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The Development of Residential and Commercial Building Energy Standards for Egypt

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ABSTRACT

In 2000, the Housing and Building Research Centre of Egypt obtained a United Nations grant to develop energy standards for residential and commercial buildings in Egypt. Over the past three years, the authors have worked as an international consultant team, bringing to the project many years of experience in the development of building energy standards in the US and other countries, surveys of existing building conditions and energy use, the use of computer simulations to analyze building energy performance, and the design and construction of energy-efficient buildings. The proposed residential energy code was completed in June 2003, to be followed by the proposed commercial energy code in the spring of 2004. Both of these standards will then undergo a public review process prior to being submitted to the government for promulgation. While the codes were being finalized, the authors also developed a detailed implementation plan for putting into place the infrastructure, training, and supporting materials and software to properly promulgate and enforce the codes, as well as initiate a major program of demonstration buildings to transform the Egyptian market for energy efficiency in buildings. The entire project will be completed by summer 2004.

A key component in the development of the proposed codes is the use of the DOE-2 hourly energy simulation program to evaluate building energy performance. The authors have (1) devoted months of effort in providing training in the use of the DOE-2 program, both in Egypt and in the U.S., and (2) provided technical support in developing Egyptian weather data and a Windows-based program to do parametric DOE-2 simulations. Several prototypical residential and commercial buildings have been developed that have been used by the project Simulation Working Group to evaluate the energy savings from a comprehensive set of envelope and HVAC system measures. Since not all buildings in Egypt are equipped with mechanical cooling, we also added the Fanger Comfort Model to DOE-2 that enabled the consultant and Egyptian teams to estimate improvements in indoor comfort in addition to building energy savings.

This presentation will describe the overall scope of the project, the research efforts undertaken in support of the standards, and give an overview of the draft residential and commercial building energy efficiency codes.

Background

In 2000, the Housing and Building Research Centre (HBRC) of Egypt obtained a grant from the United Nations Development Programme (UNDP) to develop and apply energy efficiency building codes for new residential and commercial buildings in Egypt, with the Egyptian government also providing co-funding. These codes are meant to be a set of technical design guidelines that, if followed, will ensure that the designed building will achieve a minimum expected level of energy efficiency. The initial efforts will concentrate on new buildings in new communities within Cairo and Alexandria governorates, where 50% of all the country's construction occurs (UNDP 2000). In the current Phase One of the project, the new codes will be developed and implemented on a voluntary basis. Near the conclusion of Phase One, a plan will be developed for mandatory implementation of the standard in possible following phases of the project.

At present, Egypt has no energy efficiency standards for building construction. Although the HBRC has conducted research and analysis of climate-appropriate building design, and the Organization for Energy Planning (OEP) has started a Green Architecture program to promote the concept of climate-appropriate building design, there is little indication that these efforts have succeeded in changing overall design practices in Egypt towards improved energy efficiency.

The primary responsibility for this project has been assigned to HBRC in collaboration with OEP. To carry out the technical work in support of the codes, HBRC has set up Working Groups (WG) in the following areas: building envelope, ventilation and air-conditioning, lighting, building survey, electric power and training/simulation. Each Working Group is responsible for identifying energy-efficient strategies in its area, and participating in the overall development of energy standards for residential and commercial buildings. All of the Working Groups with the exception of the building survey correspond to major sections of the codes: Building Envelope, Ventilation and Air Conditioning (VAC) Systems, Lighting Systems, Electrical Power and Distribution, and Whole Building Energy Performance (assigned to the Simulation and Training WG). In the commercial building standard, two sections on natural ventilation and daylighting systems have been added with the intent of encouraging both architects and engineers to consider these options in their designs. The Natural Ventilation section is assigned to the VAC WG, while the Daylighting System section is assigned to the Lighting WG. Both the residential and commercial standards also contain a section on Service Hot Water, which is also assigned to the VAC WG.

Since the inception of this project, the authors have participated as International Consultants (IC), bringing to the project many years of experience in developing building energy standards in the US and other countries, the use of computer simulations to evaluate building energy performance, and the design and construction of energy-efficient buildings. The technical support we provided in the development of the standards can be separated into four areas: (1) surveys of building energy use, (2) training and support in the use of the DOE-2.1E building energy simulation program, and (3) compilation of the building standards themselves, and (4) development of an implementation plan for the following phase of the project.

Our experience working on building energy standards in numerous developing countries have shown that they require many years of effort, of which the development of an energy standard, while technically challenging, is perhaps the most straightforward. For example, in the Middle East the authors are aware of a set of building energy standards developed for Kuwait in the late 1980s (Kellow 1985), and a proposed "Thermal Regulation for Dwellings in the Maghreb" in Tunisia (Ghrab-Morcos 1995) in the 1990's, but we do not know of any country that is currently implementing building energy standards. In most countries where we have worked, reasonable first drafts of standards had been developed, but government adoption was spotty and widespread enforcement even more problematic. In some cases, enforcement was hampered by the lack of familiarity with the new energy standard and basic principles of energy-efficient building design among the building industry or regulating officials. In other cases, there were pre-existing problems with government regulation of any aspect of building design and construction. Building from this experience, the authors' approach to this project has been to assist HBRC to produce technically sound and easy-to-use and understandable standards, while at the same time stressing the need to involve and inform the building industry in the code development process, and to develop and carry out a detailed implementation plan.

Survey of Building Energy Use

The purpose of this activity is to develop a reasonably accurate baseline of building conditions and energy use in Egypt through surveys. This information is useful for defining prototypical buildings for use in the computer analysis being carried out by the IC team and Simulation and Training WG, and for calibrating their simulated energy use. One of the authors (Masud) has developed and conducted this type of building survey for more than ten years in several different countries. Based on this experience, we have developed separate survey forms for residential and commercial buildings. For the past two years, Masud has been working with the Building Survey WG to develop the detailed survey approach, provide training in survey techniques, and identify candidate buildings for the residential and commercial surveys.

The scope of the residential survey is to define both the physical characteristics of the building exterior and interior, the installed power density of lighting and other equipment and their usage schedules, the characteristics and control schedule for the heating, cooling, and ventilation system, the occupant density, distribution by room, and schedule, and the monthly utility bills if available for electricity and fuel. The first page of the final residential survey form is shown in Fig 1.

The residential survey was done in two phases (Aziz et al. 2001). In Phase One, a pilot survey was conducted on a limited sample of 13 housing units to test the survey sheets and refine the survey techniques. In Phase Two, a larger survey of 125 housing units was conducted, of which 95 were located in Cairo and 30 in Alexandria.. Of the 125 sampled housing units, 22% were in high-rise buildings of more than 6 stories, 70% were in mid-rise building buildings from 5 to 6 stories, and only 8% in low-rise buildings with two floors. In terms of socio-economic level, 36% were classified as high-income, 48% as middle-income, and 16% as low-income housing units. Based on the distribution of housing conditions found, the Building Survey WG defined prototypical housing units characterized by building type (villa or apartment) and income-level (high, medium, and low). The WG also developed prototypical occupancy schedules by family type (with or without children, single or two family wage-earners) for major residential spaces (bedroom, living room, kitchen and bathroom). Unfortunately, the Building Survey WG was not able to obtain energy consumption data in their surveys.

The buildings descriptions and occupancy schedules defined through the residential survey were incorporated into the DOE-2 computer models developed by the IG and Simulation and Training WG. For example, much of the computer analysis of energy-efficiency options and indoor comfort conditions were done using a prototypical apartment units from the Mohammed Ramadan building in Cairo (see Fig. 2).

The survey of commercial buildings was completed in September 2003. According to the 1986 census, there are 131,677 commercial buildings in Egypt, with Cairo having 21% and Alexandria 12.4% of the national total (Aziz 2003). In contrast to the residential survey, the commercial survey consisted of analysis of sectoral data from the census, OEP, and the Ministry of Electricity and Energy, complemented by energy audits and surveys of a relatively small sampling of 19 commercial buildings in Cairo, including 3 banks, 2 shopping malls, 2

Figure 1. Residential Building Survey Form

EGYPT

RESIDENTIAL BUILDING ENERGY AND CHARACTERISTICS

DATABASE RECORD

BUILDING ID

Zone	Type	Income	Serial Number		

A. GENERAL INFORMATION

A.1 Name of resident

A.2 Address

Number		Floor	
Building			
Street 1			
Street 2			
Zone	**#N/A**	City	**#N/A**
Post Code		Telephone	

A.3 Person interviewed

A.4 Income level **#N/A**

Survey page 1

B. EXTERNAL FEATURES

B.1 Building type **#N/A** **B.2** Floors Above Below

B.3 No. of units/floor **B.4** No. of façades

B.5 Building façades Floor height (m)

Number	Direction	Width (m)	Color 1	Color 2	Finish 1	Finish 2	Texture
1							**#N/A**
2							**#N/A**
3							**#N/A**
4							**#N/A**
5							**#N/A**
6							**#N/A**

Survey page 2

B.6 Building structure **B.7** Building use

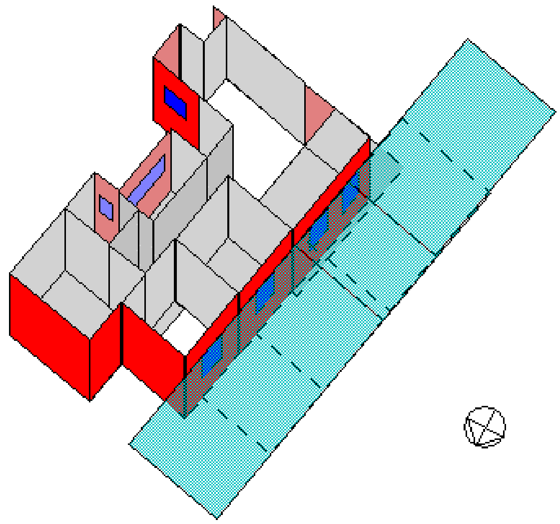
B.8 Facing buildings

Fac.	Dist. (m)	Floors	Color		Texture	Ground 1	%	Ground 2	%
1				**#N/A**					**0**
2				**#N/A**					**0**
3				**#N/A**					**0**
4				**#N/A**					**0**
5				**#N/A**					**0**
6				**#N/A**					**0**

B.9 Nearby building density **B.10** Adjacent buildings

Survey page 3

Figure 2. Computer model of prototypical apartment unit
(horizontal surface in front of front walls are window overhangs)



residential/commercial mixed-use building, 3 offices, 1 hospital, and 5 government ministries. The report presented general observations on the typical size, shape, number of floors, envelope conditions, and cooling and ventilation equipment of offices, hotels, and retail stores. The energy use characteristics of the audited buildings were also documented, although the small sampling made it difficult to draw conclusions from such data. Similar to the residential work, the IC and Simulation and Training WG have developed DOE-2 computer models of prototypical commercial buildings using this information. Figures 3 and 4 show computer representations of a prototypical mixed-use and a prototypical large hotel building.

Figure 3. Computer model of typical mixed-use commercial building

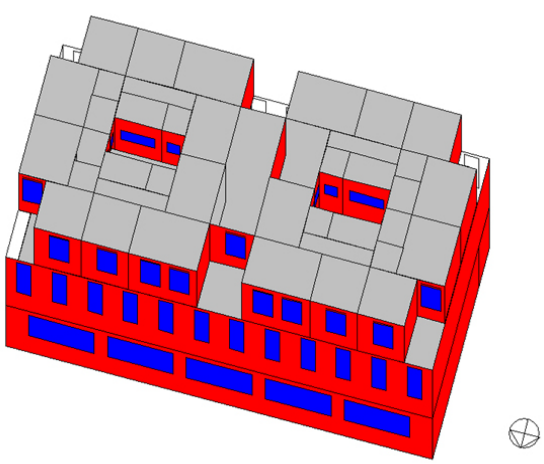
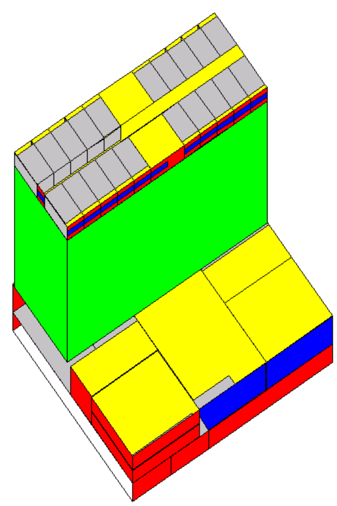


Figure 4. Computer model of typical hotel building



Training and Support in the Use of DOE-2.1E

The DOE-2.1E building energy simulation program has been used in this project as the primary tool to analyze the energy performance of different building designs, energy efficiency measures, and operational strategies. The predominant space conditioning requirement in Egypt is cooling, which is characterized by dynamic non-steady-state heat flows. Under such circumstances, a detailed hour-by-hour simulation program like DOE-2 is necessary to accuratelydetermine the cooling loads and air-conditioning energy use.

The DOE-2 program was developed by Lawrence Berkeley National Laboratory (LBNL) in 1981 and has since been maintained by LBNL, with support from the U.S. Department of Energy. The last public version of the program is 2.1E, which was completed in 1993 (Winkelmann et al. 1993). Since its introduction more than twenty years ago, DOE-2 has been used in over 30 countries, particularly for developing building energy standards in the US, such as ASHRAE 90.1 and 90.2, California's Title-24, as well in many other countries such as Singapore, Australia, Mexico, etc.

DOE-2 simulates the heat flows through the building envelope, the heat gains from solar radiation and internal sources, the performance and control of the Heating, Ventilation, and Air-conditioning (HVAC) equipment, and the net energy consumption of a building on an hour-by-hour basis for up to an entire year. Learning to use of the DOE-2 program, however, takes months of time and effort. The reasons are due partly to the amount of information required by DOE-2 in describing the thermal properties of the physical building, the temporal patterns of occupancy and various end-uses such as lighting and equipment, the performance characteristics and control of the HVAC equipment, etc., and partly to the text-based input/output procedures reflecting a computer program nearly 25 years old.

In the last ten years, several private venders have developed graphical interfaces for DOE-2 that have simplified the I/O procedures. However, the authors' experiences in teaching DOE-2 in Egypt and other countries have been that while such graphical interfaces help in introducing DOE-2 to new users, they can also prevent the more advanced users from understanding and tapping all the functionality in the underlying DOE-2 program. Consequently, through trial-and-error, we have found the most effective way of teaching DOE-2 to use a graphical interface in the beginning stages, and then gradually shift to the text-based input/output procedure of the underlying DOE-2 program. This then allowed us to customize the text-based input files to the needs and interests of the HBRC.

DOE-2 Training Sessions

Beginning in June 2001, two of the authors (Krarti and Deringer) and another project consultant conducted four one- to two-week training sessions with the Simulation WG in Cairo on the use of the DOE-2 program. In the first session, we used *VisualDOE*, a proprietary graphical interface to DOE-2, but as the Simulation WG gained experience in the program we used the input files generated by *VisualDOE* as templates and added to them parametric inputs and other special features meeting the research interests of HBRC. In the summer of 2002, one of the authors (Huang) hosted a HBRC study tour of the US, during which four members of the HBRC delegation stayed for several weeks in Berkeley to work with Huang and Deringer on DOE-2 modeling issues. Through these efforts, the Simulation and Training WG has become proficient in using DOE-2 to analyze building energy-efficiency options and to apply the results as a rational basis for setting the efficiency requirements in the building energy standards.

With the help of the IC, the Simulation and Training WG have used DOE-2.1E extensively to study the impacts of a large number of shell and equipment measures, and operational strategies on the energy use and indoor comfort in prototypical residential and commercial buildings. In residential buildings, we studied the effects of wall and roof construction, insulation level, and color, window glass type, size (window-to-wall ratio), external shading and shutters, electric lighting power density, cooling and heating setpoints, and the use of natural ventilation. In commercial buildings, we also studied the interactions between daylighting and window design, different HVAC systems, and thermal storage.

Software Support

In the interim periods between the training sessions and study tours, communication and technical support was maintained between the IC team in the US and the Simulation and Training WG in Cairo via the Internet. As the needs arose, the authors provided technical assistance either in modeling issues or developing or customizing software to support the work of the HBRC staff. For example, the authors provided or developed detailed weather data for three Egyptian locations (Cairo, Alexandria, and Aswan), and assisted the Simulation and Training WG in developing master input files for prototypical residential and commercial buildings.

Since this analysis involved a large number of parametric simulations, the authors developed a simple Windows-based parametric analysis tool called *doe2parm* to help manage the large amount of input and output data. *doe2parm* is written in C and uses a combination of Excel, the *awk* programming language (Aho et al. 1988), and DOS commands to do input pre-processing and output post-processing. Additional information and downloads of *doe2parm* are available on the Web at http://www.deringergroup.com /Software/DOE2Parm/DOE2Parm.htm.

Many buildings in Egypt, especially residential buildings, may not be air-conditioned or use only ceiling fans. Consequently, the IC team assisted the Simulation and Training WG in studying in more detail the indoor temperatures resulting from the use of natural ventilation or improvements in the building shell. To evaluate indoor comfort conditions, the authors added to the master input files the Fanger Comfort Model implemented as a DOE-2 function (Huang 2002). This feature uses the ability of DOE-2.1E to calculate the inside surface as well as air temperatures, from which the Fanger Model calculates the Predicted Mean Vote (PMV) and Predicted Percent Dissatisfied (PPD) for each space and hour of simulation.

Compilation of the Building Standards

The ultimate objective of the project is the compilation of energy efficiency standards for residential and commercial buildings in Egypt.[1] In parallel with the research activities mentioned earlier, one of the authors (Deringer) assisted and coordinated the efforts of the Code Development Main Working Group made up primarily of the WG team leaders in drafting the

[1] This paper uses the terms "standard" and "code" interchangeably. The legal distinction between the two terms is that a "standard" is a technical document that only becomes a "code" when it has been enacted into law by a government jurisdiction.

two building energy standards. A draft energy standard for residential building was completed and presented for public review in Fall 2002 (HBRC 2003). A draft energy standard for commercial and mixed-use buildings for internal review was completed in November 2003, with a draft for public review expected in early 2004.

Since the two standards are written by the same authors, it is unsurprising that they share a similar methodology and approach. The organization of the standards also shares many similarities to US standards such as ASHRAE-90.1, which was reviewed extensively during the writing of the standards. In both standards, there are two introductory chapters presenting the scope, definitions, and general requirements. In scope, both standards are targeted primarily at new buildings, but also covers new portions, as well as new systems and equipment, added to existing buildings. The chapter on general requirements explains in more detail which sections of the code are applicable depending on the project, and the required documentation to verify compliance.

The prescriptive requirements for different major building components are defined in Chapters 3 – 7 in the residential standard and Chapters 3 – 8 in the commercial standard. In both standards, Chapter 3 covers the requirements for the building envelope, Chapter 5 for the heating, ventilation, and air-conditioning system, Chapter 6 for the service hot water system, Chapter 7 or 8 for lighting, and Chapter 8 or 9 for the building electrical system, and Chapter 9 or 10 for whole building energy performance. The last chapter provides an alternate performance path that allows a building to comply so long as its total energy consumption is shown to be less than that of a building that meets all the prescriptive requirements. The combination of a simple but rigid prescriptive option with a more flexible performance option is an approach used increasingly more in building energy standards in the US and other countries. The difference in the later chapter numbers between the two standards is because the commercial standard has an extra Chapter 7 on daylighting.

Chapter 3 of the standards gives the maximum allowable U-values or minimum insulation R-values for the opaque elements of the building, and varies the maximum allowable U-factor and Solar Heat Gain Coefficient (SHGC) for glazing as a function of the Window-to-Wall or Skylight-to-Roof ratios. The general approach is that the greater the amount of windows or skylights, the better must be their thermal and solar transmission qualities. Figures 5 and 6 show the envelope requirements for conditioned and unconditioned building in Cairo. Note that the minimum requirements for wall R-values are somewhat lower in the case of unconditioned buildings. In this first version of the standards, tables are presented for only two climate zones - Cairo and Alexandria. In future versions, additional climatic zones may be added based on need and availability of weather data.

Chapter 3 also allows trade-offs in the thermal and solar properties between different envelope components as long as the overall OTTV (Overall Thermal Transmission Value) for the walls or roofs are below the values given in Section 3.3 (45 W/m^2 for walls, 25 W/m^2 for roofs in Cairo; 40 W/m^2 for walls, 20 W/m^2 for roofs in Alexandria). The use of OTTV as a simplified method to characterize the thermal performance of opaque elements dates back to the early 80's versions of ASHRAE 90. The OTTV equation for walls in given in Appendix D of the residential standard as:

$$OTTV_w = (\alpha \bullet A_w \bullet U_w \bullet TD_{eqw} + A_g \bullet U_g \bullet DT_o + A_g \bullet SF \bullet OF \bullet SC)/A_o \quad (1)$$

where:

$OTTV_w$	=	Overall thermal transfer value for walls (W/m^2)
A_w	=	Opaque wall area (m^2)
U_w	=	Thermal transmittance of opaque wall (W/m^2)
TD_{eq}	=	Equivalent temperature difference (^oC)
A_g	=	Glazing area (m^2)
U_g	=	Thermal transmittance of glazing (W/m^2)
DT_o	=	Temperature difference between exterior and interior design conditions (^oC)
SC	=	Shading coefficient of fenestration
SF	=	Solar/corrected solar factor (W/m^2)
A_o	=	Gross area of the exterior surface (m^2) ($A_w = A_g = A_d$)
α	=	Solar absorptivity (nondimensional)

The corresponding OTTV equation for roofs is similar. The OTTV formulation basically takes the DOE-2 results from an annual dynamic simulation, and recasts them into a simplified steady-state formulation using the TD_{eq} or Equivalent temperature differences for walls and roofs to "match" the steady-state calculations to the average results from the DOE-2 simulations.

A distinctive feature of the Egyptian building energy standards is that both the residential and commercial standards have a separate Chapter 4 on natural ventilation and thermal comfort. There are several reasons for including such a chapter: (1) many buildings in Egypt do not use mechanical cooling, in which case the benefits from implementing building energy efficient strategies would be primarily improved comfort rather than energy savings, and (2) our research showed that in the Egyptian climate natural ventilation was an effective strategy for saving cooling energy use or improving indoor comfort during the shoulder months, making it important for the standard to encourage its use in building design. Chapter 4 contains minimum requirements for openable window areas and opening areas to the ventilation shaft, and recommended ventilation rates for naturally ventilated buildings.

Chapters 5 and 6 of the proposed residential standard contains minimum efficiency requirements for unitary and packaged air-conditioning equipment, minimum efficiency requirements, requirements for duct and piping insulation and controls for split systems, and minimum efficiency requirements, and requirements for piping insulation and controls for service water heating equipment.. Chapters 5 and 6 of the draft commercial standard contains additional requirements appropriate to the larger HVAC and service water heating systems found in commercial buildings..

Chapters 7 of the proposed residential standard contains mandatory requirements for lighting controls and control of daylighted areas, and prescriptive requirements for lighting power density and daylighting.. In the draft commercial standard, lighting is covered in Chapter 7 and daylighting in a separate Chapter 8. The separate chapter on daylighting was done to (1) emphasize the importance of daylighting for saving electric lighting energy while improving the visual quality within Egyptian commercial buildings, and (2) encourage architects, lighting designers, and other engineers to all refer to this important section. Furthermore, in the commercial standard, daylighting requirements include the use of dimming controls whereas the residential standard requires only over half of the lights in the daylighted area can be shut off and that there are sufficient window areas to permit daylighting.

Figure 5. Prescriptive Envelope Requirements for Unconditioned Buildings in Cairo

Table 3.1

Building Envelope

Unconditioned Buildings in Cairo

Part A: Requirements

CDD 25 = 297 **HDD18.5 = 36**

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Orientation		External Surface Absorptivity	Required Min R values of Insulation for external walls and roofs (m^2°C/W)				**Max SHGC Values for Fenestration**				**or** **Min. SGR Values For Shading Devices**			
			Min R-value of assembly & Insulation	R-value of assembly only [(a) (b)]			**WWR**							
				0.4	**0.6**	**0.8**	≤10%	10-<20%	20-<30%	≥30%	≤10%	10-<20%	20-<30%	≥30%
				Min. R-value of Insulation			SHGC				SGR			
Roof		0.70	2.70	2.30	2.10	1.90								
Walls	N	0.38	0.55	0.15	NR	NR								
		0.50	0.59	0.19	NR	NR								
		0.70	0.67	0.27	NR	NR	NR	NR	0.71	0.67	NR	NR	60%	70%
	NE/NW	0.38	0.74	0.34	0.14	NR								
		0.50	0.85	0.45	0.25	NR								
		0.70	1.03	0.63	0.43	0.23	0.65	0.5	0.45	0.35	60%	80%	90%	90%
	E/W	0.38	0.92	0.52	0.32	0.12								
		0.50	1.08	0.68	0.48	0.28								
		0.70	1.35	0.95	0.75	0.55	0.5	0.4	0.35	0.27	70%	80%	90%	90%
	SE/SW	0.38	0.82	0.42	0.22	NR								
		0.50	0.95	0.55	0.35	0.15								
		0.70	1.17	0.77	0.57	0.37	0.5	0.4	0.35	0.27	60%	80%	90%	90%
	S	0.38	0.67	0.27	0.07	NR								
		0.50	0.75	0.35	0.15	NR								
		0.70	0.89	0.49	0.29	NR	0.71	0.64	0.55	0.5	60%	70%	90%	90%

R values for Building materials are indicated in Appendix (B)

(a) R Values for typical Roof construction are equivalent to:

R value 0.3 equivalent to 12 cm Concrete, 6cm of sand, 2 cm of mortar, 2 cm of tiles

R value 0.4 equivalent to 12 cm Concrete, 8 cm of slope concrete, 6cm of sand, 2 cm of mortar, 2 cm of tiles

R value 0.6 equivalent to 30 cm Hollow Blocks 8 cm of slope concrete, 6cm of sand, 2 cm of mortar, 2 cm of tiles

(b) R Values for typical Wall construction are equivalent to:

R value 0.4 equivalent to 12 cm clay brick 2cm of Plaster on both sides

R value 0.6 equivalent to 25 cm clay brick 2cm of Plaster on both sides

R value 0.8 equivalent to 38 cm clay brick 2cm of Plaster on both sides

(c) R value for typical insulation material without R_{si} & R_{so} are equivalent to:

R value 0.59 = 2 cm expanded polystyrene insulation

R value 1.18 = 3 cm expanded polystyrene insulation

R value 1.75 = 6 cm expanded polystyrene insulation

R value 2.35 = 8 cm expanded polystyrene insulation

if insulation is placed to the inside the wall the R value is reduced by 30%

R value of 100 mm non vented Cavities in the wall is considered 0.16 m^2.°C/W

Out door surface Thermal risistance = 0.04 m^2°C/W

In door surface Thermal risistance = 0.123 m^2°C/W

Fanstration Requirements: Compliance is achieved if one of the following are met for all applicable orientation:

(a) Maximnm SHGC (In columns 8-11), or

(b) Minimum SGR (in columns 12-15), or

(c) An adjusted SHGC reduced by applying the SGR factor as indicaed in part (B) to the SHGC of the glassing to achieve an SHGC less than the required maximum

Windows with shutters have no requirement for either SHGC or SGR.

* if WWR exceeds 30% SGR must be not less than 0.9

* for exposed glass windows should meet the min SHGF

* shaded windows should meet the min SGR in 21 Sept. If not, the glazing shall meet the SHGC requirement. These SHGC values are calculated including window frames

0.27 = reflective single glazing CLR 20%

0.75 = Clear single glazing

SGR = percentage of glazing surface shaded from 9 am to 5 pm on 21 September.

Part B: SGR Values and adjusted SHGC Values

SHGC Max Allowed	**SHGC of Glazing Used**							
	0.9	**0.8**	**0.7**	**0.6**	**0.5**	**0.4**	**0.3**	**0.2**
0.2	0.78	0.75	0.71	0.67	0.60	0.50	0.33	0.00
0.3	0.67	0.63	0.57	0.50	0.40	0.25	0.00	
0.4	0.56	0.50	0.43	0.33	0.20	0.00		
0.5	0.44	0.38	0.29	0.17	0.00			
0.6	0.33	0.25	0.14	0.00				
0.7	0.22	0.13	0.00					
0.8	0.11	0.00						

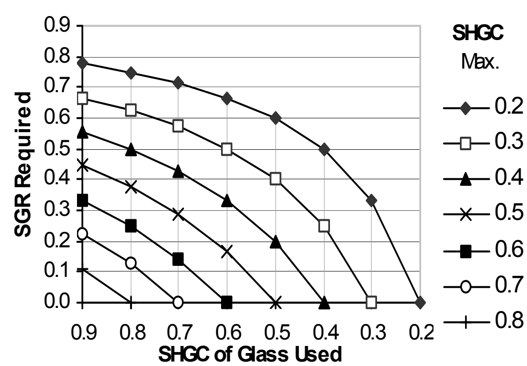


Figure 6. Prescriptive Envelope Requirements for Conditioned Buildings in Cairo

Table 3.2

Building Envelope

Part A : requirements

Conditioned Buildings in Cairo

CDD 25 = 297 **HDD18.5 = 364**

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Orientation		External Surface Absorptivity	Required Min R values of Insulation for external walls and roofs (m^{2}°C/W)				**Max SHGC Values for Fenestration**			**or**			**Min. SGR Values for Shading Devices**	
			Min R-value of assembly & Insulation	R-value of assembly only (a) (b)			**WWR**							
				0.4	**0.6**	**0.8**	≤10%	10-<20%	20-<30%	≥30%	≤10%	10-<20%	20-<30%	≥30%
				Min. R-value of Insulation			SHGC				SGR			
Roof		0.7	2.7	2.3	2.1	1.9								
Walls	N	0.38	0.70	0.30	NR	NR	NR	NR	0.71	0.67	NR	NR	60%	70%
		0.5	0.74	0.34	0.14	NR								
		0.7	0.82	0.42	0.22	NR								
	NE/NW	0.38	0.89	0.49	0.29	NR	0.65	0.5	0.45	0.35	60%	80%	90%	90%
		0.5	1.00	0.60	0.40	0.20								
		0.7	1.18	0.78	0.58	0.38								
	E/w	0.38	1.07	0.67	0.47	0.27	0.5	0.4	0.35	0.27	70%	80%	90%	90%
		0.5	1.23	0.83	0.63	0.43								
		0.7	1.50	1.10	0.90	0.70								
	SE/SW	0.38	0.97	0.57	0.37	0.17	0.5	0.4	0.35	0.27	60%	80%	90%	90%
		0.5	1.10	0.70	0.50	0.30								
		0.7	1.32	0.92	0.72	0.52								
	S	0.38	0.82	0.42	0.22	0.02	0.71	0.64	0.55	0.5	60%	70%	90%	90%
		0.5	0.90	0.50	0.30	NR								
		0.7	1.04	0.64	0.44	0.24								

R values for Building materials are indicated in Appendix (B)

(a) R Values for typical Roof construction are equivalent to:

R value 0.3 equivalent to 12 cm Concrete, 6cm of sand, 2 cm of mortar, 2 cm of tiles
R value 0.4 equivalent to 12 cm Concrete, 8 cm of slope concrete, 6cm of sand, 2 cm of mortar, 2 cm of tiles
R value 0.6 equivalent to 30 cm Hollow Blocks 8 cm of slope concrete, 6cm of sand, 2 cm of mortar, 2 cm of tiles

(b) R Values for typical Wall construction are equivalent to:

R value 0.4 equivalent to 12 cm clay brick 2cm of Plaster on both sides
R value 0.6 equivalent to 25 cm clay brick 2cm of Plaster on both sides
R value 0.8 equivalent to 38 cm clay brick 2cm of Plaster on both sides

(c) R value for typical insulation material without R_{si} & R_{so} are equivalent to:

R value 0.59 = 2 cm expanded polystyrene insulation
R value 1.18 = 3 cm expanded polystyrene insulation
R value 1.75 = 6 cm expanded polystyrene insulation
R value 2.35 = 8 cm expanded polystyrene insulation
if insulation is placed to the inside the wall the R value is reduced by 30%
R value of 100 mm non vented Cavities in the wall is considered 0.16 m^2.°C/W
Out door surface Thermal risistance = 0.04 m^{2}°C/W
In door surface Thermal risistance = 0.123 m^{2}°C/W

Fanstration Requirements: Compliance is achieved if one of the following are met for all applicable orientation:

(a) Maximnm SHGC (In columns 8-11), or
(b) Minimum SGR (in columns 12-15), or
(c) An adjusted SHGC reduced by applying the SGR factor as indicaed in part (B) to the SHGC of the glassing to achieve an SHGC less than the required maximum

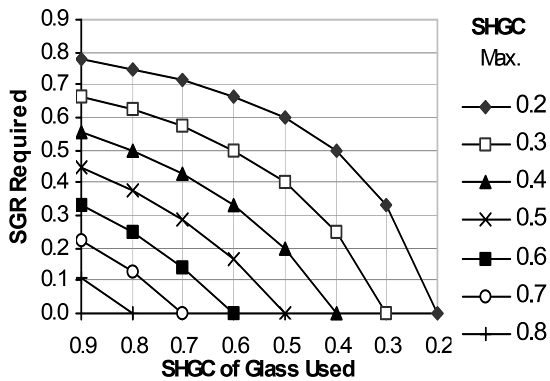
Windows with shutters have no requirement for either SHGC or SGR.

* if WWR exceeds 30% SGR must be not less than 0.9
* for exposed glass windows should meet the min SHGF
* shaded windows should meet the min SGR in 21 Sept.
If not, the glazing shall meet the SHGC requirement.
These SHGC values are calculated including window frames
0.27 = reflective single glazing CLR 20%
0.75 = Clear single glazing

SGR = percentage of glazing surface shaded from 9 am to 5 pm on 21 September.

Part B: SGR Values and adjusted SHGC Values

SHGC Max Allowed	**SHGC of Glazing Used**							
	0.9	**0.8**	**0.7**	**0.6**	**0.5**	**0.4**	**0.3**	**0.2**
0.2	0.78	0.75	0.71	0.67	0.60	0.50	0.33	0.00
0.3	0.67	0.63	0.57	0.50	0.40	0.25	0.00	
0.4	0.56	0.50	0.43	0.33	0.20	0.00		
0.5	0.44	0.38	0.29	0.17	0.00			
0.6	0.33	0.25	0.14	0.00				
0.7	0.22	0.13	0.00					
0.8	0.11	0.00						



Chapter 8 in the proposed residential standard corresponds to Chapter 9 in the draft commercial standard, and sets minimum efficiency requirements on the electric power system, including the transformers and motors.

Chapter 9 in the residential and Chapter 10 in the commercial standard permits the calculation of whole-building energy performance using a dynamic computer simulation in lieu of the prescriptive requirements in the earlier chapters. If the whole-building energy performance of the proposed building is shown to be lower than that of a reference building, the proposed building is deemed to comply with the standard. This allowance of an alternate performance "path" for compliance is similar to the approach taken in various US building energy standards such as ASHRAE 90.1 or California's Title-24.

The last chapter of the standards is a reference for definitions, abbreviations, and acronyms.

Implementation Plan

From experience, the IC team observes that successful energy code programs require extensive implementation programs. Such an extensive program has been proposed for Egypt. The program is envisioned to require about three years to accomplish, with even more time needed to complete a proposed multiple demonstration buildings program. The plan developed and submitted by the IC team identifies the set of activities need to successfully launch, administer, and enforce the Egyptian Residential and Commercial Energy Codes now being developed.

HBRC has completed the development of a Residential Energy Efficiency Building Code (EEBC) for Egypt, and expects to complete the development of a related energy code for Egyptian commercial buildings in the spring of 2004. However, the development of the code is just the first of three important steps needed to successfully launch the code so that it can help Egyptian residences use less energy and be more comfortable. These three steps are: (1) Development, (2) Implementation, and (3) Administration and Enforcement (or voluntary compliance, with incentives).

An implementation plan for the Egyptian codes should include appropriate successful activities that other countries have included in their implementation of energy efficiency commercial building codes. Such implementation activities typically include:

1. Strengthen EEBC enforcement structure and administration. Accomplish a major effort to build within HBRC (and other appropriate Egyptian institutions) permanent capabilities for the design of green and energy efficient buildings. These capabilities include (1) skilled personnel, (2) equipment and material testing laboratories, and (3) advanced energy, thermal, visual and environmental simulation tools (including emerging computational fluid dynamic models for natural ventilation). Key subtasks would include: a. delineation of authorities, responsibilities, and roles; (b) enforcement mechanisms; and (c) plan and procedure for future EEBC revisions.

2. Establish a systematic compliance process. To insure uniform and consistent implementation of the building codes, the following need to be defined or developed: compliance procedures, compliance tools, compliance forms, and field testing of the EEBC compliance process.

3. Develop a EEBC User's Manual

4. Conduct training program on the EEBC. To promote capacity building, a training program will be developed including training workshops, training in universities, and international studies for EEBC implementation.
5. Initiate outreach and public information programs to advertise the code to its target audiences.
6. Estimate energy savings and cost effectiveness of the EEBC through ongoing building surveys and energy and economic analyses
7. Sponsor a major demonstration buildings program. Conduct a demonstration program in which 30-40 residential and commercial buildings would be designed to meet or exceed the code requirements and environmental criteria. Each building would receive additional funding for (1) incremental design services to meet the combined code/ environmental rating system, (2) incremental construction costs to meet code/ rating system requirements, (3) costs of installing and using appropriate energy and environmental monitoring systems, and (4) costs of conducting comparative energy and environmental evaluations.
8. In addition to the typical implementation activities just listed above, the proposed implementation plan also includes additional innovative activities beyond the standard approach to code implementation, including:
9. Merge energy codes and environmental rating systems. This activity proposes that the Egyptian Energy Code project be used as a test bed for developing this important new concept of integrating energy codes and environmental rating systems. The Egyptian codes now being developed will be refined and implemented to become integral parts of environmental rating systems for buildings and communities in Egypt. As part of this effort, it is proposed that a new environmental rating system will be developed specifically for use for residential and commercial buildings in Egypt.
10. Develop all products as "templates" for use by others. Finally, it is proposed that Egyptian products will be developed for use (1) elsewhere within the region, and (2) in countries worldwide, including a number of countries that have previously developed energy codes but lack effective implementation. The entire set of proposed implementation activities will permit Egypt to make major improvements in the environmental sustainability and energy efficiency of its building stock and its communities. And, all products developed for Egypt will be transportable to other countries.

Conclusions

The overall work plan for this project is for HBRC, through its six WGs plus the Code Development Main WG, to build up the skills and expertise needed to develop the building energy standards, with the IC team serving largely as a technical resource in providing training, support and review. In the opinion of the authors, such a work plan has proven quite successful, due in large measure to the diligence and commitment of the HBRC management and staff. Through a three year process, HBRC has not only produced two standards that incorporate recent concepts and technologies developed abroad, but also the technical capabilities and understanding to promote, maintain, and update the standards in the future. It is our joint hope that HBRC and Egypt will find support for the implementation plan so that the hard work expended in developing the standards will be manifested in the transformation of the Egyptian building industry towards energy-efficient and comfortable residential and commercial buildings.

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- Prof. Ahmed Reda Abdin (Building Envelope WG leader)
- Prof. Essam E. Khali (VAC Systems WG leader)
- Prof. Amin Ali Rasmi (Lighting Systems WG leader)
- Prof. Suzette Michel Aziz (Building Survey WG leader)
- Prof. Adel El-Malawani (Electrical Power WG leader)
- Prof. George Bassili Hanna (Simulation and Training WG leader)
- Prof. Mohamed Elmessiry (HBRC Consultant)
- Dr. Mohab Halouda (EEIGGR Representative)
- Eng. Moustafa El Samani (OEP Representative)

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