Available online at www.sciencedirect.com
ScienceDirect
Energy and Buildings 39 (2007) 727–735
ENERGY and BUILDINGS
www.elsevier.com/locate/enbuild

Methodology developed for the energy-productive diagnosis and evaluation in health buildings

Irene Martini *, Carlos Discoli, Elías Rosenfeld

IDEHAB, Instituto de Estudios del Hábitat, Unidad de Investigación No. 2, Facultad de Arquitectura y Urbanismo, Universidad Nacional de La Plata, Calle 47 No. 162, La Plata, Buenos Aires, Argentina

Received 25 August 2005; received in revised form 3 May 2006; accepted 14 June 2006

Abstract

The public health network in Argentina consists of a wide variety of buildings presenting a complex system of services and structures. In order to modulate and study the energy behaviour of each type of health facility, a database of *Energy-Productive Building Modules* (Módulos Edilicios Energéticos Productivos: MEEP) was built. This involved evaluating the interactions among physical spaces, building envelope, infrastructure, and equipment usage with the energy consumption, for each specialty service provided in the most common buildings present in the health service network.

The MEEP database enables investigators to:

(i) Obtain detailed information on each facility.
(ii) Identify variables critical to an energy consumption perspective.
(iii) Detect areas of over consumption and/or inadequate infrastructure.
(iv) Gather essential reference material for the design of health facilities and other similar sectors.

The information of each MEEP can be summarized in typological charts.

Keywords: Energy productive building audit; Optimization; Habitability

1. Introduction

The Argentine public health building network consists of a wide diversity of high and medium complexity buildings characterized by energy intensive infrastructure and equipment.

Such a system presents various problems, particularly of hygrothermal habitability and non-conscious use of energy, which have a great impact on the quality of services provided. During the 1990s, the restructurization of the government led to the privatization and decentralization of basic public services, including energy providers. Health care buildings had to restrict energy use due to potential supply disruptions. The inadequate supply and risk of power failure necessitated an evaluation of energy consumption in this sector.

Poor administration, inadequate management and regulation of services, and inequitable resources distribution led the country into a deep socio-economic crisis, resulting in a 22% unemployment rate. The employment situation affected all levels of the health services sector (private companies, medical insurance systems, etc.) resulting in a trend for private clients to move into the public system. This unforeseen increase in users created an imbalance leading to the collapse of the budget. The situation culminated in a drastic decrease in energy consumption, which greatly compromised service quality. At the same time, medical services and technological advances led to a greater demand for energy [1], further enlarging in some cases the gap between needs and available resources.

In Argentina there are approximately 3200 public health care buildings, making up about 75,000 beds. Private institutions number around 1500, representing approximately 67,000 beds. In Buenos Aires, the country's most populated province, a high-complexity health market exists concentrated

* Corresponding author. Tel.: +54 221 423 6587/90x254.
E-mail address: irene_martini@yahoo.com.ar (I. Martini).

0378-7788/$ – see front matter
doi:10.1016/j.enbuild.2006.06.015

Nomenclature

A	area (m^2)
A_t	glass specific thermal transmittance (m^2)
A_o	wall specific thermal transmittance (m^2)
$^{\circ}D$	heating degree days (K)
DG	direct gain through window
E	luminance (lx)
$E_{\%}$	luminance (lx) according to the percentage established by the RAFIS programme in relation to the external natural lighting
EF	exposition factor
GP	gain per person (W)
h	room's height (m)
J_a	air enthalpy (kJ/kg K)
K	thermal transmittance (W/m^2 K)
K_o	thermal transmittance for opaque envelope (W/m^2 K)
K_t	thermal transmittance for glass envelope (W/m^2 K)
n	ventilation rate (vol/h)
n_d	number of days
n_e	number of equipments
n_p	number of people
OF	occupation factor
P	electricity power (kW)
TOE	tonnes of oil equivalent (1 TOE = 11,600 kWh)

Greek letters

η	luminous efficiency (lm/W)
η_C	caloric efficiency
ρ_a	air density (kg/m^3)
τ	time (h/day)

in the metropolitan area. The national average building distribution between publicly and privately administered health care buildings is approximately 25–30, and 75 and 70%, respectively [1]. In spite of attempts to improve the health care in Argentina, we still do not have a regulatory system related to the rational use and conservation of energy in this sector. The methodology developed in this paper proposes alternatives, methodologies and tools to identify and measure variables with the aim of improving energy efficiency.

2. Methodology

The analysis of energy needs for health facilities defined as nodes of a network was implemented at a global and detailed level. At the global scale, the basic units of analysis used were the nodes or buildings of the network, and on the detailed level, the basic units of analysis used were the energy-productive building modules (Módulos Edilicios Energéticos Productivos: MEEP) or ''building differentials''

The Argentine health network represents a complexity and a morphological diversity of old and new buildings. To identify the energy consumption of each area within the different health facilities, a detailed methodology was developed that enabled the relation of energy variables of each health speciality through a differential analysis construction. This methodology involves analysing the buildings from a construction typology catalogue, which modulates the representative units of various hospitals.

This analysis formed the basis of the MEEP database. The database allows us to classify, describe, compare and design different health facilities using representative typology units that characterize the buildings and energetic and productive needs of each health facility unit (laboratory, surgery, intensive care, etc.).

The methodology developed at a detailed level was based on the analysis of the different energy demands of each health facility. These MEEPs (differentials) are characterized by their specific functions, significant energy requirements, and diversity of demand related to temperature needs and type of equipment of each unit.

The construction of each MEEP was carried out by calculating the following variables:

(i) Lighting consumption: general lighting of the module and local lighting on the working plane.
(ii) Equipment consumption: quantity, use and average energy consumption of each equipment.
(iii) Comfort conditioning consumption: energy contributions and losses on a simplified energy balance. Here the analysis variables are: occupation, lighting, equipment, direct gain through windows (DG), ventilation rate and envelope characteristics. The energy needs arise from this balance.

Each MEEP is summarized in a typological chart with information related to (Fig. 1):

(i) MEEP identification and involved area.
(ii) Layout.
(iii) General characteristics: localization, dimensions, envelope characteristics, mean interior and exterior temperature and orientation.
(iv) Lighting system characteristics and energy consumption calculation values.
(v) Equipment characteristics and consumption calculation values.
(vi) Consumption calculation values for comfort conditioning (contributions and losses by occupation, direct gain through window, lighting, equipment, ventilation rate, and envelope).
(vii) Partial consumption values (of each variable) and total consumption values (of the whole MEEP).

Construction of the database involved systematization and analysis of four complementary instances for each MEEP. These are: Theoretical MEEP, Real MEEP, Optimized MEEP and Environmental MEEP.

1. *Theoretical MEEP*: the development of the theoretical catalogue describes the physical space, envelope, infrastruc-