

Energy performance and energy rating procedures of buildings in Southern Europe

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ABSTRACT

Due to the lack of national building regulation regarding the energy requirements of Directive 2002/91/EC (EPBD) in Greece, Southern countries (Italy, Spain and Portugal) have been selected as index reference because of the similar climatic conditions and location in order to report the stage of Directive's implementation (energy performance calculations and energy rating procedures) for a future enforcement in Greece.

Regarding the increasing energy demand in the island of Crete, this paper aims at the estimation of energy saving in buildings for the island of Crete. More precisely, a simulation of an office in the city of Heraklion was implemented using TRNSYS program. Various energy saving measures were tested and compared to a reference case.

1. INTRODUCTION

Building sector accounts for over 40% of final energy in EU and is responsible for more than 30% of the CO₂ emissions. In recent years numerous efforts have been undertaken at EU and national level to improve the energy efficiency of buildings. In particular building codes have been tightened gradually in most countries within the last three decades. The European Union, under the Kyoto Protocol and forthcoming commitments, has proposed an amount of Community Directives for reducing energy consumption in the building sector and hence carbon dioxide emissions.

Building energy legislation is found in Directive 93/76/EEC on Limitation of the Carbon Dioxide Emissions through the Improvement of Energy Efficiency, in Directive 2002/91/EC on Energy Performance of buildings, in Directive 89/106/EEC on Construction Products, in Directive 92/42/EEC on Efficiency Requirements for

new hot-water boilers fired with liquid or gaseous fuels, in Directive 2004/101/EC on a Scheme for Greenhouse Gas Emission Allowance Trading within the community in respect of the Kyoto Protocol's Project Mechanisms, in Directive 2004/8/EC on the Promotion of Cogeneration based on a useful heat demand in the internal energy market and amending Directive 93/42/EEC and in EU Green Paper, Towards an European Strategy for the Security of energy Supply (Rey, 2006).

Thus, EU establishes a clear framework of the needs and priorities for reducing the energy consumption in building sector, both for advancing in the compliance of international agreements as well as for reducing its energy dependency and hence for leading its development path towards sustainability.

2. STAGE OF DIRECTIVE 2002/91/EC IMPLEMENTATION IN SOUTHERN EUROPE

2.1 Italy

The energy performance of a building is expressed as an "energy requirement for heating divided by the building volume and by the degree days of the site" [MJ/(m³°C days)]. In addition, some partial energy performance indicators are applied (annual energy efficiency of the heating system, annual energy efficiency of the heat generator, transmission heat loss volumic coefficient of the building). The following specific requirements are not fulfilled:

- Air-conditioning installation is not taken into account.
- Lighting installation is not taken into account.
- Residential building are not classified into single family houses and apartment blocks, but rather into continuously occupied buildings and discontinuously occupied.

The energy performance requirements are differentiated on the basis of the kind of intervention (construction of a new building, installation of a new heating sys-

tem, renovation of the heating system, replacement of the heat generator). For public buildings, both new and under renovation, the energy performance requirements shall be met by assessing the technical and economical feasibility of installing systems based on renewable energy, CHP and heat recovery from any available process or plant (Santamouris, 2004).

According to a new legislative decree (no. 311 of 29 December 2006) that has been published in the Official Gazette of February 1st, 2007, a new list of minimum energy performance values, where the limits foreseen for 1-1-2009 have been moved forward to 2008, and new, even more restricted limits are indicated for 1-1-2010 (Antinucci, 2007).

The certification of new buildings will start immediately after application of the new Decree, using existing methods (limited to heating and DHW) in order to express the numerical value of the energy performance. The existing methods will be applied under responsibility of the building designer and the works director, until the new governmental guidelines on certification will come into force. The energy certification is gradually extended to existing buildings, in three steps (July 2007, July 2008 and July 2009), according to buildings size, and depending if whole building or flat is examined. The indicator for non-residential buildings is now expressed in kWh/m³ of building volume (Antinucci, 2007). According to the European Directive 92/42, boilers are required to have a minimum performance depending on the output power. The control of heat generators is mandatory in Italy as well as the inspection of all boilers. Boilers having a nominal output of less than 35 kW shall be inspected at least every 2 years. Boilers having a nominal output of more than 35 kW shall be inspected at least once a year. The inspection of boilers shall include a measurement of exhaust gas and ambient temperatures, O₂, CO₂ and CO concentrations in the exhaust gases, an assessment of the boiler nominal efficiency, and an evaluation of the conditions of insulation (Santamouris, 2004).

2.2 Spain

In Spain, the new regulation includes aspects related to the envelope, lighting and systems, but the energy consumption is not calculated in an integrated way. In particular, the methodology that concerns the envelope calculates the building energy demand during the heating and cooling periods and compares with a reference building (Visier, 2004).

The part of the legislation that refers to lighting is devoted to non-residential buildings, and establishes a limit value for the "lighting energy efficiency" which represents the "W/m²" needed for every 100 lux. So

lighting is evaluated independently of the rest of the energy consumption. Finally, the part of the methodology that refers to other building systems does not include any calculation procedure (Santamouris, 2004).

A voluntary energy certification scheme ("Energy Labelling" program) based on simulation results, is in use in Spain. It is voluntary and it is based on computer energy simulation (only for new buildings) and not in real energy consumption.

In Spain, the regulations include mandatory inspection for installations > 100 kW. Every concept has a different period, for example:

- CO emissions (every month).
- Evaporators and condenser cleaning (every year).
- Refrigerant and oil level checking (every month) (Soebarto, 2003).

2.3 Portugal

A new Building Energy Regulation is now being prepared in Portugal, focusing on two main goals. The first one deals with thermal insulation requirements. In the other end the overall methodology is planned to follow very closely the new European Directive and CEN standards. The working group which is now preparing the work, aware of the purposes of the new Directive, and regarding Article 3 of EPBD (Visier, 2004).

In Portugal, the requirements for new buildings, referred to Article 4 are not satisfied by the present regulation. There is an agreement on the minimum energy performance standard, and the calculation, regarding the different types of buildings (new and existent). The exceptions are also the same, except those related with the residential buildings which are used 4 months per year (Santamouris, 2004).

In Portugal, differentiation between buildings with more than 1000 m² is also planned in the future building regulation. It is intended to have more detailed and feasibility studies for the buildings with systems, when over than 1000 m² (Soebarto, 2003).

2.4 Building envelope characteristics in Southern Europe

For the improvement of building envelope, the assessment of building thermal loads is required. The envelope transmission loads are dominant as their losses affect the total energy efficiency of the building. In order to characterize the heat transfer, a thermal resistance R value or a U Value must be defined. The indicative U values in Southern Europe are represented in Table 1 (Visier, 2004).

Table 1: Indicative U Values in Southern Europe

U Values	Roof	Outer walls	Ground floors	Windows
	W/m ² K	W/m ² K	W/m ² K	W/m ² K

Italy	0,3 - 0,4	0,4 - 0,5	0,4 - 0,5	2,5 - 3,5
Spain	0,5 - 0,6	0,5 - 0,6	0,5 - 0,6	2,5 - 3,5
Portugal	0,5 - 0,6	0,5 - 0,6	0,5 - 0,6	2,0 - 3,0

3. BUILDING CODE IN GREECE

In Greece, the Building Thermal Insulation Regulation has been in use since 1981, setting the minimum requirements for thermal conductivity of the building envelope for different climatic zones.

In accordance to the General Building Regulation and the Common Ministerial Decision (OHJ 880/B/19-8-98), a new code is under development (Regulation on Rational Use and Energy Conservation in buildings) regarding the energy performance requirements of the Directive 2002/91/EC (Balaras, 2007).

Four different climatic zones are defined in the new code based on Heating Degree Days (HDDs):

- Climatic Zone A (601-1100)
- Climatic Zone B (1101-1600)
- Climatic Zone C (1601-2200)
- Climatic Zone D (2201-2620)

In addition, the great majority of Hellenic building stock is not thermally insulated, despite the fact that HDDs range reach over 2600 HDD in Northern Greece due to local weather conditions (Cartalis, 2004).

4. ENERGY EFFICIENCY MEASURES IN THE REGION OF CRETE, GREECE

According to the classification of Greece in four climatic zones, Crete falls into climatic zone A which is characterized by mild winter and mild humid summer (Kolokotroni, 1990).

The existing building stock in Crete enumerates about 288.000 buildings, whereas only 28,4% was constructed before 1981 that Building Thermal Insulation Regulation came into force.

A simplified method is applied in order to determine the heating and cooling degree days (which actually provide an estimation of the heating and cooling loads of a building) for the city of Heraklion, knowing the mean hourly temperature for one year and assuming the balance temperature at 18 °C (Krarti, 2000). As a result, the degree days of heating and cooling were estimated to be equal to 910 and 1100 respectively.

According to the Building Thermal Insulation Regulation (BTIR) and the Regulation on Rational Use and Energy Conservation (RRUEC) in buildings, the U Values for climatic zone A are defined in Table 2.

The estimated energy use saving for heating and cooling was calculated by the equation (1) (Krarti, 2000):

$$\Delta E = \frac{24 \cdot (BLC_E - BLC_R) \cdot DD(T_b, E)}{\eta} \quad (1)$$

Where:

$BLC_E - BLC_R$: Difference in U Values (UBTIR-UR-UEC)

DDs: Degree days of heating or cooling, correspondingly

T_b : Balance temperature (assumed to be 18 °C)

η : System efficiency (set to be one)

The energy saving in heating & cooling based on the difference in U Values of the two regulations as well as the calculated degree days of heating and cooling, are represented in Table 3.

4.1 Energy use saving in an office using TRNSYS simulation program

Table 2: U Values in Greece

U Values	BTIR	RRUEC
	W/m ² K	W/m ² K
Outer walls, UW	0,7	0,55
Outer horizontal surface, UD	0,5	0,4
Floor on no heating space, UG	3	1,3
Internal partitions, UDL	3	1,3

Table 3: Energy saving in heating & cooling

Energy saving	Heating	Cooling
	kWh/m ² .yr	kWh/m ² .yr
ΔEW	3,28	3,96
ΔED	2,18	2,64
ΔEG	37,13	44,88
ΔEDL	37,13	44,88

TRNSYS is a transient system simulation program with a modular structure that was designed to solve complex energy system problems, as the ones in buildings. In building simulations, all HVAC-system components are solved simultaneously with the building envelope thermal balance and the air network at each time step (Crawley, 2005). A simulation of a not thermally insulated office (270 m² surface area) in Heraclion was implemented, in order to estimate the energy saving in heating and cooling. The office was divided in six thermal zones based on the thermal (heating and cooling) loads. More precisely, the under investigation office is consisted of nine rooms equipped by twenty nine electrical devices such as PC, plotter, fax. The heating is provided in the office by district heating as well as ten space heaters. On the other hand, cooling is provided by ten air cooling systems. At first, the total energy load of the building was calcu-

lated as base case. Hereupon, four different scenarios for energy saving were examined:

- Insulation (25 mm)
- Side fins (top bottom extension 0.5 m and the left , right gap 0.3 m)
- Overhangs (located 0.5 m above the window and extend 1 m both sides of the window) & side fins
- Venetian blinds

The appraisal results are depicted in Figure 1.

According to the results of the simulation, the energy saving for each individual scenario is shown in Table 4.

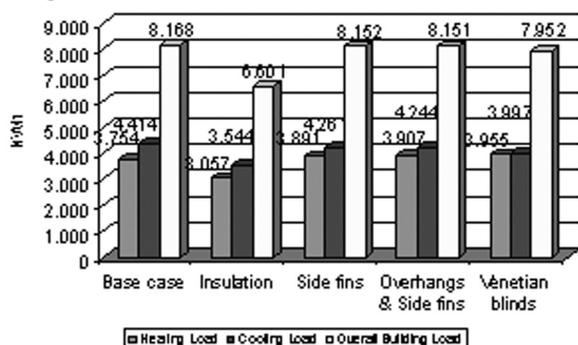


Figure 1: Loads calculation per scenario.

Table 4: Energy saving per scenario

	Normalised energy consumption	Energy Savings
	KWh/m2	%
Base case	30,25	
Insulation	24,45	19,18
Side fins	30,19	0,20
Overhangs & Side fins	30,18	0,24
Venetian blinds	29,45	2,64

5. CONCLUSIONS

In this paper, the stage of Directive's implementation in terms of building energy performance and certification schemes in Southern Europe is reported.

The evaluation of energy use savings in an office in the city of Heraklion, region of Crete was implemented comparing four different scenarios. In accordance with the applied scenarios, the highest energy use saving is accomplished by adding insulation at external walls. As a consequence, the building incurs lower energy losses and thus higher savings improving the energy efficiency of the building. Furthermore, energy use saving is also observed at the other scenarios both of external (side fins, overhangs and side fins) and internal (Venetian blinds) shading.

According to the current state of building sector in the region of Crete, where the majority of buildings are not insulated, the addition of thermal insulation as well as

external and internal shading can lead to the reduction of energy losses, improving at the same time the energy efficiency of buildings.

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