Energy Efficiency in Buildings – A GRIHA Approach

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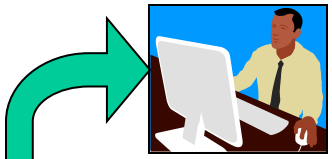
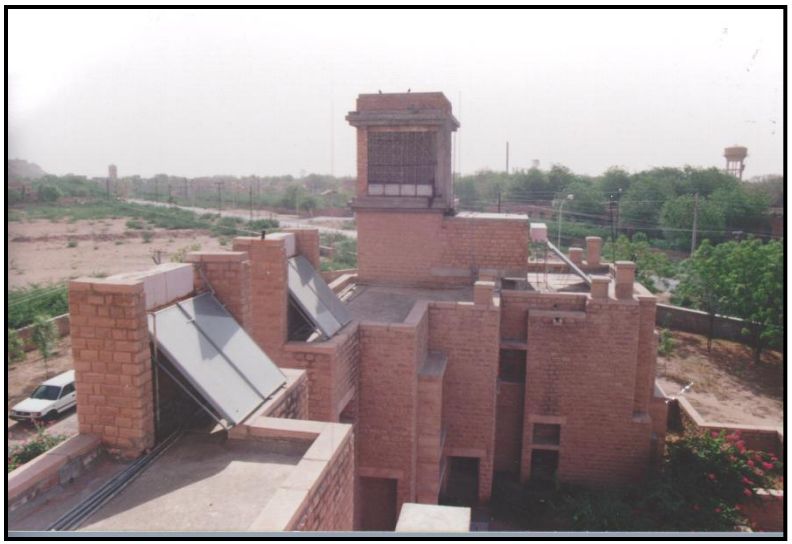
Design Challenge

Non-Air conditioned Buildings



Room Temperature :
Up to 38 ^{0} C



EPI

45 kWh/m^{2}-yr

Air conditioned Buildings

Room Temperature

24 ^{0} C

EPI

200 kWh/m^{2}-yr

Energy Efficient Building

Room conditions

24 ^{0} C

EPI

200 kWh/m^2-yr

Room conditions

26~28 ^{0} C

EPI

< 90 kWh/m^2-yr

Design Approach

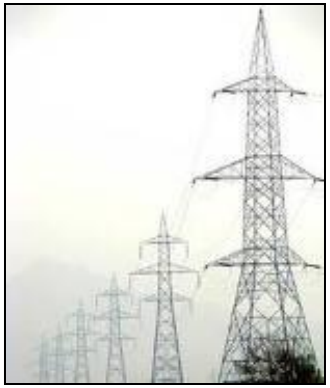
Room conditions

26~28 ^{0} C

EPI

90 kWh/m^2-yr

45 kWh



45 kWh

Inefficiency in Building

Why?

Inefficient buildings

↓

Analysis

↓

Regulation

↓

Efficient building

Energy Efficiency in Green Building

Green Buildings

350 kWh/m^2-yr

210 kWh/m^2-yr

40% reduction

200 kWh/m^2-yr

120 kWh/m^2-yr

40% reduction

Energy Efficiency – GRIHA Approach

WWR – Criterion 13

High Performance Materials - ECBC

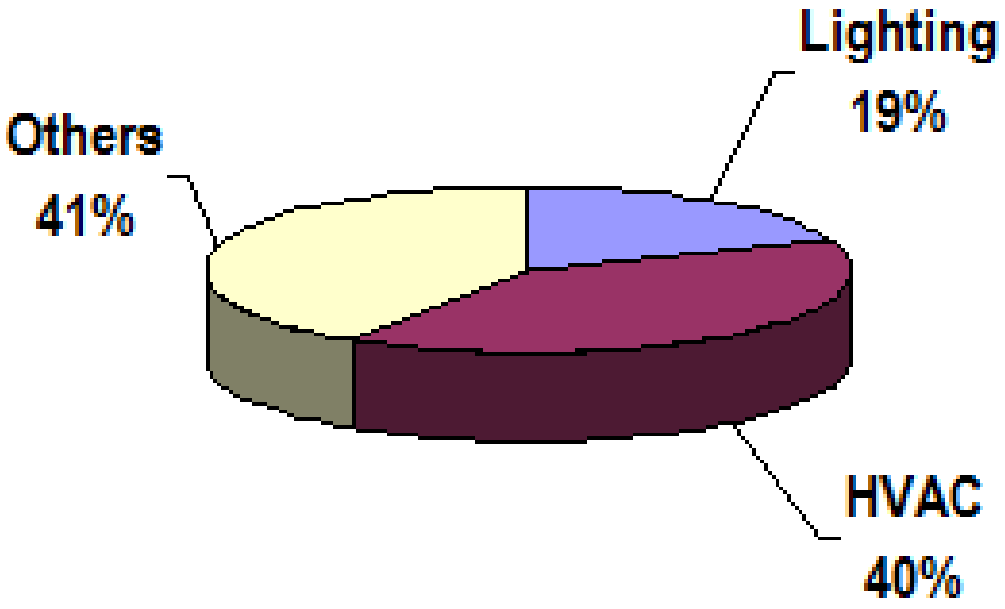
Energy Performance Benchmark – Criterion 14

Reduce demand on Non-Renewable Energy Sources – Criterion 18 & 19

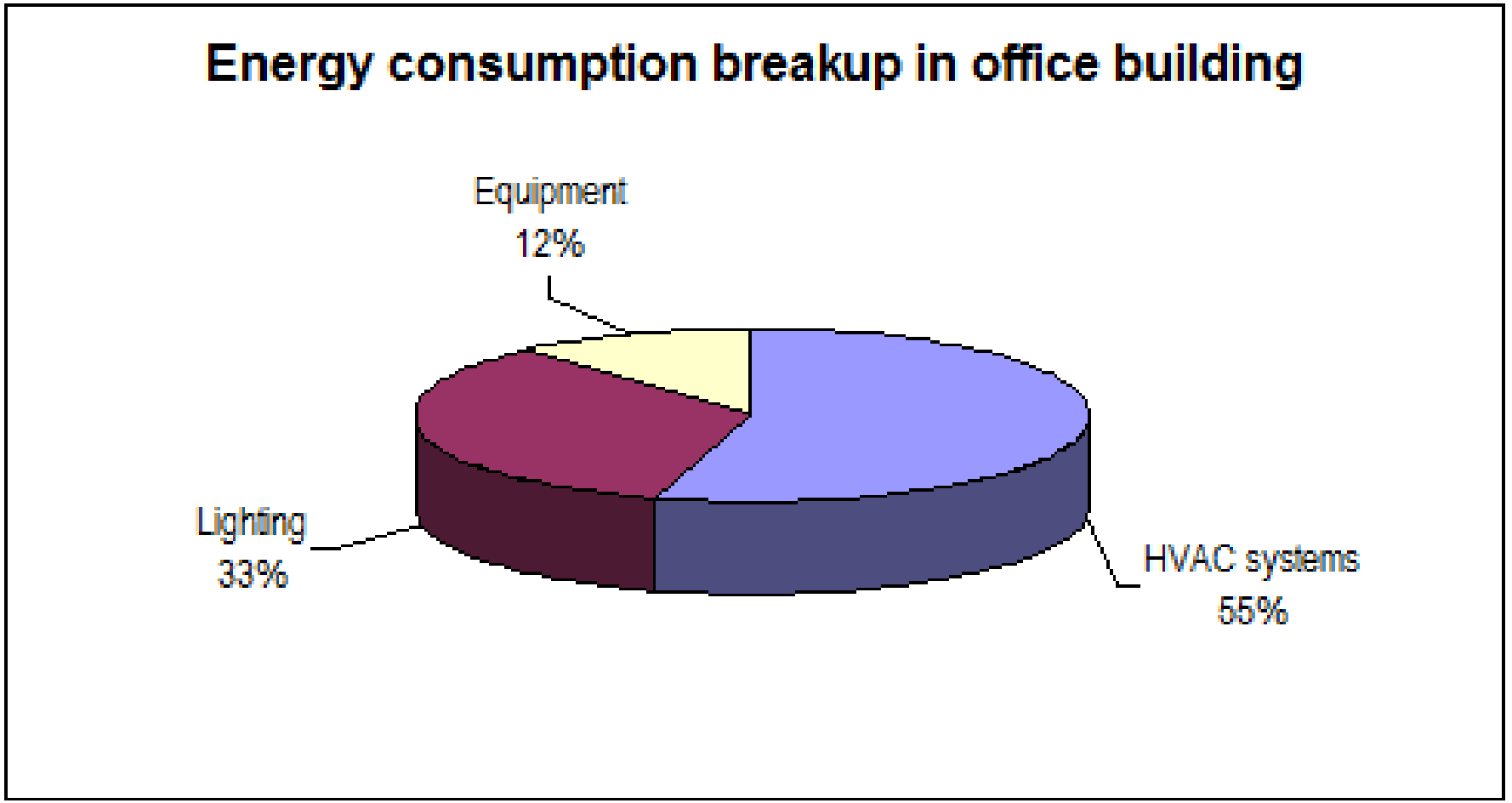
Energy Consumption Breakup in Existing Building

Luxury Hotel

Systemwise breakup of electricity consumption

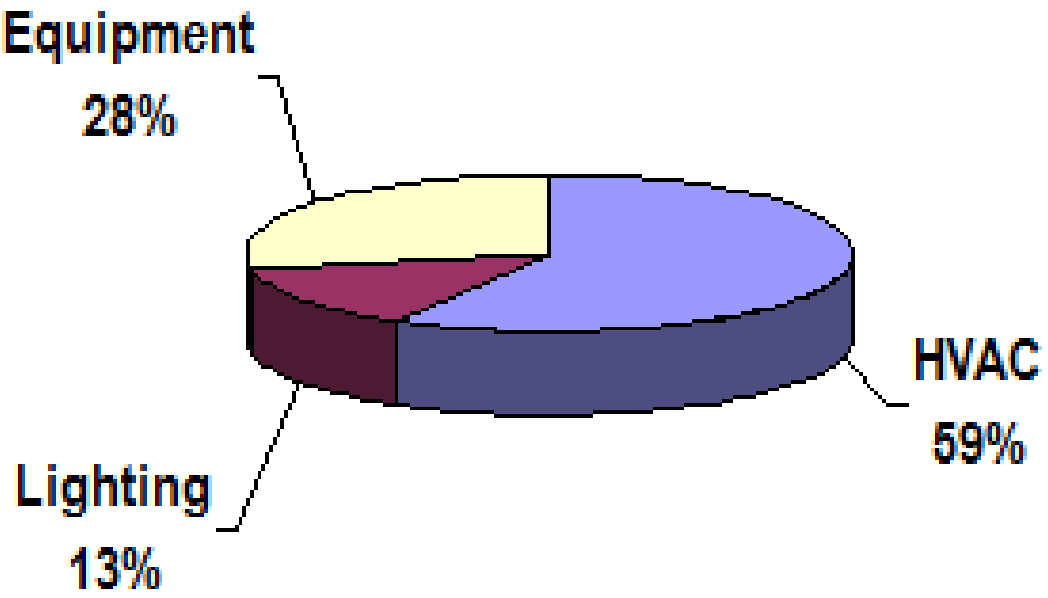


Office Building



Hospital

Systemwise energy consumption break-up



Efficient HVAC System

Adequate comfort

Reduced energy demand

Adequate control to optimize part load performance

Use renewable energy sources

Adequate comfort condition in India

- NBC recommends temperature range of 23 ° C ~ 26 ° C and RH range of 50 ~ 60%
- LEED India accepts comfort range 26 +/- 2 ° C and RH 60%
- Many people in favor of 27+2 ° C and RH 65%

Present Trends in HVAC System Design

- Distributed system
  - VRV or VRF system
  - Wall mounted split system with inverter control
- Centralized system
- Air system
  - AHUs with VFD fan control & VAV boxes
  - ERVs
- Plant Design
  - VSD Chillers
  - Only variable primary CHW loop
  - CSD CW pumps & CTs
  - Dedicated Plant Management System

Innovative HVAC System Design

- Active chilled beam with DOAS and geothermal cooling for condenser water
- Radiant floor cooling system with DOAS system
- Earth air tunnel system along with two stage evaporative cooling system and CHW coil
- Thermal mass storage system along with two stage evaporative cooling system and CHW coil

Energy Efficiency in HVAC System

Project Description

- **Building type:** 600 room 5-star luxury hotel
- **Location:** Chennai
- **Total AC built-up area:** 820000 ft^2

Load estimation

- Total coil load: 3930 TR
- Peak building load: 2950 TR (Diversity @ 0.75)

→ Variable centrifugal chiller

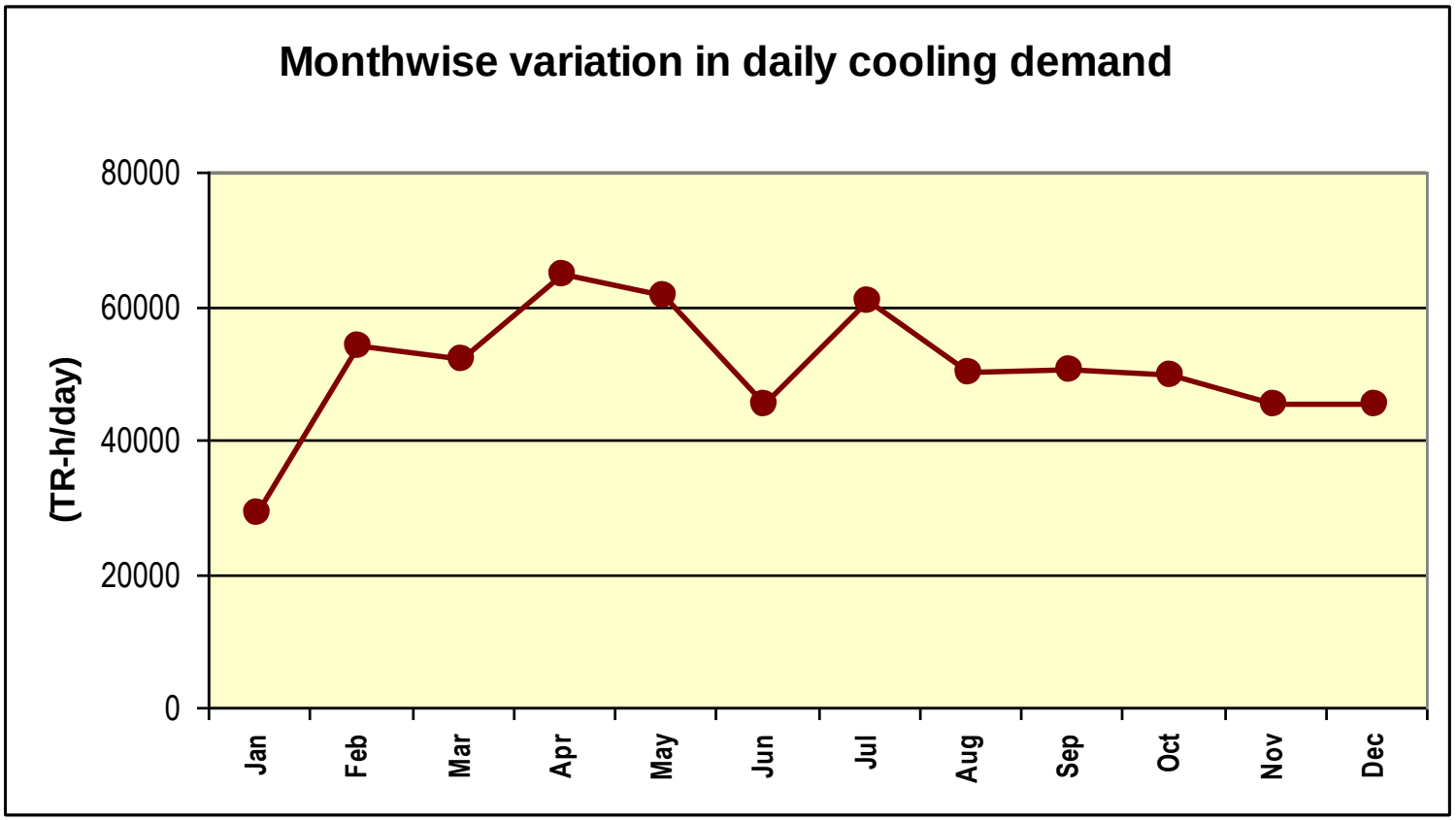
→ Variable primary pumps

→ Constant condenser pumps

→ Constant cooling tower

Case-1 : Only Chiller performance optimized

Estimated cooling demand



Annual cooling demand : 18448307 TR-h

Performance analysis

January					6#600 TR CSD Chiller			
Hour	DBT (0F)	WBT (0F)	Cooling load (TR)	ECWT (0F)	No of operating chillers	Capacity of each chiller (TR)	IKW/TR	kW
0	67.1	65.8	1183	72.8	2	592	0.512	606
1	66.6	64.6	1083	71.6	2	542	0.501	543
2	65.5	64	1083	71	2	542	0.497	538
3	65.1	63.7	1063	70.7	2	532	0.497	528
4	64.2	63.1	1002	70.1	2	501	0.503	504
5	63.7	60.8	845	67.8	2	423	0.504	426

Total daily load * No. of days* DF = Monthly kWh

Chiller sizing

6*600 CSD Chiller

11264940 kWh/yr

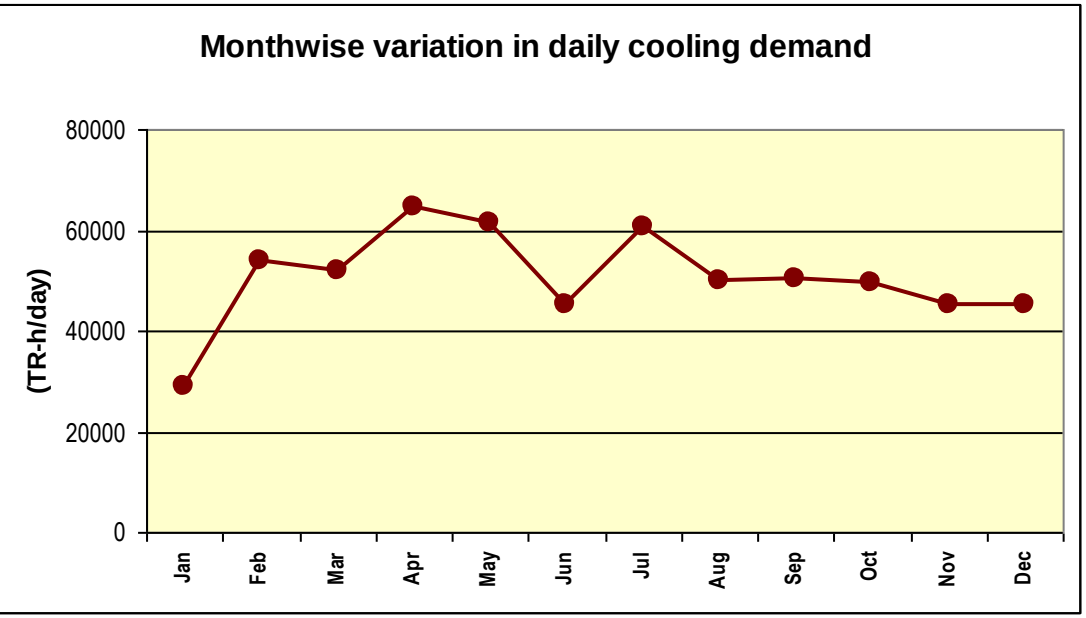
6*600 VSD Chiller

10750300 kWh/yr

5*750 VSD Chiller

10407327 kWh/yr

Avg. operating Chiller COP



Annual cooling demand: 18448307 TR-h

4 * 750 VSD Chillers → **10407327 kWh/yr**

?

IKW/TR : 10407327/18448307 = 0.564

COP : 6.23

Avg. operating plant COP

Annual cooling demand: 18448307 TR-h

10407327 kWh/yr

3224794 kWh/yr

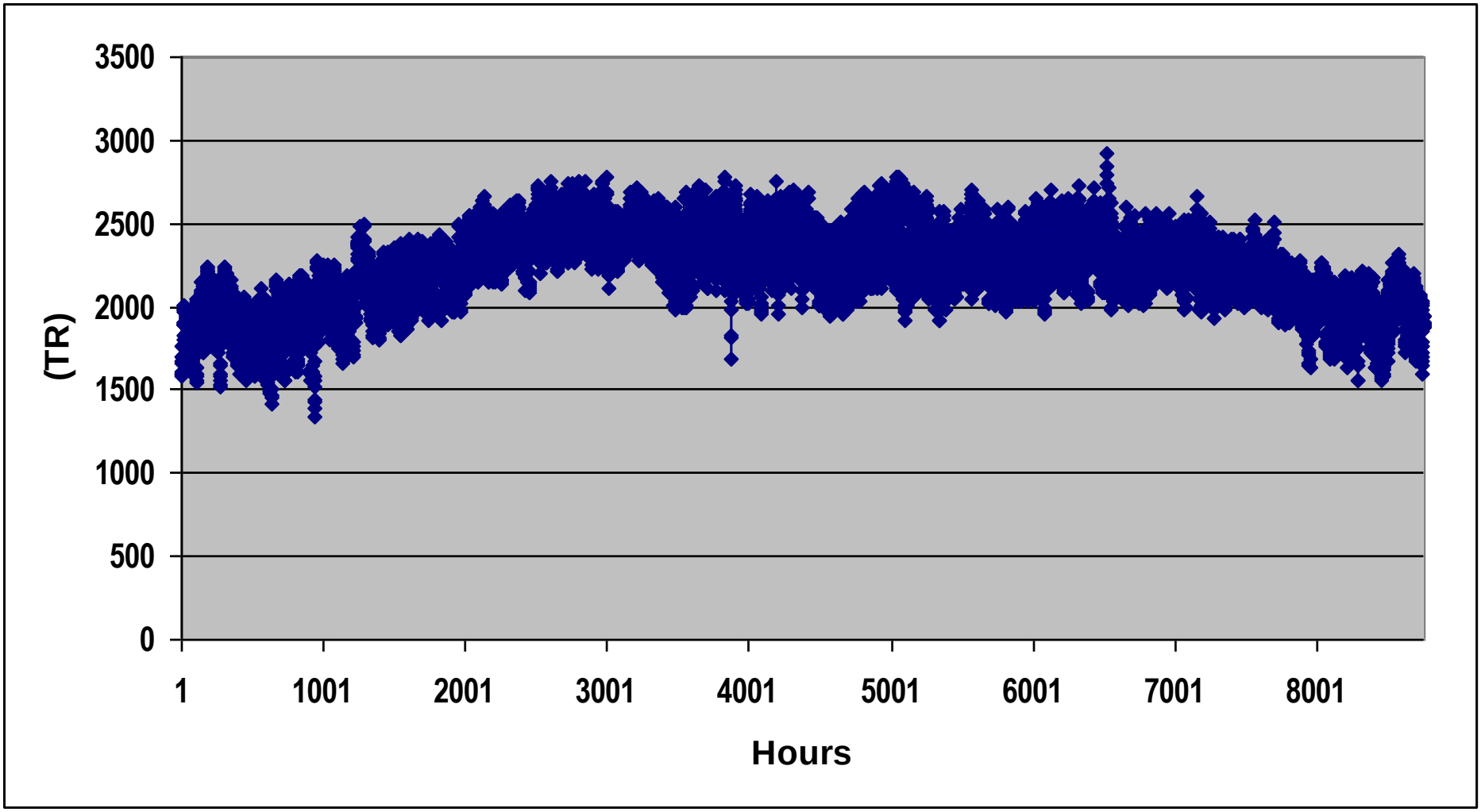
IKW/TR : 13632121/18448307 = **0.739**

COP : **4.76**

Case-2 : Chiller & Auxiliaries performance optimized

Simulated hourly cooling demand

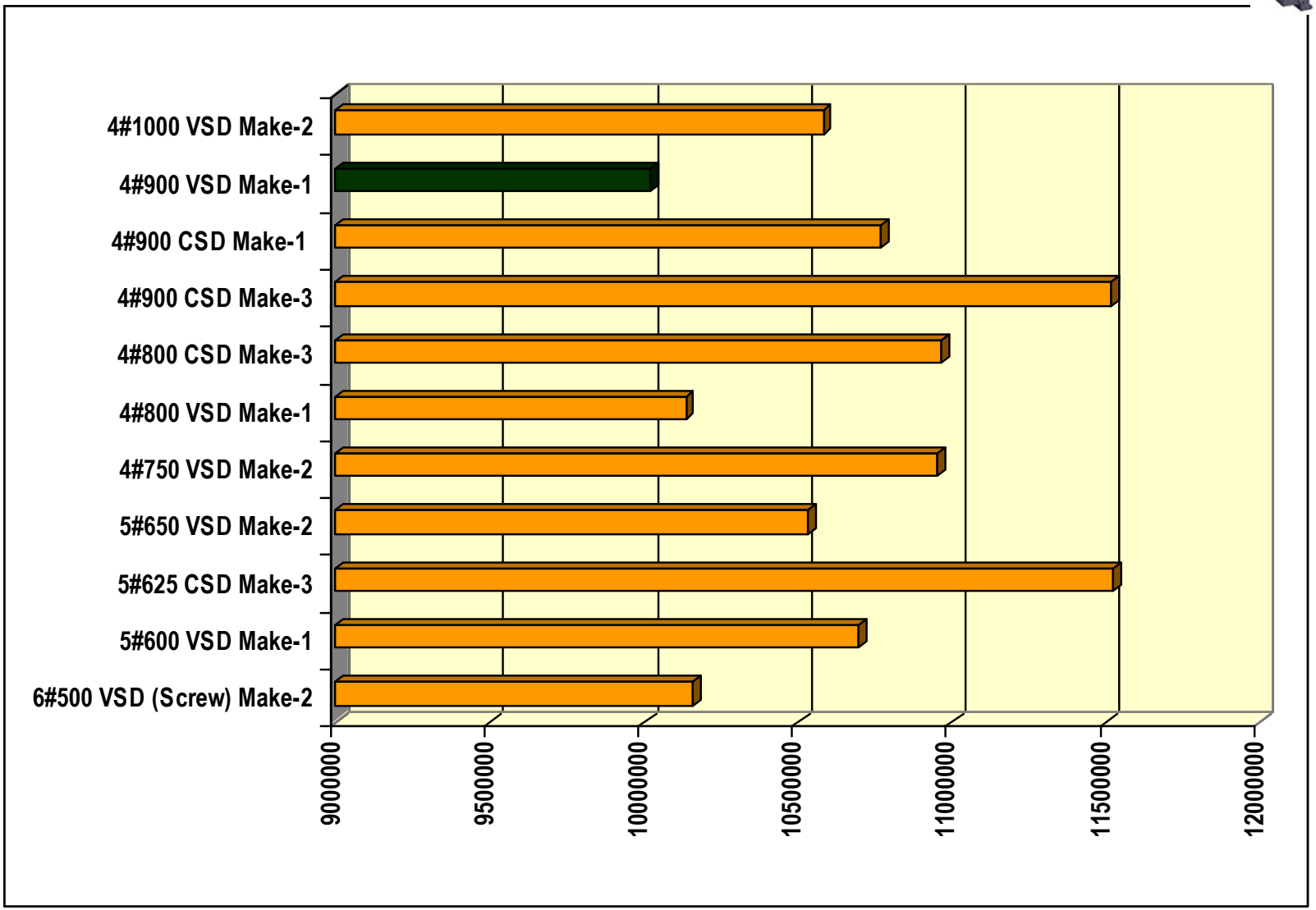
Annual cooling demand: 19623809 TR-h



Energy Performance of Chiller

Hour	Cooling demand (TR)	Chiller (kW)
1	1759	767
2	1697	728
3	1671	714
4	1657	706
5	1605	660
6	1589	652

Chiller Sizing



Equipment Sizing

- Total coil load: 3930 TR
- Peak building load: 2950 TR (Diversity @ 0.75)

→ 4 # 900 VSD centrifugal chillers

CHW flow @2gpm/TR

CDW flow @ 3gpm/TR

→ 4 # 1800 gpm/135’

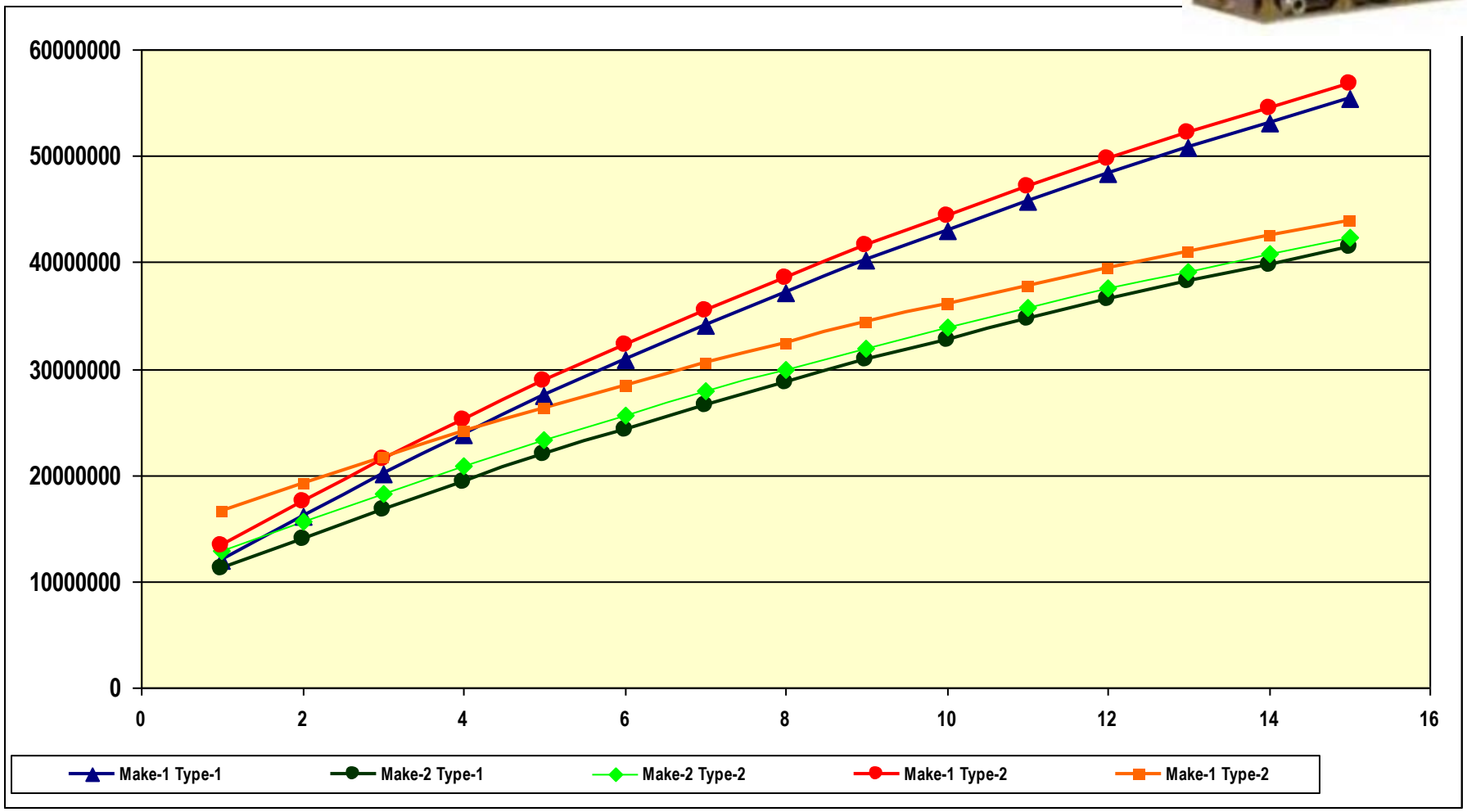
→ 4 # 2700 gpm/105

→ 4 # 900 TR

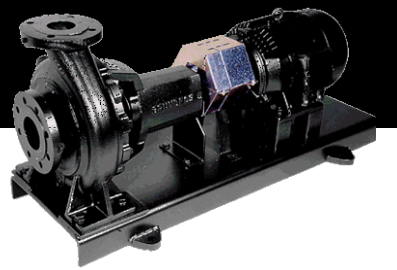
Energy performance of auxiliary equipment

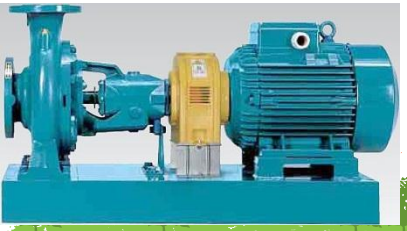
Hour	Cooling demand (TR)	Variable primary chilled water (KW)	CW pump (KW)	Cooling tower fan (KW)
1	1759	91.46	110	60
2	1697	88.24	110	60
3	1671	86.89	110	60
4	1657	86.14	110	60
5	1605	83.45	110	60
6	1589	82.65	110	60

CT Selection



Pump Selection





Avg. Operating COP

Hour	Cooling demand (TR)	Variable primary chilled water (KW)	CW pump (KW)	Cooling tower fan (KW)	Chiller (kW)	Plant (IKW/TR)
1	1759	91.46	110	60	767	0.585
2	1697	88.24	110	60	728	0.581
3	1671	86.89	110	60	714	0.581
4	1657	86.14	110	60	706	0.581
5	1605	83.45	110	60	660	0.569
6	1589	82.65	110	60	652	0.569

Avg. operating COP : 0.674 IKW/TR

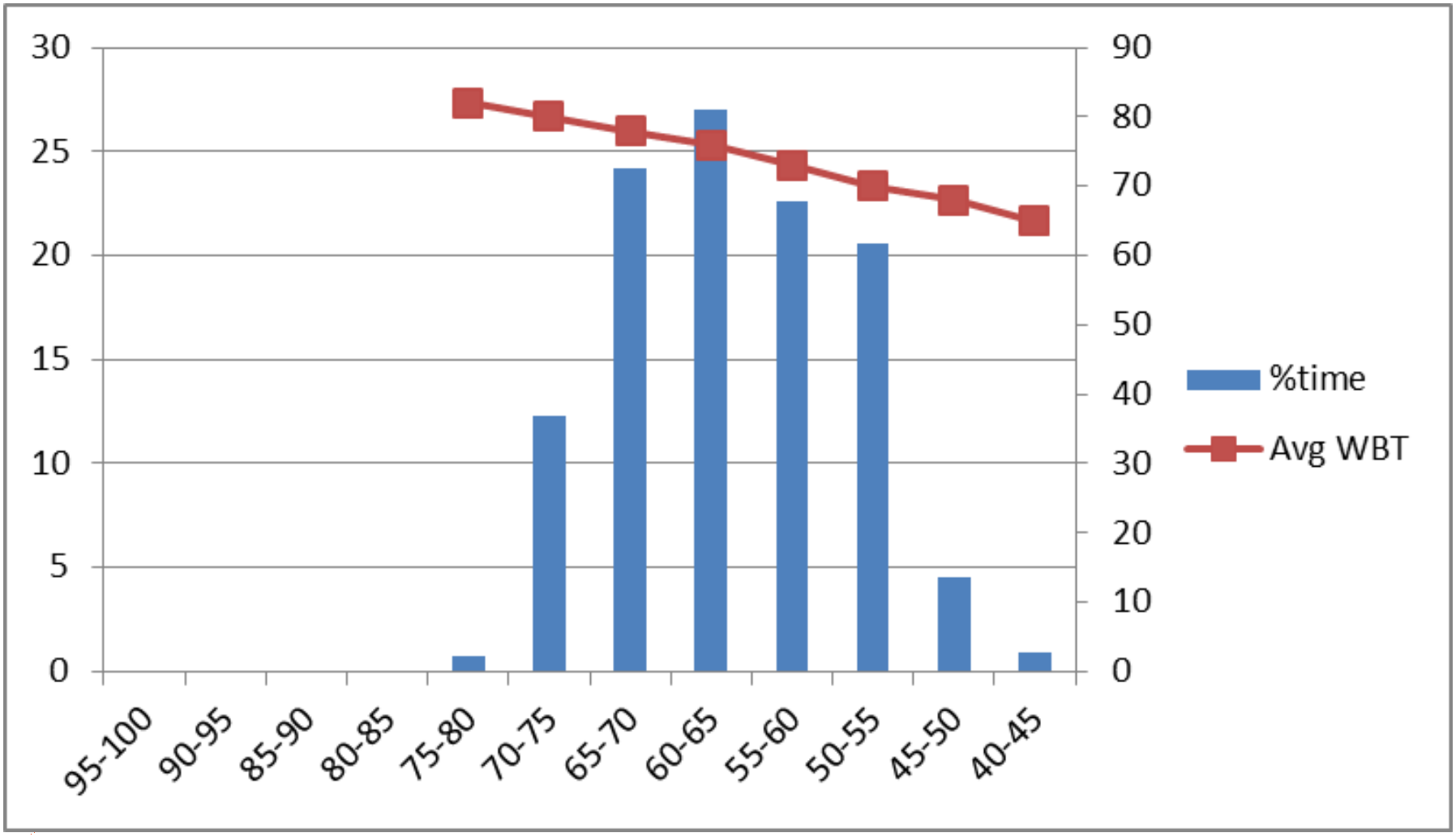
Case-3 : Plant performance optimized

Plant Optimization

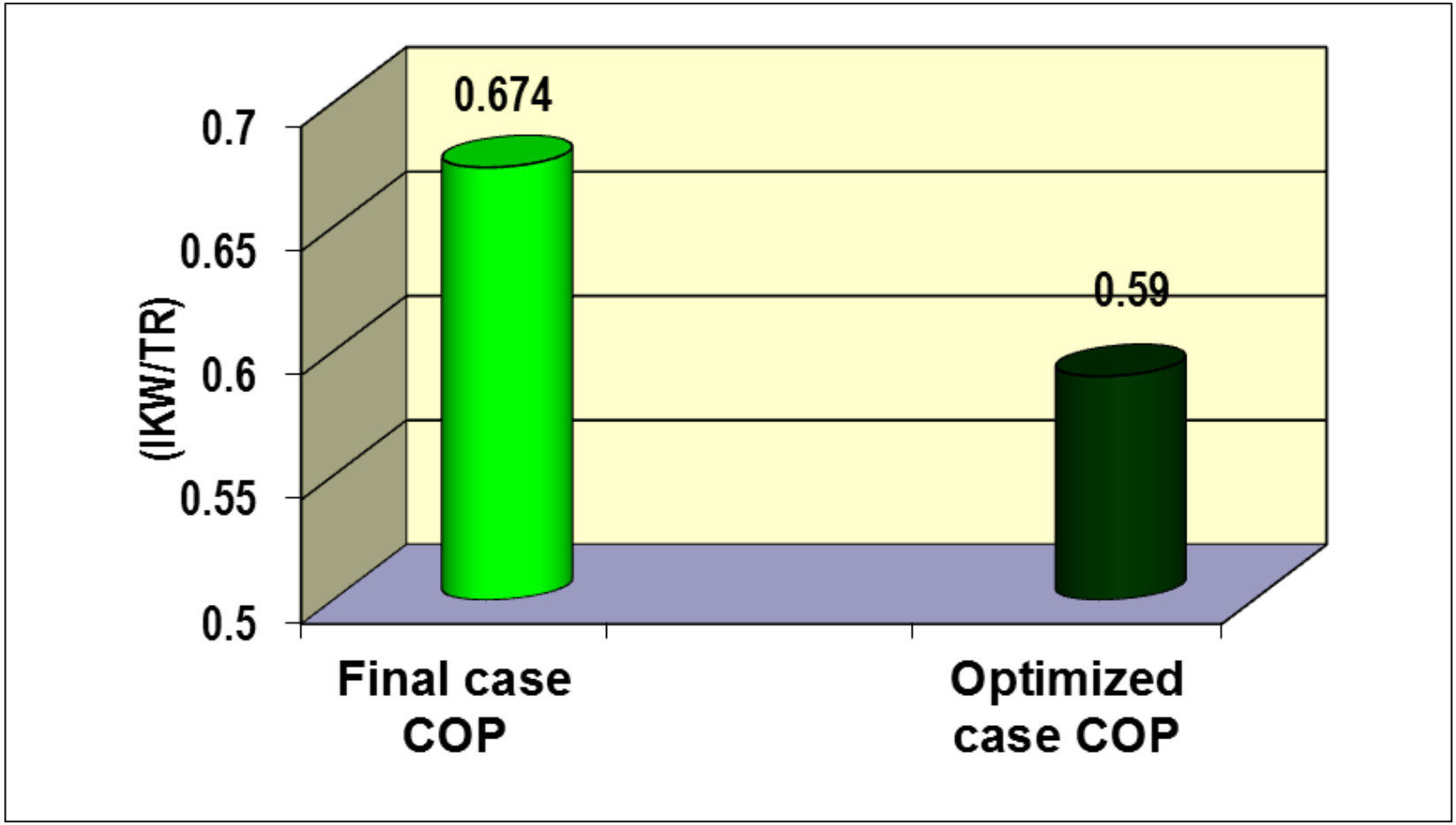
Case-1: 4 # 900 VSD Centrifugal Chiller with PIDs controls

Case-2: 4 # 900 VSD Centrifugal Chiller with all variable system with demand based controls

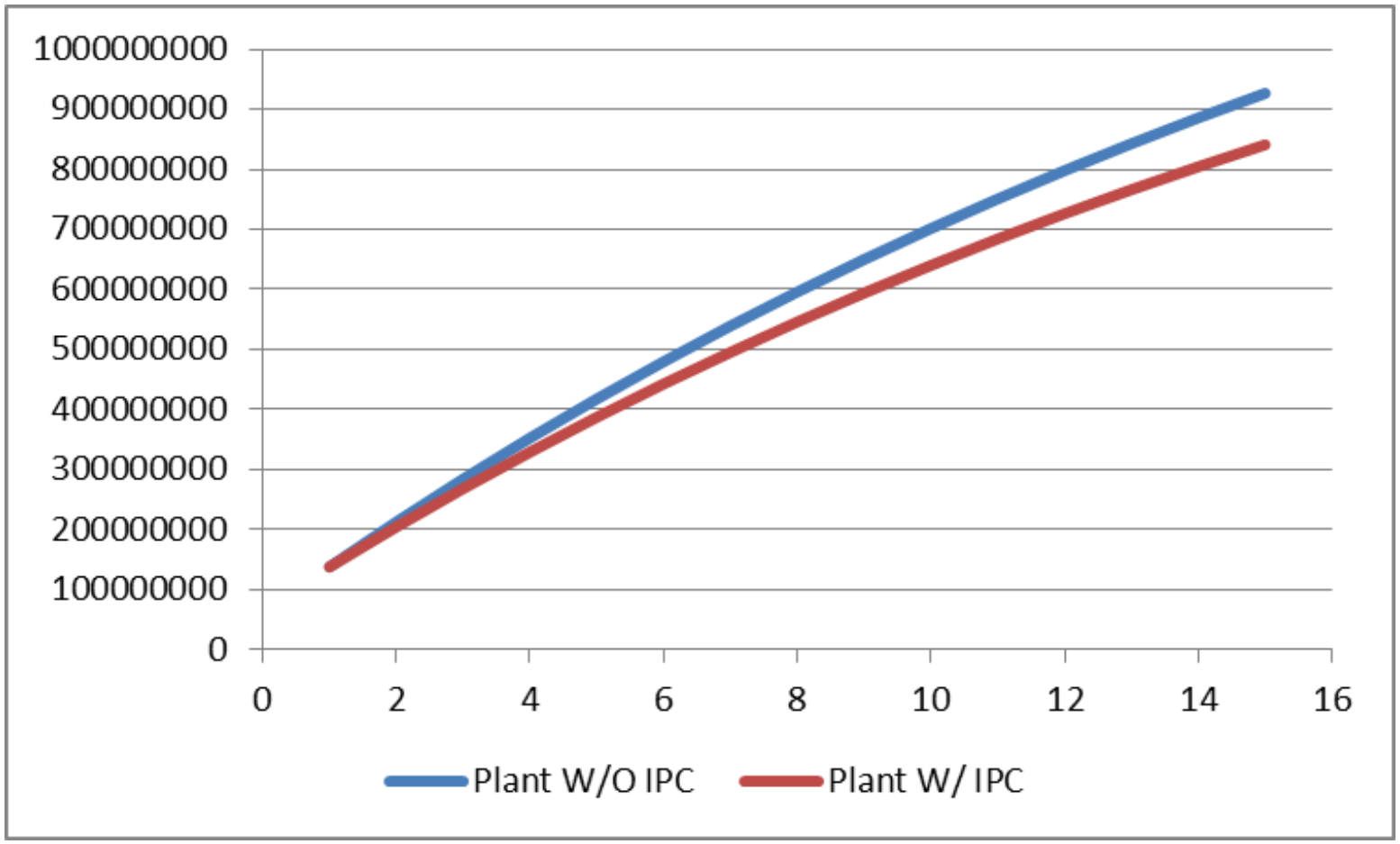
Load curve


30
25
20
15
10
5
0
90
80
70
60
50
40
30
20
10
0
%time
Avg WBT
95-100
90-95
85-90
80-85
75-80
70-75
65-70
60-65
55-60
50-55
45-50
40-45

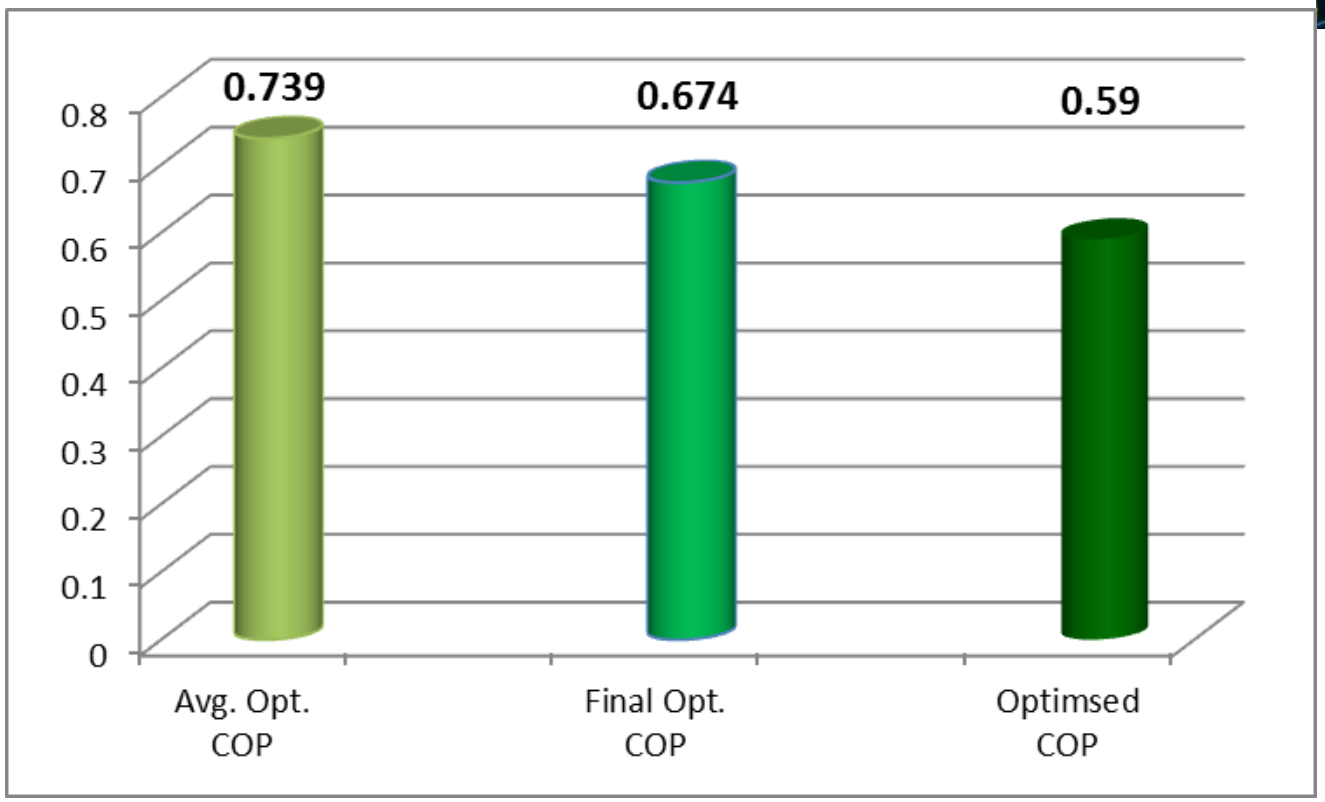
Optimsed COP with IPC



Plant Selection



Plant COPs



Design COP of plant: 0.8 IKW/TR or less

Avg. Opt. COP of plant: 0.6 IKW/TR or less

Recommendation

- Optimize WWR as per CRIHA criterion -13
- Select building materials as recommended by ECBC
- Target cooling load (> 500 ft^2/TR) and energy performance (< 95 kWh/m^2-yr) – CRIHA criterion-14
- Take plant efficiency as a measure of cooling system efficiency
- Target plant efficiency (< 0.8 kW/TR) * avg. opt. plant efficiency (< 0.6 kW/TR)
- Reduce dependence on Non – Green Power – GRIHA criterion 18 & 19


Thank you