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Energy efficiency in

Air conditioning
&
Refrigeration systems

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Air conditioning - not a luxury but a modern necessity:

Air conditioning is a must in:

- **Healthcare**
- **Pharmaceuticals**
- **Software centers**
- **Call centers**
- **Server rooms**
- **Modern offices**
- **Manufacturing units**

Previous Experience from Building Energy Studies in early 1980s showed that A**ir-conditioning uses 40%** and **lighting 20%** of electricity in a building.

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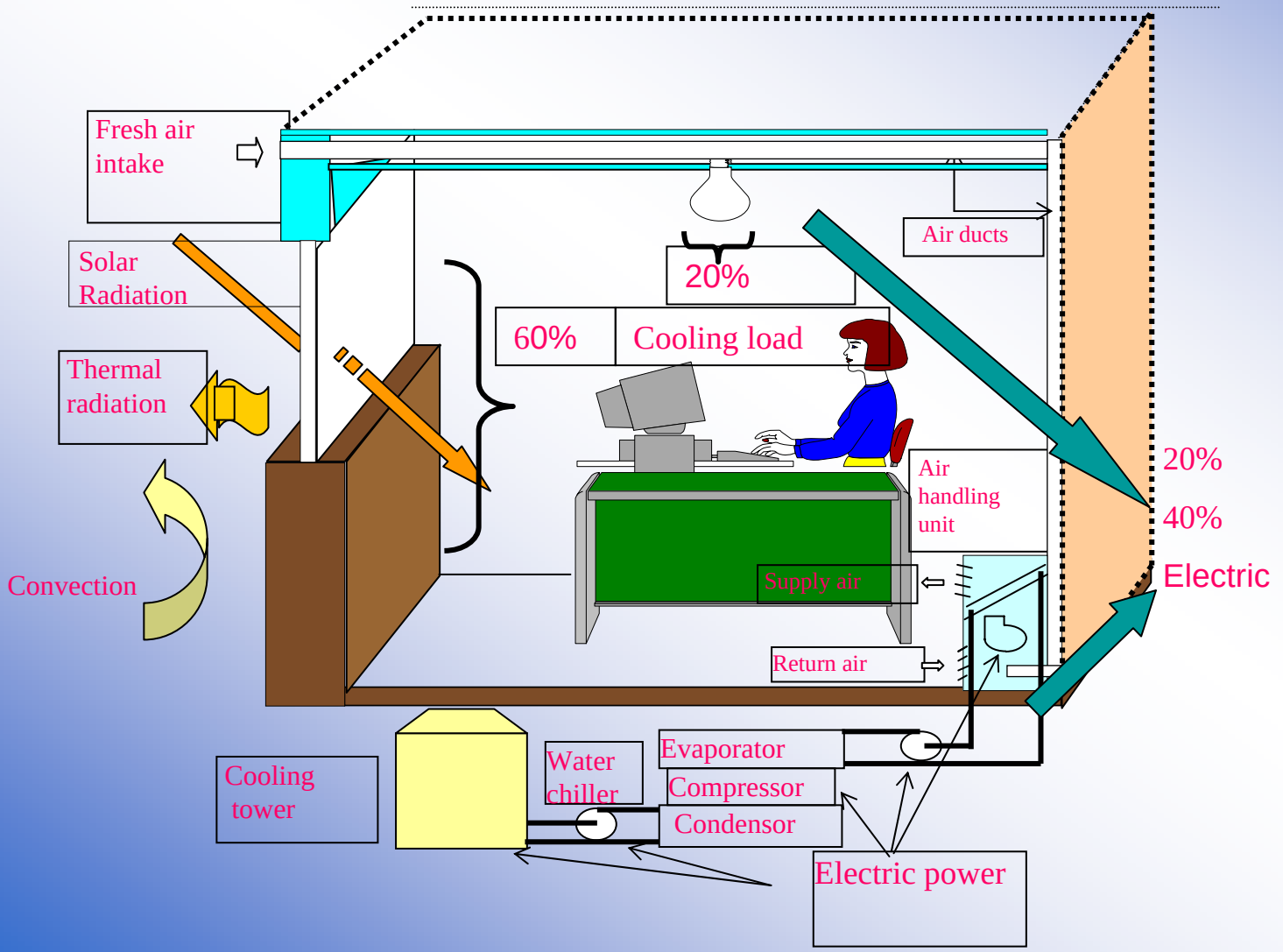

Heat gain through building envelope contributes 60% and lighting 20% of load to the air-conditioning system.

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As of TODAY the Estimated Power consumption for Air conditioning System for various applications are as follows:

Application	% of Power consumption by AC Equipment.
Residential	13%
Commercial / Office	35%
Industrial Application	
Pharmaceuticals	15%
Control Room Air conditioning	10%
Process Cooling	10%

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- There is a very large NEED & POTENTIAL for energy savings in the Air conditioning systems

  As per study:

  - 1 kwh Saved = 1.67 to 1.83 kwh (Generated)

- ENERGY consumed by Air conditioning systems can be reduced by 30% - 50%
  - Incase of new buildings
  - Incase of Existing buildings reduction possible to certain extent

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How and when to start work on Efficient Air conditioning system?

- **The Building Envelope:**

  Building envelope consists of the walls, windows, doors, roof, floor and foundation.This exoskeleton is a major contributor to the heating and cooling load, more than simply containing the conditioned air for the comfort of the occupants.

- Use of Quality material with low U value as envelope will control HEAT INFILTRATION.

- Scientific Heat load Estimate of the space to be air-conditioned to decide on the Air conditioning system capacity.

- Building Heat Load Minimization:

  Minimize the air conditioning loads by measures such as roof cooling, roof reflectance, efficient lighting, optimal thermostat setting of temperature of air conditioned spaces, sun film applications, etc.

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- **Select high-efficiency HVAC equipment:**

  Computerized system selection using software for optimized selection in line with the requirements

  Selecting higher-efficiency Air conditioning units.

- **Efficient and proper designing of Air distribution.**

- **Solar Heat Gain Control:**

  Install awnings, overhangs, or coated windows with low Solar Heat Gain Coefficient (SHGC)

- **Periodic Maintenance of the Air-conditioning system makes it power efficient**

Heat gain Through Different Glasses Along Different Directions
Chennai –May-4 PM TR/100 sq.ft

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Sl.No:	Direction	Single Common Window Glass(1/8")	Single Regular Plate Glass(1/4")	Single Heat absorbing Plate Glass	Double Common Window Glass	Double Regular Plate Glass	Heat absorbing plate(Out Door) &Regular Plate Door Indoor
1	N	0.58	0.51	0.34	0.33	0.23	0.13
2	NE	0.33	0.31	0.26	0.14	0.12	0.09
3	E	0.34	0.31	0.27	0.15	0.12	0.09
4	SE	0.35	0.32	0.27	0.16	0.13	0.09
5	S	0.36	0.33	0.27	0.17	0.13	0.10
6	SW	0.88	0.73	0.43	0.55	0.37	0.18
7	W	1.66	1.34	0.66	1.12	0.72	0.30
8	NW	1.52	1.23	0.62	1.02	0.66	0.27

Heat gain Through Different Glasses Along Different Directions

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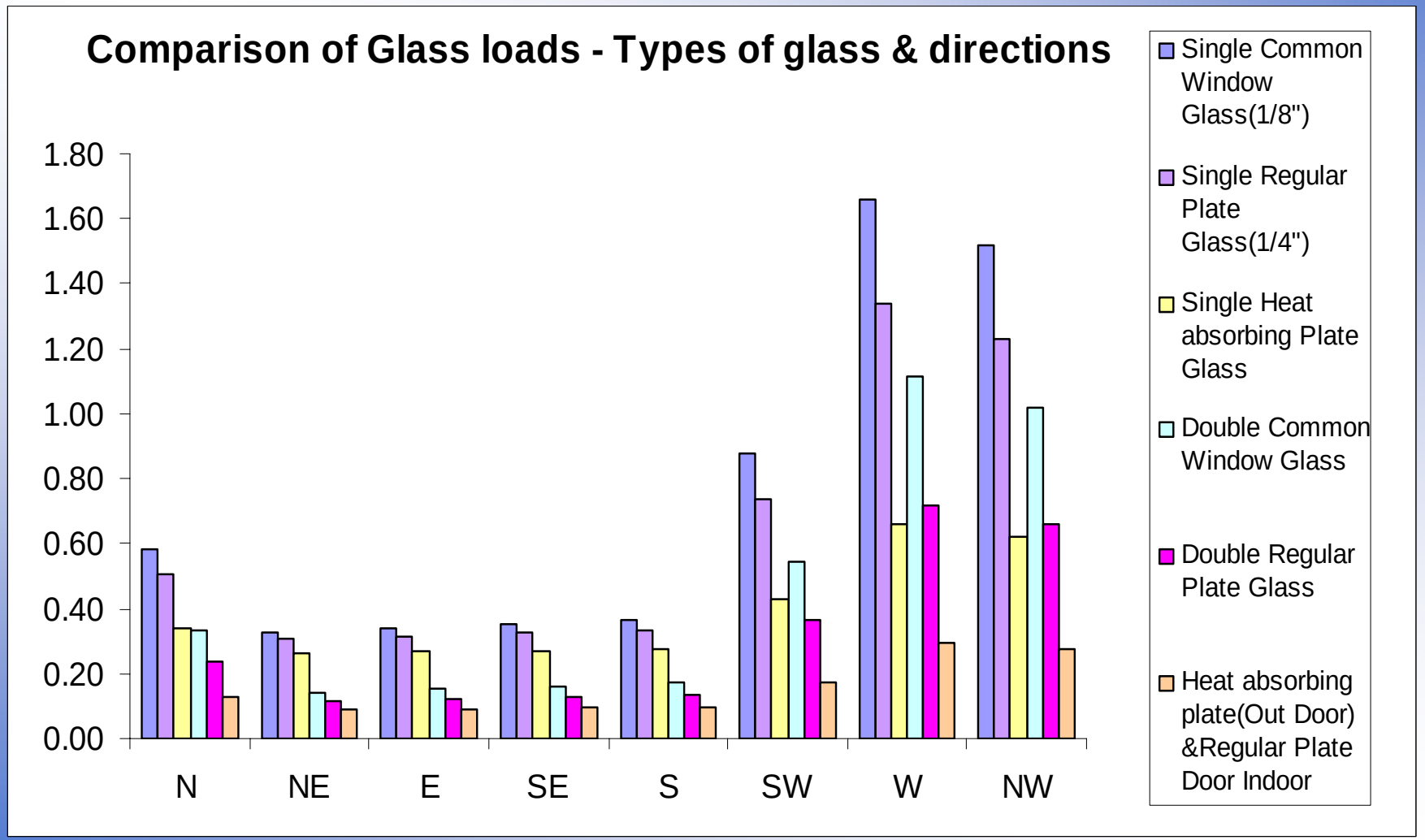
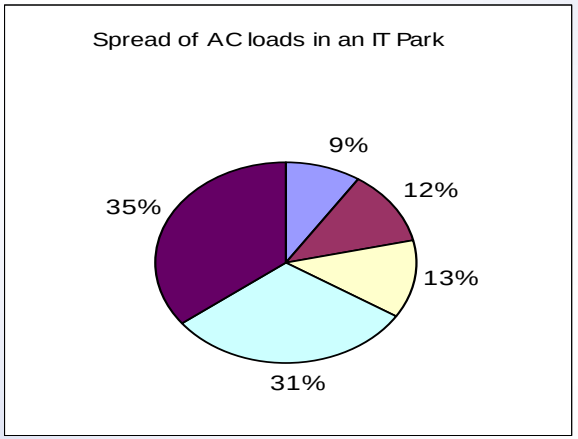
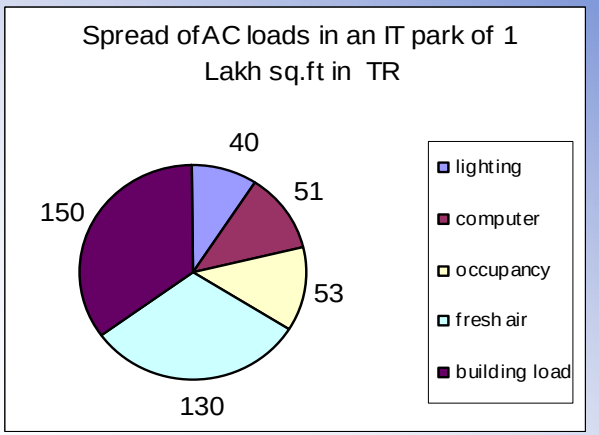
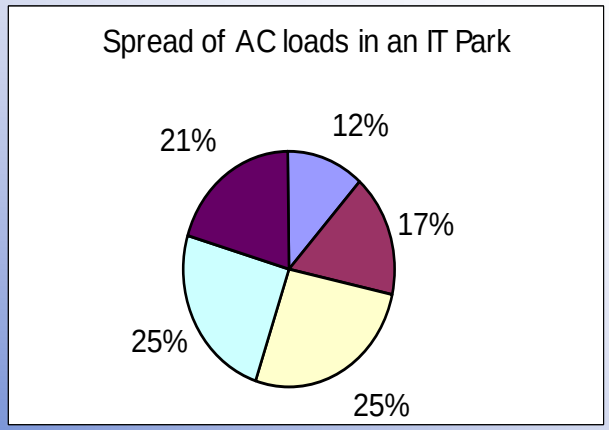


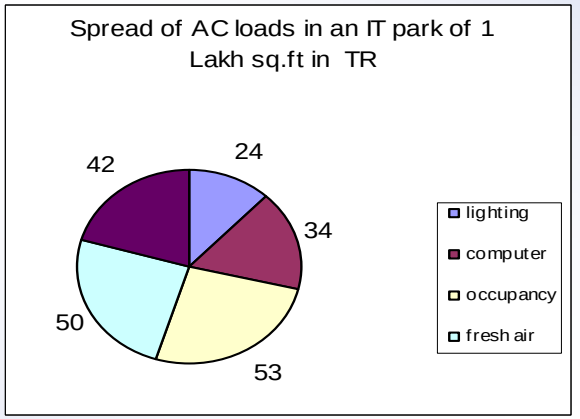
Spread of AC Load-Normal System





Spread of AC Load-Special Design





Assumptions made in Air conditioning as per ASHRAE and Trade Behavior.

◆ 1.5 Watts/sq.ft	-Lighting	-40 TR
◆ 150 Watts/Person	-Computer	-51 TR
◆ 80 Sq.ft./ Person	-Occupancy	-53 TR
◆ 20 Cfm/Person	-Fresh Air	-130 TR

Example: air-conditioning duct installation

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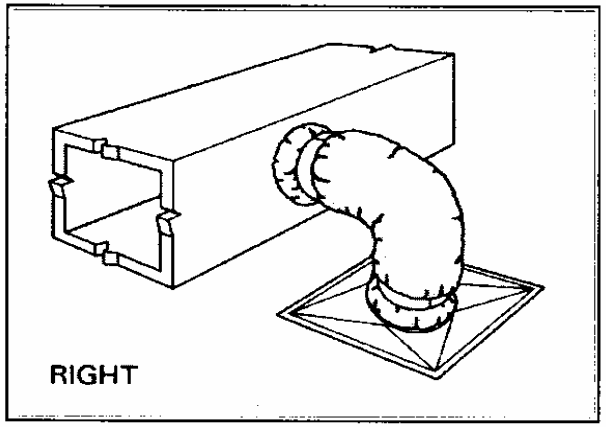
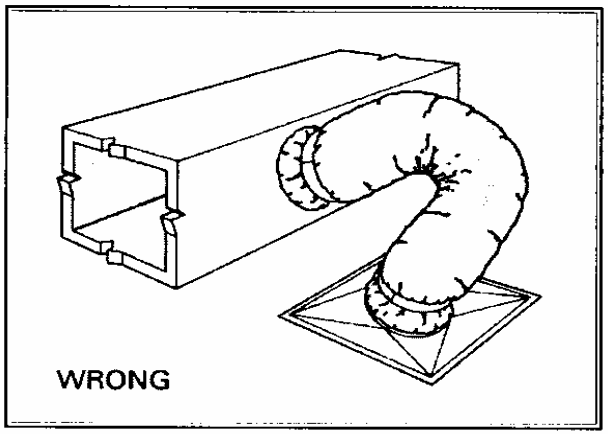
Figure 2-12 – Duct Installation (Right)



Ducts shall be installed fully extended as shown in Figure 2-12. If compressed or with excess lengths, as shown in

Figure 2-13, friction losses are increased.

Figure 2-13 – Duct Installation (Wrong)



Avoid bending ducts across sharp corners or incidental contact with metal fixtures, pipes or conduits. Also avoid installing the duct near hot equipment such as furnaces, boilers, or steam pipes, which are above the recommended flexible duct use temperature.

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- **ENERGY savings in the existing buildings can be achieved by following**
  - **Coating the rooftop with suitable reflective building material & under deck insulation could reduce the heat ingress and thereby power consumption considerably**
  - **Keeping low ratio of wall (70%) to window (30%)**
  - **Changing less efficient (and hotter) lights to cooler-operating, more energy-efficient lights.**

    The change will also reduce the "heat" and therefore load on the Air conditioning system
  - **Minimize the Air conditioning loads by optimal thermostat setting of temperature of air conditioned spaces, sun film applications, etc.**
  - **Proper maintenance of HVAC systems, such as cleaning filters and maintaining proper refrigerant charge**

Maintenance in existing Air-conditioning system for better Efficiency

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- **Air Handling Unit:**
  - Cooling Coil efficiency – by cleaning with proper cleaning agent at regular intervals. Use of UV light to reduce bacteria growth in the coil.
  - Fan efficiency
- **Pumps:**
  - High efficiency pumps with mechanical seals
  - Use of VFD on Secondary chilled water system with 2 way valves for AHU.
- **Cooling Tower (for water-cooled system):**
  - Proper spray of water
  - Clean of fills
  - Proper adjustment of fan blades
  - Use of water bleed off for circulating water
  - Only soft water to be used for make up to reduce fouling in the condenser
- **Electrical Panel**
  - Power factor improvement

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Power Consumption & Pay Back Analysis for a 500 TR Capacity operating Chiller Plan

	Existing Recip Chiller	New Screw Chiller
Operating Chiller Capacity	500	500
Power Consumption at 100% Load (IKW/TR)	1 - 1.1	0.65
Average Power Consumption (Including Partial Load Operation) - IKW/TR	1	0.5
Operation Hours per day	14	14
Average no. of working days per year	300	300
TR-HRS of Chiller per year (Assuming a diversity of 0.6)	1260000	1260000
Rate of Electricity per KWH (in Rs.)	5.5	5.5
Cost of Power Cusumption per annum (In Rs.)	6930000	3465000
Net power saving of Screw Chiller over Reciprocating Chiller per Annum (In Rs.)	0	3465000
Net power saving of Screw Chiller over Reciprocating Chiller per Month (In Rs.)	**0**	**288750**
First Cost of 2 nos. 250 TR Screw Chiller		7800000
Finance Cost (@ 11% Flat) on Capital investment for 3 years		2574000
Total Investment Cost		10374000
EMI Per Month		288167
Pay Back Period		**Three Years**

Initiatives by HVAC industry in development of Energy efficient AC systems

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- Compressor Technologies:

Reciprocating → Rotary → Twin Rotary → Scroll → Screw

- Coils
  - Grooved copper tubes for better heat transfer.
  - Super Slit Fins for better heat transfer.

- As a result the power consumption has reduced to:

	Old	New
WAC 1.5 Tr	2.4 Kw	1.8 Kw
SAC 1.5 Tr	2.5 Kw	1.8 Kw
PAC 5 Tr	1.4 Kw /TR	1.1 Kw / Tr
WATER COOLED CHILLERS	0.9 Kw /TR	0.65 Kw/ TR

Energy Labeling Program for WAC & SAC from BEE

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Star Rating Band valid from 01st Jan 2007 to 31st Dec 2007

EER (W/W)		
Star Rating	**Min**	**Max**
1 Star *	2.30	2.49
2 Star **	2.50	2.69
3 Star ***	2.70	2.89
4 Star ****	2.90	3.09
5 Star *****	3.10	

Star Rating Band valid from 01st Jan 2008 to 31st Dec 2009

EER (W/W)		
Star Rating	**Min**	**Max**
1 Star *	2.50	2.69
2 Star **	2.70	2.89
3 Star ***	2.90	3.09
4 Star ****	3.10	3.29
5 Star *****	3.30	

Star Rating Band valid from 01st Jan 2010 to 31st Dec 2012

EER (W/W)		
Star Rating	**Min**	**Max**
1 Star *	2.70	2.89
2 Star **	2.90	3.09
3 Star ***	3.10	3.29
4 Star ****	3.30	3.49
5 Star *****	3.50	

Initiatives by HVAC industry in development of Energy efficient AC systems

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- **Water-Cooled Chillers**
  - Better efficiency screw chiller (0.75 IKW/TR) introduced replacing Reciprocating Chillers (1.1 IKW/TR) almost a decade back.
  - New range of Screw chiller introduced couple of years back & are available with IKW/TR from 0.6 to 0.7
  - Efforts are on to achieve IKW/TR of 0.5 with high efficiency screw compressor & heat exchanger
  - New centrifugal chillers with IKW/TR of 0.55-0.65 compared to IKW/TR of 0.65 to 0.75.

Initiatives by HVAC industry in development of Energy efficient AC systems

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- **Air-Cooled Screw Chiller**
  - Initial generation of air cooled screw chiller was with 1.25 to 1.4 IKW/TR
  - The new generation chiller have high efficiency as high as 1 IKW/TR.
  - Efforts are on to develop next generation air cooled screw chiller to achieve IKW/TR of 0.85
  - Development of Heat Recovery condensers

Initiatives by HVAC industry in development of Energy efficient AC systems

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- Water Pumping System
  - Constant speed pumping system replaced with variable speed pumping system.
  - Variable speed pumping system save 30% operating cost as the building HVAC load varies a lot due to varying ambient through out the day, internal load variation etc.
- Cooling Tower
  - Earlier Tower Design with 7 F Approach are now improving to 5 F or even lower. The improvement in approach reduce the power consumption by chiller to a good extent.
  - VFD is applied to cooling tower fan to reduce on running cost.

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Initiatives by HVAC industry in development of Energy efficient AC systems

- **Air Handling Unit**
  - Use of variable speed high efficiency fan design for energy saving for less load conditions
  - Use of heat recovery wheel to reduce the refrigerant load due to fresh air. Most comfort application have a fresh air load of 7.5% to 15%
  - High efficiency cooling coils have been applied to reduce the size of AHU while saving energy
  - UV Lamps are being used to reduce the fungus on the cooling coil for better IAQ, which improves coil efficiency as well

Initiatives by HVAC industry in development of Energy efficient AC systems

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- **Variable Refrigerant Flow (VRF) System:**
  - High efficiency DX system with variable refrigerant flow
  - The technology uses high efficiency scroll compressor
  - Multiple indoor units can be connected with one outdoor unit
  - Very less space required for installation of units & pipes
  - Can be incorporated for residential to light commercial applications
  - Overall power consumption in a year varies from 0.6 to .75 IKW/TR.
  - True to its feature, it's a product of architect delight.

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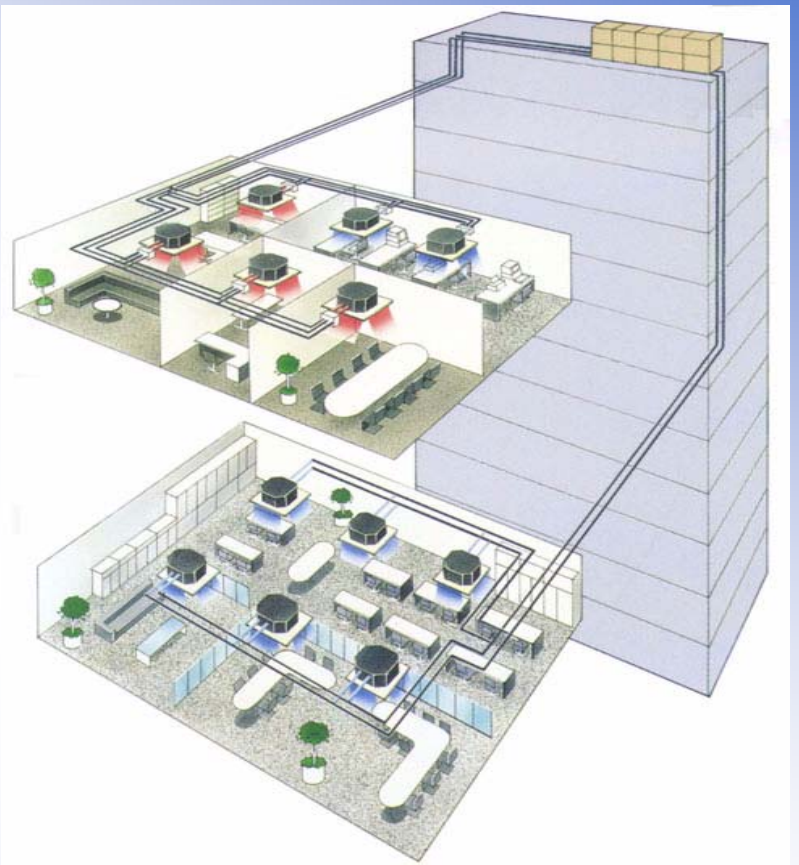
VRF
(Variable Refrigerant Flow System)



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Set Free

- Intelligent Building Air conditioning System
- Precise capacity control by Inverter technology
- Precise temperature control by Electronic expansion valve

The future of air conditioning….

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What is INVERTER Control?

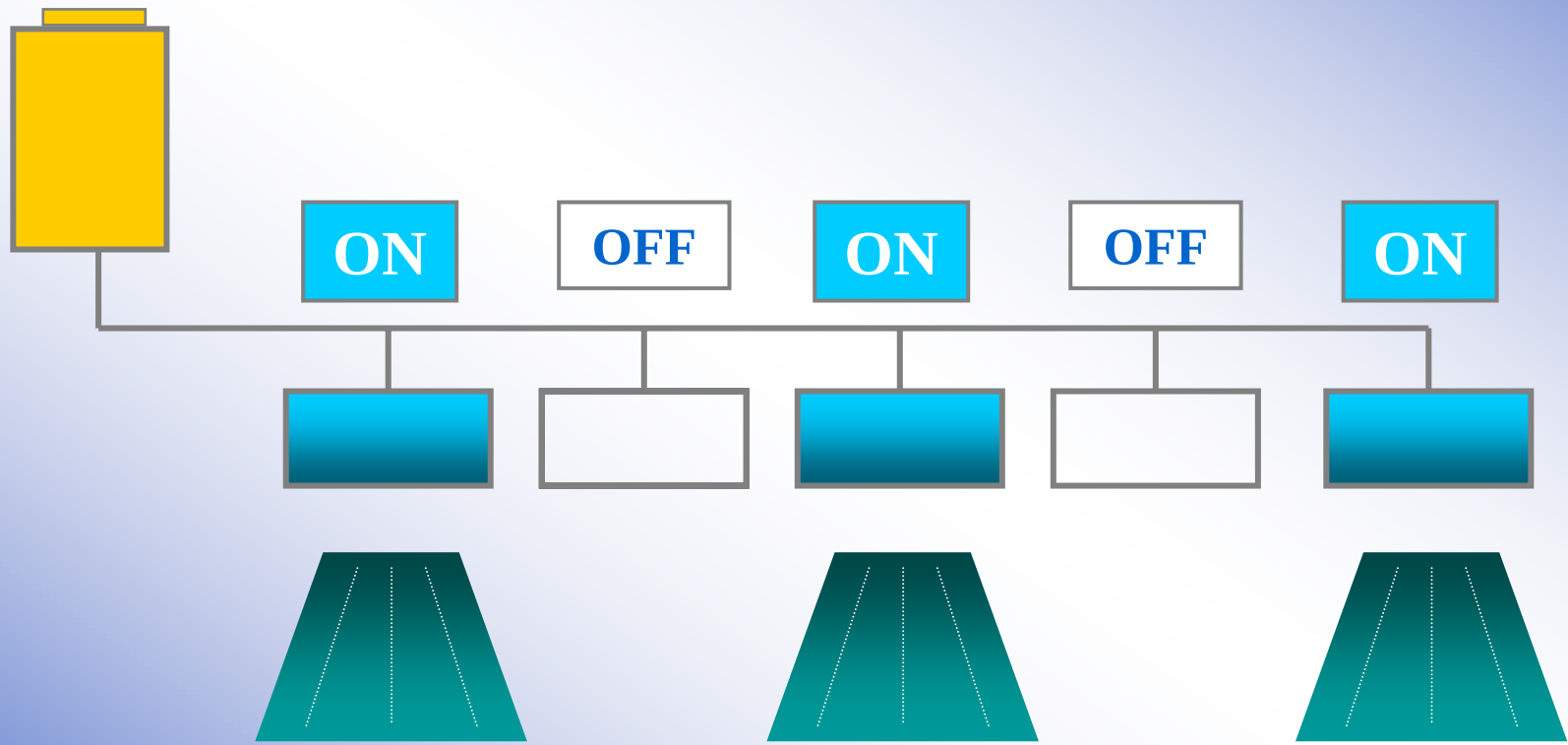
Mechanism of Controlling Compressor Rotating Speed

+

Electric Expansion Valve Opening Control

Why Set-Free

Individual Indoor Unit Operation



How Is Such Operation Possible? → ***INVERTER*** **Control**

R410A SET-FREE (VRF)

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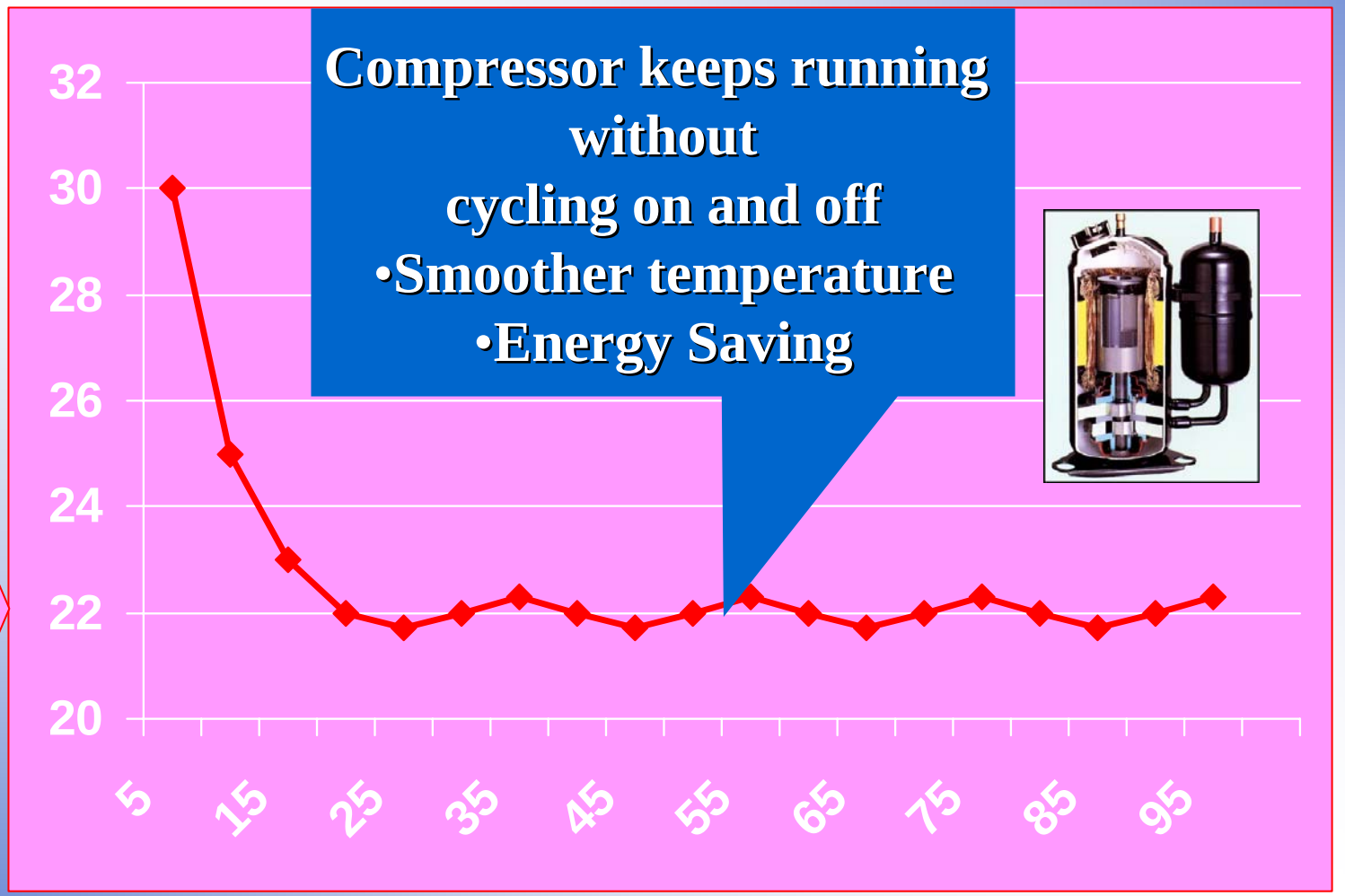
Set Temperature



R410A SET-FREE (VRF)

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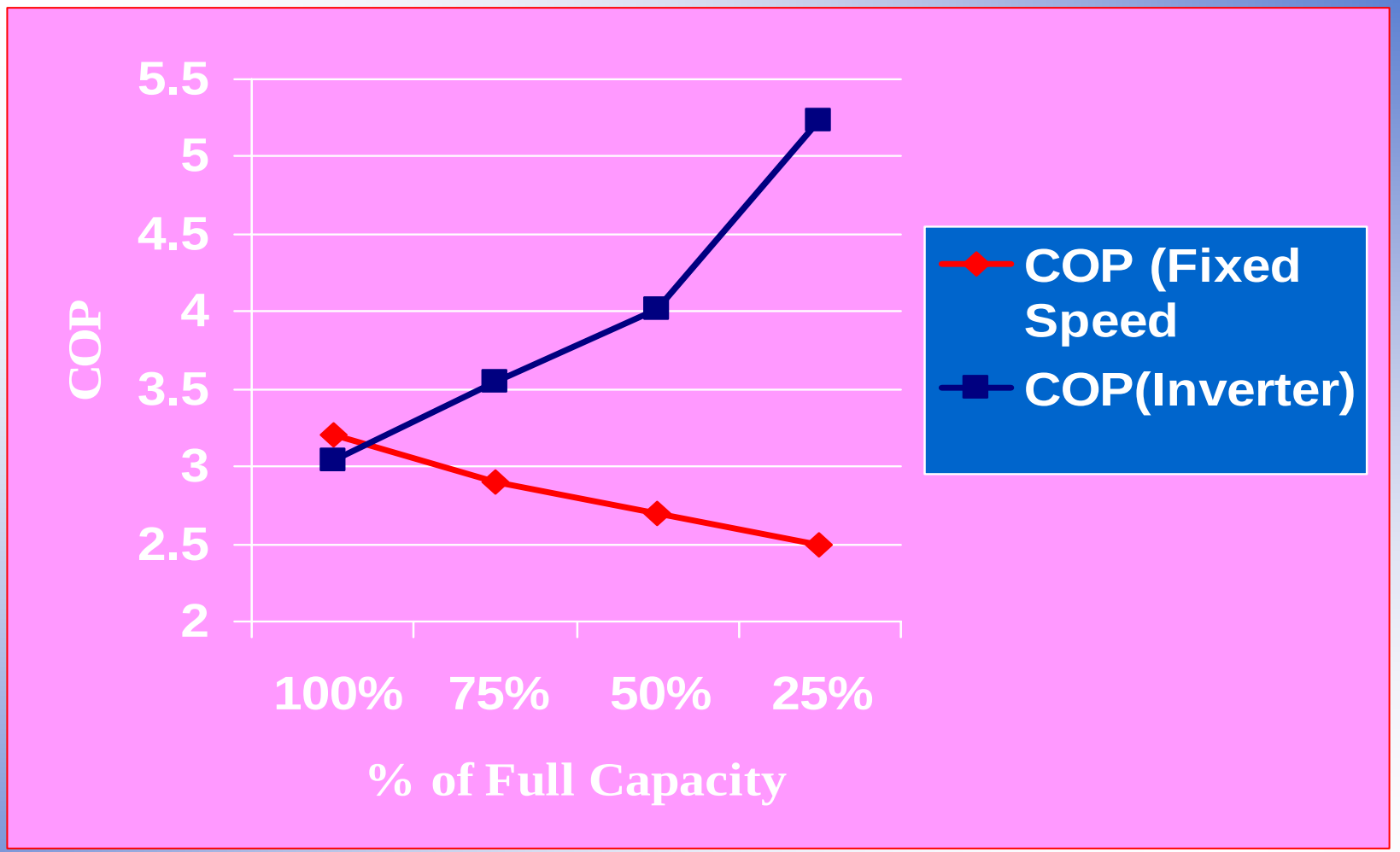

Inverter is More Efficient at Part Load

Appearance

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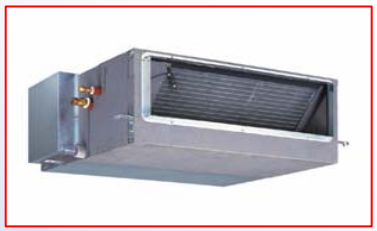
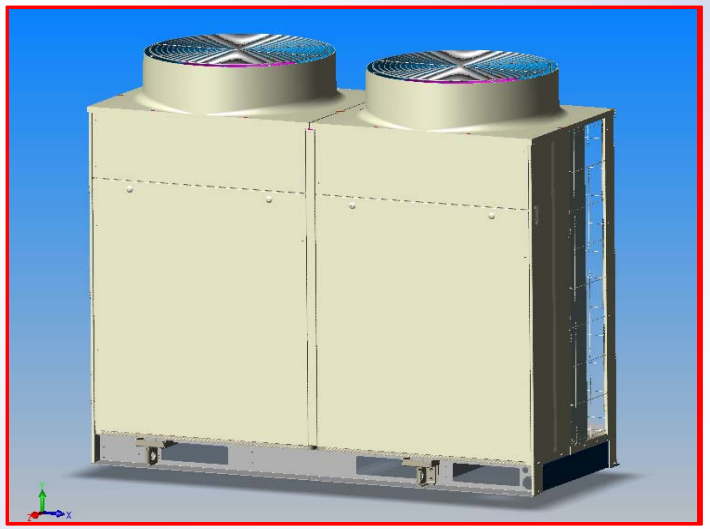
1.Choice of Multiple Indoor Units







2.Choice of Different capacities Outdoor Units



Recommendations:

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- The potential for savings in buildings is very large
- New buildings can be built with much better energy performance, without major costs for the users and owners
- Building Codes is an important and cost efficient way to improve energy efficiency in new buildings
- ECBC (Energy Conservation Building Code 2006 from BEE to be considered for New & Existing buildings
- There is a need for supporting initiatives, such as financing mechanisms, information, standards solutions and demonstration projects
- Consideration for Energy efficient systems

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Thank you !