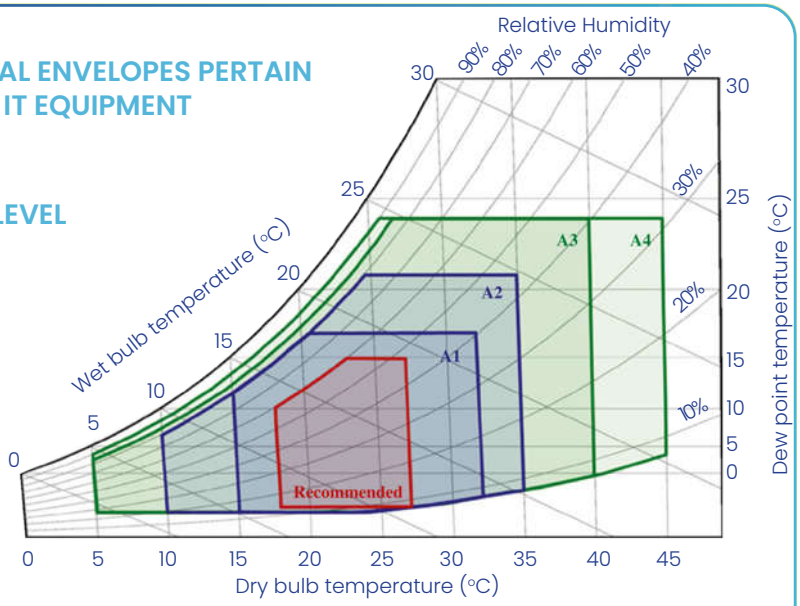
# DC ASHRAE
## THERMAL GUIDELINE

ASHRAE's Technical Committee 9.9 provided recommendation on temperature and humidity ranges for reliable operation of IT equipment. Earlier in 2021, ASHRAE's Technical Committee 9.9 published an update 2021 ASHRAE Thermal Guidelines for Data Processing Environments, Fifth Ed. The update recommends important changes to data center thermal operating envelopes.

The guideline recommends that the server inlet air temp to be between 18-27°C. Recommended high RH expanded to 70%, but it is conditional on the data hall having low concentrations of pollutant gases. Low moisture limit lower to -9C. Uptime Institute further recommends that the upper limit be reduced to 25°C to allow for upsets, variable conditions in operation, or to compensate for errors inherent in temperature sensors and/or controls systems. For the upper moisture limit, the limit is the minimum absolute humidity of the DP andRH stated. For the lower moisture limit, the limit is the maximum absolute humidity of the DP and RH stated.

**THESE ENVIRONMENTAL ENVELOPES PERTAIN TO AIR ENTERING THE IT EQUIPMENT**

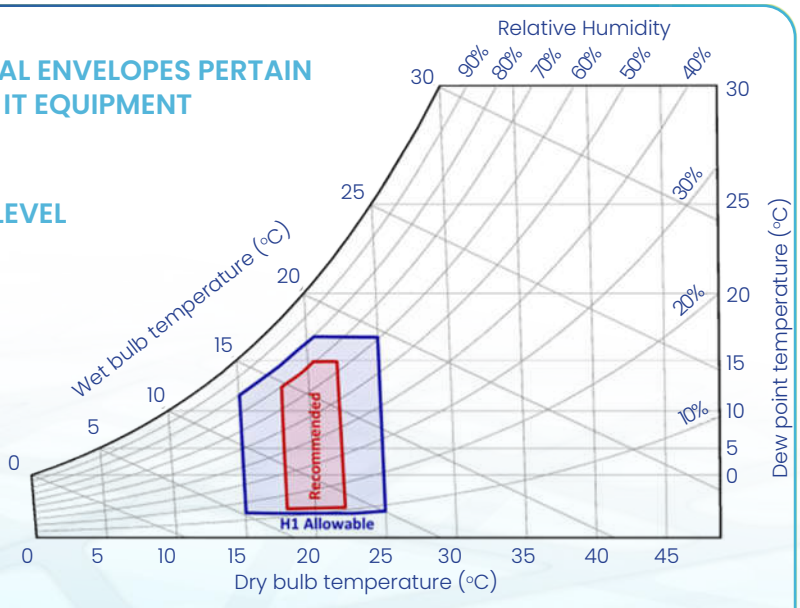
**CONDITIONS AT SEA LEVEL**




For the upper moisture limit, the limit is lower value of DP and RH stated.
For the lower moisture limit, the limit is higher value of the DP and RH stated

**THESE ENVIRONMENTAL ENVELOPES PERTAIN TO AIR ENTERING THE IT EQUIPMENT**

**CONDITIONS AT SEA LEVEL**




New class, H1,high density IT. ASHRAE does not stipulate what makes a system class H1, IT vendor to specify.

Red zone: Recommended range  Blue zone: Allowable range for limited operating period

# DC ASHRAE
## THERMAL GUIDELINE

Since the original release in 2004, ASHRAE's Thermal Guidelines have been instrumental in setting cooling standards for data centers globally. The 9.9 committee continuously update the thermal guideline based on the rapid IT development.

In terms of humidity control in DC, it used to recommend narrow RH range. From fourth version, low moist level could be lower to -9 C DP, which means normally humidification is not required for almost all DC.

High RH limit still be recommended due to the concern of corrosion of pollutant gases. Low RH is not a concern because electro-static discharge (ESD) can be well controlled by regulated working process and power system design In the fifth edition, relative humidity (RH) extend the range up to 70% (the previous cut-off was 60%), this is conditional on the data hall having low concentrations of pollutant gases. If the presence of corrosive gases is above the set thresholds, ASHRAE now recommends operators keep RH under 50% — below its previous recommended limit.

TABLE 1:
2021 THERMAL GUIDELINES FOR AIR COOLING-SI VERSION

| EQUIPMENT ENVIRONMENT SPECIFICATIONS FOR AIR COOLING | | | | | | | |
|---|---|---|---|---|---|---|---|
| | PRODUCT OPERATION | | | | | PRODUCT POWER OFF | |
| CLASS | Dry-Bulb Temp., °C | Humidity Range, Noncond. | Max. Dew Point, °C | Max. Elev., m | Max. Rate of Change, °C/h | Dry-Bulb Temp., °C | RH, % |
| Recommended (suitable for Classes A1 to A4; explore date center metrics in this book for conditions outside this range) | | | | | | | |
| A1 to A4 | 18 to 27 | -9 °C DP to 15 °C DP and 70%rh or 50%rh | | | | | |

TABLE 2:
EVOLUTION OF RECOMMENDED AIR-COOLED DATA CENTER ENVIRONMENTAL CONDITIONS

| Class | FIRST EDITION 2004 | SECOND EDITION 2008 | THIRD EDITION 2012 | FOURTH EDITION 2015 | FIFTH EDITION 2021 |
|---|---|---|---|---|---|
| Recommended Temperature (A1-A4) | 68°F to 77°F | 64.4°F to 80.6°F | 64.4°F to 80.6°F | 64.4°F to 80.6°F | 64.4°F to 80.6°F |
| Recommended Temperature (H1) | N/A | N/A | N/A | N/A | 64.4°F to 71.6°F |
| Recommended Relative Humidity (All Classes) | 40% to 55% RH | 60% RH Max. (See Dew Point for Min.) | 60% RH Max. (See Dew Point for Min.) | 60% RH Max. (See Dew Point for Min.) | 70% RH Max. Or 50% Max. |
| Recommended Dew Point (All Classes) | N/A | 41.9°F to 59°F | 41.9°F to 59°F | 15.8°F to 59°F | 15.8°F to 59°F |

# DC POWER USAGE EFFECTIVENESS (PUE)

## PUE

Power Usage Effectiveness  measure of how efficiently a Data Centre uses its power, how much of the power is actually used by the computing equipment (in contrast to cooling and other overheads).

**PUE= Total Facility Load/IT Load,**
**Total facility load=IT load +infrastructure load**

Cooling is the majority of Infrastructure energy In a typical  data centre. Some existing lousy DC, its cooling energy could be larger than IT load and DC PUE could be hight than 2. To achieve lower PUE and minimized DC energy consumption, DC cooling system operating efficiency is critical.

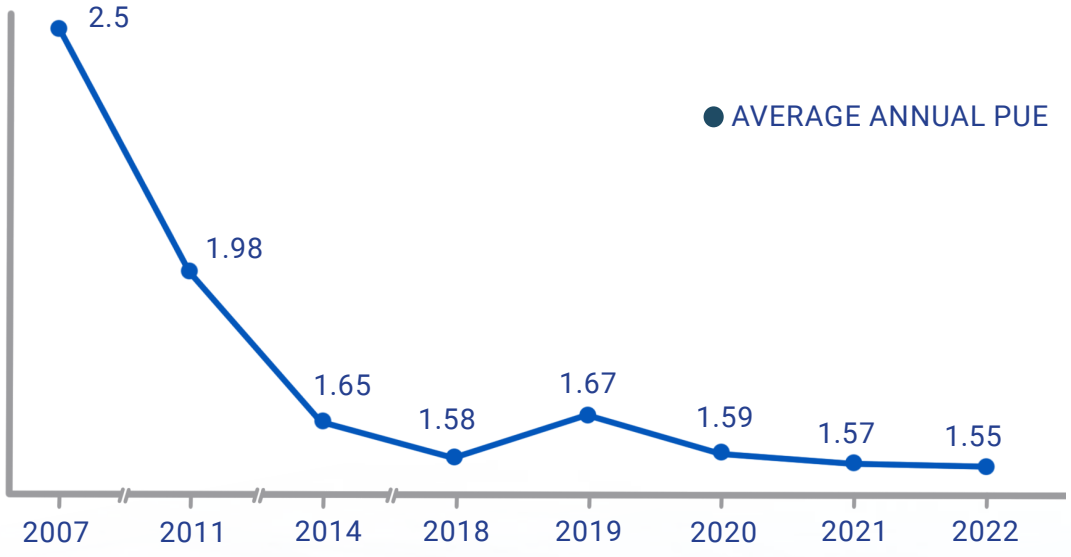
Based on Uptime Institute research, the average annual PUE is around 1.55 currently which is typically based on air cooling. With the development of liquid cooling and hybrid cooling, PUT could be lower to 1.1 or even lower.

For air cooling dominant DC, Efficient DC PUE is target to be 1.2-1.5 depending on weather location and project requirements.

For SEA, Sg DC Green mark criteria provides a good reference, which evaluates DC PUE at different part load, and more critical at 25% of IT load and better air distribution.

### PUE PROGRESS HAS STALLED

What is the average annual PUE for your largest data center? (n=669)




SOURCE: UPTIMEINSTITUTE.COM

| PUE | DCiE | Level of Efficiency |
|---|---|---|
| 3.0 | 33% | Very Inefficient |
| 2.5 | 40% | Inefficient |
| 2.0 | 50% | Average |
| 1.5 | 67% | Efficient |
| 1.2 | 83% | Very Efficient |

SOURCE: GREEN GRID

# GM NDC
## 2019 GREEN MARK FOR NEW DATA CENTRES
## PREREQUISITE REQUIREMENTS FOR NEW DATA CENTRE CRITERIA

### P.1 POWER USAGE EFFECTIVENESS (PUE)

| Green Mark Rating | PUE at 25% IT Load |
|---|---|
| Green Mark Gold | 1.60 |
| Green Mark Gold$^{PLUS}$ | 1.55 |
| Green Mark Platinum | 1.50 |

Note:
1. PUE is a metric that illustrates data centre efficiency using the total annual facility energy divided by total annual IT equipment energy. The IT equipment energy shall be measured at PDU output [PUE category 2]. Please refer to SS 564 for PUE definition.
2. PUE performance of the data centres shall be determined using energy modelling software at the 25%, 50%, 75% and 100% of IT load.

### SECTION 1 ENERGY EFFICIENCY
### 1.1 POWER USAGE EFFECTIVENESS (PUE)

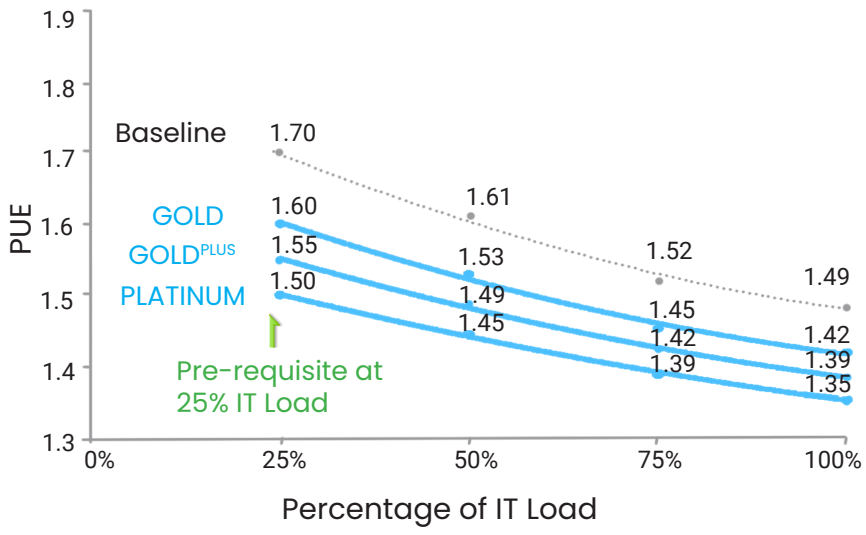
Use a computer simulation to access the energy performance of the proposed data centre to achieve the most efficient design.

Compute PUE at various load points, 25%, 50%, 75% and 100% of the IT load under Singapore climatic conditions.

As data centres often operate at part load, the design of data centre and cooling systems should aim to achieve good efficiency at part load.

| | PUE at 25% IT load |
|---|---|
| Baseline | 1.7 |

#### PUE REFERENCE CURVE




### PUE SCORING METHODOLOGY:

PUE at 25% IT load is used for base point calculation. However, if PUEs at 50% or 75% cannot meet the reference PUE curve of respective ratings, points will be deducted, i.e. Base Point = 1.4 x (Percentage Improvement at 25% IT load from Baseline PUE)

Final Point = Point scored x [ 1- (20 x highest % deviation from the reference PUE curve at 50% or 75% IT load)]

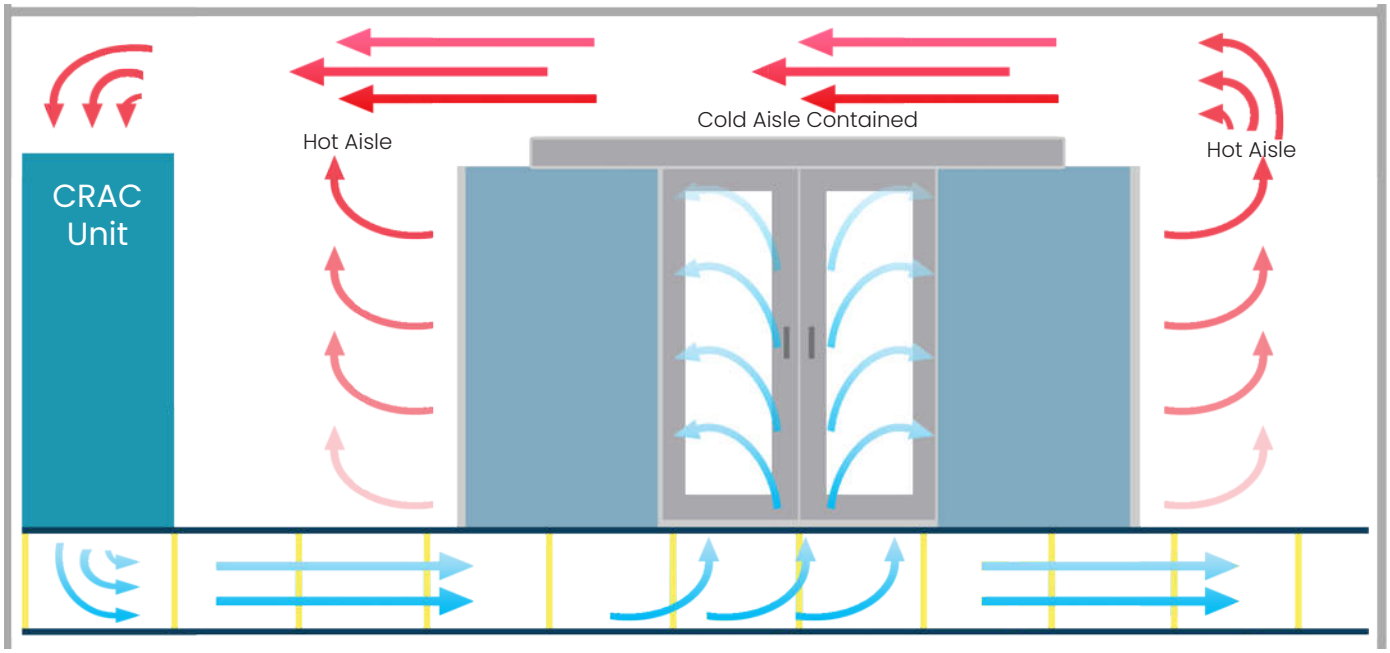
Note: The PUE Deviation Percentage shall be capped at 2%.
For project with PUE<1.4, there are maximum another 3 points available in sec 5 (h)

# DATA HALL AIR DISTRIBUTION

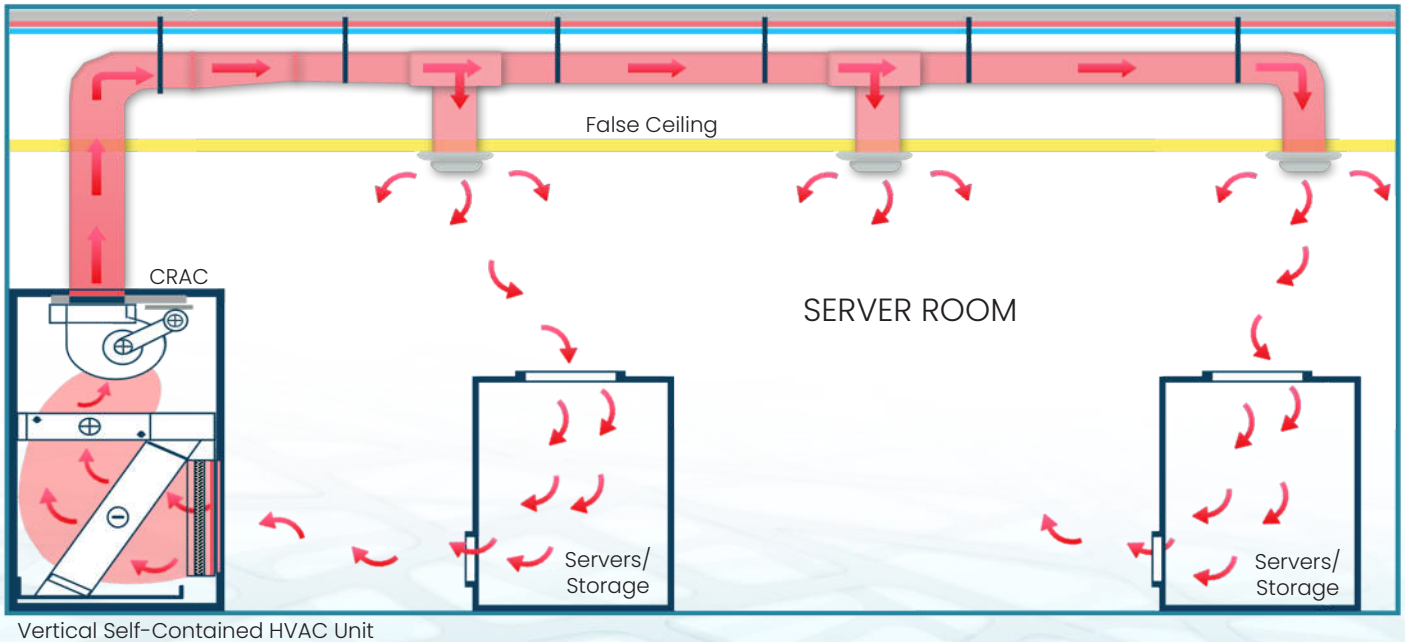
RAISED FLOOR SYSTEM (LEGACY DESIGN): used to be most commonly used in data centres. Warm air returned from top, cooled down and delivered through raised floor plenum and perforated tiles/grilles. Cooled air to the front of the IT racks, hot air from the rear of the racks and drawn to the ceiling.

OVERHEAD AIR DISTRIBUTION(DUCTING/PLENUM): Cold air discharged from the top into the ceiling plenum/ duct, through diffusers to IT cold aisle, Hot air return from space at the lower louver or ceiling return to cooling equipment.

FLOODED ROOM AIR DISTRIBUTION: Data Hall space cooling by centralized fall wall AHU with Hot aisle containment, No raised floor, no ducting .The cooling system floods the room with cool air. As air is removed from the cool side of the room by server fans, the lower pressure area causes more air to flow to replace it. Hot air into hot plenum overhead and go back to centralized fall wall AHU. This is becoming more popular for big DC because it offers low fan energy consumption and better air distribution.




RAISED FLOOR SYSTEM(WITH COLD AIR CONTAINMENT)




Vertical Self-Contained HVAC Unit

HVAC LAYOUT -OVERHEAD AIR DISTRIBUTION

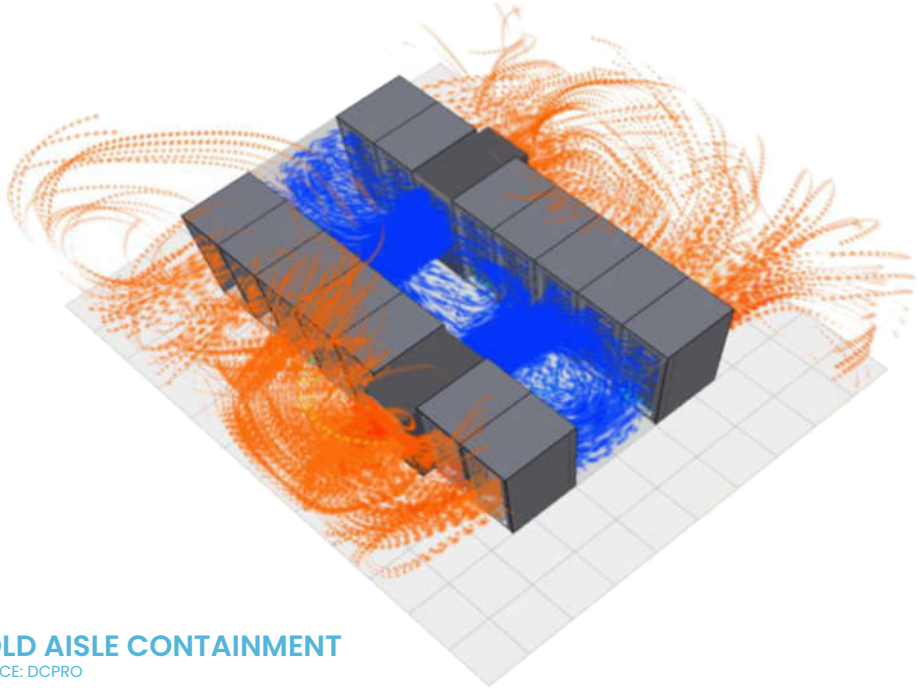
SOURCE: DATA CENTRES-COMFONOMICS

# DATA CENTER AISLE CONTAINMENT

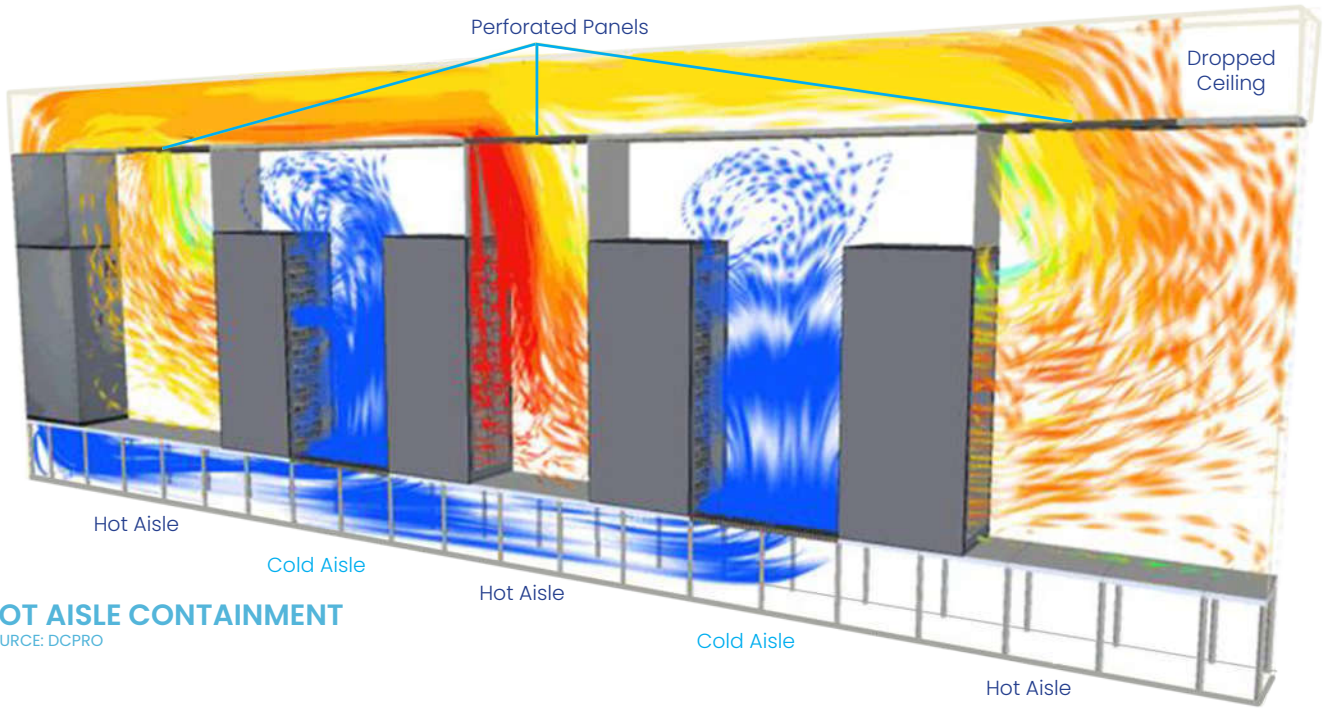
Data center rack layout needs isolate hot air from cold air by aligning IT equipment racks in rows, front to front, back to back, and hot aisle containment and/or cold aisle containment. Aisle containment would be very effective to avoid recirculation, bypass and hot spots, and also saves energy.

Cold aisle containment: cold aisle which is rack/cabinet front air intake, is contained and isolated from server outlet hot air . Cold air direct to IT server, commonly with raised floor design, can also be used with overhead ducting. The room is HOT.

Hot aisle containment: contain the hot air and use the dropped ceiling area as a return path directly back to cooling units. Works with all air distribution design, including the popular room flooded design. Data hall is cold.



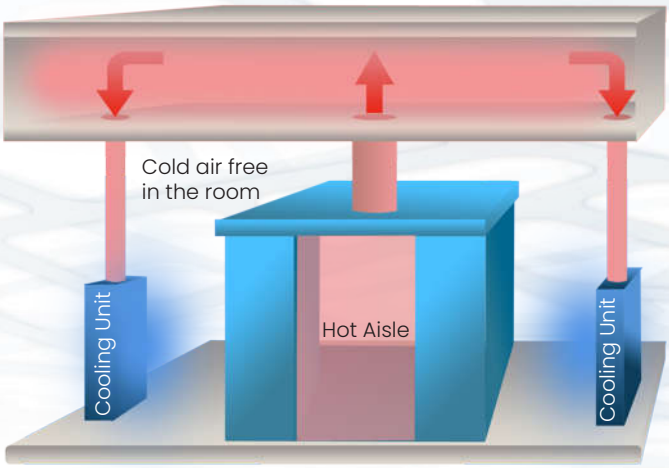
**COLD AISLE CONTAINMENT**
SOURCE: DCPRO




**HOT AISLE CONTAINMENT**
SOURCE: DCPRO

# DC HOT AISLE CONTAINMENT

## FLOODED ROOM AIR DISTRIBUTION WITH FAN WALL CRAH




### EFFECTIVE AND EFFICIENT DATA HALL DESIGN

HOT AISLE CONTAINMENT:
To isolate hot air from cold air.

FLOODED ROOM AIR DISTRIBUTION:
Low energy cooling solution for high density data centre without pressurized ductwork, easy to incorporate with localized cooling system for high density servers.

CENTRALIZED EC FAN WALL CRAH:
Offer high operating efficiency and better air distribution.


EC FAN WALL



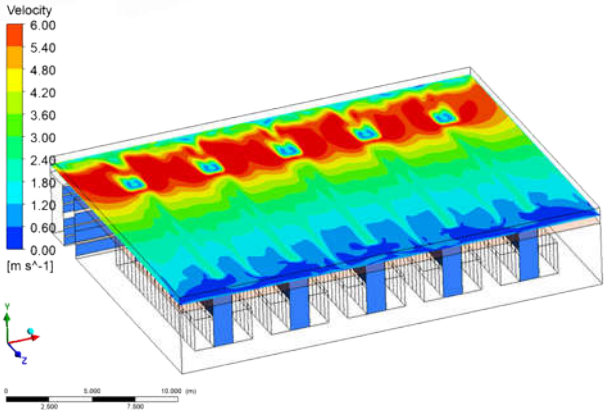
Hot aisle containment with chimneys and overhead plenum, flooded air distribution
SOURCE: YOUTUBE

# DC AIR DISTRIBUTION ANALYSIS

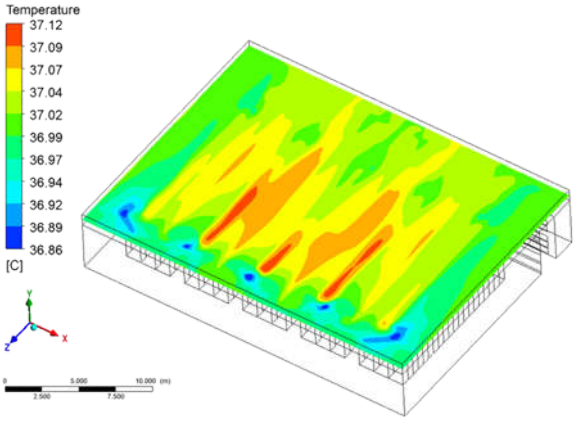
## CFD SIMULATION

DC Air Flow Management is very important to avoid hot spot, bypass and recirculation in order to ensure server reliability and minimized operating energy. CFD (computational fluid dynamics) Simulations have been used in data hall air distribution analysis for over 30 years. It has been used to Design/Optimise the layout of IT and cooling equipment, identify air distribution problems, maximize cooling energy savin, optimize space utilization, compare and analysis alternative and operating changes during the design stage and regular operation and problem solving.

### VELOCITY CONTOUR AND VELOCITY VECTORS (Y=4.5M)

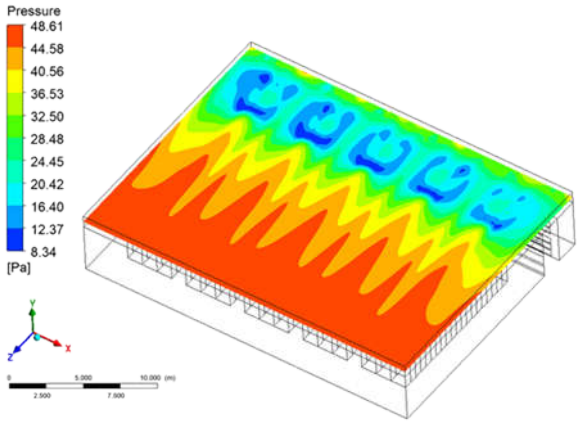



Example of Air Temperature distribution across a single horizontal plane




Example of Air Velocity distribution across a single horizontal plane

### STATIC PRESSURE (Y=4.5M)




Example of Air Pressure distribution across a single horizontal plane

CFD Simulation to provide DH thermal profiles in terms of air temperature, velocity, static pressure, as well air flow streamline in different ways.

1. Air temp distribution in different horizontal/ vertical cross sections
2. Air velocity distribution in different horizontal/vertical cross section
3. Air pressure distribution in different horizontal/vertical cross sections
4. 3D rendering of temp, pressure and velocity
5. 3D airflow streamline

CFD target and benefits

1. To avoid hot spot, bypass, and recirculation, achieve good air distribution, ensure server reliability
2. Optimized layout, equipment capacity design, avoid over cooling to save energy
3. Simulate IT change, layout change, utilization change to optimize the design and operation
4. Identify air distribution problem to save energy

# DC FREE COOLING

Free Cooling is the ability to minimize or eliminate the amount of time mechanical cooling by taking advantage of the cold ambient conditions.

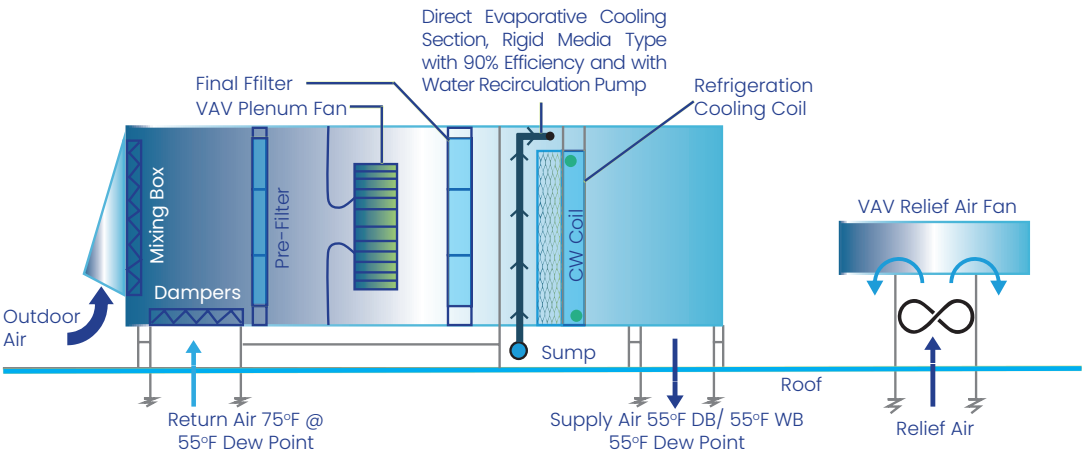
Effectiveness is location/weather dependent.

DC is energy intensive, need to take the advantage of free cooling as can as possible.

Water side economizer/free cooling: Effective in colder climate, enquires additional equipment to separate the open water from chilled water, less operating hours.

Air side economizer/free cooling: more operating hours, simplest, require filtration or HE, more fan power, more space required.

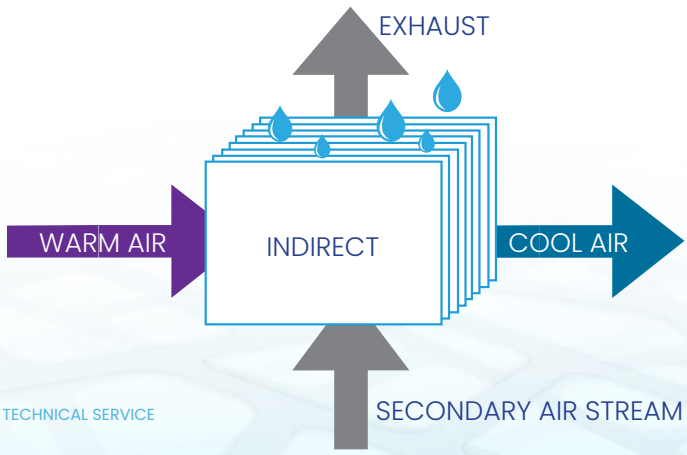
## DIRECT FREE AIR COOLING:




SOURCE: MIKE SCOFIELD AND TOM WEAVER CONSERVATION MECHANICAL SYSTEMS

**Direct free air cooling with direct adiabatic cooling with/without mechanical cooling** to extend the free cooling hours, efficient for dry cool weather.

## INDIRECT AIR SIDE FREE COOLING:

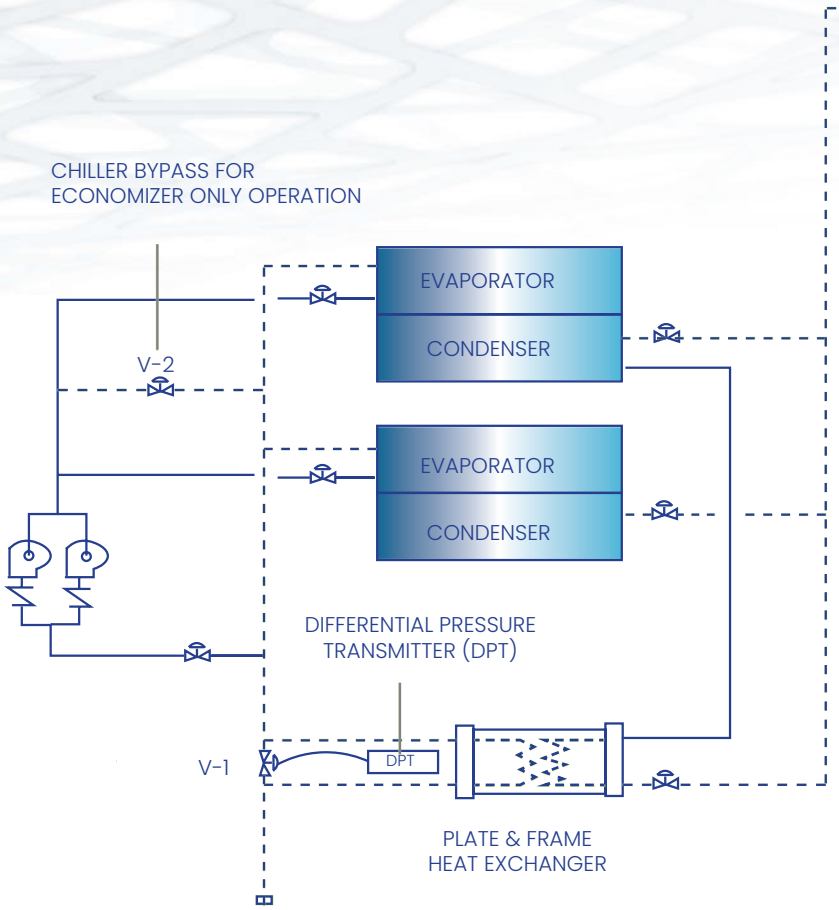


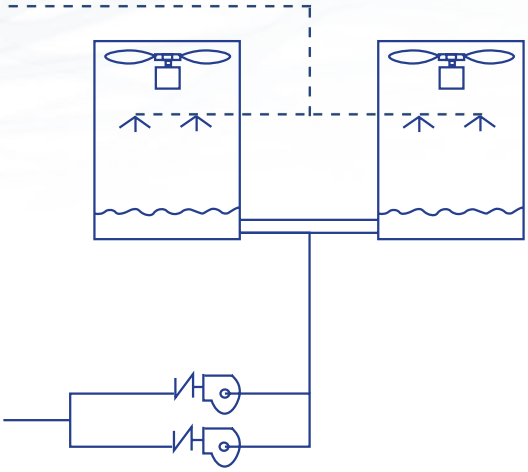

SOURCE: TRENT TECHNICAL SERVICE

**Indirect air side free cooling(Air to Air HE) with adiabatic cooling (water spray on HE)** with/without mechanical cooling

# DC FREE COOLING

## WATER SIDE FREE COOLING:

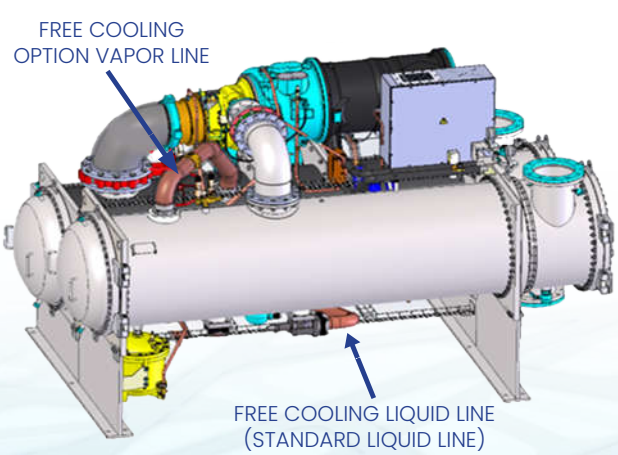


### INTEGRATED ECONOMIZER FOR VPF

Water side free cooling by plant solution: Use heat exchanger or closed CT that allows condenser water to cool the air directly.

## WATER SIDE FREE COOLING INCORPORATED WITH CHILLER




### WC CHILLER WITH REFRIGERANT MIGRATION FREE COOLING




### AC CHILLER WITH ADDITIONAL COIL FREE COOLING

# DATA CENTER COOLING SYSTEM BEST PRACTISES

- Data center energy consumption for cooling system is the major energy consumer,only smaller than IT sever. Some DC with worse cooling system, cooling energy could be larger than IT load. DC cooling system optimization is critical for low PUE DC.
- Better Air Flow Management is very important to avoid hot spot, bypass and recirculation in order to make DC operating reliably and efficiently, such asInstallation of blanking plates to reduce and prevent hot air re-circulating through gaps in the cabinet. Close all unwanted opening.
- Use CFD or thermal imaging technology(infrared camera) to identify air flow problem.
- Listed below are typical best practises in order to achieve high performance cooling system.

- ✓ Better Air Flow Management: avoid hot spot, bypass and recirculation.
- ✓ Optimize air inlet/outlet design: IT equipment will increase fan speed in response to higher intake air temps. Some IT equipment may see significant increases in fan power. Balance the IT fan power increase and cooling power decrease with an optimal supply air temp design
- ✓ Optimize chilled water supply/return temp design
- ✓ Contained hot or/and cold air: contain and separate the cold inlet air from hot return air
- ✓ Data Hall Temperature, Dewpoint, Humidity, pressure monitoring
- ✓ Chilled water system and CRAH operating monitoring
- ✓ Incorporated with data center infrastructure management system(DICM) to further optimize performance and ensure the reliability
- ✓ Optimize DC cooling system operating performance at low part loading
- ✓ Advanced cooling solution technology: Hot aisle containment with Fan wall for Data Hall and High performance DC chiller plant design and control
- ✓ All VSD plant
- ✓ HE equipment
- ✓ VPF
- ✓ Low GWP chiller
- ✓ Optimized sequencing
- ✓ VSD pump speed control
- ✓ Optimized cooling tower control
- ✓ Low pressure plant design
- ✓ Integrated control system
- ✓ Continuous and accurate M&V
- ✓ Professional service and maintenance

# DAIKIN TOTAL COOLING SOLUTION FOR DATA CENTER

- Daikin offers high efficient integrated cooling solution to ensure Data center reliability, stability, and sustainability;
- Water cooled and Air cooled chiller with Low GWP refrigerant
- FCU, AHU and fan wall CRAH with integrated control
- Data Hall CFD air distribution simulation and analysis
- High performance guaranteed chiller plant
- Plant room optimization solution and control
- Accurate and continuous monitoring, measurement and verification
- Professional service and maintenance



# DAIKIN TOTAL COOLING SOLUTION FOR DATA CENTER

Complete cooling products offering to satisfy different data center design requirements, ensure reliability & sustainability, reduce downtime, and minimize energy consumption.

## WATER COOLED MAGNETIC BEARING CENTRIFUGAL CHILLER



## AIR COOLED CHILLER – MAGNETIC, SCREW & SCROLL



# DATA CENTER APPLICATION

Daikin exemplifies **sustainability** with its commitment to incorporating **magnetic bearing technology**, **low GWP refrigerants**, and **high efficiency** in its wide range of **application** for Data Center.

1. SUSTAINABILITY
2. RELIABILITY & SAFETY
3. REDUCE DOWNTIME
4. ECONOMICAL
5. COMPLIANCE



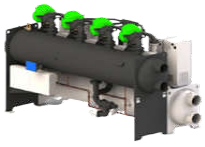

## LOW GWP REFRIGERANT

- Low GWP, Zero ODP
- High Efficiency, Full Load and Part Load
- Tailored specific PUE requirement

WMTC ABOVE & BEYOND



HXEV-TG/VTX



WLT A BALANCE PERSPECTIVE



UXEV-TG



HFO-1233zde | HFO-1234zE

## MAGNETIC BEARING TECHNOLOGY

- Permanent Magnet Motor
- Magnetic Bearing
- 1 or 2 Stage Impeller
- IGV + VSD

R134a — Daikin HXEV-TT



HFO Refrigerant R1234ze — Daikin HXEV-TGS



Daikin HXEV-VTX





Daikin HXEV-Daikin — R134a

Daikin WMTC



HFO-R1233zd(E)

100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 TONS

Daikin UXEV-TT — R134a

Daikin UXEV-TG — HFO Refrigerant R1234ze



HFO

HFC

# DAIKIN TOTAL COOLING SOLUTION FOR DATA CENTER

Daikin WC chiller provide premium COP at common DC design and part load operating condition, also provide reliable operating at extreme operating condition.

**Example Chiller 1:**

WC magnetic bearing R134a chiller, excellent operating efficient from 0.21kW/RT to 0.29kW/RT at normal condition, which could make whole plant operating efficiency from 0.31kW/RT to 0.4kW/RT with Daikin integrated optimized control

| UNIT PERFORMANCE | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Performance Points Rated with VPF (Evap & Cond) | | | | | | | | | | | | | | |
| Point # | % of Full Load | Capacity kW | Input kW | Cooling COP kW/kW | Cooling kW/tonR | RLA A | Evaporator Fluid | | | | Condenser Fluid | | | |
| | | | | | | | Flow l/s | EWT °C | LWT °C | PD kPA | Flow l/s | EWT °C | LWT °C | PD kPA |
| 1 | 100.0 | 2814 | 233.8 | 12.04 | 0.2922 | 368 | 84.39 | 29.00 | 21.00 | 24.5 | 133.5 | 29.50 | 35.00 | 40.3 |
| 2 | 90.0 | 2533 | 194.1 | 13.05 | 0.2695 | 307 | 75.95 | 29.00 | 21.00 | 20.4 | 133.5 | 29.50 | 34.42 | 40.4 |
| 3 | 80.0 | 2251 | 159.1 | 14.15 | 0.2486 | 256 | 67.51 | 29.00 | 21.00 | 16.7 | 133.5 | 29.50 | 33.85 | 40.5 |
| 4 | 70.0 | 1970 | 129.8 | 15.18 | 0.2317 | 214 | 59.07 | 29.00 | 21.00 | 13.2 | 133.5 | 29.50 | 33.29 | 40.6 |
| 5 | 60.0 | 1688 | 105.6 | 15.99 | 0.2199 | 179 | 59.07 | 27.85 | 21.00 | 13.3 | 133.5 | 29.50 | 32.74 | 40.7 |
| 6 | 50.0 | 1407 | 84.53 | 16.65 | 0.2113 | 148 | 59.07 | 26.71 | 21.00 | 13.3 | 133.5 | 29.50 | 32.19 | 40.8 |
| 7 | 40.0 | 1126 | 67.30 | 16.73 | 0.2102 | 123 | 59.07 | 25.57 | 21.00 | 13.4 | 133.5 | 29.50 | 31.66 | 40.8 |
| 8 | 30.0 | 844.2 | 54.43 | 15.51 | 0.2268 | 103 | 59.07 | 24.43 | 21.00 | 13.4 | 133.5 | 29.50 | 31.12 | 40.9 |
| 9 | 20.0 | 562.8 | 44.10 | 12.76 | 0.2756 | 86 | 59.07 | 23.28 | 21.00 | 13.5 | 133.5 | 29.50 | 30.60 | 41.0 |

**Example Chiller 1:**

WC magnetic bearing R134a chiller is able to operate at extreme weather condition with high efficiency 0.31kW/RT

| UNIT PERFORMANCE | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Performance Points Rated with VPF (Evap & Cond) | | | | | | | | | | | | | | |
| Point # | % of Full Load | Capacity kW | Input kW | Cooling COP kW/kW | Cooling kW/tonR | RLA A | Evaporator Fluid | | | | Condenser Fluid | | | |
| | | | | | | | Flow l/s | EWT °C | LWT °C | PD kPA | Flow l/s | EWT °C | LWT °C | PD kPA |
| 1 | 100.0 | 2814 | 289.9 | 9.707 | 0.3623 | 454 | 84.39 | 29.00 | 21.00 | 24.5 | 136.2 | 34.50 | 40.00 | 40.3 |
| 2 | 90.0 | 2533 | 248.3 | 10.20 | 0.3448 | 389 | 75.95 | 29.00 | 21.00 | 20.4 | 136.2 | 34.50 | 39.43 | 40.4 |
| 3 | 80.0 | 2251 | 210.0 | 10.72 | 0.3281 | 332 | 67.51 | 29.00 | 21.00 | 16.7 | 136.2 | 34.50 | 38.87 | 40.5 |
| 4 | 70.0 | 1970 | 176.0 | 11.20 | 0.3141 | 282 | 59.07 | 29.00 | 21.00 | 13.2 | 136.2 | 34.50 | 38.31 | 40.5 |
| 5 | 60.0 | 1688 | 146.6 | 11.52 | 0.3054 | 240 | 59.07 | 27.85 | 21.00 | 13.3 | 136.2 | 34.50 | 37.76 | 40.6 |
| 6 | 50.0 | 1407 | 121.8 | 11.55 | 0.3044 | 205 | 59.07 | 26.71 | 21.00 | 13.3 | 136.2 | 34.50 | 37.22 | 40.7 |
| 7 | 40.0 | 1126 | 103.4 | 10.88 | 0.3231 | 178 | 59.07 | 25.57 | 21.00 | 13.4 | 136.2 | 34.50 | 36.69 | 40.8 |
| 8 | 30.0 | 844.2 | 88.47 | 9.542 | 0.3686 | 156 | 59.07 | 24.43 | 21.00 | 13.4 | 136.2 | 34.50 | 36.16 | 40.8 |

# DAIKIN TOTAL COOLING SOLUTION FOR DATA CENTER

Daikin WC chiller provide premium COP at common DC design and part load operating condition, also provide reliable operating at extreme operating condition

**Example Chiller 2:**

WC magnetic chiller with low GWP HFO refrigerant : excellent operationg efficient from 0.25kW/RT to 0.3kW/RT at normal condition, which could make whole plant operating efficiency from 0.35kW/RT to 0.4kW/RT with Daikin integrated optimized control

| UNIT PERFORMANCE | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Performance Points Rated with VPF (Evap & Cond) | | | | | | | | | | | | | | |
| Point # | % of Full Load | Capacity kW | Input kW | Cooling COP kW/kW | Cooling kW/tonR | RLA A | Evaporator Fluid | | | | Condenser Fluid | | | |
| | | | | | | | Flow l/s | EWT °C | LWT °C | PD kPA | Flow l/s | EWT °C | LWT °C | PD kPA |
| 1 | 100.0 | 2814 | 233.8 | 12.04 | 0.2922 | 368 | 84.39 | 29.00 | 21.00 | 24.5 | 133.5 | 29.50 | 35.00 | 40.3 |
| 2 | 90.0 | 2533 | 194.1 | 13.05 | 0.2695 | 307 | 75.95 | 29.00 | 21.00 | 20.4 | 133.5 | 29.50 | 34.42 | 40.4 |
| 3 | 80.0 | 2251 | 159.1 | 14.15 | 0.2486 | 256 | 67.51 | 29.00 | 21.00 | 16.7 | 133.5 | 29.50 | 33.85 | 40.5 |
| 4 | 70.0 | 1970 | 129.8 | 15.18 | 0.2317 | 214 | 59.07 | 29.00 | 21.00 | 13.2 | 133.5 | 29.50 | 33.29 | 40.6 |
| 5 | 60.0 | 1688 | 105.6 | 15.99 | 0.2199 | 179 | 59.07 | 27.85 | 21.00 | 13.3 | 133.5 | 29.50 | 32.74 | 40.7 |
| 6 | 50.0 | 1407 | 84.53 | 16.65 | 0.2113 | 148 | 59.07 | 26.71 | 21.00 | 13.3 | 133.5 | 29.50 | 32.19 | 40.8 |
| 7 | 40.0 | 1126 | 67.30 | 16.73 | 0.2102 | 123 | 59.07 | 25.57 | 21.00 | 13.4 | 133.5 | 29.50 | 31.66 | 40.8 |
| 8 | 30.0 | 844.2 | 54.43 | 15.51 | 0.2268 | 103 | 59.07 | 24.43 | 21.00 | 13.4 | 133.5 | 29.50 | 31.12 | 40.9 |
| 9 | 20.0 | 562.8 | 44.10 | 12.76 | 0.2756 | 86 | 59.07 | 23.28 | 21.00 | 13.5 | 133.5 | 29.50 | 30.60 | 41.0 |

**Example Chiller 2:**

WC magnetic chiller with low GWP HFO refrigerang is able to operate at extreme weather condition with high reliability and high efficiency

| UNIT PERFORMANCE | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Performance Points Rated with VPF (Evap & Cond) | | | | | | | | | | | | | | |
| Point # | % of Full Load | Capacity kW | Input kW | Cooling COP kW/kW | Cooling kW/tonR | RLA A | Evaporator Fluid | | | | Condenser Fluid | | | |
| | | | | | | | Flow l/s | EWT °C | LWT °C | PD kPA | Flow l/s | EWT °C | LWT °C | PD kPA |
| 1 | 100.0 | 2814 | 289.4 | 9.723 | 0.3617 | 447 | 84.39 | 29.00 | 21.00 | 30.2 | 136.2 | 34.50 | 40.00 | 27.5 |
| 2 | 90.0 | 2533 | 254.9 | 9.937 | 0.3539 | 395 | 75.95 | 29.00 | 21.00 | 26.0 | 136.2 | 34.50 | 39.44 | 27.5 |
| 3 | 80.0 | 2251 | 224.1 | 10.05 | 0.3501 | 349 | 67.51 | 29.00 | 21.00 | 22.2 | 136.2 | 34.50 | 38.89 | 27.6 |
| 4 | 70.0 | 1970 | 195.4 | 10.08 | 0.3488 | 305 | 59.07 | 29.00 | 21.00 | 18.8 | 136.2 | 34.50 | 38.34 | 27.6 |
| 5 | 60.0 | 1688 | 168.3 | 10.03 | 0.3507 | 265 | 59.07 | 27.85 | 21.00 | 18.8 | 136.2 | 34.50 | 37.80 | 27.7 |
| 6 | 50.0 | 1407 | 143.1 | 9.832 | 0.3577 | 228 | 59.07 | 26.71 | 21.00 | 18.8 | 136.2 | 34.50 | 37.26 | 27.7 |
| 7 | 40.0 | 1126 | 118.7 | 9.483 | 0.3709 | 193 | 59.07 | 25.57 | 21.00 | 18.8 | 136.2 | 34.50 | 36.71 | 27.8 |
| 8 | 30.0 | 844.2 | 97.18 | 8.687 | 0.4048 | 161 | 59.07 | 24.43 | 21.00 | 18.7 | 136.2 | 34.50 | 36.18 | 27.8 |

# DAIKIN TOTAL COOLING SOLUTION FOR DATA CENTER

Daikin WC chiller provide premium COP at common DC design and part load operating condition, also provide reliable operating at extreme operating condition.

**Example Chiller 3:**
AC screw chiller with low GWP HFO refrigerant : excellent operating efficiency COP from 5- 7 at normal condition

| PART LOADS INFORMATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CALCULATION TYPE | USER DEFINED | | | | | | | | | |
| Cooling Capacity [kW] | 1400 | 1260 | 1120 | 980.0 | 840.0 | 700.0 | 560.0 | 420.0 | 280.0 | 0.000 |
| Power Input [kW] | 307.3 | 255.2 | 210.2 | 169.4 | 135.1 | 105.8 | 79.26 | 71.65 | 40.92 | 0.000 |
| EER [kW/kW] | 4.556 | 4.937 | 5.329 | 5.786 | 6.216 | 6.619 | 7.065 | 5.862 | 6.842 | 0.000 |
| Evap. Fluid IN/OUT [°C] | 29/21 | 29/21 | 29/21 | 29/21 | 28/21 | 27/21 | 26/21 | 25/21 | 24/21 | 23/21 |
| Evap. Fluid Flow [l/s] | 41.07 | 36.82 | 33.07 | 30.17 | 30.17 | 30.17 | 30.17 | 30.17 | 30.17 | 0.000 |
| Evap. Pressure Drops [kPa] | 11.3 | 9.67 | 8.29 | 7.29 | 7.29 | 7.29 | 7.29 | 7.29 | 7.29 | 0.00 |
| Ambient Temp. [°C] | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 |

**Example Chiller 3:**
AC screw chiller with low GWP HFO refrigerant : operate at extreme weather condition with high reliability and high efficiency

| PART LOADS INFORMATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CALCULATION TYPE | USER DEFINED | | | | | | | | |
| Cooling Capacity [kW] | 1400 | 1260 | 1120 | 980.0 | 840.0 | 700.0 | 560.0 | 420.0 | 280.0 |
| Power Input [kW] | 391.5 | 332.5 | 273.1 | 234.8 | 190.1 | 154.9 | 119.1 | 95.74 | 62.28 |
| EER [kW/kW] | 3.576 | 3.790 | 4.101 | 4.174 | 4.418 | 4.518 | 4.702 | 4.387 | 4.496 |
| Evap. Fluid IN/OUT [°C] | 29/21 | 29/21 | 29/21 | 29/21 | 28/21 | 27/21 | 26/21 | 25/21 | 24/21 |
| Evap. Fluid Flow [l/s] | 40.72 | 37.16 | 32.49 | 30.17 | 30.17 | 30.17 | 30.17 | 30.30 | 30.17 |
| Evap. Pressure Drops [kPa] | 11.2 | 9.80 | 8.09 | 7.29 | 7.29 | 7.29 | 7.29 | 5.63 | 7.29 |
| Ambient Temp. [°C] | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 |

# DAIKIN TOTAL COOLING SOLUTION FOR DATA CENTER

Daikin chiller provide premium COP at common DC design and part load operating condition, also provide reliable operating at extreme operating condition.

**Example Chiller 3:**
AC screw chiller with low GWP HFO refrigerant : excellent operating efficiency COP from 5- 7 at normal condition

| PART LOADS INFORMATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CALCULATION TYPE | USER DEFINED | | | | | | | | | |
| Cooling Capacity [kW] | 1400 | 1260 | 1120 | 980.0 | 840.0 | 700.0 | 560.0 | 420.0 | 280.0 | 0.000 |
| Power Input [kW] | 307.3 | 255.2 | 210.2 | 169.4 | 135.1 | 105.8 | 79.26 | 71.65 | 40.92 | 0.000 |
| EER [kW/kW] | 4.556 | 4.937 | 5.329 | 5.786 | 6.216 | 6.619 | 7.065 | 5.862 | 6.842 | 0.000 |
| Evap. Fluid IN/OUT [°C] | 29/21 | 29/21 | 29/21 | 29/21 | 28/21 | 27/21 | 26/21 | 25/21 | 24/21 | 23/21 |
| Evap. Fluid Flow [l/s] | 41.07 | 36.82 | 33.07 | 30.17 | 30.17 | 30.17 | 30.17 | 30.17 | 30.17 | 0.000 |
| Evap. Pressure Drops [kPa] | 11.3 | 9.67 | 8.29 | 7.29 | 7.29 | 7.29 | 7.29 | 7.29 | 7.29 | 0.00 |
| Ambient Temp. [°C] | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 |

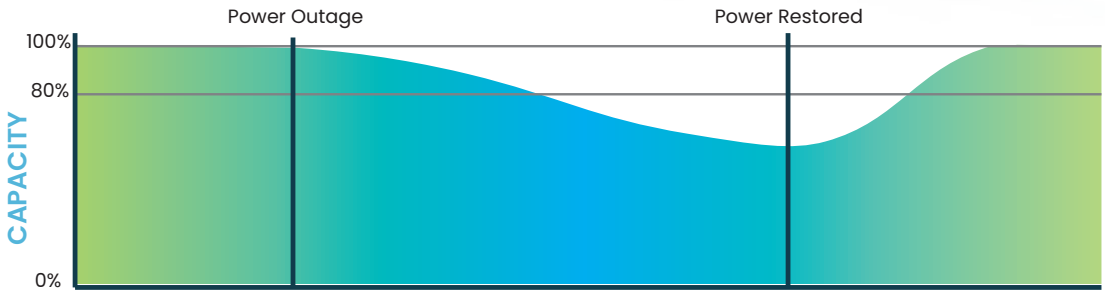
**Example Chiller 3:**
AC screw chiller with low GWP HFO refrigerant : operate at extreme weather condition with high reliability and high efficiency

| PART LOADS INFORMATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CALCULATION TYPE | USER DEFINED | | | | | | | | |
| Cooling Capacity [kW] | 1400 | 1260 | 1120 | 980.0 | 840.0 | 700.0 | 560.0 | 420.0 | 280.0 |
| Power Input [kW] | 391.5 | 332.5 | 273.1 | 234.8 | 190.1 | 154.9 | 119.1 | 95.74 | 62.28 |
| EER [kW/kW] | 3.576 | 3.790 | 4.101 | 4.174 | 4.418 | 4.518 | 4.702 | 4.387 | 4.496 |
| Evap. Fluid IN/OUT [°C] | 29/21 | 29/21 | 29/21 | 29/21 | 28/21 | 27/21 | 26/21 | 25/21 | 24/21 |
| Evap. Fluid Flow [l/s] | 40.72 | 37.16 | 32.49 | 30.17 | 30.17 | 30.17 | 30.17 | 30.30 | 30.17 |
| Evap. Pressure Drops [kPa] | 11.2 | 9.80 | 8.09 | 7.29 | 7.29 | 7.29 | 7.29 | 5.63 | 7.29 |
| Ambient Temp. [°C] | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 |

# DAIKIN TOTAL COOLING SOLUTION FOR DATA CENTER

Daikin chillers'ride through, rapid restart and harmonic filter design to minimize downtime in data centers, ensuring uninterrupted cooling and reducing the risk of equipment failure.

## Daikin Ride Through® Water Cooled Mag Bearing, HXE (Daikin)



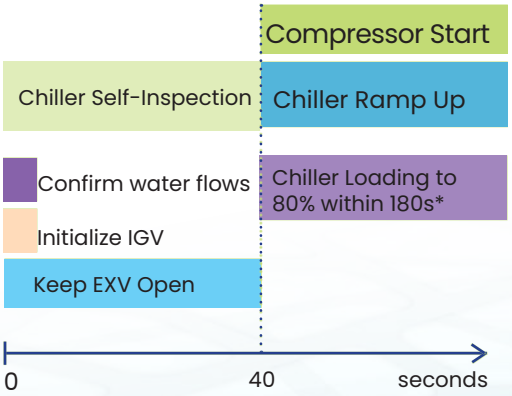

When **Ride Through®** is enabled and a short term power loss **(20s)** occurs, the **compressor motor maintains rotation** and the VFD catches and **re-synchronizes with the spinning rotor,** permitting the chiller to **return to its pre-power loss capacity** within seconds of power being restored.



## Rapid Restart

### WC Mag Bearing

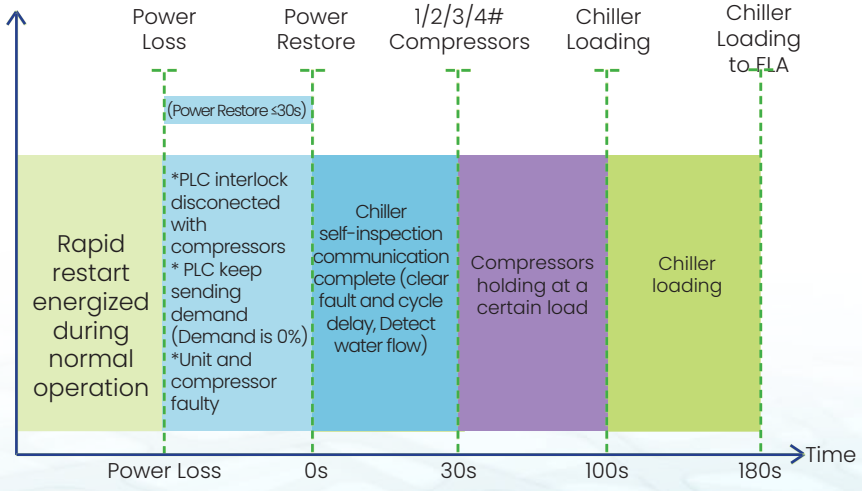
HXE (TT/TG)Restart Time with UPS




*With UPS :Chiller loading to 80% within 180 seconds from restart and 100% load within 3-6min

### AC Mag Bearing

UXEV Rapid Restart with UPS (power restore ≤30s)




*With UPS :Chiller loading to FLA within 180 seconds, from power restore <30s

# DAIKIN TOTAL COOLING SOLUTION FOR DATA CENTER

Data Hall air distribution is critical for IT serves operation and energy saving. Daikin EC fan wall CRAH with integrated control fits well with advanced flooded air distribution and hot aisle containment design, offers high operating performance and better air distribution at different operating modes to avoid hot spot, recirculation and bypass.

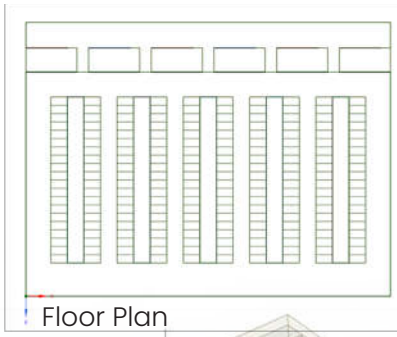
EC fan wall CRAH with integrated control,full load effi 0.2kW/RT (0.22w/CMH) actual part load operating eff much better due to multiple EC fan design.



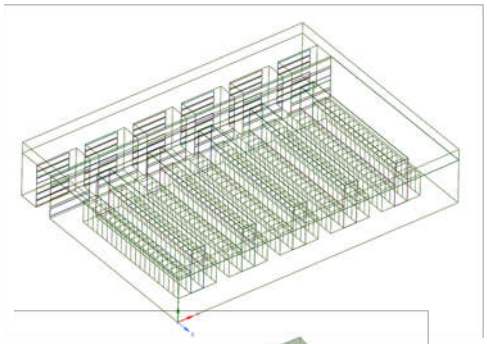


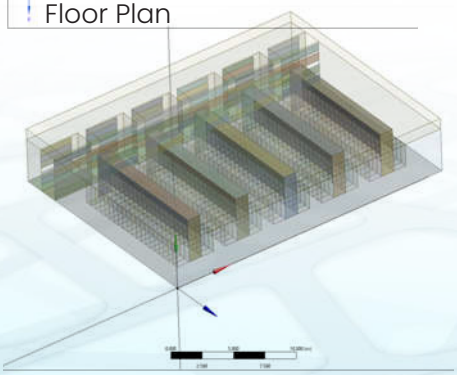
| GENERAL | | | AIR SIDE | | | WATER SIDE | | |
|---|---|---|---|---|---|---|---|---|
| *Coil Medium | Water | | Air Volume | 55000 | $m^3/h$ | EWT/LWT | 21.00/29.00 | °C |
| *Rows/Fin per Inch | 8/12 | | EDB/EWB | 37.00/21.70 | °C | Flow Rate (Total) | 6.58 | L/s |
| Coil Layers | 2 | | LDB/LWB | 25.03/17.96 | °C | Tube Velocity | 0.67 | m/s |
| *Circuits per Coil | 44/44/- | | ERH/LRH | 25.5/50.4 | % | Pressure Drop | 10.35 | kPa |
| Coil Volume | 169.590 | $dm^3$ | Pressure Drop (Wet) | 261.17 | Pa | Glycol Percentage | 0 | % |
| Coil -Wet Weight | 1656 | kg | Pressure Drop (Dry) | 261.17 | Pa | ERH= Entering Air Relative Humidity | | |
| *Total Capacity | 220.52 | kW | Mass Flow Rate | 66000.00 | kg/h | LRH= Leaving Air Relative Humidity | | |
| Sensible Capacity | 220.52 | kW | Velocity | 3.30 | m/s | | | |
| | | | Extra PRessure Drop | 0.00 | Pa | | | |

## Data Hall CFD Simulation example

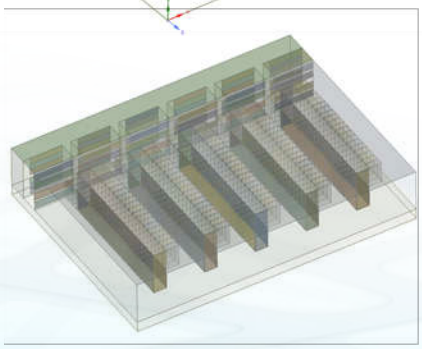


Floor Plan





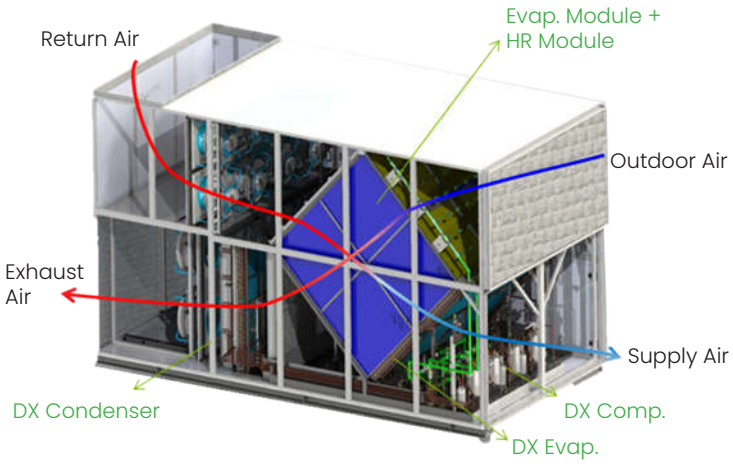
Above floor level (below ceiling)



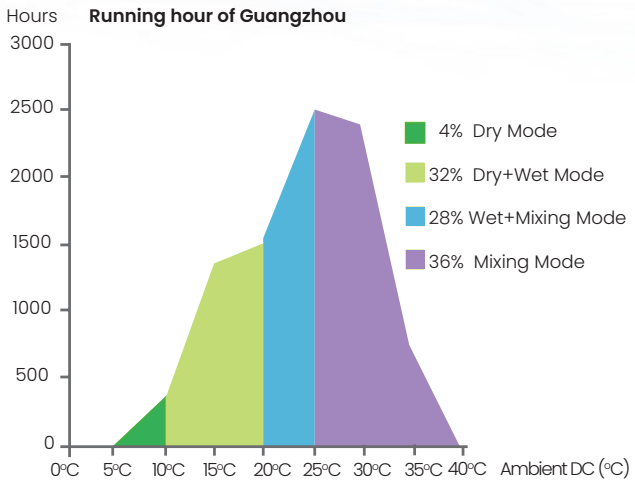
Side view (including ceiling plenum)

# DAIKIN TOTAL COOLING SOLUTION FOR DATA CENTER

## INDIRECT FREE AIR COOLING: AIR TO AIR HE WITH SUPPLEMENTARY COOLING



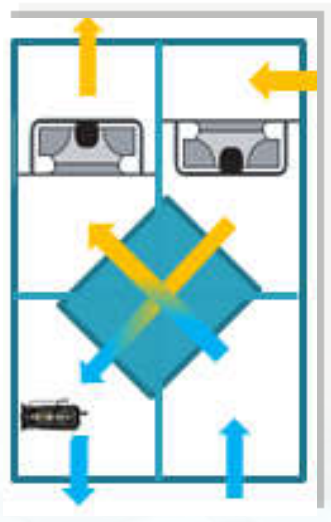

### Energy saving analysis




- More than 55% hours no need to open comp.
- Cop of the whole year is around 5.49

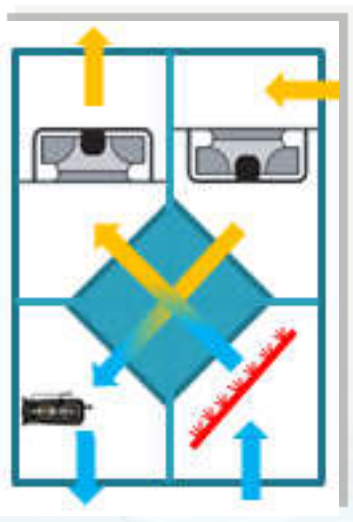
## RUNNING MODE:

### DRY MODE



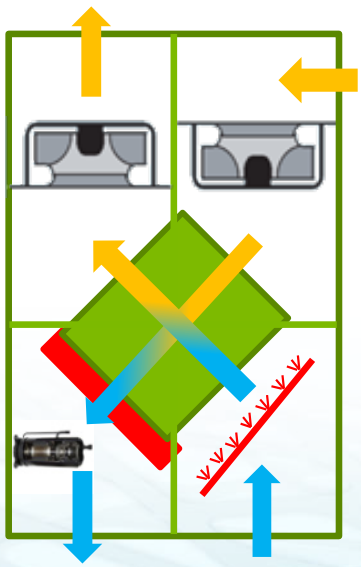
Free cooling
(Comp. off)

### WET MODE



Free cooling+ Evap. cooling
(Comp. off)

### MIX MODE



Free cooling+ Evap. cooling+
DX cooling (Comp. **on**)

# DAIKIN TOTAL COOLING SOLUTION FOR DATA CENTER

## IPLANTMANAGER

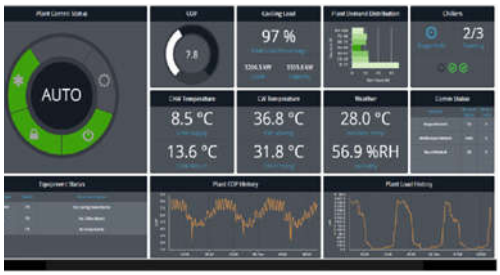
The reliability & redundancy is critical for Data Center design and operation. Cooling system and its control redundancy depend on DC tier design, type of system and the required level of redundancy. iPlant Manager (iPM) is a dedicated **plant room optimization solution and control software** – capable of delivering efficiency beyond the individual components. It utilizes on-board, real-time analytics, diagnostics and M&V system to continually readjust chiller plant for optimal performance.

**HARDWARE**

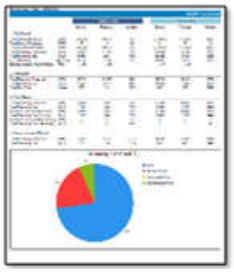


The software is embedded in EDGE gateways hardware and ready for on site data integration

**DASHBOARD**




**MONTHLY REPORTS**

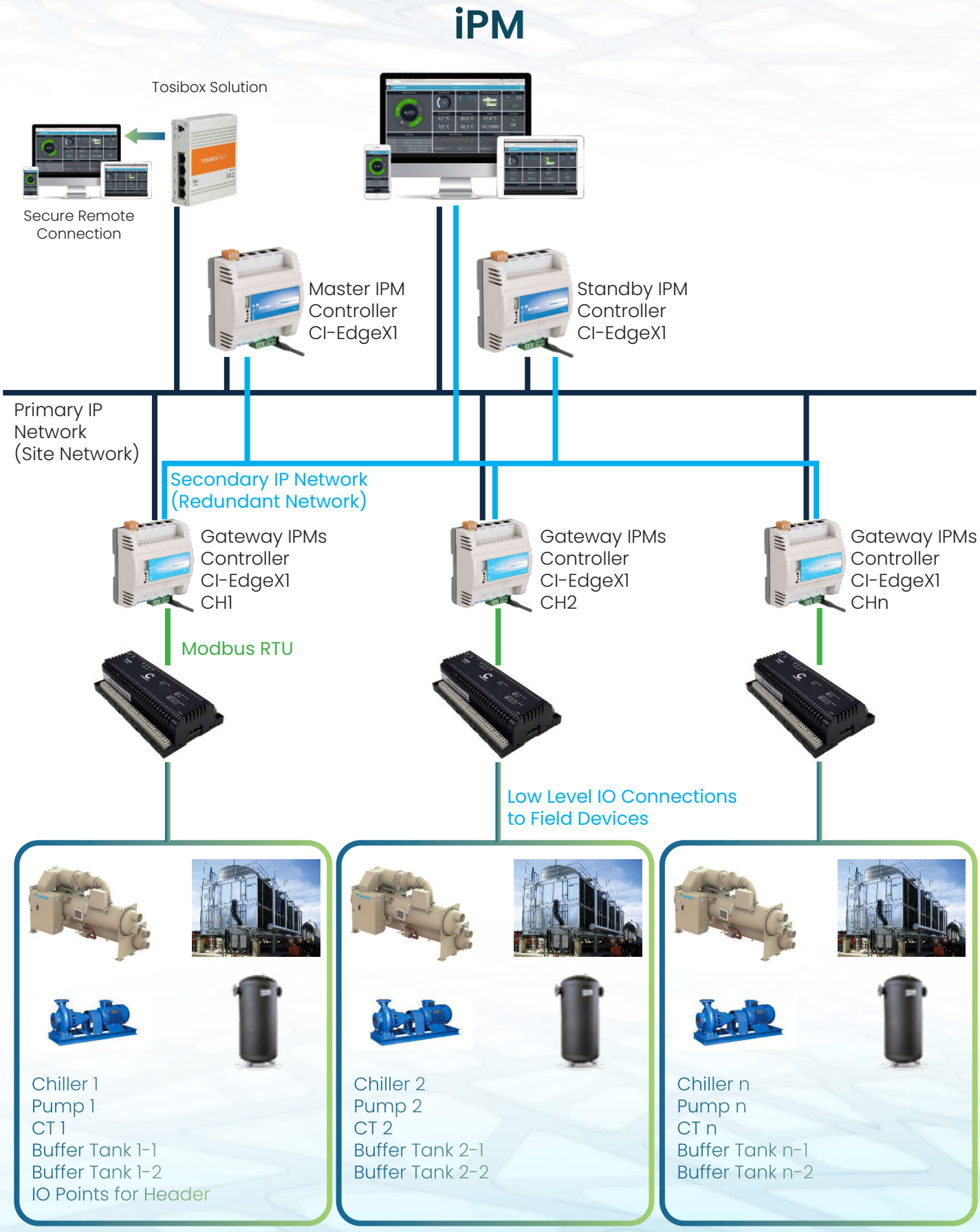


- CHILLER PLANT PERFORMANCE MONITORING
- CHILLER PLANT ANALYTICS AND FDD
- ADVANCED CHILLER PLANT OPTIMISATION
- CHILLER PLANT MEASUREMENT AND VERIFICATION
- CHILLER PLANT CONTROL AND AUTOMATION
- CHILLER PLANT CONTINUOUS COMMISSIONING AND TUNING

**PERFORMANCE** **RELIABILITY** **OPTIMIZATION**

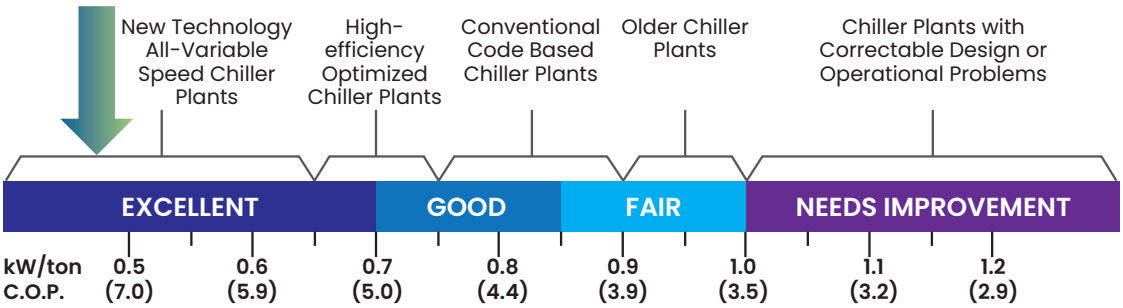
# DATA CENTRE ARCHITECTURE

## MASTER/STANDBY

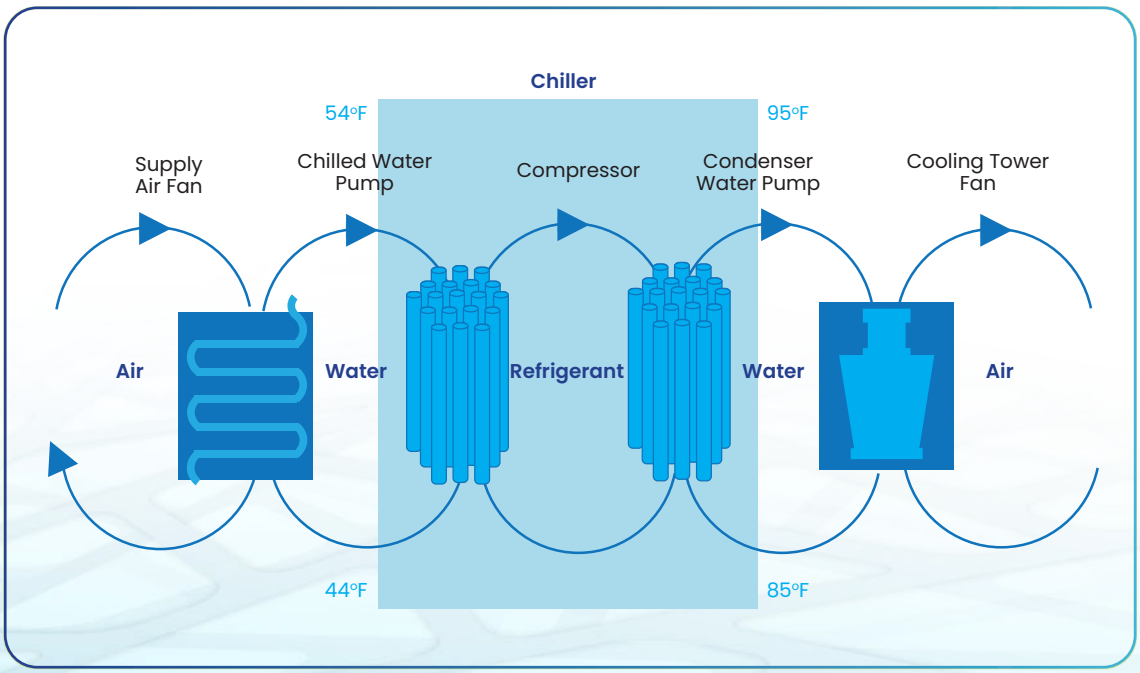


# DAIKIN TOTAL COOLING SOLUTION FOR DATA CENTER

## HIGH PERFORMANCE DC CHILLER PLANT: PLANT OPERATING EFF. @0.3-0.45KW/RT




- High performance equipment: Chiller@0.2-0,35kW/RT,CT@0.02-0.03kW/RT
- High performance system integrated design
- **VPF** Low water flow system, low pressure system @ 0.07-0.08kW/RT
- Accurate measurement and continuous monitoring
- Optimized control system to ensure optimized plant performance over the whole operating period
- Professional maintenance and facility engineer's expertize



# MEMO

# MEMO

AP | DATA CENTER | 01-06/25

# DAIKIN TOTAL COOLING SOLUTIONS LEAD A WAY TO A RELIABLE SUSTAINABLE EFFICIENT DATA CENTER

**SIAM DAIKIN SALES CO.,LTD.**
22 Soi Onnuch 55/1
Pravet Subdistrict, Pravet District,
Bangkok 10250

Tel.1271

DAIKIN