BEEP
BUILDING ENERGY EFFICIENCY PROJECT

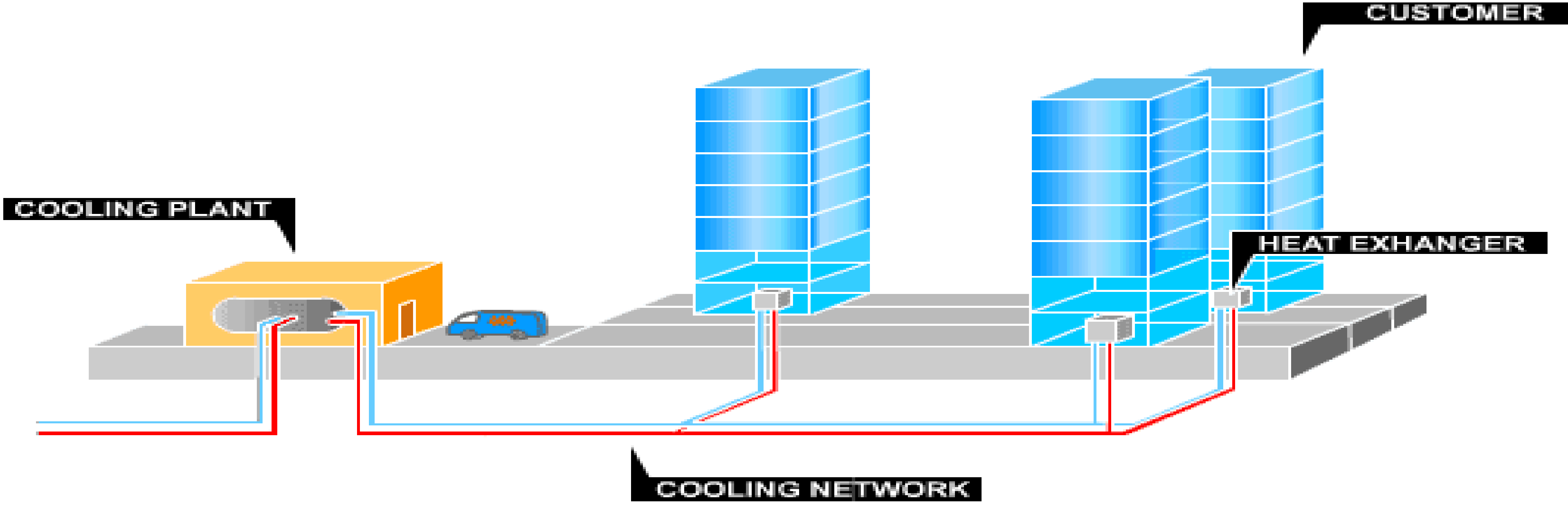
Energy Efficiency in District Coiling System

CONTENTS

- Introduction to district cooling system
  - Applicability, benefits
  - Heat flow diagram, energy split up
- Energy efficient practices in district cooling systems
  - Central chilled water plant
  - Building side systems
- Advanced Technologies
  - Radiant Cooling Systems
  - Thermal Energy Storage
- Summary – An Overall view

What is District Cooling ??

- Chilled water is generated at a single point to meet the requirements of entire site



Section 1 Central chilled water plant	→	Section 2 Distribution System	→	**Section 3 - Building level** **Energy transfer stations**

Introduction to District Cooling

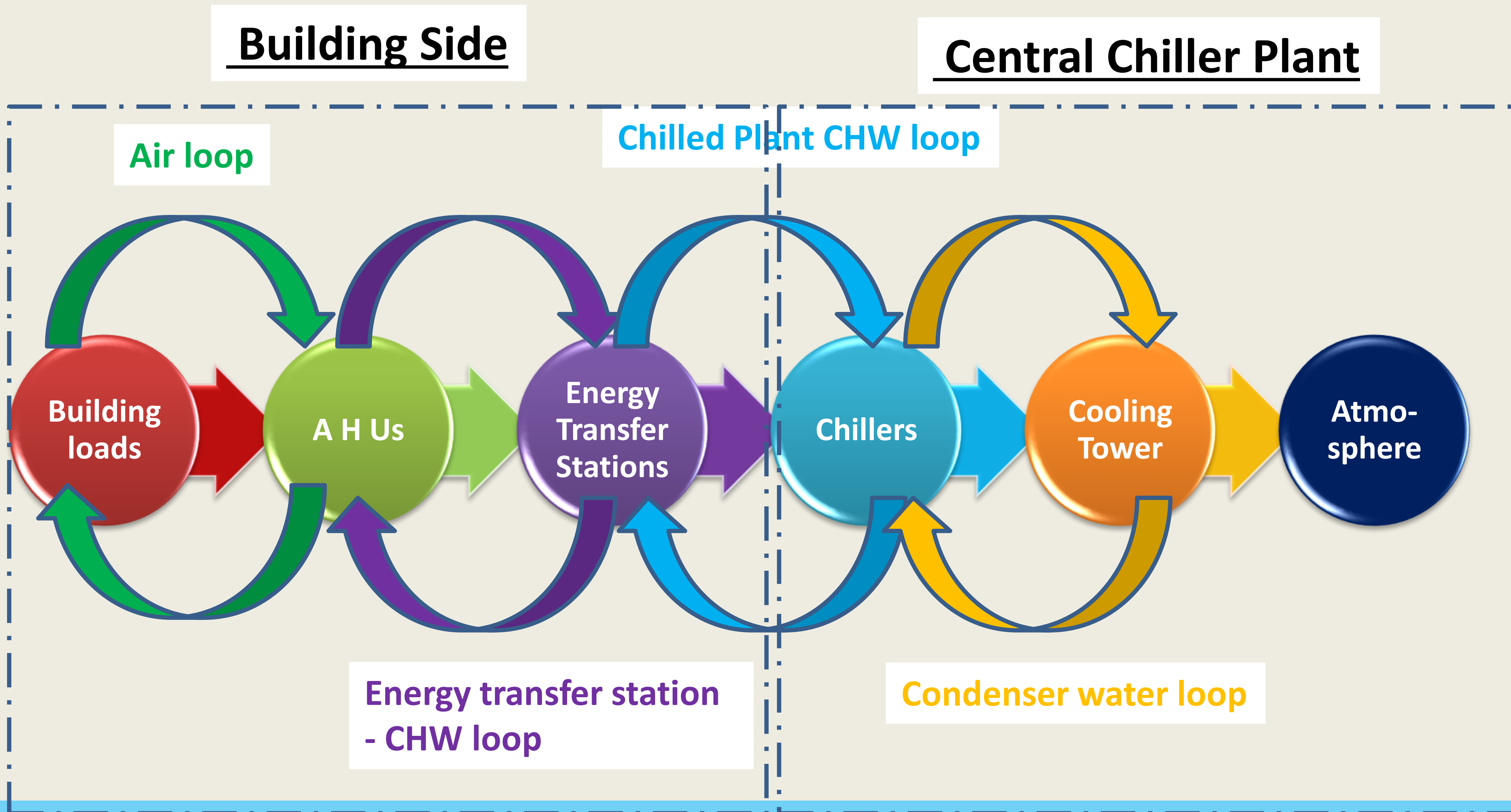
<u>Applicability</u>

- Higher building density and high cooling demand
  - Business districts
  - Universities
- Diversity of cooling loads in different buildings

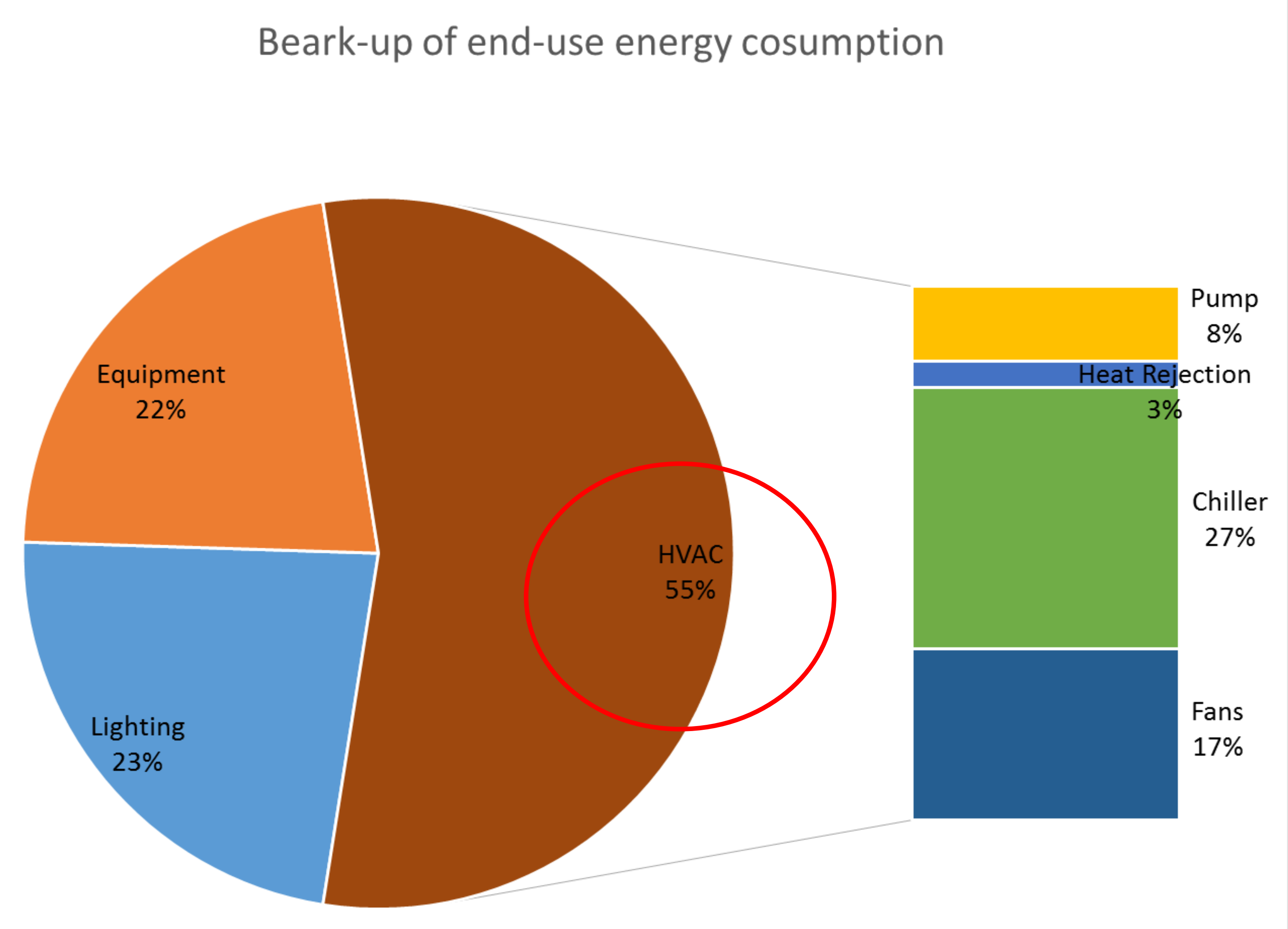
<u>Benefits</u>

- Reduction in system cooling capacity compared to aggregate capacities of buildings
- Operating all equipment near to their optimum conditions (Upon reaching to critical mass of cooling demand)

Heat flow diagram



Energy split up - Typical

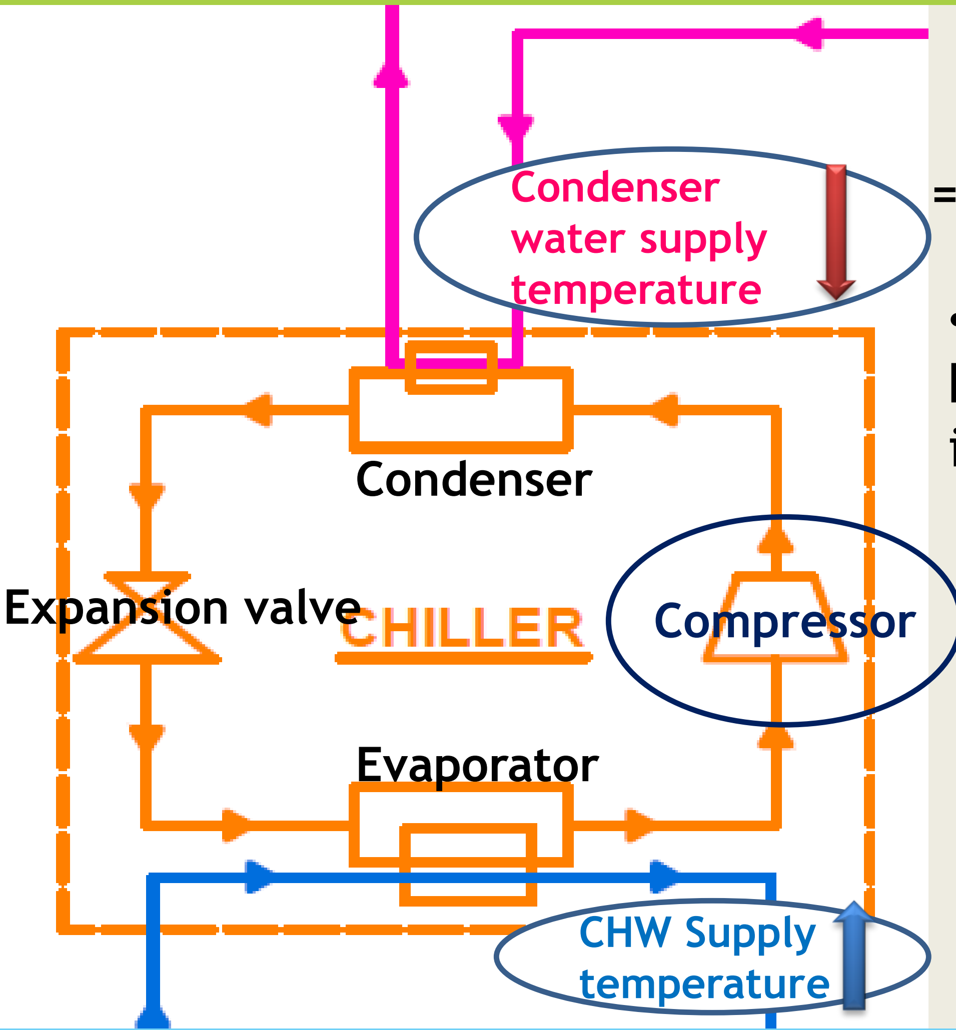


- Energy Efficiency in District Cooling System
  - **Central chilled water plant**
  - **Distribution system**
  - **Building side**

At 3 levels

Energy Efficiency practices – Centralized chiller plant

Chiller efficiency - C O P



Coefficient of performance or **COP**

$$= \frac{\text{Cooling provided in kW}}{\text{Compressor Energy Consumption in kW}}$$

- For a given cooling load, compressor has to consume less energy, then C O P increases
- In other terms, COP of chiller increases,

if the temperature difference between

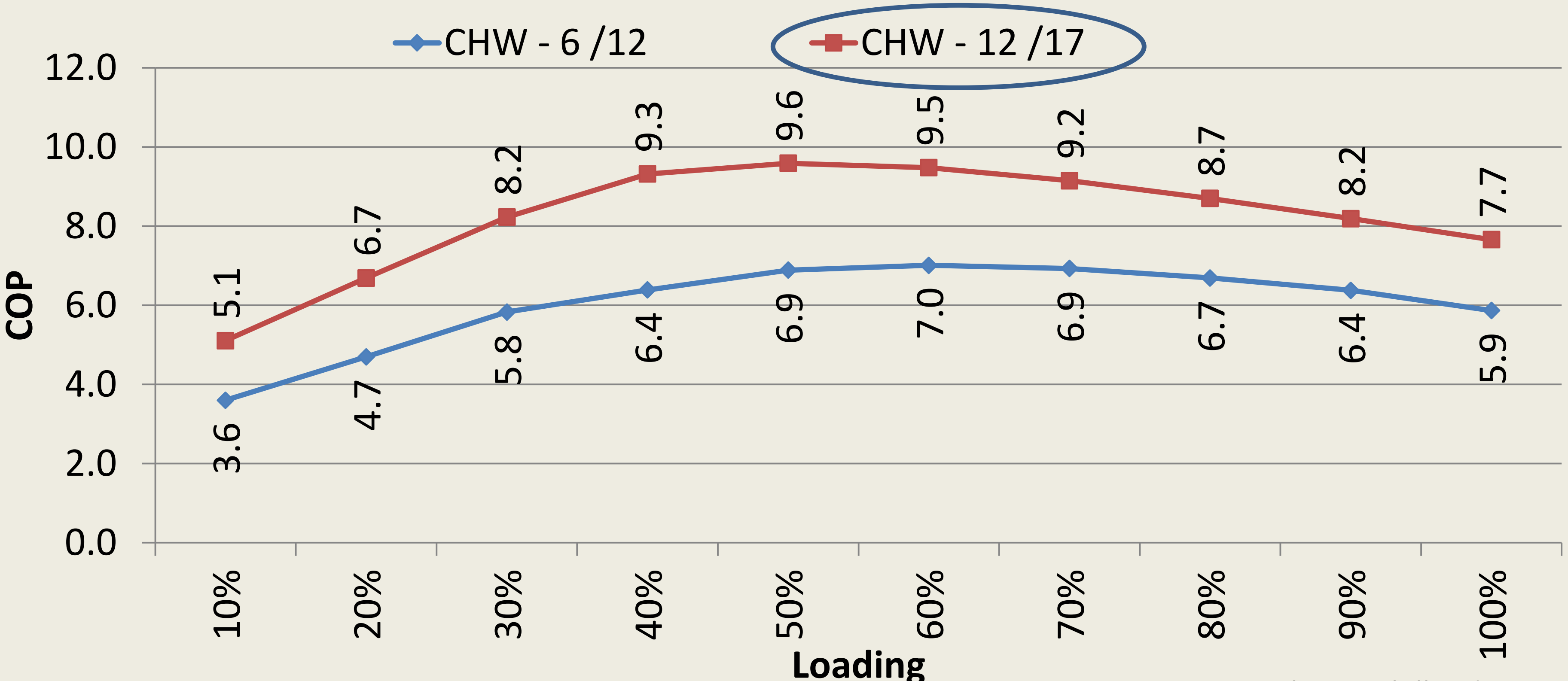
"Condenser water supply temperature "

and "Chilled water supply temperature"

decreases

Effect of chilled water supply temperature on chiller COP

Constant condenser water temperatures - 28 / 34

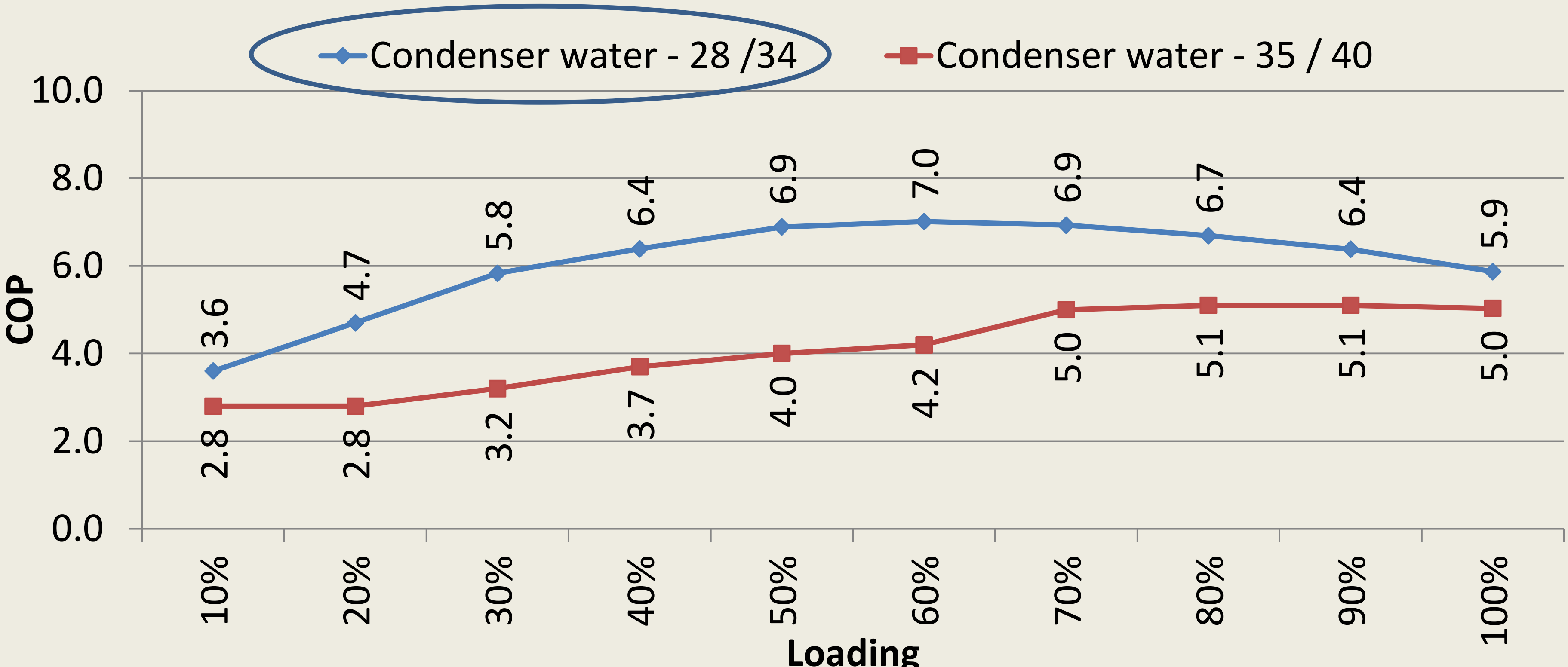


Source: Johnson chiller data

- **Improvement in COP is in the range of 30 – 40 %**

Effect of condenser water supply temperature on chiller COP

<u>Constant chilled water temperatures – 6 / 12</u>

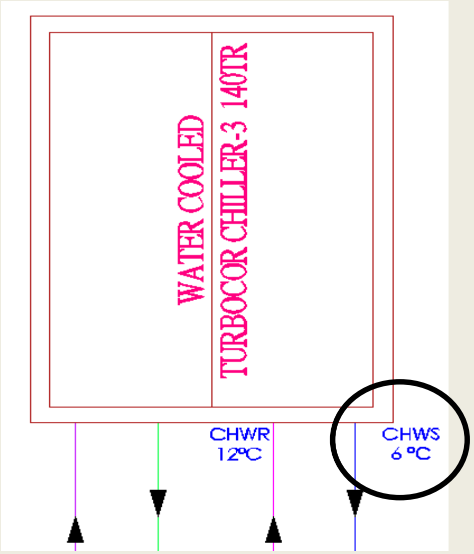


Source: Johnson chiller data

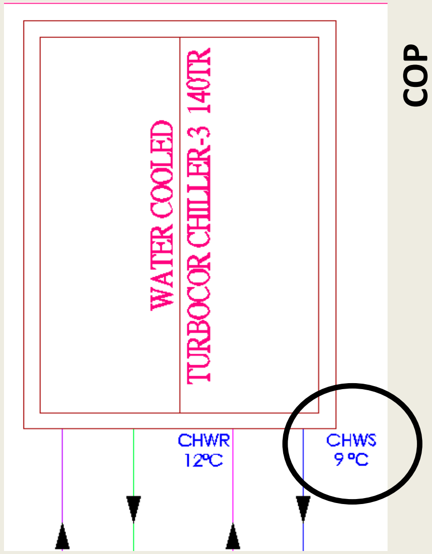
- **Improvement in COP is in the range of 40 – 50 %**

Gliding chilled water supply temperature

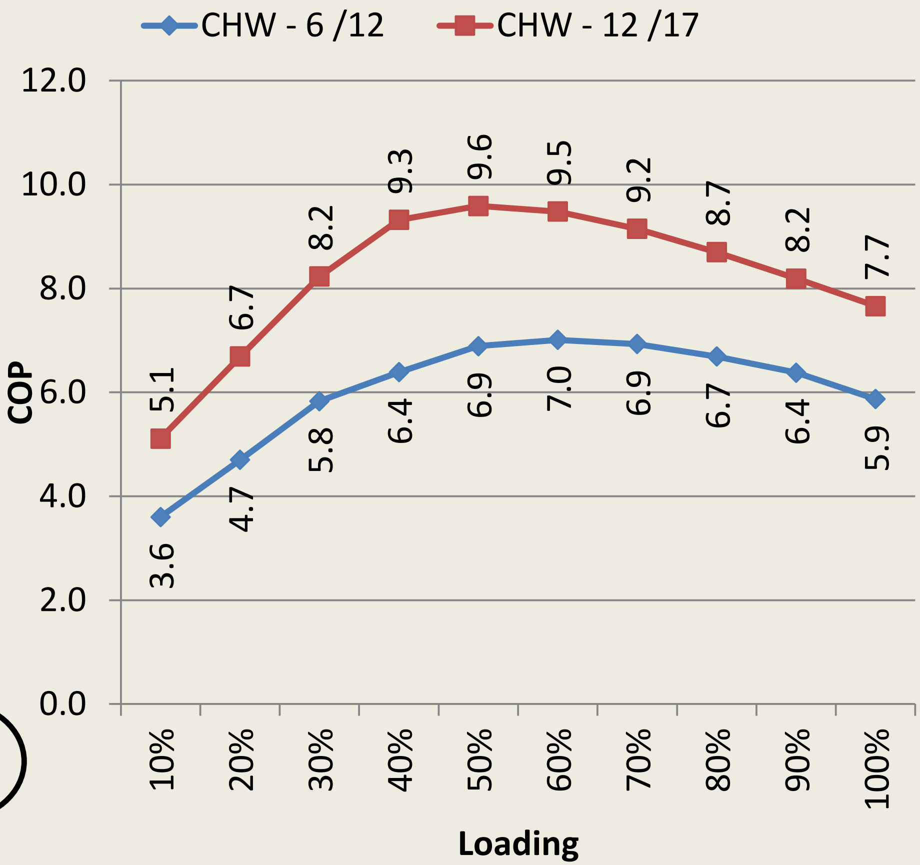
- COP increases with increased chilled water supply temperature
- Hence, rise the chilled water temperature as per the load



100% load

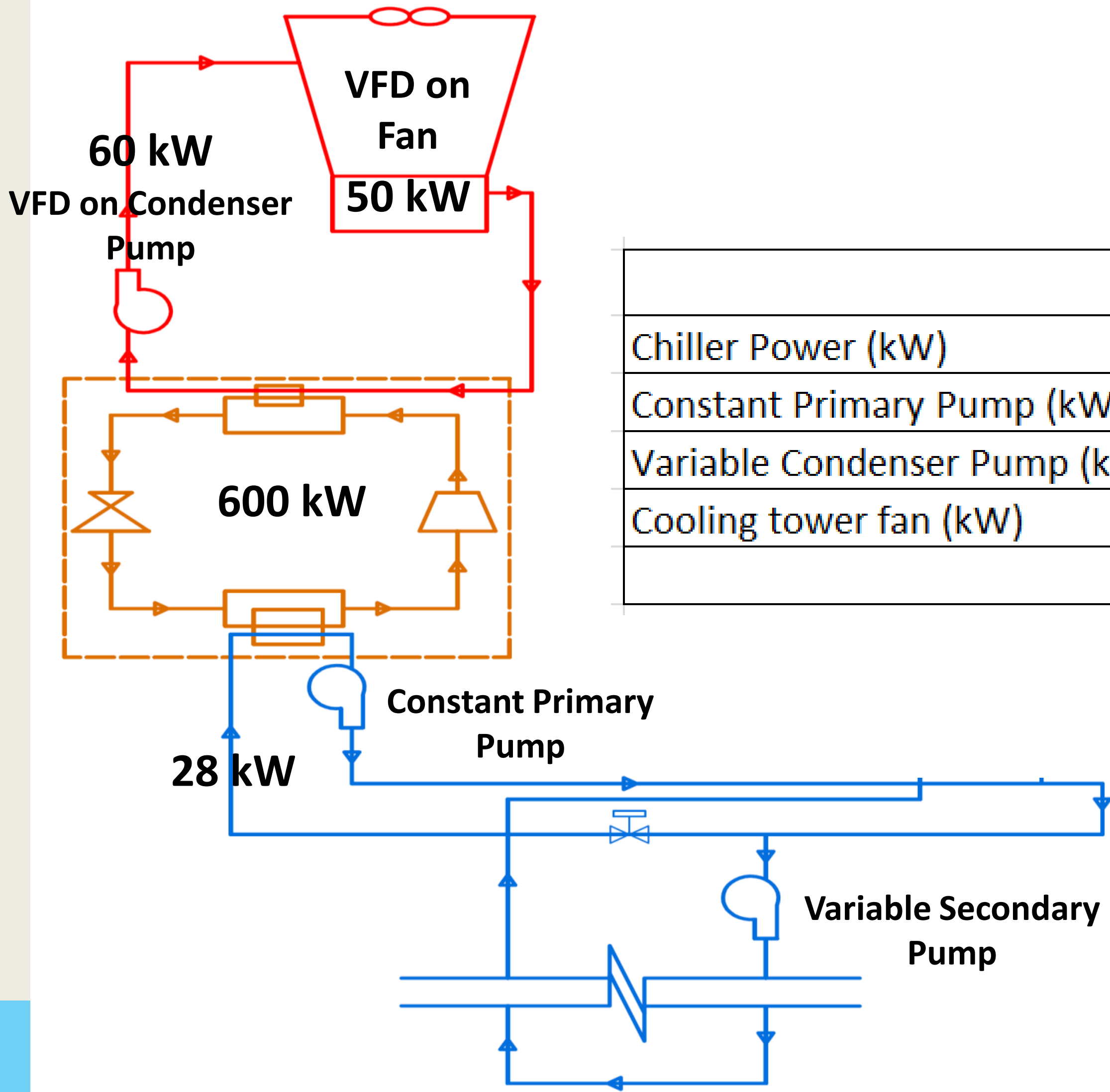


50% load



Source: Johnson chiller data

Using multiple chillers to meet the total system load

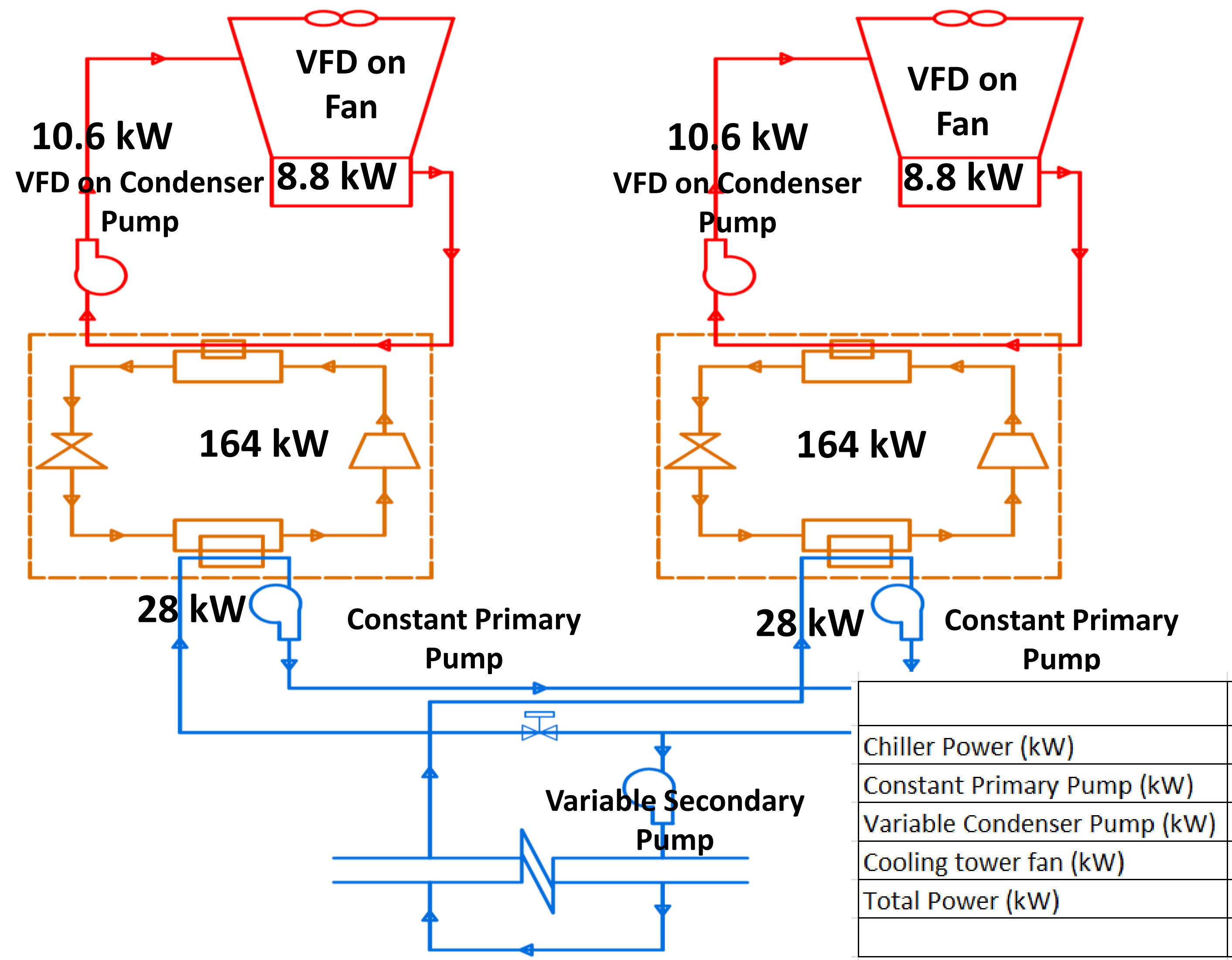


	1000 TR
Chiller Power (kW)	600
Constant Primary Pump (kW)	28
Variable Condenser Pump (kW)	60
Cooling tower fan (kW)	50
	738

Situation 1

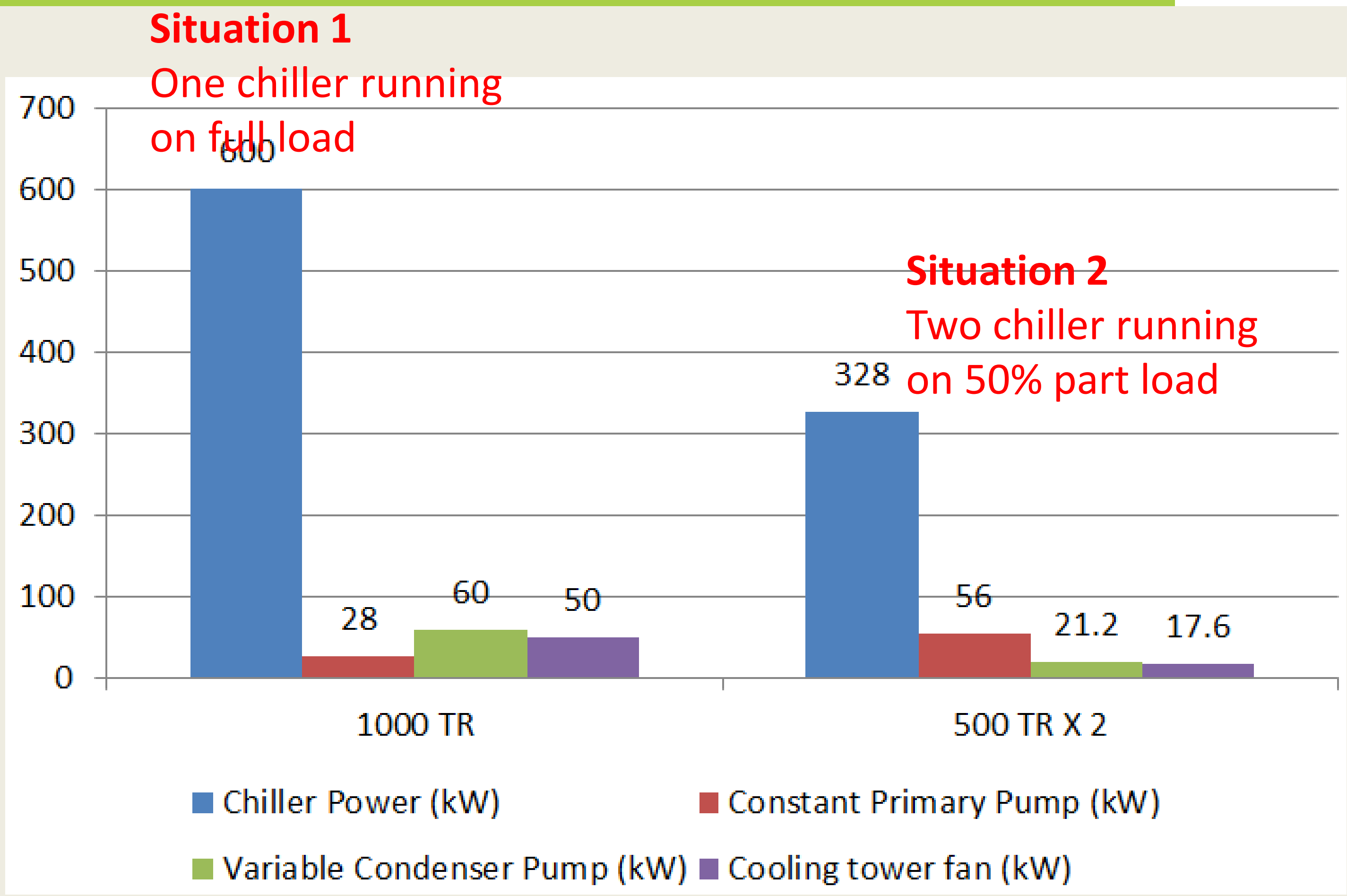
One chiller running at full load

Situation 2
Two chiller running at 50% part load



	Chiller 1: 500 TR	Chiller 2: 500 TR
Chiller Power (kW)	164	164
Constant Primary Pump (kW)	28	28
Variable Condenser Pump (kW)	10.6	10.6
Cooling tower fan (kW)	8.8	8.8
Total Power (kW)	211.4	211.4
		422.8

Performance Comparison



Installing VFDs for Centrifugal Chillers

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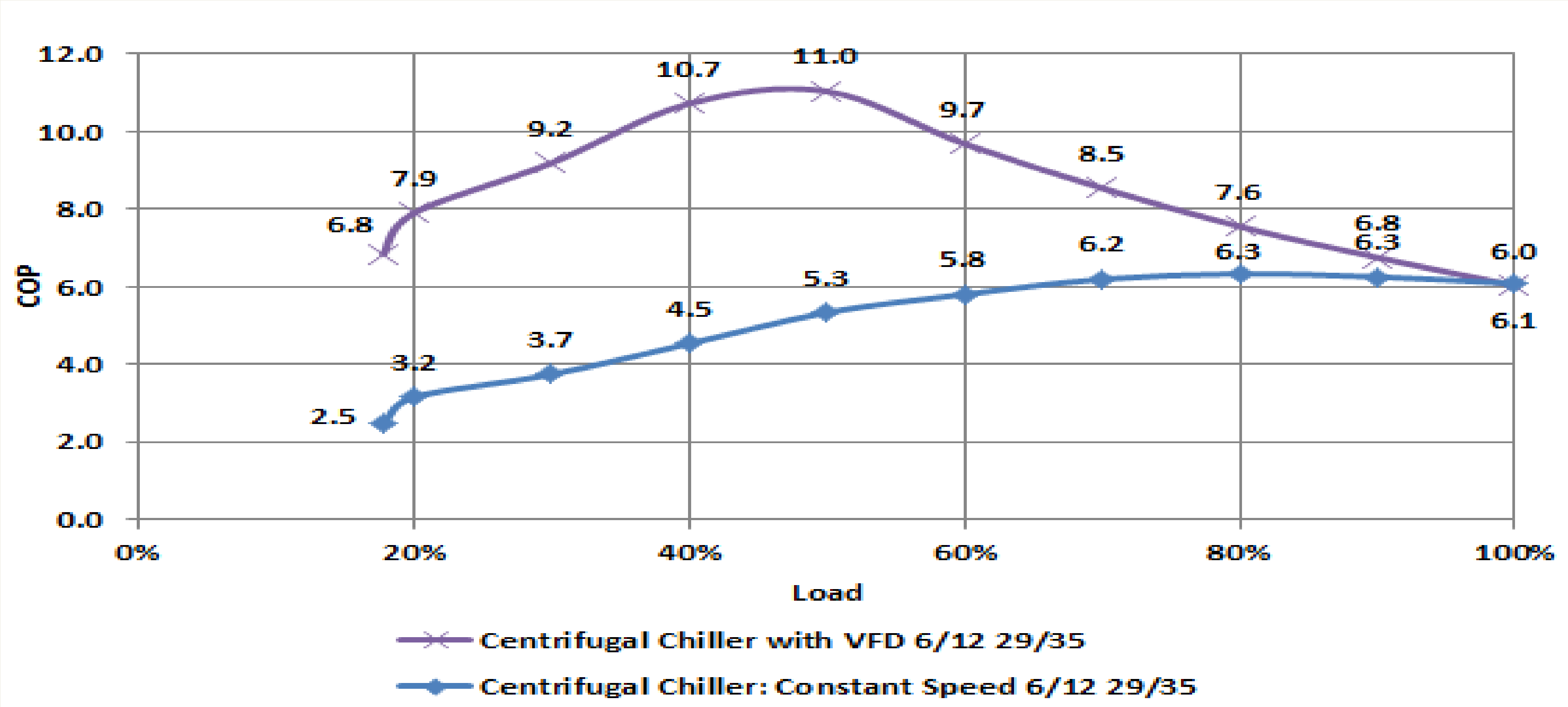
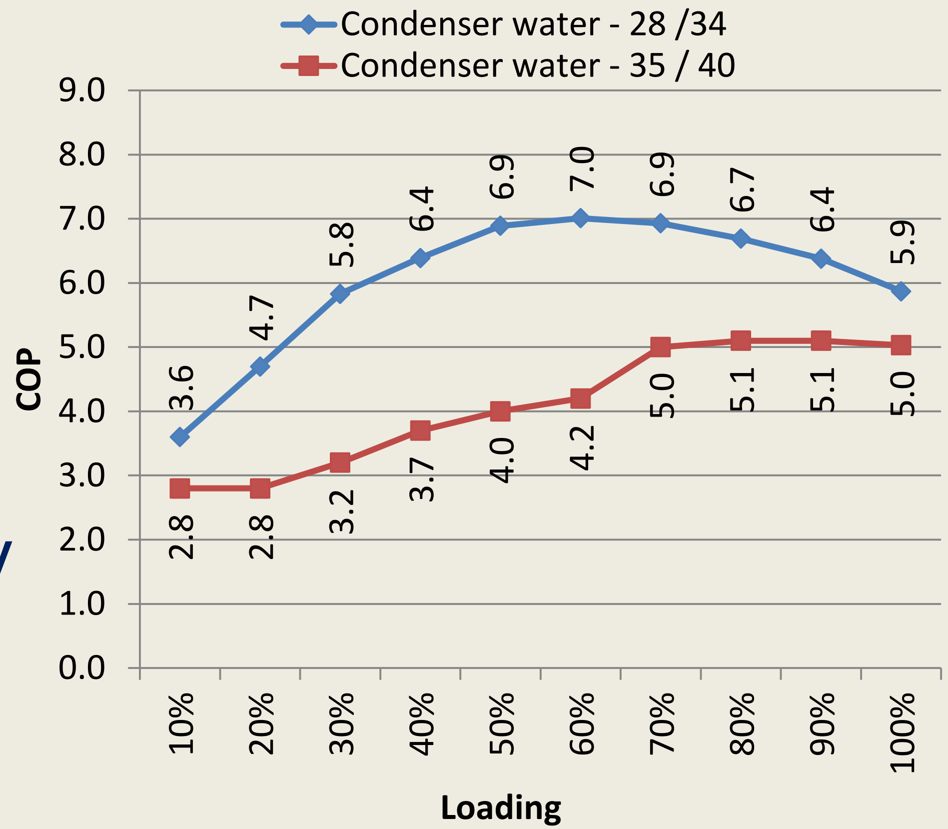
- **VFD operation of compressor increases COP at part load**



- **VFD operation decreases energy consumption with same output , hence the higher COP at part loads**

Cooling Tower

- Cooling tower supplies water to condenser, Hence performs the heat rejection part of the chiller
- Condenser water supply temperature effects the COP of the chiller
- **Lesser the condenser water supply temperature, higher the COP of chiller**
- Condenser supply temperature depends on effectiveness of the cooling tower



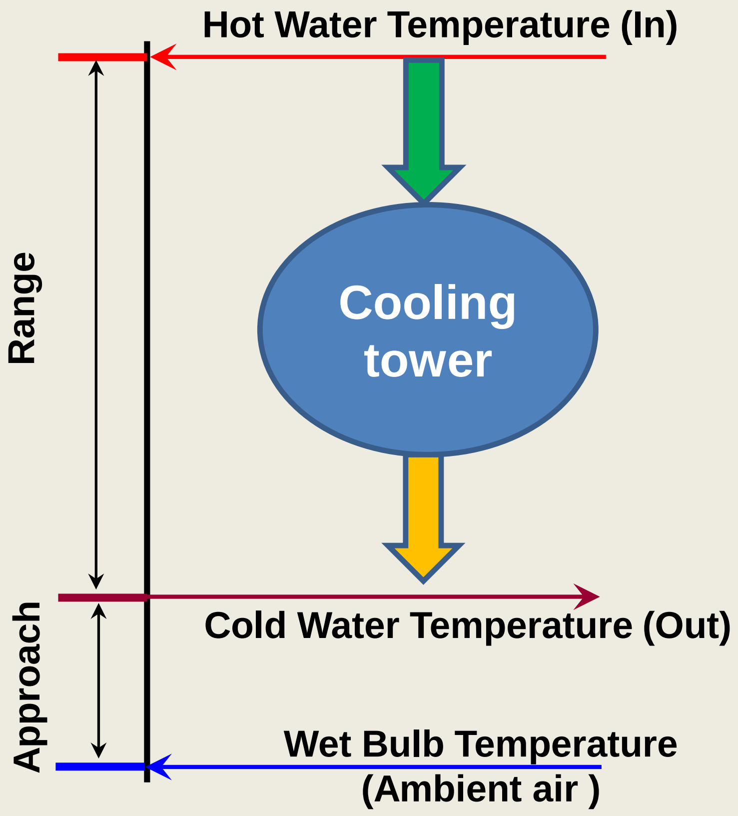
Source: Johnson chiller data

Cooling tower - Performance

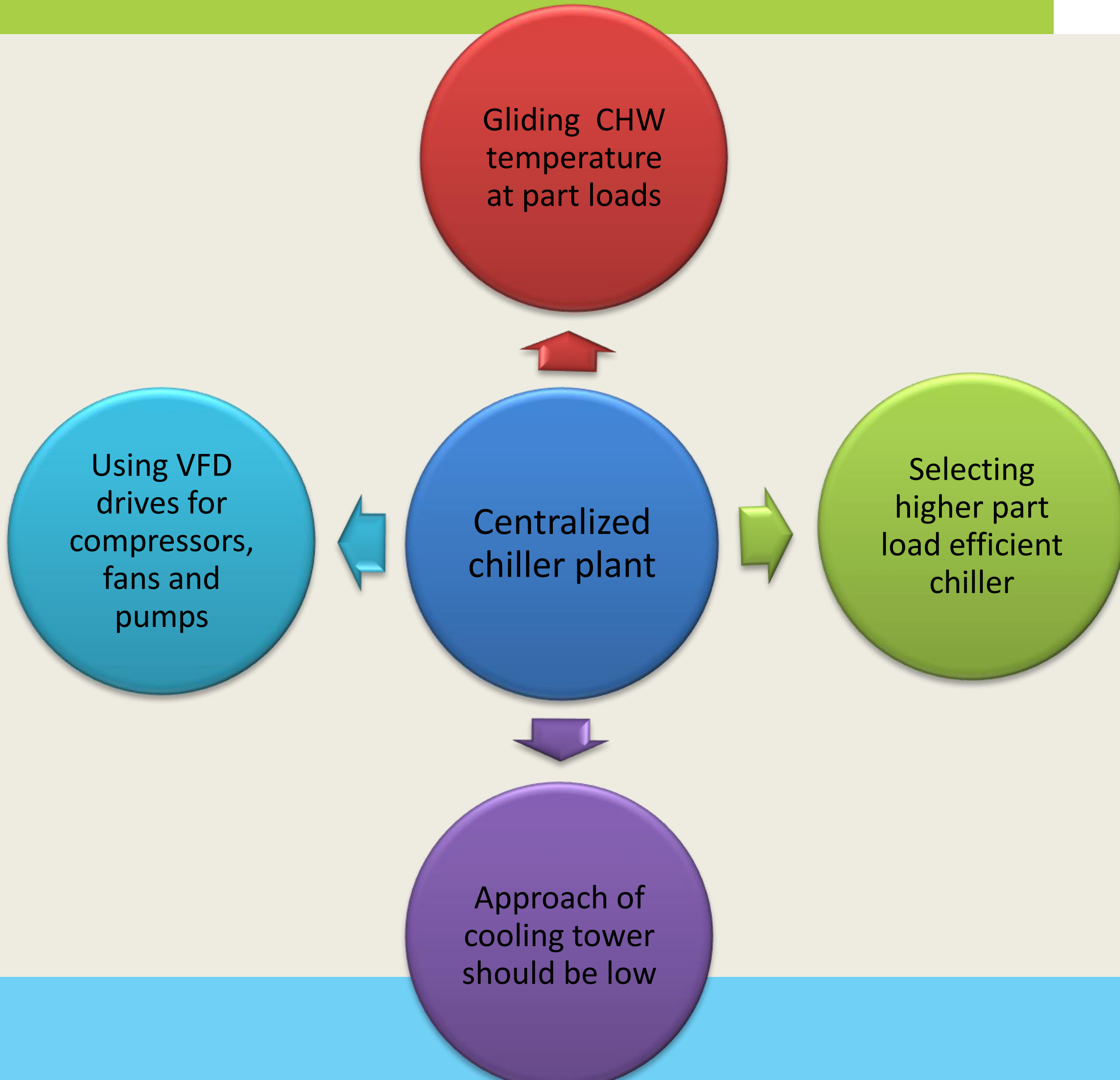
Effectiveness =

Range / (Range + Approach)

- Condenser supply temperature is **limited by wet bulb temperature of ambient air**
- Approach should be as less as possible
- Approach depends on the **effective heat transfer between air and water. It depends on Heat transfer medium (fills).**



Sum up - Energy Efficiency practices

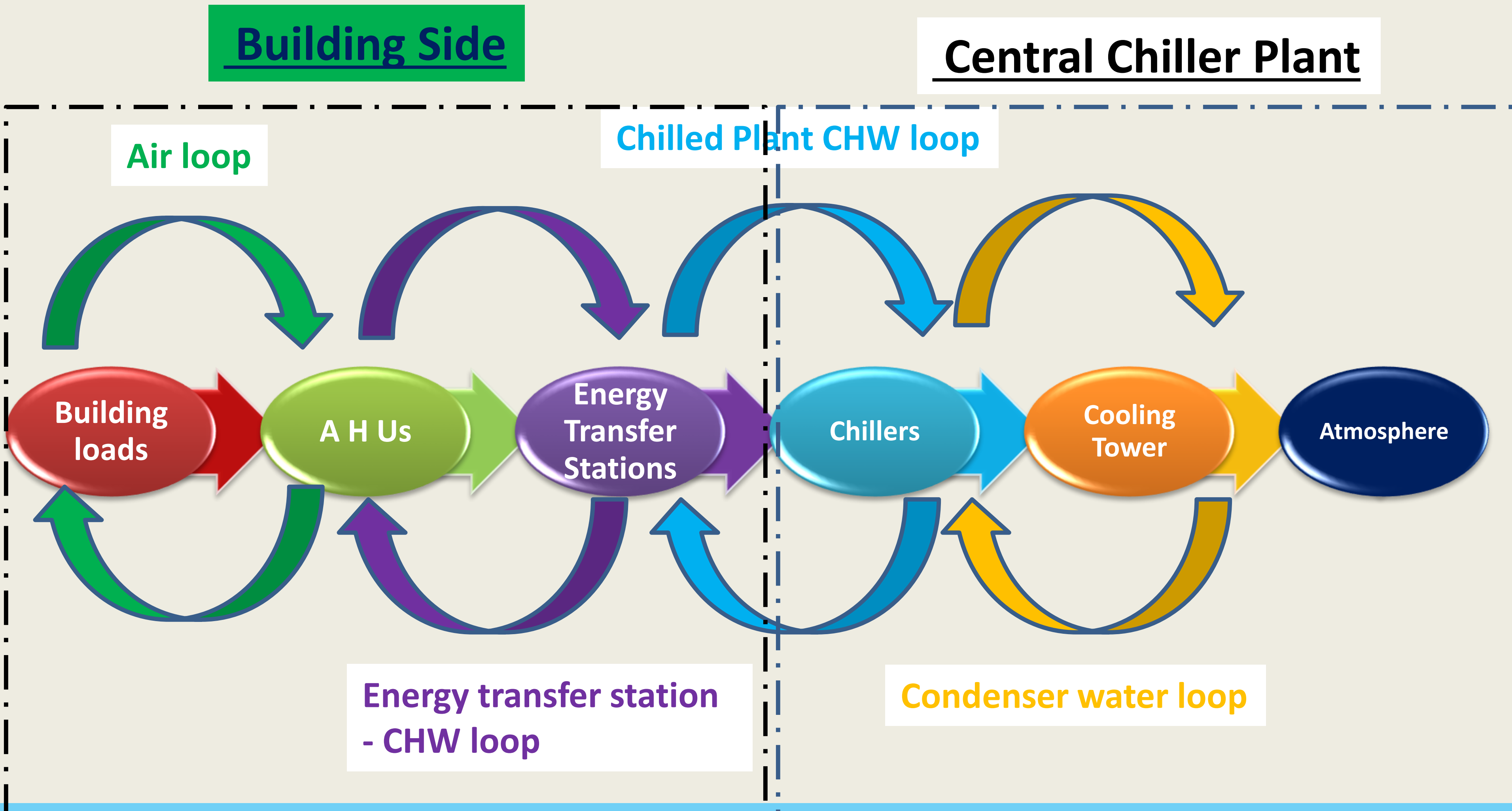


Energy Efficiency practices - Building side

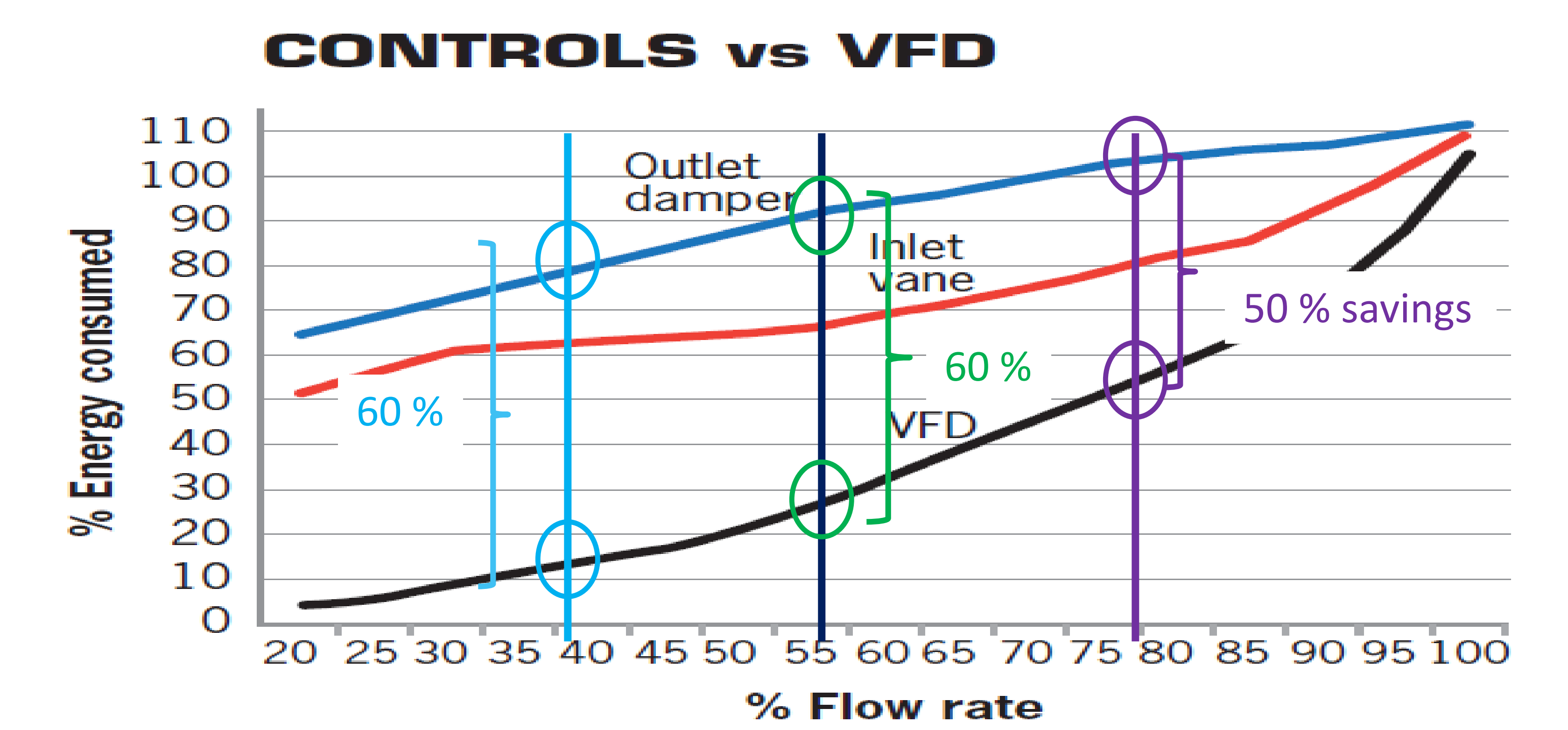
Building side systems

- Energy Transfer stations
  - Plate HX
  - Tertiary chilled water loop
- Air distribution system
  - AHU
  - Fans

Heat flow diagram



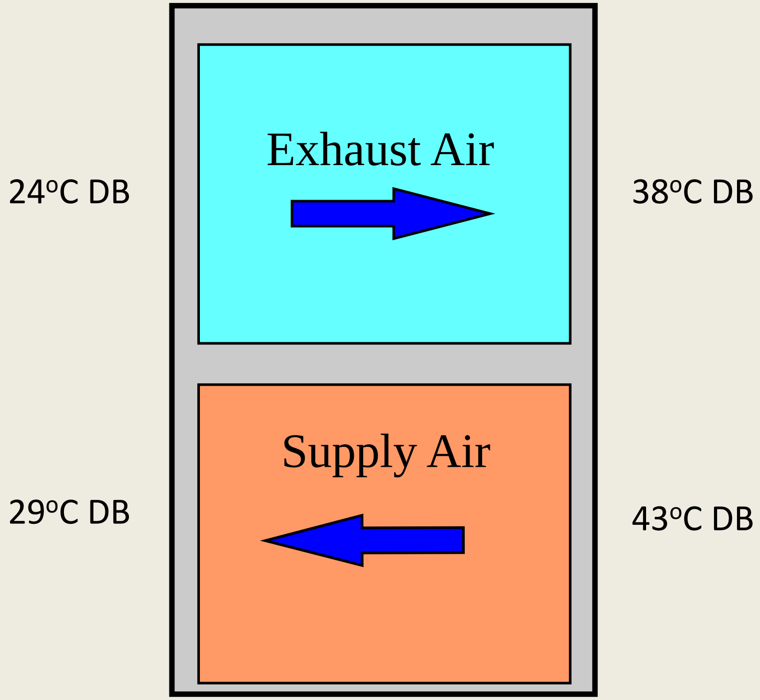
Installing VFD drives for fans and pumps



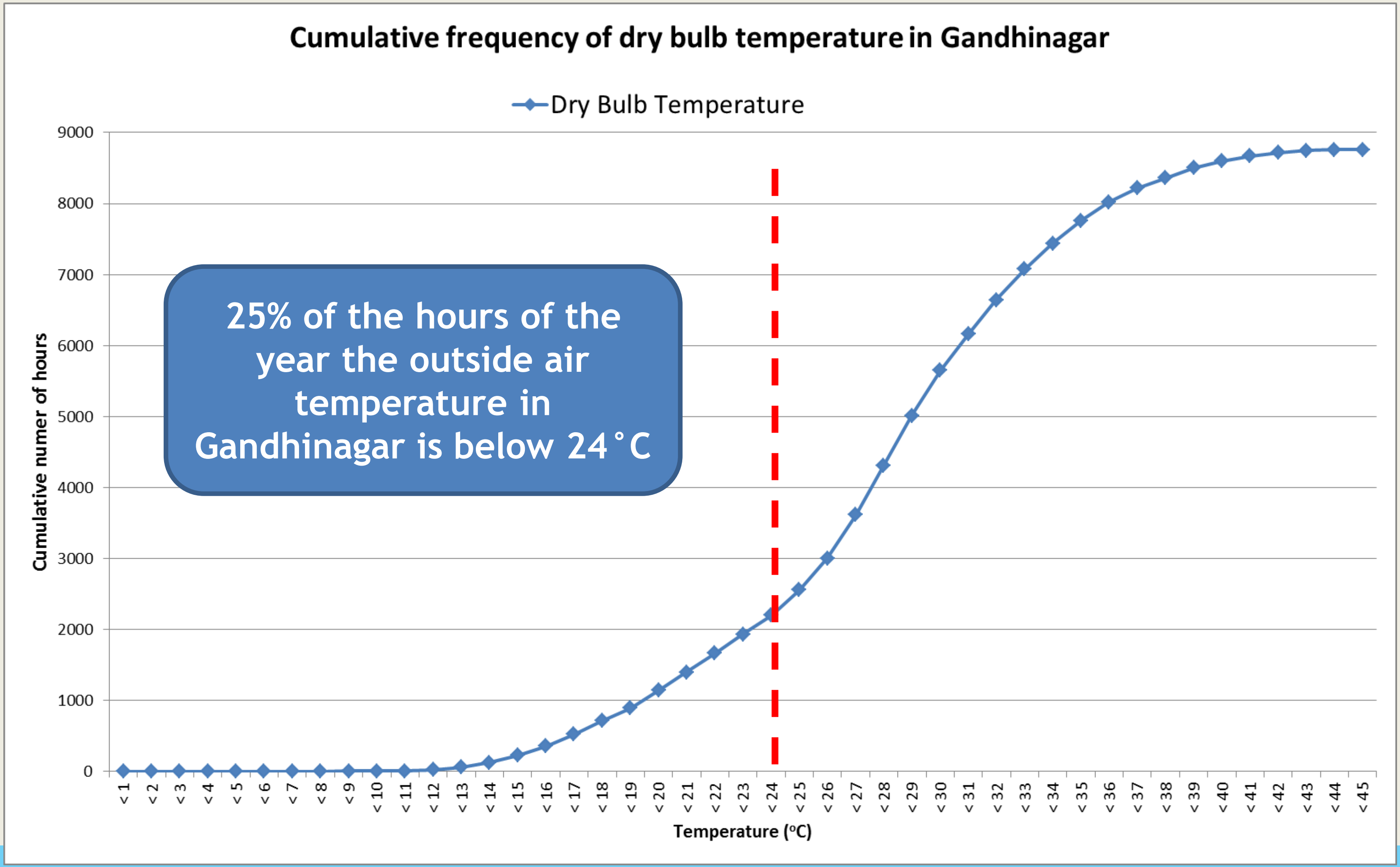
- Varying flows by VFD is more efficient mode of control
- **Reduction in energy savings in the range of 50 to 60 % at part loads compared to damper control**

Heat Recovery at AHU units

- Heat recovery with Enthalpy wheels
  - Effectiveness (Sensible & Latent) ≥ 75%
- Purge section to control air quality and cross contamination

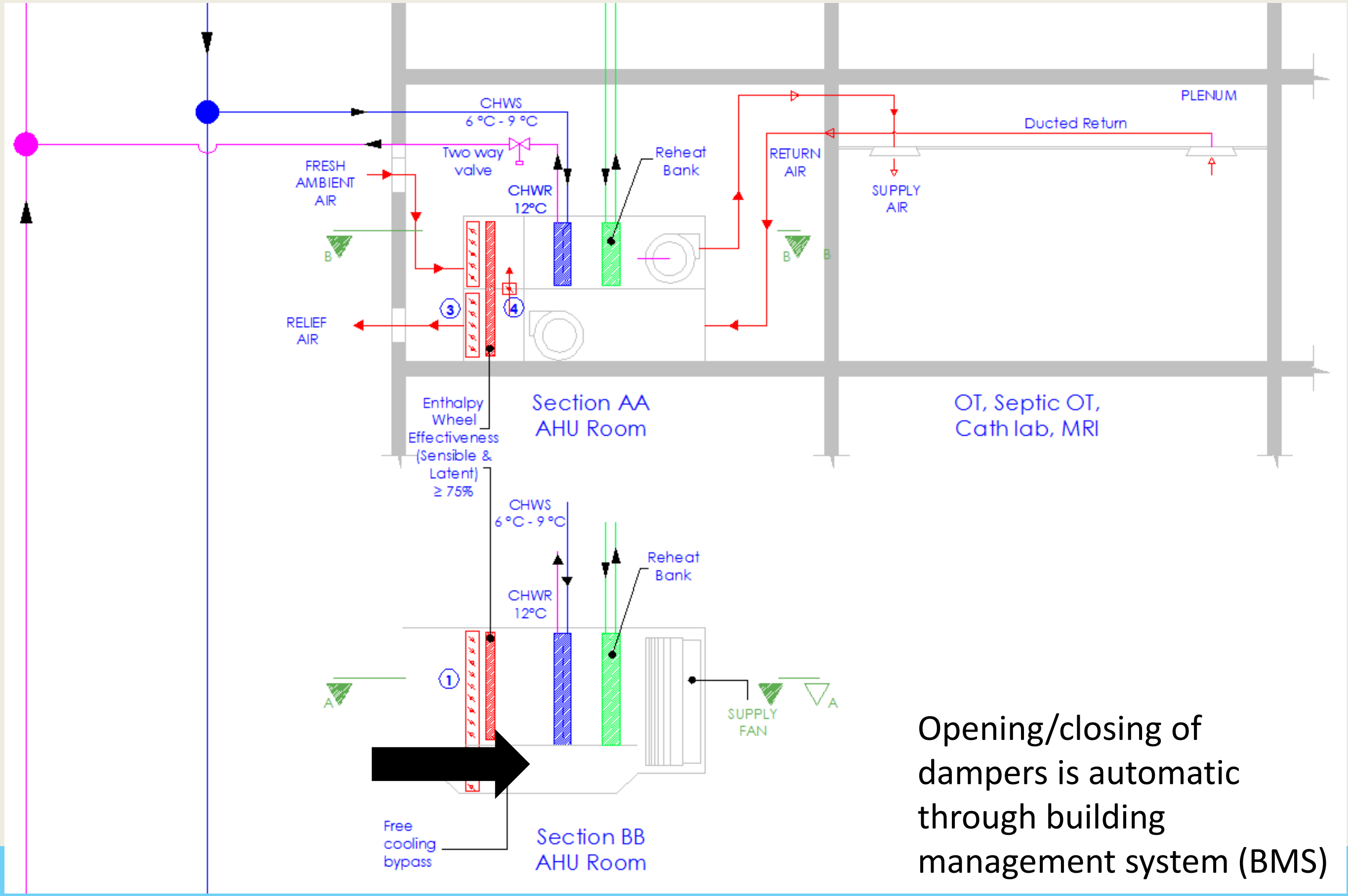


Potential for Free Cooling in Gandhinagar



Free Cooling at AHU units

- Control logic for opening/closing of dampers & fan operation
  - Zone set point, Ambient air temperature & enthalpy, Return air enthalpy
- Provision to bypass cooling coil to minimize fan energy

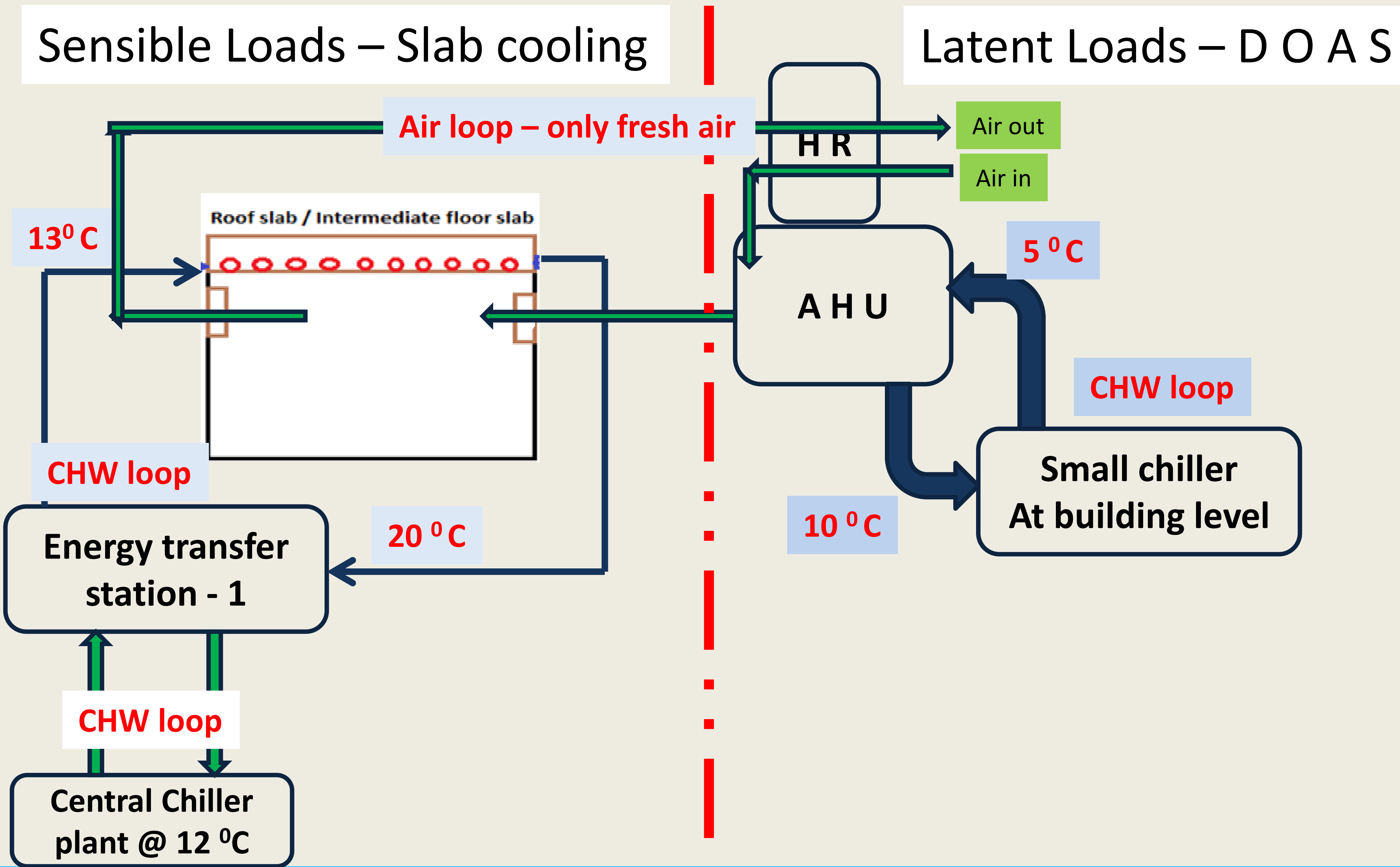


Opening/closing of dampers is automatic through building management system (BMS)

Incorporating Advanced Technologies in District cooling

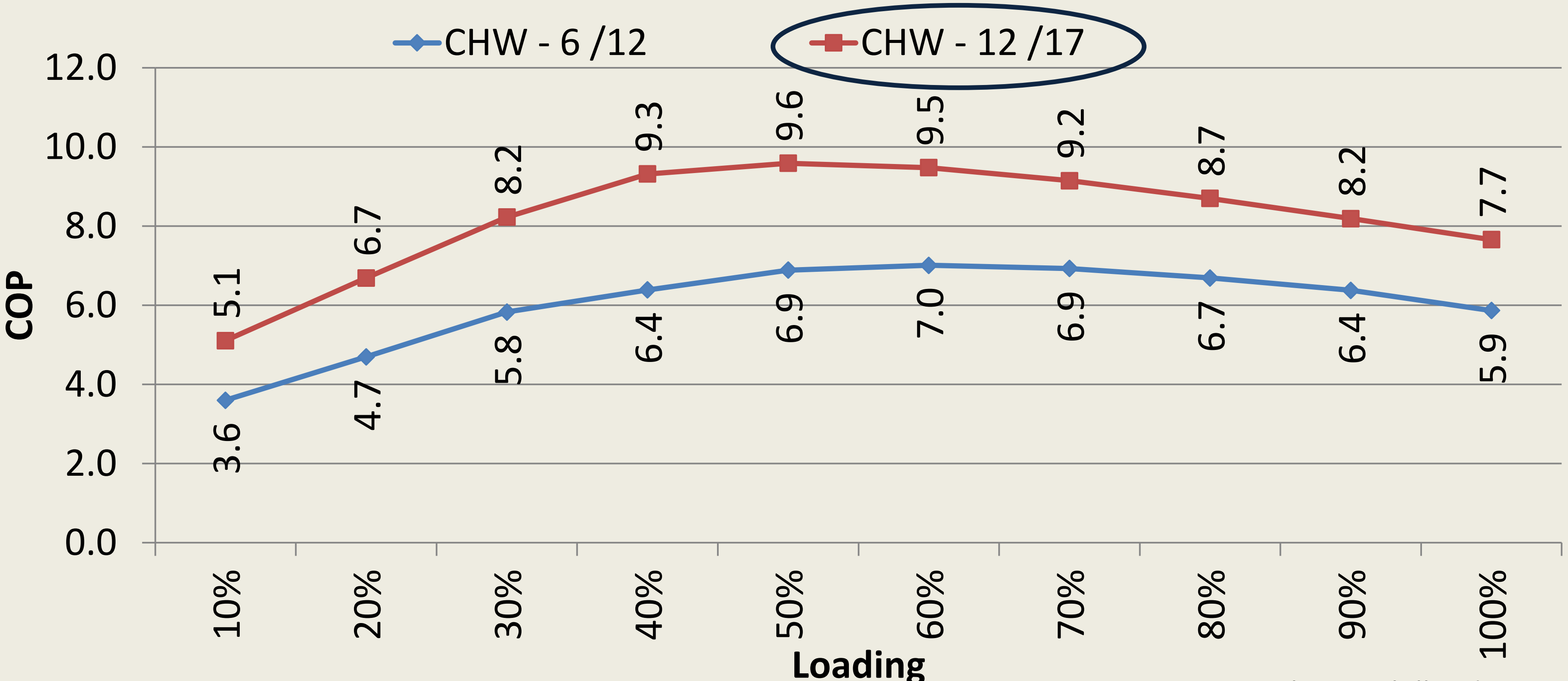
RADIANT COOLING SYSTEM

Radiant Cooling Systems – Integration with district cooling



Chiller C O P - Improvement

<u>Constant condenser water temperatures - 28 / 34</u>



Source: Johnson chiller data

- **Improvement in COP is in the range of 40 – 50 %**

Additional Benefits

- **Savings on fan energy consumption**
  - Only fresh air supply (No recirculation)
  - Estimated overall energy savings in the range of 30 - 45 % compared to air systems
- **Better IEQ (Indoor Environment Quality)**
  - Less noise due to less draft
  - Even temperature distribution

CASE STUDY
Infosys - SDB 1 Building , Hyderabad

Conventional half | Radiant half

- Symmetric building with 2 halves
- Building built up area = 23 200 m^2
- Long facades facing north and south
- Total occupancy = 2 500
- Envelope heat load = 10.8 W / m^2

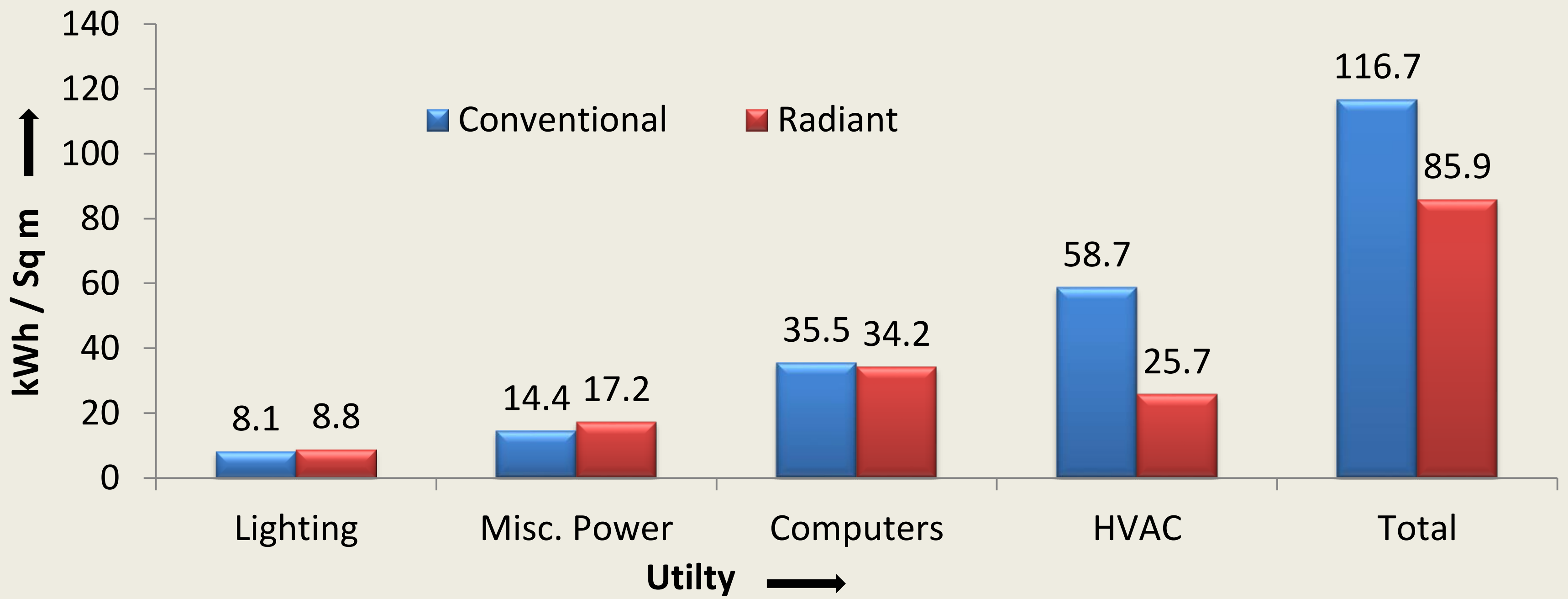
  = 1 W / ft^2
- Lighting load = 0.45 W / ft^2
- Equipment load = 3.5 W / ft^2
- Built in 2011

Source : Infosys_TechnicalPapaer_Guruprakash sastry

CASE STUDY

Infosys - SDB 1 Building , Hyderabad

Building Energy Index for 2011 – 12



- Radiant cooling system consumed **56 %** less energy for HVAC than VAV cooling system for 2011 – 12 FY

Source : Infosys_TechnicalPapaer_Guruprakash sastry

CASE STUDY

Infosys - SDB 1 Building , Hyderabad

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Cost analysis for both the systems:

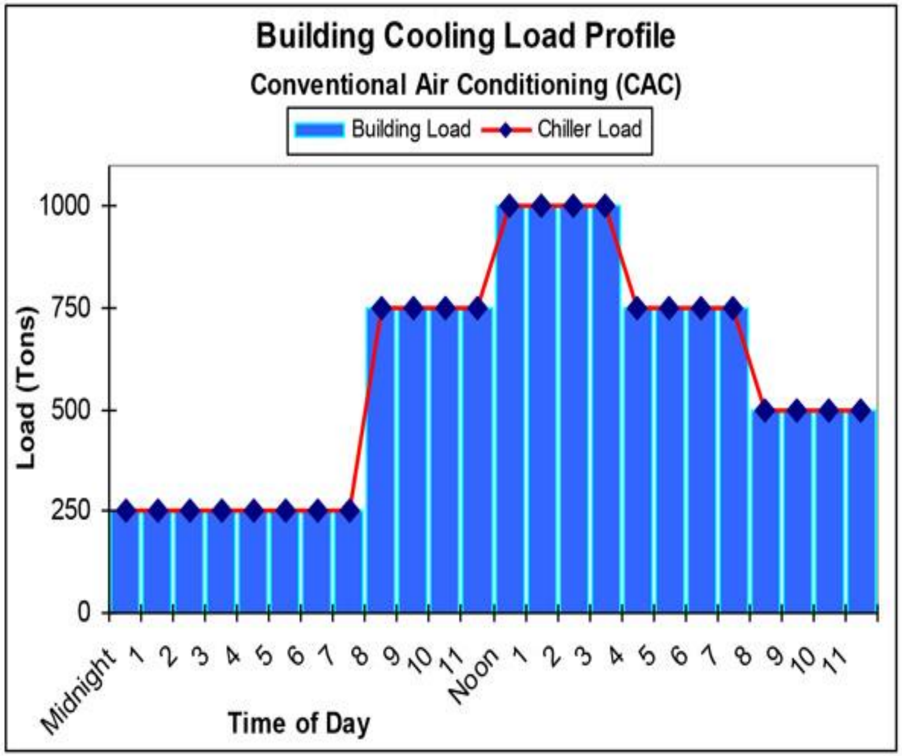
No	Utility	Conventional	Radiant
		INR	
1	Chiller	31 45 200	31 45 200
2	Cooling tower	13 06 400	13 06 400
3	**HVAC low side works**	**2 28 39 000**	**1 53 10 000**
4	**AHUs, DOAS, HRW**	**51 18 200**	**28 78 900**
5	**Radiant piping, accessories, installation, etc.**	**0**	**90 75 800**
6	Building Automation System	61 84 000	65 84 000
7	Total cost (INR)	3 85 92 600	3 83 00 300
8	Area (m^2)	11 600	11 600
9	**Cost / m^2 area**	**3 327**	**3 302**

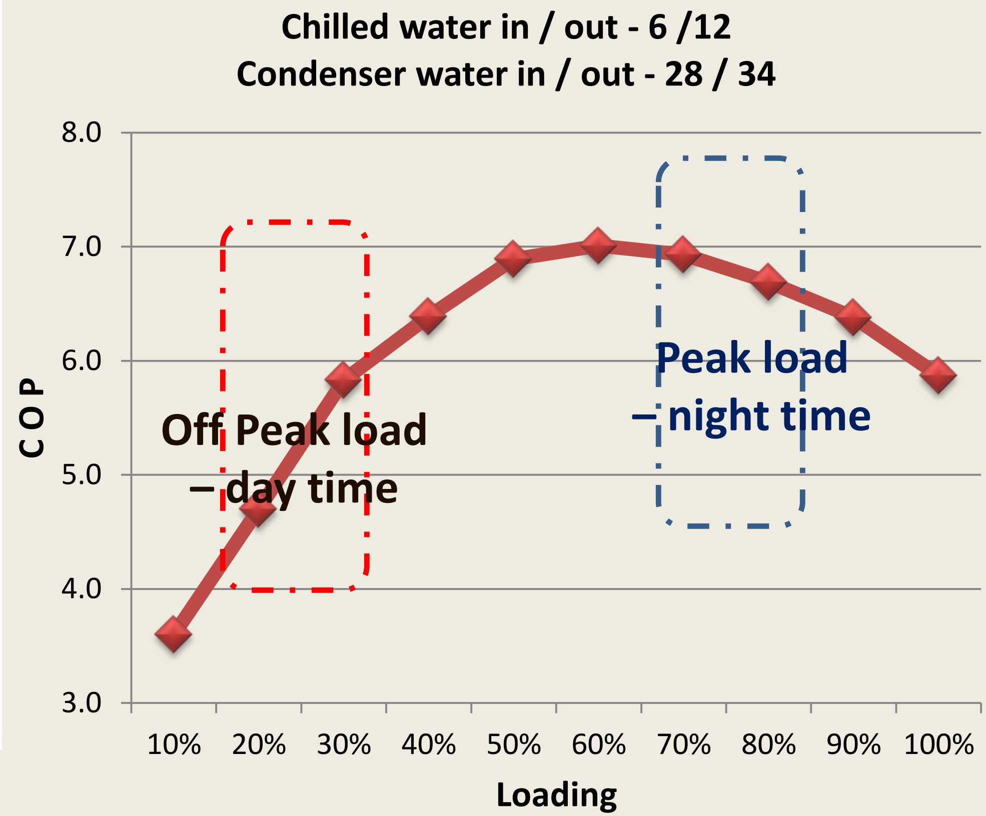
Almost same capital cost incurred for both the systems

Source : Infosys_TechnicalPapaer_Guruprakash sastry

THERMAL ENERGY STORAGE – T E S

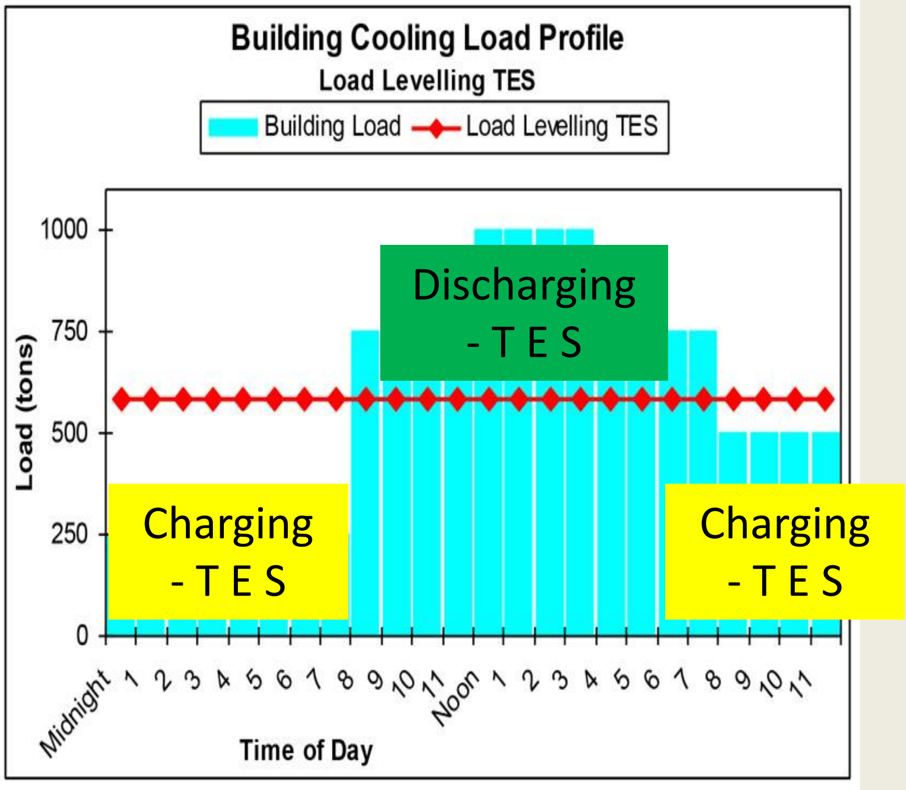
Chiller Operation - According to building loads

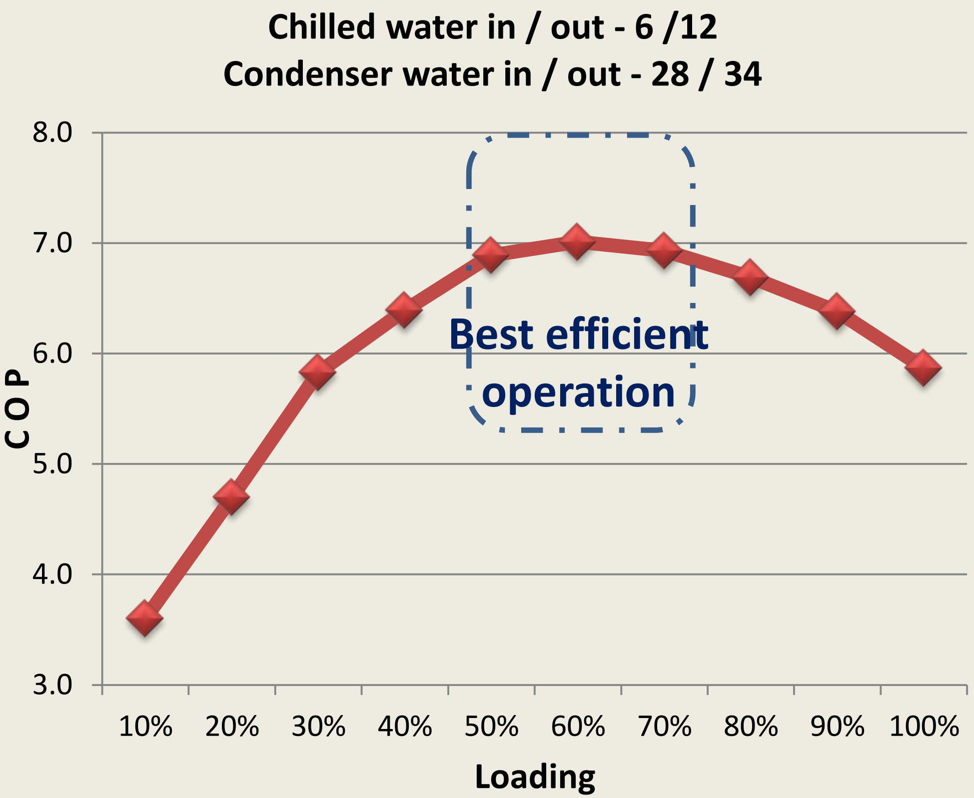




- Chiller is being operated at lesser efficient load during both Peak load and Off - peak load periods

Chiller with T E S - Operation





- Chiller is operated at best efficient point
- During off peak periods, chilled water is stored
- During Peak period , stored chilled water is used to meet the peak load

Summary – An overall view

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Chiller Plant

- Selecting high efficient chiller at part loads
- Increasing the CHW supply temperature to gain the COP advantage
- Installing VFDs for Compressors, fans and pumps
- Thermal Energy Storage integration

Building Side Systems

- Radiant cooling system integration
- Heat recovery
- Free cooling concept

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THANK YOU