ACMV IN GREEN BUILDINGS

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PE 0286
ELECTRICAL (BS)

U.S. Green Building Council

The U.S. Green Building Council (USGBC) and its community are changing the way buildings and communities are designed, built and operated.

USGBC believes in better buildings: places that complement our environment and enhance our communities; places that give people better, brighter, healthier spaces to live, work and play.

USGBC's Vision

Buildings and communities will regenerate and sustain the health and vitality of all life within a generation.

ABOUT USGBC

Defining Green Building

- Green buildings are specifically designed structures that reduce the overall negative impact of the built environment on human health and the natural environment.

Why is Green Building necessary?

THE ENVIRONMENTAL IMPACTS OF BUILDINGS

Why is green building necessary? Buildings and communities, including the resources used to create them and the energy, water, and materials needed to operate them, have a significant effect on the environment and human health. In the United States, buildings account for:

- 14% of potable water consumption[1]
- 30% of waste output
- 40% of raw materials use[2]
- 38% of carbon dioxide emissions
- 24% to 50% of energy use
- 72% of electricity consumption[3]

Leadership in Energy & Environmental Design (LEED)

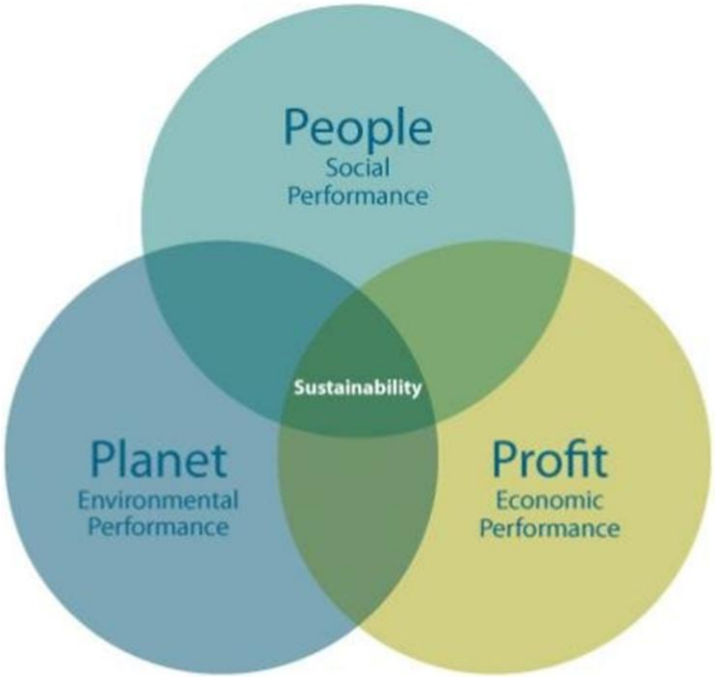
LEED® GREEN BUILDING PROGRAM

USGBC's Leadership in Energy and Environmental Design (LEED) program is a third-party green building certification program and an international symbol of excellence in the design, construction, and operation of high-performance green buildings and neighborhoods. It encourages and accelerates adoption of sustainable building and community development practices through the creation and implementation of a green building benchmark that is voluntary, consensus based, and market driven.

ABOUT LEED

LEED
Triple Bottom Line

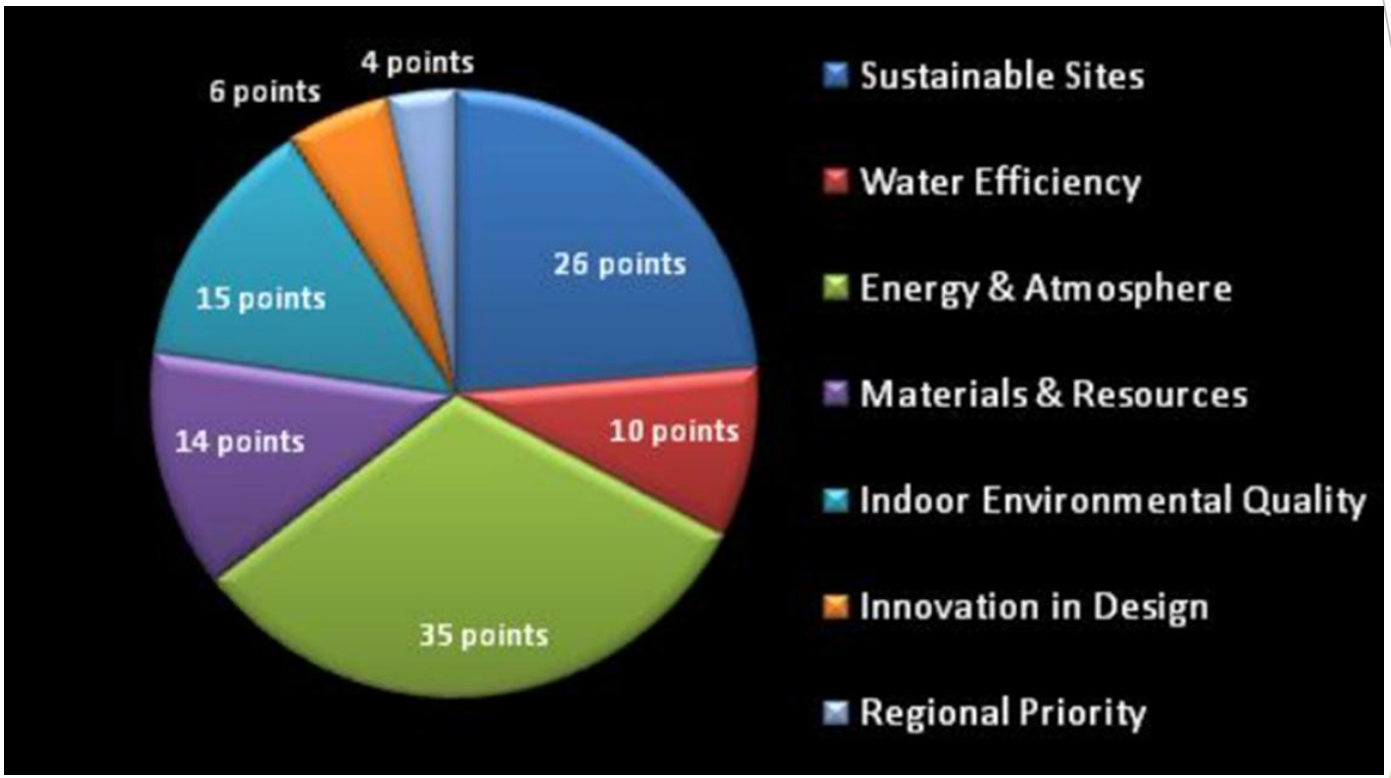
- Better Living Conditions
- Less Impact on Environment
- Reduce the Life Cycle Cost of Building



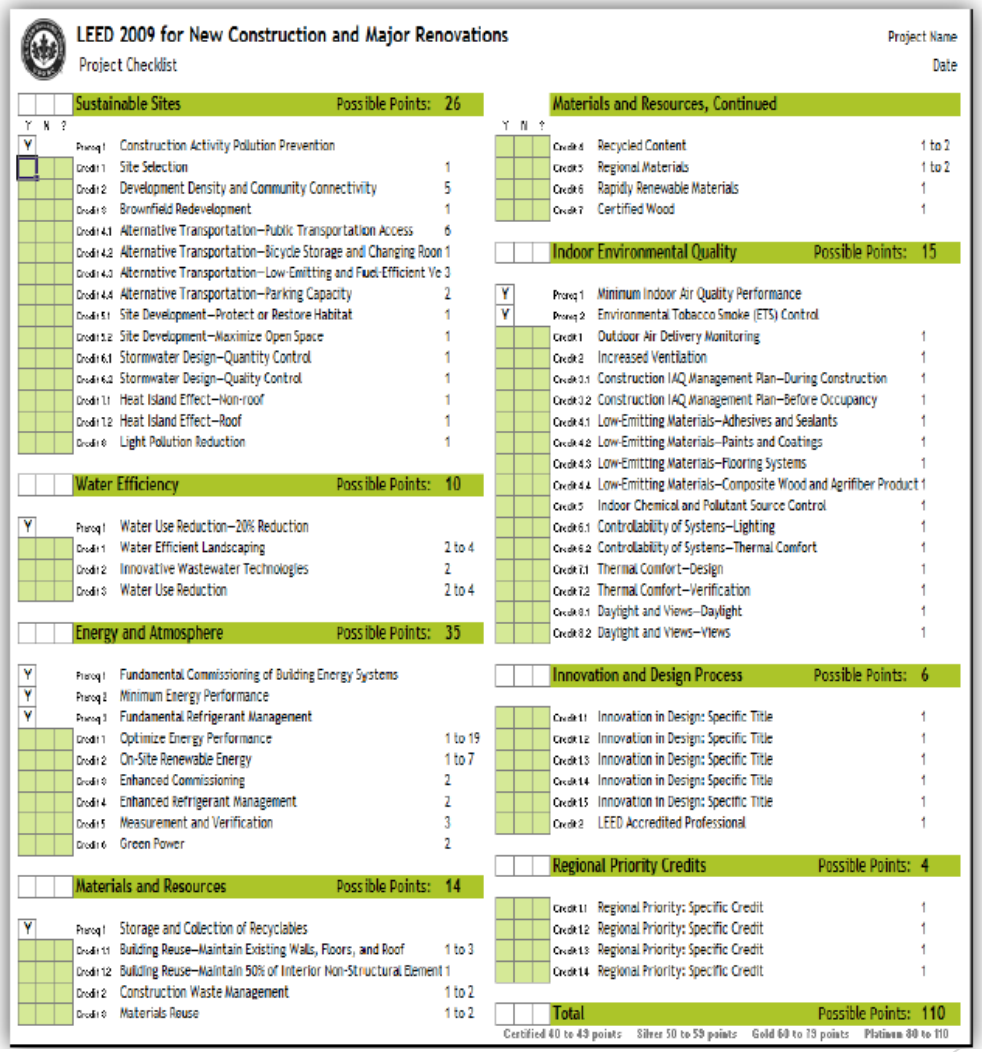
Levels of LEED Certification

LEED Rating System Categories

LEED Certification Scorecard



LEED Checklist and Scorecard



LEED 2009 for New Construction and Major Renovations

Project Checklist

Project Name

Date

Y	N	?	Sustainable Sites	Possible Points: 26
Y			Prereq 1 Construction Activity Pollution Prevention	
			Credit 1 Site Selection	1
			Credit 2 Development Density and Community Connectivity	5
			Credit 3 Brownfield Redevelopment	1
			Credit 4.1 Alternative Transportation—Public Transportation Access	6
			Credit 4.2 Alternative Transportation—Bicycle Storage and Changing Room	1
			Credit 4.3 Alternative Transportation—Low-Emitting and Fuel-Efficient Ve	3
			Credit 4.4 Alternative Transportation—Parking Capacity	2
			Credit 5.1 Site Development—Protect or Restore Habitat	1
			Credit 5.2 Site Development—Maximize Open Space	1
			Credit 6.1 Stormwater Design—Quantity Control	1
			Credit 6.2 Stormwater Design—Quality Control	1
			Credit 7.1 Heat Island Effect—Non-roof	1
			Credit 7.2 Heat Island Effect—Roof	1
			Credit 8 Light Pollution Reduction	1

			Water Efficiency	Possible Points: 10
Y			Prereq 1 Water Use Reduction—20% Reduction	
			Credit 1 Water Efficient Landscaping	2 to 4
			Credit 2 Innovative Wastewater Technologies	2
			Credit 3 Water Use Reduction	2 to 4

			Energy and Atmosphere	Possible Points: 35
Y			Prereq 1 Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2 Minimum Energy Performance	
Y			Prereq 3 Fundamental Refrigerant Management	
			Credit 1 Optimize Energy Performance	1 to 19
			Credit 2 On-Site Renewable Energy	1 to 7
			Credit 3 Enhanced Commissioning	2
			Credit 4 Enhanced Refrigerant Management	2
			Credit 5 Measurement and Verification	3
			Credit 6 Green Power	2

			Materials and Resources	Possible Points: 14
Y			Prereq 1 Storage and Collection of Recyclables	
			Credit 1.1 Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
			Credit 1.2 Building Reuse—Maintain 50% of Interior Non-Structural Element	1
			Credit 2 Construction Waste Management	1 to 2
			Credit 3 Materials Reuse	1 to 2

Y	N	?	Materials and Resources, Continued	
			Credit 4 Recycled Content	1 to 2
			Credit 5 Regional Materials	1 to 2
			Credit 6 Rapidly Renewable Materials	1
			Credit 7 Certified Wood	1

			Indoor Environmental Quality	Possible Points: 15
Y			Prereq 1 Minimum Indoor Air Quality Performance	
Y			Prereq 2 Environmental Tobacco Smoke (ETS) Control	
			Credit 1 Outdoor 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 and Sealants	1
			Credit 4.2 Low-Emitting Materials—Paints and Coatings	1
			Credit 4.3 Low-Emitting Materials—Flooring Systems	1
			Credit 4.4 Low-Emitting Materials—Composite Wood and Agrifiber Product	1
			Credit 5 Indoor Chemical and 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 and Views—Daylight	1
			Credit 8.2 Daylight and Views—Views	1

			Innovation and Design Process	Possible Points: 6
			Credit 1.1 Innovation in Design: Specific Title	1
			Credit 1.2 Innovation in Design: Specific Title	1
			Credit 1.3 Innovation in Design: Specific Title	1
			Credit 1.4 Innovation in Design: Specific Title	1
			Credit 1.5 Innovation in Design: Specific Title	1
			Credit 2 LEED Accredited Professional	1

			Regional Priority Credits	Possible Points: 4
			Credit 1.1 Regional Priority: Specific Credit	1
			Credit 1.2 Regional Priority: Specific Credit	1
			Credit 1.3 Regional Priority: Specific Credit	1
			Credit 1.4 Regional Priority: Specific Credit	1

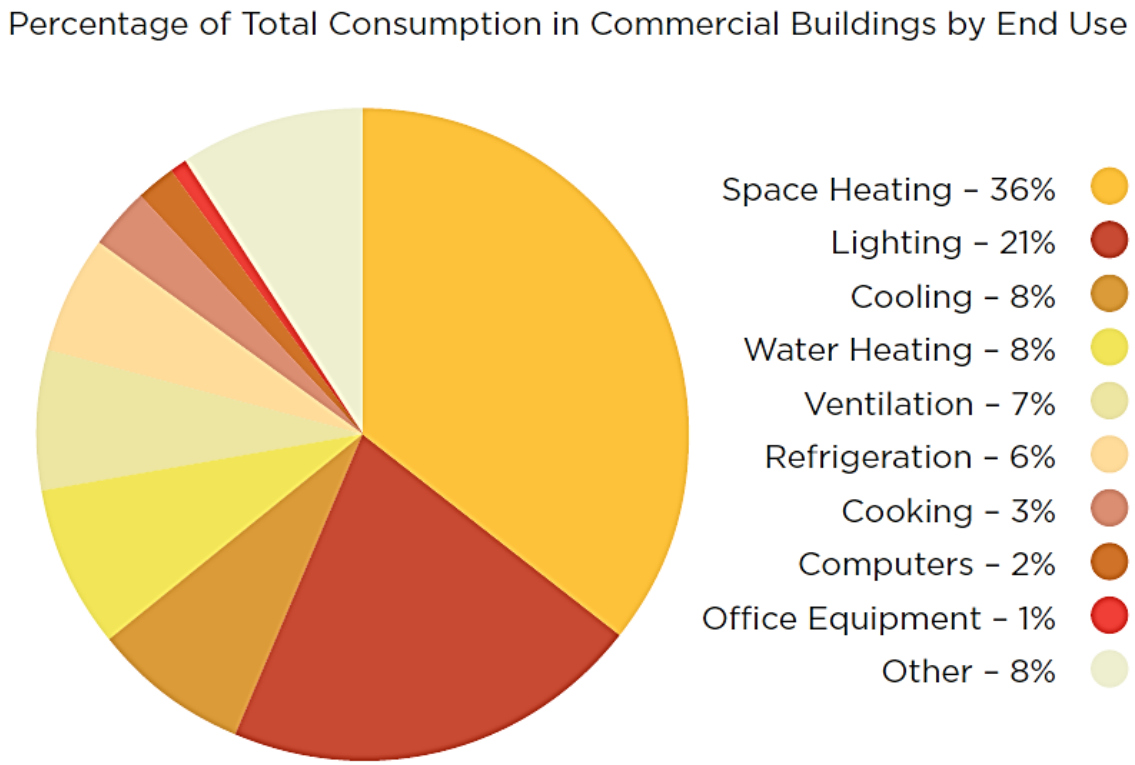
			Total	Possible Points: 110

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

LEED Energy and Atmosphere

- Energy Performance
- Refrigerant Management
- Commissioning
- Measurement and Verification
- Renewable Energy

Building Energy Use (US)



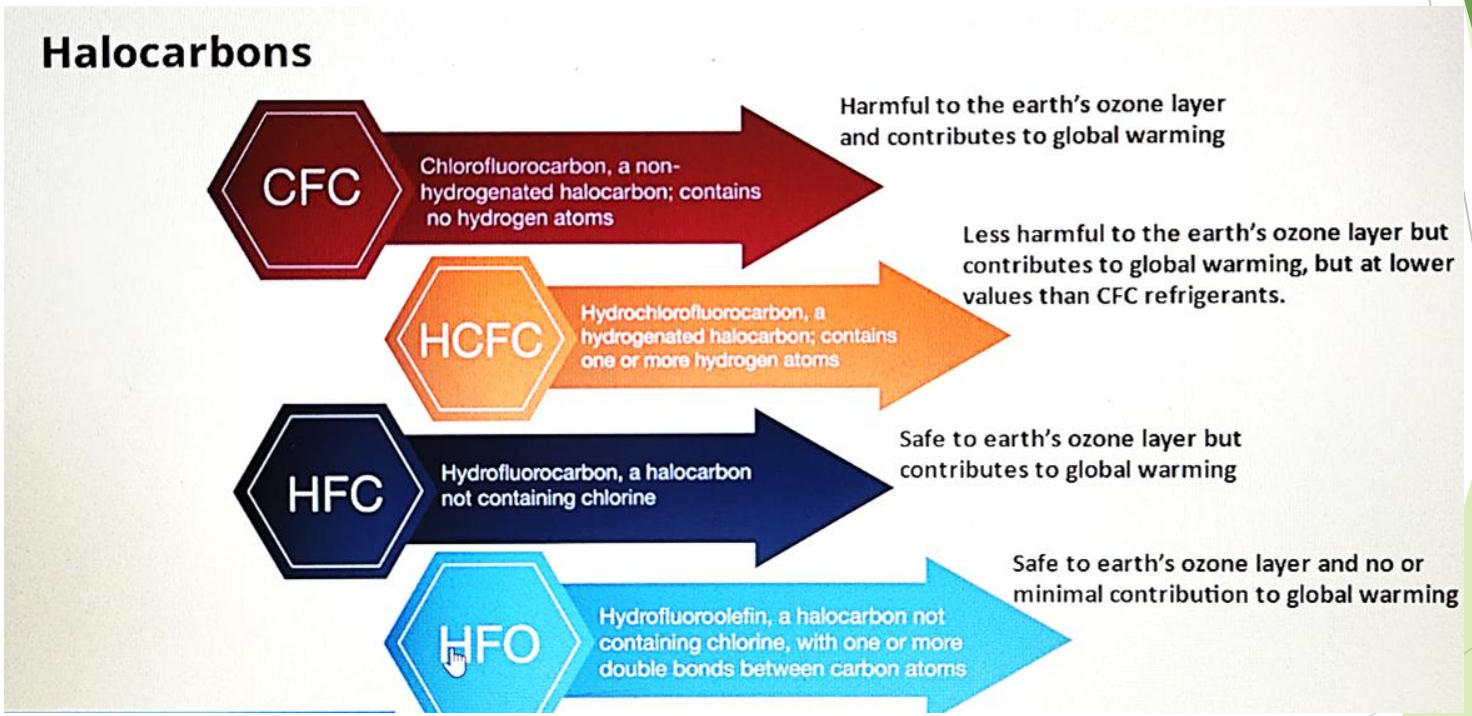
LEED Energy Performance

- Proper Orientation of the Building
- Optimized Building Envelope
- Efficient ACMV Equipment
- Efficient Lighting
- Intelligent Controls

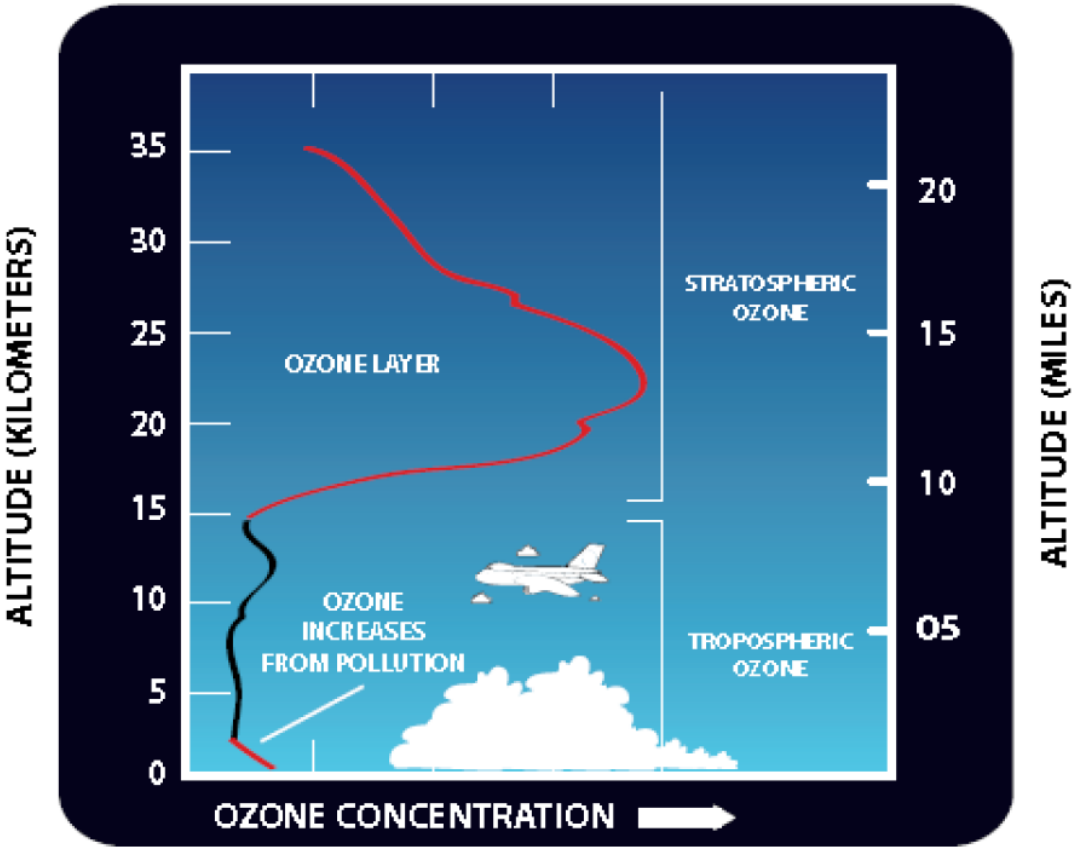
LEED Refrigerant Management

- No CFCs
- No HCFCs
- Zero ODP and Low GWP Refrigerants
- Reduce the Leakage Rate of Refrigerants
- Select Equipment with Higher Life

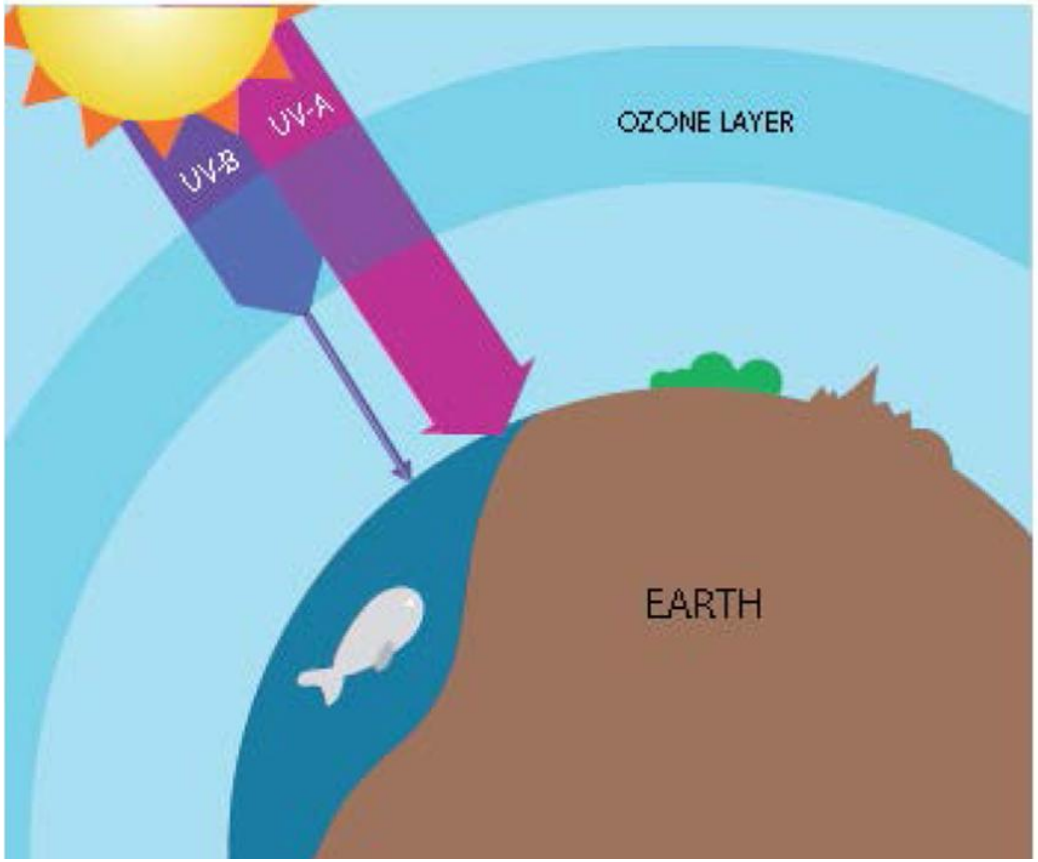
Refrigerants



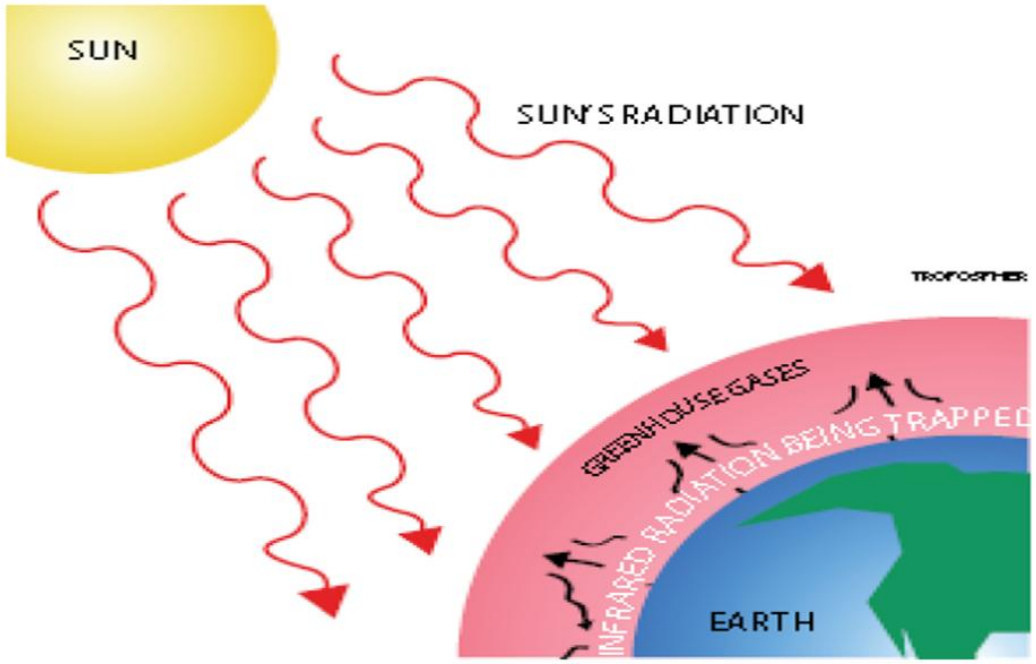
Ozone Layer


ALTITUDE (KILOMETERS)
35
30
25
20
15
10
5
0
OZONE LAYER
STRATOSPHERIC OZONE
OZONE INCREASES FROM POLLUTION
TROPOSPHERIC OZONE
OZONE CONCENTRATION
20
15
10
05
ALTITUDE (MILES)

Ozone Depletion



Global Warming



LEED Commissioning

- ACMV Equipment and its associated Controls
- Lighting and Day Lighting Controls
- Domestic Hot Water System
- Renewable Energy System

LEED Measurement and Verification

- Energy Efficiency Measures
- Sub Metering Different Utilities
- Simulation

LEED Renewable Energy
(Onsite / Green Power)

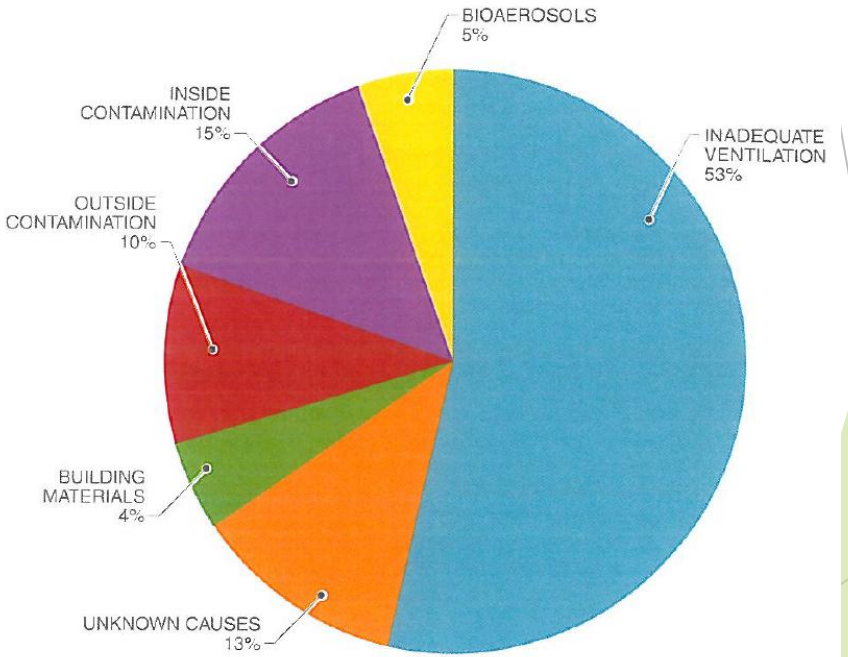
- Photovoltaic Cells
- Wind Energy
- Solar Thermal Energy Systems
- Geothermal Power
- Tidal Energy

LEED Indoor Environmental Quality

- Air Quality
- Thermal Comfort
- Lighting Comfort
- Acoustic Comfort

Indoor Air Quality Problem

- Inadequate Ventilation
- Inside Contamination
- Outside Contamination
- Building Materials
- Bio Aerosols
- Unknown Causes



Improve Indoor Air Quality

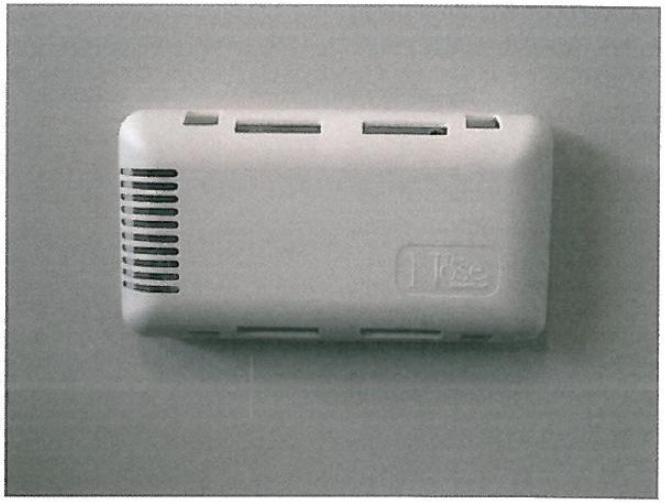
- Ventilation
- Environmental Tobacco Smoke Control
- Outdoor Air Monitoring
- Indoor Air Quality Management

  (during construction, before occupancy)
- Low Emitting Materials
- Indoor Chemical and Pollutant Control

Carbon Dioxide Monitor

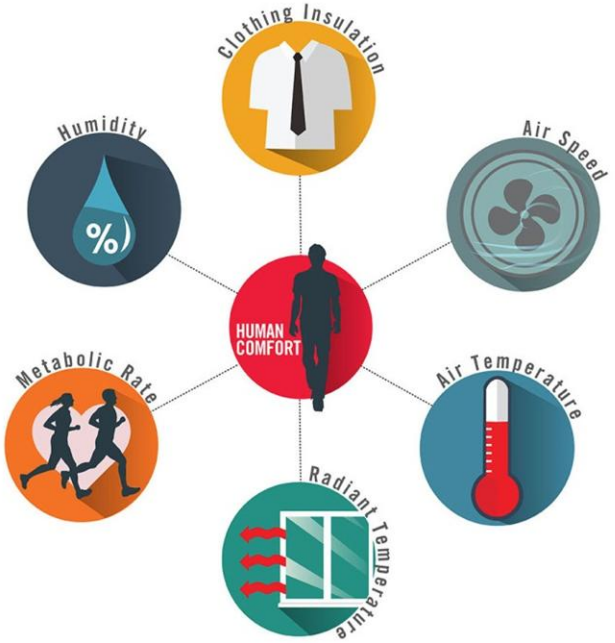
CO_2 [ppm]	Air Quality
2100	BAD Heavily contaminated indoor air Ventilation required
2000	
1900	
1800	
1700	
1600	
1500	MEDIOCRE Contaminated indoor air Ventilation recommended
1400	
1300	
1200	
1100	
1000	FAIR
900	
800	GOOD
700	
600	EXCELLENT
500	
400	

CARBON DIOXIDE MONITORS IN A LEED BUILDING



Thermal Comfort Factors

- Air Temperature
- Relative Humidity
- Air Speed
- Metabolic Rate
- Radiant Temperature
- Clothing Insulation

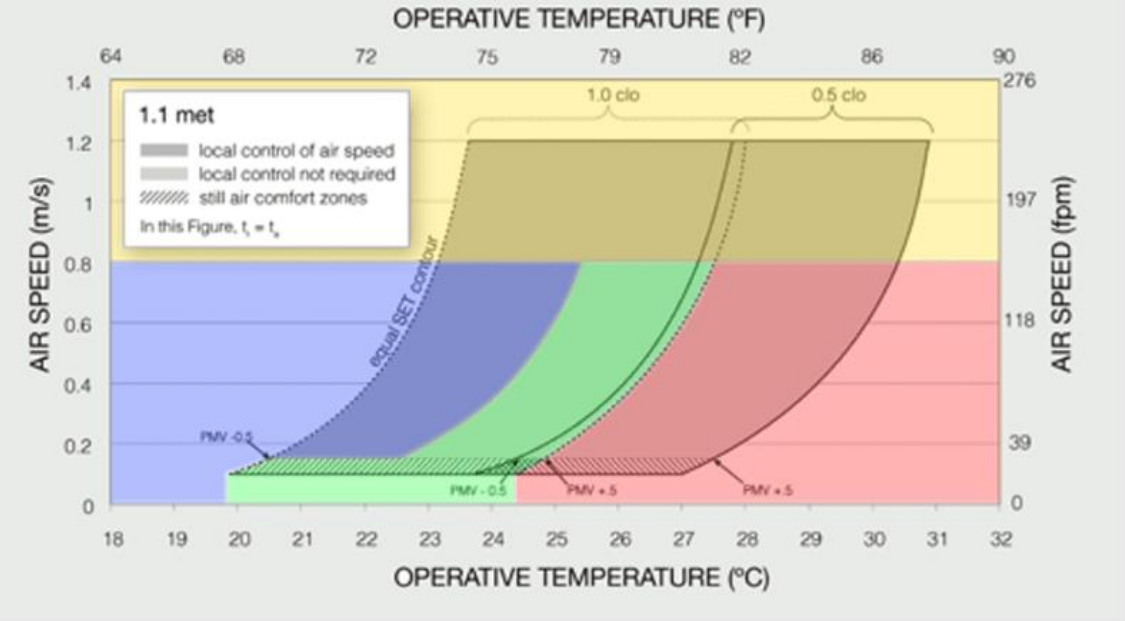


RH and Comfort

Room Dry Bulb Temperature	Equivalent "Feel Like" Temperatures					
	80% RH	70% RH	60% RH	50% RH	40%RH	30%RH
62	66	65	64.5	64	63	62
63	67	66	65.5	65	64	63
64	67.5	67	66	65.5	65	64
65	69	68	67.5	67	66	65
65	70	69	68	67.5	66.5	66
66	71	70	69	68	67.5	66.5
68	72	71	70	69.5	68.5	67.5
68	73	72	71	70	69	68
69	73.5	72.5	71.5	70.5	70	69
69	74.5	73.5	72.5	71.5	70.5	69.5
70	76	75	74	73	71.5	70.5
71	77.5	76	75	74	73	71.5
72	78	77	76	75	73.5	72
73	79	78	77	75.5	74	73
74	80	79	77.5	76	75	74
75	81	79.5	78	77	76	75
76	82.5	80	79	78	77	76
77	83	81.5	80	79	78	77
78	84	83	81.5	80	79	78
79	85	84	83	81.5	80	79
80	86	85	84	83	81.5	80

Winter Comfort Range
Summer Comfort Range

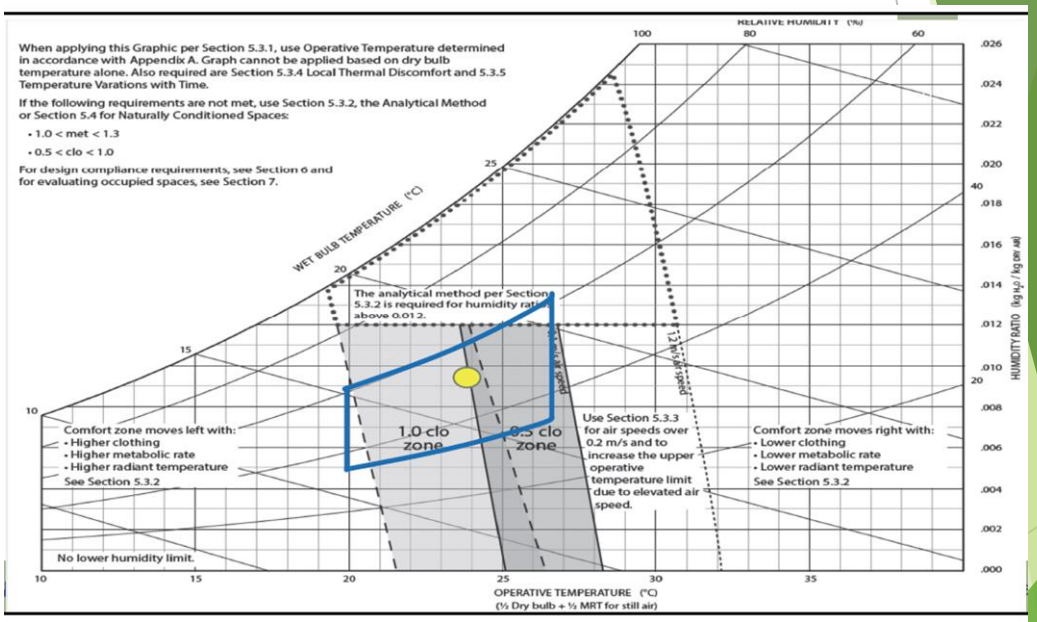
Air Speed and Comfort



Comfortable | **Too Hot** | **Too Cold** | **Too Drafty**

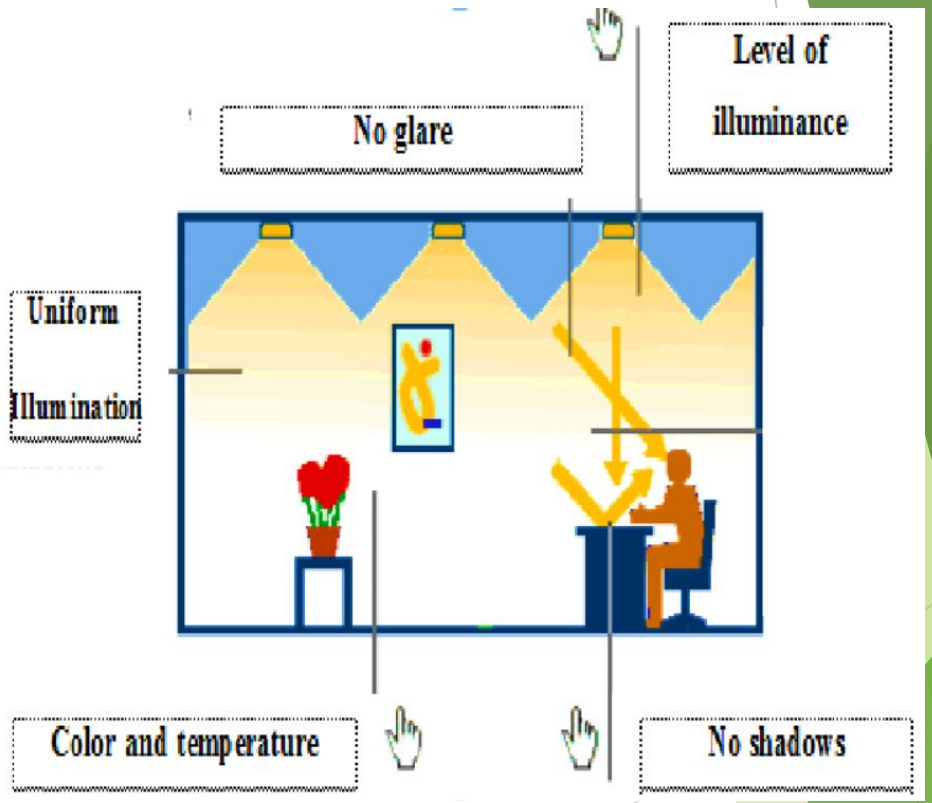
Thermal Comfort Zone

- Comfort Design
- Controllability
- Operable Windows
- Comfort Verification
- Take Corrective Action



Lighting Comfort

- Uniform Illumination
- Level of Illuminance
- Color Temperature
- No Shadows
- No Glare



Lighting Quality

- Color Temperature
- Color Rendering Index
- Brightness
- Contrast
- Glare

- **Correlated Color Temperature (CCT)**: Relative whiteness of a light source, measured in Kelvin (°K)

- **Color Rendering Index (CRI)**: Ability to produce colors
- **Brightness**: Impression of the amount of light leaving a surface & reaching the eye
- **Contrast**: The difference between brightness of the object compared to that of its immediate background
- **Glare**: Extremely bright object against a dark background

Color Temperature

Typical Color Types	
Warm White	≈3,000K
Cool White	≈4,000K
Daylight	≈6,500K

Color Rendering Index

- Color Rendering Index (CRI) is a measure of the ability of a light source to reproduce the colors of various objects being lit by the source.
- The best possible rendition of colors is specified by a CRI of one hundred.

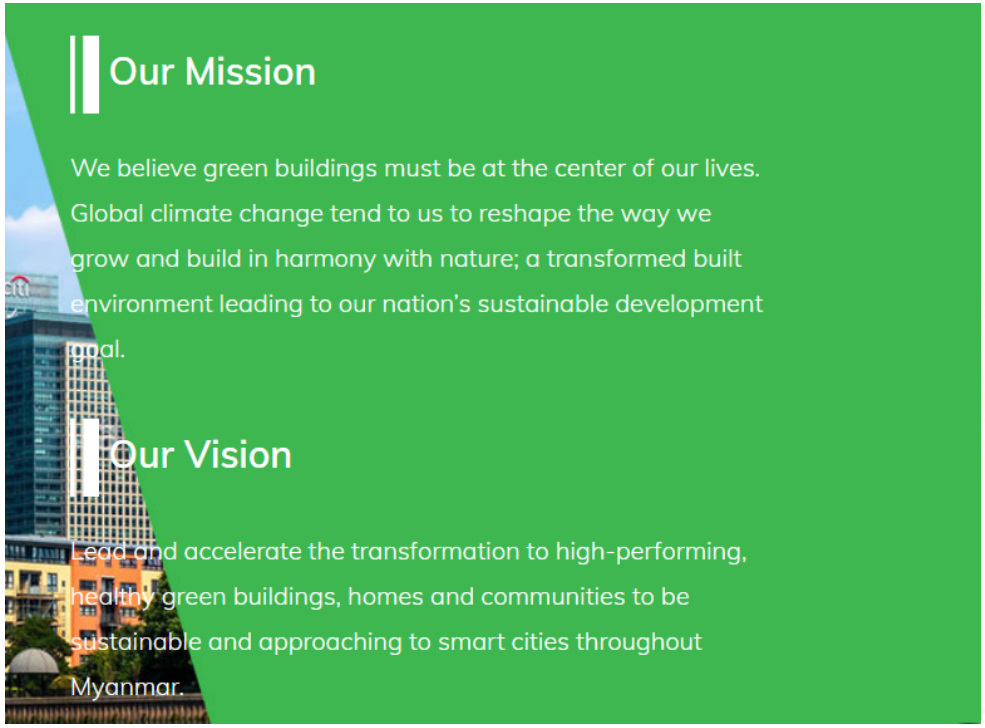
Day Lighting and Views

Figure 4.5. Daylit Classroom. photo credit: Josh Partee 2009

Acoustic Comfort

- Sound Source
- Sound Penetration
- Sound Reflection
- Sound Absorption

Myanmar Green Building Society



Our Mission

We believe green buildings must be at the center of our lives. Global climate change tend to us to reshape the way we grow and build in harmony with nature; a transformed built environment leading to our nation's sustainable development goal.

Our Vision

Lead and accelerate the transformation to high-performing, healthy green buildings, homes and communities to be sustainable and approaching to smart cities throughout Myanmar.

MGBS
MYANMAR
GREEN BUILDING
SOCIETY

JADE - Myanmar

For new constructions or major retrofitted buildings, Green Building Rating System shall be practiced by Myanmar Green Building Society: **JADE – Myanmar**.

JADE is a set of Green Building to develop by the Myanmar Green Building Society (MGBS) specifically for the Myanmar built environment. JADE rating tools are based on various international green building rating systems (LEED, Green Star, BREEAM, GBI, Green Mark, and have the following goals:

- To establish standards and bench marks specific to Myanmar
- To guide the local construction industry towards efficient use of natural resources
- To introduce and promote environmentally friendly practices JADE rating tools have been developed to long term research, with the expert advices of specialist giving particular consideration to Myanmar's cultural and natural characteristics and to existing Myanmar standards and policy. MGBS has developed three grades; Grade A, B and C.
- To award Green Building certificate for Non-Residential and Residential buildings in operation.

Five Criteria for GB in Myanmar

1. Sustainable Site
2. Efficient Consumption of Energy, Water and Natural Resources Management
3. Indoor Environment and Materials
4. Innovative Architecture and Identity
5. Social Sustainability and Humanities for Community

Three Grades of MGBS Recognition

- JADE - Myanmar - Grade - A (Excellent) , (above 80 %)
- JADE - Myanmar Grade - B (Good) , (60 – 80 %)
- JADE - Myanmar Grade - C (Satisfactory) , (40 – 60 %)

E.E For Water Cooled Chiller Plant (MNBC)

Prerequisite	Peak Building Cooling Load	
	≥ 500 RT	< 500 RT
Minimum Design System Efficiency for Central Chilled Water Plant	0.7 kW/RT	0.8 kW/RT

E.E For Air Cooled Chiller Plant and Unitary Air-conditioners (MNBC)

Prerequisite	Peak Building Cooling Load	
	≥ 500 RT	< 500 RT
Minimum Design System Efficiency for Central Chilled Water Plant	0.9 kW/RT	1.0 kW/RT

Fan Power Limitation (MNBC)

Prerequisite	Fan Power ≥ 4 kW Constant Volume (kW / CMS)	Fan Power ≥ 4 kW Variable Volume (kW / CMS)	Fan Systems with Name Plate Motor ≤ 4 kW
Fan System Motor Name Plate Power	1.7	2.4	–
Fan System Input Power	1.5	2.1	0.6

Pump Power Limitation (MNBC)

Prerequisite	Chilled Water Pump (kW / LPS)	Condenser Water Pump (kW / LPS)
Pump System Power ≥ 7.5 kW	0.349	0.301

Refrigerants (MNBC)

All air-conditioning system in the buildings should use refrigerants with a low ozone depletion potential and low global warming potential to mitigate climate change. The refrigerants should also be low hazardous of toxicity and flammability.

Zero use of chlorofluorocarbon (CFC) based refrigerants in new building heating, ventilation, air-conditioning and refrigeration systems.

A refrigerant leak detection system should also be installed in critical areas of plant rooms containing chillers and/or other equipment using refrigerants.

Environmental Characteristics of Refrigerants

Table 2. Environmental Characteristics of Several Refrigerants
Source: (ASHRAE 2013)

ASHRAE Designation	Name or Composition	Chemical Formula	ODP	GWP	Atmos. Life (years)
Halocarbons: Chlorofluorocarbons (CFC)					
R-11	Trichlorofluoromethane	CCl_3F	1.00	4750	45
R-12	Dichlorodifluoromethane	CCl_2F_2	0.820	10900	100
R-13	Chlorotrifluoromethane	$CClF_3$	1.00	14400	640
Halocarbons: Hydrochlorofluorocarbons (HCFC)					
R-22	Chlorodifluoromethane	$CHClF_2$	0.040	1790	11.9
R-123	2,2-dichloro-1,1,1-trifluoroethane	$CHCl_2CF_3$	0.010	77	1.3
Halocarbons: Hydrofluorocarbons (HFC)					
R-23	Trifluoromethane	CHF_3	0	14200	222
R-32	Difluoromethane	CH_2F_2	0	716	5.2
R-125	Pentafluoroethane	CHF_2CF_3	0	3420	28.2
R-134a	1,1,1,2-tetrafluoroethane	CH_2FCF_3	0	1370	13.4
R-143a	1,1,1-trifluoroethane	CH_3CF_3	0	4180	47.1
R-152a	1,1-difluoroethane	CH_3CHF_2	0	133	1.5
Halocarbons: Hydrofluoroolefins (HFO)					
R-1233zd(E)	Trans-1-chloro-3,3,3-trifluoro-1-propene				
R-1234yf	2,3,3,3-tetrafluoro-1-propene	$CF_3CF=CH_2$	0	<4.4	0.029
R-1234ze(E)	Trans-1,3,3,3-tetrafluoro-1-propene	$CF_3CH=CHF$	0	6	0.045
R-1336mzz(Z)	Cis-1,1,1,4,4,4-hexafluoro-2-butene				

OA Requirement for Comfort Air-conditioning (MNBC)

Building/Occupancy Category	Occupancy Load	Minimum Outdoor Air Supply base on People (l/s per person)	Minimum Outdoor Air Supply base on floor area (l/s per m^2)
Office	10 m^2/person	6	0.6
Conference/Seminar Room	2.5m^2/person	6	0.3
Hotel Guest Room	-	-	50 m3 / hr per room
Workshop	10 m^2/person	3.5	-
Night Club	1.5m^2/person	10	7.0
Shopping Center	5 m^2 /person	3.5	1.1
Market	5 m^2 /person	3.5	1.1

Outdoor Air Intake Location (MNBC)

Descriptions	Minimum Distance (meter)
Class 2 air exhaust / relief outlet	3
Class 3 air exhaust / relief outlet	5
Class 4 air exhaust / relief outlet	10
Cooling Tower intake or basin	5
Cooling Tower exhaust	7.5
Driveway, street, or parking place	1.5
Garbage storage / pick up area, dumpsters	5
Thoroughfare with high traffic volume	7.5

Air Classifications (MNBC)

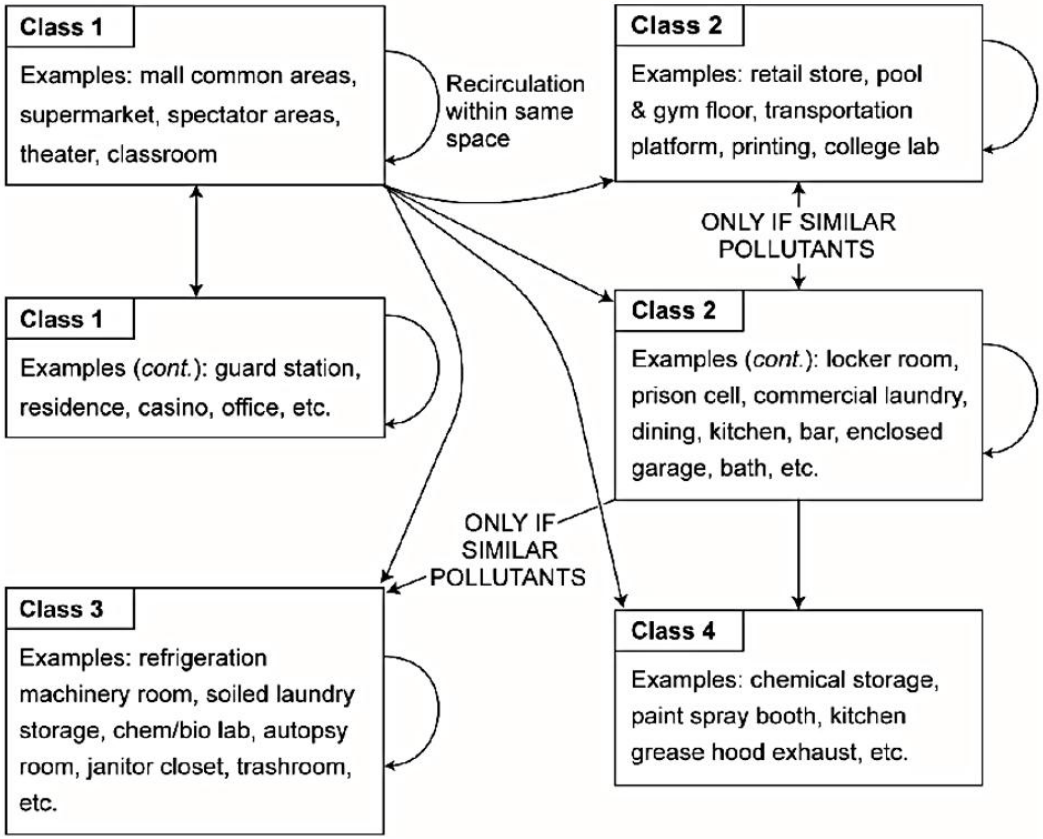
a) Class 1 – Air with low contaminant concentration, low sensory-irritation intensity and inoffensive smell.

b) Class 2 – Air with moderate contaminant concentration, mild sensory-irritation intensity or mildly offensive smell.

c) Class 3 – Air with significant contaminant concentration, significant sensory-irritation intensity or offensive smell.

d) Class 4 – Air with highly objectionable fumes or gases or with potentially dangerous particles, biological aerosols, or gases, at concentration high enough to be considered dangerous.

Limitation of Air Recirculation (MNBC)



Air Filtration (MNBC)

The double stage air filtration shall be provided for cleaning the air in all air-handling units. The Minimum Efficiency Reporting Value (MERV) for air filtration shall be equivalent to the following requirements.

(a) Primary Air Filtration - MERV 6 or better

(b) Secondary Air Filtration - MERV 12 or better

The air filtration for cleaning outdoor air to pre-cooled fan coil units /air handling units should be equivalent to MERV 6 or better.

Air Filter Classification

ASHRAE Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite average particle size efficiency, % in size range, µm			Average *arrestance, % by ASHRAE Standard 52.1
	0.3 to 1.0	1.0 to 3.0	3.0 to 10.0	
1	NA	NA	$E_3 < 20$	$A_{avg} < 65$
2	NA	NA	$E_3 < 20$	$65 \le A_{avg}$
3	NA	NA	$E_3 < 20$	$70 \le A_{avg}$
4	NA	NA	$E_3 < 20$	$75 \le A_{avg}$
5	NA	NA	$20 \le E_3 < 35$	NA
6	NA	NA	$35 \le E_3 < 50$	NA
7	NA	NA	$50 \le E_3 < 70$	NA
8	NA	$20 \le E_2$	$70 \le E_3$	NA
9	NA	$35 \le E_2$	$75 \le E_3$	NA
10	NA	$50 \le E_2$	$80 \le E_3$	NA
11	$20 \le E_1$	$65 \le E_2$	$85 \le E_3$	NA
12	$35 \le E_1$	$80 \le E_2$	$90 \le E_3$	NA
13	$50 \le E_1$	$85 \le E_2$	$90 \le E_3$	NA
14	$75 \le E_1$	$90 \le E_2$	$95 \le E_3$	NA
15	$85 \le E_1$	$90 \le E_2$	$95 \le E_3$	NA
16	$95 \le E_1$	$95 \le E_2$	$95 \le E_3$	NA

Air Filter Application

ASHRAE Standard 52.2 MERV	EN 779/EN 1822 Class	Possible applications
1	G1	Remove coarse dust
2	G2	
3		
4		
5	G3	
6		
7	G4	
8		
9		Remove coarse dust that cause plugging to the cooling coil
10	F5	
11	F6	
12		
13	F7	
14	F8	Reduce indoor particulates and provide better protection for AHU and cleaner ductwork
15	F9	High removal rate against sub-micron particle size. Improve IAQ and provide good protection for cooling coil and reducing frequency or eliminating duct cleaning
16	H10	

Thermal Comfort (MNBC)

The objective of air-conditioning system implementing in the building is to provide safe and comfort environment for the building occupants.

The indoor design temperature for comfort air-conditioning should be 24±1 °C and relative humidity should not exceed of 65%.

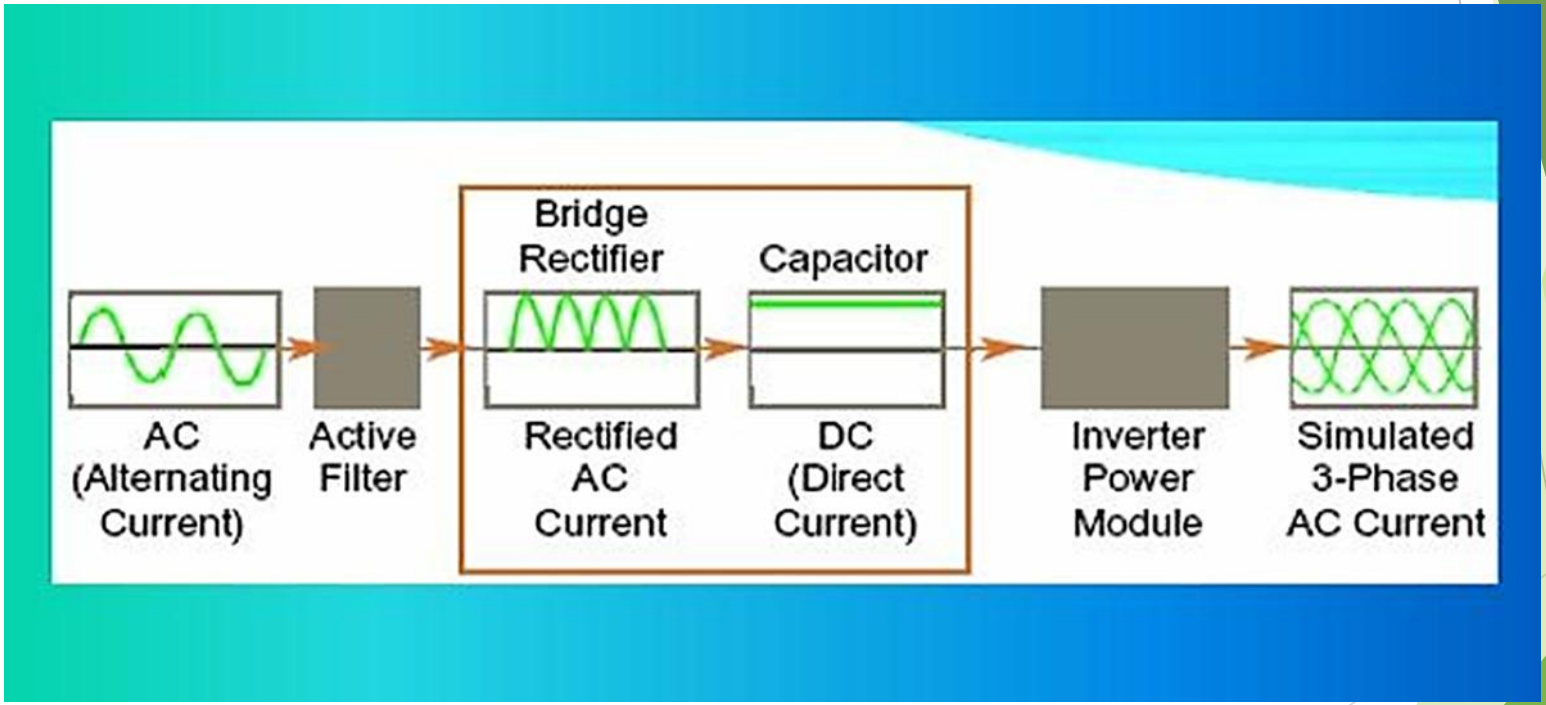
The air speed within the occupied space should be designed not to exceed 0.30 m/s measured at the occupants' level 1500 mm from the floor.

Maximum Acceptable Sound Level (MNBC)

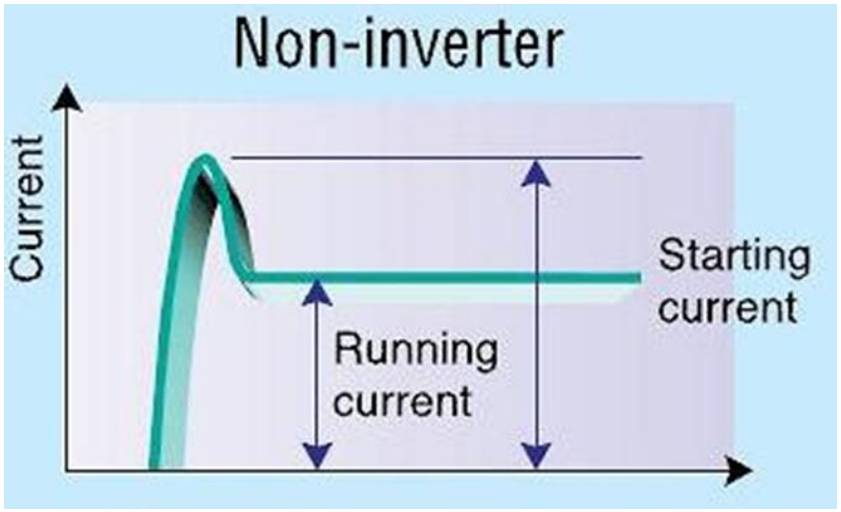
Area	Sound Level (dBA)
Cinemas, Theaters, Concert Hall	35
School, Lecture Room	35
Library	35
Auditorium	35
Ball Room	35
Office	40
Restaurant	45
Supermarket	50

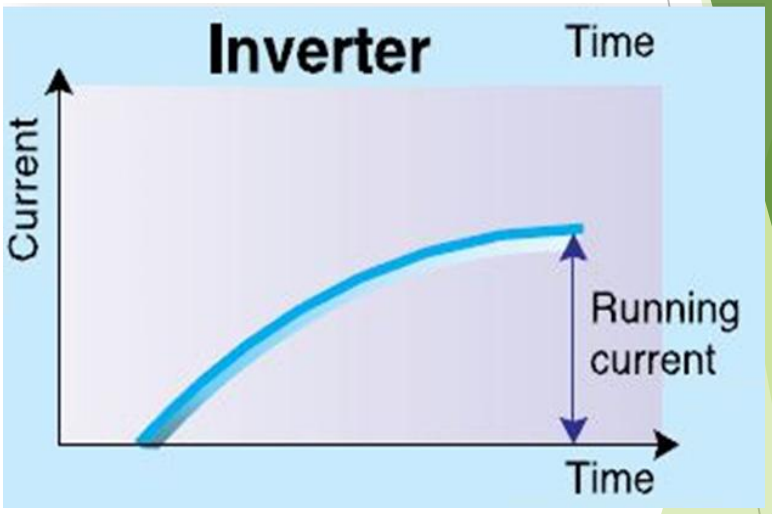
Inverter Air-conditioner

Inverter Circuit Block Diagram

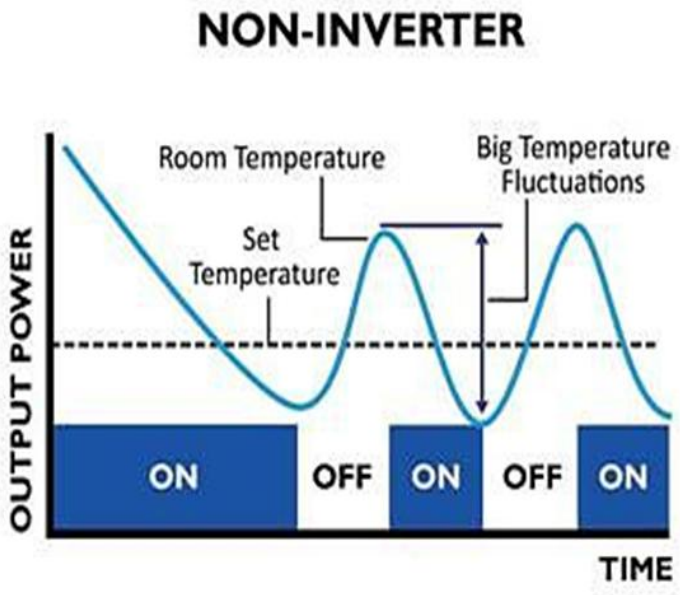


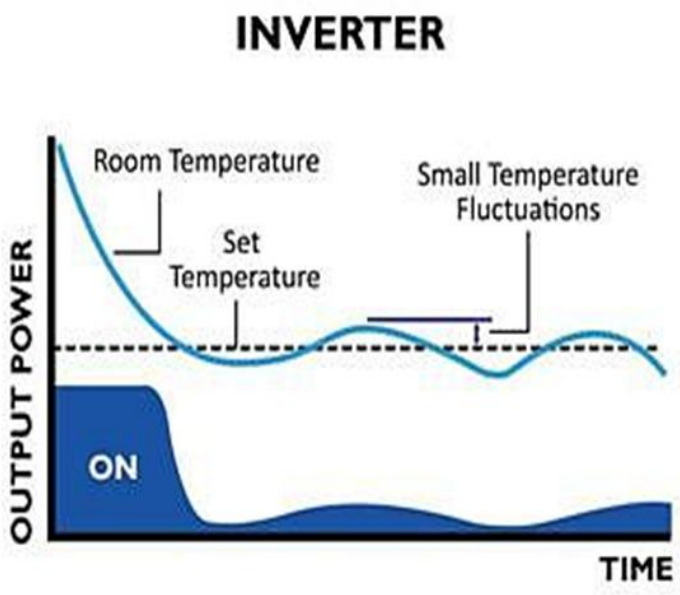
Starting Current



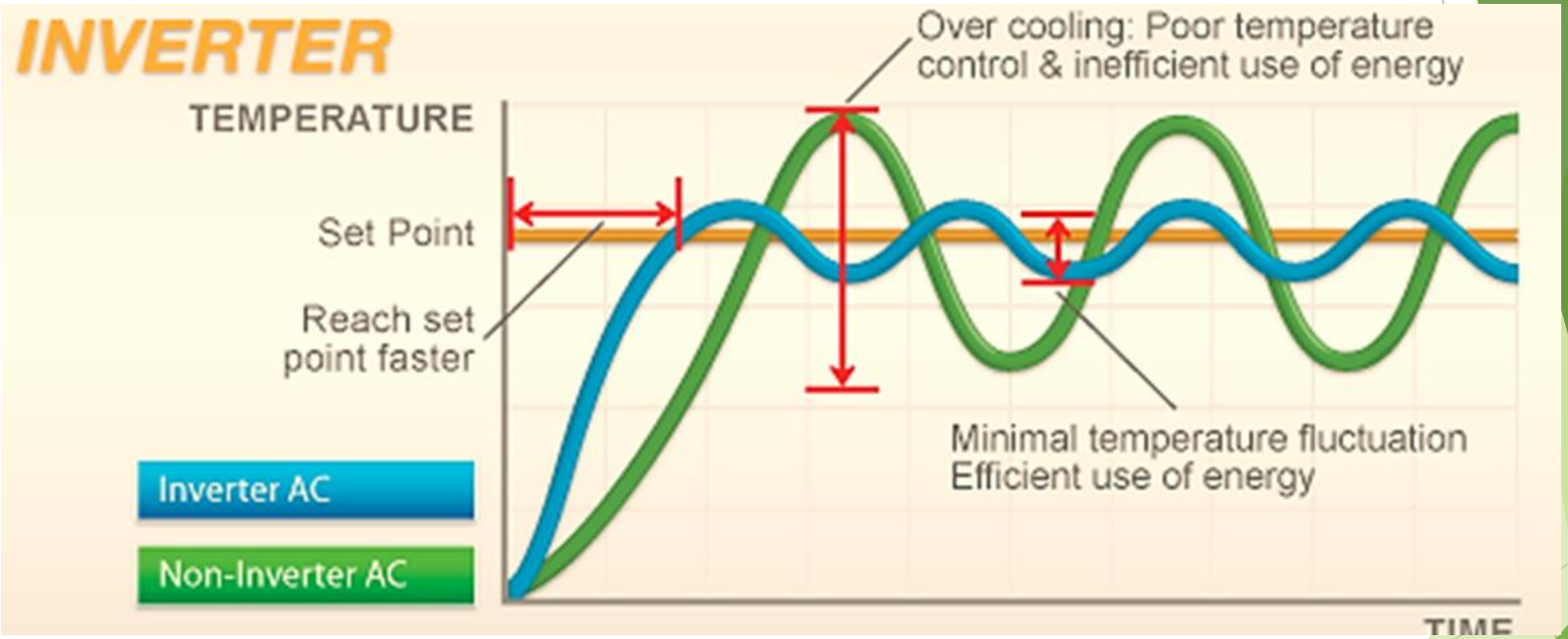


Power Consumption

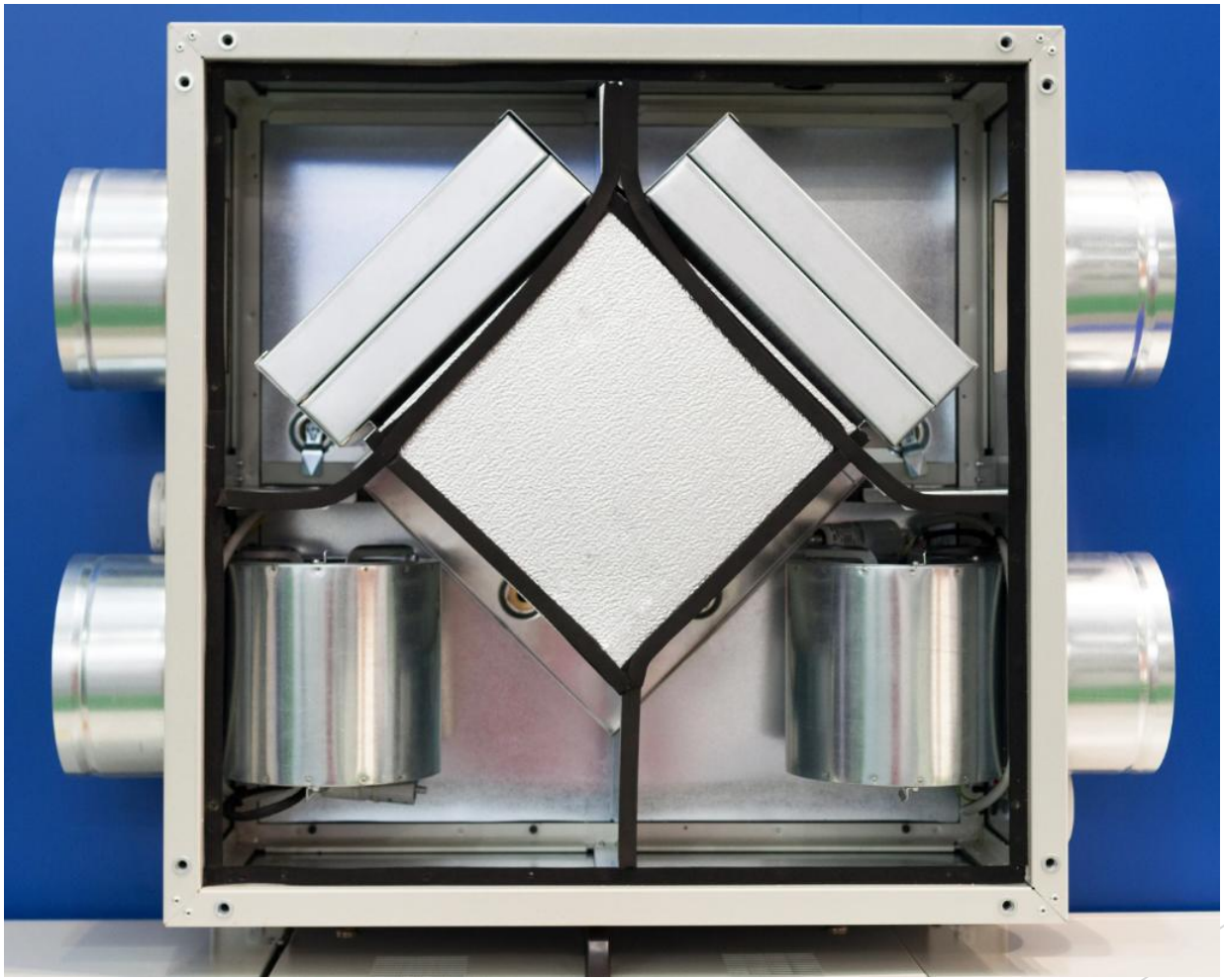




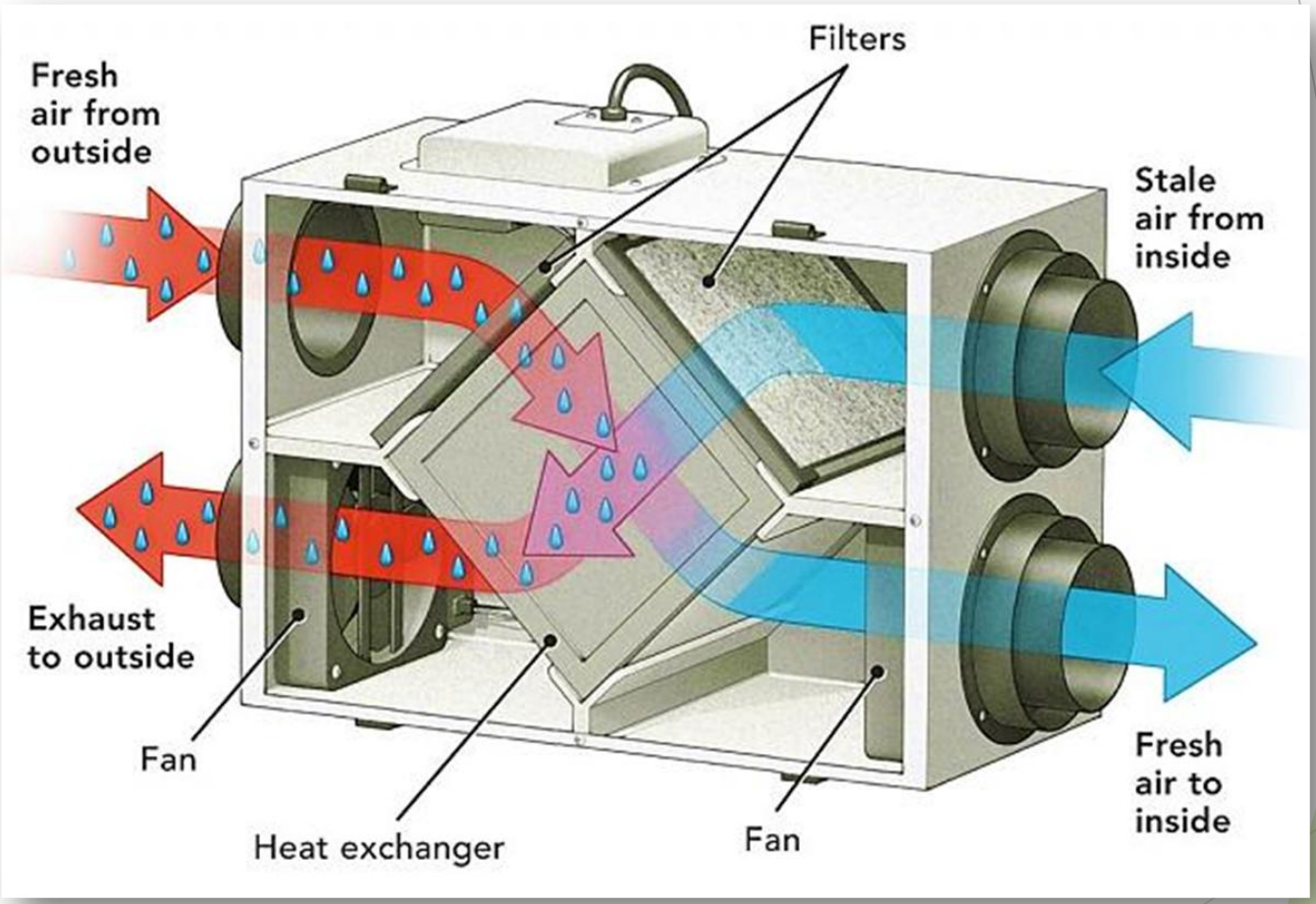
Room Temperature



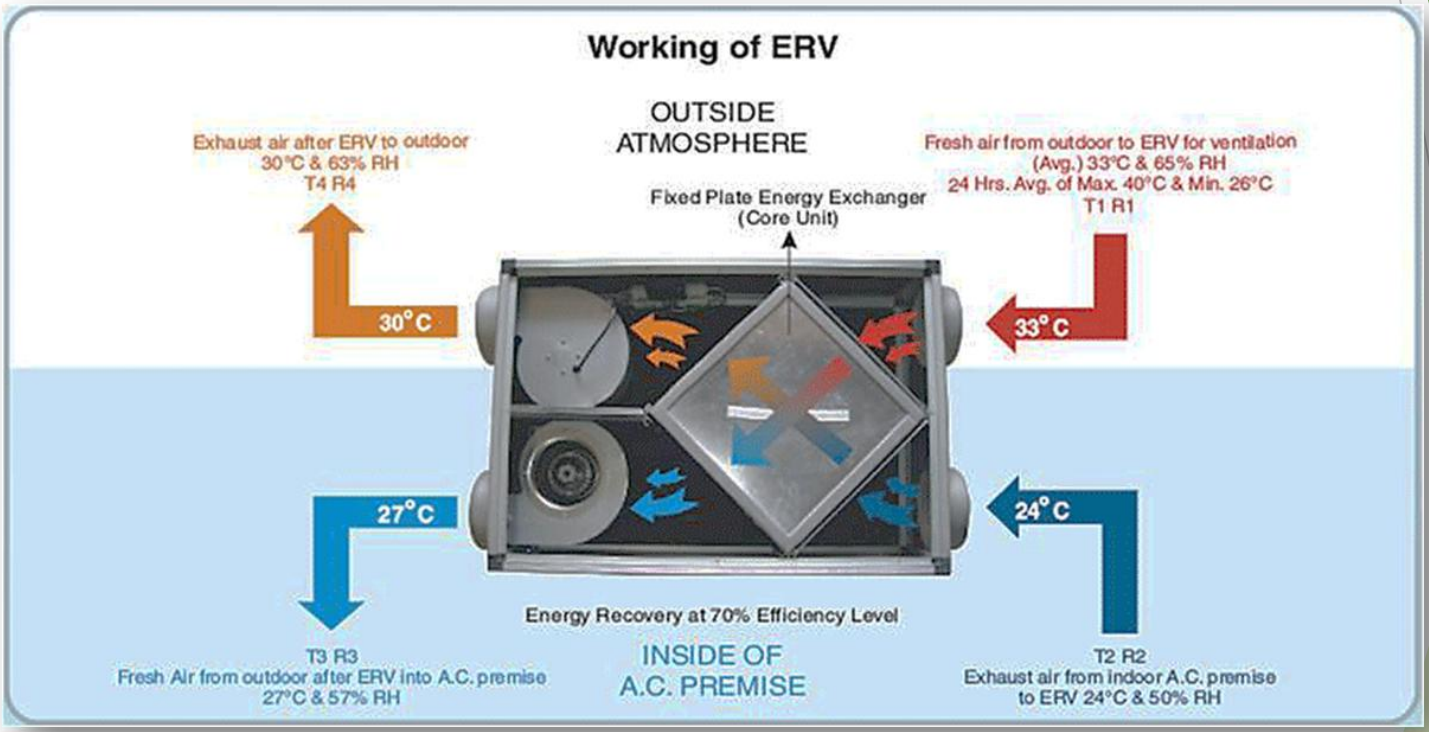
Energy Recovery Ventilator



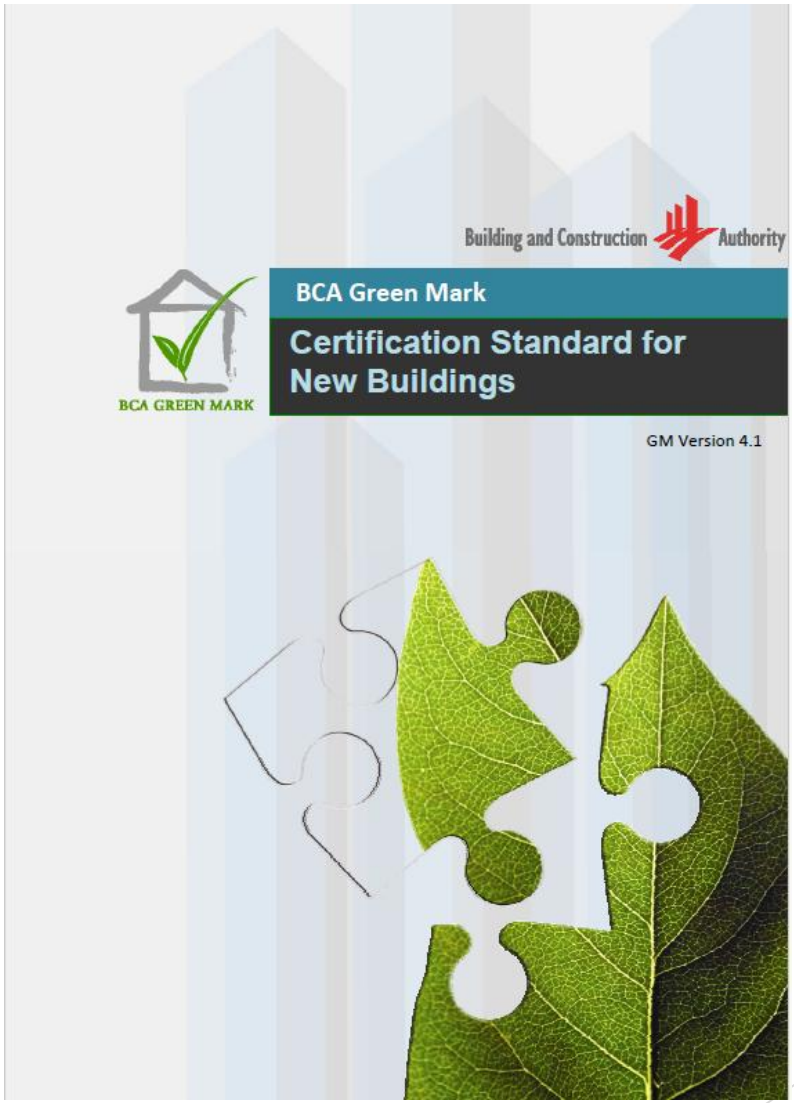
ERV Working Principle



ERV for EE


Working of ERV
OUTSIDE ATMOSPHERE
Exhaust air after ERV to outdoor
30°C & 63% RH
T4 R4
Fixed Plate Energy Exchanger
(Core Unit)
Fresh air from outdoor to ERV for ventilation
(Avg.) 33°C & 65% RH
24 Hrs. Avg. of Max. 40°C & Min. 26°C
T1 R1
30°C
33°C
27°C
24°C
Energy Recovery at 70% Efficiency Level
T3 R3
Fresh Air from outdoor after ERV into A.C. premise
27°C & 57% RH
INSIDE OF A.C. PREMISE
T2 R2
Exhaust air from indoor A.C. premise
to ERV 24°C & 50% RH

BCA Green Mark (Singapore)



BCA Green Mark (Singapore)

Table 5.2 – BCA Green Mark Award Rating and Prerequisite Requirements

Green Mark Score	Green Mark Rating
90 and above	Green Mark Platinum
85 to < 90	Green Mark Gold^{Plus}
75 to < 85	Green Mark Gold
50 to <75	Green Mark Certified

BCA GM Scorecard (Singapore)

Table 5.3.1(a) : Framework and Point Allocations for Residential Building Criteria

	Category	Point Allocations
(I)	**Energy Related Requirements**	
Minimum 30 points	**Part 1 : Energy Efficiency**	
	RB 1-1 Thermal Performance of Building Envelope – RETV	15
	RB 1-2 Naturally Ventilated Design and Air-Conditioning System	22
	RB 1-3 Daylighting	6
	RB 1-4 Artificial Lighting	10
	RB 1-5 Ventilation in Carparks	6
	RB 1-6 Lifts	1
	RB 1-7 Energy Efficient Features	7
	RB 1-8 Renewable Energy	20
	Category Score for Part 1 – Energy Efficiency	**87 (Max)**
(II)	**Other Green Requirements**	
Minimum 20 points	**Part 2 : Water Efficiency**	
	RB 2-1 Water Efficient Fittings	10
	RB 2-2 Water Usage Monitoring	1
	RB 2-3 Irrigation System and Landscaping	3
	Category Score for Part 2 – Water Efficiency	**14**
	Part 3 : Environmental Protection	
	RB 3-1 Sustainable Construction	10
	RB 3-2 Sustainable Products	8
	RB 3-3 Greenery Provision	8
	RB 3-4 Environmental Management Practice	8
	RB 3-5 Green Transport	4
	RB 3-6 Stormwater Management	3
	Category Score for Part 3 – Environmental Protection	**41**
	Part 4 : Indoor Environmental Quality	
	RB 4-1 Noise Level	1
	RB 4-2 Indoor Air Pollutants	2
	RB 4-3 Waste Disposal	1
	RB 4-4 Indoor Air Quality in Wet Areas	2
	Category Score for Part 4 – Indoor Environmental Quality	**6**
	Part 5 : Other Green Features	
	RB 5-1 Green Features & Innovations	7
	Category Score for Part 5 – Other Green Features	**7**
	Green Mark Score :	**155**

Table 5.3.1(b) : Framework and Point Allocations for Non-Residential Building Criteria

	Category		Point Allocations
(I)	**Energy Related Requirements**		
Minimum 30 points	**Part 1 : Energy Efficiency**		
	NRB 1-1 Thermal Performance of Building Envelope - ETTV	Section (A) Applicable to air-con areas	12
	NRB 1-2 Air-Conditioning System		30
	Sub-Total (A) – NRB 1-1 to 1-2		42
	NRB 1-3 Building Envelope – Design/Thermal Parameters	Section (B) Applicable to non air-con areas excluding carparks and common areas	35
	NRB 1-4 Natural Ventilation / Mechanical Ventilation		20
	Sub-Total (B) – NRB 1-3 to 1-4		55
	NRB 1-5 Daylighting	Section (C) Generally applicable to all areas	6
	NRB 1-6 Artificial Lighting		12
	NRB 1-7 Ventilation in Carparks		4
	NRB 1-8 Ventilation in Common Areas		5
	NRB 1-9 Lifts and Escalators		2
	NRB 1-10 Energy Efficient Practices & Features		12
	NRB 1-11 Renewable Energy		20
	Sub-Total (C) – NRB 1-5 to 1-11		61
	Category Score for Part 1 – Energy Efficiency Prorate Subtotal (A) + Prorate Subtotal (B) + Prorate Subtotal (C)		**116 (Max)**
(II)	**Other Green Requirements**		
Minimum 20 points	**Part 2 : Water Efficiency**		
	NRB 2-1 Water Efficient Fittings		10
	NRB 2-2 Water Usage and Leak Detection		2
	NRB 2-3 Irrigation System and Landscaping		3
	NRB 2-4 Water Consumption of Cooling Towers		2
	Category Score for Part 2 – Water Efficiency		**17**
	Part 3 : Environmental Protection		
	NRB 3-1 Sustainable Construction		10
	NRB 3-2 Sustainable Products		8
	NRB 3-3 Greenery Provision		8
	NRB 3-4 Environmental Management Practice		7
	NRB 3-5 Green Transport		4
	NRB 3-6 Refrigerants		2
	NRB 3-7 Stormwater Management		3
	Category Score for Part 3 – Environmental Protection		**42**
	Part 4 : Indoor Environmental Quality		
	NRB 4-1 Thermal Comfort		1
	NRB 4-2 Noise Level		1
	NRB 4-3 Indoor Air Pollutants		2
	NRB 4-4 Indoor Air Quality (IAQ) Management		2
	NRB 4-5 High Frequency Ballasts		2
	Category Score for Part 4 – Indoor Environmental Quality		**8**
	Part 5 : Other Green Features		
	NRB 5-1 Green Features & Innovations		7
	Category Score for Part 5 – Other Green Features		**7**
	Green Mark Score :		**190 (Max)**

Green Building Index (Malaysia)

Green Building Index (Malaysia)

NON-RESIDENTIAL NEW CONSTRUCTION (NRNC)

ASSESSMENT CRITERIA
OVERALL POINTS SCORE

PART	ITEM	MAXIMUM POINTS
1	Energy Efficiency (EE)	35
2	Indoor Environmental Quality (EQ)	21
3	Sustainable Site Planning & Management (SM)	16
4	Material & Resources (MR)	11
5	Water Efficiency (WE)	10
6	Innovation (IN)	7
	TOTAL SCORE	100

GREEN BUILDING INDEX CLASSIFICATION

POINTS	GBI RATING
86 to 100 points	Platinum
76 to 85 points	Gold
66 to 75 points	Silver
50 to 65 points	Certified

GBI Scorecard (Malaysia)

PART	CRITERIA	ITEM	POINTS	SUBMITTER	GBI
1	**EE**	**ENERGY EFFICIENCY**			
	Design				
	EE1	Minimum EE Performance	1		
	EE2	Lighting Zoning	3		
	EE3	Electrical Sub-metering	1		
	EE4	Renewable Energy	5		
	EE5	Advanced EE Performance - BEI	15		
	Commissioning				
	EE6	Enhanced Commissioning	3		
	EE7	Post Occupancy Commissioning	2		
	Verification & Maintenance				
	EE8	EE Verification	2		
	EE9	Sustainable Maintenance	3		
2	**EQ**	**INDOOR ENVIRONMENTAL QUALITY**			
	Air Quality				
	EQ1	Minimum IAQ Performance	1		
	EQ2	Environmental Tobacco Smoke (ETS) Control	1		
	EQ3	Carbon Dioxide Monitoring and Control	1		
	EQ4	Indoor Air Pollutants	2		
	EQ5	Mould Prevention	1		
	Thermal Comfort				
	EQ6	Thermal Comfort: Design & Controllability of Systems	2		
	EQ7	Air Change Effectiveness	1		
	Lighting, Visual & Acoustic Comfort				
	EQ8	Daylighting	2		
	EQ9	Daylight Glare Control	1		
	EQ10	Electric Lighting Levels	1		
	EQ11	High Frequency Ballasts	1		
	EQ12	External Views	2		
	EQ13	Internal Noise Levels	1		
	Verification				
	EQ14	IAQ Before & During Occupancy	2		
	EQ15	Post Occupancy Comfort Survey: Verification	2		

PART	CRITERIA	ITEM	POINTS	SUBMITTER	GBI
3	**SM**	**SUSTAINABLE SITE PLANNING & MANAGEMENT**			
	Site Planning				
	SM1	Site Selection	1		
	SM2	Brownfield Redevelopment	1		
	SM3	Development Density & Community Connectivity	2		
	SM4	Environment Management	2		
	Construction Management				
	SM5	Earthworks - Construction Activity Pollution Control	1		
	SM6	QLASSIC	1		
	SM7	Workers' Site Amenities	1		
	Transportation				
	SM8	Public Transportation Access	1		
	SM9	Green Vehicle Priority	1		
	SM10	Parking Capacity	1		
	Design				
	SM11	Stormwater Design – Quantity & Quality Control	1		
	SM12	Greenery & Roof	2		
	SM13	Building User Manual	1		
4	**MR**	**MATERIALS & RESOURCES**			
	Reused & Recycled Materials				
	MR1	Materials Reuse and Selection	2		
	MR2	Recycled Content Materials	2		
	Sustainable Resources				
	MR3	Regional Materials	1		
	MR4	Sustainable Timber	1		
	Waste Management				
	MR5	Storage & Collection of recyclables	1		
	MR6	Construction Waste Management	2		
	Green Products				
	MR7	Refrigerants & Clean Agents	2		
5	**WE**	**WATER EFFICIENCY**			
	Water Harvesting & Recycling				
	WE1	Rainwater Harvesting	2		
	WE2	Water Recycling	2		
	Increased Efficiency				
	WE3	Water Efficient - Irrigation/Landscaping	2		
	WE4	Water Efficient Fittings	2		
	WE5	Metering & Leak Detection System	2		
6	**IN**	**INNOVATION**			
	IN1	Innovation in Design & Environmental Design Initiatives	6		
	IN2	Green Building Index Accredited Facilitator	1		
		TOTAL POINTS	**100**		

Thai's Rating of Energy and Environmental, Sustainability

TGBI

TREES – NC Version 1.1

Thai's Rating of
Energy and Environmental Sustainability
for New Construction and Major Renovation

By

Thai Green Building Institute (TGBI)

Supported by

The Engineering Institute of Thailand under Royal Patronage and

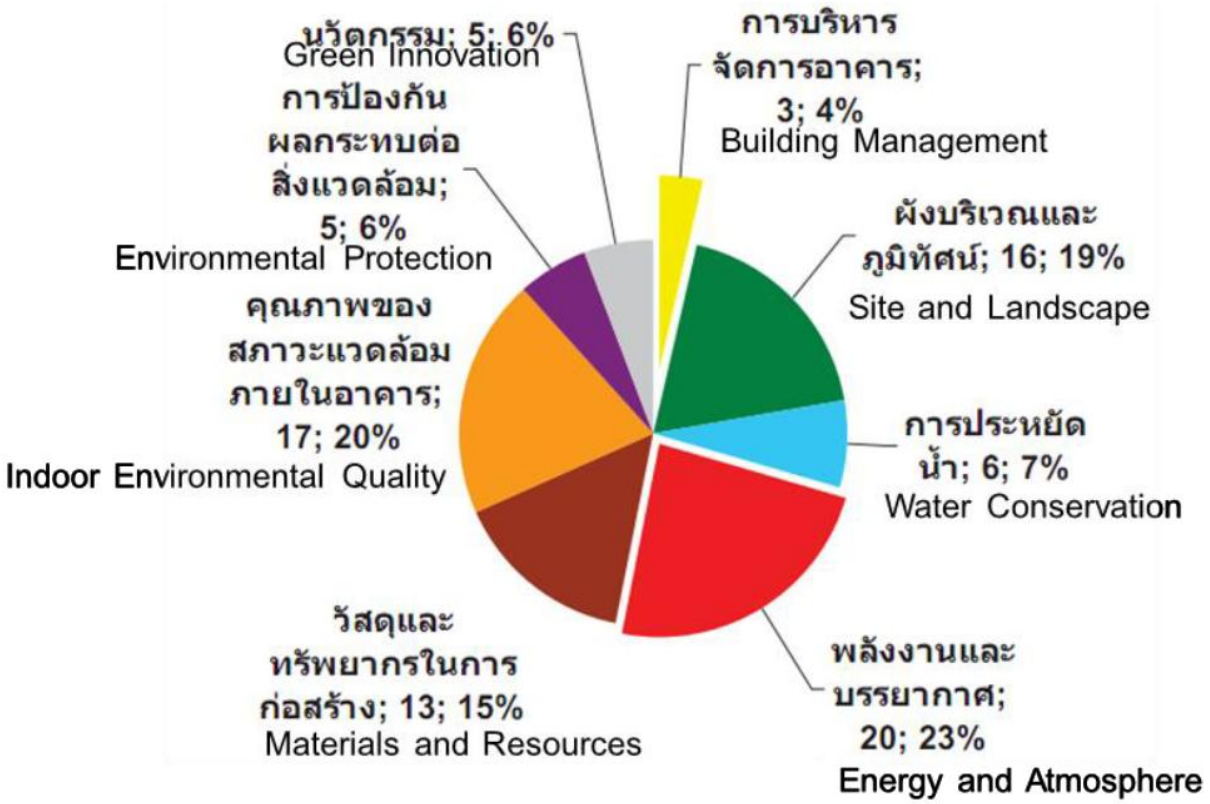
The Association of Siamese Architects under Royal Patronage

TREES (Thai)

PLATINUM	more than 60 points
GOLD	46-60 points
SILVER	38-45 points
CERTIFIED	30-37 points
All level must pass prerequisite topics	9 prerequisite topics.

TREES-NC has 8 assessment sections: 1) Building Management, 2) Site and Landscape, 3) Water Conservation, 4) Energy and Atmosphere, 5) Materials and Resources, 6) Indoor Environmental Quality, 7) Environmental Protection, 8) Green Innovation. The score proportions are as follows:

TREES (Thai)


นวัตกรรม; 5; 6%
Green Innovation
การป้องกัน
ผลกระทบต่อ
สิ่งแวดล้อม;
5; 6%
Environmental Protection
คุณภาพของ
สภาวะแวดล้อม
ภายในอาคาร;
17; 20%
Indoor Environmental Quality
วัสดุและ
ทรัพยากรในการ
ก่อสร้าง; 13; 15%
Materials and Resources
การบริหาร
จัดการอาคาร;
3; 4%
Building Management
ผังบริเวณและ
ภูมิทัศน์; 16; 19%
Site and Landscape
การประหยัด
น้ำ; 6; 7%
Water Conservation
พลังงานและ
บรรยากาศ;
20; 23%
Energy and Atmosphere

Team Members Working Isolation

Integrative Team Members


Thank You


Q&A