Unofficial Translation

Ministry of Energy's Notification On Criteria and Calculation Methods for Building Design of Various Systems, Overall Energy Consumption of Buildings and Use of Renewable energy of Various Building Systems B.E. 2552

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

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Translated by Direction Plan. Co.,ltd. (www.Directionplan.org)

Ministry of Energy's Notification
On Criteria and Calculation Methods for Building Design of Various Systems, Overall Energy Consumption of Buildings and Use of Renewable energy of Various Building Systems
B.E. 2552

By the authority of the particulars in Item 10 of the Ministerial Regulation prescribing type or size of buildings and standard, criteria and Procedure in designing building for energy conservation B.E. 2552, issued according to the particulars of the Energy Conservation Promotion Act B.E. 2535 as amended by the Energy Conservation Promotion Act (Vol. 2) B.E. 2550, i.e. the law pertaining to certain stipulations on the limitation of rights and freedom of individuals. Section 29 and Sections 33, 41 and 43 of the Constitution of Thailand stipulate that this may be done under the authority of the law. The Minister of Energy, therefore, does hereby issue the following announcement:

1. For the purposes of this announcement:

"Building" refers to a structure according to Item 2 of the the Ministerial Regulation prescribing type or size of buildings and standard, criteria and Procedure in designing building for energy conservation B.E. 2552, which has been issued according to the 1992 Energy Conservation Promotion Act.

"Reference buildings" refers to buildings designed to have the same type of work area, location, directions, perimeter on each side of the building and usage as the building to be constructed or renovated wherein the aforementioned building must have the value of the building perimeter, lighting and air conditioning system in compliance with the specifications of each system.

Section 1

Calculation of the Building's Perimeter System Overall Heat Radiation

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Part 1

Calculation of The Building's Overall Thermal Transfer Value

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2. The calculation of the building's overall thermal transfer value shall be carried out according to the following specified criteria and methods:

(1) A building's overall thermal transfer value (OTTV)

(1.1) A building's overall thermal transfer value *(OTTV)* shall be calculated using the following equation:

$$OTTV_i = (U_w)(1\ WWR)(TD_{eq}) + (U_f)(WWR)(\Delta T)\ (WWR)(SHGC)(SC)(ESR)$$

When $OTTV_i$ is the overall thermal transfer value of the outer wall being considered, the unit is Watt per square meters (W/m^2).

U_w is the coefficient of the overall thermal transfer value of a solid wall, the unit is Watt per square meter-degree Celsius ($W/(m^2.^oC)$).

WWR is the ratio between the area of transparent windows and/or transparent walls and total area of the wall being considered.

TD_{eq} is the equivalent temperature difference between the outside and inside of the building, including the results of the solar ray absorption of the solid wall, the unit is in Celsius degrees (^oC).

U_f is the coefficient of the overall thermal transfer value of a transparent or glass wall; its unit is Watts per square meter-degrees Celsius ($W/(m^2.^oC)$).

ΔT is the difference between the temperature inside and outside the building; its unit is degree Celsius (^oC).

$SHGC$ is the coefficient of the thermal transfer value from solar rays which is sent through a transparent or glass wall.

SC is the shading coefficient of the shading instrument.

ESR is the solar ray value which has an effect on the thermal transfer through transparent and/or solid walls; its unit is in (W/m^2)

(1.2) A building's overall thermal transfer value *(OTTV)* is the weighted average value of the overall thermal transfer value *(OTTV)* of each outer wall and shall be calculated by the following equation:

$$OTTV = \frac{(A_{w1})(OTTV_1) + (A_{w2})(OTTV_2) + \ldots + (A_{wi})(OTTV_i)}{A_{w1+} A_{w2} + \ldots + A_{wi}}$$

When A_i is the area of the wall being considered, including the area of solid wall and the area of window or transparent wall; its unit is in square meters (m^2).

$OTTV_i$ is the overall thermal transfer value of the outer wall being considered; its unit is Watts per square meter (W/m^2).

(2) The coefficient of the overall thermal transfer of a solid wall (U_w).

The coefficient of the overall thermal transfer of each side of outer solid wall (U_w) shall be calculated by the following equation:

(2.1) The Overall Thermal Transfer Coefficient *(U)*

The Overall Thermal Transfer Coefficient *(U) is the inverse of the total thermal resistance and shall be calculated as follows:*

$$U = \frac{1}{R_r}$$

When R_r is the total thermal resistance; its unit is in (($m^2.^oC$)/W)

(2.2) Thermal Resistance *(R)*

The thermal resistance of any material shall be calculated as follows:

$$R = \frac{\Delta x}{k}$$

When R is the thermal resistance; its unit is square meter-degree Celsius per Watt (($m^2.^oC$)/W).

Δx is the material's thickness; its unit is in meters (m).

k is the coefficient of the material's thermal conductivity; its unit is Watt per square meter-degrees Celsius (W/($m^2.^oC$)).

(2.3) The Building's Overall Thermal Resistance

The calculation of the building's overall thermal resistance depends upon the type of wall material as follows:

(2.3.1) The wall consists of various types of materials:

The overall thermal resistance (R_r) *of any part of a building wall which consists of n types of materials and shall be calculated as follows:*

$$R_T = R_0 + \frac{\Delta x_1}{K_1} + \frac{\Delta x_2}{K_2} + \ldots + \frac{\Delta x_n}{K_n} + R_i$$

When R_T is the building wall's total thermal resistance; its unit is square meter-degrees Celsius per Watt (W/(m^2.^{o}C)).

R_0 is the building wall's total thermal resistance; its unit is square meter-degree Celsius per Watt (W/(m^2.^{o}C)).

R_i is the building wall's total thermal resistance; its unit is square meter-degree Celsius per Watt (W/(m^2.^{o}C)).

$\Delta x_1, \Delta x_2, \Delta x_3, \ldots, \Delta x_n$ is the thickness of each type of material contained in the building wall; its unit is meters (m).

$K_1, K_2, K_3, \ldots, K_n$ is the coefficient of thermal conductivity of each type of material used in the building wall.

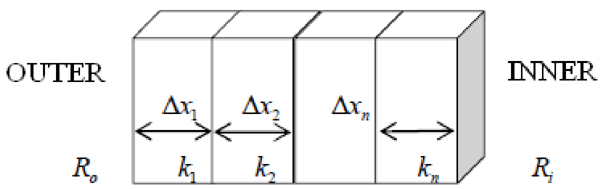

Figure 1 Thermal transfer through the building wall with the structure consisting of *n* types of different materials.

(2.3.2) A wall with air space inside

The overall thermal resistance (R_T) of any part of a building wall consisting of n types of different materials and with air space inside shall be calculated as follows*:*

$$R_T = R_0 + \frac{\Delta x_1}{K_1} + \frac{\Delta x_2}{K_2} + \ldots + R_a + \ldots + + \frac{\Delta x_n}{K_n} + R_i$$

When R_a is the thermal resistance of the air space within the building wall; its unit is square meter-degrees Celsius per Watt ((m^2.^{o}C) /W).

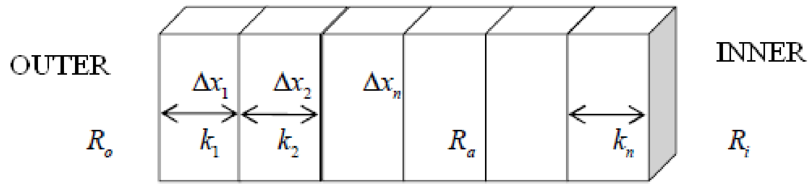

Figure 2 Thermal Resistance Through a Building Wall With Structure Consisting of N Types Of Different Materials and Air Space Inside

(2.4) Air film and space thermal resistance

The thermal resistance of air film on a building wall depends upon the air movement around building wall surface and the building wall's coefficient of thermal emittance with the values specified in Table 1.1 as follows:

Table 1.1 thermal resistance of air film for building walls:

Type of Materials Used for Building Wall	Thermal Resistance of Air Film ((m^2.^{o}C)/W)	
	At wall inner surface (R_i)	At wall outer surface (R_a)
Wall Surface With High Radiation Coefficient	0.120	.044
Wall Surface With Low Radiation Coefficient	0.299	-

In cases where the wall surface has a high thermal emittance coefficient, the use for the general wall surface will be deemed as having a high thermal emittance coefficient. In cases where the wall surface has a low thermal emittance coefficient, the surface will be used only for building walls with ray reflecting surfaces e.g. walls with ray reflecting foil, etc.

The thermal resistance of air space within a building wall depends upon the coefficient for thermal emittance of the wall surface adjoining the air space according to the values specified in Table 1.2 as follows:

Table 1.2 thermal resistance of air space within a building walls:

Types of Material Used As Inner Wall of Air Space	Thermal Resistance of Air Space According to Thickness of Air Space ((m^2.^{o}C)/W)		
	5 millimeters	20 millimeters	100 millimeters
Wall Surface With High Thermal Emittance Coefficient	0.110	0.148	0.160
Wall Surface With Low Thermal Emittance Coefficient	0.250	0.578	0.606

The coefficient for low thermal emittance shall be used when any or both surfaces in the air space are light reflective e.g. In cases where aluminum sheet is installed in the air space, etc. For general cases, the surface in the air space shall be deemed as having a high thermal emittance coefficient.

For air spaces between 5 millimeters and 20 millimeters thick or between 20 millimeters and 100 millimeters thick, the linear interpolation method shall be used to calculate the desired air space thermal resistance. For air spaces thicker than 100 millimeters, use the thermal resistance value for air spaces thicker than 100 millimeters.

(2.5) Coefficient of Thermal Conductivity *(k)* and Other Properties of the Materials

For normal construction materials, use the thermal conductivity coefficient with units in square meter-degrees Celsius per Watt (W m^2.^{o}C)). /(The material's density *(ρ),* which has a unit of kilograms per cubic meter (kg/m^3) and specific heat *(C_p),* which has a unit in kilojules per kilogram-degrees Celsius (kJ/(kg.^{0}C)) as specified in Table 1.3 as follows:

Table 1.3 Heat conductivity coefficient (*k*), density *(ρ),* specific heat *(C_p)* of various types of materials

Item	Materials	*k* (W m^2.°C))	*P* (kg/m^3)	C_p (kJ/(kg.°C))
1	Roof materials			
	(a) Concrete Roof Tiles	0.993	2400	0.79
	(b) Small Corrugated Asbestos Tiles	0.384	1700	1.00
	(c) Large Corrugated Asbestos Tiles	0.881	2000	1.00
	(d) Double-Corrugated Asbestos Tiles	0.395	2000	1.00
	(e) Asphalt Roofing Materials	0.821	1500	1.51
	(f) Light-weight Rooftop Tiles	0.341	930	0.88
	(g) Smooth Translucent Fiberglass Tiles	0.213	1340	1.88
	(h) Large Corrugated Translucent Fiberglass Tiles	0.181	1700	1.878
	(h) Translucent Ribbed Tiles	0.160	1340	1.88
	(i) Opaque White Fiberglass Tile Pairs	0.208	1500	1.88
2	Floor/wall materials			
	(a) Linoleum (petroleum carpet)	0.227	1200	1.263
	(b) Rubber Tiles	0.573	1900	1.26
	(c) Ceramic Tiles	0.338	2100	0.80
	(d) Marble	1.250	2700	0.80
	(e) Granite	1.2765	2600	0.79
	(f) Stone Slabs	0.290	2680	0.96
	(g) Sandstone	0.721	2440	0.96
	(h) Parquet Wood	0.167	600	0.96
3	Brick/concrete wall			
	(a) Non-plastered bricks	0.473	1600	0.798
	(b) Double-plastered bricks.	1.102	1700	0.79
	(c) Plastered bricks or bricks closed with mosaic or tiles on one side	0.807	1760	0.84
	(d) 80 mm Wide Non-Plastered Concrete Blocks	0.546	2210	0.92

Item	Materials	k (W m^2.°C))	P (kg/m^3)	C_p (kJ/(kg.^{0}C))
	(e) Concrete Slab	1.442	2400	0.92
	(f) Plastered Concrete (Cement Mixed with Sand)	0.72	1860	0.84
4	Lightweight Concrete; Varied Density			
	(a) 620 kilograms/cubic meters	0.180	620	0.84
	(b) 700 kilograms/cubic meters	0.210	700	0.84
	(c) 960 kilograms/cubic meters	0.303	960	0.84
	(d) 1,120 kilograms/cubic meters	0.346	1,120	0.84
	(e) 1,280 kilograms/cubic meters	0.476	1,280	0.84
	(f) Light Density Concrete Plaster	0.326	1,200	0.84
5	Ceiling/wall materials			
	(a) Gypsum sheets	0.282	800	1.09
	(b) Smooth asbestos tiles	0.397	1700	1.00
	(c) Ply wood	0.213	900	1.21
	(d) Fiber boards	0.052	264	1.30
	(e) Regular cello-crete	0.106	500	1.30
	(f) Foam celloi-crete	0.068	300	1.30
	(g) Sugarcane pulp fiber boards	0.052	250	1.26
	(h) Cork	0.042	144	2.01
	(i) Gypsum plaster	0.230	720	1.09
6	Fiberglass (blanket, rigid board and rigid pipe section)			
	(a) 10 kg density/cubic meter	0.046	10	0.96
	(b) 12 kg density/cubic meter	0.042	12	0.96
	(c) 16 kg density/cubic meter	0.038	16	0.96
	(d) 24 kg density/cubic meter	0.035	24	0.96
	(e) 32-48 kg density/cubic meter	0.033	36-48	0.96
	(f) 56-69 kg density/cubic meter	0.031	56-69	0.96

Item	Materials	k (W m^2.^{o}C))	P (kg/m^3)	C_p (kJ/(kg.^{0}C))
7	Asbestos (blanket and rigid board)			
	6.4-32 density	0.039	6.4-32	0.8
8	Polystyrene foam insulation			
	(a) 9 kg/cubic meter density	0.047	9	1.21
	(b)16 kg/cubic meter density	0.037	16	1.21
	(c) 20 kg/cubic meter density	0.036	20	1.21
	(d) 24-32 kg/cubic meter density	0.035	24-32	1.21
9	Polyethylene foam	0.029	45	1.21
10	Polyurethane foam	0.023-0.026	24-40	1.59
11	Wood			
	(a) Hard Wood	0.217	800	1.30
	(b) Moderately Hard Wood	0.176	600	1.30
	(c) Soft Wood	0.131	500	1.30
	(d) Ply Wood	0.144	800	1.30
12	Compressed Paper	0.086	400	1.38
13	Glass			
	(a) Clear Glass	0.960	2500	0.88
	(b) Tinted Glass	0.913	2500	0.88
	(c) Reflective Glass	0.931	2500	0.88
	(d) Mirror	0.853	2500	0.88
14	Metal			
	(a) Normal Aluminum Alloy	211	2672	0.896
	(b) Copper	388	8784	0.390
	(c) Steel	47.6	7840	0.500

In cases where the wall material is different from the materials specified in Table 1.3, use the test results or values obtained from an accredited agency.

(3) Equivalent Temperature Difference (TD_{eq})

The equivalent temperature difference is the difference between the temperature outside and inside the building, including the results of thermal absorption of solid wall, depending upon the wall's duration for the thermal absorption, coefficient for thermal absorption, wall mass, direction and slope. The following equation is to be used for the calculation:

(3.1) Thermal Absorption Coefficient

The thermal absorption coefficient of the outer surface of the solid wall used to calculate the equivalent temperature difference is to be used as specified in Table 1.4

Table 1.4 Thermal absorption coefficient of wall material and external paint of various types of wall used to calculate the equivalent temperature difference

Outer Surface of Building Wall	Thermal Absorption Coefficient	Remarks
Materials used to cover the surface Reflectors made of aluminum White marble White-washed gravels External paint White Silver Sparkled Silver or bronze	0.3	Reflective surface and white materials
Materials used to cover the surface Cream color or light color marble Cream color or light color granite Cream color or light color washed gravel Light color materials	0.5	Light colored materials

Outer Surface of Building Wall	Thermal Absorption Coefficient	Remarks
External paint Cream Light blue Light green Light yellow Light orange		

Table 1.4 – The Thermal Absorption Coefficient of the Outer Wall and External Paint of Various Types of Walls Used to Calculate the Equivalent Temperature Difference (cont'd)

Outer Surface of Building Wall	Thermal Absorption Coefficient	Remarks
Materials used to cover the surface Unpainted concrete Unpainted brick Unpainted fiber sheet Gray washed gravel Unpainted cemented asbestos External paint Red Blue Green Orange Rustic	0.7	Dark Colored Materials
Materials used to cover the surface Red brick Asphalt Dark gray and black concrete Dark green and dark red roofing materials	0.9	Dark Colored Materials

Outer Surface of Building Wall	Thermal Absorption Coefficient	Remarks
External paint Dark Blue or Dark Green Dark Gray Dark Brown Black		

(3.2) Wall Material's Density-Specific Heat Product (DSH)

In cases where the solid wall consists of one i material with density equal to ρ_i, specific heat equal to c_{pi} *and a e thickness of* Δx_i, *the* density-specific heat product is to be calculated by using the following equation:

$$DSH_i = (\rho_i)(c_{pi})(\Delta x_i)$$

For cases where the walls are opaque and made from various "n" materials, the product of the density and specific heat is to be calculated by the following equation:

$$DSH = DSH_1 + DSH_2 + \cdots + DSH_n$$

When DSH_i is the product of density and specific heat of material *i; its unit* is kilojules per square meter-degrees Celsius (kJ/(m^2.^{0}C)).

ρ_i is the density of material *i; its unit* is kilograms per square meter (kg/m^3) according to the value specified in Table 1.3.

c_{pi} is the volume of specific heat of material *i; its unit* is kilojules per kilogram-degree Celsius (kJ/(kg. ^{0}C)) according to the value specified in Table 1.3.

Δx_i is the thickness of material *i; its unit* is meters (m).

In cases where the wall has air space inside, aforementioned air space will be deemed as not having changed the wall's density-specific heat product.

(3.3) The wall's slope is the angle where the wall sits on the earth's surface or the ground. The vertical wall's slope is set to be 90 degrees.

(3.4) Solid wall's equivalent temperature difference (TD_{eq})

A solid wall's equivalent temperature difference for each type of building depends upon the thermal absorption coefficient of the wall's outer surface. The product of the density-specific heat of the wall materials, direction and slope will be according to the value specified in the appendix of this announcement.

(4) Overall thermal transfer coefficient of glass or transparent walls (U_f)

The overall thermal transfer coefficient of glass or transparent wall shall be calculated using the same method as the calculation of the overall thermal transfer coefficient of solid walls according to Item 2(2) using the equations in 2(2), 2(2.3), (2.3.1) or (2.3.2) depending upon the case and the type of glass or transparent wall.

The overall thermal transfer coefficient will use the values from the manufacturer wherein the aforementioned coefficient must have test results and calculation methods obtained from an accredited agency. In cases where there are no such values from the manufacturers, the calculation will be according to the following equation:

(4.1) Single layer glass

The overall thermal transfer coefficient of single layer glass or transparent walls will be calculated by the following equation:

$$U_f = \frac{1}{R_f} \quad \text{and}$$

$$R_f = R_i + \frac{\Delta x}{k_g} + R_o$$

When R_f is the overall thermal resistance of glass or transparent walls; its unit is square meter-degrees Celsius per Watt ((m^2.^{o}C) /W).

R_i *and* R_o is thermal resistance of the air film inside and outside the building; its unit is square meter-degrees Celsius per Watt ((m^2.^{o}C) /W) and will be according to the value specified in Table 1.1.

Δx is the thickness of the glass or transparent wall; its unit is in meters (m).

k_g is the thermal conduction coefficient of glass or transparent wall; its unit is Watt per square meter-degree Celsius (W/(m^2.^{o}C)).

(4.2) Laminated glass

The overall thermal transfer coefficient of laminated glass is to be calculated using the equations in 2(2), (2.3), (2.3.1)

(4.3) The window system consisting of multiple layers of glass or transparent wall and with air space inside.

The thermal resistance coefficient of the window system consisting of multiple layers of glass or transparent wall is to be calculated using the equations in 2(2), 2(2.3), and (2.3.2), and the thermal resistance of the air space is to be used as specified in Table 1.5 as follows:

Table 1.5 Thermal Resistance of Air Space In Between Glass or Transparent Wall

Air Space Thickness (mm)	Thermal Resistance of Air Space (($m^2.^oC$) /W)	
	Wall Surface with High Thermal Emittance Coefficient	Wall Surface with Low Thermal Emittance Coefficient
13	0.119	0.345
10	0.110	0.278
7	0.097	0.208
6	0.091	0.196
5	0.084	0.167

For air space between normal glass or transparent walls, the value for wall surfaces with high thermal emittance coefficients are to be used. For air space with values between the values specified in Table 1.5, the linear interpolation method shall be used to calculate the desired air space thermal resistance. For air spaces thicker than 13 millimeters, use the thermal resistance value of the air space thicker than 13 millimeters.

(5) The difference between the temperatures inside and outside the building (ΔT):

The Difference between the temperature inside and outside the building is the difference between the air temperature in the air conditioned areas of the building and the temperature outside the building which is used to calculate thermal conductivity through glass or transparent walls. In calculating $OTTV_i$ in 2(1) (1.1), the difference between the temperature inside and outside of the building is to use the values specified in Table 1.6 as follows:

Table 1.6 Temperature Differences Inside and Outside the Building for Each Type of Building

Building Type	Temperature Difference Inside and Outside the Building $\Delta T(^{o}C)$
Education Facility, Offices	5
Theaters, Department Stores, Service Facilities, Community Buildings	5
Hotels, Hospitals, Condominiums	3

(6) Solar Heat Gain Coefficient (SHGC)

The solar heat gain coefficient is the proportion of solar heat sent through the transparent or clear part of the wall material and roof and allowing the thermal transfer to enter the building. The aforementioned value includes the combination of solar heat directly sent through the glass or clear material and thermal transfer as a result of thermal absorption in the glass or clear material.

To calculate the solar heat gain coefficient, use the value obtained from the manufacturer of the glass or clear material with test results and calculation methods from an accredited agency. In cases where the aforementioned data is available, the values specified in Table 1.7 are to be used.

Table 1.7 - Solar Heat Gain Coefficient and Visible Transmittance, τ_{vis} of Various Types of Glass

Glass Thickness (mm)	Glass Type	Visible Transmittance (τ_{vis})	Solar Heat Gain Coefficient (SHGC)
Single Layer Non-Laminated Glass			
6	Clear glass	0.88	0.73
6	Bronze color glass	0.54	0.54
6	Green glass	0.76	0.54
6	Gray glass	0.46	0.52
6	Greenish blue glass	0.45	0.55
Single Layer Reflective Glass			
6	20%-Stainless Metal Plated Glass	0.20	0.28

Glass Thickness (mm)	Glass Type	Visible Transmittance (τ_{vis})	Solar Heat Gain Coefficient (SHGC)
6	20% Titanium plated clear glass	0.20	0.27
6	30% Titanium plated clear glass	0.30	0.35
Double layer non-plated glass			
6	Clear glass-clear glass	0.78	0.60
6	Bronze –clear glass	0.47	0.41
6	Green – clear glass	0.68	0.41
6	Gray – clear glass	0.41	0.39
6	Greenish blue – clear glass	0.67	0.43
6	High quality green –clear glass	0.59	0.33
Double layer reflective glass			
6	30% Titanium plated and clear glass	0.27	0.25
Double layer glass with plated material with low thermal emittance coefficient (thermal emittance coefficient = 0.2)			
6	Glass plated with low thermal emittance coefficient and clear glass	0.73	0.53
Double layer glass with plated material with low thermal emittance coefficient (thermal emittance coefficient = 0.1)			
6	Glass plated with low thermal emittance coefficient and clear glass	0.72	0.44
6	High quality green glass–glass plated with low thermal emittance coefficient	0.57	0.27

(7) Shading coefficient (*SC*)

The shading coefficient is the proportion of the solar thermal that passes through the shading instrument to the transparent or glass part of the window and shall be calculated using the following equation:

(7.1) Sun Position And Direction

The sun's position and direction acting upon any point on the earth can be identified by using the sun's altitude (αs), which is the angle where the vertical ray of the sun acts upon the earth's surface and the sun's azimuth (γ_s), which is the angle where the sun's horizontal position acts upon the earth's south.

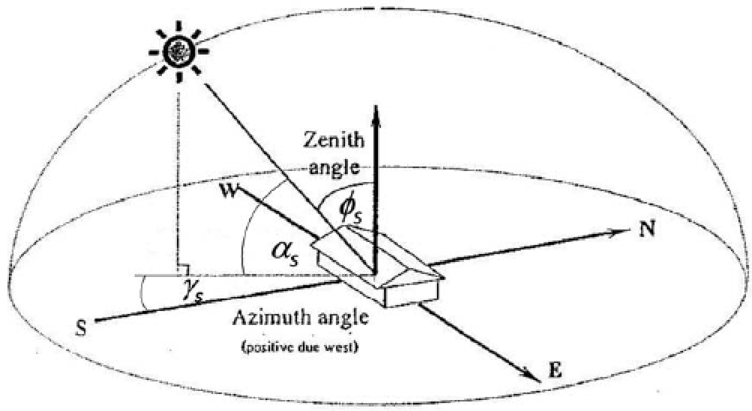

Figure 3 The sun's position and direction related to the building site on the earth's surface:

The sun's position and direction are to be calculated by the following equation:

(7.1.1) Solar Time

Solar time is the time that corresponds to the sun's position. The time when the sun's altitude is at the highest point is solar noon. Solar time is to be calculated using the following equation:

$$t_s = t_l - 4(L_{gs} - L_{gl}) + E_{qt}$$

Where t_s is solar time.

t_l is local standard time.

L_{gs} is the standard longitude for Thailand, which is 105 degrees east.

L_{gl} is the longitude of the position under consideration for Thailand. The value of 100.5 degree east will be used.

E_{qt} is the equation of time or the difference between solar time and normal time. Its unit is in minutes.

The equation for time can be calculated by:

$$E_{qt} = 9.87(\sin 2B) - 7.53(\cos B) - 1.5(\sin B)$$

$$B = \frac{(360^{o})(j_d - 81)}{364}$$

Where j_d is the Julian date, i.e., the order of the days in one year. For example, 1 = 1 January or 152 = 1 June, etc.

(7.1.2) The mathematical relationship between the sun's altitude and azimuth can be calculated by the following equation:

$$\text{Sin } \alpha_s = (\sin L_t)(\sin \delta) + (\cos L_t)(\cos \delta)(\cos \omega)$$

$$\sin \gamma_s = \frac{(\cos \delta)(\sin \omega)}{(\cos \alpha_s)}$$

Where L_t is the latitude of the site being considered, e.g., Bangkok's latitude is 13.7 degrees north.

δ is the sun's declination angle. Its unit is in radians (rad).

ω is the solar hour angle. Its unit is in radians (rad)

$$\omega = \pi (t_s - 12) / 12$$

The sun's declination angle is the angle where the sun's beam to the middle of the earth acts upon the equatorial plane. The sun's declination angle for any Julian day (j_d) can be calculated by using the following equation:

$$\delta = 23.45 \sin\left(\frac{(360^{\circ})(284 + j_d)}{365}\right)$$

(7.2) Calculation of the Shading Coefficient

The sun's position and direction are to be calculated from the following equation:

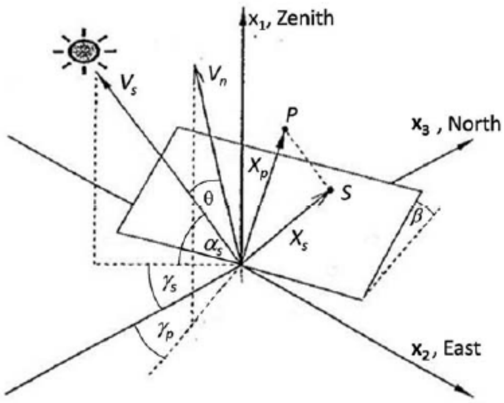

Figure 4 Position and direction of various planes and points on planes related to the sun's position

Consider the coordinate (*x1 ,x2 ,x3*) ,which is specified by the zenith line, the east and the north, the vector showing the sun's direction solar vector (V_s^x)and the vector of tilted plane (V_n^x) , which is perpendicular to the tilted plane, can be calculated from the following equation:

$$V_s^x = \begin{bmatrix} \sin\alpha_s \\ -\cos\alpha_s \cdot \sin\gamma_s \\ -\cos\alpha_s \cdot \cos\gamma_s \end{bmatrix} , \quad \text{Solar Vector}$$

$$V_n^x = \begin{bmatrix} \cos\beta \\ -\sin\beta \cdot \sin\gamma_p \\ -\sin\beta \cdot \cos\gamma_p \end{bmatrix} , \quad \text{Tilted Surface Vector}$$

Where θ is the angle between the two vectors, the value for cos θ is to be calculated from the following equation:

$$\cos\theta = (V_s^x . V_n^x)$$

$$= (\sin\alpha_s)(\cos\beta) + (\cos\alpha_s)(\sin\gamma_s)(\sin\beta)(\sin\gamma_p) + (\cos\alpha_s)(\cos\gamma_s)(\sin\beta)(\cos\gamma_p)$$

Where β *is the inclination angle of the surface*

γ_p *is the azimuth of the surface* cos θ is the cosine of the angle between the surface being considered and the sun's direction (solar vector)

(7.2.1) Solar thermal on the surface without shading

In the event that the wall's light opening or any surface has no shading, the total thermal falls on the aforementioned surface can be calculated from the following equation:

$$E_{et\theta} = E_{es}\cos\theta + E_{ed}\frac{(1+\cos\beta)}{2}$$

Where E_{es} is the sun's direct ray, its unit is Watt per square meter (W/m2)

E_{ed} is the sun's diffusions ray on the horizontal surface. Its unit is Watt per square meter (W/m2)

(7.2.2) Position of shadow over the surface being cosidered

From figure , if X_p is the vector for the coordinate of point *P,* which is above the surface being considered and the distance from the tilted surface to point *P is h.*

Let S be the shadow of point P that falls on the surface under consideration when receive sunlight, vector X_s being the coordinate of point *S, vector* X_s *, vector* X_p*, and vector* V_s^x

$$X_s = X_p - \frac{hV_s^x}{\cos\theta}$$

The shadow will appear on the surface being considered only when the point that causes shadow is above or in front of the surface and when the sun faces the surface being considered.

(7.2.3) Shadow causes by shading instrument

Consider the horizontal shading instrument installed at the front of the window in the picture as follows:

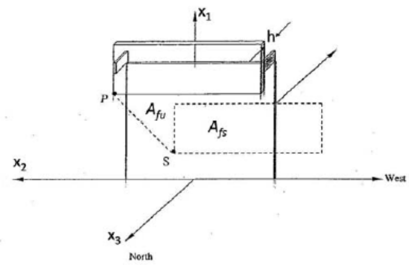

Figure 5 - The Horizontal Shading Instrument Installed at the Front of the Window

When the window faces north, point P is at the corner of the shading instrument. If the coordinate of point P can be replaced by $X\,p$, the coordination of point S or the shadow point occurs on the window surface due to point P being replaced by $X\,s$, X_s can be calculated using the equation in 2(7) (7.2) (7.2.2). In this case, h is the distance between shading instrument and window, the area of shade that occurs is the area caused by the connection of point of shadow caused by each corner of the shading instrument. Area *Afs* is area that the shade occurs on the window,
which is the area not receiving direct radiation from the sun. *Afu* is the area the shade not occurred on the window. Both the direct radiation and partial solar radiation thus falls on this area *Afu* while there is only partial solar radiation that falls on the area *Afs.*

(7.2.4) Solar radiation that falls on window with shading instrument

If the area of window not under the shade is *Afu* and total window area is Af , Solar radiation that falls on window with shading instrument(*Eew*) for window with tilt angle βcan be calculated using the following equation:

$$E_{ew} = (A_{fu} / A_f)(E_{es})(\cos\theta) + (E_{ed})\frac{(1+\cos\beta)}{2}$$

(7.2.5) Shading coefficient (*SC*)

Shading coefficient (*SC*)is to be calculated using the following equation:

$$SC = \frac{E_{ew}}{E_{et\theta}}$$

When E_{ew} is solar radiation that passes through shading instrument and falls onto the window being considered. Its unit is Watt per square meter (W/m2)

$E_{et\theta}$ is total solar radiation that falls falls onto the window being considered. Its unit is Watt per square meter (W/m2).

The annual average shading coefficient can be calculated from the ratio of the sum of solar radiation that falls on the window being considered throughout building usage on each of the 4 reference days and the sum of total solar radiation that falls on the window being considered virtually there are no shading instrument during the same period of time wherein the 4 reference days are 21 March, 22 June, 23 September and 22 December.

Annual average shading coefficient can be calculated using the following equation:

$$(SC)_y = \left[\frac{\left(\sum_{h=i}^{n} E_{ew}\right)_{21March} + \left(\sum_{h=i}^{n} E_{ew}\right)_{22June} + \left(\sum_{h=i}^{n} E_{ew}\right)_{23September} + \left(\sum_{h=i}^{n} E_{ew}\right)_{22December}}{\left(\sum_{h=i}^{n} E_{et\theta}\right)_{21March} + \left(\sum_{h=i}^{n} E_{et\theta}\right)_{22June} + \left(\sum_{h=i}^{n} E_{et\theta}\right)_{23September} + \left(\sum_{h=i}^{n} E_{et\theta}\right)_{22December}} \right]$$

When $(SC)y$ is annual average of shading coefficient of the instrument outside the building
i and n are the hour that the sun rises and falls

For direct radiation (*Ees*) and fragmented radiation (*Eed*) of the sun on a horizontal surface for 4 reference days, use the values specified in Table 1.8 as follows:

Table 1.8 – Sun Beams (E_{es}) and Diffusions, (E_{ed}) for 4 Reference Days

Time	Solar Radiation Energy (W/m^2)							
	21 March		22 June		23 September		22 December	
	Beam	Diffuse	Beam	Diffuse	Beam	Diffuse	Beam	Diffuse
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.00	0.0	0.0	7.5	5.6	0.0	0.0	0.0	0.0
7.00	68.5	44.9	105.0	77.8	94.4	77.1	64.4	19.9

Time	Solar Radiation Energy (W/m^2)							
	21 March		22 June		23 September		22 December	
	Beam	Diffuse	Beam	Diffuse	Beam	Diffuse	Beam	Diffuse
8.00	185.7	121.6	196.2	145.4	202.3	165.1	270.0	83.5
9.00	290.1	190.0	275.6	204.3	296.2	241.8	454.4	140.5
10.00	374.8	245.5	338.6	250.9	369.9	302.0	603.3	186.5
11.00	433.8	284.1	381.2	282.6	418.3	341.4	704.9	217.9
12.00	463.2	303.4	401.1	297.3	437.9	357.5	751.3	232.2
13.00	461.0	301.9	397.0	294.2	427.6	349.0	738.9	228.4
14.00	427.3	279.8	369.1	273.6	388.0	316.7	668.7	206.7
15.00	364.5	238.7	319.1	236.5	321.7	262.6	546.1	168.8
16.00	276.7	181.2	250.0	185.3	233.5	190.6	380.8	117.7
17.00	170.0	111.3	165.9	123.0	129.2	105.5	185.6	57.4
18.00	51.7	33.9	72.0	53.3	16.1	13.1	0.0	0.0
19.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(8) Effective solar radiation (*ESR*)

Effective solar radiation is solar radiation that falls on walls with different tilted angles. The wall's tilt angle is to be measured from the corner of the wall that acts upon the earth's surface (or the ground) wherein the vertical wall has a tilt angle of 90 degree and the horizontal wall (or flat roof) has a tilt angle of 0 degree.

For effective solar radiation for various angles and wall directions of various types of building, the values specified in table 1.9, 1.10 and 1.11 are to be used (for tilt angles and directions not shown in the table, an estimated value is to be used) as follows:

Table 1.9 Effective Solar Radiation (*ESR*) For Education Buildings or Offices

Angle (Degrees)	Effective Solar Radiation According to Wall Direction (W/m^2)							
	North	North-east	East	South-east	South	South-west	West	North-west
0	437.38	437.38	437.38	437.38	437.38	437.38	437.38	437.38
15	405.00	421.74	433.61	440.00	441.62	438.90	431.51	419.53
30	358.99	390.20	412.96	425.48	428.59	422.98	408.39	358.65
45	306.68	348.31	379.58	397.17	401.47	393.20	372.57	341.61
60	255.37	301.60	337.61	358.44	363.45	353.20	328.62	293.33
75	212.39	255.60	291.21	312.65	317.70	306.52	281.11	246.70
90	185.06	215.84	244.53	263.14	267.41	256.82	234.58	207.62

Table 1.10 Effective solar radiation for theaters, business center, service facility, department store, or community building

Angle (Degrees)	Effective Solar Radiation According to Wall Direction (W/m^2)							
	North	North-east	East	South-east	South	South-west	West	North-west
0	326.55	326.55	326.55	326.55	326.55	326.55	326.55	326.55
15	303.15	307.90	315.66	323.63	330.14	333.80	331.91	321.31
30	268.08	278.60	293.82	308.44	319.42	324.35	319.10	299.32
45	227.46	243.07	264.27	283.71	297.18	301.59	292.50	266.04
60	187.41	205.70	230.29	252.20	266.21	268.90	256.53	226.97
75	154.06	170.92	195.12	216.63	229.31	229.66	215.55	187.56
90	133.52	143.11	162.04	179.75	189.27	187.26	173.98	153.31

Table 1.11 - The Effective Solar Radiation (ESR) For Hotels, Hospitals Or Condominiums

Angle (Degrees)	Effective Solar Radiation According to Wall Direction (W/m^2)							
	North	North-east	East	South-east	South	South-west	West	North-west
0	191.44	191.44	191.44	191.44	191.44	191.44	191.44	191.44
15	177.19	185.24	190.45	193.01	193.33	191.76	188.38	183.39
30	157.51	171.84	181.79	186.87	187.63	184.64	178.12	168.59
45	134.67	153.68	167.29	174.48	175.71	171.59	162.54	149.52
60	112.13	133.17	148.76	157.33	158.93	154.12	143.54	128.65
75	93.08	112.74	128.05	136.87	138.66	133.74	123.01	108.45
90	80.68	94.81	106.98	114.57	116.26	111.96	102.86	91.40

Part 2

The Calculation of Roof Thermal Transfer Value (RTTV)

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3. The roof thermal transfer value is to be calculated according to specified criteria and methods as follows:

(1) Roof thermal transfer value (*RTTV*)

(1.1) The roof thermal transfer of each section ($RTTV_i$) is to be calculated using the following equation:

$$RTTV_i = (U_r)(1 - SRR)(TD_{eq}) + (U_s)(SRR)(\Delta T) + (SRR)(SHGC)(SC)(ESR)$$

Where $RTTV_i$ is the overall thermal transfer of section of the roof being considered. Its unit is Watt per square meter (W/m^2)

U_r is the coefficient of the overall thermal transfer value of a solid wall, it's unit is Watt per square meter-degree celcius (W/(m^2.^{o}C))

SRR is the ratio between transparent area of the roof and the roof's total area being considered

TDeq is the equivalent temperature difference between outside and inside the building including the result of the solar ray absorption of the roof. Its unit is degree celcius (^{o}C)

U s is the coefficient of the overall thermal transfer value of transparent roof. Its unit is Watt per square meter-degree celcius (W/(m^2.^{o}C))

ΔT is the difference between the temperature inside and outside the building, its unit is degree celcius (^{o}C)

SHGC is the coefficient of the thermal transfer value from solar ray which is sent through a transparent roof

SC is the shading coefficient of the shading instrument

ESR is the value solar radiation which has an effect on the thermal transfer through transparent and/or solid roof. Its unit is in Watt per square meter (W/m^2)

(1.2) The roof thermal transfer, which is the overall weighted average value of each part of the roof ($RTTV_i$), is to be calculated by the following equation:

$$RTTV = \frac{(A_{w1})(RTTV_1) + (A_{w2})(RTTV_2) + \cdots + (A_{wi})(RTTV_i)}{A_{w1} + A_{w2} + \cdots + A_{wi}}$$

Where A_{wi} is the area of the roof being considered including solid and transparent areas. Its unit is square meter (m^2)

$RTTV_i$ is thermal transfer of each section of the roof. Its unit is Watt per square meter (W/m^2)

(2) Solid Wall Thermal Transfer Coefficient (U_r)

The solid wall thermal transfer coefficient (U_r) for each section is to be calculated using the following method:

(2.1) Thermal Transfer Coefficient (U)

Calculate by the same method as in 2 (2) (2.1).

(2.2) Roof Thermal Resistance Coefficient (R)

Calculate by the same method as in 2 (2) (2.2).

(2.3) The roof total thermal resistance (R) is to be calculated using the following method:

(2.3.1) For roofs consisting of various types of materials, the calculation will employ the same method as in 2 (2) (2.3) (2.3.1).

(2.3.2) For roofs with air space inside, the calculation will employ the same method as 2 (2) (2.3) (2.3.2).

(2.4) Roof Tilt Angle

The roof tilt angle is the angle where the roof acts upon the earth's surface or the ground. The horizontal roof is specified to have a tilt angle of 0 degrees.

(2.5) Thermal resistance of air film and air space

The thermal resistance of air film and air space are to be calculated according to the following method:

(2.5.1) For roof air film thermal resistance, values specified in the following table 1.12 are to be used:

Table 1.12 Roof Air Film Thermal Resistance Values

Types of Materials Used to Build Walls	Thermal Resistance of Air Film ($(m^2.^oC)/W$)				
	At Roof's Inner Surface (R_i)				At the Roof's Outer Surface (R_a) at Any Tilt Angle
	0 degrees	22.5 degrees	45 degrees	60 degrees	
Roof With High Radiation Coefficient	0.162	0.148	0.133	0.126	.055
Roof With Low Radiation Coefficient	0.801	0.595	0.391	0.249	

(2.5.2) For roof air space thermal resistance, use the values specified in Table 1.13:

Table 1.13 Roof Air Space Thermal Resistance Values

Types of Material Used as Outer Surface of the Roof		Thermal Resistance of Air Space According to the Thickness of Air Space ($(m^2.^oC)/W$)		
		5 millimeters	20 millimeters	100 millimeters
Roof Surface With High Thermal Emittance Coefficient				
Angle from Horizontal Surface	0 degrees	0.11	0.148	0.174
	22.5 degrees	0.11	0.148	0.165
	45 degrees	0.11	0.148	0.158
Wall Surface With Low Thermal Emittance Coefficient				
Angle from Horizontal Surface	0 degrees	0.25	0.572	0.423
	22.5 degrees	0.25	0.571	1.095
	45 degrees	0.25	0.570	0.768

For cases in general, the roof surface shall be deemed as having a high thermal emittance coefficient. The coefficient for low thermal emittance is to be used when the roof surface on the side adjoining the air space is thermal reflective, e.g. a roof with an installation of reflective foil, etc.

For air spaces in the roof between 5 millimeters and 20 millimeters or 20 millimeters and 100 millimeters thick, the linear interpolation method is to be used to calculate the desired air space thermal resistance for each section. For air spaces thicker than 100 millimeters, use a thermal resistance value of air space with 100 millimeters thickness.

(2.5.3) In case of the ceiling exceeds 200 millimeter from the roof and there is no insulation insert between them, Air Space Thermal Resistance Values between them should be used for the calculation as followings:

Table 1.14: Air Space Thermal Resistance Values between roof and ceiling

Types of Materials Used to Make the Ceiling	Air Space Thermal Resistance $((m^2.^oC)/W)$
Roof Surface with High Thermal Emittance Coefficient	0.458
Roof Surface with Low Thermal Emittance Coefficient	1.356

(2.6) For the thermal conductivity coefficient (*k*) and other properties of the materials, use the values in Table 1.3:

(3) Equivalent Temperature Difference (TD_{eq})

The equivalent temperature difference is the difference between the temperatures inside and outside the building roof, including the results of the roof thermal absorption, depending upon the roof's duration for the thermal absorption, thermal absorption coefficient, roof mass and direction and tilt angle. The following equation is to be used for the calculation:

(3.1) Thermal Absorption Coefficient

For the thermal absorption coefficient of the outer surface of the roof used to calculate the equivalent temperature difference, values specified in Table 1.4 are to be used.

(3.2) Solid roof Density-Specific Heat Product (*DSH*)

A solid roof's density-specific heat product is to be calculated using the same method as 2 (3) (3.2)

(3.3) Solid roof Equivalent Temperature Difference (TD_{eq})

For a solid roof's equivalent temperature difference (TD_{eq}) for various types of buildings, the values specified in the appendix are to be used.

(4) Overall Thermal Transfer Coefficient of Glass or Transparent Roofs (U_f)

The overall thermal transfer coefficient of a transparent roof will use the values from the manufacturer wherein the aforementioned coefficient must have test results and calculation methods obtained from an accredited agency. In cases where there are no such values from the manufacturers, the calculation method is to be the same as the thermal transfer of glass or transparent walls (U_f) according to 2(4). For the thermal resistance of air film and air space within transparent roofs, use the values in Table 1.12, 1.13 and 1.14:

(5) Temperature Difference between the Inside and Outside the Building (ΔT)

The temperature difference between the inside and outside of the building is the difference between the air temperature in the air conditioned area within the roof and the temperature outside the building which is used to calculate thermal conductivity through glass or transparent walls. In calculating the $RTTV_i$ in 3(1) (1.1). Use the values specified in Table 1.6 for the temperature difference between inside and outside the building for each type of building just as in the case of building walls.

(6) Solar Heat Gain Coefficient (SHGC)

The solar heat gain coefficient is the proportion of solar heat sent through the transparent or clear part of the roof material and allowing heat to occur within the building. The aforementioned value includes the combined value of solar heat directly sent through the transparent roof and the thermal emittance absorbed in the roof transparent material and transferred into the building. For the calculation of the solar heat gain coefficient, use the value obtained from the manufacturer with test results and calculation methods from an accredited agency. In cases where the aforementioned is not available, use the values specified in Table 1.7.

(7) Shading Coefficient (SC)

For the roof shading coefficient, the calculation method will be the same as 2(7)

(8) Effective Solar Radiation (ESR)

For the effective solar radiation of various types of roofs, use the values specified in Table 1.9, 1.10 and 1.11 as in the case of building walls.

Section 2
Calculation of Maximum Lighting Power

4. The calculation of maximum lighting power must comply with the following criteria and methods:

The maximum lighting power in area i, i.e. the average lighting power per total usage area of area, is to be calculated by the following equation:

$$LPD = \frac{\sum_{i=1}^{n}(A_i(LPD_i))}{\sum_{i=1}^{n}A_i}$$

Where *LPD i* is the average lighting power installed per *i* area. Its unit is Watts per square meter (W/m2)

LW_i is the sum of the rating of all light bulbs installed in area *i*. Its unit is Watts (W).

BW_i is the sum of power lost of all ballasts installed in area *i*. Its unit is Watt (W).

NW_i is the sum of power rating of the lighting system in area *i* replaced by natural light under the conditions of the use of renewable power in the building. Its unit is Watts (W) in Section 6.

A_i is the total usage space of area *i*. Its unit is square meter (m^2)

Maximum lighting power installed in the building, which is the average maximum power installed per building area excluding parking space, is to be calculated using the following equation:

$$LPD = \frac{\sum_{i=1}^{n}(A_i(LPD_i))}{\sum_{i=1}^{n}A_i}$$

Where *LPDi* is the average lighting power installed per *i* area. Its unit is Watt per square meter(W/m2)

Section 3
The Calculation of the Coefficient of Performance, Energy Efficiency, and Power per Refrigeration TON for the Air Condition System

5. The coefficient of performance energy efficiency and power per refrigeration TON for the air conditioning system are to be calculated according to the following criteria and method:

(1) Small air conditioner

The coefficient of performance (*COP*), i.e. the ratio between the total net performance of the air conditioning system (Watts) and power rating (Watts), is to be calculated by the following equation:

$$COP = \frac{Q}{W}$$

Where *Q* is the total net performance of the air conditioning system; its unit is Watts (W).
W is the power rating of the air conditioner. Its unit is Watts (W).

The energy efficiency is the efficiency of the air conditioning system, which is specified in the form of energy efficiency ratio.

The energy efficiency ratio (*EER*), i.e. the ratio between the air conditioning system's net performance (BTU/hour) and power rating (Watts), is to be calculated by the following equation:

$$EER = 3.412(COP)$$

Where *EER* is the energy efficiency ratio; its unit is BTU/hour/Watt (Btu/h) /W)

(2) Large air conditioning system.

For large water cooling systems for air conditioning systems installed in the building, the coefficient of performance (*COP*), and power per refrigeration TON are to be calculated as follows:

The coefficient of performance is to be calculated by the same method as the small air conditioning system.

Power per refrigeration TON, i.e. the ratio between the power rating (kW) and the total net performance of the water cooling system (*TON*), is to be calculated by the following equation:

$$CHP = \frac{kW}{TON}$$

Where *CHP* is power per refrigeration TON; its unit is kilowatt per ton.

kW is the power rating of the water cooling system at maximum load. Its unit is kilowatts. Use the values from test results or values certified by the manufacturer of the instrument or an accredited institute.

TON is the water cooling system's net refrigeration performance at maximum load. Its unit is refrigeration TON, (RFT). The value from the test results or the value certified by the manufacturer of the instrument or by an accredited institute is to be used.

For power per refrigeration TON for other parts of the air conditioning system powered by electricity consisting of a heat radiation system, cooling water distribution system, and cool air distribution system are to are to be calculated using the following equation

$$MP = \frac{CW + PW + FW}{TON}$$

Where *MP* is the power per refrigeration TON for other parts of the air conditioning system powered by electricity; its unit is kilowatts per refrigeration TON.

CW is the power rating of the heat radiation system. Its unit is kilowatts (kW). Use the values from the test results or the values certified by the manufacturer of the instrument or an accredited institute.

PW is the power rating of the cooling water distribution system. Its unit is kilowatts (kW). Use the values from the test results or the values certified by the manufacturer of the instrument or an accredited institute.

FW is the power rating of the cool air distribution system. Its unit is kilowatts (kW). Use the values from the test results or the values certified by the manufacturer of the instrument or an accredited institute.

Section 4
The Calculation of Efficiency and Coefficient of Performance of Water Heater

6. For the efficiency and coefficient of the performance of water heating devices installed in the building, calculate according to the following criteria and methods:

(1) The calculation of efficiency for steamers and boilers
Steamer and boiler efficiency are to be calculated using the following equation:

$$Eff = \left(\frac{h_s - h_w}{(F)(HHV)} \right) S \times 100$$

Where Eff is the steamer and boiler efficiency (%).

h_s is the enthalpy value of the hot steam or hot water produced at the steamer and boiler (mega Joule/ton :MJ/ton) from the steam table for steam and from the enthalpy table for hot water.

h_w is the enthalpy value of water at 27 degrees Celsius and the pressure one atmosphere. Use the value of 113 mega Joule/ton here.

S is the amount of steam or hot water produced. Its unit is tons/day (ton/d) and can be obtained from the steam or boiler measuring instrument.

F is the amount of oil or gas consumed. Its unit is tons/day (ton/d)

HHV is the higher heating value of the oil or gas consumed; its unit is mega Joules/ton (MJ/ton)

(2) The calculation of the coefficient of the performance of air-source heat pump water heaters.

The coefficient of the performance of the air-source heat pump water heaters, i.e. the ratio between the water heating performance and power consumption, is to be calculated by the following equation:

$$COP = \frac{Q}{W}$$

Where *COP* is the coefficient of the performance of the air-source heat pump water heater.

Q is the heat used to produce hot water; its unit is in Watts (W)

W is the power rating used; its unit is in Watts (W)

Section 5
The Calculation of Overall Power Consumption for the Building

7. The Calculation of Overall Power Consumption for the Building

In cases where the efficiency of the instrument or one or more systems of the building under consideration does not pass the criteria for energy efficiency specified in Section 1, 2 or 3, the aforementioned building may be evaluated according to overall building energy consumption criteria by calculating the building's overall power consumption within a period of 1 year and comparing the value obtained with the overall power consumption for 1 year in the reference building. The building will pass overall power consumption criteria only when the building's overall power consumption for 1 year is lower than that of the reference building which has the same usage area, direction, and building perimeter area on each side as the building under construction or renovation. In addition, the reference building must have values for the building perimeter system, lighting system and air conditioning systems according the requirements for each system.

The building overall power consumption for both cases is to be calculated by using the following equation:

$$E_{pa} = \sum_{i=1}^{n}\left[\frac{A_{wi}(OTTV_i)}{COP_i} + \frac{A_{ri}(RTTV_i)}{COP_i} + A_i\left\{\frac{C_l(LPD_i) + C_e(EQD_i) + 130C_o(OCCU_i) + 24C_v(VENT_i)}{COP_i}\right\}\right]n_h + \sum_{i=1}^{n} A_i(LPD_i + EQD_i)n_h - PVE$$

Where *LPD i* is average lighting power installed per area *I*; its unit is Watts/square meter (W/m2).

EQD_i is the power used for equipment and instrument per area *i*. Its unit is Watts/square meter (W/m^2).

$OCCU_i$ is the building user density in area *I*; its unit is person per square meter ($person/m^2$).

$VENT_i$ is the air ventilation rate per area I; its unit is liter per second (l/s)

COP_i is the minimum coefficient of performance for small air conditioning systems or large air conditioning systems used for area *i*.

A i is air conditioned area *i* (area *i*)*; i*ts unit is square meters (m^2).

PVE is the annual average power value produced by solar cells. Its unit is kilowatts/hour (kWh) (refer to Section 6) for the calculation of overall power consumption of the reference building. There is no PVE in the equation in cases

where the building outer walls surround area i

$OTTV_i$ is the overall thermal transfer of the outer wall under consideration, its unit is Watts/ square meter (W/m^2)

$RTTV_i$ is the overall thermal transfer for the building under consideration. Its unit is Watts/ square meter) (W/m^2).

A_{wi} is area of the wall being considered, including solid and transparent areas of the walls; tts unit is square meters (m^2)

A_{ri} is area of the roof being considered, including the solid and transparent areas of the roof. Its unit is square meters (m^2)

C_l, C_e ,C_o and C_v is the coefficient of heat that is a burden to the air conditioning system from lighting, equipment and appliances, building users and air conditioning systems, respectively. Use coefficients from Table 1.15 which shows the coefficient of heat that is a burden to the air conditioning system and number of usage hours for each type of building.

n_h is the number of usage hours for each type of building

Table 1.15 The coefficient of heat that is a burden to the air conditioning system and number of usage hours for each type of building

Building Type	C_l	C_e	C_o	C_v	n_h
Education facilities, offices	0.84	0.85	0.90	0.90	2340
Theaters, shopping centers, service facilities, department stores, community buildings	0.84	0.85	0.90	0.90	4380
Hotels, hospitals, condominiums	1.0	1.0	1.0	1.0	8760

Section 6
The calculation of effectiveness, Light to Solar Gain Ratio and average annual power production of the use of renewable energy in the building's various systems

8. Exclusion of partial power use in building with recyclable power- In cases where the building is designed to use natural light so lighting will meet the requirements and terms stating that window glass along the building perimeter must have at least 0.3 for the effectiveness of the shading coefficient and the Light to Solar Gain Ratio over 1.0 wherein the following calculation method is to be used:

(1) The effectiveness of the shading coefficient is to be calculated using the following equation

$$SC_{eff} = (SC)(\tau_{vis})$$

Where SC_{eff} is the effectiveness of the shading coefficient
SC is the shading coefficient
τ_{vis} *is* visible transmittance

(2) The Light to Solar Gain ratio of the glass is to be calculated using the following equation:

$$LSG = \frac{\tau_{vis}}{SHGC}$$

Where *LSG* is the ratio for Light to Solar Gain
SHGC is solar heat gain coefficient

In the event that there is power generation in the building, it is possible to deduct the power value generated from the overall power consumption of the building prior to comparing to overall power consumption of the reference building in Section 5.

The solar power produced is to be calculated from the average annual power value produced by the solar cell obtained from the calculation according to the following equation:

$$PVE = \frac{(9)(365)(A_{mod})(\eta_{sys})(ESR_{PV})}{1000}$$

Where *PVE* is annual the average power value produced by the solar cell. Its unit is kilowatt hours (kWh)

(9)(365) is the average number of hours the solar cell can produce power in one year wherein (9) is the average number of hours that sunlight is available in 1 day and (365) is the number of days in 1 year.

A_{mod} is the total area in which the solar cell panel is installed. Its unit is square meters (m^2)

η_{sys} is the system's overall efficiency

ESR PV is the effective solar radiation at tilt angle and direction corresponding to the installation of the solar cell, its unit is Watts per square meter (W/m^2), use the values specified in Tables 1.9 for all types of buildings (for tilt angles and directions not shown in the table, an estimated value is to be used).

Announced on 14th July, 2009
Wannarat Channukul
Minister of Energy

Appendix

Table 1 – Equivalent temperature difference, TD_{eq} of the opaque wall for educational place and office building.

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	0.5	0.7	0.9
0	***All direction***	15	16.5	25.0	33.6	42.1
		30	16.2	24.6	33.0	41.5
		50	15.7	24.0	32.3	40.6
		100	14.4	22.3	30.3	38.2
		200	12.1	19.1	26.1	33.1
		300	10.5	16.8	23.0	29.2
		400	10.2	16.2	22.2	28.3
15	***North***	15	15.8	23.6	31.5	39.3
		30	15.4	23.2	31.0	38.7
		50	14.9	22.6	30.2	37.9
		100	13.7	21.0	28.3	35.6
		200	11.6	18.0	24.5	30.9
		300	10.1	15.9	21.6	27.4
		400	9.8	15.4	20.9	26.5
	Northeast	15	16.2	24.4	32.6	40.8
		30	15.8	24.0	32.1	40.2
		50	15.4	23.4	31.4	39.4
		100	14.1	21.8	29.4	37.0
		200	11.9	18.7	25.4	32.2
		300	10.4	16.4	22.4	28.4
		400	10.1	15.9	21.7	27.5

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
15	***East***	15	16.4	24.9	33.3	41.8
		30	16.1	24.4	32.8	41.2
		50	15.6	23.8	32.1	40.3
		100	14.4	22.2	30.1	37.9
		200	12.1	19.0	25.9	32.9
		300	10.5	16.7	22.8	29.0
		400	10.2	16.2	22.1	28.1
	Southeast	15	16.6	25.1	33.7	42.3
		30	16.2	24.7	33.2	41.7
		50	15.7	24.1	32.4	40.8
		100	14.5	22.4	30.4	38.4
		200	12.2	19.2	26.2	33.2
		300	10.6	16.8	23.1	29.3
		400	10.2	16.3	22.3	28.4
	South	15	16.6	25.2	33.8	42.5
		30	16.2	24.8	32.6	41.0
		50	15.8	24.2	32.6	41.0
		100	14.5	22.5	30.5	38.5
		200	12.2	19.3	26.3	33.4
		300	10.6	16.9	23.1	29.4
		400	10.3	16.3	22.4	28.5
	Southwest	15	16.5	25.1	33.7	42.2
		30	16.2	24.7	33.1	41.6
		50	15.7	24.0	32.4	40.7
		100	14.5	22.4	30.4	38.3
		200	12.2	19.2	26.2	33.2
		300	10.6	16.8	23.0	29.3
		400	10.2	16.3	22.3	28.3

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
15	***West***	15	16.4	24.8	33.2	41.6
		30	16.0	24.4	32.7	41.0
		50	15.5	23.7	31.9	40.1
		100	14.3	22.1	29.9	37.7
		200	12.0	18.9	25.8	32.7
		300	10.5	16.6	22.7	28.8
		400	10.2	16.1	22.0	27.9
	Northwest	15	16.1	24.3	32.5	40.6
		30	15.8	23.9	31.9	40.0
		50	15.3	23.2	31.2	39.1
		100	14.1	21.6	29.2	36.7
		200	11.8	18.5	25.2	31.9
		300	10.3	16.3	22.2	28.2
		400	10.0	15.8	21.5	27.3
30	***North***	15	14.7	21.6	28.5	35.4
		30	14.4	21.2	28.0	34.9
		50	13.9	20.6	27.3	34.0
		100	12.8	19.2	25.5	31.9
		200	10.8	16.5	22.1	27.8
		300	9.5	14.6	19.7	24.8
		400	9.3	14.2	19.1	24.0
	Northeast	15	15.5	23.1	30.7	38.3
		30	15.2	22.7	30.2	37.7
		50	14.7	22.1	29.5	36.9
		100	13.6	20.6	27.7	34.8
		200	11.5	17.8	24.1	30.3
		300	10.1	15.7	21.3	26.9
		400	9.8	15.2	20.6	26.0

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
30	***East***	15	16.0	24.1	32.1	40.1
		30	15.7	23.6	31.6	39.5
		50	15.2	23.0	30.9	38.7
		100	14.0	21.5	29.0	36.4
		200	11.8	18.5	25.1	31.7
		300	10.3	16.3	22.2	28.1
		400	10.0	15.7	21.4	27.1
	Northeast	15	16.3	24.6	32.8	41.1
		30	15.9	24.1	32.3	40.5
		50	15.4	23.5	31.6	39.6
		100	14.2	21.9	29.6	37.3
		200	12.0	18.8	25.6	32.4
		300	10.4	16.5	22.6	28.6
		400	10.1	16.0	21.8	27.7
	South	15	16.3	24.7	33.0	41.4
		30	16.0	24.2	32.5	40.7
		50	15.5	23.6	31.7	39.9
		100	14.3	22.0	29.7	37.5
		200	12.0	18.8	25.7	32.5
		300	10.5	16.5	22.6	28.7
		400	10.1	16.0	21.9	27.8
	Southwest	15	16.2	24.4	32.7	40.9
		30	15.9	24.0	32.1	40.3
		50	15.4	23.4	31.4	39.4
		100	14.1	21.8	29.4	37.0
		200	11.9	18.6	25.4	32.1
		300	10.4	16.4	22.4	28.4
		400	10.1	15.9	21.7	27.5

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
30	***West***	15	15.9	23.9	31.8	39.7
		30	15.5	23.4	31.2	39.1
		50	15.0	22.8	30.5	38.2
		100	13.8	21.1	28.5	35.8
		200	11.6	18.1	24.6	31.0
		300	10.2	16.0	21.7	27.5
		400	9.9	15.5	21.1	26.7
	Northwest	15	15.4	22.9	30.4	37.9
		30	15.0	22.4	29.8	37.2
		50	14.6	21.8	29.1	36.4
		100	13.3	20.2	27.1	34.0
		200	11.3	17.4	23.4	29.5
		300	9.9	15.4	20.8	26.3
		400	9.6	14.9	20.2	25.5
45	***North***	15	13.5	19.4	25.2	31.0
		30	13.2	18.9	24.7	30.4
		50	12.7	18.4	24.0	29.7
		100	11.7	17.0	22.4	27.8
		200	9.9	14.7	19.5	24.3
		300	8.9	3.2	17.5	21.9
		400	8.6	2.8	17.0	21.2
	Northeast	15	14.7	21.4	28.2	34.9
		30	14.3	21.0	27.7	34.4
		50	13.9	20.5	27.1	33.7
		100	12.8	19.1	25.4	31.8
		200	10.9	16.6	22.2	27.9
		300	9.7	14.8	19.8	24.9
		400	9.4	14.3	19.1	24.0

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
45	***East***	15	15.3	22.7	30.1	37.4
		30	15.0	22.3	29.6	36.9
		50	14.5	21.7	28.9	36.1
		100	13.4	20.3	27.2	34.0
		200	11.4	17.6	23.7	29.8
		300	10.1	15.6	21.1	26.5
		400	9.7	15.0	20.3	25.6
	Southeast	15	15.7	23.4	31.1	38.8
		30	15.3	23.0	30.6	38.2
		50	14.9	22.4	29.9	37.4
		100	13.7	20.9	28.0	35.1
		200	11.6	18.0	24.3	30.7
		300	10.2	15.9	21.6	27.3
		400	9.9	15.4	20.8	26.3
	South	15	15.8	23.5	31.3	39.1
		30	15.4	23.1	30.8	38.5
		50	14.9	22.5	30.0	37.6
		100	13.7	20.9	28.1	35.3
		200	11.6	18.0	24.3	30.7
		300	10.2	15.9	21.6	27.3
		400	9.9	15.4	20.9	26.4
	Southwest	15	15.6	23.2	30.8	38.4
		30	15.2	22.7	30.2	37.8
		50	14.7	22.1	29.5	36.9
		100	13.5	20.5	27.5	34.5
		200	11.4	17.6	23.8	30.0
		300	10.0	15.6	21.1	26.7
		400	9.8	15.1	20.5	25.9

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
45	***West***	15	15.2	22.4	29.6	36.8
		30	14.8	21.9	29.0	36.1
		50	14.3	21.3	28.2	35.2
		100	13.1	19.7	26.3	32.9
		200	11.0	16.9	22.7	28.5
		300	9.7	15.0	20.2	25.5
		400	9.5	14.6	19.7	24.7
	Northwest	15	14.5	21.1	27.7	34.3
		30	14.1	20.6	27.1	33.6
		50	13.6	20.0	26.4	32.7
		100	12.4	18.5	24.5	30.5
		200	10.5	15.9	21.2	26.5
		300	9.3	14.2	19.0	23.8
		400	9.1	13.8	18.5	23.1
60	***North***	15	12.4	17.1	21.9	26.6
		30	12.0	16.7	21.4	26.1
		50	11.6	16.2	20.8	25.4
		100	10.6	14.9	19.3	23.7
		200	9.1	13.0	16.9	20.9
		300	8.2	11.8	15.4	19.0
		400	8.0	11.5	15.0	18.5
	Northeast	15	13.7	19.5	25.3	31.1
		30	13.4	19.1	24.9	30.7
		50	12.9	18.6	24.3	30.0
		100	11.9	17.4	22.9	28.4
		200	10.3	15.3	20.2	25.2
		300	9.2	13.7	18.2	22.7
		400	8.9	13.2	17.5	21.8

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
60	***East***	15	14.5	21.0	27.5	34.0
		30	14.2	20.6	27.1	33.5
		50	13.7	20.1	26.5	32.9
		100	12.7	18.8	24.9	31.1
		200	10.9	16.4	21.9	27.4
		300	9.7	14.7	19.7	24.6
		400	9.4	14.1	18.9	23.7
	Southeast	15	14.9	21.8	28.7	35.5
		30	14.6	21.4	28.2	35.0
		50	14.1	20.8	27.5	34.2
		100	13.0	19.4	25.8	32.2
		200	11.1	16.9	22.6	28.3
		300	9.9	15.1	20.2	25.4
		400	9.6	14.5	19.5	24.5
	South	15	15.0	22.0	28.9	35.9
		30	14.6	21.5	28.4	35.2
		50	14.1	20.9	27.6	34.4
		100	13.0	19.4	25.8	32.3
		200	11.1	16.8	22.5	28.2
		300	9.8	15.0	20.1	25.3
		400	9.5	14.5	19.5	24.4
	Southwest	15	14.8	21.5	28.3	35.1
		30	14.4	21.1	27.7	34.4
		50	13.9	20.4	26.9	33.5
		100	12.7	18.9	25.1	31.2
		200	10.8	16.3	21.7	27.2
		300	9.6	14.5	19.5	24.5
		400	9.3	14.1	18.9	23.7

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
60	***West***	15	14.3	20.6	26.9	33.2
		30	13.9	20.1	26.3	32.5
		50	13.3	19.4	25.5	31.5
		100	12.1	17.9	23.6	29.3
		200	10.3	15.3	20.4	25.4
		300	9.2	13.8	18.4	23.0
		400	9.0	13.4	17.9	22.3
	Northwest	15	13.5	19.1	24.7	30.4
		30	13.1	18.6	24.1	29.7
		50	12.6	18.0	23.4	28.8
		100	11.4	16.5	21.6	26.7
		200	9.7	14.2	18.7	23.2
		300	8.7	12.8	17.0	21.1
		400	8.5	12.5	16.5	20.5
	North	15	11.4	15.2	19.1	23.0
		30	11.0	14.8	18.6	22.4
		50	10.6	14.3	18.1	21.8
		100	9.7	13.2	16.7	20.3
		200	8.3	11.5	14.8	18.0
		300	7.6	10.6	13.6	16.6
		400	7.5	10.4	13.2	16.1
	Northeast	15	12.7	17.6	22.5	27.4
		30	12.4	17.3	22.1	27.0
		50	12.0	16.8	21.6	26.5
		100	11.1	15.8	20.4	25.1
		200	9.7	13.9	18.2	22.5
		300	8.8	12.7	16.6	20.5
		400	8.5	12.2	15.9	19.6

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
75	***East***	15	13.6	19.1	24.7	30.3
		30	13.2	18.8	24.3	29.8
		50	12.8	18.3	23.8	29.3
		100	11.9	17.2	22.5	27.7
		200	10.3	15.2	20.0	24.8
		300	9.3	13.7	18.1	22.5
		400	9.0	13.2	17.4	21.5
	Eastเฉียงใต้	15	14.0	19.9	25.8	31.7
		30	13.6	19.5	25.4	31.2
		50	13.2	19.0	24.8	30.5
		100	12.2	17.7	23.3	28.8
		200	10.5	15.5	20.6	25.6
		300	9.5	14.1	18.6	23.2
		400	9.2	13.5	17.9	22.3
	South	15	14.1	20.0	26.0	32.0
		30	13.7	19.6	25.5	31.4
		50	13.2	19.0	24.8	30.6
		100	12.1	17.6	23.1	28.6
		200	10.4	15.3	20.3	25.2
		300	9.4	13.9	18.4	22.9
		400	9.1	13.4	17.8	22.1
	Westเฉียงใต้	15	13.8	19.6	25.4	31.2
		30	13.4	19.1	24.8	30.4
		50	12.9	18.4	24.0	29.5
		100	11.7	17.0	22.2	27.4
		200	10.0	14.7	19.3	24.0
		300	9.1	13.3	17.6	21.8
		400	8.8	13.0	17.1	21.2

Slope angles of wall, degree	Direction	DSH ($kJ/(m^2.^0C)$)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
75	***West***	15	13.3	18.6	24.0	29.3
		30	12.9	18.1	23.3	28.5
		50	12.3	17.4	22.5	27.6
		100	11.1	15.9	20.6	25.4
		200	9.5	13.7	17.9	22.1
		300	8.6	12.5	16.4	20.3
		400	8.4	12.2	16.0	19.8
	Northwest	15	12.5	17.2	21.9	26.6
		30	12.1	16.7	21.3	25.9
		50	11.6	16.0	20.5	25.0
		100	10.4	14.6	18.8	23.0
		200	8.9	12.6	16.3	20.1
		300	8.1	11.6	15.0	18.5
		400	8.0	11.3	14.7	18.1
90	***North***	15	10.8	14.1	17.4	20.7
		30	10.4	13.7	16.9	20.1
		50	10.0	13.2	16.3	19.5
		100	9.1	12.1	15.1	18.1
		200	7.9	10.6	13.4	16.1
		300	7.3	9.9	12.5	15.1
		400	7.1	9.6	12.2	14.7
	Northeast	15	11.9	16.0	20.1	24.2
		30	11.6	15.7	19.8	23.8
		50	11.2	15.3	19.3	23.4
		100	10.4	14.3	18.3	22.2
		200	9.1	12.8	16.5	20.2
		300	8.4	11.8	15.2	18.6
		400	8.1	11.3	14.5	17.8

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
90	***East***	15	12.6	17.2	21.9	26.5
		30	12.3	16.9	21.5	26.1
		50	11.9	16.5	21.1	25.6
		100	11.1	15.5	20.0	24.4
		200	9.8	13.9	18.0	22.2
		300	9.0	12.8	16.6	20.4
		400	8.6	12.2	15.8	19.4
	Southeast	15	13.0	17.9	22.7	27.6
		30	12.6	17.5	22.3	27.2
		50	12.2	17.0	21.8	26.5
		100	11.3	15.9	20.5	25.1
		200	9.9	14.1	18.4	22.6
		300	9.1	13.0	16.9	20.8
		400	8.7	12.5	16.2	19.9
	South	15	13.0	18.0	22.9	27.8
		30	12.7	17.5	22.3	27.1
		50	12.2	16.9	21.6	26.3
		100	11.1	15.6	20.1	24.6
		200	9.7	13.7	17.8	21.9
		300	8.9	12.7	16.5	20.3
		400	8.6	12.2	15.9	19.5
	Southeast	15	12.8	17.6	22.3	27.0
		30	12.4	17.0	21.6	26.3
		50	11.8	16.3	20.8	25.3
		100	10.7	14.9	19.1	23.3
		200	9.2	13.0	16.7	20.5
		300	8.5	12.0	15.5	19.0
		400	8.3	11.7	15.1	18.5

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
90	***West***	15	12.3	16.7	21.1	25.5
		30	11.9	16.2	20.4	24.7
		50	11.3	15.5	19.6	23.7
		100	10.2	14.0	17.8	21.6
		200	8.7	12.1	15.5	18.9
		300	8.1	11.2	14.4	17.6
		400	7.9	11.0	14.1	17.2
	Northwest	15	11.7	15.6	19.5	23.4
		30	11.2	15.0	18.9	22.7
		50	10.7	14.4	18.1	21.8
		100	9.6	13.0	16.4	19.9
		200	8.2	11.3	14.3	17.4
		300	7.6	10.5	13.4	16.3
		400	7.5	10.3	13.1	16.0

Table 2 – Equivalent temperature difference, TD_{eq} of the opaque wall for Building of department store or trade center, Entertainment service building, Building for congregation and Theatrical building.

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
0	***All Direction***	15	12.1	17.8	23.4	29.0
		30	12.4	18.3	24.2	30.0
		50	12.7	18.8	24.9	31.0
		100	13.1	19.6	26.0	32.5
		200	12.6	19.0	25.5	31.9
		300	11.5	17.5	23.5	29.5
		400	11.0	16.9	22.7	28.5
15	***North***	15	11.7	16.9	22.1	27.4
		30	11.9	17.4	22.8	28.2
		50	12.2	17.9	23.5	29.2
		100	12.5	18.5	24.5	30.4
		200	12.1	18.0	24.0	29.9
		300	11.0	16.6	22.1	27.7
		400	10.5	15.9	21.3	26.7
	Northeast	15	11.8	17.1	22.5	27.8
		30	12.1	17.6	23.1	28.7
		50	12.4	18.1	23.9	29.6
		100	12.7	18.8	24.9	31.0
		200	12.2	18.3	24.4	30.5
		300	11.2	16.9	22.6	28.2
		400	10.7	16.2	21.8	27.3

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
15	***East***	15	11.9	17.4	22.9	28.3
		30	12.2	17.9	23.6	29.2
		50	12.5	18.4	24.3	30.2
		100	12.9	19.1	25.4	31.6
		200	12.4	18.6	24.9	31.1
		300	11.3	17.1	23.0	28.8
		400	10.8	16.5	22.2	27.8
	Southeast	15	12.1	17.7	23.3	28.8
		30	12.4	18.2	24.0	29.8
		50	12.7	18.7	24.8	30.8
		100	13.0	19.4	25.8	32.2
		200	12.6	18.9	25.3	31.7
		300	11.5	17.4	23.4	29.3
		400	11.0	16.8	22.6	28.3
	South	15	12.2	17.9	23.6	29.3
		30	12.5	18.4	24.3	30.3
		50	12.8	19.0	25.1	31.3
		100	13.2	19.7	26.2	32.8
		200	12.7	19.2	25.7	32.2
		300	11.6	17.6	23.7	29.8
		400	11.1	17.0	22.9	28.8
	Southwest	15	12.2	18.0	23.8	29.5
		30	12.6	18.6	24.5	30.5
		50	12.9	19.1	25.4	31.6
		100	13.3	19.9	26.5	33.1
		200	12.8	19.4	26.0	32.5
		300	11.6	17.8	23.9	30.1
		400	11.2	17.1	23.1	29.1

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	0.5	0.7	0.9
15	***West***	15	12.2	17.9	23.7	29.4
		30	12.5	18.5	24.4	30.4
		50	12.8	19.0	25.2	31.4
		100	13.2	19.8	26.4	32.9
		200	12.7	19.3	25.8	32.4
		300	11.6	17.7	23.8	29.9
		400	11.1	17.1	23.0	29.0
	Northwest	15	12.0	17.6	23.1	28.7
		30	12.3	18.1	23.9	29.6
		50	12.6	18.6	24.6	30.6
		100	13.0	19.3	25.7	32.0
		200	12.5	18.8	25.2	31.5
		300	11.4	17.3	23.2	29.1
		400	10.9	16.7	22.4	28.1
30	***North***	15	11.0	15.6	20.2	24.9
		30	11.2	16.0	20.8	25.6
		50	11.4	16.4	21.4	26.3
		100	11.7	16.9	22.2	27.4
		200	11.2	16.4	21.7	26.9
		300	10.3	15.2	20.0	24.9
		400	9.8	14.6	19.3	24.0
	Northeast	15	11.2	16.1	20.9	25.8
		30	11.5	16.5	21.6	26.6
		50	11.8	17.0	22.2	27.4
		100	12.1	17.6	23.1	28.6
		200	11.6	17.2	22.7	28.2
		300	10.7	15.9	21.0	26.2
		400	10.2	15.2	20.3	25.3

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
30	***East***	15	11.5	16.6	21.7	26.8
		30	11.8	17.1	22.4	27.7
		50	12.1	17.6	23.1	28.6
		100	12.4	18.2	24.1	29.9
		200	12.0	17.8	23.6	29.4
		300	11.0	16.4	21.9	27.3
		400	10.5	15.8	21.1	26.4
	Southeast	15	11.8	17.1	22.5	27.8
		30	12.1	17.6	23.2	28.7
		50	12.4	18.1	23.9	29.6
		100	12.7	18.8	24.9	31.0
		200	12.3	18.3	24.4	30.5
		300	11.2	16.9	22.6	28.3
		400	10.7	16.2	21.8	27.3
	South	15	12.0	17.5	23.0	28.6
		30	12.3	18.0	23.8	29.5
		50	12.6	18.6	24.5	30.5
		100	13.0	19.3	25.6	31.9
		200	12.5	18.7	25.0	31.3
		300	11.4	17.2	23.1	29.0
		400	10.9	16.6	22.3	28.0
	Southwest	15	12.1	17.7	23.3	28.9
		30	12.4	18.2	24.0	29.9
		50	12.7	18.8	24.8	30.9
		100	13.1	19.5	25.9	32.3
		200	12.6	19.0	25.3	31.7
		300	11.5	17.4	23.4	29.4
		400	11.0	16.8	22.6	28.4

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
30	***West***	15	12.0	17.5	23.0	28.6
		30	12.3	18.0	23.8	29.5
		50	12.6	18.6	24.5	30.5
		100	12.9	19.2	25.5	31.8
		200	12.4	18.7	25.0	31.3
		300	11.4	17.2	23.1	28.9
		400	10.9	16.6	22.3	28.0
	Northwest	15	11.7	16.9	22.1	27.3
		30	11.9	17.3	22.7	28.1
		50	12.2	17.8	23.4	29.0
		100	12.5	18.4	24.3	30.2
		200	12.0	17.9	23.7	29.6
		300	11.0	16.4	21.9	27.4
		400	10.5	15.8	21.1	26.5
45	***North***	15	10.2	14.1	18.0	22.0
		30	10.4	14.4	18.5	22.5
		50	10.5	14.7	18.7	23.1
		100	10.7	15.1	19.5	23.8
		200	10.3	14.6	19.0	23.4
		300	9.4	13.5	17.6	21.7
		400	9.0	12.9	16.9	20.9
	Northeast	15	10.6	14.9	19.1	23.4
		30	10.8	15.2	19.6	24.1
		50	11.0	15.6	20.2	24.8
		100	11.3	16.1	21.0	25.8
		200	10.9	15.8	20.6	25.5
		300	10.1	14.6	19.2	23.8
		400	9.6	14.0	18.4	22.9

Slope angles of wall, degree	Direction	DSH (kJ/(m².⁰C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
45	***East***	15	11.0	15.6	20.2	24.8
		30	11.3	16.0	20.8	25.6
		50	11.5	16.5	21.4	26.4
		100	11.8	17.0	22.3	27.5
		200	11.4	16.7	21.9	27.2
		300	10.5	15.5	20.4	25.4
		400	10.0	14.8	19.6	24.4
		400	10.0	14.8	19.6	24.4
	Southeast	15	11.4	16.3	21.2	26.1
		30	11.6	16.7	21.8	26.9
		50	11.9	17.2	22.5	27.8
		100	12.2	17.8	23.4	29.0
		200	11.8	17.4	22.9	28.5
		300	10.8	16.0	21.3	26.5
		400	10.3	15.4	20.5	25.6
	South	15	11.6	16.8	21.9	27.0
		30	11.9	17.2	22.5	27.9
		50	12.2	17.7	23.2	28.7
		100	12.5	18.3	24.1	30.0
		200	12.0	17.8	23.6	29.5
		300	11.0	16.4	21.9	27.3
		400	10.5	15.8	21.1	26.3
	Southwest	15	11.7	16.9	22.2	27.4
		30	12.0	17.4	22.8	28.2
		50	12.3	17.9	23.5	29.1
		100	12.6	18.5	24.4	30.3
		200	12.1	18.0	23.9	29.8
		300	11.0	16.5	22.1	27.6
		400	10.5	15.9	21.2	26.6

Slope angles of wall, degree	Direction	DSH (kJ/(m².⁰C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
45	***West***	15	11.6	16.7	21.8	26.9
		30	11.8	17.1	22.4	27.6
		50	12.1	17.5	23.0	28.5
		100	12.4	18.1	23.8	29.6
		200	11.9	17.6	23.3	29.0
		300	10.8	16.2	21.5	26.9
		400	10.3	15.5	20.7	25.9
	Northwest	15	11.1	15.8	20.4	25.1
		30	11.3	16.1	20.9	25.8
		50	11.5	16.5	21.5	11.5
		100	11.7	17.0	22.2	27.4
		200	11.3	16.4	21.6	26.8
		300	10.3	15.2	20.0	24.9
		400	9.8	14.5	19.2	23.9
60	***North***	15	9.4	12.6	15.9	19.1
		30	9.5	12.8	16.2	19.5
		50	9.6	13.0	16.5	19.9
		100	9.7	13.3	16.8	20.4
		200	9.3	12.9	16.4	19.9
		300	8.6	11.9	15.3	18.6
		400	8.1	11.4	14.6	17.8
	Northeast	15	9.9	13.6	17.2	20.9
		30	10.1	13.9	17.6	21.4
		50	10.3	14.2	18.1	22.0
		100	10.5	14.6	18.7	22.8
		200	10.2	14.3	18.5	22.6
		300	9.4	13.4	17.3	21.2
		400	8.9	12.7	16.5	20.4

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
60	***East***	15	10.4	14.4	18.5	22.5
		30	10.6	14.8	19.0	23.2
		50	10.8	15.2	19.5	23.8
		100	11.1	15.7	20.3	24.8
		200	10.8	15.4	20.0	24.6
		300	10.0	14.3	18.7	23.1
		400	9.5	13.7	17.9	22.2
	Southeast	15	10.8	15.2	19.6	24.0
		30	11.0	15.6	20.1	24.6
		50	11.3	16.0	20.6	25.3
		100	11.5	16.5	21.4	100
		200	11.2	16.1	21.1	26.0
		300	10.3	15.0	19.7	24.3
		400	9.8	14.3	18.8	23.3
	South	15	11.1	15.7	20.3	24.9
		30	11.3	16.1	20.8	25.6
		50	11.5	16.5	21.4	26.3
		100	11.8	17.0	22.2	27.3
		200	11.4	16.5	21.7	26.9
		300	10.4	15.3	20.2	25.0
		400	9.9	14.6	19.3	24.0
	Southwest	15	11.2	15.9	20.6	25.2
		30	11.4	16.2	21.1	25.9
		50	11.6	16.6	21.6	26.6
		100	11.8	17.1	22.3	27.5
		200	11.4	16.6	21.8	27.0
		300	10.4	15.3	20.2	25.0
		400	9.9	14.6	19.3	24.0

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
60	***West***	15	11.0	15.5	20.0	24.5
		30	11.2	15.8	20.5	25.1
		50	11.4	16.2	21.0	25.7
		100	11.6	16.6	21.6	26.6
		200	11.1	16.0	21.0	25.9
		300	10.1	14.8	19.4	24.1
		400	9.6	14.1	18.6	23.1
	NorthWest	15	10.4	14.5	18.5	22.5
		30	10.6	14.7	18.9	23.0
		50	10.7	15.0	19.3	23.5
		100	10.9	15.3	19.7	24.2
		200	10.4	14.8	19.1	200
		300	9.5	13.6	17.7	21.9
		400	9.0	13.0	17.0	20.9
75	***North***	15	8.7	11.4	14.0	16.7
		30	8.8	11.5	14.2	16.9
		50	8.9	11.7	14.4	17.2
		100	8.9	11.8	14.6	17.5
		200	8.6	11.4	14.2	17.0
		300	7.9	10.6	13.3	16.0
		400	7.5	10.0	12.6	15.2
	Northeast	15	9.3	12.3	15.4	18.5
		30	9.4	12.6	15.7	18.9
		50	9.6	12.8	16.1	19.4
		100	9.7	13.2	16.6	20.1
		200	9.5	13.0	16.5	19.9
		300	8.8	12.2	15.5	18.9
		400	8.3	11.6	14.8	18.0

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
75	***East***	15	9.8	13.2	16.7	20.2
		30	9.9	13.5	17.1	20.7
		50	10.1	13.8	17.5	21.2
		100	10.4	14.3	18.1	22.0
		200	10.1	14.1	18.0	22.0
		300	9.4	13.2	17.0	20.8
		400	8.9	12.5	16.2	19.8
	Southeast	15	10.2	14.0	17.8	21.5
		30	10.4	14.3	18.2	22.1
		50	10.5	14.6	18.6	22.6
		100	10.8	15.0	19.2	23.4
		200	10.5	14.7	19.0	23.2
		300	9.7	13.8	300	9.7
		400	9.2	13.1	17.0	20.9
	South	15	10.5	14.5	18.4	22.4
		30	10.6	14.7	18.8	22.9
		50	10.8	15.0	19.2	23.5
		100	11.0	15.4	19.8	24.2
		200	10.6	15.0	19.4	23.8
		300	9.8	14.0	18.1	22.3
		400	9.3	13.3	17.3	21.3
	Southwest	15	10.5	14.6	18.6	22.6
		30	10.7	14.8	19.0	23.1
		50	10.8	15.1	19.3	23.6
		100	11.0	15.4	19.8	24.2
		200	10.5	14.9	19.2	23.6
		300	9.7	13.8	17.9	22.0
		400	9.1	13.1	17.0	21.0

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
75	***West***	15	10.3	14.2	18.0	21.9
		30	10.4	14.4	18.3	22.3
		50	10.6	14.6	18.6	22.7
		100	10.6	14.8	18.9	23.1
		200	10.2	14.2	18.3	22.4
		300	9.3	13.2	17.0	20.9
		400	8.8	12.5	16.2	19.9
	Northwest	15	9.7	13.2	16.6	20.0
		30	9.8	13.3	16.8	20.3
		50	9.9	13.5	17.0	20.5
		100	10.0	13.6	17.2	20.9
		200	9.5	13.1	16.6	20.2
		300	8.7	12.1	15.5	18.8
		400	8.2	11.5	400	8.2
90	***North***	15	8.3	10.6	12.9	15.2
		30	8.4	10.7	13.1	15.4
		50	8.4	10.8	13.2	15.5
		100	8.4	10.9	13.3	15.7
		200	8.1	10.5	12.9	15.2
		300	7.5	9.8	12.1	14.4
		400	7.0	9.2	11.4	13.6
	Northeast	15	8.8	11.4	14.0	16.6
		30	8.9	11.6	14.2	16.9
		50	9.0	11.8	14.5	17.3
		100	9.1	12.0	14.9	17.8
		200	8.9	11.9	14.8	17.8
		300	8.3	11.2	14.1	16.9
		400	7.8	10.6	13.4	16.1

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
90	***East***	15	9.2	12.1	15.0	17.9
		30	9.3	12.3	15.3	18.3
		50	9.5	12.6	15.7	18.7
		100	9.7	12.9	16.2	19.4
		200	9.5	12.8	16.1	19.5
		300	8.9	12.1	15.3	18.5
		400	8.3	11.4	14.5	17.6
	Southeast	15	9.5	12.7	15.9	19.0
		30	9.7	12.9	16.2	19.4
		50	9.8	13.1	16.5	19.8
		100	10.0	13.5	16.9	20.4
		200	9.7	13.3	16.8	20.3
		300	9.1	12.5	15.9	19.3
		400	8.5	11.8	15.0	18.3
	South	15	9.8	13.1	15	9.8
		30	9.9	13.3	16.6	20.0
		50	10.0	13.4	16.9	20.3
		100	10.1	13.7	17.2	20.8
		200	9.8	13.3	16.9	20.4
		300	9.1	12.5	15.9	19.3
		400	8.5	11.8	15.0	18.3
	Southwest	15	9.8	13.2	16.5	19.8
		30	9.9	13.3	16.7	20.1
		50	10.0	13.4	16.9	20.3
		100	10.0	13.5	17.0	20.5
		200	9.6	13.0	16.5	19.9
		300	8.9	12.2	15.4	18.7
		400	8.3	11.4	14.5	17.7

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
90	***West***	15	9.7	12.8	16.0	19.2
		30	9.7	12.9	16.2	19.4
		50	9.7	13.0	16.3	19.5
		100	9.7	13.0	16.3	19.6
		200	9.2	12.4	15.7	18.9
		300	8.5	11.6	14.6	17.6
		400	8.0	10.9	13.7	16.6
	Northwest	15	9.2	12.0	14.9	17.7
		30	9.2	12.1	15.0	17.8
		50	9.2	12.1	15.1	18.0
		100	9.2	12.1	15.1	18.0
		200	8.7	11.6	14.5	17.3
		300	8.1	10.8	13.5	16.2
		400	7.5	10.1	12.7	15.3

Table 3 – Equivalent temperature difference, TD_{eq} of the opaque wall for Clinic, Hotel building and Condominium.

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
0	***All Direction***	15	7.3	10.7	14.1	17.5
		30	7.3	10.7	14.2	17.6
		50	7.3	10.8	14.3	17.7
		100	7.4	10.9	14.5	18.0
		200	7.5	11.2	14.9	18.6
		300	7.6	11.4	15.2	19.1
		400	7.7	11.5	15.4	19.3
15	***North***	15	6.9	10.1	13.3	16.5
		30	7.0	10.1	13.3	16.5
		50	7.0	10.2	13.4	16.6
		100	7.0	10.3	13.6	16.9
		200	7.2	10.6	14.0	17.4
		300	7.3	10.8	14.3	17.8
		400	7.3	10.9	14.5	18.1
	Northeast	15	7.1	10.4	13.8	17.1
		30	7.1	10.5	13.8	17.2
		50	7.2	10.5	13.9	17.3
		100	7.2	10.7	14.1	17.5
		200	7.4	10.9	14.5	18.1
		300	7.5	11.2	14.8	18.5
		400	7.5	11.3	15.0	18.8
	East	15	7.2	10.6	14.1	17.5
		30	7.3	10.7	14.1	17.6
		50	7.3	10.7	14.2	17.7
		100	7.4	10.9	14.4	17.9
		200	7.5	11.2	14.8	18.5
		300	7.6	11.4	15.2	19.0
		400	7.6	11.5	15.4	19.2

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
15	***Southeast***	15	7.3	10.7	14.2	17.7
		30	7.3	10.8	14.3	17.7
		50	7.3	10.8	14.3	17.9
		100	7.4	11.0	14.6	18.1
		200	7.5	11.3	15.0	18.7
		300	7.6	11.5	15.3	19.2
		400	7.7	11.6	15.5	19.5
	South	15	7.3	10.8	14.2	17.7
		30	7.3	10.8	14.3	17.8
		50	7.3	10.9	14.4	17.9
		100	7.4	11.0	14.6	18.2
		200	7.5	11.3	15.0	18.7
		300	7.6	11.5	15.4	19.2
		400	7.7	11.6	15.6	19.5
	Southwest	15	7.3	10.7	14.1	17.6
		30	7.3	10.7	14.2	17.7
		50	7.3	10.8	14.3	17.8
		100	7.4	10.9	14.5	18.0
		200	7.5	11.2	14.9	18.6
		300	7.6	11.4	15.3	19.1
		400	7.7	11.6	15.5	19.3
	West	15	7.2	10.6	13.9	17.3
		30	7.2	10.6	14.0	17.4
		50	7.2	10.7	14.1	17.5
		100	7.3	10.8	14.3	17.8
		200	7.4	11.1	14.7	18.3
		300	7.5	11.3	15.0	18.8
		400	7.6	11.4	15.2	19.0

Slope angles of wall, degree	Direction	DSH (kJ/(m^{2}.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
15	***Northwest***	15	7.1	10.4	13.7	16.9
		30	7.1	10.4	13.7	17.0
		50	7.1	10.5	13.8	17.1
		100	7.2	10.6	14.0	17.4
		200	7.3	10.9	14.4	17.9
		300	7.4	11.1	14.7	18.4
		400	7.5	11.2	14.9	18.6
30	***North***	15	6.5	9.3	12.1	14.9
		30	6.5	9.3	12.1	15.0
		50	6.5	9.4	12.2	15.0
		100	6.6	9.5	12.4	15.3
		200	6.7	9.7	12.7	15.7
		300	6.8	9.9	13.0	16.1
		400	6.8	10.0	13.1	16.3
	Northeast	15	6.8	9.9	13.0	16.1
		30	6.8	10.0	13.1	16.2
		50	6.9	10.0	13.1	16.3
		100	6.9	10.1	13.3	16.5
		200	7.1	10.4	13.7	17.0
		300	7.2	10.6	14.0	17.4
		400	7.2	10.7	14.2	17.6
	East	15	7.1	10.3	13.6	16.8
		30	7.1	10.4	13.6	16.9
		50	7.1	10.4	13.7	17.0
		100	7.2	10.5	13.9	17.3
		200	7.3	10.8	14.3	17.8
		300	7.4	11.0	14.6	18.2
		400	7.4	11.1	14.8	18.5

Slope angles of wall, degree	Direction	DSH (kJ/(m².⁰C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
30	***Southeast***	15	7.2	10.5	13.9	17.2
		30	7.2	10.5	13.9	17.3
		50	7.2	10.6	14.0	17.4
		100	7.3	10.7	14.2	17.7
		200	7.4	11.0	14.6	18.2
		300	7.5	11.2	14.9	18.7
		400	7.6	11.3	15.1	18.9
	South	15	7.2	10.5	13.9	17.3
		30	7.2	10.6	14.0	17.3
		50	7.2	10.6	14.0	17.4
		100	7.3	10.8	14.2	17.7
		200	7.4	11.0	14.7	18.3
		300	7.5	11.3	15.0	18.7
		400	7.6	11.4	15.2	19.0
	Southwest	15	7.1	10.4	13.7	17.0
		30	7.1	10.5	13.8	17.1
		50	7.2	10.5	13.9	17.2
		100	7.2	10.6	14.1	17.5
		200	7.3	10.9	14.5	18.0
		300	7.4	11.1	14.8	18.5
		400	7.5	11.2	15.0	18.7
	West	15	7.0	10.2	13.3	16.5
		30	7.0	10.2	13.4	16.6
		50	7.0	10.2	13.5	16.7
		100	7.1	10.4	13.7	17.0
		200	7.2	10.6	14.1	17.5
		300	7.3	10.8	14.4	17.9
		400	7.4	11.0	14.6	18.2

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
30	***Northwest***	15	6.7	9.8	12.8	15.8
		30	6.8	9.8	12.8	15.9
		50	6.8	9.9	12.9	16.0
		100	6.9	10.0	13.1	16.2
		200	7.0	10.2	13.5	16.7
		300	7.1	10.4	13.8	17.1
		400	7.1	10.5	13.9	17.3
45	***North***	15	5.9	8.3	10.7	13.1
		30	6.0	8.4	10.8	13.2
		50	6.0	8.4	10.8	13.2
		100	6.0	8.5	10.9	13.4
		200	6.1	8.7	11.2	13.8
		300	6.2	8.8	11.4	14.1
		400	6.2	8.9	11.6	14.2
	Northeast	15	6.4	9.2	12.0	14.8
		30	6.5	9.2	12.0	14.8
		50	6.5	9.3	12.1	14.9
		100	6.5	9.4	12.2	15.1
		200	6.6	9.6	12.6	15.5
		300	6.7	9.8	12.8	15.9
		400	6.8	9.9	13.0	16.1
	East	15	6.7	9.8	12.8	15.8
		30	6.8	9.8	12.8	15.8
		50	6.8	9.8	12.9	15.9
		100	6.8	10.0	13.1	16.2
		200	7.0	10.2	13.4	16.6
		300	7.1	10.4	13.7	17.0
		400	7.1	10.5	13.9	17.2

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
45	***Southeast***	15	6.9	10.0	13.1	16.3
		30	6.9	10.1	13.2	16.3
		50	6.9	10.1	13.3	16.4
		100	7.0	10.2	13.5	16.7
		200	7.1	10.5	13.8	17.2
		300	7.2	10.7	14.1	17.6
		400	7.3	10.8	14.3	17.8
	South	15	6.9	10.1	13.2	16.3
		30	6.9	10.1	13.3	16.4
		50	7.0	10.1	13.3	16.5
		100	7.0	10.3	13.5	16.8
		200	7.1	10.5	13.9	17.3
		300	7.2	10.7	14.2	17.7
		400	7.3	10.8	14.4	17.9
	Southwest	15	6.8	9.9	13.0	16.0
		30	6.8	9.9	13.0	16.1
		50	6.9	10.0	13.1	16.2
		100	6.9	10.1	13.3	16.4
		200	7.1	10.4	13.6	16.9
		300	7.2	10.5	13.9	17.3
		400	7.2	10.7	14.1	17.6
	West	15	6.6	9.5	12.4	15.3
		30	6.6	9.6	12.5	15.4
		50	6.7	9.6	12.6	15.5
		100	6.7	9.7	12.7	15.8
		200	6.9	10.0	13.1	16.2
		300	6.9	10.2	13.4	16.6
		400	7.0	10.3	13.5	16.8

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
45	***Northwest***	15	6.3	9.0	11.7	14.4
		30	6.3	9.0	11.7	14.4
		50	6.4	9.1	11.8	14.5
		100	6.4	9.2	12.0	14.7
		200	6.5	9.4	12.3	15.2
		300	6.6	9.6	12.5	15.5
		400	6.7	9.7	12.7	15.7
60	***North***	15	5.4	7.4	9.4	11.3
		30	5.4	7.4	9.4	11.4
		50	5.4	7.4	9.4	11.4
		100	5.5	7.5	9.6	11.6
		200	5.6	7.7	9.8	11.8
		300	5.7	7.8	9.9	12.1
		400	5.7	7.9	10.0	12.2
	Northeast	15	6.0	8.4	10.8	13.2
		30	6.0	8.4	10.9	13.3
		50	6.0	8.5	10.9	13.3
		100	6.1	8.6	11.0	13.5
		200	6.2	8.7	11.3	13.8
		300	6.3	8.9	11.5	14.1
		400	6.3	9.0	11.6	14.3
	East	15	6.3	9.0	11.7	14.4
		30	6.4	9.1	11.8	14.5
		50	6.4	9.1	11.8	14.5
		100	6.4	9.2	12.0	14.7
		200	6.6	9.4	12.3	15.1
		300	6.6	9.6	12.5	15.4
		400	6.7	9.7	12.7	15.6

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
60	***Southeast***	15	6.5	9.3	12.2	15.0
		30	6.5	9.4	12.2	15.0
		50	6.6	9.4	12.3	15.1
		100	6.6	9.5	12.4	15.3
		200	6.7	9.7	12.8	15.8
		300	6.8	9.9	13.0	16.1
		400	6.9	10.0	13.2	16.3
	South	15	6.5	9.4	12.2	15.1
		30	6.6	9.4	12.3	15.1
		50	6.6	9.5	12.3	15.2
		100	6.7	9.6	12.5	15.4
		200	6.8	9.8	12.8	15.9
		300	6.9	10.0	13.1	16.2
		400	6.9	10.1	13.3	16.4
	Southwest	15	6.4	9.2	11.9	14.7
		30	6.5	9.2	12.0	14.7
		50	6.5	9.3	12.1	14.8
		100	6.5	9.4	12.2	15.1
		200	6.7	9.6	12.5	15.5
		300	6.8	9.8	12.8	15.8
		400	6.8	9.9	12.9	16.0
	West	15	6.2	8.8	11.3	13.9
		30	6.2	8.8	11.4	14.0
		50	6.2	8.9	11.5	14.1
		100	6.3	9.0	11.6	14.3
		200	6.4	9.2	11.9	14.7
		300	6.5	9.3	12.2	15.0
		400	6.6	9.4	12.3	15.2

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
60	***Northwest***	15	5.9	8.2	10.5	12.8
		30	5.9	8.2	10.5	12.8
		50	5.9	8.2	10.6	12.9
		100	6.0	8.3	10.7	13.1
		200	6.1	8.5	11.0	13.5
		300	6.1	8.7	11.2	13.7
		400	6.2	8.8	11.3	13.9
75	***North***	30	5.0	6.6	8.2	9.9
		50	5.0	6.6	8.3	9.9
		100	5.0	6.7	8.4	10.0
		200	5.1	6.8	8.5	10.2
		300	5.2	6.9	8.7	10.4
		400	5.2	7.0	8.7	10.5
	Northeast	15	5.5	7.6	9.7	11.7
		30	5.6	7.6	9.7	11.8
		50	5.6	7.7	9.7	11.8
		100	5.6	7.7	9.8	11.9
		200	5.7	7.9	10.0	12.2
		300	5.8	8.0	10.2	12.4
		400	5.8	8.1	10.3	12.5
	East	15	5.9	8.2	10.6	12.9
		30	5.9	8.3	10.6	12.9
		50	5.9	8.3	10.6	13.0
		100	6.0	8.4	10.7	13.1
		200	6.1	8.5	11.0	13.4
		300	6.2	8.7	11.2	13.7
		400	6.2	8.8	11.3	13.8

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
75	***Southeast***	15	6.1	8.5	11.0	13.5
		30	6.1	8.6	11.0	13.5
		50	6.1	8.6	11.1	13.6
		100	6.2	8.7	11.2	13.7
		200	6.3	8.9	11.5	14.1
		300	6.4	9.0	11.7	14.3
		400	6.4	9.1	11.8	14.5
	South	15	6.1	8.6	11.0	13.5
		30	6.1	8.6	11.1	13.6
		50	6.1	8.6	11.1	13.6
		100	6.2	8.7	11.3	13.8
		200	6.3	8.9	11.6	14.2
		300	6.4	9.1	11.8	14.4
		400	6.5	9.2	11.9	14.6
	Southwest	15	6.0	8.4	10.7	13.1
		30	6.0	8.4	10.8	13.2
		50	6.0	8.4	10.8	13.3
		100	6.1	8.5	11.0	13.4
		200	6.2	8.7	11.3	13.8
		300	6.3	8.9	11.5	14.1
		400	6.3	9.0	11.6	14.2
	West	15	5.7	7.9	10.1	12.3
		30	5.8	8.0	10.2	12.4
		50	5.8	8.0	10.3	12.5
		100	5.9	8.1	10.4	12.7
		200	6.0	8.3	10.6	13.0
		300	6.0	8.4	10.8	13.2
		400	6.1	8.5	10.9	13.4

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
75	***Northwest***	15	5.4	7.4	9.3	11.3
		30	5.4	7.4	9.3	11.3
		50	5.5	7.4	9.4	11.4
		100	5.5	7.5	9.5	11.5
		200	5.6	7.7	9.7	11.8
		300	5.7	7.8	9.9	12.0
		400	5.7	7.9	10.0	12.1
90	***North***	15	4.7	6.1	7.5	8.9
		30	4.7	6.1	7.5	8.9
		50	4.7	6.1	7.5	8.9
		100	4.8	6.2	7.6	9.0
		200	4.8	6.3	7.7	9.2
		300	4.9	6.3	7.8	9.3
		400	4.9	6.4	7.9	9.4
	Northeast	15	5.2	6.9	8.6	10.4
		30	5.2	6.9	8.7	10.4
		50	5.2	6.9	8.7	10.4
		100	5.2	7.0	8.8	10.5
		200	5.3	7.1	8.9	10.7
		300	5.4	7.2	9.0	10.9
		400	5.4	7.3	9.1	11.0
	East	15	5.5	7.4	9.4	11.3
		30	5.5	7.4	9.4	11.4
		50	5.5	7.5	9.4	11.4
		100	5.5	7.5	9.5	11.5
		200	5.6	7.7	9.7	11.7
		300	5.7	7.8	9.8	11.9
		400	5.7	7.8	9.9	12.0

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
90	***Southeast***	15	5.6	7.7	9.7	11.8
		30	5.6	7.7	9.7	11.8
		50	5.6	7.7	9.8	11.9
		100	5.7	7.8	9.9	12.0
		200	5.8	7.9	10.1	12.2
		300	5.9	8.0	10.2	12.4
		400	5.9	8.1	10.3	12.6
	South	15	5.6	7.7	9.7	11.8
		30	5.6	7.7	9.8	11.8
		50	5.7	7.7	9.8	11.9
		100	5.7	7.8	9.9	12.0
		300	5.9	8.1	10.3	12.5
		400	5.9	8.2	10.4	12.6
	Southwest	15	5.5	7.5	9.5	11.4
		30	5.5	7.5	9.5	11.5
		50	5.6	7.6	9.6	11.6
		100	5.6	7.7	9.7	11.7
		200	5.7	7.8	9.9	12.0
		300	5.8	7.9	10.0	12.2
		400	5.8	8.0	10.1	12.3
	West	15	5.3	7.1	9.0	10.8
		30	5.3	7.2	9.0	10.9
		50	5.4	7.2	9.1	10.9
		100	5.4	7.3	9.2	11.1
		200	5.5	7.5	9.4	11.3
		300	5.6	7.6	9.5	11.5
		400	5.6	7.6	9.6	11.6

Slope angles of wall, degree	Direction	DSH (kJ/(m^2.^{0}C)	Coefficient of the Solar ray absorption			
			0.3	**0.5**	**0.7**	**0.9**
90	***Northwest***	15	5.0	6.7	8.3	10.0
		30	5.0	6.7	8.3	10.0
		50	5.1	6.7	8.4	10.1
		100	5.1	6.8	8.5	10.2
		200	5.2	6.9	8.7	10.4
		300	5.3	7.0	8.8	10.6
		400	5.3	7.1	8.9	10.6