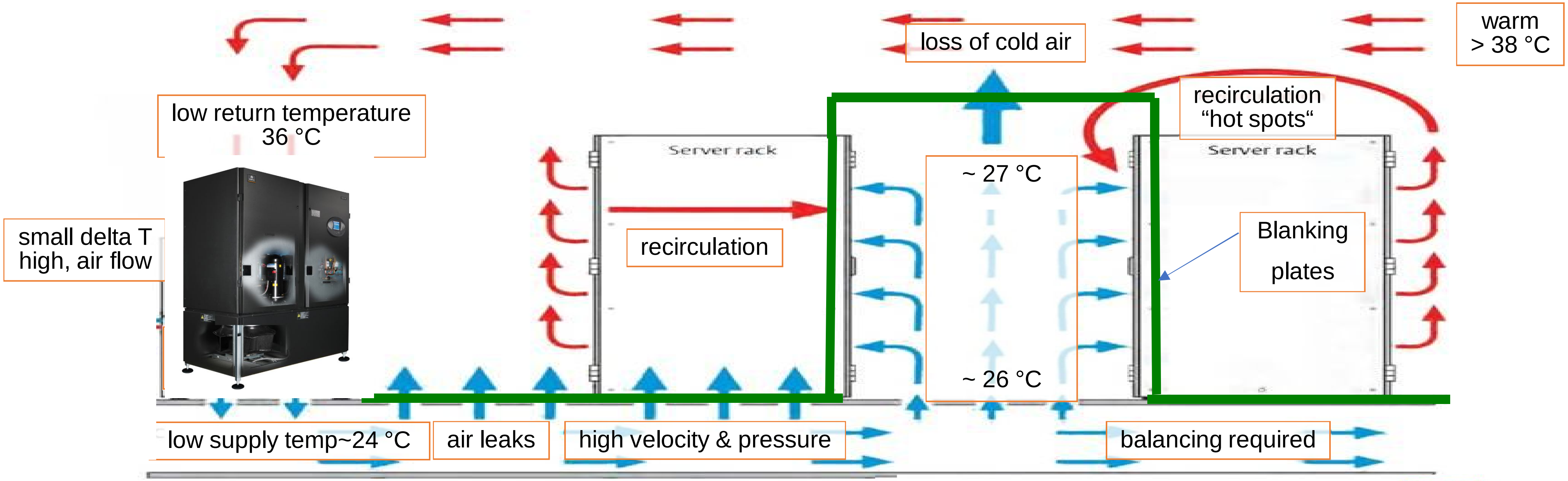


Comments on the ECBC+ :

A. Racks should be aligned properly in hot & cold aisle configuration and gaps between the racks must be closed fully to eliminate the hot/cold air mixing
B. Blanking plates should be used to eliminate the recirculation of hot / Cold air mixing from the aisles
C. Target inlet temperature should be no more than 4˚C higher than the CRAC Supply air without containment
D. We recommend EC fans instead of VFD
E. Units should operate on fixed supply air temperature control, not return air temperature control
F. Open architecture without containment, No more than 20% extra supply air relative to IT airflow
G. We recommend to add variable capacity based (Digital/Inverter) DX CRAC to maintain constant supply air temperature

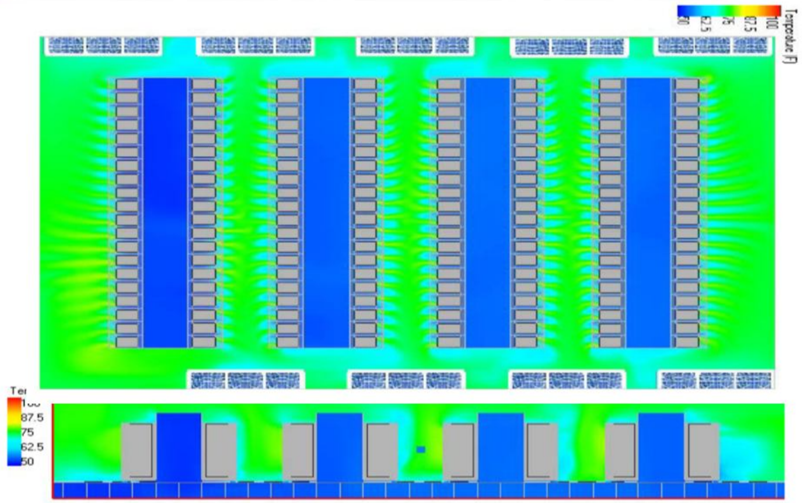


Air Management: ECBC+



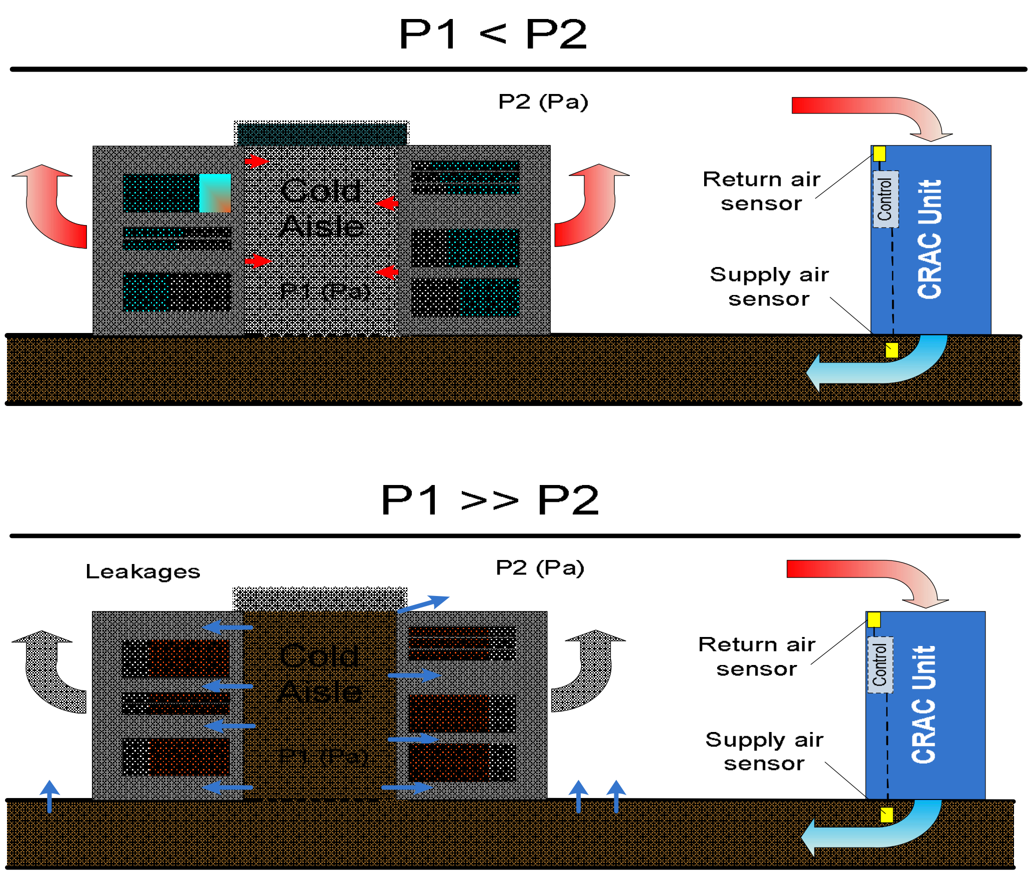
Group recommendation:

A. All recommendation of ECBC+
B. We would like to recommend full containment wherever possible. This will improve the power consumption of the CRAC Units
C. Manufacturer should design Units suitable for ASHRAE server inlet temperature recommendations (18 to 27 Deg.C)
D. Target inlet temperature should be no more than 3˚C higher than the CRAC Supply air with containment
E. Units should operate on fixed supply air temperature control, not return air temperature control
F. Open architecture without containment, No more than 10% extra supply air relative to IT airflow

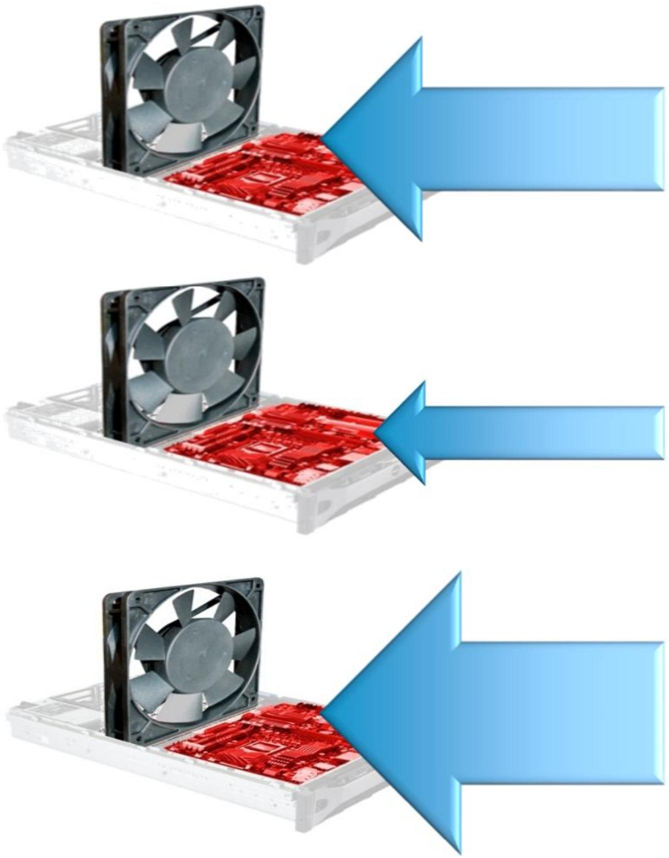


Air Management: Why Not Just Containment?

- Servers are not getting enough air
- Risk of hot air intrusion into the cold aisle
- Over-blowing server fans
- Loss of cold air = low efficiency
- Reducing server fans life-time
- Monitoring & Controls?



Air Management: Airflow Can Vary -
Thermal Solution Always Needs to Match It!



q_1

q_2

q_n

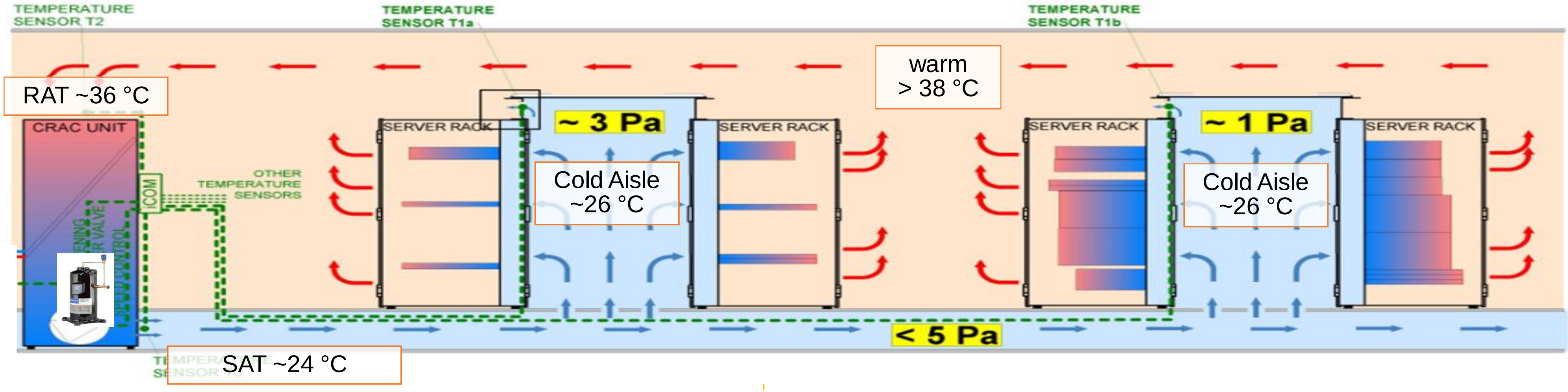
Servers' Airflow

$$q_{servers} = q_1 + q_2 + \ldots q_n$$

Cooling Unit Airflow

$$q_{cooling} = q_{servers}$$

Air Management – SuperECBC



Comments on the SuperECBC :

A. All recommendations of ECBC+
B. Target inlet temperature should be no more than 4˚C higher than the CRAC Supply air Temperature
C. Open architecture with containment, No more than 10% extra supply air relative to IT airflow
D. Dynamic Airflow and capacity control and monitoring by differential Pressure sensors or Cold aisle remote sensors. Cold remote temperature sensor logic is more preferred for controlling the CRAC fan speed as it provided better control on the aisle conditions and this control allows fans to operate at slightly lower power compared to differential pressure logic where fans are set to run at minimum static, thus resulting in higher power savings
E. Pressure Control Setting: P1: Inside the unit body or outside in the room & P2: In the raised floor or cold aisle, Open architecture: ~ 20 Pa. Hot / cold aisle containment: ~ 10– 20 Pa
F. Remote temperature sensor Setting: 1 or 2 Deg.C higher than the Supply Air temperature settings
G. Manufacturer must design CRAC Units to satisfy ASHRAE IT inlet temperature limits

Group recommendation:

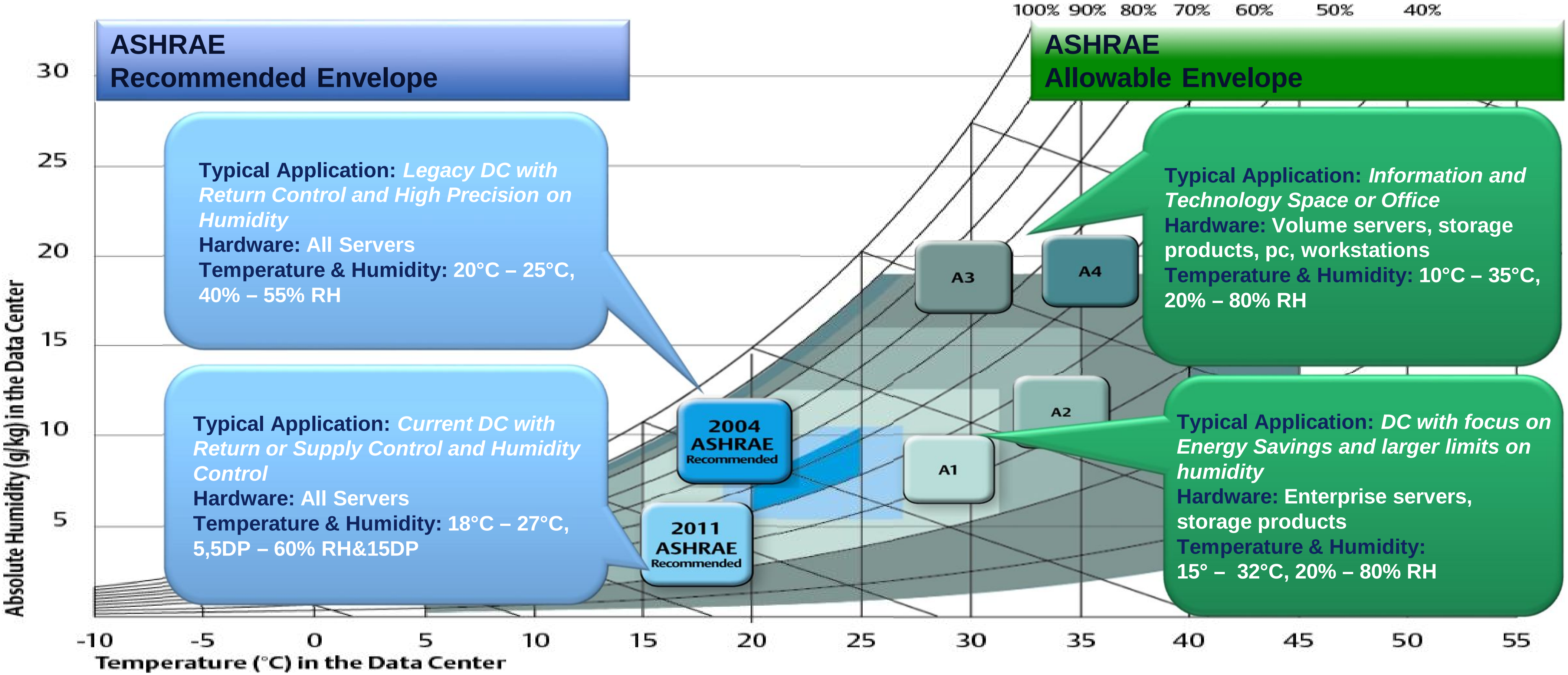
A. All recommendation of ECBC+
B. Target inlet temperature should be no more than 2˚C higher than the CRAC Supply air Temperature
C. Open architecture with containment, No more than 10% extra supply air relative to IT airflow
D. Dynamic Airflow and capacity control and monitoring by differential Pressure sensors or Cold aisle remote sensors. Cold remote temperature sensor logic is more preferred for controlling the CRAC fan speed as it provided better control on the aisle conditions and this control allows fans to operate at slightly lower power compared to differential pressure logic where fans are set to run at minimum static, thus resulting in higher power savings . Above picture, depicts the cold aisle remote temperature sensor logic.
E. Pressure Control Setting: P1: Inside the unit body or outside in the room & P2: In the raised floor or cold aisle, Open architecture: ~ 20 Pa. Hot / cold aisle containment: ~ 10–20 Pa
F. Remote temperature sensor Setting: 1 or 2 Deg.C higher than the Supply Air temperature settings
G. Manufacturer must design CRAC Units to satisfy ASHRAE IT inlet temperature limits

Temperature & Humidity Control

Measure Type	ECBC Compliant	ECBC+ & Level II	SuperECBC & Level III
Temperature & Humidity Control	✓ Each floor or building block shall be installed with at least one control to manage the temperature. ✓ Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3.0°C within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum. ✓ Where separate heating and cooling equipment serve the same temperature zone, temperature controls shall be interlocked to prevent simultaneous heating and cooling. ✓ Separate thermostat control shall be in each computer room of educational.	**ECBC+** In addition to ECBC Compliant: ✓ Centralized demand shed controls shall have capabilities to be disabled by facility operators and be manually controlled by a central point by facility operators to manage heating and cooling set points. ✓ Supply air temperature reset capabilities. Controls shall reset the supply air temperature to at least 25% of the difference between the design supply air temperature and the design room air temperature. ✓ Chilled water systems with a design capacity>350 kWr supplying chilled water to comfort conditioning systems shall have controls that automatically reset supply water temperatures by representative building loads (including return water temperature) or by outdoor air temperature. ✓ Exceptions : Controls to automatically reset chilled water temperature shall not be required where the supply temperature reset controls causes improper operation of equipment. ECBC Reference ECBC 2017, Sections 5.2.4.1 - 5.2.4.3	**Super ECBC** ✓ Same as ECBC+ ECBC Reference ECBC 2017, Sections 5.2.4.1 - 5.2.4.3

Temperature & Humidity Control -

ASHRAE - Operating Thresholds



Temperature & Humidity Control

Measure Type	ECBC Compliant	ECBC+ & Level II	SuperECBC & Level III
Comments on Temperature & Humidity Control	**Comments on the ECBC Compliant**: ✓ Application rooms which requires controls on cooling & Heating humidification & De-humidification, all devices should be part of one CRAC to prevent modes fighting. Maintaining the temperature should be given priority over Humidity.	**Comments on the ECBC+ :** ✓ CRAC temperature, humidity, heating, de-humidification , all modes to be monitored from central monitoring systems ✓ CRAC Controller should be designed to set and operate within AHRAE recommended limits ✓ Controls to prevent simultaneous humidification & dehumidification, heating & cooling ✓ CRAC Control must be on supply air temperature & humidity (not return air) ✓ Supply air temperature control can work with variable capacity units as fix capacity units can not maintain constant supply air temperature thus variable capacity units should be used **Group Recommendations:** ✓ CRAC ability to operate at the upper limit of the ASHRAE recommended temperature range Means systems to support high supply air temperature 26/27deg.C and return air temperature of 38/40 deg.C ✓ Dew Point control to be adopted instead of RH ✓ We recommend team mode operation	**Comments on the ECBC+ :** ✓ Meet level ECBC+ specs and following additional points ✓ Along with supply air temperature control, evaporator fan speed should be controlled by differential pressure or by cold aisle remote temperature sensor control methods. Whenever load is less fan speed should be reduced vice versa ✓ Fan speed controlled from server air inlet temperature will be preferred **Group Recommendations:** ✓ CRAC ability to operate at the upper limit of the ASHRAE recommended temperature range Means systems to support high supply air temperature 26/27deg.C and return air temperature of 38/40 deg.C ✓ Dew Point control to be adopted instead of RH ✓ Sever inlet temperature control and airflow control information to be shared on central monitoring system ✓ We recommend team mode operation

Fan Control

Measure Type	ECBC Compliant	ECBC+ & Level II	SuperECBC & Level III
Fan Control	-NONE-	**Recommended for Level II** ✓ Provide variable fan speed to minimize excess airflow.* ✓ Fans in Variable Air Volume (VAV) systems shall have controls or devices that will result in fan motor demand of no more than 30% of their design wattage at 50% of design airflow based on manufacturer's certified fan data.* As required by SuperECBC	**SuperECBC** ✓ Fans in Variable Air Volume (VAV) systems shall have controls or devices that will result in fan motor demand of no more than 30% of their design wattage at 50% of design airflow based on manufacturer's certified fan data. ECBC Reference ECBC 2017, Section 5.2.5.1
Comments on Fan Control	-NONE-	**Comments on the ECBC+ & super CEBC** **EC fans should be used in CRAC**