# ENERGY SOLUTION FOR DATA CENTRE

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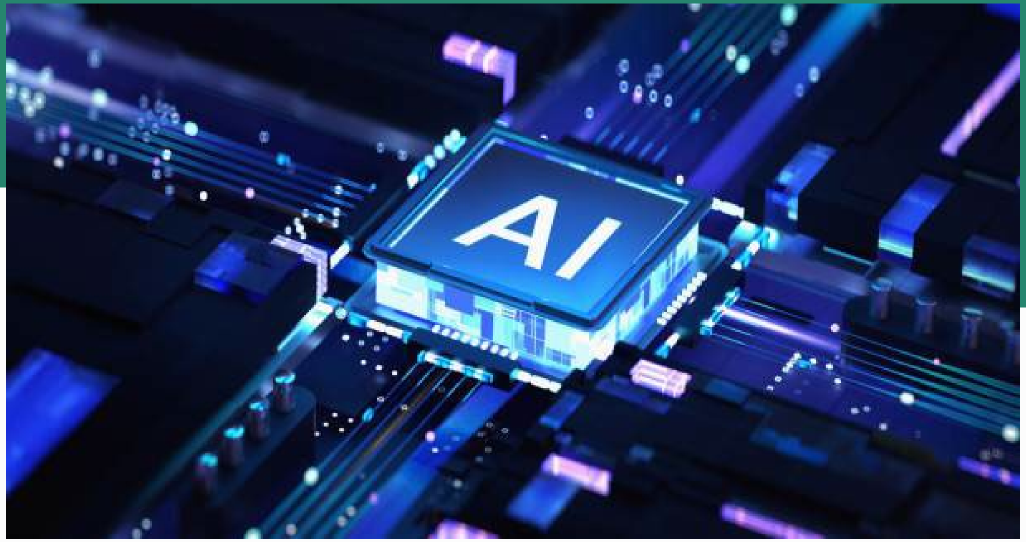
# INTRODUCTION

# INTRODUCTION

## AGE of AI

Data Centres are crucial for modern digital infrastructure but are also significant energy and water consumers. Implementing energy and water-efficient systems are essential for reducing operational costs and minimizing environmental impact. Especially in the age of Artificial Intelligence (AI), its importance is more prominent than ever.



# INTRODUCTION

## EAGLE EYE (2008)


In the final scene, the hero beat the AI by overheating it. Thus, proven cooling is essential in a data centre

# INTRODUCTION

## ChatGPT

For every 10 searches on ChatGPT, it will consume approximately 500ml of water.

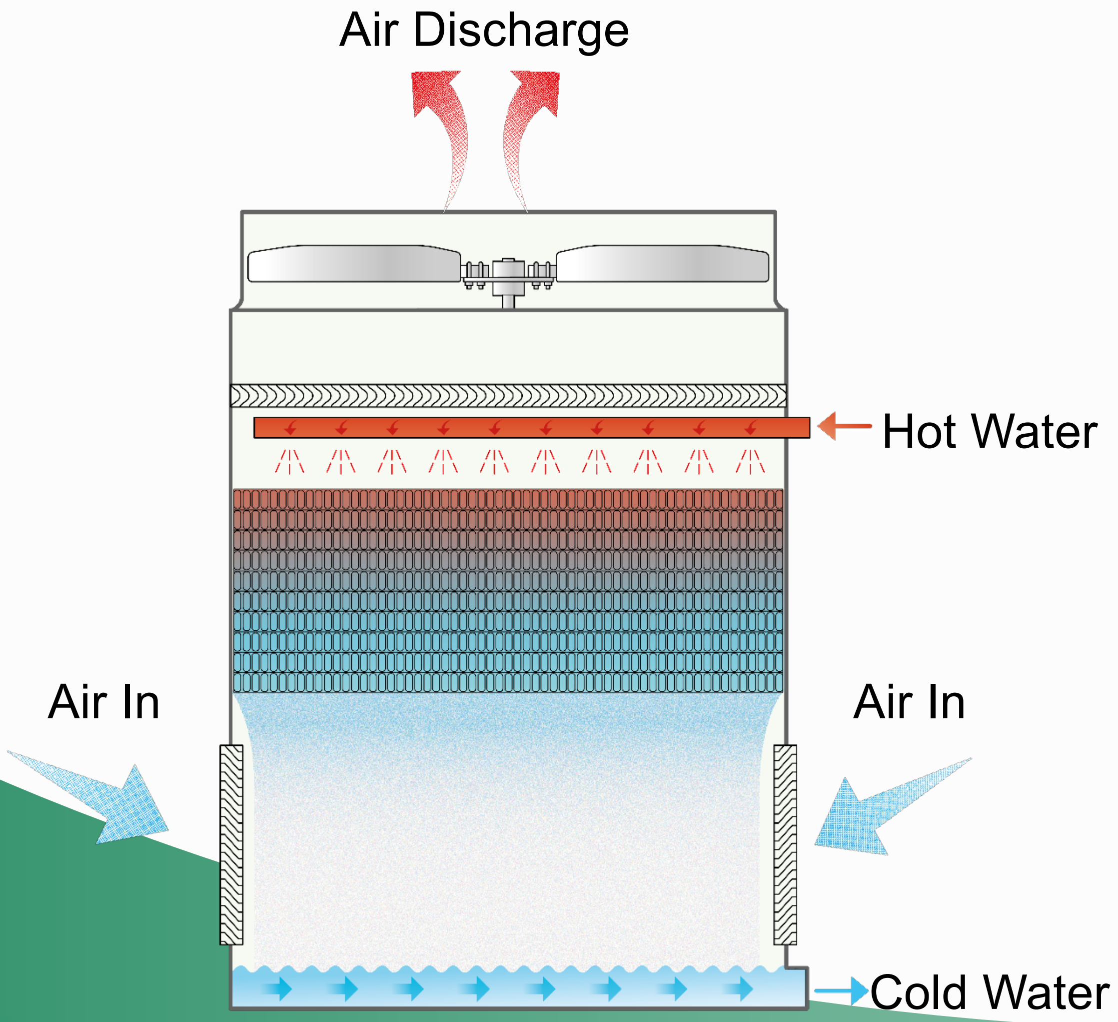
# FUNDAMENTAL OF EVAPORATIVE COOLING

# WORKING PRINCIPAL

**Definition of Cooling Tower**

According to the Cooling Technologies Institute (CTI), a cooling tower is a heat rejection device, which extracts waste heat to the atmosphere through the cooling of a water stream to a lower temperature through a heat rejection process termed as “evaporation”

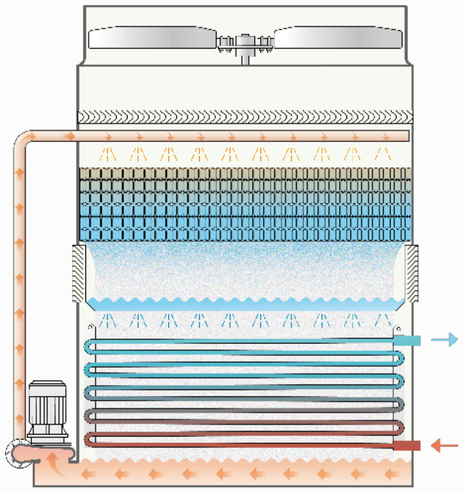
# MECHANISM



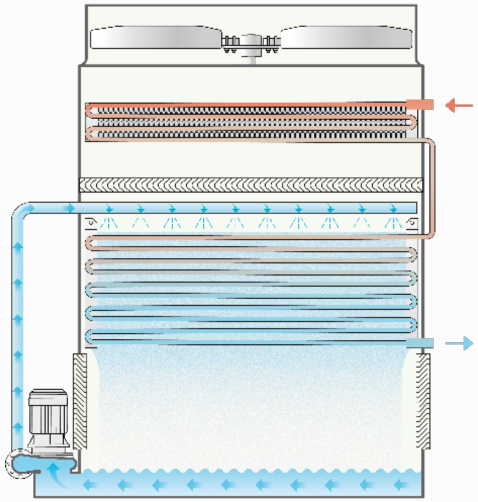

- Hot water from a process system flows over the infill
- Tower fan draws ambient air across water on the infill.
- Heat from the water is transferred to the air by latent and sensible cooling

# TYPES OF COOLING TOWER (CLOSED)

## INDUCED DRAFT

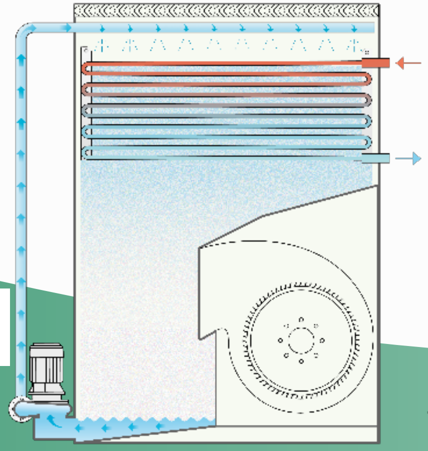


Counter Flow

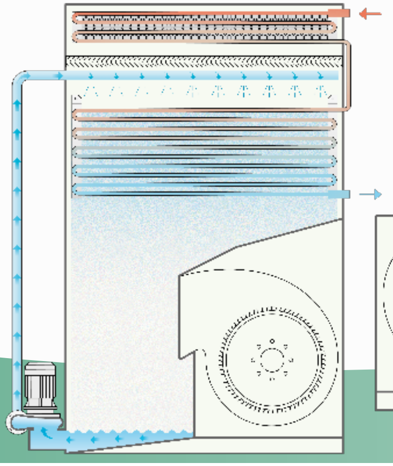


Counter Flow (hybrid model)

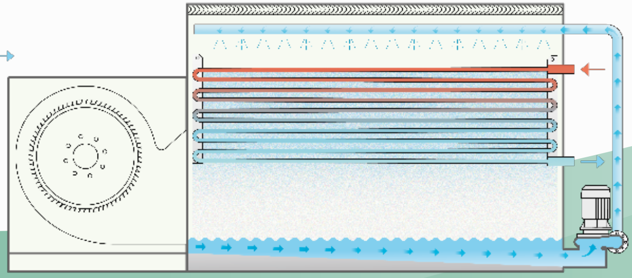
## FORCED DRAFT



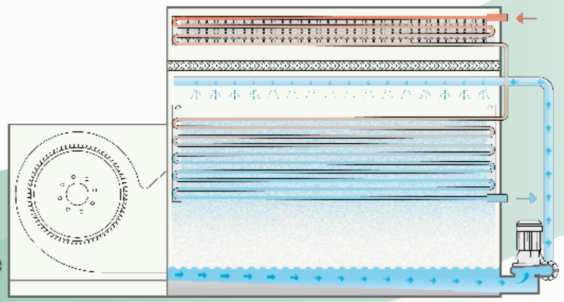
Counter Flow



Counter Flow (hybrid model)



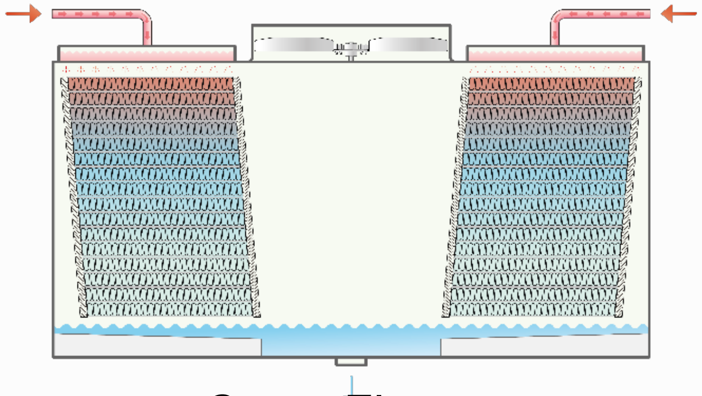
Counter Flow Low Height



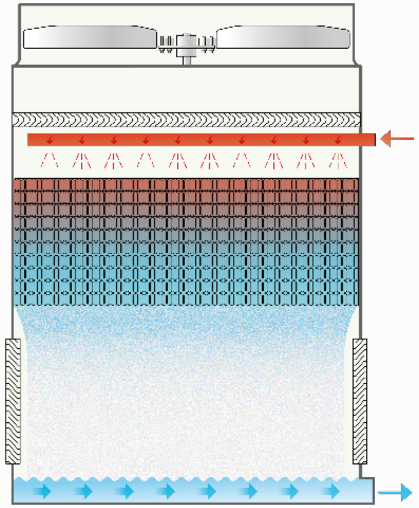
Counter Flow Low Height (hybrid model)

# TYPES OF COOLING TOWER (OPEN)

## INDUCED DRAFT

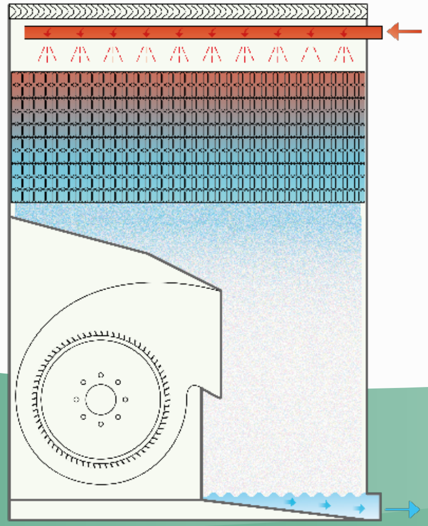


Cross Flow

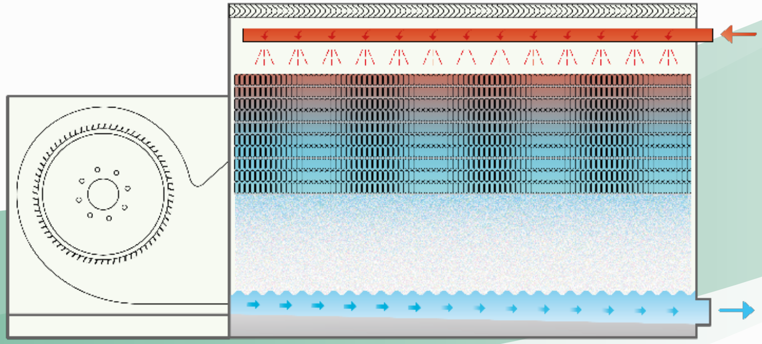


Counter Flow

## FORCED DRAFT



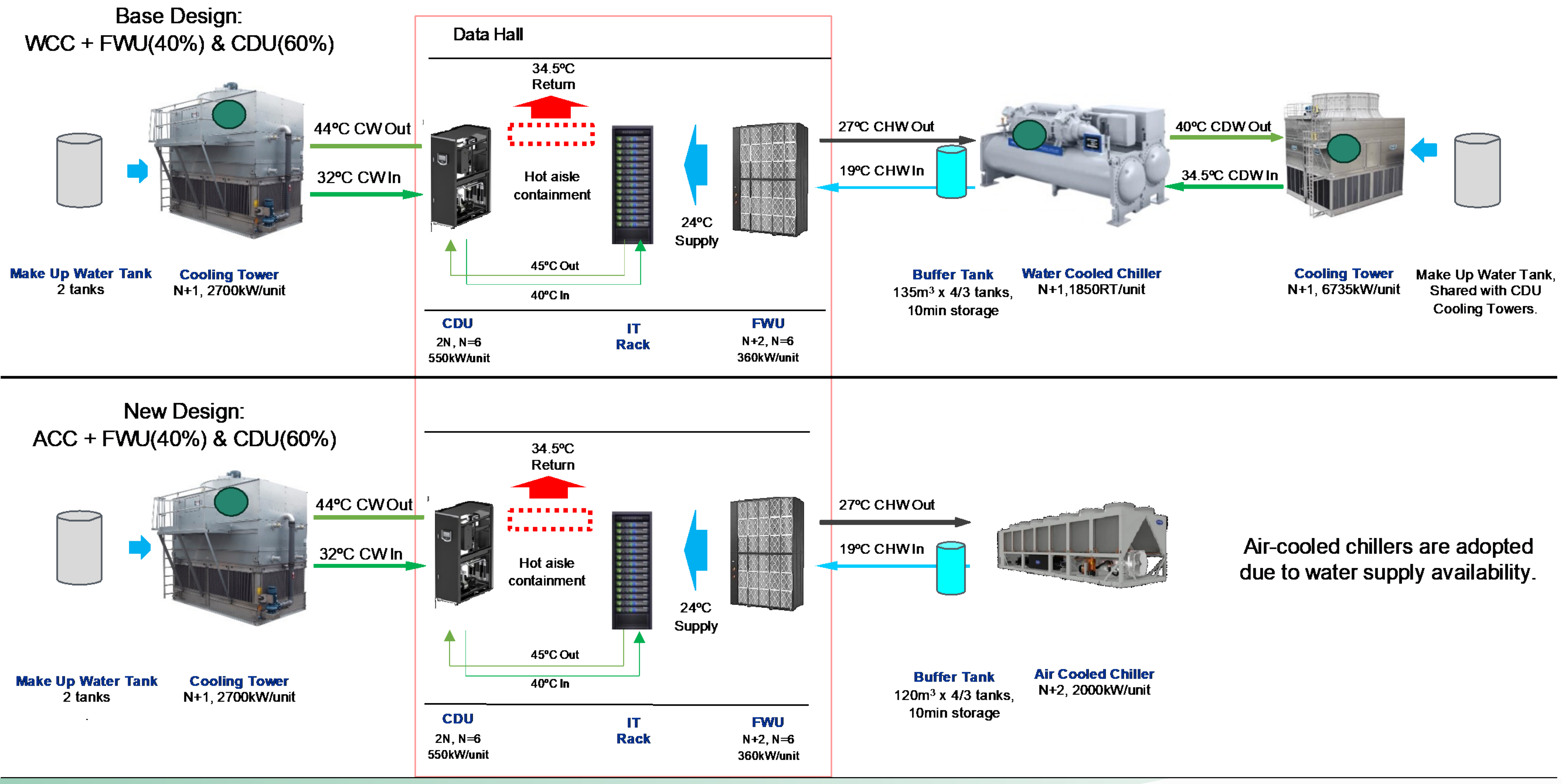
Counter Flow



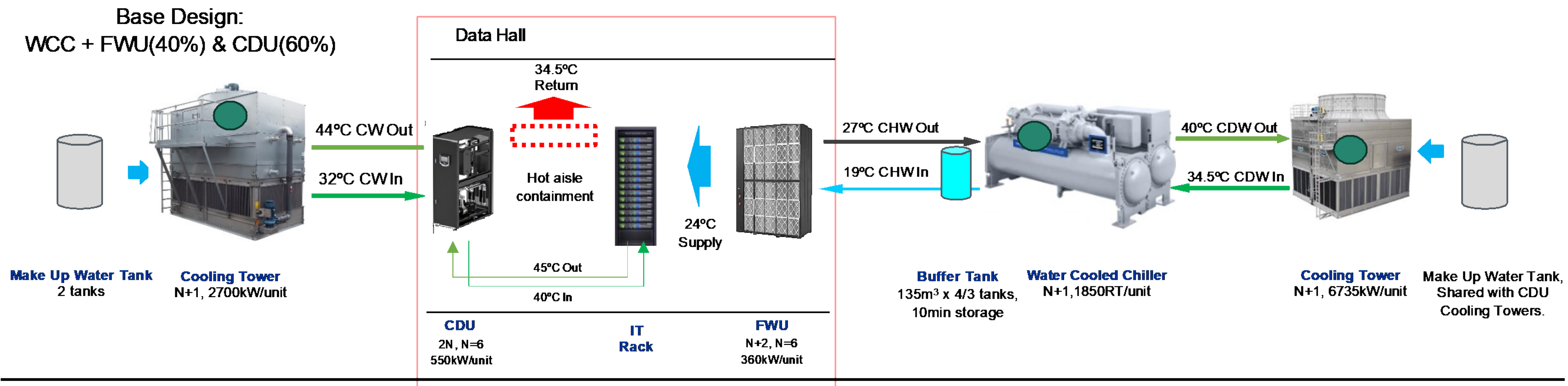
Counter Flow (Low Height)

# EVAPORATIVE COOLING IN IMPROVING DATA CENTRE POWER USAGE EFFICIENCY (PUE)

# CASE STUDY - PUE



# OPTION-1


Base Design:
WCC + FWU(40%) & CDU(60%)
Data Hall
34.5°C
Return
44°C CW Out
32°C CW In
Hot aisle
containment
24°C
Supply
45°C Out
40°C In
27°C CHW Out
19°C CHW In
40°C CDW Out
34.5°C CDW In
Make Up Water Tank
2 tanks
Cooling Tower
N+1, 2700kW/unit
CDU
2N, N=6
550kW/unit
IT
Rack
FWU
N+2, N=6
360kW/unit
Buffer Tank
135m³ x 4/3 tanks,
10min storage
Water Cooled Chiller
N+1,1850RT/unit
Cooling Tower
N+1, 6735kW/unit
Make Up Water Tank,
Shared with CDU
Cooling Towers.

# WATER COOLED CHILLER

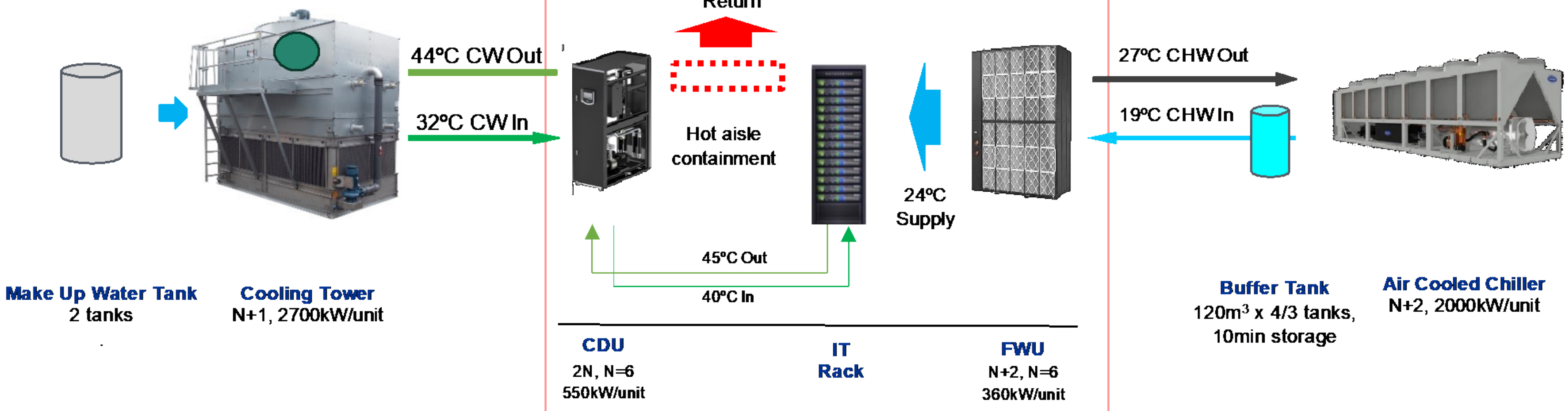
## Partload Information

Constant Condenser at 10% interval

| % Load % | Cooling Capacity tons | Evap LWT C | Evap FR gpm | Evap EWT C | Evap PD ft H2O | Cond EWT C | Cond FR L/s | Cond LWT C | Cond PD ft H2O | kW kW | Amps A | Cooling Eff kW/ton |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 1850 | 19.00 | 3088 | 27.00 | 12.5 | 34.50 | 317.6 | 40.00 | 27.3 | 722.8 | 1063.70 | 0.3907 |
| 90 | 1665 | 19.00 | 2779 | 27.00 | 10.1 | 34.50 | 317.6 | 39.43 | 27.4 | 617.4 | 915.30 | 0.3708 |
| 80 | 1480 | 19.00 | 2470 | 27.00 | 8.05 | 34.50 | 317.6 | 38.86 | 27.4 | 529.2 | 789.00 | 0.3575 |
| 70 | 1295 | 19.00 | 2162 | 27.00 | 6.19 | 34.50 | 317.6 | 38.32 | 27.4 | 458.5 | 686.20 | 0.3541 |
| 60 | 1110 | 19.00 | 1853 | 27.00 | 4.55 | 34.50 | 317.6 | 37.78 | 27.4 | 404.6 | 608.90 | 0.3645 |
| 50 | 925.0 | 19.00 | 1544 | 27.00 | 3.15 | 34.50 | 317.6 | 37.25 | 27.5 | 357.3 | 539.80 | 0.3862 |
| 40 | 740.0 | 19.00 | 1235 | 27.00 | 1.99 | 34.50 | 317.6 | 36.72 | 27.5 | 308.7 | 472.40 | 0.4171 |
| 30 | 555.0 | 19.00 | 1121 | 25.61 | 1.63 | 34.50 | 317.6 | 36.19 | 27.5 | 261.4 | 407.00 | 0.4710 |
| 20 | 370.0 | 19.00 | 1121 | 23.40 | 1.62 | 34.50 | 317.6 | 35.66 | 27.5 | 217.8 | 338.20 | 0.5885 |
| 10 | 185.0 | 19.00 | 1121 | 21.20 | 1.62 | 34.50 | 317.6 | 35.12 | 27.6 | 164.4 | 256.50 | 0.8886 |

# OPTION-2

New Design:
ACC + FWU(40%) & CDU(60%)




Air-cooled chillers are adopted due to water supply availability.

# AIR COOLED CHILLER

## Partload Information

| Constant Entering Condenser at 10% interval | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Load %** | **Cap. kW** | **LWT Evap C** | **EWT Evap C** | **Flow Evap L/s** | **WPD Evap kPa** | **Ambient C** | **Power kW** | **Eff. COP (kW/kW)** |
| **100** | 2000 | 19.00 | 27.00 | 59.91 | 26.9 | 36.50 | 468.1 | 4.273 |
| **90** | 1800 | 19.00 | 27.00 | 53.92 | 21.9 | 36.50 | 393.5 | 4.575 |
| **80** | 1600 | 19.00 | 27.00 | 47.93 | 17.4 | 36.50 | 331.8 | 4.823 |
| **70** | 1400 | 19.00 | 27.00 | 41.94 | 13.4 | 36.50 | 278.7 | 5.022 |
| **60** | 1200 | 19.00 | 27.00 | 35.94 | 9.89 | 36.50 | 220.9 | 5.432 |
| **50** | 1000 | 19.00 | 25.92 | 34.60 | 9.17 | 36.50 | 176.7 | 5.659 |
| **40** | 800.0 | 19.00 | 24.54 | 34.60 | 9.17 | 36.50 | 137.1 | 5.835 |
| **30** | 600.0 | 19.00 | 23.15 | 34.60 | 9.17 | 36.50 | 108.0 | 5.557 |
| **20** | 400.0 | 19.00 | 21.77 | 34.60 | 9.17 | 36.50 | 67.50 | 5.926 |
| **10** | 200.0 | 19.00 | 20.38 | 34.60 | 9.17 | 36.50 | 34.57 | 5.782 |

# SUMMARY

- Under similar total capacity, water cooled chiller is much efficient in terms of power consumption
- However, according to ASHRAE Handbook – HVAC Application Chapter 40, typical evaporation loss is 1% of the flowrate for each 7°C of water temperature range
- Approximate 9.0m3/hr = 9000 litre/hr for 1 x 1850RT chiller
- A balance on energy and water consumption must be considered when deciding on which option

# HYBRID COOLER IN IMPROVING WATER USAGE EFFICIENCY (WUE)

# LEED SYSTEM GOALS

- Reduce contribution to global climate change
- Enhance individual human health
- Protect and restore water resources
- Protect and enhance biodiversity and ecosystem services
- Promote sustainable and regenerative material cycle
- Enhance community quality of life

# MERKEL EQUATION (EVAPORATIVE COOLING)

Heat gain by AIR

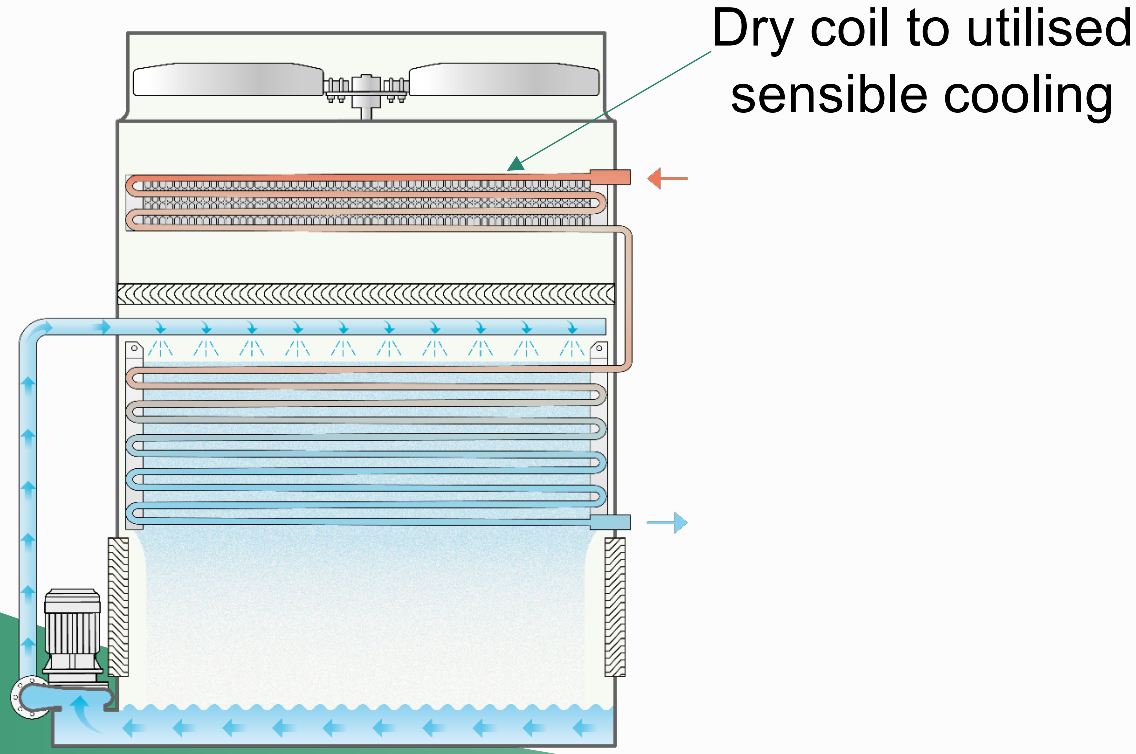
Heat loss from WATER

(Total Heat Gained) $Gdh = Ldt + GdH(t2 - 32)$ (Total Heat Lossed)

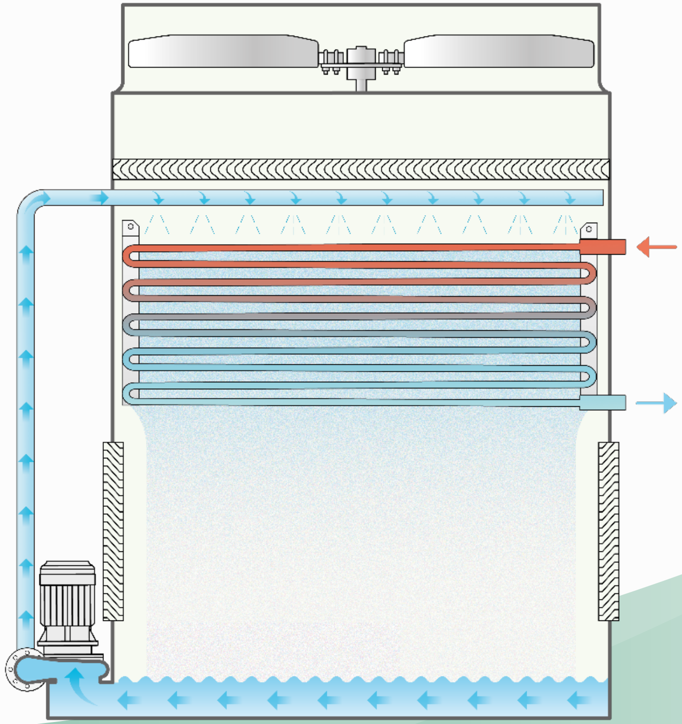
Evaporation Component

1. G = Air Flow rate
2. h = Enthalpy of moist air
3. L = Mass water rate
4. H = Absolute humidity
5. t = Temperature

# HYBRID COOLER VS CONVENTIONEL COOLER

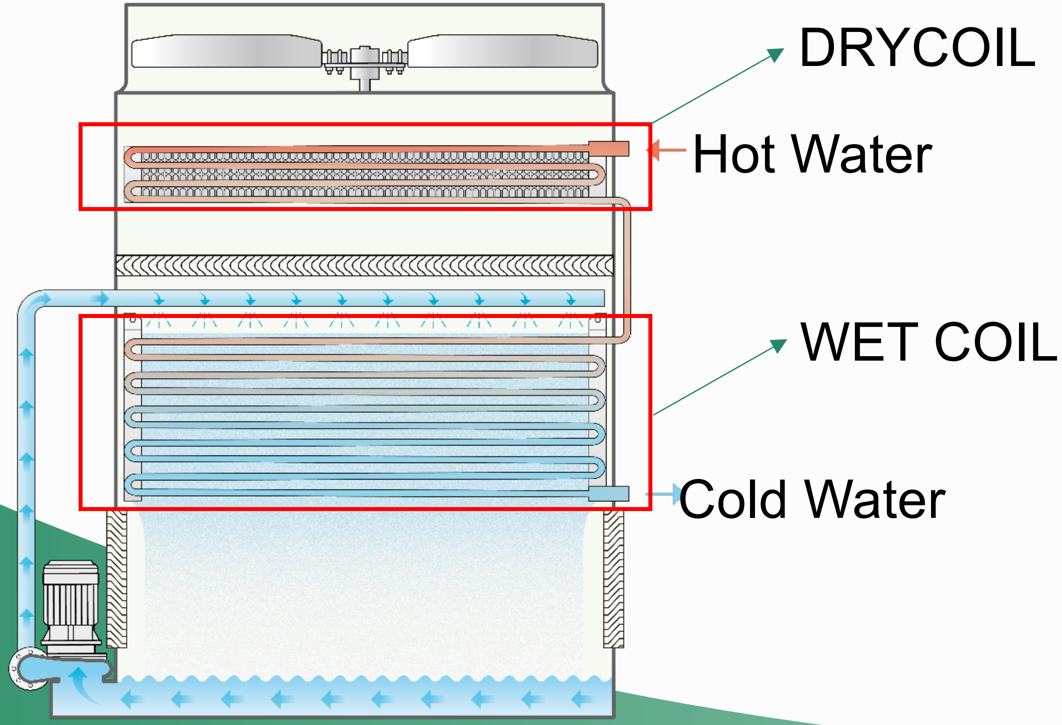



Hybrid type close loop counter flow



Conventional close loop counter flow

# HYBRID COOLER MECHANISM




1. The process fluid is circulated through the dry coil. A portion is of the heat is rejected to the air passing over the dry coil. The process fluid then enters the wet coil where the remaining heat of the process fluid is transferred through the tube wall and extended surface fins to the water cascading downward over the tubes.

2. Simultaneously, air is drawing in through the air inlet louvers at the base of the cooler and travels upward over the coil opposite the spray water flow. A small portion of the water is evaporated which rejects heat. The warm moist air is drawn to the top of the closed-circuit cooler by the fan and is discharged to the atmosphere.

3. The remaining water falls to the sump at the bottom of the cooler where it is recirculated by the pump through the water distribution system and back down over the coils.

4. For cold climate country, the dry coil serves as plume abatement as secondary function.

# CASE STUDY

| Selection Criteria | Total | Each Unit |
| --- | --- | --- |
| Flow: | 54.6 LPS | 54.6 LPS |
| Fluid: | Water | Water |
| Entering Fluid Temp: | 44.0 C | 44.0 C |
| Leaving Fluid Temp: | 32.0 C | 32.0 C |
| Entering Wet Bulb: | 29.4 C | 29.4 C |

## Required Capacity

2,740.00 kW
2,356,426 kcal/hr
623.39 Tons

| | |
| --- | --- |
| Entering Dry Bulb Switchover: | 10.7 C |
| % Dry Load: | 23.8 % |

Sensible cooling by dry coil before the wet coil

# CASE STUDY

| | Conventional Closed Loop Counter Flow | Hybrid Type Closed Loop Counter Flow |
|---|---|---|
| Evaporation Loss (m3/hr) | 4.1 | 2.60 |
| Drift Loss (m3/hr) | 0.01 | 0.01 |
| Blowdown Loss (m3/hr), COC 7 | 0.67 | 0.43 |
| Total Make Up (m3/hr) | 4.79 | 3.04 |
| Savings (%) | ≈ 35% of savings | |
| Remark | Precool coil reduce heat load before the evaporation coil, hence, able to reduce the heat load at the evaporation coil and achieve water savings | |

# CASE STUDY (OPTIMIZED)

| Selection Criteria | Total | Each Unit |
|---|---|---|
| Flow: | 54.6 LPS | 54.6 LPS |
| Fluid: | Water | Water |
| Entering Fluid Temp: | 44.0 C | 44.0 C |
| Leaving Fluid Temp: | 32.0 C | 32.0 C |
| Entering Wet Bulb: | 29.2 C | 29.2 C |

**Required Capacity**

2,738.75 kW
2,355,348 kcal/hr
623.11 Tons

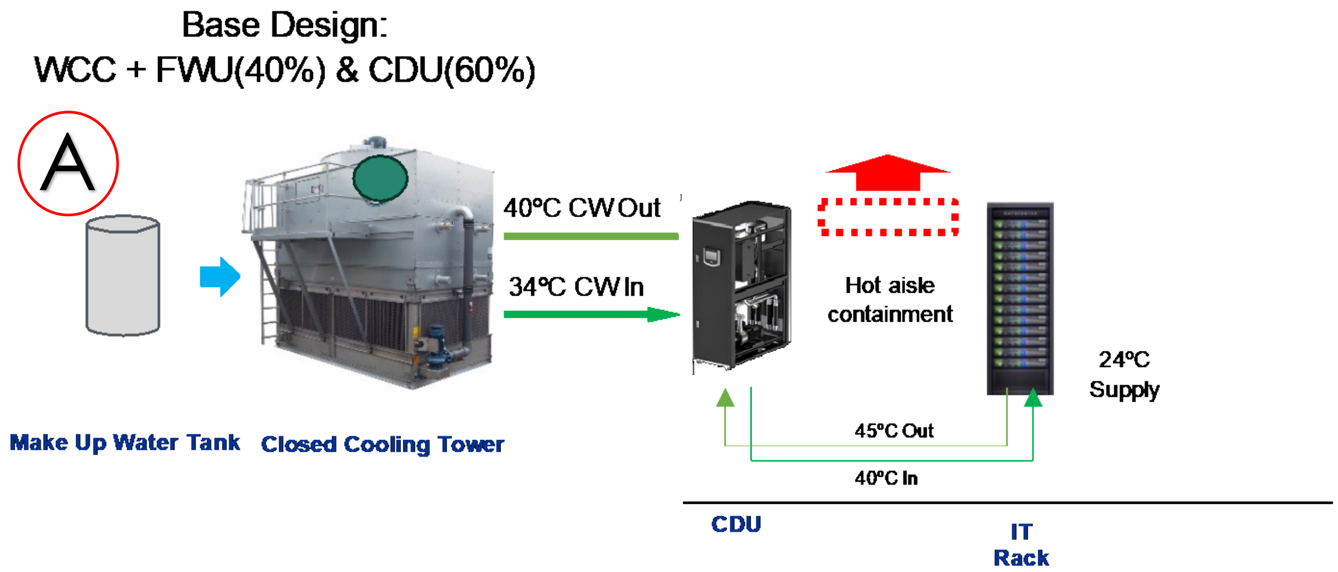
| | |
|---|---|
| Entering Dry Bulb Switchover: | 13.6 C |
| % Dry Load: | 33.51 % |

Sensible cooling by dry coil before the wet coil

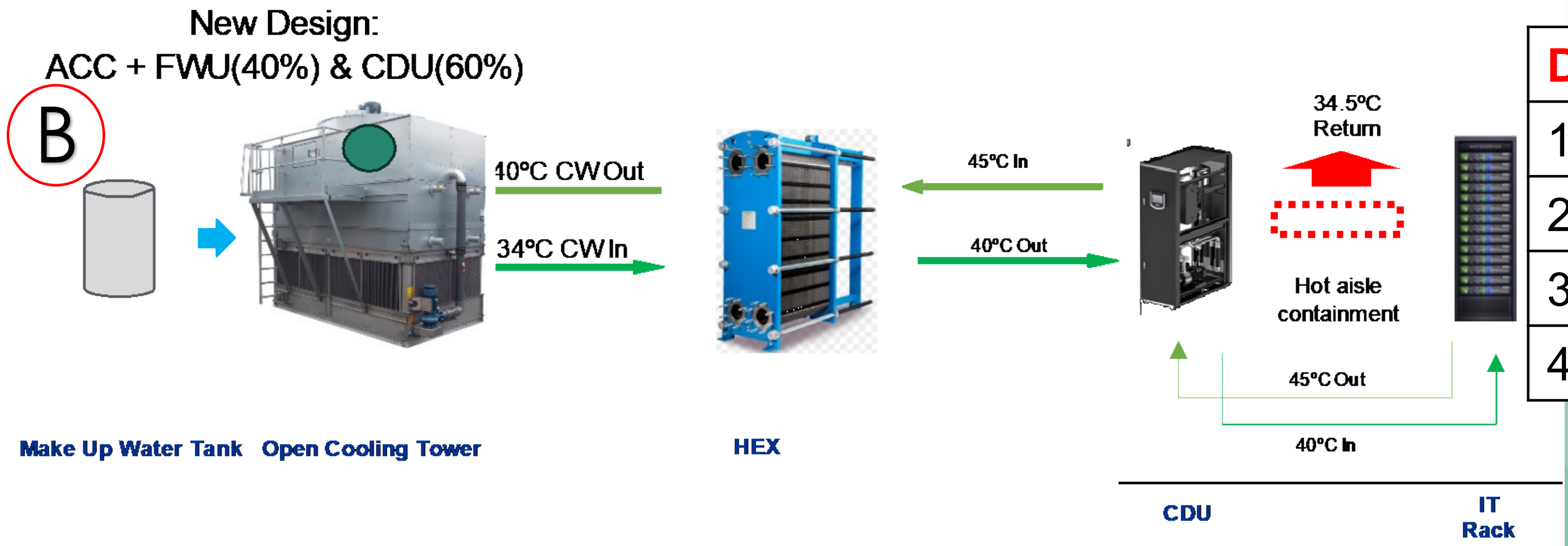
# CASE STUDY (OPTIMIZED)

| | Conventional Closed Loop Counter Flow | Hybrid Type Closed Loop Counter Flow |
|---|---|---|
| Evaporation Loss (m3/hr) | 4.1 | 2.20 |
| Drift Loss (m3/hr) | 0.01 | 0.01 |
| Blowdown Loss (m3/hr), COC 7 | 0.67 | 0.37 |
| Total Make Up (m3/hr) | 4.79 | 2.58 |
| Savings (%) | ≈ 46% of savings | |
| Remark | Precool coil reduce heat load before the evaporation coil, hence, able to reduce the heat load at the evaporation coil and achieve water savings | |

# ALTERNATIVE SOLUTION




| Advantages |
|---|
| 1. Compact and space savings |
| 2. Eliminate one loop of piping |
| 3. Eliminate one side of pumps |
| 4. Low kW for cooling tower spray pump |




| Disadvantages |
|---|
| 1. Takes up extra space |
| 2. Extra one loop of piping |
| 3. Extra one side of pumps |
| 4. High energy consumption by pumps |

# DESIGN CONSIDERATION

| | |
|---|---|
| Capex (Initial Capital Expenditures) | |
| Design  - A | Design – B |
| Closed loop cooling tower price | Open cooling tower |
| Not required | Flat plate Hex |
| Not required | Circulating pump |
| Not required | Extra piping |
| Not required | Additional space |
| Opex (Operation Expenditures) | |
| Spray pump consumption per year (Minor) | Circulating pump consumption per year (Major) |

# SUMMARY

1. FUNDAMENTAL OF EVAPORATIVE COOLING
2. EVAPORATIVE COOLING IMPROVED PUE
3. HYBRID COOLER ABLE TO REDUCED WATER USAGE
4. ALTERNATIVE DESIGN FOR NOT USING CLOSED LOOP COOLING TOWER IN LIDUID COOLING CDU APPLICATION

# Q & A

# THANK YOU

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