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ISHRAE

ACREHEALTH
2022
Air With Care

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Air conditioning & Ventilation Options for Large, Standard & Resource Constrained Hospitals.

Broad Classification of Hospitals

Each has a role to play

Large Hospitals

- Large Hospitals can have 100~500+ beds
- These hospitals may offer a wide spectrum of diagnostics & treatments with In-House resources.
- Will have all the functional facilities viz. Operation Theatres, ICUs, Isolation Rooms, Emergency, Casualty, Treatment Rooms, etc.
- Deal with a large number of patients
- Mostly located in Cities & Towns

Departments

- Anaesthetics
- Breast Screening
- Burns Unit
- Cardiology
- Casualty
- Cath Lab
- Chemotherapy
- CSSD
- CT Scan
- Dislysis
- Echocardiagram
- ENT
- Elderly Services
- Emergency
- Gamma Knife
- Gastroenerology
- General Surgery
- Gynecology
- Hematology
- Histopathology
- ICUs
- Isolation Rooms
- LINIAC
- Neonatal Unit
- Neurology
- Nutrition and Dietetics
- Obstetrics and Gynecology
- Oncology
- Ophthalmology
- Orthopedics
- Operation Theatres
- MRI
- Mental Health
- Pathology
- PET Scan
- Physiotherapy
- Patient Rooms
- Renal Unit
- Sexual Health
- Urology
- X Ray

CHALLENGES OF LARGE HOSPITALS

MANY FOOTFALLS

- Many people come into these hospitals with varied illnesses & disease

- **Higher Chance of infection**

MANY DEPARTMENTS & EQUIPMENT

- Many pieces of equipment to maintain, calibrate & validate
- Huge HVAC Requirement
- Many equipment require precise HVAC control

- **Overburdened engineering department**

BUSINESS REQUIREMENTS

- Routine maintenance
- Preventive maintenance
- Predictive maintenance
- O & M Contracts
- Refurbishment of Areas to create upgraded facilities

Consolidation of resources to make it manageable for the Engineering Department

HVAC CONTEXT

CENTRAL CHIILER SYSTEMS FOR MOST AREAS

LOCAL CONDENSING UNITS FOR SPECIFIC REQUIREMENTS

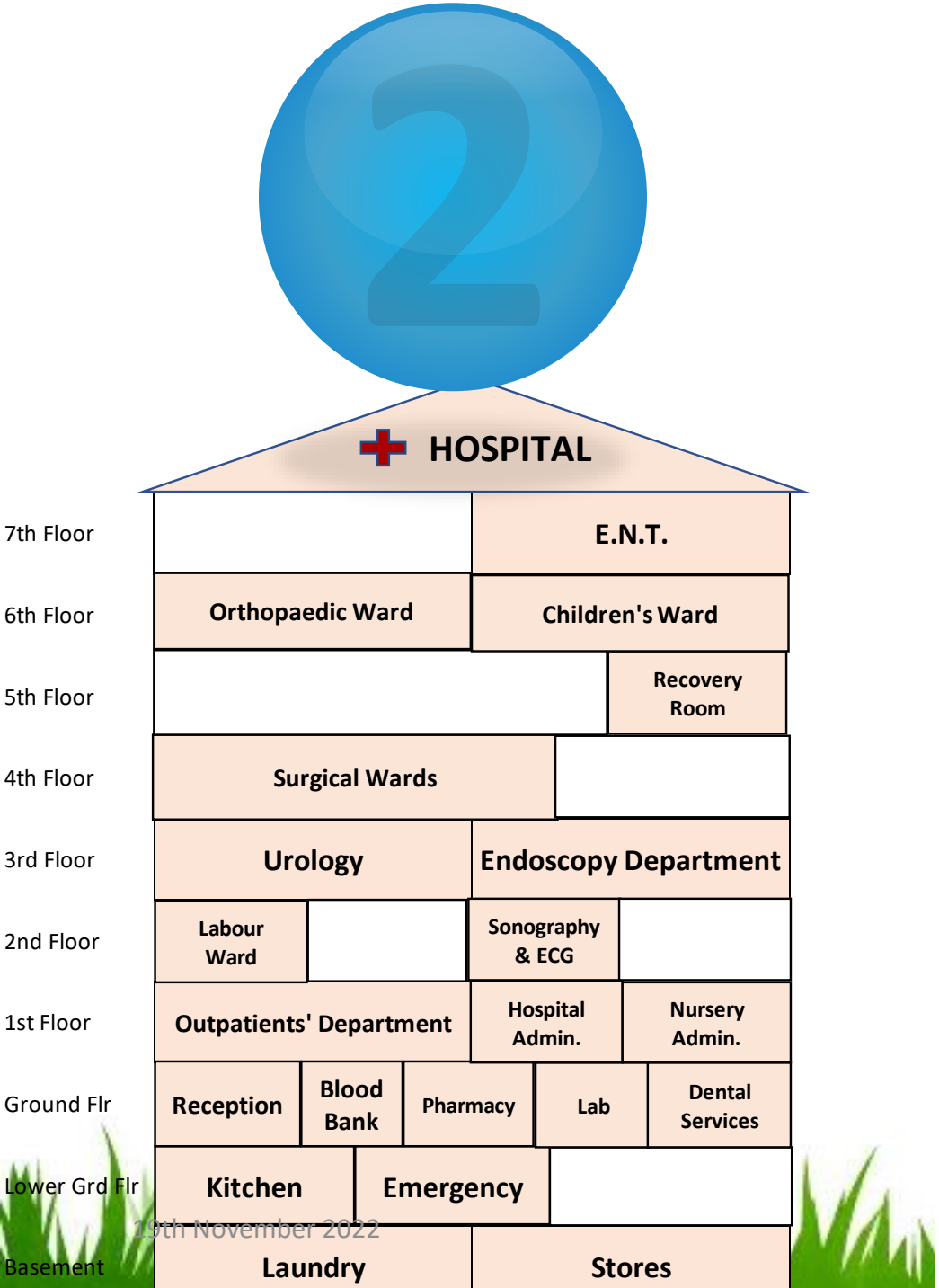
CONSOLIDATE RESOURCES & MAKE THEM MANAGEABLE

COMBINE AREAS FOR LARGER AIR HANDLING UNITS , WHERE POSSIBLE

BMS FOR CONTROL & INFORMATION

LARGE HOSPITALS
CAN PROVIDE ECONOMY OF SCALE

Standard Hospitals



- Standard Hospitals can have 50~100+ beds
- Some of these hospitals offer state-of-the-art specialized diagnostics & treatments. These may have some of the functional facilities viz. Operation Theatres, ICUs, Isolation Rooms, Emergency, Casualty, Treatment Rooms, etc.
- Deal with a lesser number of patients compared to large hospitals
- Mostly located in Cities & Towns

HVAC CONTEXT

CHILLER SYSTEMS MAY NOT BE ECONOMICAL.

SOPHISTICATED MEDICAL EQUIPMENTS STILL REQUIRE PRECISE HVAC SYSTEMS

ISSUES OF INFECTION CONTROL ARE DOMINANT

A COMBINATION OF CONDENSING UNITS WITH AHUS & VRF SYSTEMS/UNITARY AC CAN BE CONSIDERED

THE ECONOMY OF SCALE IS AN ISSUE ENGINEERING DEPARTMENT IS CHALLENGED WITH O&M AND ENERGY BILLS

Resource Constrained Hospitals

3

Resource Constrained Hospitals

Each has a role to play

Resource Constrained Hospitals

- These hospitals may be in cities, towns, or rural areas.
- These are typically District Medical Centres & may have Operation Theatres, ICUs & Patient Rooms.
- These hospitals cater to huge masses of the population.
- Resource constraints are primarily:

I. Financial support
II. Stable electricity
III. Availability of trained manpower for Medical & HVAC equipment

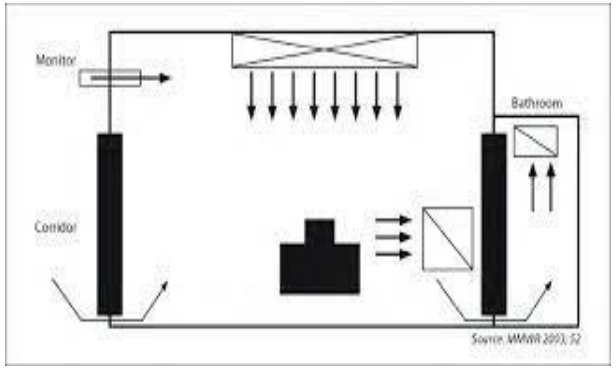
Resource Constrained Hospitals

HVAC PERSPECTIVE

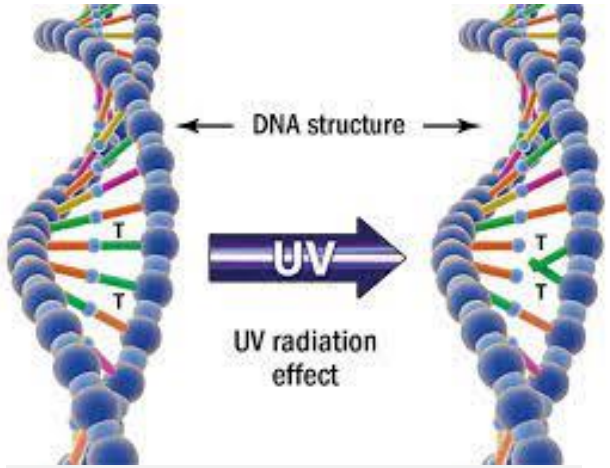
- Infection Control is a Must
- Sciography & Cool Roof
- AC with AHU is a Must for Operation Theatres
- Sustainable Technologies with Radiant Cooling & Ventilation for Other Areas
- Training of Local Technicians

INFECTION CONTROL STRATEGIES IN HVAC

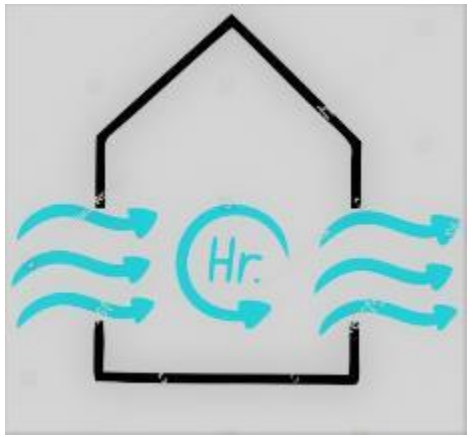
Pressure Relationships of Areas & Air Flow Currents



Handling exhaust from containment areas



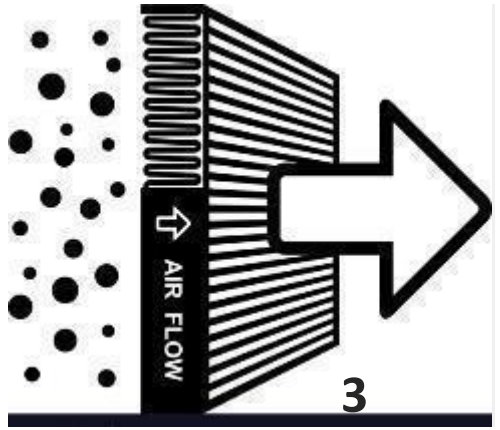
Air Purification with UVGI



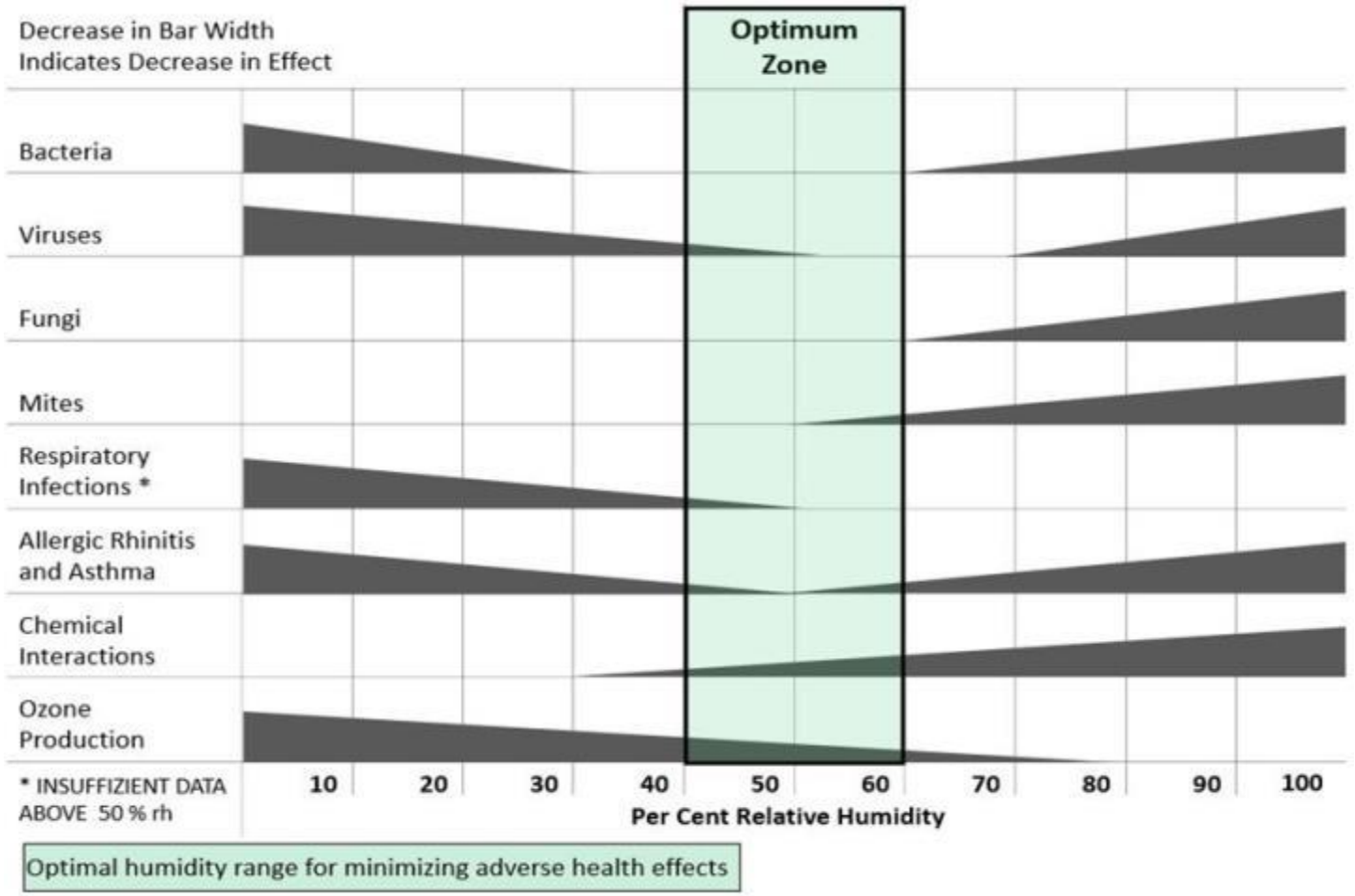
Air Change Rates: Fresh Air & Recirculation

Temperature & Relative Humidity

Filtration Systems



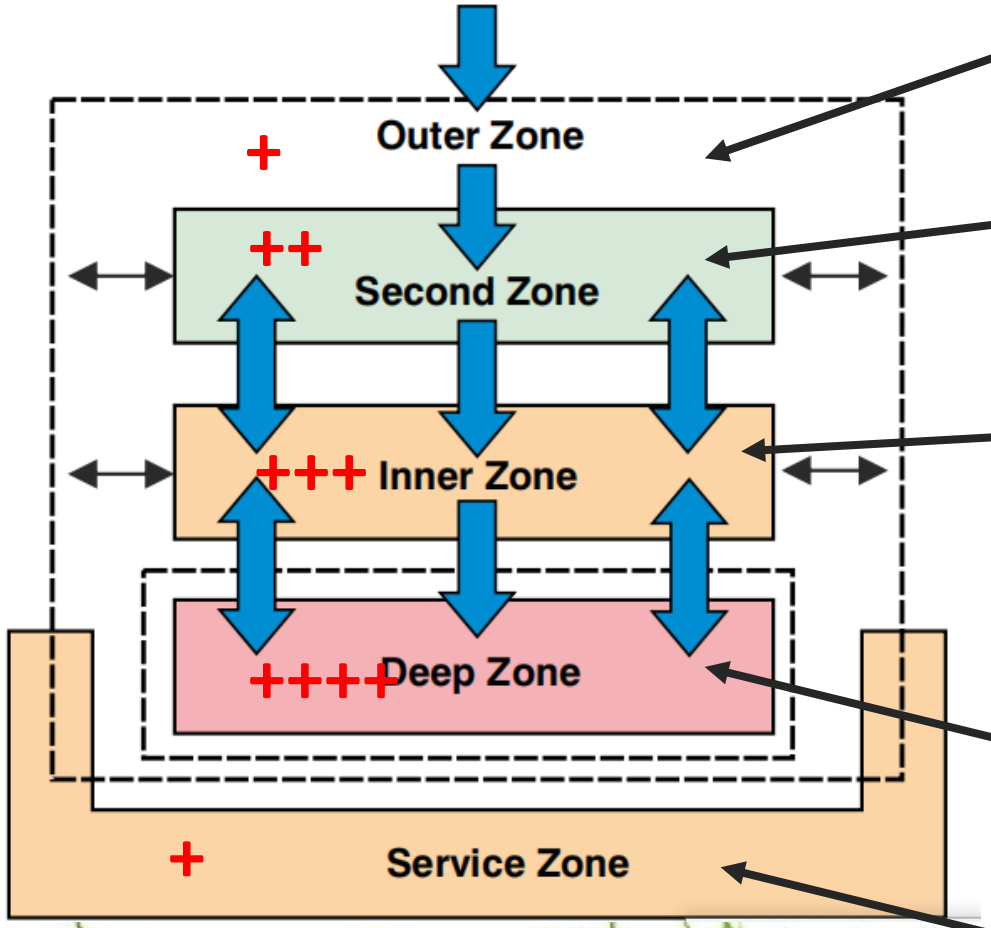
Relative Humidity: Impact on growth of pathogens

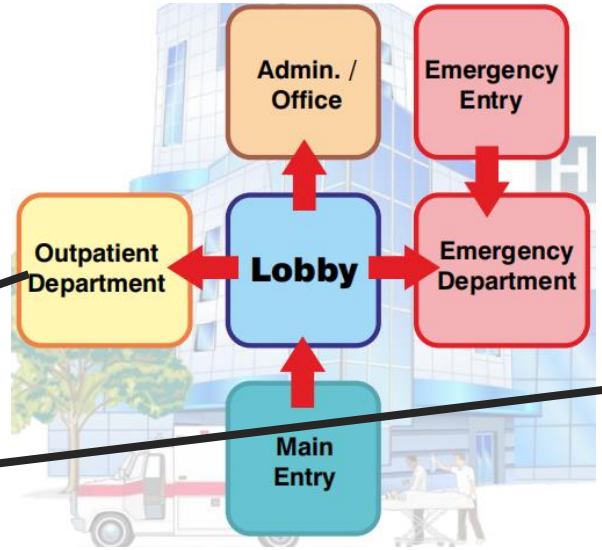


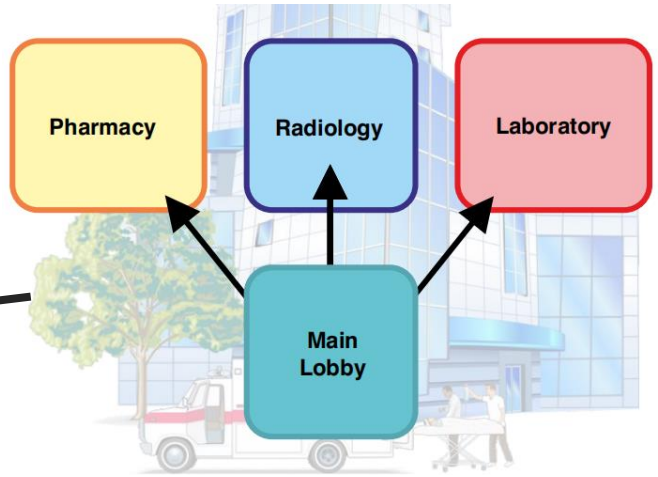
Relative humidity range of 40-60% is considered a healthy range for conditioned spaces

Criteria for Human Exposure to Humidity in Occupied Buildings, E.M. Sterling, 1985 ASHRAE Transactions CH85-13-1

Pressure Gradients







Inner Zone :

Physical areas which provide nursing and supportive care under medical supervision are generally classifed as restricted entry areas but may be accessible to the patient attendants.

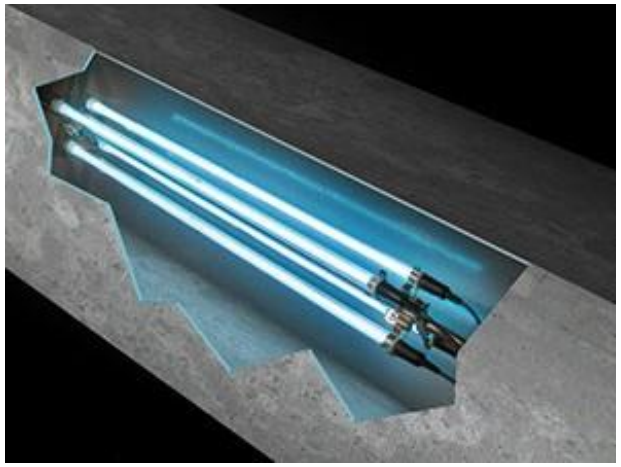
Deep Zone :

Physical areas, require strict infection control protocols for activities such as medical procedures, surgical procedures, childbirth, postpartum care, neonatal care, critical care, isolation, etc. Such areas have restricted entry.

Service Zone: Physical areas, which offer back-end support for various day-to-day activities.

AIR PURIFICATION WITH UVGI

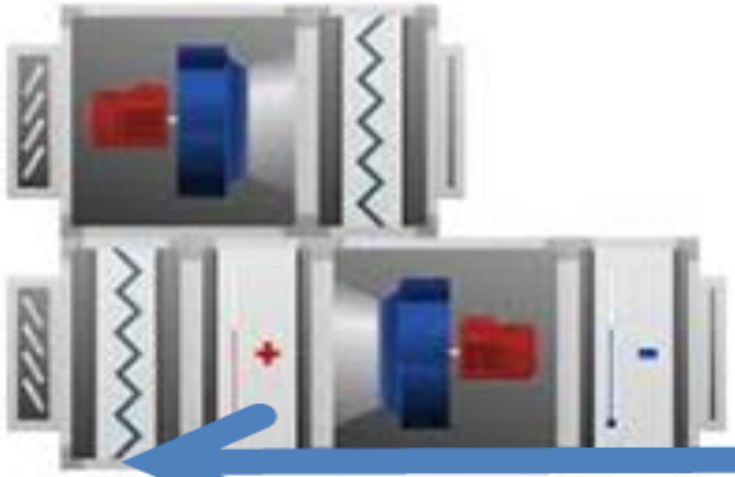
UVGI in AHUs
To keep cooling coils & condensate drain pans clean



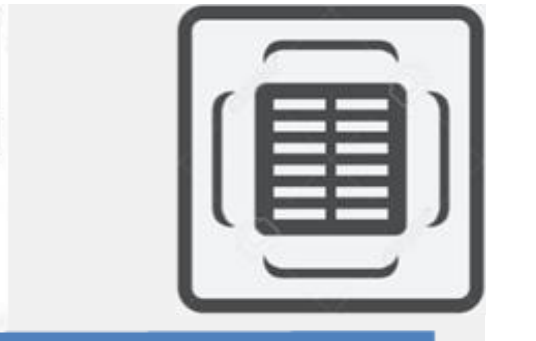
Duct mounted UVGI for re-circulatory AHU based systems to kill virus & pathogens in supply air

Upper Room UVGI to work in conjunction with unitary AC units, mechanical ventilation systems & natural ventilation system to improve air quality

4 TYPES OF HVAC SYSTEMS

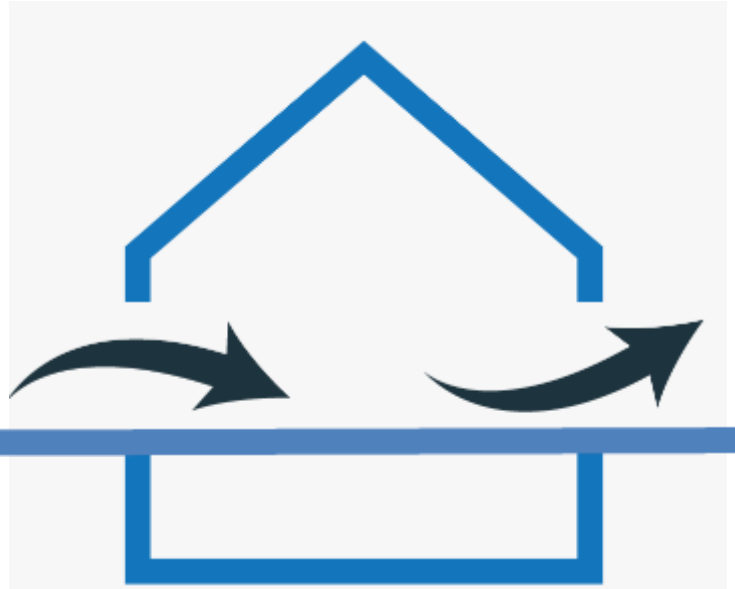


Increased Costs



1. AHU Systems with filtration & ASHRAE Std.170

2.Unitary equipment viz. wall units/ window AC or cassette units& VRF systems



4. Natural Ventilation

3. Mechanical Ventilation for Supply & Exhaust Air

4

WHICH OPTION TO USE? Air Handling Unit Based Systems

- Provide Filtration as Required by the Standards
- Can induct Fresh Air, provide Dehumidification, and create Pressure Gradients as required
- Can control Temperature, Relative Humidity and provide air patterns as required

Correct Option

- **Proper Option** for all critical areas viz**. OTs, Isolation Rooms & ICUs**

Preferred Option

- **Preferred option** for **Emergency, Quarantine, and Triage.**

Good Option

- **Good Option for all other areas,** but economy to be evaluated

WHICH OPTION TO USE? Unitary AC Equipment & VRF

Can be Used in

- Quarantine,
- Triage,
- Patient waiting areas,
- Doctors' and nurses' rooms

Down side

- No filtration or fresh air

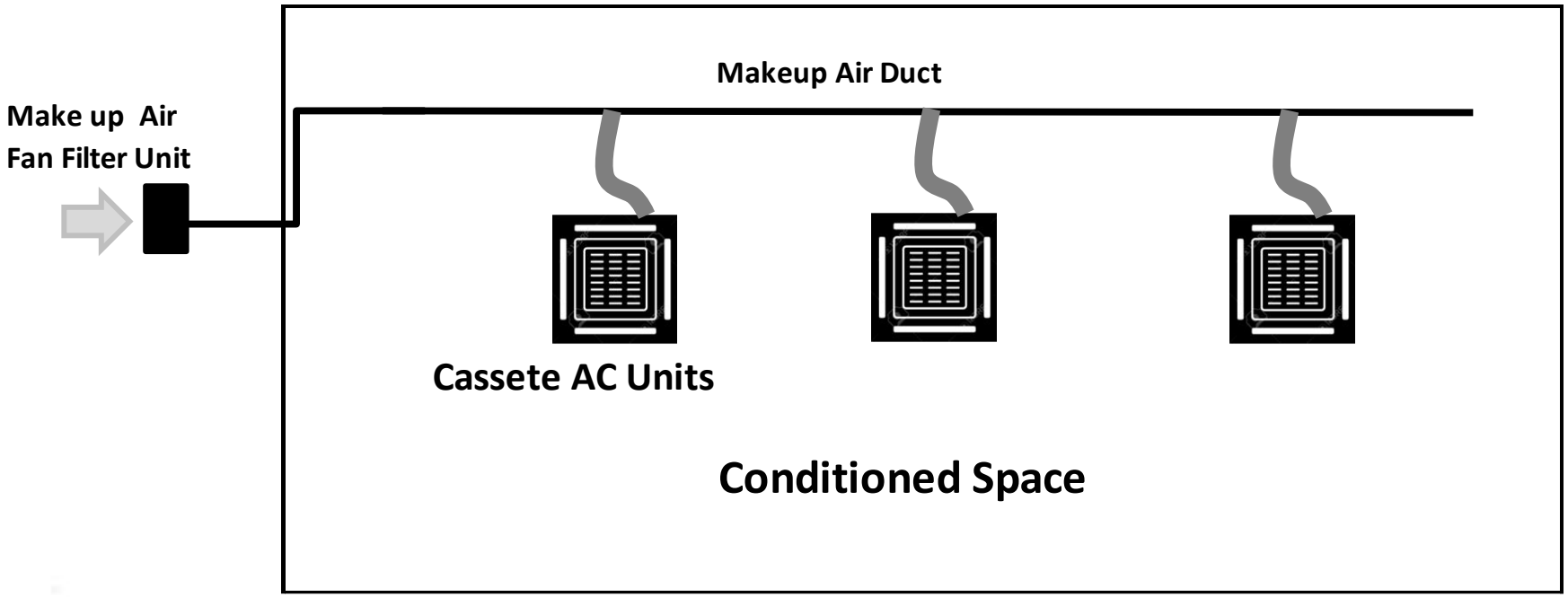
How to Use

- Providing for **separate fresh air & exhaust** is a must

- Economic option
- Can be considered when mechanical ventilation can't give comfort

Inducting Make-up Air for Unitary Equipment

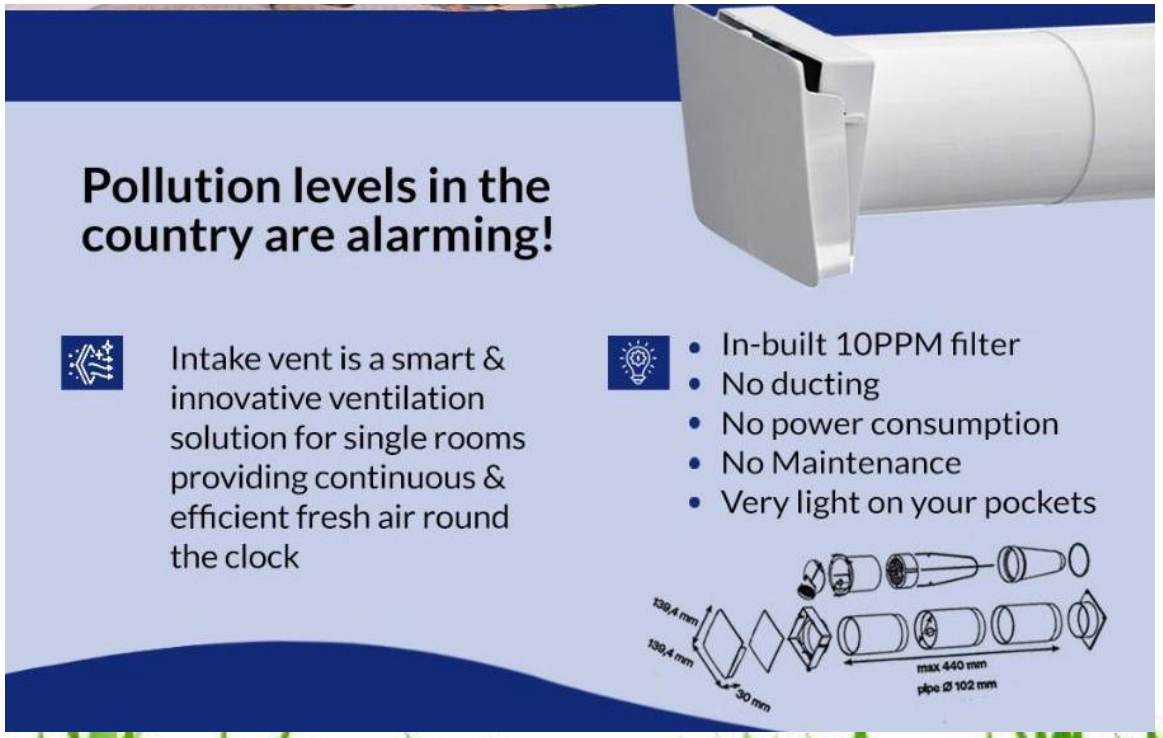
Using Make up Air Fan Filter Unit



Cassette Unit & Make up Air Nozzle Connection

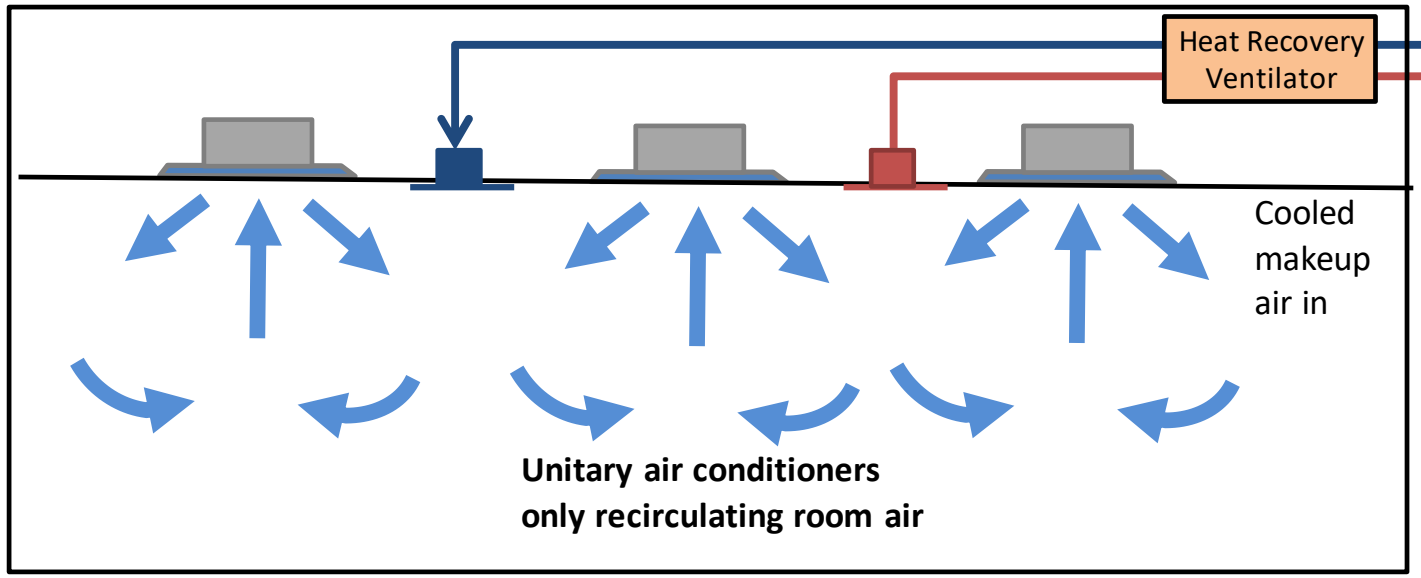
Inducting Make-up Air for Unitary Equipment

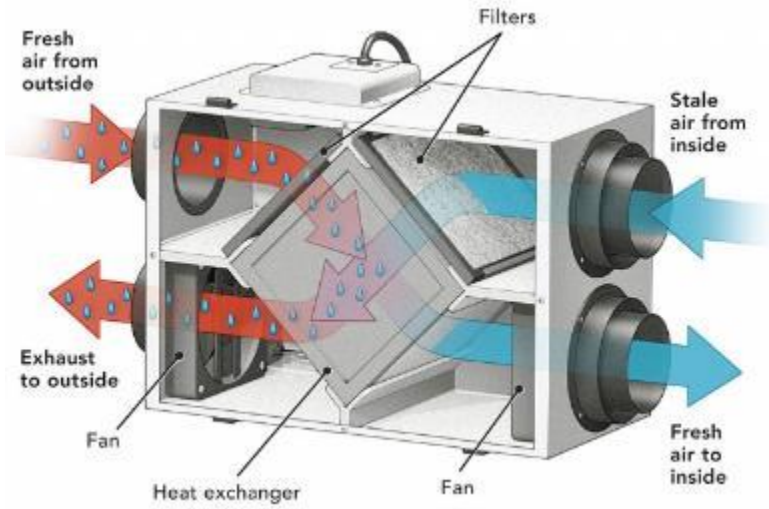
Using Compact Make up Air Filter Unit for Small Rooms with Hi Wall Splits



Inducting Make-up Air for Unitary Equipment

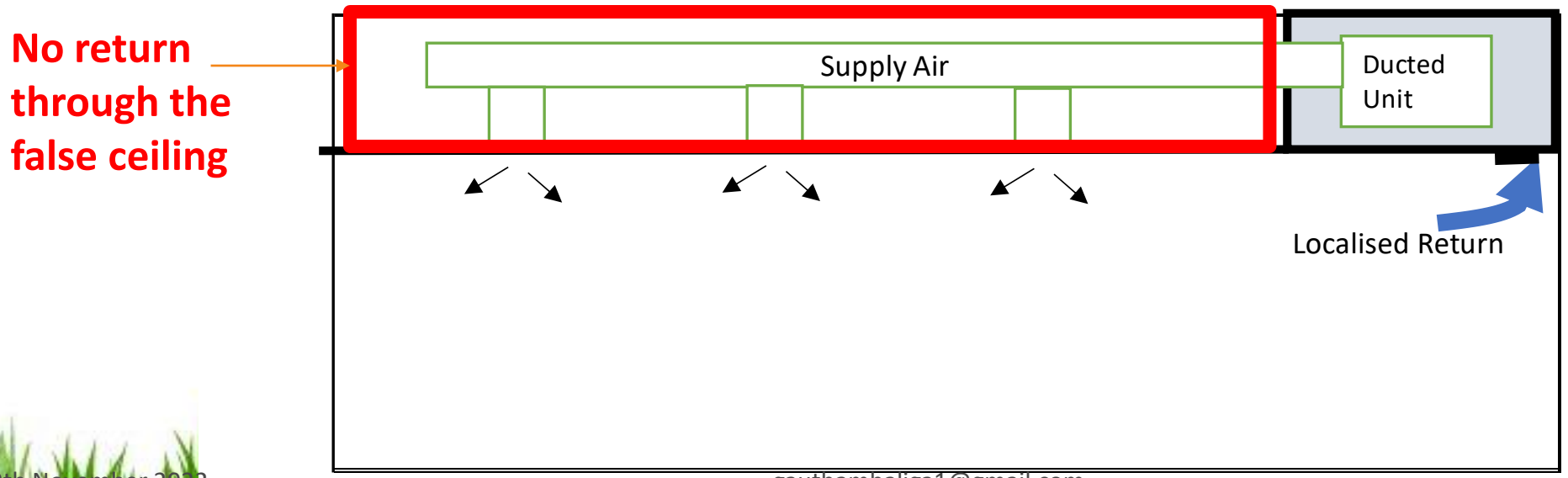
Using Heat Recovery Ventilator





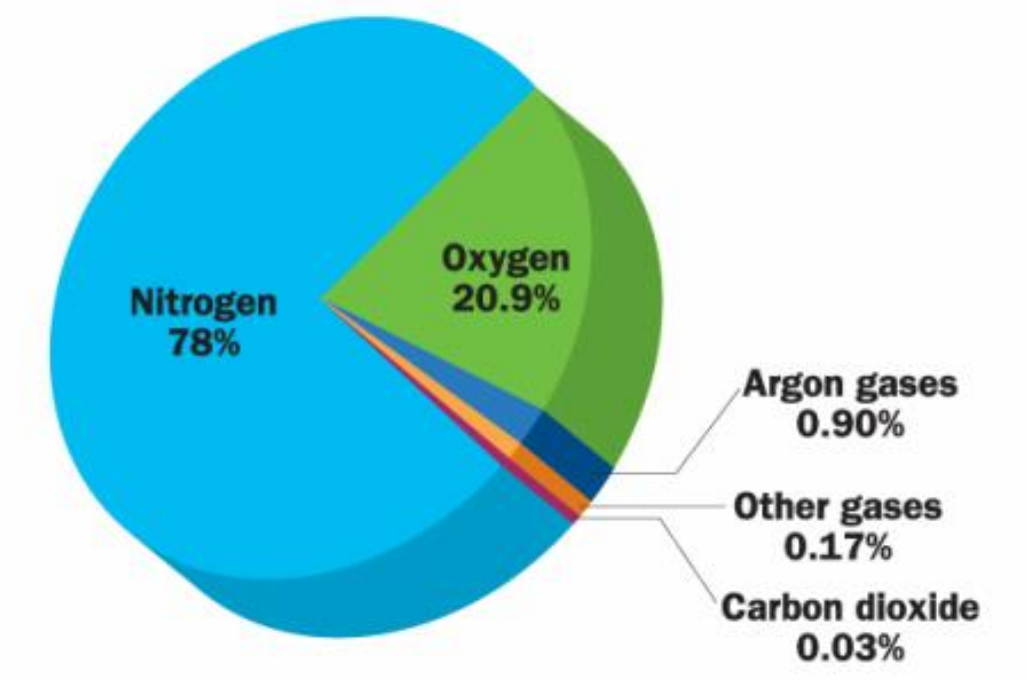
Special Considerations with Ducted Unitary/VRF Units

- False ceiling plenum return not acceptable
- The space above the false ceiling can have pathogenic growth & can be harmful.
- If using ducted units, make sure return is through localized plenum:



Dangers of Using Unitary AC Units in ICUs without Makeup Fresh Air

Normal Atmosphere



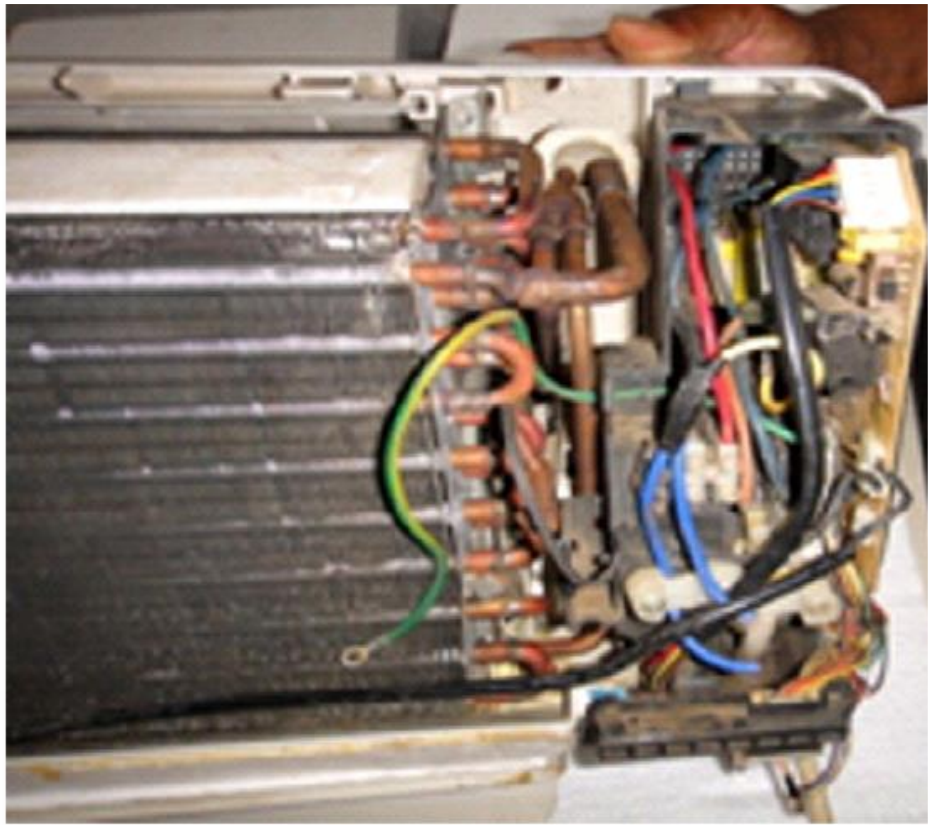
Oxygen Rich Atmosphere

As per NFPA when O_2 content exceeds 23.5% by volume, the atmosphere is considered Oxygen Rich

- Many materials which are not combustible at all or not easily combustible in normal air, become readily combustible and burn actively in an O_2-rich atmosphere.
- A higher O_2 concentration lowers the ignition temperature and minimum ignition energy requirement of a material.
- **Window and split ACs** have limited ventilation ability (**split ACs do not suction fresh air**), and they cannot prevent the build-up of O_2 concentration inside the ward**.** As the frequency of door opening decreases at the night, ventilation almost ceases.

Where Does The Ignition Come From?

Split air conditioner above the patient's bed in an ICU. Voltage stabilizer is also a potential source



Electrical components & wiring in Split AC are potential fire sources

WHICH OPTION TO USE? Mechanical Ventilation

- **It is an option where the climate is favorable**
- **Low on Power Consumption**

Can be Used in

Is **acceptable** in areas viz.

- Quarantine, & Triage,
- Areas like resident gathering / activity / dining, physical therapy rooms,
- wash, janitor room, store rooms

When to use

- Can be used when there is **no risk of heat stress or pollution due to ambient air**

Note

- Can be used when natural ventilation is not practical

WHICH OPTION TO USE?

- Depends entirely on favorable climate conditions (e.g. no risk of heat stress, no air pollution).
- **Best option for sustainability**

Natural Ventilation

Can be Used in

Can be considered **instead of mechanical ventilation** when room location & building orientation make natural ventilation feasible

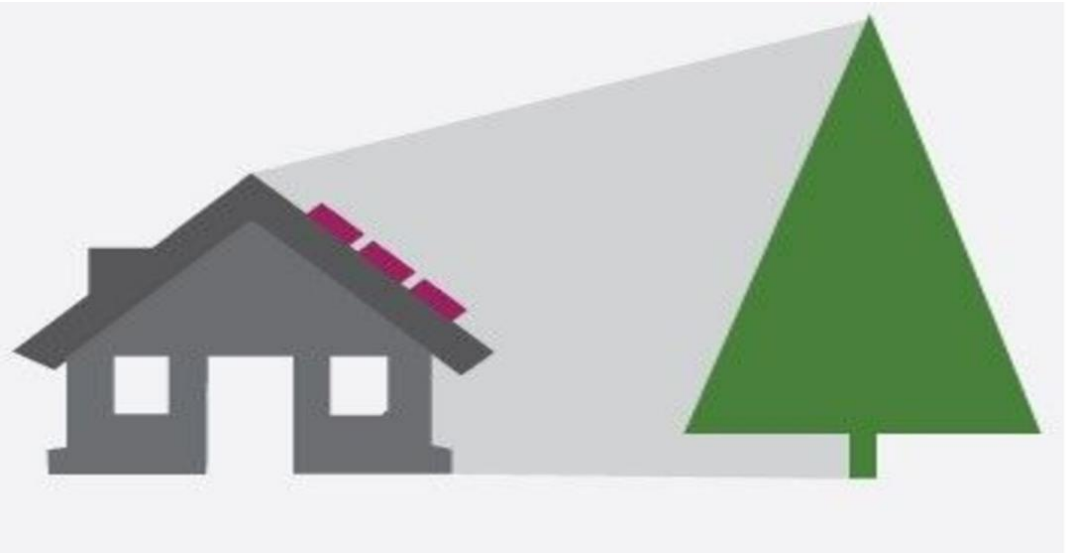
When to use

- Can be used when there is **no risk of heat stress or pollution due to ambient air**

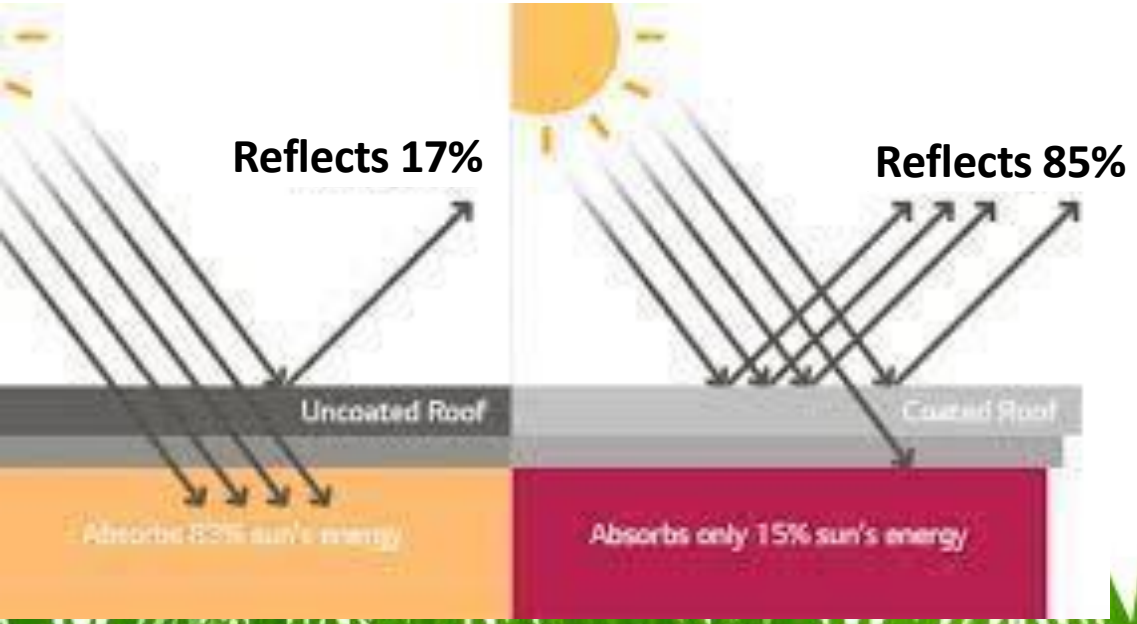
Downside

- Subject to changing climate and wind velocities
- Needs careful engineering design

Sciography & Cool Roof



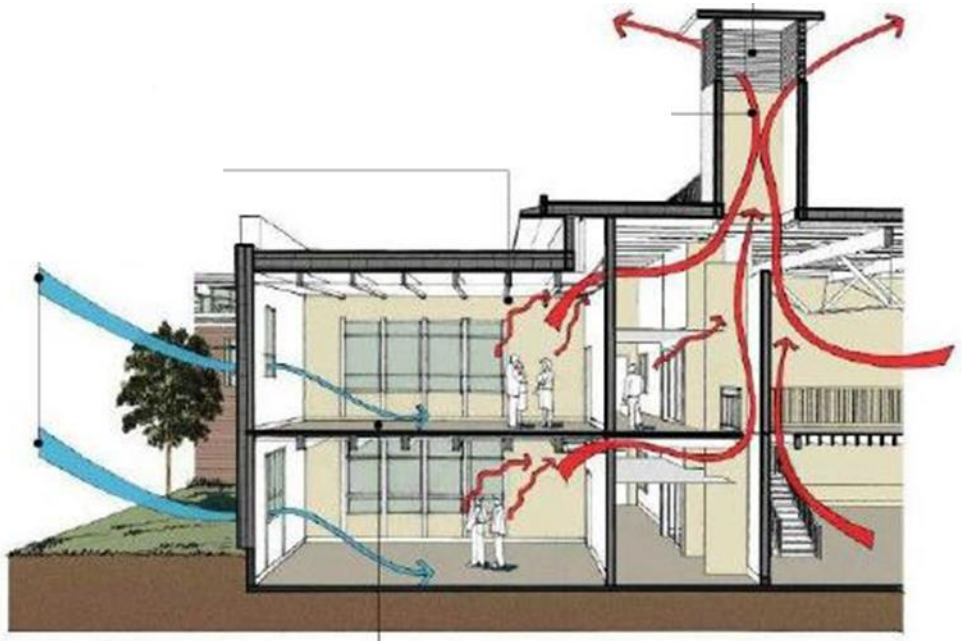
Use of Shadows



Use of Cool Roofs

Natural Ventilation

•Natural ventilation is the intentional passive flow of outdoor air into a building through planned openings (such as louvers, doors, and windows). It relies entirely on passive physical phenomena, such as wind pressure, or the stack effect.



Natural ventilation openings may be fixed, or adjustable. Adjustable openings may be controlled automatically (automated), controlled by occupants (operable), or a combination of both.

Natural Ventilation

The benefits of natural ventilation include:

- Improved Indoor air quality (IAQ)
- Energy savings
- Reduction of greenhouse gas emissions
- Reduction in occupant illness associated with Sick Building Syndrome

Cross ventilation is a phenomenon of natural ventilation.

HVAC SYSTEM: For ICUs

Parameters

Temperature F [C]	Relative Humidity %	Room Pressure w.r.t surroundings	Min. Fresh air ach	Min. Recirculation air ach
70F~75F [21~24]	40~70%	i. > (-) 2.5Pa * ii. Nil** iii. (+) 8Pa***	2	12

HVAC Options

AHU	Unitary AC	Mechanical Ventilation	Natural Ventilation	Remarks # 1	Remarks # 2
AHU	Unitary AC + Fresh Air/Exhaust Modules	N/A	N/A		
MERV7 + MERV14 for AHU	Coarse Filters of AC units and (MERV7 + MERV14) for Fresh Air Module	N/A	N/A	H13 HEPA/Chemical treatment/Plume for Exhaust for both AHU based & Unitary AC systems	UVGI for Cooling coil for AHU option

HVAC SYSTEM: Laboratories [General]

Parameters

Temperature F [C]	Relative Humidity %	Room Pressure w.r.t surroundings	Min. Fresh air ach	Min. Recirculation air ach
70F~75F [21~24]	N/R	Negative	2	6

HVAC Options

AHU	Unitary AC	Mechanical Ventilation	Natural Ventilation	Remarks # 1	Remarks # 2
AHU	Unitary AC + Fresh Air/Exhaust Modules	Mechanical Ventilation with minimum 12ACH fresh air supply	N/A		
MERV7 for AHU	MERV7 for Fresh Air	MERV7 for fresh Air supply	N/A	All exhausts to be to safe place	UVGI for Cooling coil for AHU option

HVAC SYSTEM: Quarantine

Parameters

Temperature F [C]	Relative Humidity %	Room Pressure w.r.t surroundings	Min. Fresh air ach	Min. Recirculation air ach
70F~75F [21~24]	40~70%	Negative	2	12

HVAC Options

AHU	Unitary AC	Mechanical Ventilation	Natural Ventilation	Remarks # 1	Remarks # 2
AHU	Unitary AC + Fresh Air/Exhaust Modules acceptable for converted hospitals only	Mechanical Ventilation with minimum 12ACH fresh air supply	Natural Ventilation (Supply Air 160Litres/s per person)		
MERV7 + MERV14 for AHU	Coarse Filters of AC units and (MERV7 + MERV14) for Fresh Air Module	(MERV7 + MERV14) for Supply Air	N/A	All exhausts to be to safe place	1. Upper Room UVGI Recommended for all options 2. UVGI for cooling coil for AHU option 3 .Duct mounted UVGI for supply air for AHU option

HVAC SYSTEM: Resident Gathering/ Activity/ Dining

Parameters

Temperature F [C]	Relative Humidity %	Room Pressure w.r.t surroundings	Min. Fresh air ach	Min. Recirculation air ach
70F~75F [21~24]	N/R	N/R	4	4

HVAC Options

AHU	Unitary AC	Mechanical Ventilation	Natural Ventilation	Remarks # 1	Remarks # 2
AHU	Unitary AC + Fresh Air Modules	Mechanical Ventilation with minimum 12ACH fresh air supply	Natural Ventilation (Supply Air 160Litres/s per person)		
MERV7 for AHU	MERV7 for fresh Air	MERV7 for fresh Air supply	N/A	All exhausts to be to safe place	1. Upper Room UVGI Recommended for all options 2. UVGI for cooling coil for AHU option 3.Duct mounted UVGI for supply air for AHU option

Key Points

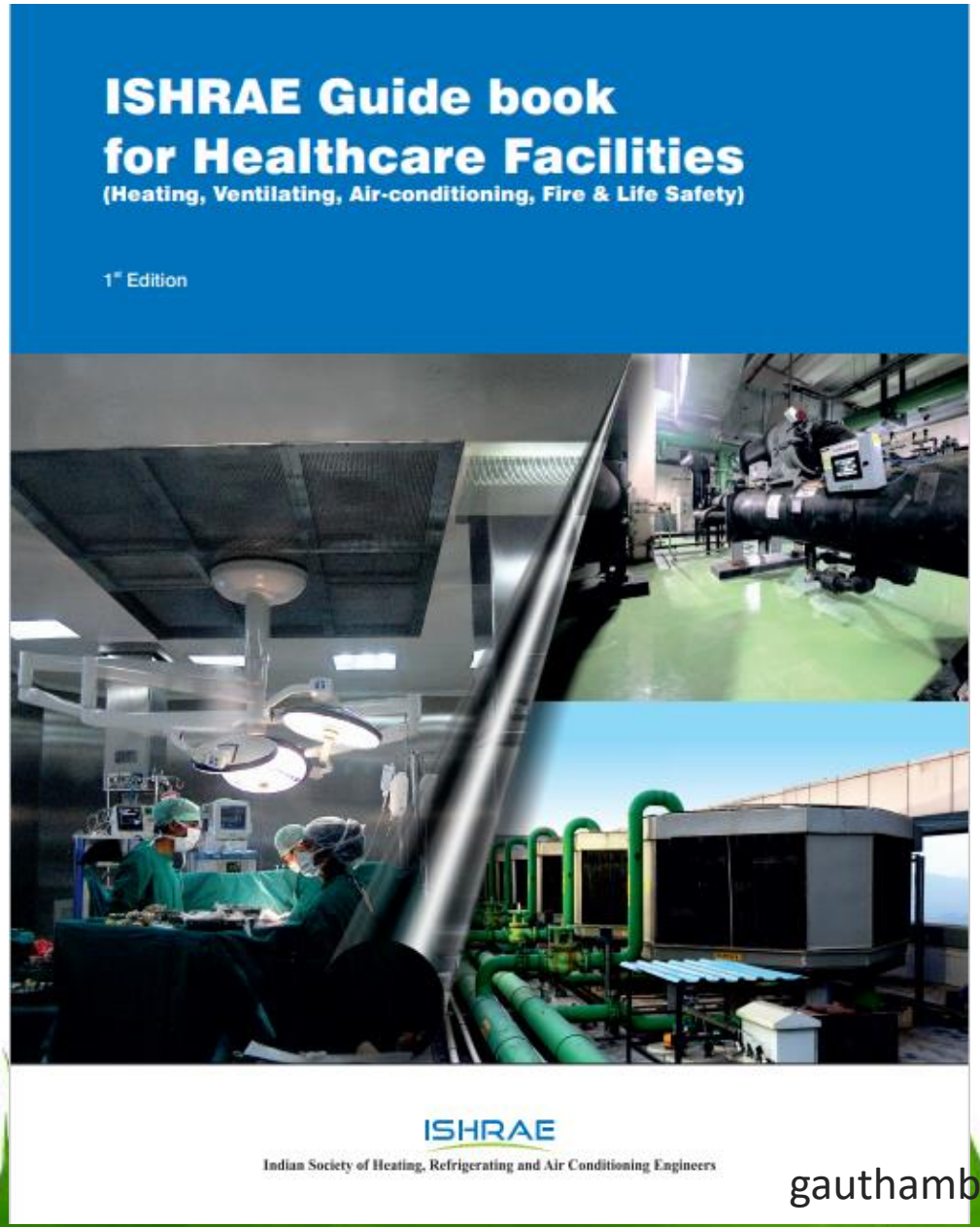
01 Resource Constrained Hospitals are not necessarily Rural Hospitals. They can be Large or Standard Hospitals as well!

02 Resources can be Funds, Skilled Manpower, Electricity & Water

03 For Critical Rooms don’t look at Options for air conditioning!

04 Keep contamination control always in mind.

ISHRAE HEALTHCARE GUIDE



The book is prepared by ISHRAE and covers, heating, ventilating, Air conditioning, Fire and Life Safety

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Healthcare has to be inclusive

- Dr Chandrashekhar, Chairman, IGBC Green Healthcare Facilities Rating System & Chairman, Task Force - IGBC's Green Guidelines for Fast Track and Emergency Facilities for Treating COVID-19 Patients
- Dr Shakti Gupta, Med Suptd., Dr RP centre AIIMS New Delhi
- Mr B Gautham Baliga, Chair, Healthcare Technical Group, ISHRAE & Director, Opal HVAC Engineers Pvt. Ltd.
- Dr Rajiv Kumar Jain, Chief Consultant, Indian Railways
- Mr Jit Kumar Gupta, Chair, IGBC Chandigarh Chapter & Chief Town Planner, SPCL
- Dr. Vishavdeep Goyal, COO and Unit Head, Apollo Hospitals, Ahmedabad
- Ar Hiten Sethi, Co-Chair, IGBC Mumbai Chapter & Founder, Hiten Sethi Architects, Mumbai
- Mr Chitranjan Kaushik, COO, Ecofirst Services Limited, Mumbai
- Ar Shamit Manchanda, Chief Architect Manchanda Associates, New Delhi