Republic of Lebanon
Ministry of Public Works and Transport
General Directorate of Urban Planning

UNDP

GEF

THERMAL STANDARD FOR BUILDINGS IN LEBANON

2005

PROJECT CAPACITY BUILDING FOR THE ADOPTION AND APPLICATION OF THERMAL STANDARDS FOR BUILDINGS

Republic of Lebanon
Ministry of Public Works and Transport
General Directorate of Urban Planning

THERMAL STANDARD FOR BUILDINGS IN LEBANON

UNDP is the UN's global development network, advocating for change and connecting countries to knowledge, experience and resources to help build a better life. We are on the ground in 166 countries, working with them on their own solutions to global and national development challenges. As they develop local capacity, they draw on the people of UNDP and our wide range of partners.

For further information:

United Nations Development Programme, www.undp.org.lb

General Directorate of Urban Planning, www.public-works.gov.lb

Note: The information contained within this document has been developed within a specific scope, and may be updated in the future.

:: PREFACE

This study has been developed in the context of Project "Capacity Building for the adoption and application of Thermal Standards for Buildings". The project was funded by the Global Environment Facility, Managed by the United Nations Development Programme, and Executed under the Lebanese General Directorate of Urban Planning, Ministry of Public Works and Transport. The project falls under the Climate Change focal area and aims at the establishment of Thermal Standards for Buildings, and at enabling their adoption and application through the provision of capacity building and information dissemination.

:: ACKNOWLEDGEMENTS

This study is the result of a collaborative input between national efforts and international expertise. The project wishes to thank all individuals and institutions who supported and contributed to this study.

Particular acknowledgements to:

The General Directorate of Urban Planning
The Lebanese Standards Institution
The Order of Engineers and Architects, Beirut
The Directorate of Meteorological Services

:: FORWARD

The requirements of the *Thermal Standard for Buildings in Lebanon* were established by modeling typical representative buildings and determining cost effective building envelope improvement levels. To determine the improvement levels, the incremental construction cost was balanced against the savings in heating and cooling energy costs.

The proposed building envelop improvement levels were determined according to the most likely energy price scenario, cost and inflation.

To be noted however, that this study was limited in scope. Certain building envelop parameters could not be included in this study and as such require further investigation in the future. These include, but are not limited to, the building thermal mass and thermal bridges.

This Standard is proposed to be voluntary until 2010 in order to allow a transitional period of trial and adaptation. Nonetheless, it is to be noted that the new Lebanese Building Law has already introduced incentives to encourage the improvement of the thermal performance of building envelopes.

:: TABLE OF CONTENTS

:: LIST OF TABLES

:: LIST OF FIGURES

:: LIST OF EQUATIONS

1 :: PURPOSE

The purpose of the *Thermal Standard for Buildings* is to improve the thermal performance of building envelopes which in turn reflects on an improvement in the thermal comfort conditions within buildings and consequently on the reduction of the energy needed for space heating and cooling. In order to fulfill this, the *Thermal Standard for Buildings* addresses the following:

- Sets minimum requirements for the thermal performance of building envelopes
- Provides methods for determining compliance with these requirements

2 :: SCOPE

2.1 Included Buildings

The requirements of the *Thermal Standard for Buildings* are applicable to the following categories of new buildings and new additions to existing buildings:

Category 1: Residential

This category covers all new buildings and parts of buildings that are destined for residential human occupancy. This category includes, but is not limited to:

- Residential buildings and complexes
- Individual residences
- Secondary seasonal residences and chalets
- Dormitories
- Etc.

Category 2: Non-Residential

This category covers all new buildings and parts of buildings that are destined for non-residential human occupancy. This category includes, but is not limited to:

- Commercial and Retail (offices, stores, shopping malls, restaurants, cinemas, etc.)
- Hospitality facilities (hotels, motels, etc.)
- Educational Facilities (schools, universities, etc.)
- Health care facilities (hospitals, nursing homes, etc.)
- Institutional facilities (government services, etc.)
- Indoor Sports facilities
- Etc.

2.2 Exempt Buildings

The requirements of the *Thermal Standard for Buildings* are not applicable to the following:

- Existing buildings;
- Buildings and parts of buildings that are intended for uses other than basic human occupancy, such as manufacturing, industrial processing, storage, etc.;
- Buildings and parts of buildings that require particular indoor environmental conditions such as greenhouses, warehouses, etc.;
- Religious buildings;
- Etc.

3 :: DEFINITIONS, ABBREVIATIONS AND SYMBOLS

The main terms, abbreviations and symbols that are used in this standard are presented and defined in Table 1.

:: Table 1 – Parameter Definitions

Parameter	Symbol	Definition	Unit
Thermal Transmittance	U	Heat flow rate in steady state divided by the area and the temperature difference between the surroundings on each side of a system.	$W/m^2.K$
Thermal Resistance	R	Reciprocal of thermal transmittance from surface to surface of the construction component.	$m^2.K/W$
Fenestration Ratio	FR	The ratio of total window and skylight area (including sash and frame) to total gross exterior wall and roof area. The gross exterior wall and roof areas include the window and skylight areas.	---
Effective Fenestration Ratio	EFR	The effective fenestration ratio provides a global evaluation of the exposure of the building to solar gain. This factor takes into consideration the orientation of windows and skylights, the shading coefficient of the glazing material as well as the architectural shading factor.	%
Shading Coefficient	SC	The ratio of solar heat gain that will pass through the fenestration glazing material to the solar heat gain that will pass through an equivalent area of unshaded clear glass. The shading coefficient can be obtained from the manufacturer's product documentation.	%
Projection Factor	PF	For overhangs: External horizontal length (extension) of overhang divided by the distance from the bottom of the fenestration to the bottom of the overhang. For fins: External horizontal length (extension) of fin divided by the distance from the farthest side of the window protected by the fins to the side of the fin nearest to the window.	---
Architectural Shading Factor	ASF	The ratio of solar radiation that will reach the fenestration taking into consideration the shading provided by architectural features (overhangs, lateral fins or a combination) divided by the solar radiation that will reach an equivalent unshaded fenestration.	---

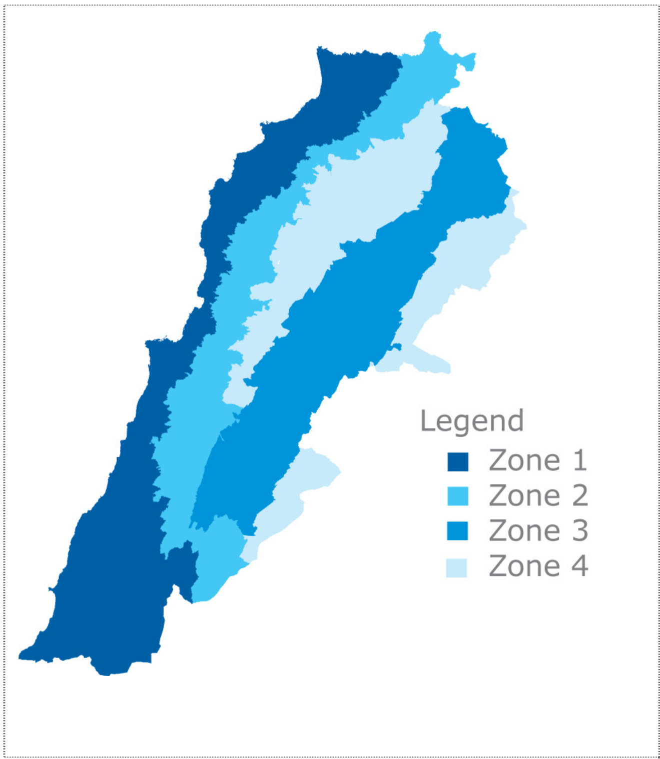
4 :: CLIMATIC ZONES

The Climatic Zones that are applicable to this Standard are presented in Figure 1. These are:

Zone 1 – Coastal
Zone 2 – Western Mid-mountain
Zone 3 – Inland Plateau
Zone 4 – High Mountain

The characteristics and altitude thresholds of the climatic zones, as well as the administrative real-estate districts related to each climatic zone are presented in the *Technical Guide for the application of the Thermal Standard for Buildings in Lebanon*.

:: Figure 1 - Climatic zoning



5 :: COMPLIANCE PATHS

The Thermal Standard for Buildings provides a choice between two compliance paths: the Prescriptive Path and the Performance Path. The aim of having more than one compliance path is to allow greater flexibility, whereby the user can select the compliance path that best responds to the proposed building design.

The prescriptive path is based on the use of equations and tabulated reference values, and involves the demonstration of compliance with two separate requirements: the thermal transmittance value and the effective fenestration ratio. Compliance with the thermal transmittance value can be demonstrated using one of two approaches: the individual component approach or the overall building envelope approach.

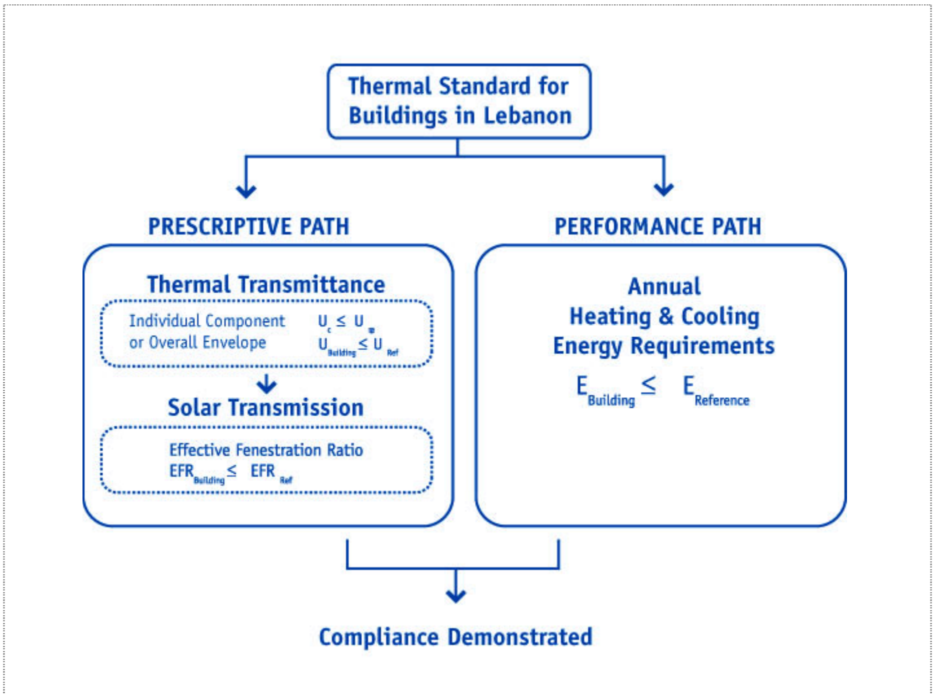
The performance path is based on the use of an hourly energy simulation software, and involves the demonstration that the annual heating and cooling energy requirements of the proposed building are less than or equal to the annual heating and cooling energy requirements of a similar hypothetical reference building which meets the prescriptive path.

The prescriptive path requires relatively less effort to demonstrate compliance but allows less design flexibility. Where as the performance path requires relatively more effort to demonstrate compliance but allows greater design flexibility.

The performance path may be used when innovative design concepts are being considered or when the proposed design fails to meet the prescriptive requirements.

The prescriptive path cannot be used when the proposed building has a window to gross wall ratio (the gross wall area is inclusive of the window area) greater than 0.30, or when the proposed building has a skylight to gross roof ratio (the gross roof area is inclusive of the skylight area) greater than 0.05. The performance path should be used in these cases.

:: Figure 2 - Compliance paths



6 :: PRESCRIPTIVE PATH

The prescriptive path specifies the maximum thermal transmittance levels and the maximum exposure to solar gains.

The maximum thermal transmittance requirement can be demonstrated using one of two approaches: the individual component approach or the overall building envelope approach. The thermal transmittance requirement addresses the following building envelope components: Roofs, Walls, Windows and Skylights, Floors (exposed and semi exposed), and Slabs on ground.

The maximum exposure to solar gain can be demonstrated using the effective fenestration ratio which takes into consideration several characteristics that have an influence on solar gain. These include window size, tilt, orientation, glass shading coefficient and architectural shading factor.

6.1 Compliance with the Thermal Transmittance using the Individual Component Approach

The individual component approach for thermal transmittance requires that each building envelope component meets a maximum tabulated reference value. For Roofs, Walls, Glazing, and Exposed and semi-exposed Floors, the requirement is expressed as a maximum U-value. For slabs on ground, the requirement is expressed as a minimum thermal resistance and a minimum width for an insulation layer placed on the perimeter of the slab on ground.

The individual component approach for thermal transmittance normally involves the least efforts to achieve compliance.

6.1.1 Maximum U-value for Roof, Wall, Glazing and Floor

Compliance with this requirement can be demonstrated by first using Equation 1 to calculate the U-value of the proposed building envelope component, and then by fulfilling equation 2 where by the maximum reference U-values for roofs, walls, glazing and exposed and semi-exposed floors are presented in Table 2.

To be noted that the calculation should exclude the effects of interior and exterior air films.

Equation 1 Calculation of the U-value of a Building Component

$$U_i = \Sigma(1/R_1 + 1/R_2 \ldots..)$$

U_i = thermal transmittance of the proposed building component ($W/m^2.K$)
$1/R_1$, $1/R_2$, etc. = thermal resistance of each layer of material ($m^2.K/W$)

Equation 2 Compliance with the Reference U-value

$$U_i \leq U_{ref}$$

U_i = thermal transmittance of the proposed building component ($W/m^2.K$)
U_{ref} = maximum allowable thermal transmittance of a building component ($W/m^2.K$)

:: Table 2 - Reference Thermal Transmittance Values per Component

Climatic Zone	Building Category	Maximum U-value[1] (W/m².K)					
		Roof	Wall	Vertical Glazing[2]	Skylight[2]	Exposed Floor[3]	Semi-Exposed Floor[4]
Zone 1: Coastal	1	0.57	2.10	6.2	4.3	2.60	2.60
	2	0.57	2.10	6.2	4.3	2.60	2.60
Zone 2: Western Mid-mountain	1	0.57	0.77	4.3	4.3	0.76	1.35
	2	0.57	0.77	4.3	4.3	0.76	1.35
Zone 3: Inland Plateau	1	0.57	0.77	4.3	4.3	0.66	1.00
	2	0.57	0.77	4.3	4.3	0.66	1.00
Zone 4: High Mountain	1	0.44	0.55	2.8	2.8	0.55	0.80
	2	0.44	0.55	2.8	2.8	0.55	0.80

1) The U-values presented in Table 2 do not include the effects of interior and exterior air films. Thus the calculation of the U-value of the proposed component should exclude interior and exterior air films.
2) For windows and skylights, the thermal transmittance values presented in Table 2 are for the center of the glass and do not include the effect of the frame used for glazing.
3) Exposed floor: ground floor in direct contact with the exterior air.
4) Semi-exposed floor: ground floor above a non air-conditioned space.

6.1.2 Minimum Thermal Resistance for Slabs on Ground

This requirement is limited to slabs on ground constituting the floors of conditioned spaces only. In these cases, slabs on ground are to be insulated under the outside perimeter of the slab with a specified width of thermal insulation having the required thermal resistance (R value) as presented in Table 3. The thermal resistances presented in Table 3 are exclusively for the insulation material of the slab composition and should specifically exclude internal air films as well as the thermal resistance of the ground.

:: Table 3 - Reference Thermal Resistance and Width of Thermal Insulation for Slab on Ground

Climatic Zone	Building Category	Minimum Thermal Resistance (m².K/W)	Insulation Width (m)
Zone 1: Coastal	1	NR	NR
	2	NR	NR
Zone 2: Western Mid-Mountain	1	0.75	1.00
	2	0.75	1.00
Zone 3: Inland Plateau	1	1.00	1.25
	2	1.00	1.25
Zone 4: High Mountain	1	1.25	1.5
	2	1.25	1.5

NR: Not Required

6.2 Compliance with the Thermal Transmittance using the Overall Envelope Approach

This approach is based on the calculation of the overall envelope U-value, and involves the demonstration that the overall envelope U-value of the proposed building (U_{env}) is less than or equal to the overall envelope U-value of a similar hypothetical reference building (U_{ref}), where by, the U-values of the individual envelope components of the reference building, must comply with the tabulated prescriptive requirements of the individual component approach (tables 2 and 3). The overall envelope approach permits trade off between building envelope components, and as such provides more building design flexibility.

It is to be noted that at this first stage of application of the Thermal Standard, the calculation of thermal bridges has been deliberately excluded from the equations of the overall envelope U-value. However, in future updates of the Thermal Standard, the issue of thermal bridges will be incorporated.

Equation 3 Calculation of the Overall Envelope U-value of the Proposed Building

$$U_{env} = \Sigma\ (U_i \times A_i)\ /\ \Sigma A$$

Equation 4 Calculation of the Overall Envelope U-value of the Reference Building

$$U_{ref} = \Sigma(U_{i\text{-}ref} \times A_i)\ /\ \Sigma A$$

U_i	=	Thermal transmittance of the individual component assemblies (roofs, exposed walls, exposed ground floors, semi-exposed ground floors, windows and skylights) ($W/m^2.K$)
$U_{i\text{-}ref}$	=	Reference Thermal transmittance of the individual component assemblies ($W/m^2.K$) as per the component approach of the prescriptive path.
A_i	=	Area of individual component assemblies (m^2).
A	=	Area of all envelope components enclosing conditioned spaces or exterior components for unconditioned building (roofs, exposed walls, exposed ground floors, semi-exposed ground floors, windows and skylights) (m^2).

Compliance with the overall building envelope thermal transmittance requirement is achieved if Equation 5 is satisfied.

Equation 5 Compliance with the Overall Building Envelope U-value

$$U_{env} \leq U_{Ref}$$

6.3 Compliance with the Effective Fenestration Ratio

For any building with fenestration, one can evaluate the ratio of the total amount of solar radiation entering the building to the total solar radiation reaching the fenestration areas over an entire year. This ratio is used to determine the impact of the solar load on the heating and cooling energy usage of a building. This ratio depends on the following factors: ratio of windows to gross wall areas, ratio of skylight to roof area, glass shading coefficient and architectural shading factor. It is defined as the effective fenestration ratio (EFR).

The maximum allowable effective fenestration ratio presented in Table 8 was determined from a review of the current average fenestration ratio of existing buildings in Lebanon and the economics of using improved glazing and architectural shading devices to control the solar cooling load and to optimize the beneficial solar heat gain during the heating season.

The EFR for the proposed building is calculated using Equation 6:

Equation 6 Calculation of the Effective Fenestration Ratio of the Proposed Building

$$EFR = \Sigma (Aw_i \times SCw_i \times ASFw_i) / \Sigma Av + 2 \Sigma (As_i \times SCs_i) / \Sigma Ah$$

Aw_i = Area of the individual window (m^2)
SCw_i = Shading coefficient of the individual window
$ASFw_i$ = Architectural shading factor of the individual window
Av = Area of all vertical surfaces (opaque walls + windows) (m^2)
As_i = Area of the individual skylight (m^2)
SCs_i = Shading coefficient of the individual skylight
Ah = Area of all horizontal surfaces (roofs + skylights) (m^2)

The Shading Coefficient (SC) to be considered is only that of the glazing material. Movable or removable shading devices are not considered. The glass shading coefficients can normally be obtained from the manufacturer's documentation.

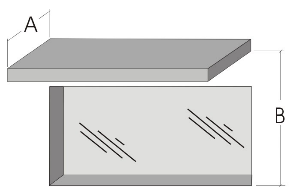
The Architectural Shading Factor (ASF) is a coefficient related to the external shading projection factor of overhangs and/or lateral fins and for which values can be found in Table 4. These values were calculated by modeling overhangs and fins per orientation, and by tracking the net amount of solar energy that penetrates the window opening with and without the shading device over the heating and cooling season. Tables 4, 5, 6 and 7 summarize respectively the results for unprotected windows, windows with overhangs, windows with fins, and windows with both overhangs and fins.

The projection factor (PF) of the architectural shading device is calculated as shown in figures 3 and 4. When both overhangs and fins are used simultaneously, the projection factors for the overhangs and fins should be calculated separately using figures 3 and 4. Then the appropriate architectural shading factor should be selected from Table 7. If the projection factor ranges in Table 7 do not exactly fit the proposed ratios of fins and overhang, then the value with the closest fit to the projection factor of the overhang should be used from table 7.

:: Figure 3 - Projection Factor for Overhangs

The projection factor for overhangs is expressed as a dimensionless ratio defined as follows:

$$PF_{Overhang} = \frac{A}{B}$$

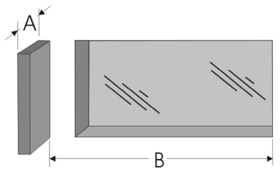


$PF_{Overhang}$ = Projection factor for overhangs (dimensionless)
A = Horizontal extension of the overhang from the vertical wall plane that contains the fenestration(m)
B = Distance between the bottom edge of the fenestration and the bottom edge of the overhang (m)

:: Figure 4 - Projection Factor for Fins

The projection factor for fins is expressed as a dimensionless ratio defined as follows:

$$PF_{fins} = \frac{A}{B}$$



PF_{fins} = Projection factor for fins (dimensionless)
A = horizontal extension of the fin from the vertical wall plane that contains the fenestration (m)
B = Distance between the farthest side of the fenestration to the face of fin closest to the fenestration(m)

:: Table 4 - Architectural Shading Factor (ASF) for Unprotected Windows

PF - *Fins or Overhangs*	ASF per Orientation			
	N	NE,NW	E,W	S,SE,SW
PF < 0.05	0.26	0.47	0.82	1.00

:: Table 5 - Architectural Shading Factor (ASF) for Windows Protected by Overhangs Only

PF - *Overhangs*	ASF per Orientation			
	N	NE,NW	E,W	S,SE,SW
0.05 ≤ PF < 0.15	0.24	0.43	0.74	0.89
0.15 ≤ PF < 0.30	0.23	0.40	0.68	0.80
0.30 ≤ PF < 0.50	0.21	0.34	0.57	0.64
0.50 ≤ PF < 0.70	0.19	0.31	0.49	0.54
0.70 ≤ PF < 0.90	0.18	0.28	0.43	0.46
0.90 ≤ PF < 1.25	0.17	0.26	0.38	0.41
PF ≥ 1.25	0.16	0.24	0.31	0.34

:: Table 6 - Architectural Shading Factor (ASF) for Windows Protected by Fins Only

PF - *Fins*	ASF per Orientation			
	N	NE,NW	E,W	S,SE,SW
0.05 ≤ PF < 0.15	0.23	0.42	0.76	0.92
0.15 ≤ PF < 0.25	0.20	0.38	0.71	0.85
0.25 ≤ PF < 0.35	0.19	0.35	0.67	0.78
PF ≥ 0.35	0.17	0.32	0.63	0.74

:: Table 7 - Architectural Shading Factor (ASF) for Windows Protected by Fins and Overhangs

PF – *Fins and Overhangs*	ASF per Orientation			
	N	NE,NW	E,W	S,SE,SW
Overhangs: 0.05 ≤ PF < 0.30 Fins: 0.05 ≤ PF < 0.15	0.20	0.35	0.63	0.72
Overhangs: 0.30 ≤ PF < 0.60 Fins: 0.15 ≤ PF < 0.30	0.15	0.26	0.47	0.50
Overhangs: 0.60 ≤ PF < 1.05 Fins: 0.30 ≤ PF < 0.50	0.11	0.17	0.30	0.27
Overhangs: PF ≥ 1.05 Fins: PF ≥ 0.50	0.08	0.11	0.17	0.13

Compliance with the Thermal Standard for Buildings is achieved if the effective fenestration ratio (EFR) of the proposed building is less than or equal to the respective tabulated maximum reference effective fenestration ratio (EFR_{ref}) presented in Table 8.

The maximum reference effective fenestration ratio is defined according to the climatic zone and category of buildings. It is mandatory that the window size and orientation used for the calculation of EFR and EFR_{ref} be the same.

Equation 7 Compliance with the Effective Fenestration Ratio

$$EFR \leq EFR_{ref}$$

:: Table 8 - Reference Effective Fenestration Ratio (EFR_{ref})

Climatic Zone	Building Category[1]	Maximum Effective Fenestration Ratio (EFR_{ref})
Zone 1: Coastal	1	11%
	2	10%
Zone 2: Western mid-mountain	1	13%
	2	13%
Zone 3: Inland Plateau	1	11%
	2	11%
Zone 4: High Mountain	1	16%
	2	21%

Category 1: Residential Category 2: Non-Residential

7 :: PERFORMANCE PATH

The performance path can be used as an alternative to the prescriptive path in order to demonstrate compliance with the thermal standard. This path provides more flexibility in the architectural design, and in the choice of building materials and building envelope components. Under the performance path, the designer has to demonstrate that the total annual heating and cooling energy requirements of the proposed building are less than or equal to the total annual heating and cooling energy requirements of a similar reference building which complies with the prescriptive path. Compliance is to be demonstrated by means of an hourly energy simulation software approved by the competent Lebanese authority.

7.1 General

Performance path

The performance path is based on computing the annual heating and cooling energy requirements in kilowatt-hours (kWh) of the proposed building and ensuring that it is not greater than the annual heating and cooling energy requirements of a similar reference building which meets the prescriptive path.

Proposed building

The proposed building is to be submitted in the form of typical drawings and is to include the specifications (size and composition) of the thermal envelope. The designer must submit construction detail sketches and drawings and calculations demonstrating how the thermal transmittance (U value) for floor, windows, walls and roofs have been determined for all zones and blocks as inputted into the simulation software. The input file for the simulation software should be submitted.

Proposed building thermal energy usage ($E_{building}$)

The proposed Building thermal energy usage is the total heating and cooling energy requirements in kilowatt-hours (kWh) determined by the building simulation software using inputs of the proposed building including the weather files and the fixed simulation parameters which have been approved by the competent Lebanese authority.

Reference building

The reference building is similar to the proposed building except that the building envelop components should comply with the requirements of the individual *component approach* of the prescriptive path. All necessary documentation to prove that the reference building complies with the *component approach* of the prescriptive path should be submitted with the compliance verification request as per the requirements of the *component approach* of the prescriptive path.

The general building geometry, roof area, floor area, total gross wall, wall surfaces on each orientation should be the same for the simulation of the proposed building energy usage and the reference building energy usage.

Except for considerations listed in paragraphs a) and b) below, the window and skylight areas for the reference building and the proposed building should be the same.

a) For the reference building, the Window to gross wall ratio (the gross wall area is inclusive of the window area) should not exceed 0.30 even if the proposed building uses larger fenestration areas. In this case, the window areas in the reference building should be reduced on each orientation by the difference between the window to wall ratio of the proposed building and the set limit of 0.30.

b) For the reference building, the skylight to gross roof ratio (the gross roof area is inclusive of the skylight area) should not exceed 0.05 even if the proposed building uses larger skylight areas. In this case, the skylight areas in the reference building should be reduced to the set limit of 0.05.

Except for the limitations above, the reference building should use the same input values as per the proposed building for all parameters except the ones related to thermal transmittance characteristics of the roof, walls, floors, windows, skylight windows and the solar heat gain characteristics (shading coefficient) of windows and the architectural shading devices (fins and overhangs).

For a building in a climatic zone that does not require wall insulation where the designer may decide to add wall insulation to permit using larger window areas as a trade-off, the wall in the proposed building should be inputted exactly as the proposed construction detail. The wall for the reference building should be entered as specified in the individual approach of the prescriptive path.

For a building requiring wall insulation but where the designer decides not to insulate the wall, the proposed building should be entered as per the proposed construction details. The reference building should be entered as specified in the individual approach of the prescriptive path.

Reference building thermal energy usage (E_{ref})

The Reference Building thermal energy usage is the total heating and cooling energy requirements in kilowatt-hours (kWh) determined by the building simulation software using the same inputs as the reference building, including the same weather files and fixed simulation parameters which have been approved by the competent Lebanese authority.

7.2 Fixed Simulation Parameters

In order to avoid variations in building performances not related to the thermal performance of building envelopes, there are a number of simulation parameters which have to be fixed and which have to be identical for both the proposed building and the reference building. These fixed simulation parameters include:

- Weather file for simulation
- Exterior design temperatures
- Interior temperature set-point in cooling mode
- Typical occupancy schedule
- Occupant density
- Occupant internal heat gain

- Equipment internal heat gain
- Equipment schedule
- Lighting internal heat gain
- Lighting schedule
- Process heat gain
- Process schedule
- Temperature set-points in heating
- Temperature set-points in cooling
- Temperature schedule
- Infiltration level
- Infiltration schedule
- External energy usage (e.g. Lighting)
- Domestic hot water input details (all zeros)
- System type and performance (fans, coil, compressors, boilers)
- System capacity
- System efficiency
- System operation schedule

Total energy requirements for heating and cooling (kWh)

Input energy requirements used for heating and cooling by the space conditioning system. The total annual thermal energy requirement includes the needed energy for comfort heating and cooling. The competent authority will indicate the approved software that can be used and the acceptable reporting form.

Software

The list of approved software packages will be established by the relevant National Institution. From then, any of the approved software packages can be used for the calculation of the expected total annual energy requirements for heating and cooling for the proposed and reference buildings.

7.3 Compliance

Compliance with Thermal Building Standard is achieved if:

Equation 8 Compliance with the Annual Heating and Cooling Energy Requirements

$$E_{building} \leq E_{Reference}$$

$E_{building}$: computed annual thermal energy needs of the proposed building (kWh/year)
$E_{Reference}$: computed annual thermal energy needs of the reference building (kWh/year)

:: REFERENCES

- "Climatic Zoning for buildings in Lebanon", UNDP/GEF and MPWT/DGU – 2005.
- "Energy Analysis and Economic Feasibility Study for the development of viable solutions for the Thermal Standard for Buildings in Lebanon", UNDP/GEF and MPWT/DGU – 2005.
- ASHRAE 90.1 "Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings", American Society of heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA ,1989.
- ASHRAE 90.2 "Energy Efficient Design of New Low-Rise Residential Buildings", American Society of heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA, 1993.
- ASHRAE Fundamentals Handbook, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA, 1993,
- ASHRAE Refrigeration Handbook, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA, 1998.
- Réglementation Thermique Française 2000 "Caractéristiques Thermiques des Bâtiments nouveaux et des parties nouvelles des bâtiments", RT2000 Centre Scientifique et Technique du Bâtiment, CSTB, France, 2000.
- Méthodes de calcul Th-C et Th-E, Centre Scientifique et Technique du Bâtiment, Centre Scientifique et Technique du Bâtiment, CSTB, France, 2000.
- California Energy Code, California Building standards Commission, USA, 1998.
- Model National Energy Code of Canada for Buildings, Institute for Research in Construction, Canadian Commission on Building and Fire Codes, 1997.
- Model National Energy Code of Canada for Houses, Institute for Research in Construction, Canadian Commission on Building and Fire Codes, 1997.
- AS 2627.1-1993 Thermal insulation of dwellings, Part 1: Thermal insulation of roof/ceilings and walls in dwellings, Standards Australia, 1993.
- ISO 13789 "Thermal performance of buildings – Transmission heat loss coefficient – calculation method", International Organization for Standardization, 1999.
- ISO 13786 "Thermal performance of building components – Dynamic thermal characteristics – Calculation methods", International Organization for Standardization, 1999.
- ISO 10077-1 "Thermal performance of windows, doors and shutters – Calculation methods", International Organization for Standardization, 2000.
- ISO 13370 "Thermal performance of buildings - Heat transfer via the ground – Calculation methods", International Organization for Standardization, 1998.
- ISO 7345 "Thermal Insulation – Physical quantities and definitions", International Organization for Standardization, 1987.
- "International Survey of Building Energy Codes", Australia Greenhouse Office, www.greenhouse.gov.au/energyefficiency/buildings, 2000.