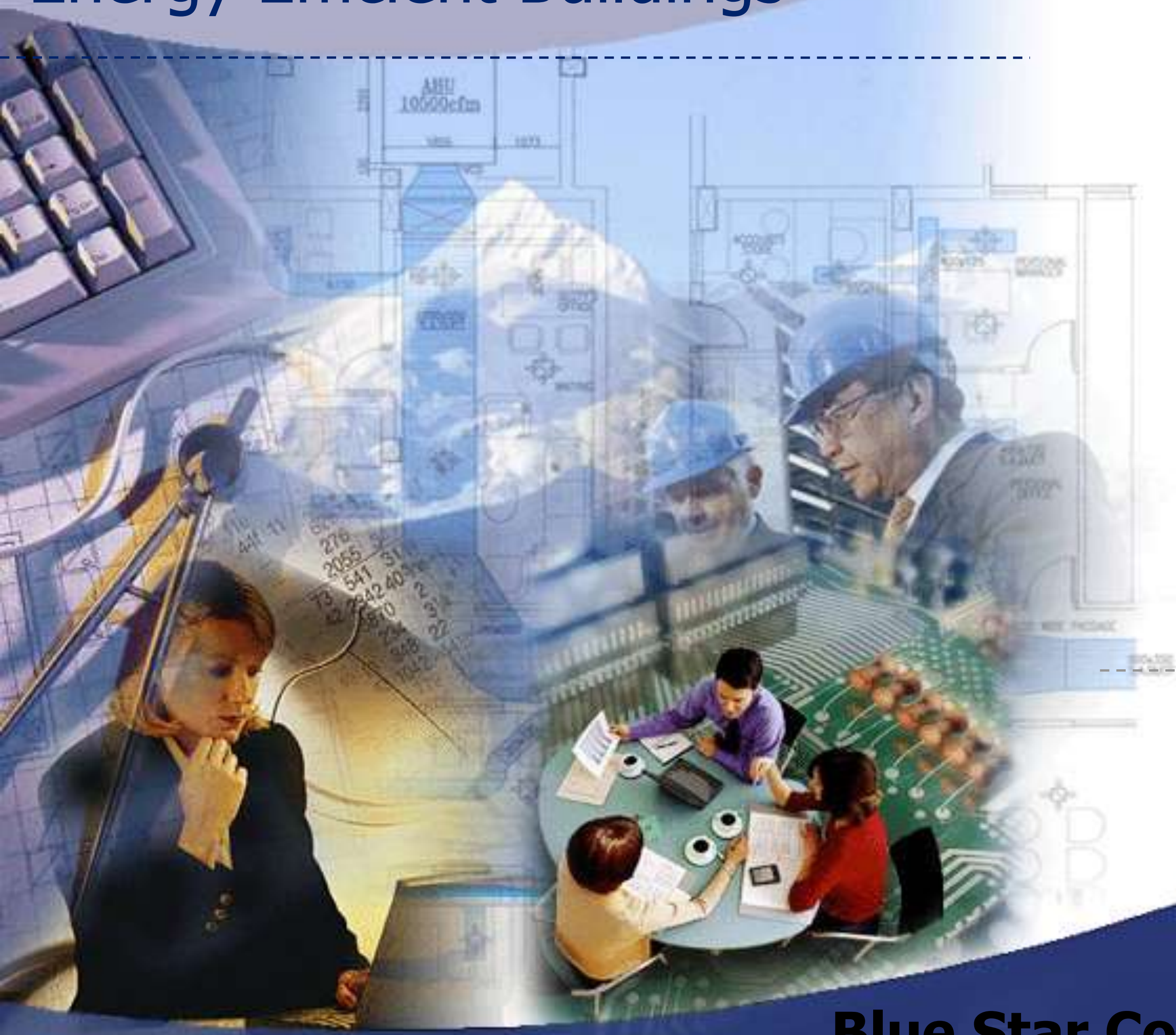
Importance of HVAC in Energy Efficient Buildings



Life Long Learning (3L) Programme at Goa

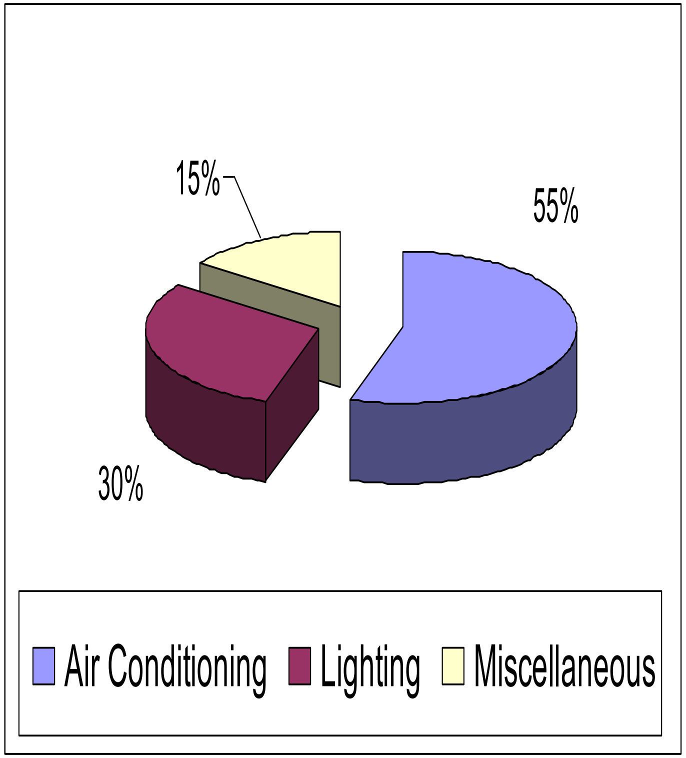
19.05.2010

Blue Star Cooling Solutions

Facts of HVAC in a building

- Air-conditioning is No. 1 energy guzzler
  - 55 to 65% in office buildings
  - 70 to 75% in hospitals & hotels
- Lighting is 2nd highest energy guzzler
- Building industry is booming
- No legislation exists to design energy-efficient buildings

Commercial Building Energy Consumption Pattern



Elements that contribute the HVAC system

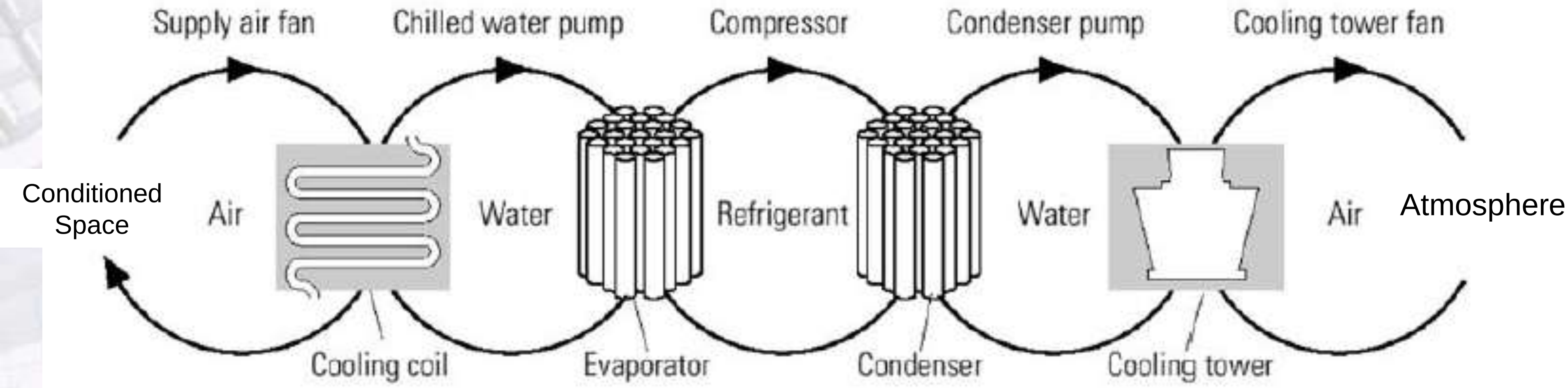
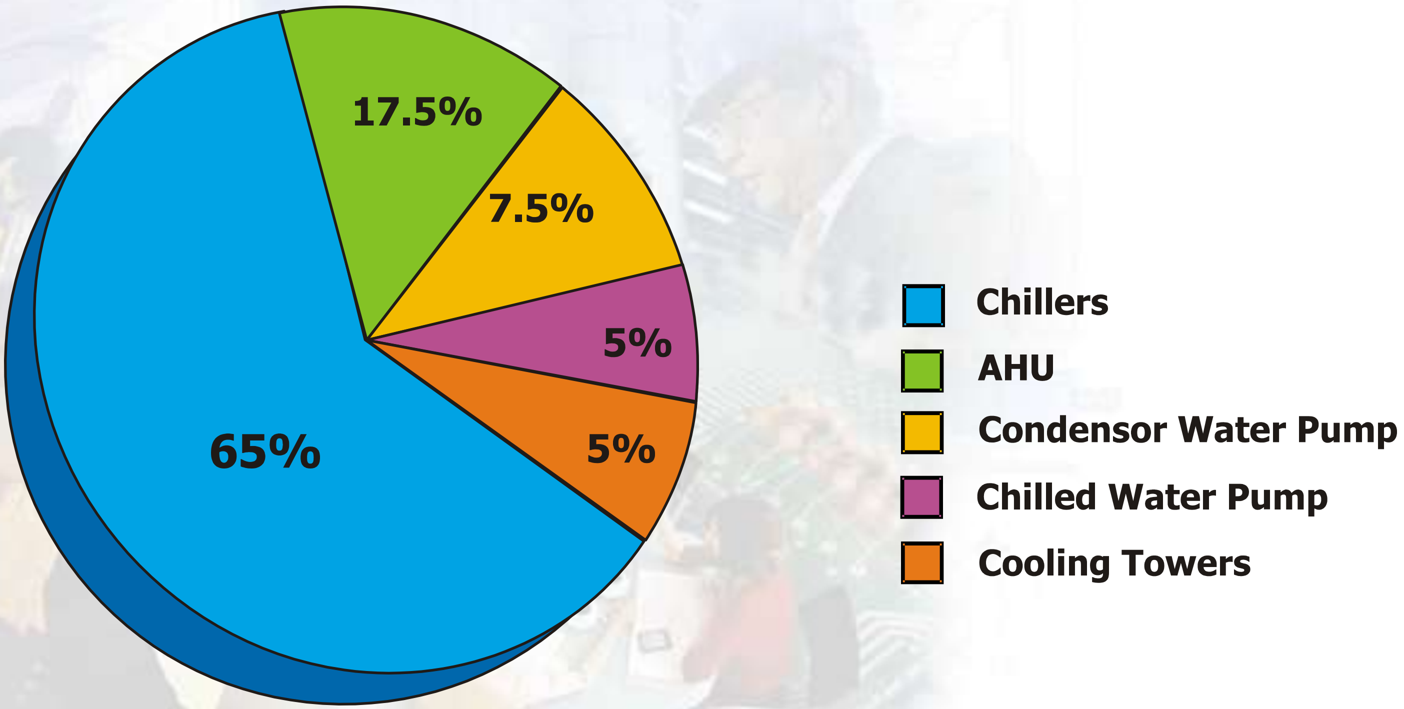


Figure 4.1 Heat Transfer Loops In Refrigeration System

Electrical Gadgets which contribute Power consumption in Air conditioning System:

- Compressor
- Chilled water Pumps
- Condenser Pump
- AHU Blower
- Cooling Tower Fan
- Motorized Actuators to control air & water

Relative Power Consumption



Elements of System Optimisation for Power Savings in HVAC

Energy-efficient building design

Basic lighting system

Energy-efficient air-conditioning design

Optimized equipment selection

Energy-efficient building design

Factors of Building Envelope

- Building Orientation
- Type of integral shading Devices
- Type of Glazing
- Type of wall/roof/floor construction material & construction aspects
- Window to wall ratio
- Type of insulations for building Envelope

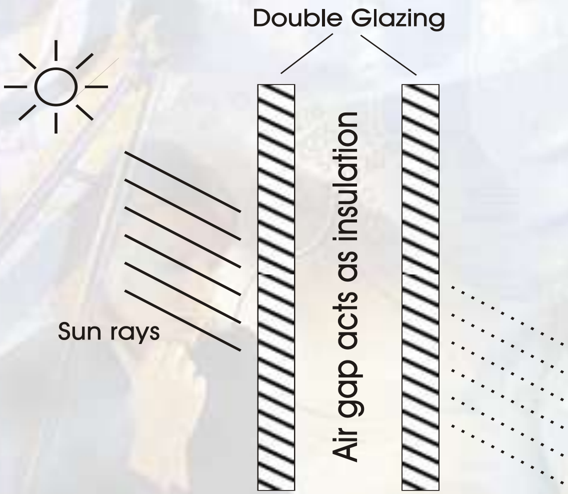
Energy-efficient buildings?

- Avoid **glass walls**

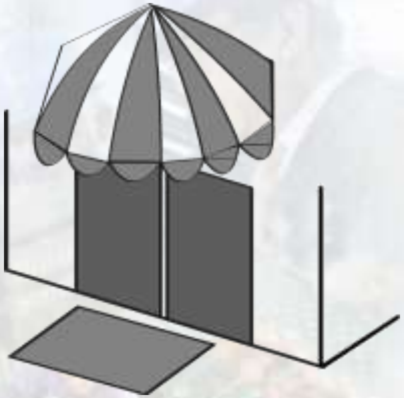
More glass, **More heat.**

Energy-efficient buildings?

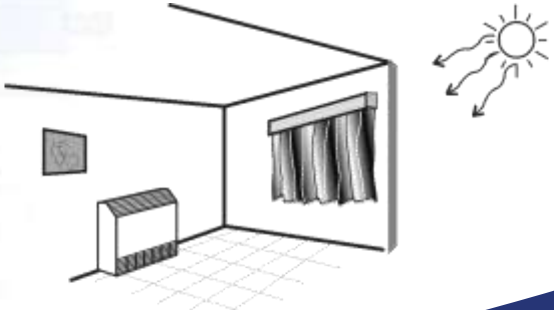
If you must use glass, use:



double glass walls



awnings



curtains/blinds

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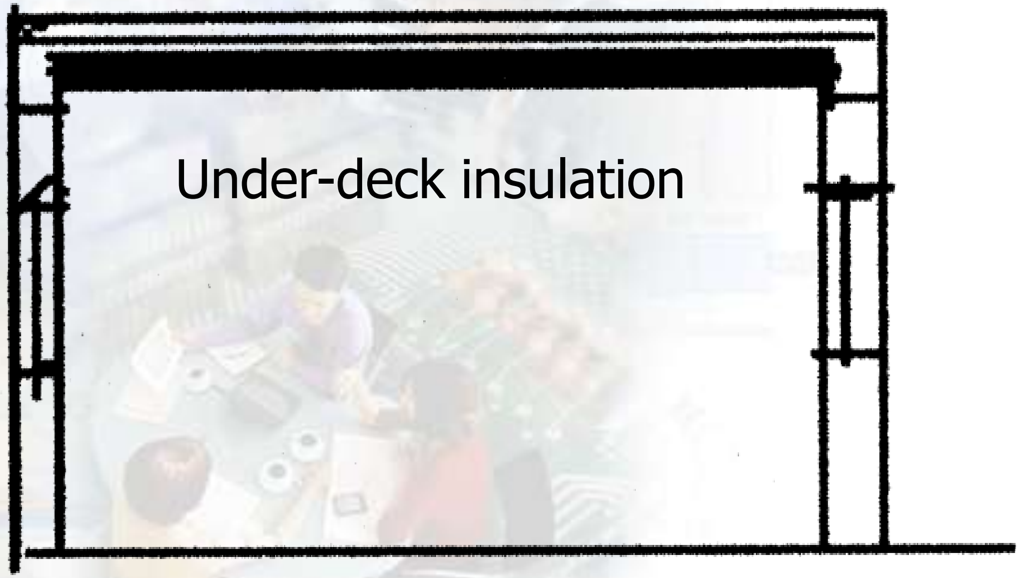
Energy-efficient buildings?

- Insulate **the roof**

Over-deck Insulation

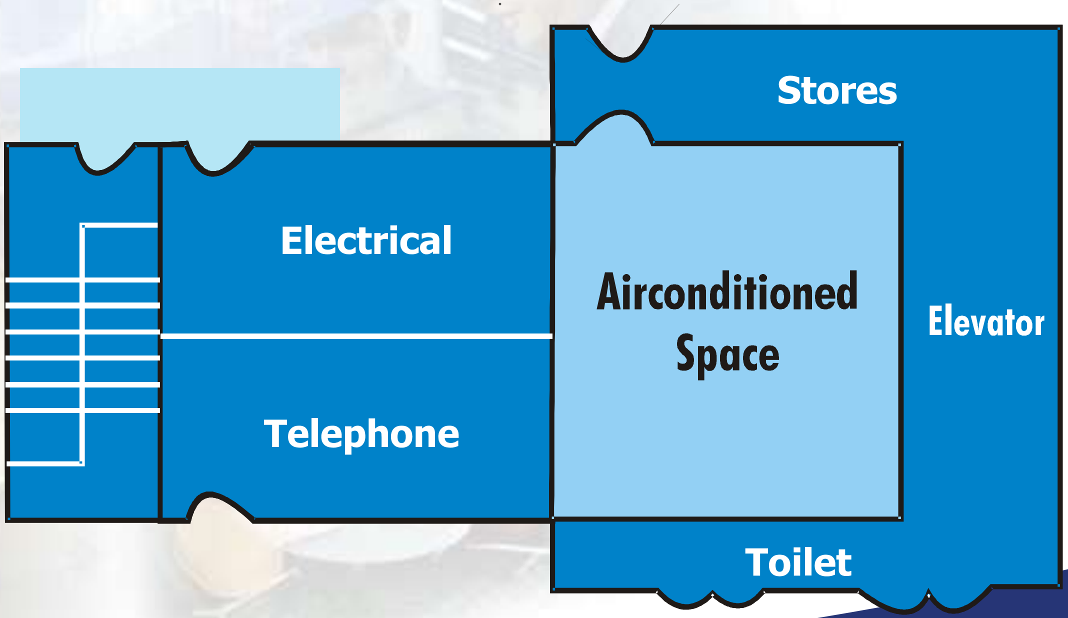


Energy-efficient buildings?

- Use **light colours** outside

Energy-efficient buildings?

- Locate **services on periphery**



Energy-efficient buildings?

- Follow the Green Building Features as Per Green Building Councils & ECBC Codes Drafted by GoI

The basic building design improvements seen so far can save

over 10%

in air-conditioning power consumption!

Energy-efficient Air-conditioning design

Air- conditioning design: The first step

- Calculate heat load & Understand

  Part Loads,

- HVAC System & Controls

Air- conditioning design: The first step

- **Easier said than done:**
  For example, an auditorium needs 100 tons when packed, only 10 tons when empty!
- Enter concept of **peak-load** and **part-load**
- **Load profile**

Peak-load and Part-load

- **Offices** see peak load in **mornings and evenings**
- **Restaurants** see peak loads at **lunch and dinner** times
- **Training schools** see peak loads only **a few months** in the year!
- **Designing air -conditioning for peak load can be inefficient**

Design for Part-load

Efficient AC design must

- Work out number of hours of operation at various loads
- Optimize equipment selection at part load at which it is expected to operate for maximum period
- Take guidance from ARI's research findings to estimate tonnage

ARI's weighted average

% load	1992 standard	1998 standard
100%	17%	1%
75%	39%	42%
50%	33%	45%
25%	11%	12%

As per latest findings, peak-load occurs **only 1% of the time!**

ARI therefore recommends an

Integrated Part Load Value (IPLV)

for designing

the most efficient

air-conditioning system

Optimized Equipment Selection

Main Equipment

- Chillers
- Air Handling Units
- Chilled Water Pumps
- Condenser Water Pumps
- Cooling Towers

See this example of a 400 TR Chiller

Particulars	FSD	VSD
Peak Load	0.538	0.555
IPLV	0.508	0.334

Power Consumption		
100% Load	0.538	0.555
70%	0.482	0.382
40%	0.538	**0.300**
15%	0.908	0.466

In Multiple Chiller Applications…
Running more Chillers at part-load than less Chillers at full-load is **more efficient**

For example...

- Total load: 2000 TR
- 4 x 500 TR Chillers installed
- Part Load occurs at 1000 TR
- **3 chillers** operating at 66% load each are **more efficient** than 2 chillers at full-load

Energy Savings at AHU

Extreme conditions (Design Conditions of HVAC System)

- Peaks Outside Temperature in the year
- Maximum Equipment Load
- Maximum Human Load
- **Safety factor – 10 to 15%**

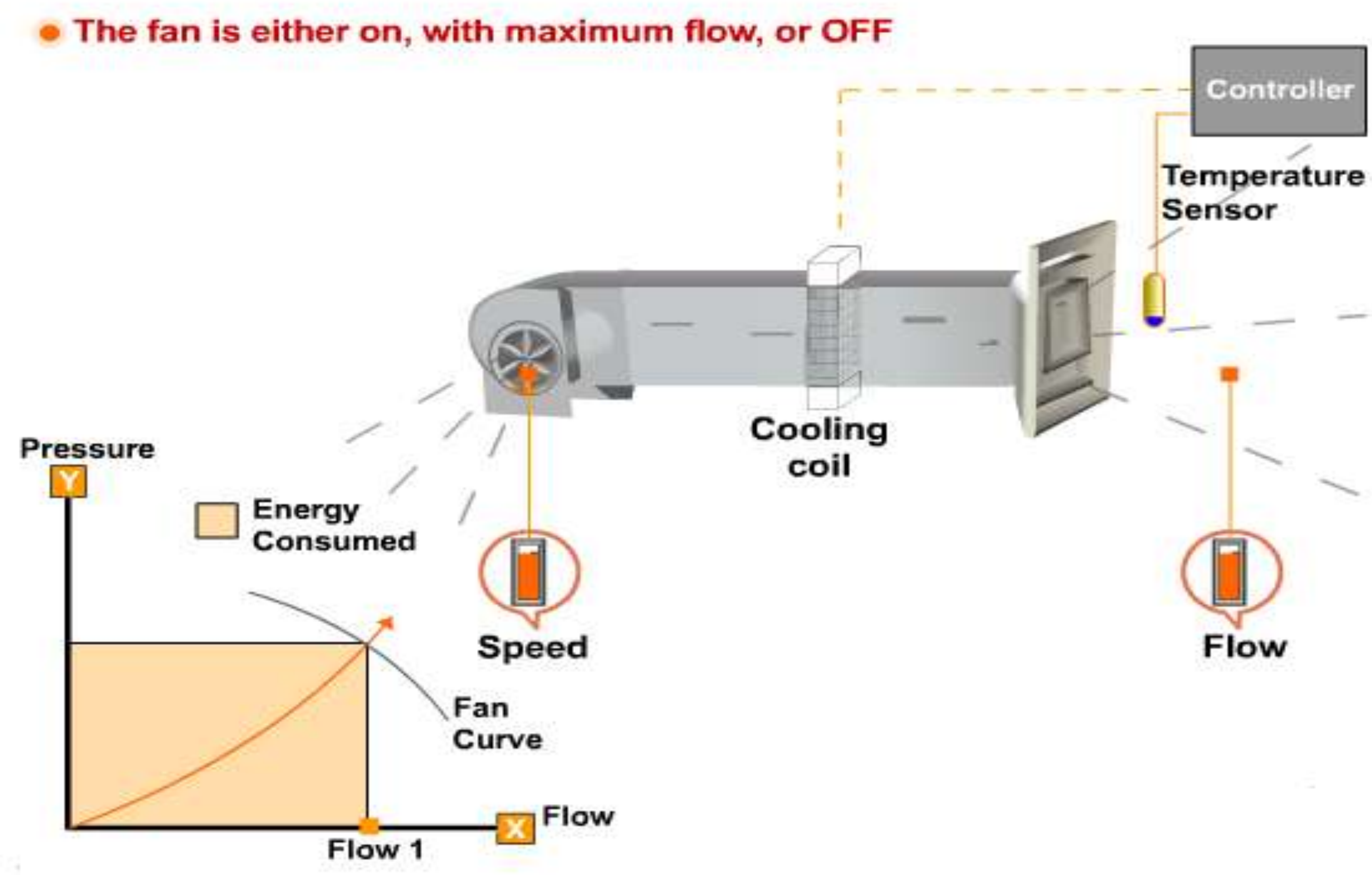
OVER CAPACITY EQUIPMENT

Heat Load Variation

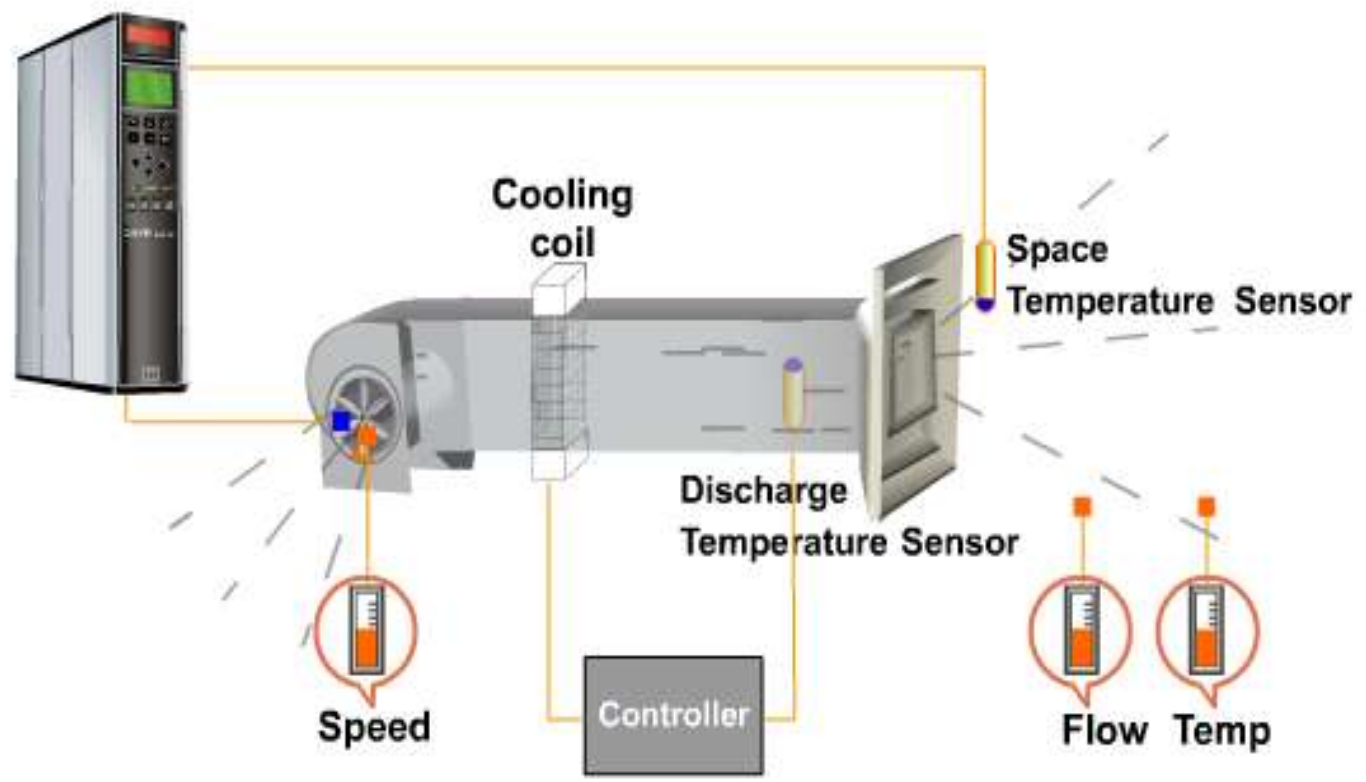
- Outside temperature variations in a day (Ambient Temperature)
- Continuously changing weather conditions in a year
- No. of persons in the air-conditioned area
- Equipment diversity

SURPLUS WORK –
CONSUMING COSTLY ENERGY

The Traditional Solution



The New Standard



Energy Savings

- **Fan designed for supplying 1000 CFM of air**
- **Current requirement due to heat load variation is 800 CFM**

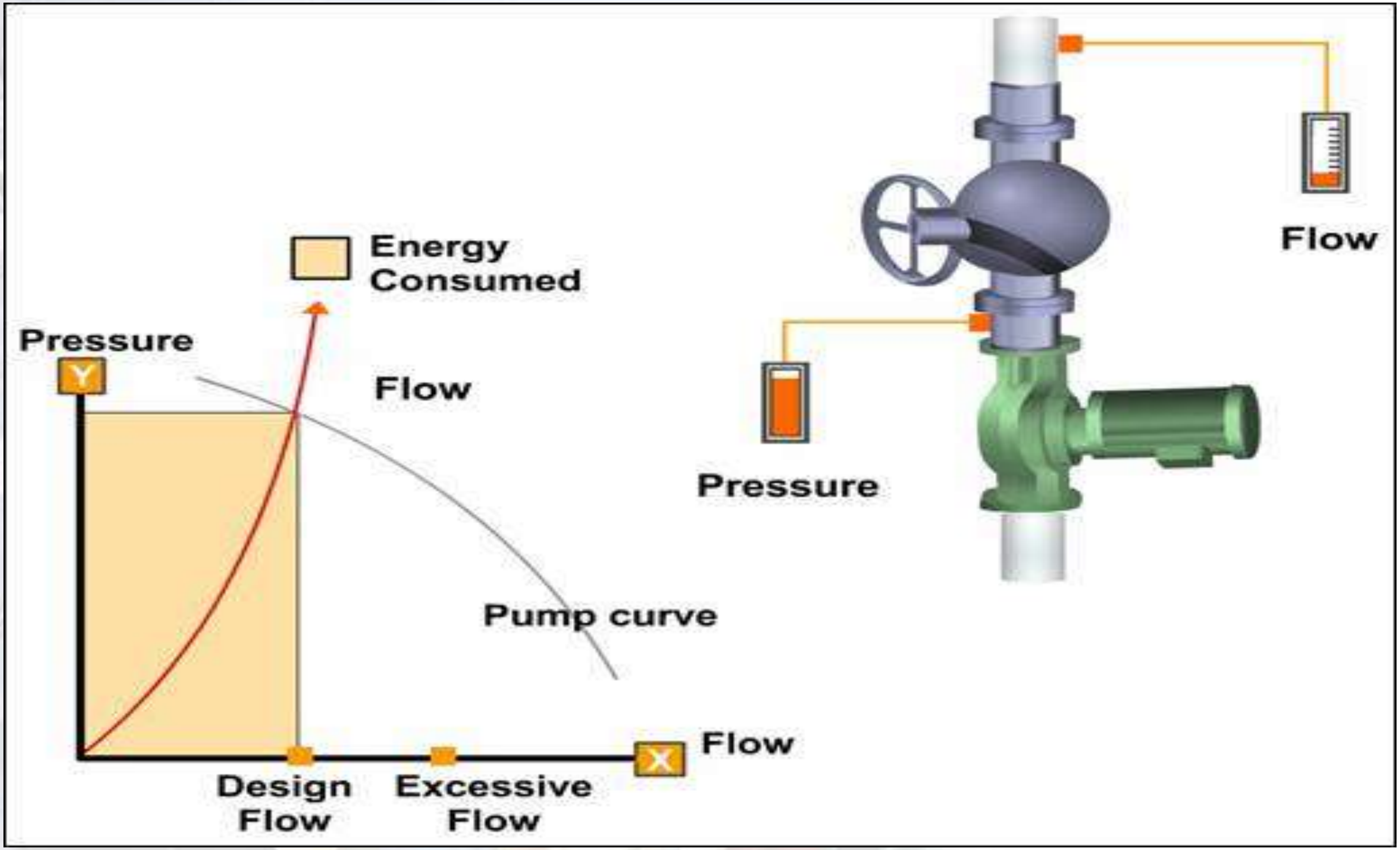
<u>Using centrifugal laws</u>

- **Power consumption at 1000 CFM- P1**
- **$P1 \propto (1000)^3$**
- **Power consumption at 800 CFM- P2**
- **$P2 \propto (800)^3 = (0.8 * 1000)^3 = (0.8)^3 * (1000)^3 = (0.512) * P1$**
- **Thus, when the fan speed is reduced by 20% the fan power consumption is reduced by 48%**

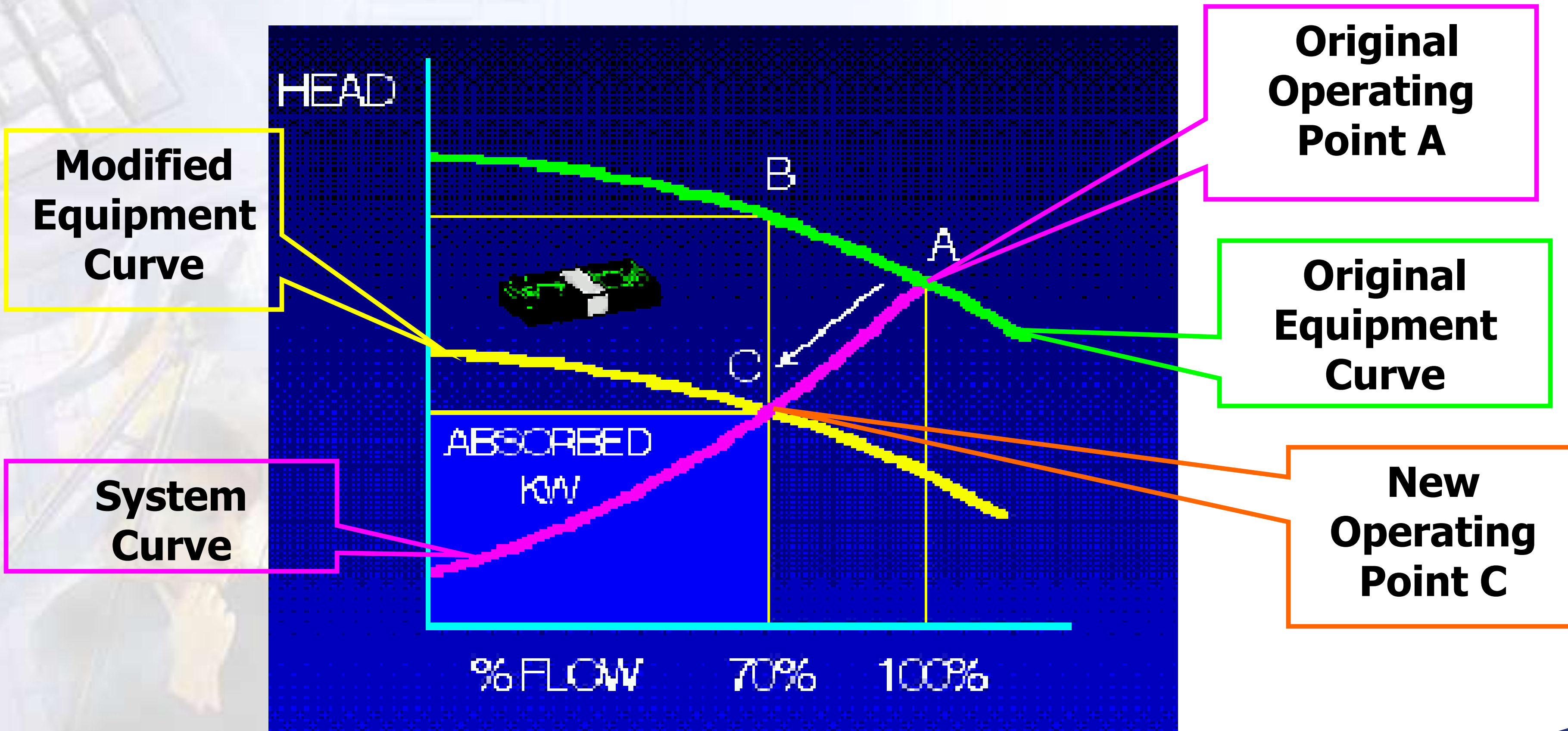
Pumps

- Sizing & Selection of Pumps
- Variable Flow system using VFD systems
- Use of 2 way valves in AHU distribution
- Use of Pipe material (Low Friction)
- Proper Piping engineering
- Right selection of pumps as per the duty points

Pumps


Energy Consumed
Pressure
Y
Flow
Pump curve
X
Flow
Design Flow
Excessive Flow
Flow
Pressure

VSD Control



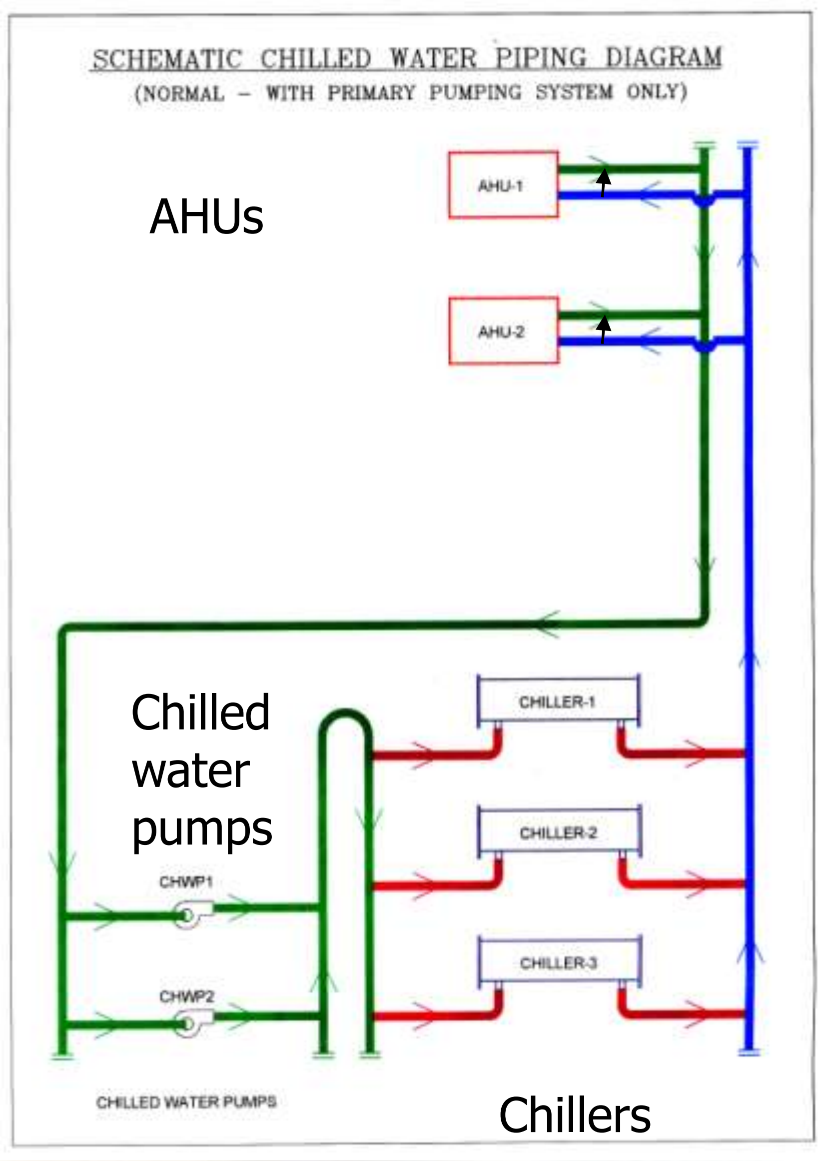
HEAD
B
A
C
ABSORBED
KW
% FLOW
70%
100%
Modified Equipment Curve
Original Operating Point A
Original Equipment Curve
System Curve
New Operating Point C

Principle of Operation of VSDs
Basic Centrifugal Laws

$$\text{Flow} \propto \text{Speed}$$

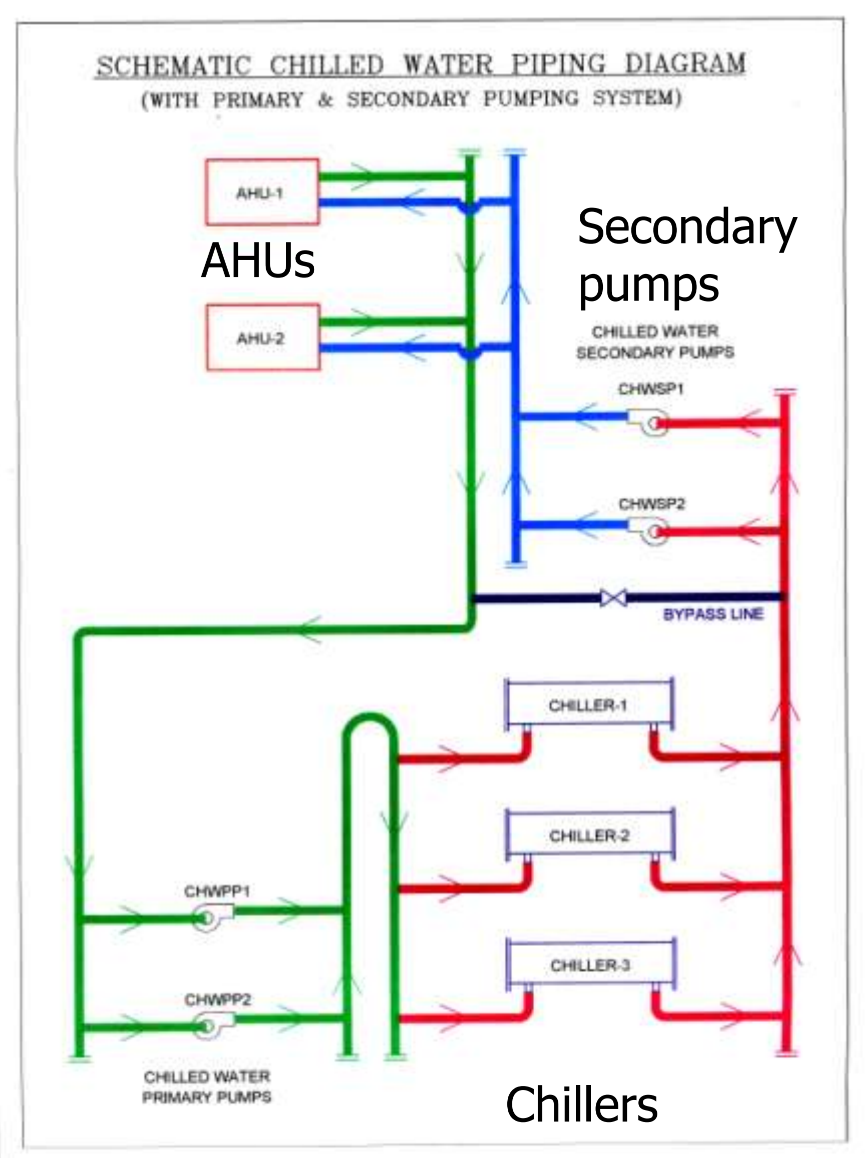
$$\text{Pressure} \propto (\text{Speed})^2$$

$$\text{Energy} \propto (\text{Speed})^3$$



Other chilled water piping system improvements

- More systems are with single set of pumps for chilled water circulation



Other chilled water piping system improvements

- Provide **primary** and **secondary** chilled water pump sets or **only primary variable** system using VFD

VSD Applications

- Constant Air Volume
- Variable Air Volume
- Cooling Tower Fans
- Condenser Water Pumps
- Primary Pumps
- Secondary Pumps
- Pressurization
- Filter Control

Sizing of Cooling Towers

Energy efficient cooling towers which have

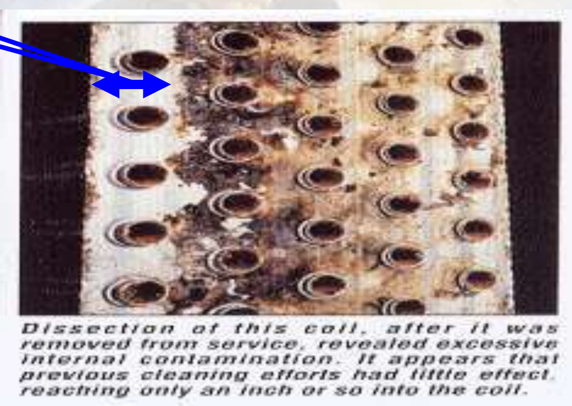
- Energy efficient motors,
- Proper construction,
- Lower air pressure static across cooling tower,
- FRP blades
- Inbuilt mechanism for temperature controls through VFD

Optimization of Chiller/Pumps/Cooling Towers as a high Side Solution

- Use Measurement & Monitoring system to evaluate the overall kW/TR & individual kW/TR for Chiller, pumps & cooling towers
- Use of variable flow system

Other Energy Optimisation options

- Use of VAV boxes in ducts
- Use of 2 way valves in AHU & VFD on Chilled water Pumps
- Use of Variable water Flow Primary pumping System
- Inbuilt mechanism to maintain the clean coil of the AHU
- Duct Cleaning



Other energy saving techniques

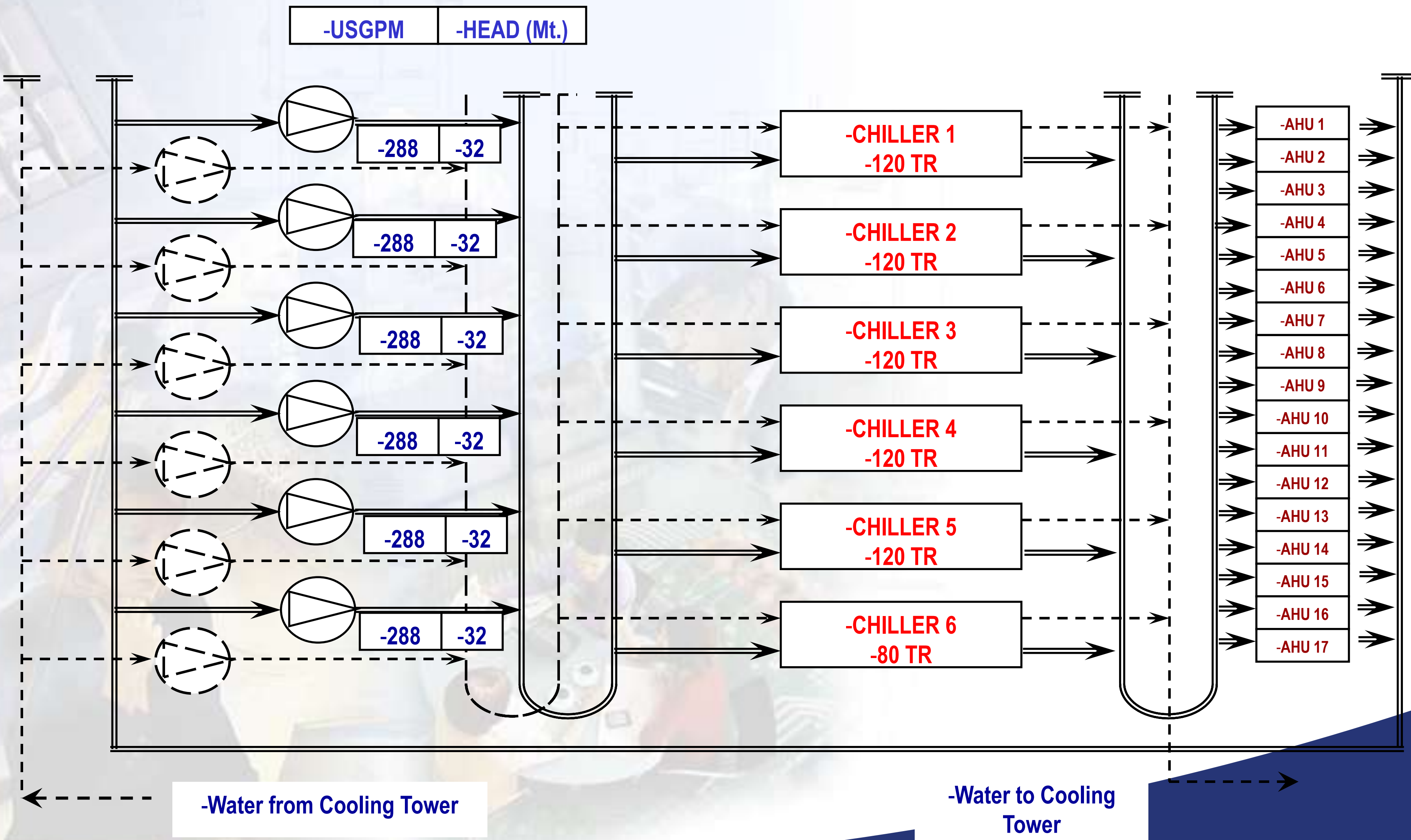
- Evaporative Cooling
- Thermal Storage Systems
- Heat Recovery System

Case Studies
In
Retrofitting HVAC Systems
For
Energy Efficiency

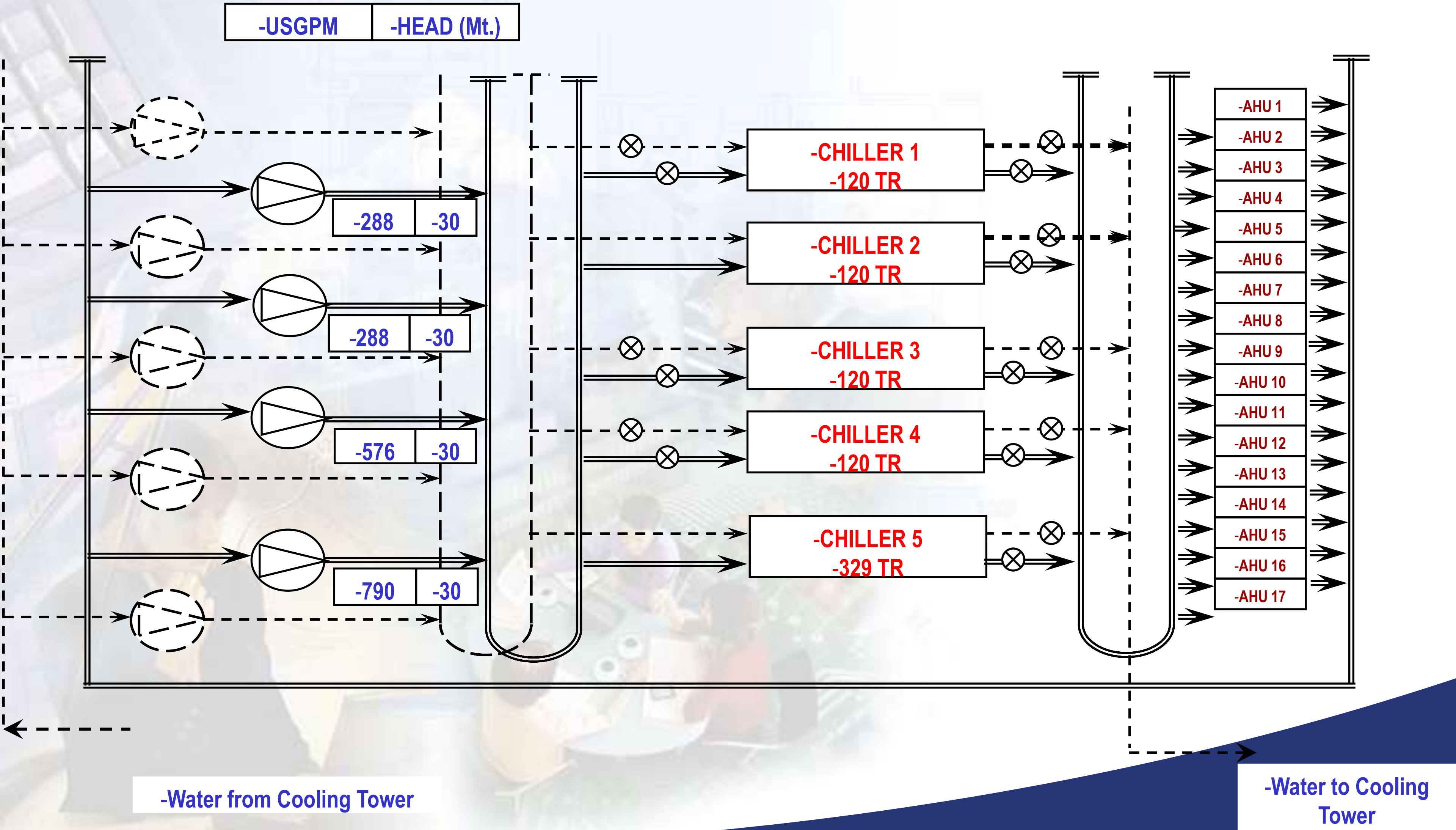
Existing System

- Installed capacity 680 TR
- Water cooled Reciprocating Chillers :
  # 120 TR x 5 Nos. & 80TR X 1 No.
- Almost 8 years old system
- Corresponding Chilled Water & Condenser Water Pumping System
- Annual running pattern was absolutely variable for Chillers and Pumps
- Pump operation was excess, even though design was 1:1.

Existing System Description



Proposed System Description



Economics

S N	Item	Annual Saving (kWh)
1	Replacing existing reciprocating chiller by 329 Screw Chiller and also refurbishing the 3 Nos. 120 TR Chiller	630581
2	Pumping system Optimization & Modification	34340
	Total	**664921**
3	**Annual Monetary Savings (Rs. Lacs/Annum)**	**36.57**
4	**Investment, Rs. Lacs (Refurbishing + New Screw Chiller + New Pumping System)**	**65.5**
5	**Simple Payback Period in Months**	**22**

Case Study II

Air Handling Unit
&
VFD Application

Case Study : II

Background

Energy Audit was carried out for one of the leading multiplex in Mumbai. The cooling requirement of the multiplex is catered by central plant which consist of air cooled screw chiller. The air is distributed through air handling units which are provided with VFD as well as three way balancing valves.

With VFD in operation as only control mechanism they were facing suffocation problem in the theatre. Here 3 way valve was working as primary control function & VFD as secondary control function.

Hence even with VFD in the system, they were not getting the benefits of VFD.

Case Study : II

Proposed System

After Detailed Energy audit it was suggested to use the VFD at primary control function with setting of minimum achievable frequency at 35. Beyond these existing 3 way balancing valve will work as secondary control mechanism

Results

This proposal was implemented with immediate effect. Dedicated monitoring and verification has carried out on Energy Consumption of AHU motors. Beyond that suffocation problem was also sorted out.

Facility team was impressed by the Reduction in Energy Consumption without facing any problem of suffocation.

Cost Benefit Analysis

Annual Energy Cost Saving - Rs. 3.4 Lacs

One time Investment - Nil

Return on Investment (ROI) - Immediate

Case Study III

Pumping System Optimisation

Case Study : III

Background

Energy Audit was carried out for one of the leading commercial Establishment in Chennai, Tamil Nadu. Facility Team was facing increase in energy consumption on HVAC system over a period of time. Detailed Energy Audit was undertaken and it was observed that the Facility has installed 3 Nos. of 100 TR Reciprocating Chiller with 4 Nos. of 10 HP Chilled water pumps.

Facility operates Chiller and Auxiliaries from 8:30 AM to 9:30 PM to maintain temperature of 23 deg. C. Based on the Load Pattern Analysis it was observed that the system will require full load only for 50 – 60 % of the time.

Proposed System

Conversion of Primary to Secondary Chilled Water Pumping System with Variable Frequency Drive on Secondary Pump.

Case Study : III

Results

Establishment's Facility Management team and Blue Star team has jointly implemented the proposal. Dedicated monitoring and verification has carried out on Energy Consumption, Running Hours and Temperature.

Facility team was impressed by the Reduction in Energy Consumption both on Chilled water pumps and Compressor Motor.

Cost Benefit Analysis

Annual Energy Cost Saving	-	Rs. 8.2 Lacs
One time Investment	-	Rs. 7.4 Lacs
Return on Investment (ROI)	-	10.8 months.

Case Study IV

Fresh Air Ventilation
&
Heat Recovery Wheels

Case Study : IV

Background

We conducted energy audit for one of the Leading Multi million Company located in Secunderabad, Andhra Pradesh. Client's EHS Team has conducted an Internal performance audit and they have come-out with decrease in productivity due to absenteeism.

Based on our audit it was revealed that the building HVAC system was designed based on 10 CFM per person and it also esta blished that the CO_2 level was 1200 PPM more than normal ambient and their were no Fresh Air Supply.

Audit result come out with supply of 18,500 CFM fresh air and revised Heat Load requires increase in Tonnage of 85 TR.

Case Study : IV

Proposed System

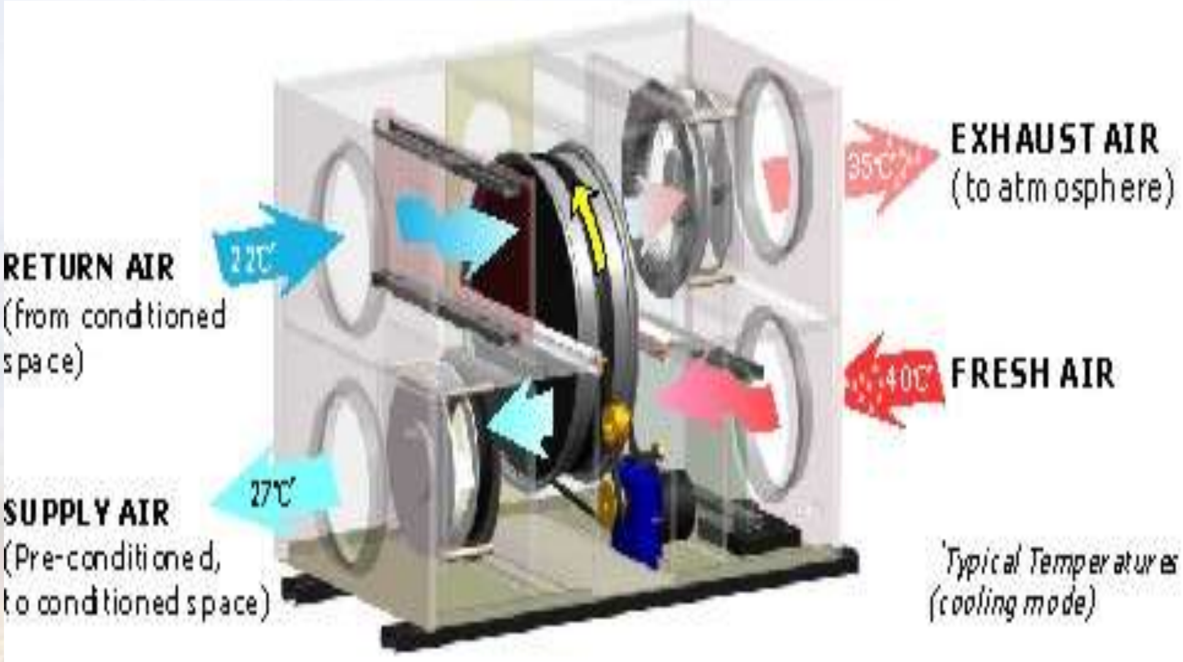
Option I :

Increase in 85 TR Capacity, and Supply Fresh Air through common Treated Fresh Air AHU

Option II :

Install Energy Recovery Ventilators and Increase 40 TR to meet the fresh air requirement and heat load.

Case Study : IV



Energy Recovery Ventilator

Case Study : IV

Parameter	Option I	Option II
Capital Investment (Rs. Lacs)	23.46	33.87
Running cost per Annum (Rs. Lacs)	59.56	24.27
System Life (Yrs.)	10	8
Discount Rate (%)	18	18
Net Present Value (Rs.Lacs)	6.2	9.4

(As per ASHRAE 62.1 – 2004CIBSE Manual 10:2005)

Product Life Cycle Cost

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WINDOW
AC

Product Life Cycle Cost- Window AC

- Cost of 1.5 TR Window AC = Rs 18,800/-
- Energy Consumption per hour = 1.5 kWh
- Operating hours per day = 8
- Average cost per unit = Rs 5
- Operating costs per day = Rs 60
- Operating costs per month = Rs 1,800/-
- Operating costs per year = Rs 21,600/-
- Now compare Rs 18,800/- with Rs 21,600/- that you are going to pay per year for the rest of the product life cycle!
- True in the case of larger systems as well

Factors which affects power consumption:

- Return Temperature Set Points
- Design of AHU Coil
- Condition of AHU coil
- AHU connections for air Supply to conditioned space
- Type of AHU Panels
- Air control Mechanisms in AHU
- Quantity of required Vs idle flow
- Efficiency of used pump & piping layout
- Type of flow controls used on Pumps
- Chiller Condenser & Cooler Approach
- Leaving chilled water temperature
- Entering & Leaving Condenser water Temperature
- Water Flow Vs Pressure drop across cooler & condenser
- Type of compressors

Factors which affects power consumption:

- Type of condenser
- Size of condenser & cooler
- Type of refrigerant used
- Capacity control Mechanism in chillers
- Cooling tower approach
- Cooling tower performance Vs Fan power consumption
- Static Pressure across the PVC fills of the Cooling Tower
- Type of fan & motor used in Cooling Tower
- Type of blades used in Cooling tower
- Temperature Control mechanism of cooling tower
- Quality of water
- Operating & Maintenance Practices of whole plant including low side equipmen
- User end cooling load

Thank You

For any clarification , please feel free to contact the undersigned :

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