

**Cityscape**  
*Abu Dhabi*

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# Sustainable Design for Healthcare Facilities

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# Green Guidelines

- **US Green Building Council (US GBC)  
LEED Green Building Rating**  
(Version 2.1 Released 3/2000)  
(Version 2.2 Released 10/2005)
- **Emirates Green Building Council (EGBC)**  
(Released 9/2007)
- **Green Guide for Healthcare (GGHC)**  
(Version 2.0 Released 11/2004)  
(Version 2.1 Released 9/2005)  
(Version 2.2 Released 1/2007)

# Green Principals

(American Society of Hospital Engineers)

- Integration Design
- Site Design
- Water
- Energy
- Indoor Environmental Quality
- Material & Products
- Construction Practices
- Commissioning
- Operations & Maintenance
- Innovation

# Construction

CATEGORY	USGBC	EGBC	GGHC
Sustainable Sites	14	13	21
Water Efficiency	5	12	6
Energy & Atmosphere	17	16	21
Materials & Resources	13	11	21
Indoor Environmental Quality	15	15	24
Innovation & Design Process	5	5	4
Total Points	69	72	97

CERTIFICATION	USGBC	EGBC	GGHC
Certified	26 - 32	29 - 35	N/A
Silver	33 - 38	36 - 43	N/A
Gold	39 - 51	44 - 57	N/A
Platinum	52 or more	58 or more	N/A

# Operations

CATEGORY	USGBC	EGBC	GGHC
Integrated Operations	N/A	N/A	5
Transportation Operations	N/A	N/A	3
Energy Efficiency	N/A	N/A	18
Water Conservation	N/A	N/A	8
Chemical Management	N/A	N/A	5
Waste Management	N/A	N/A	6
Environmental Services	N/A	N/A	9
Environmental Preferable Purchases	N/A	N/A	11
Innovation in Operations	N/A	N/A	7
Total Points	N/A	N/A	72

# Construction

## USGBC

### Sustainable Sites 14 Points

Credit 1	Site Selection	1
Credit 2	Development Density & Community Connectivity	1
Credit 3	Brownfield Redevelopment	1
Credit 4.1	Alternative Transportation	1
Credit 4.2	Alternative Transportation	1
Credit 4.3	Alternative Transportation	1
Credit 4.4	Alternative Transportation	1
Credit 5.1	Reduced Site Disturbance	1
Credit 5.2	Reduced Site Disturbance	1
Credit 6.1	Storm Water Management	1
Credit 6.2	Storm Water Management	1
Credit 7.1	Landscape & Exterior Design to Reduce Heat Islands	1
Credit 7.2	Landscape & Exterior Design to Reduce Heat Islands	1
Credit 8	Light Pollution Reduction	1

## EGBC

### Sustainable Sites 13 Points

Credit 1	Site Selection	1
Credit 2	Development Density & Community Connectivity	1
Credit 3	Brownfield Redevelopment	1
Credit 4.1	Alternative Transportation	1
Credit 4.2	Alternative Transportation	1
Credit 4.3	Alternative Transportation	1
Credit 4.4	Alternative Transportation	1
Credit 5.1	Reduced Site Disturbance	1
Credit 5.2	Reduced Site Disturbance	1
Credit 6	Storm Water Management	1
Credit 7.1	Landscape & Exterior Design to Reduce Heat Islands	1
Credit 7.2	Landscape & Exterior Design to Reduce Heat Islands	1
Credit 8	Light Pollution Reduction	1

## GGHC

### Sustainable Sites 21 Points

Credit 1	Site Selection	1
Credit 2	Development Density & Community Connectivity	1
Credit 3.1-3	Brownfield Redevelopment	3
Credit 3.2	Brownfield Redev Residential	
Credit 3.3	Brownfield Redev Min. Future Hazards	
Credit 4.1	Alternative Transportation	1
Credit 4.2	Alternative Transportation	1
Credit 4.3	Alternative Transportation	1
Credit 4.4	Alternative Transportation	1
Credit 5.1	Site Development	1
Credit 5.2	Site Development	1
Credit 5.3	Site Development	1
Credit 6.1	Stormwater Design	1
Credit 6.2	Stormwater Design	1
Credit 7.1	Heat Island Effect: Non-roof	1
Credit 7.2	Heat Island Effect: Roof	1
Credit 8	Light Pollution Reduction	1
Credit 9.1	Connection to the Natural World: Outdoor	1
Credit 9.2	Connection to the Natural World: Exterior	1
Credit 10.1	Community Contaminant Prevention: Airborne	1
Credit 10.2	Community Contaminant Prevention: Leaks	1

# Sustainable Sites

- Minimize Future Hazard
- Structured Parking 50% or more of Total Parking
- Outdoor Spaces for Patient, Staff and Visitors
- Prevent Contaminant Releases to Air, Land and Water

# Construction

## USGBC

### Water Efficiency 5 Points

Credit 1.1	Water Efficiency Landscaping, Reduce by 50%	1
Credit 1.2	Water Efficiency Landscaping, No Potable Use or No Irrigation	1
Credit 2	Innovative Wastewater Technologies	1
Credit 3.1	Water Use Reduction, 20% Reduction	1
Credit 3.2	Water Use Reduction, 30% Reduction	1

## EGBC

### Water Efficiency 12 Points

Credit 1	Irrigation 100% Non-portable water	1
Credit 2.1	Reduce Potable Water for A/C make-up by 50%	1
Credit 2.2	Reduce Potable Water for A/C make-up by 75%	1
Credit 2.3	Harvest 50% of Condensate	1
Credit 2.4	Harvest 100% of Condensate	1
Credit 3.1	Reduce Potable Water for sewage conveyance by 50%	1
Credit 3.2	Treat 100% of waste water on site to tertiary standards	1
Credit 4.1-4	Water Use Reduction, 10% Reduction	5

## GGHC

### Water Efficiency 6 Points

Credit 1	Water Efficient Landscaping: No Potable Water Use or No Irrigation	1
Credit 2.1	Potable Water Use Reduction: Measurement & Verification	1
Credit 2.2	Potable Water Use Reduction: Domestic Water	1
Credit 2.3	Potable Water Use Reduction: Domestic Water	1
Credit 2.4	Potable Water Use Reduction: Process Water & Building System Equipment	1
Credit 2.5	Potable Water Use Reduction: Process Water & Building System Equipment	1



# Water Efficiency

- Eliminate Potable Water Use for Medical Cooling
- Potable Water Measurement and Verification
- Reduce Use of Potable Water in Building Systems Equipment
- Provide System to Capture AHU Condensate

# Construction

## USGBC

### Energy & Atmosphere 17 Points

Credit 1.1-10	Optimize Energy Performance, 10.5% – 42%	10
Credit 2.1	On-Site Renewable Energy	3
Credit 3	Enhanced Commissioning	1
Credit 4	Enhanced Refrigerant Management	1
Credit 5	Measurement & Verification	1
Credit 6	Green Power	1

## EGBC

### Energy & Atmosphere 16 Points

Credit 1.1-10	Optimize Energy Performance, less 4-40%	10
Credit 2.1	On-Site Renewable Energy	3
Credit 3	Enhanced Commissioning	1
Credit 4	Enhanced Refrigerant Management	1
Credit 5	Measurement & Verification	1

## GGHC

### Energy & Atmosphere 21 Points

Credit 1.1-10	Optimize Energy Performance	10
Credit 2.1	On-Site Renewable Energy	3
Credit 3	Enhanced Commissioning	1
Credit 4	Enhanced Refrigerant Management	1
Credit 5	Measurement & Verification	1
Credit 6.1	20% Provided by Green Power	1
Credit 6.2	50% Provided by Green Power	1
Credit 6.3	80% Provided by Green Power	1
Credit 6.4	100% Provided by Green Power	1
Credit 7	Equipment Efficiency	1

# Energy and Atmosphere

- Green Power
  - 20% of Annual Electricity
  - 50% of Annual Electricity
  - 80% of Annual Electricity
  - 100% of Annual Electricity
- Reduce Energy Consumption of Medical and other Equipment

# Construction

## USGBC

### Materials & Resources 13 Points

Credit 1.1	Building Reuse	1
Credit 1.2	Building Reuse	1
Credit 1.3	Building Reuse	1
Credit 2.1-2	Construction Waste Management	2
Credit 3.1-2	Material Reuse	2
Credit 4.1-2	Recycled Content	2
Credit 5.1-2	Local/Regional Materials	2
Credit 6	Rapidly Renewable Materials	1
Credit 7	Certified Wood	1

## EGBC

### Material & Resources 11 Points

Credit 1.1	Building Reuse	1
Credit 1.2	Building Reuse	1
Credit 1.3	Building Reuse	1
Credit 2.1-2	Construction Waste Management	2
Credit 3.1-2	Material Reuse	1
Credit 4.1-2	Recycled Content	2
Credit 5.1-2	Regional Materials	1
Credit 6	Rapidly Renewable Materials	1
Credit 7	Certified Wood	1

## GGHC

### Materials & Resources 21 Points

Credit 1.1	Building Reuse	1
Credit 1.2	Building Reuse	1
Credit 1.3	Building Reuse	1
Credit 2.1-2	Construction Waste Management	2
Credit 2.3	Construction Practices	1
Credit 2.4	Construction Practices	1
Credit 3.1-5	Sustainably Sourced Materials	5
Credit 4.1-3	PBT Elimination: Dioxins	3
Credit 5.1	Furniture & Medical Furnishings	1
Credit 5.2	Furniture & Medical Furnishings	1
Credit 5.3	Furniture & Medical Furnishing	1
Credit 6	Copper Reduction	1
Credit 7.1-2	Resource Use: Design for Flexibility	2

# Materials & Resources

- Sustainable Sourced Materials
- Eliminate the use of: Dioxins, Mercury, Lead & Cadmium
- Furniture & Medical Furnishings: Refurbished, locally sourced
- Design for Durability
- Increase Flexibility
- Copper Reduction

# Construction

## USGBC

### Indoor Environmental Quality 15 Points

Credit 1	Outside Air Delivery Monitoring	1
Credit 2	Increased Ventilation	1
Credit 3.1	Construction IAQ Management Plan, During Construction	1
Credit 3.2	Construction IAQ Management Plan, Before Occupancy	1
Credit 4.1	Low-Emitting Materials, Adhesive & Sealants	1
Credit 4.2	Low-Emitting Materials, Paints & Coatings	1
Credit 4.3	Low-Emitting Materials, Carpet Systems	1
Credit 4.4	Low-Emitting Materials, Composite Wood & Agrifiber Products	1
Credit 5	Indoor Chemical & Pollutant Source Control	1
Credit 6.1	Controllability of Systems, Lighting	1
Credit 6.2	Controllability of Systems, Thermal Comfort	1
Credit 7.1	Thermal Comfort, Design	1
Credit 7.2	Thermal Comfort, Verification	1
Credit 8.1	Daylight & Views	1
Credit 8.2	Daylight & Views	1

## EGBC

### Indoor Environmental Quality 15 Points

Credit 1	Outside Air Delivery Monitoring	1
Credit 2	Increased Ventilation	1
Credit 3.1	Construction IAQ Management Plan, During Construction	1
Credit 3.2	Construction IAQ Management Plan, Before Occupancy	1
Credit 4.1	Low-Emitting Materials, Adhesives & Sealants	1
Credit 4.2	Low-Emitting Materials, Paints & Coatings	1
Credit 4.3	Low-Emitting Materials, Carpet Systems	1
Credit 4.4	Low-Emitting Materials, Composite Wood & Agrifiber Products	1
Credit 5	Indoor Chemical & Pollutant Source Control	1
Credit 6.1	Controllability of Systems, Lighting	1
Credit 6.2	Controllability of Systems, Thermal Comfort	1
Credit 7.1	Thermal Comfort, Design	1
Credit 7.2	Thermal Comfort, Verification	1
Credit 8.1	Daylight & Views	1
Credit 8.2	Daylight & Views	1

## GGHC

### Environmental Quality 24 Points

Credit 1	Outdoor Air Delivery Monitoring	1
Credit 2.1	Natural Ventilation	1
Credit 3.1	Construction EQ Management Plan: During Construction	1
Credit 3.2	Construction EQ Management Plan: Before Occupancy	1
Credit 4.1	Low-Emitting Materials, Adhesives & Sealants	1
Credit 4.2	Low-Emitting Materials: Wall & Ceiling Finishes	1
Credit 4.3	Low-Emitting Materials: Flooring Systems	1
Credit 4.4	Low-Emitting Materials, Composite Wood & Insulation	1
Credit 4.5	Low-Emitting Materials: Furniture & Medical Furnishings	1
Credit 4.6	Low-Emitting Materials: Exterior Applied Products	1
Credit 5.1-2	Chemical & Pollutant Source Control: Outdoor / Indoor	2
Credit 6.1-2	Controllability of Systems, Lighting & Thermal Comfort	2
Credit 7	Thermal Comfort	1
Credit 8.1a -e	Daylight & Views	5
Credit 8.2	Daylight & Views	1
Credit 8.3	Daylight & Views	1
Credit 9.1-2	Acoustic Environment:	2

# Indoor Environmental Quality

- Minimize cross-contamination
- Low Emitting Materials i.e. finishing, flooring, wood
- Daylight & Views to Natural World
- Reduce Noise Levels

# Construction

## USGBC

### Innovation & Design Process 11 Points

Credit 1.1	Innovation in Design	1
Credit 1.2	Innovation in Design	1
Credit 1.3	Innovation in Design	1
Credit 1.4	Innovation in Design	1
Credit 2	LEED Accredited Professional	1
Credit 2.1	On-Site Renewable Energy	3
Credit 3	Enhanced Commissioning	1
Credit 4	Enhanced Refrigerant Management	1
Credit 5	Measurement & Verification	1

## EGBC

### Innovation & Design Process

Credit 1.1	Innovation in Design	1
Credit 1.2	Innovation in Design	1
Credit 1.3	Innovation in Design	1
Credit 1.4	Innovation in Design	1
Credit 2	LEED Accredited Professional	1

## GGHC

### Innovation & Design Process 4 Points

Credit 1.1	Innovation in Design	1
Credit 1.2	Innovation in Design	1
Credit 1.3	Innovation in Design	1
Credit 2	Documenting Health, Quality of Care & Productivity Performance Impacts: Research Initiatives	1



# Innovation & Design Process

- Enhanced Building Performance
- Document Absenteeism
- Document Healthcare Costs
- Document Employee Retention

# Unique Design Challenge

- Initial and Operating Costs
- Integrated Design
- Design for Medical Indoor Environment
- Continuously Changing Medical Technology
- Design for Future Expansion
- Design for Diverse Functions
- Diverse Occupancy and Operating Schedules

# Optimize Energy Performance

- Heat Recovery
  - Exhaust
  - Kitchen Equipment
  - Re-heat Coils
- Displacement Ventilation
- Double Skin Defensive Buffer Zone
- Variable Air Volume

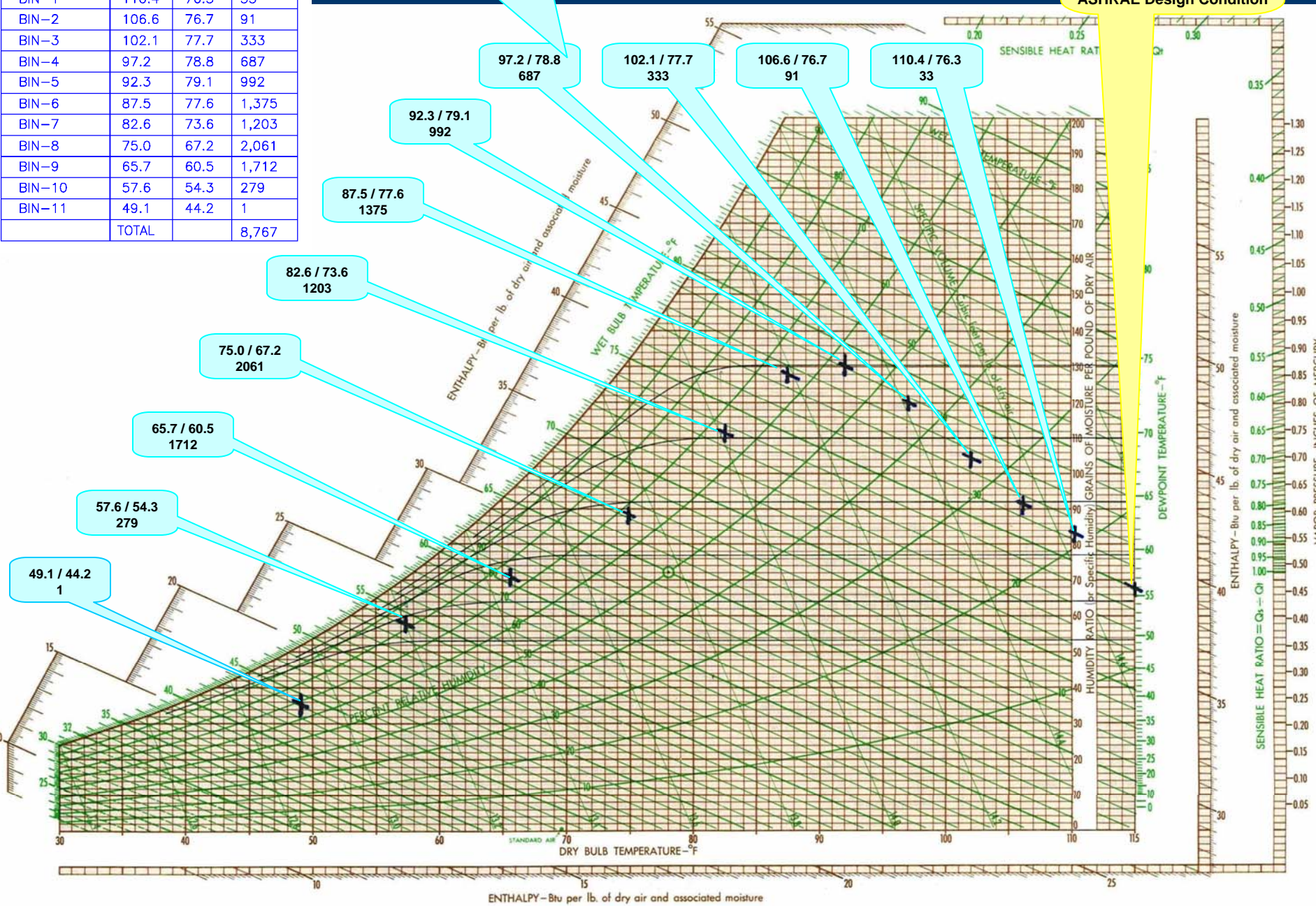
# Unique UAE Design Challenge

- High Temperature
- High Humidity
- Sand Storms
- Water

	Tdb °F	Twb °F	BIN HOURS
BIN-1	110.4	76.3	33
BIN-2	106.6	76.7	91
BIN-3	102.1	77.7	333
BIN-4	97.2	78.8	687
BIN-5	92.3	79.1	992
BIN-6	87.5	77.6	1,375
BIN-7	82.6	73.6	1,203
BIN-8	75.0	67.2	2,061
BIN-9	65.7	60.5	1,712
BIN-10	57.6	54.3	279
BIN-11	49.1	44.2	1
TOTAL			8,767

Dry Bulb, F / Wet Bulb, F  
Bin Hours

115.0 / 75.0  
Design Condition  
111.0 / 74.0  
ASHRAE Design Condition

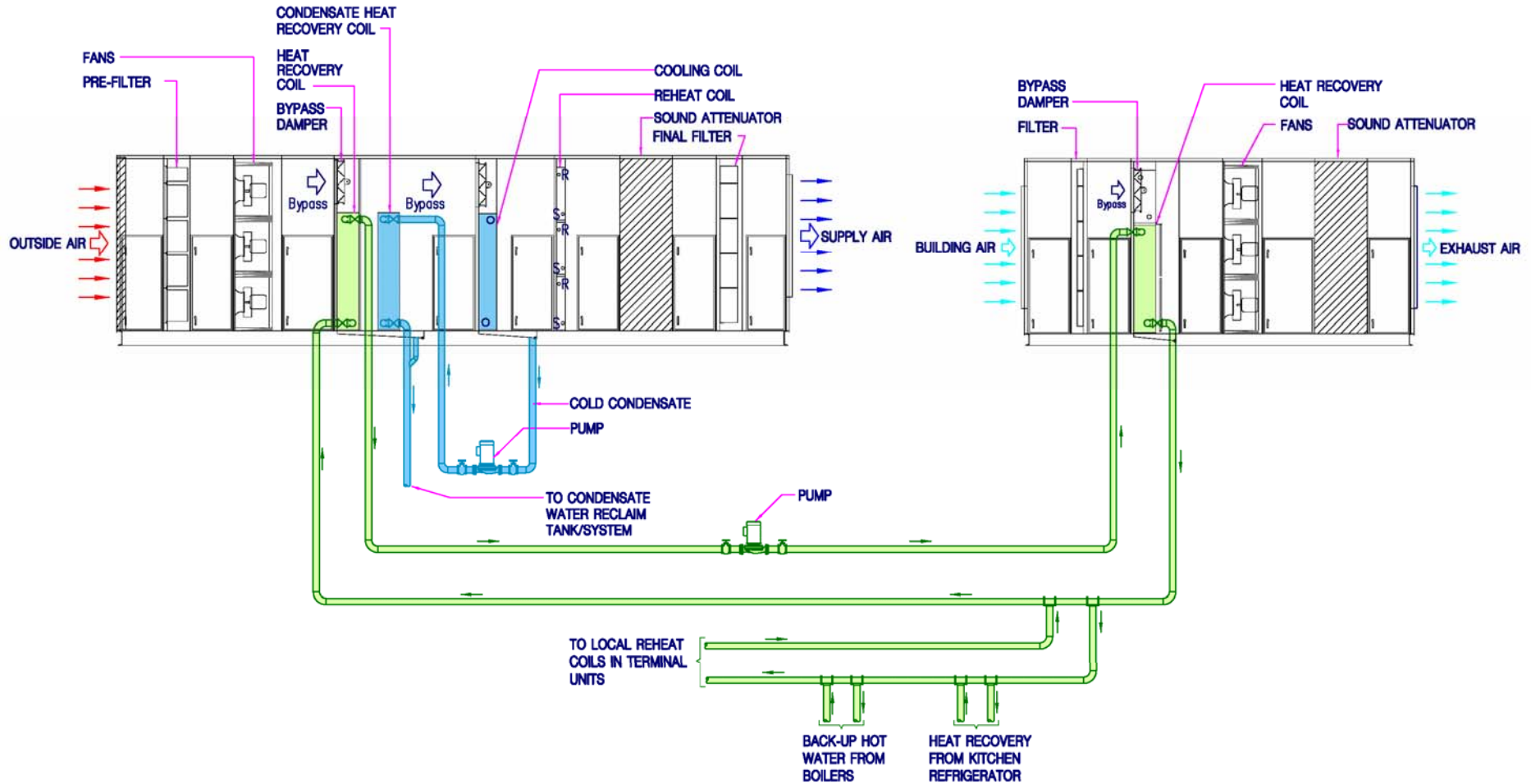


ENTHALPY - Btu per lb. of dry air and associated moisture

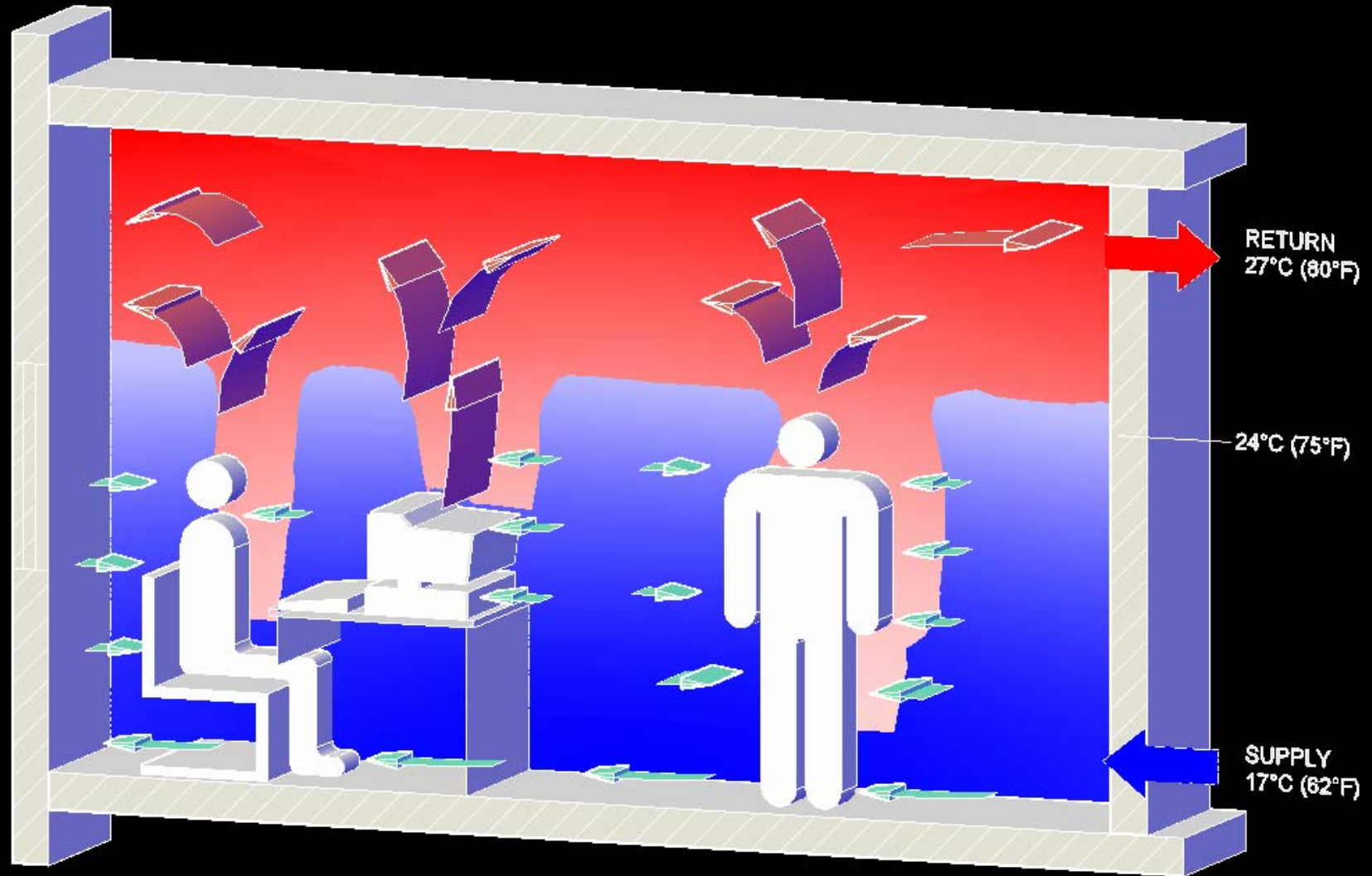
ENTHALPY - Btu per lb. of dry air and associated moisture  
HUMIDITY RATIO (lb Specific Humidity) GRAINS OF MOISTURE PER POUND OF DRY AIR  
DEWPOINT TEMPERATURE - °F  
VAPOR PRESSURE - INCHES OF MERCURY  
SENSIBLE HEAT RATIO =  $\frac{Q_s}{Q_t}$



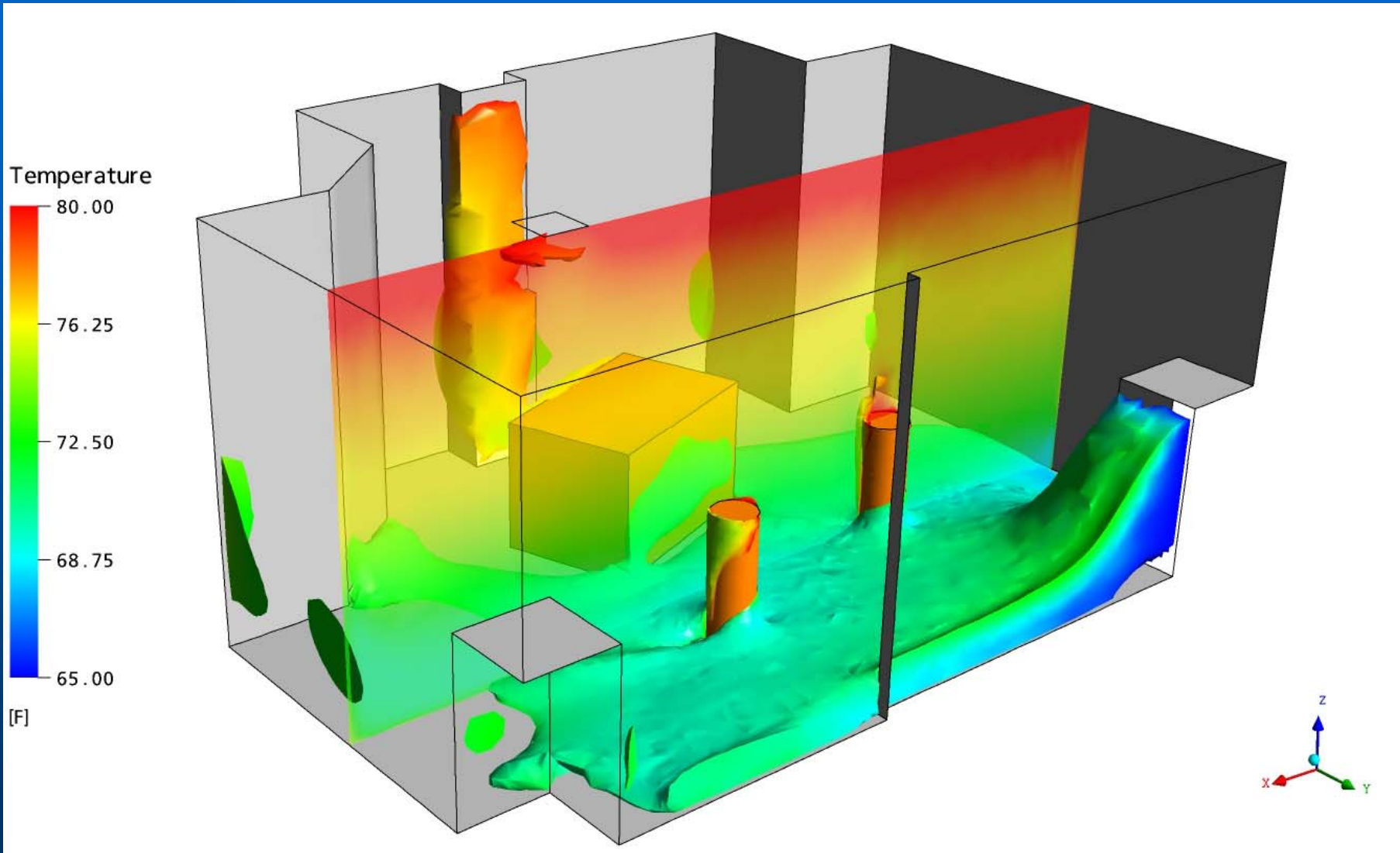
# Heat Recovery



# Displacement Ventilation



# Displacement Ventilation



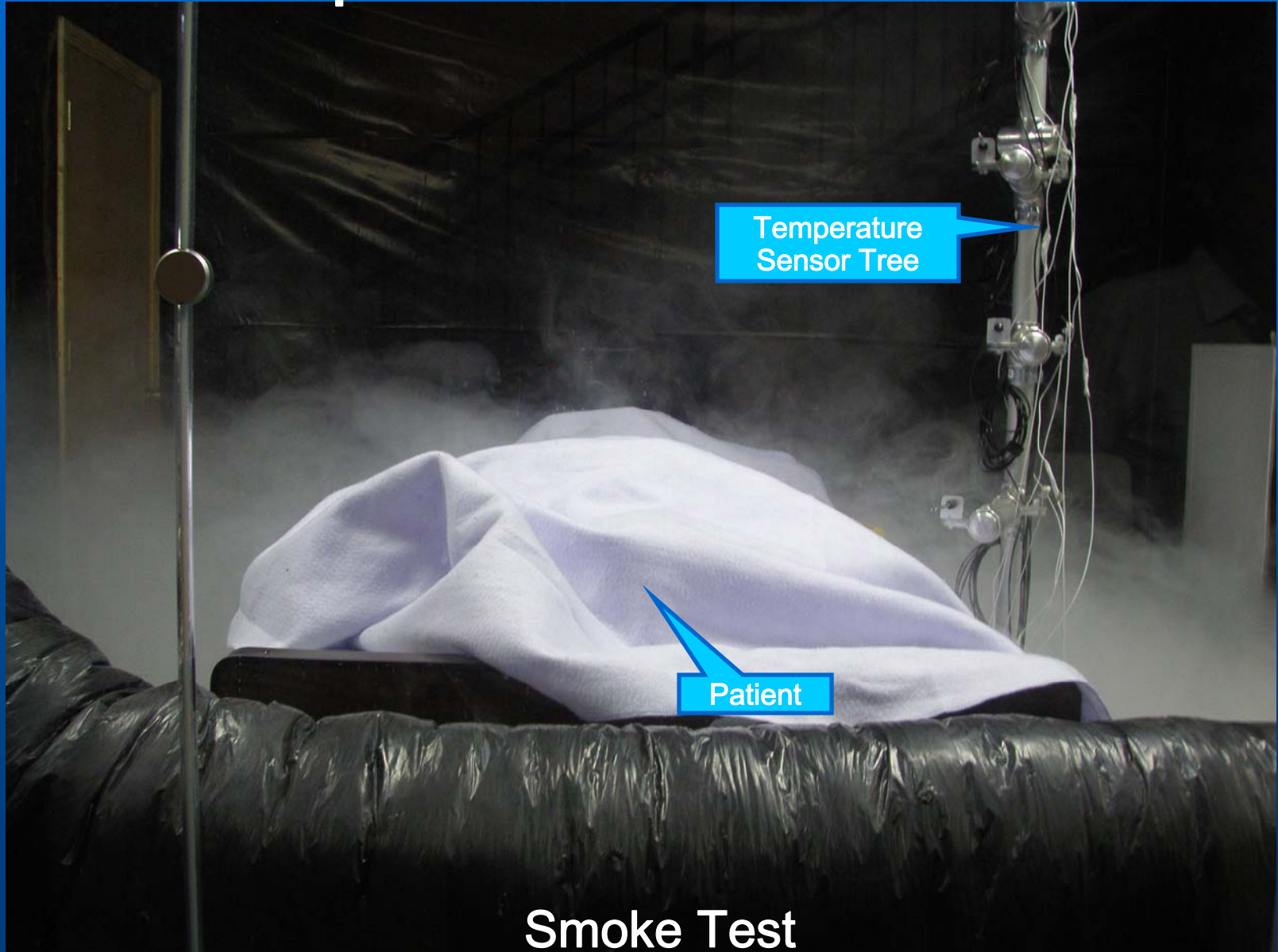


# Displacement Ventilation



Smoke Test

# Displacement Ventilation

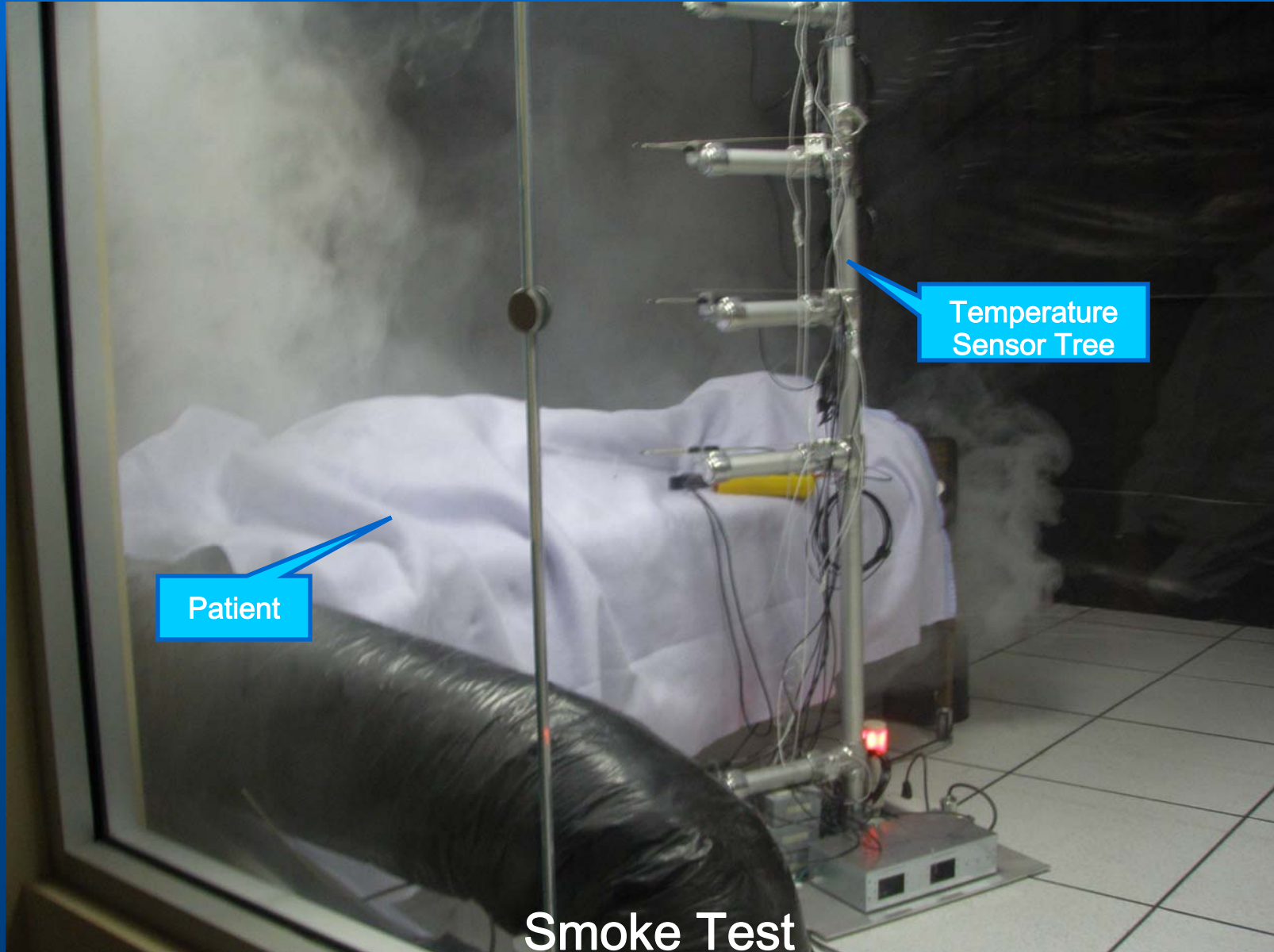


Temperature  
Sensor Tree

Patient

Smoke Test

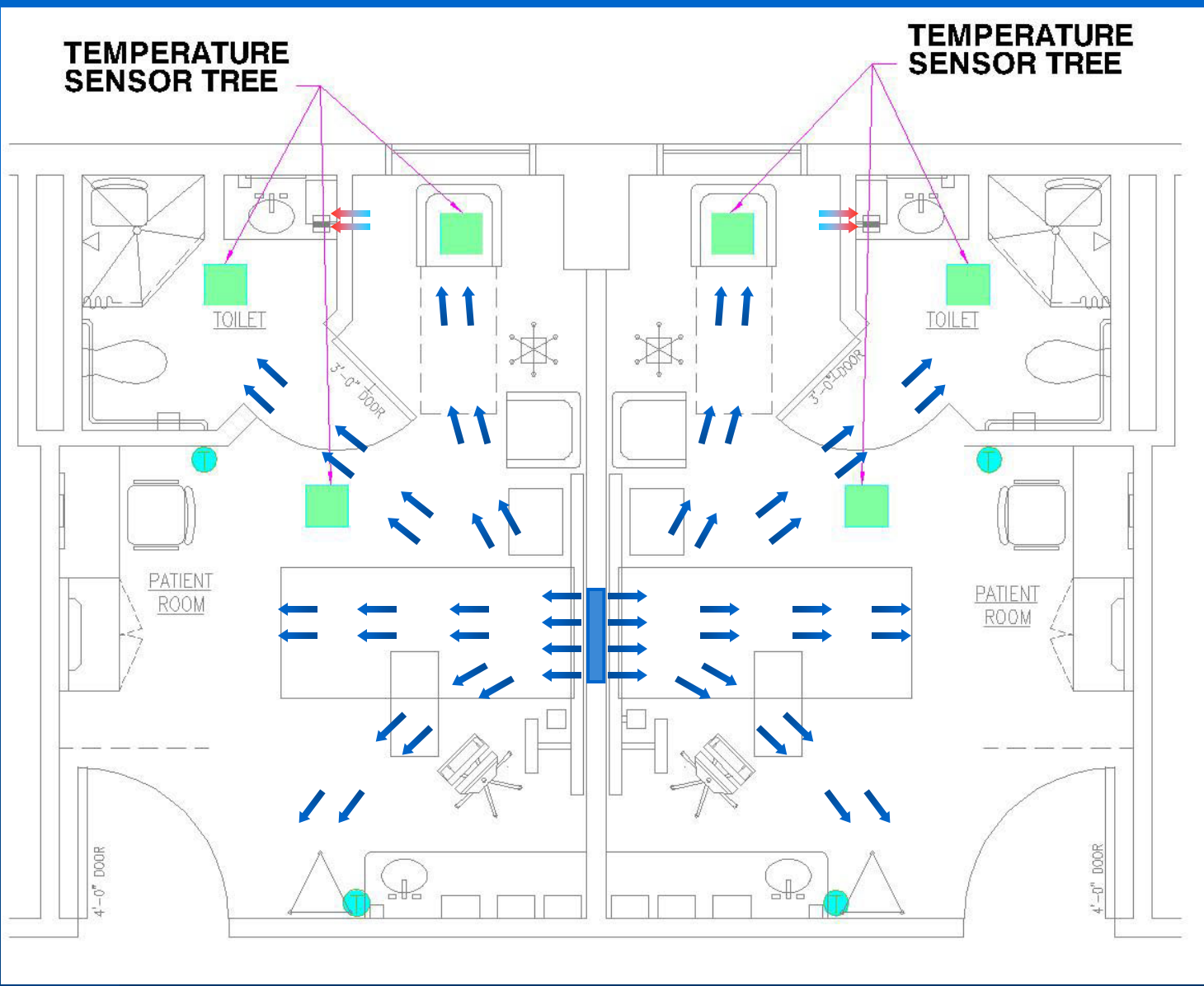
# Displacement Ventilation



Patient

Temperature  
Sensor Tree

Smoke Test



Plan - Patient Room (typical)

# Displacement Ventilation

## 240 CFM @ 7.2 AC/HR

Cooling: 18.0 °C Supply Air

Height	Room	Window	Bath
9'-0"	-	-	-
8'-6"	23.6	24.7	22.2
8'-0"	23.3	23.6	21.9
7'-0"	22.8	23.6	21.9
6'-0"	22.8	22.5	21.7
5'-0"	22.7	22.5	21.8
4'-0"	22.7	22.3	22.2
3'-0"	22.0	21.9	22.2
2'-0"	21.0	21.6	21.3
1'-0"	-	-	-

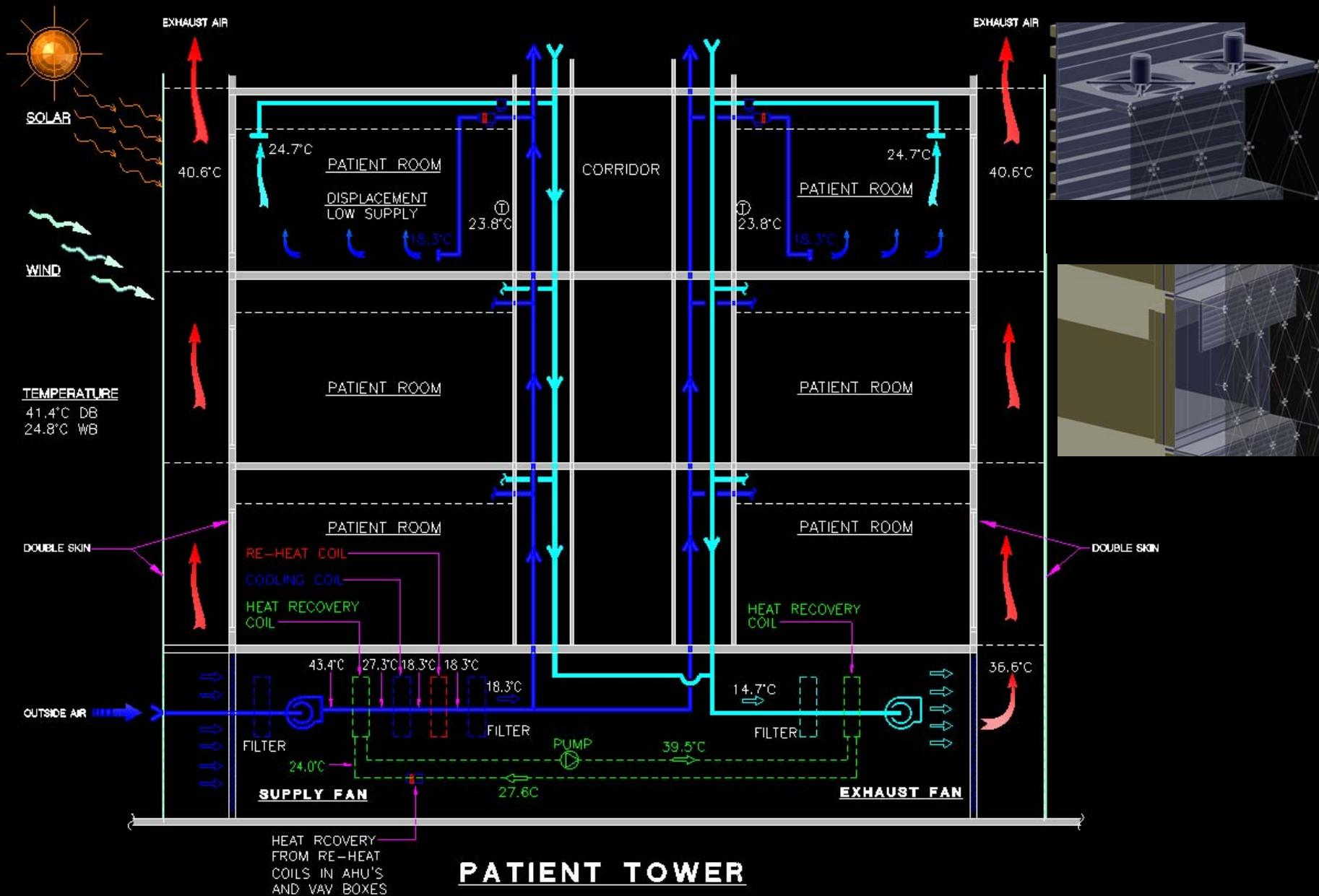
## 120 CFM @ 3.6 AC/HR

Cooling: 18.0 °C Supply Air

Height	Room	Window	Bath
9'-0"	-	-	-
8'-6"	24.1	24.4	21.1
8'-0"	23.7	24.4	21.3
7'-0"	23.6	23.5	21.6
6'-0"	23.4	23.3	21.9
5'-0"	23.3	23.3	22.2
4'-0"	23.3	23.3	22.2
3'-0"	23.0	23.3	22.3
2'-0"	21.2	20.5	22.5
1'-0"	-	-	-

## Room Temperature Profile





# Life Cycle Cost

## Sustainable Hospital vs. Traditional Hospital

- First Cost
- Operation Cost
- Replacement Cost
- Payback

# Integrating Building Systems

- Building Control
- Life Safety
- Operations
- Security
- Facilities Management



# Green Power

- Photo Voltaic
- Solar Heating
- Wind
- Cooling by Sea Water
- Day Lighting

# Green Principals

(American Society of Hospital Engineers)

- Integration Design
- Site Design
- Water
- Energy
- Indoor Environmental Quality
- Material & Products
- Construction Practices
- Commissioning
- Operations & Maintenance
- Innovation

# INNOVATIONS