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WAYS OF REDUCING THE IMPACT OF RESIDENTIAL BUILDINGS ON THE ENVIRONMENT

BY

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Abstract. The major climate changes with extreme phenomena on a global scale have imposed reconsidering the environmental policies and applying requirements for a Sustainable Development. Romania is one of the first countries that approved the Kyoto Protocol. Specific standards which establish the saving of primary energy are useful in new and existing buildings and will be implemented in the near future. At the same time, a series of old buildings, that are structurally and thermally rehabilitated, are already in the stage of implementing the energy consumption diminishing measures. The aim is to decrease the energy dependence on fossil fuels and to reduce the impact on environment, while ensuring an adequate comfort. Large amounts of energy are consumed for heating, in winter, and for cooling or air conditioning, in summer. Beside all, thermal energy is necessary to provide the hot domestic water and electricity for artificial lighting. This paper analyses the effects on residential buildings in the 3rd climate zone areas produced by applying thermal rehabilitation measures for the envelope.

Key words: environment; global resistance; thermal insulation.

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1. Introduction

The climate changes (global heating, floods, land-slides, extreme temperatures, etc.), with severe effects on a global scale, are determined mostly by human activities (anthropogenic effects).

The present-day economic crisis has been doubled by an energy crisis due to the depletion of gaseous and liquid fossil fuels, phenomenon which is affecting both the developing states as the industrialized ones.

The international treaties concluded so far (Kyoto, Lisbon) determined the signatory states to reconsider their environmental policies by committing themselves to reduce the greenhouse gas (GHG) emission effects. Consequently, the industrial processes, transportation, services, agriculture and domestic users are required to reconsider their current energy balance.

Major political decisions are not easily applicable, but are interested to satisfy the exigencies of Sustainable Development and they refer to a step by step diminishing of primary energy consumptions of fossil fuels, by using white and green energy sources (solar, wind, biomass, etc.), restricting up to eliminating the automobile transportation systems in favour of the public one, adjusting to an ecologic behaviour, etc.

2. Implications of Kyoto Protocol for the Signatory States

Within this protocol it is provided that, between 2008 and 2012, 38 of the signatory countries are committed themselves to a reduction of CO_2 emission, considered the main greenhouse gas, by 5.2% against 1990 values.

England, Germany, China, France and the Arab Emirates have achieved projects of low energy consumption residential districts or towns. The main targeted objectives are:

a) collective dwellings, highly insulated thermally, with yearly consumptions under 50 $kWh/m^2 \cdot year$;

b) using solar energy to create “active houses”;

c) reuse of rain water (Bed ZED – residential district in south of London);

d) co-generating of energy (biomass);

e) cars diminishing from the urban traffic and, instead, use of the public transportation to maximum;

f) zero CO_2 emissions, to reduce the impact on environment.

Major landmarks in applying the Kyoto protocol commitments are the Bed ZED residential district erected in London in 2002, the Vauban district in Freiburg in Breisgau, Germany and the one in Lille, France, in 2006.

China and the Arab Emirates, countries with very high energy consumption, have committed themselves to introduce the automatic public transport which would replace the car use, during 2010...2016 period of time.

Projects for the building of residential districts follow this trend (in China – Dongtan, in France – Seine - Saint Denis - Paris, in the Netherlands – Apldoorm) (Radu & Vasilache, 2007).

3. Specific Standards for Residential Buildings in Romania

Since 1997, a series of standards on the fossil energy savings in the existing and newly-built dwelling houses have entered into force.

Assimilating and adapting the norms elaborated in countries as France, Germany and Switzerland can be considered to be important steps in approaching primary energy consumption in buildings, since 1980.

Romania's climate conditions, a severe temperate zone area, (with thermal extremes in summer and winter time) require an important energy use for heating in the cold season and for air conditioning in the hot one, with values of number of degrees days of N_{12}^{20} = 2,840…4,580 K·days. Some examples are given in Table 1, considering several cities from Romania

Table 1
Yearly Number of Degrees – Calculated Days
(Extract from C107/1-2005 Standard)

No. crt.	Location	θ_a °C	N_{12}^{20} K·days	D_{12} days
1	Constanța	11.5	2,840	186
2	Roman	8.8	3,700	210
3	Suceava	7.5	4,080	230
4	Vatra Dornei	5.3	4,580	257
5	Câmpulung Muscel	7.9	3,820	224
6	București	10.6	3,170	190
7	Iaşi	9.4	3,510	201
8	Caracal	10.9	3,100	187
9	Caransebeș	10.1	3,180	196
10	Cluj	8.3	3,730	218

The successive modifications made on Romanian standards (C107, NP048, Mc0001) show the permanent specialists concern for adapting the norms to the internationally accepted standards.

The main concerns are for adjusting the existing buildings to reasonable consumption of primary energy and obtaining some reduced emissions of the main greenhouse gas, the CO_2.

3.1. Collective Residential Buildings

The level of thermal protection in the new buildings evolved between 1997 and 2006 so as to obtain an annual energy consumption of under 70 kWh/m^2·year for the buildings in the A energy class (Table 2 and Fig. 1).

Table 2
Minimum Values for Global Resistance, R′ [m^2·K/W],
(Mc001, 2006; C107 /1-6, 2005)

	Envelope element	C107/1 Norm	Methodology Mc001/2006
1	Outer walls	1.40	1.50
2.	Roof	3.00	3.50
3.	Basement floor	1.65…4.50	1.65…4.50
4.	Exterior carpentry works	0.50	0.55

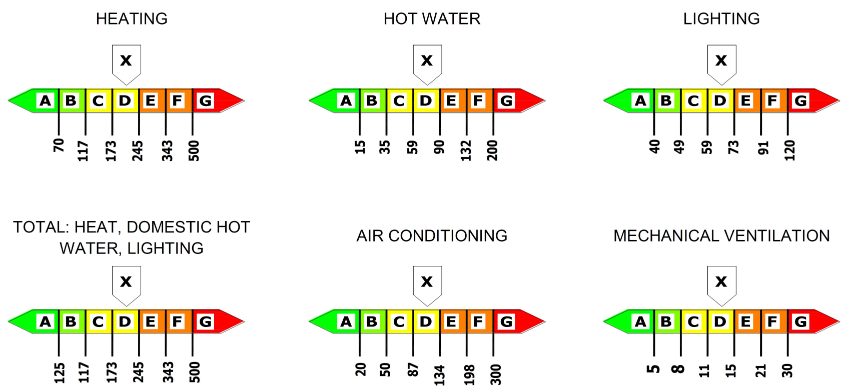

Fig.1 – Energy classification grids for buildings depending on the annual specific heat consumption for occupied space heating, domestic hot water, lighting, air conditioning and mechanical ventilation (Mc001, 2006).

3.2. Existing Stock of Collective Residential Buildings

75% of the residential buildings from the existing housing stock in Romania were erected when the energy was cheap. These buildings have a high remaining service life of approximate 40…60 years, a modest thermal protection, an exaggerated consumption of energy and an important emission of CO_2, as it can be seen in Table 3.

Table 3

Residential Building, Erected in 1966, 30 Apartments U+B+4F

Outer walls - large panels, [m^2·K/W]	R' = 0.42
Inner walls towards staircase, [m^2·K/W]	R' = 0.32
Joining walls, [m^2·K/W]	R' = 0.30
Roof terrace floor, [m^2·K/W]	R' = 0.57
Basement floor, [m^2·K/W]	R' = 0.30
Outer carpentry works, [m^2·K/W]	R' = 0.43
Inner carpentry works, [m^2·K/W]	R' = 0.39
n = 0.9 h^{-1}	
G = 1.103 [W/m^2·K]	
GN = 0.567 [W/m^3·K]	
Heating – annual consumption, [kWh/m^2·year]	264.35
Energy class	*E*
CO^2, [kg/year]	139,976.3

The field investigations have disclosed the existence of some geometric thermal bridges at the joints of the structural parts, in the area of which major heat losses occur (Fig. 2 – Vasilache & Ilie, 2009).

The present-day standards concerning the energy auditing of existing buildings aim at their adjusting to energy performance levels which are close to those of the new buildings.

Elaborating a suggestive energy grid and introducing the certificate of energy performance for functional units or buildings are two important elements of progress in the field of standards.

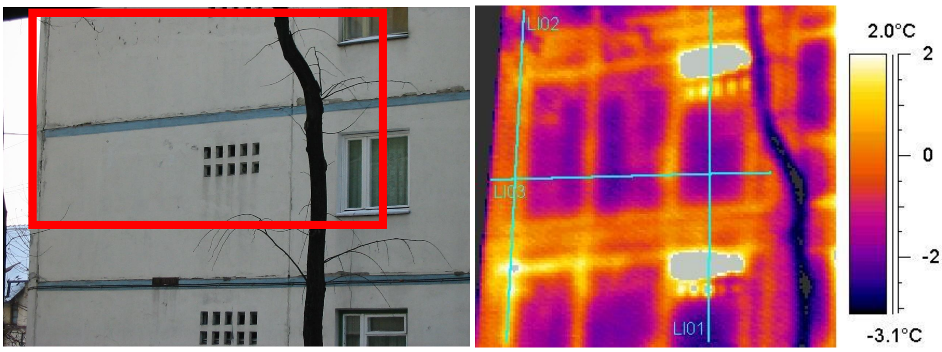

Fig. 2 – Residential building with large prefab panels exterior walls – IR investigations, winter of 2007. Thermal bridge areas with very large heat losses are seen. Corresponding to these areas, because inner surface temperatures drop under the dew temperature, condense stains on inner walls surface appear.

4. Suggested Solutions for Thermal Rehabilitation for Existing Residential Buildings Stock

From the classification grid, it can be seen that the energy consumed for the space heating during the cold season has the maximum weight in the energy balance of the building.

The measures proposed for the meeting of present-day thermal protection exigencies referred to: an efficient thermal insulation of the outer opaque walls, of the walls towards the staircase and the joining ones; replacing the outer carpentry with high performance windows and doors; insulating the top floor (terrace roof) and the basement floor; reducing the heat losses due to lack of proper sealing (ventilation rate decreasing).

Complete results obtained after applying the proposed thermal insulation are included in Table 4. Primary heating energy savings in the range of 50%…65% and a corresponding reduction in the CO_2 emission have been obtained.

The writing-off of the investment made for implementing the thermal rehabilitation solutions varies between 4 and 8 years, depending on the size of the works, the developed surface of the building, the estimated energy saving, etc.

Table 4
Residential Building, Characteristics after Applying Thermal Protection Increase Solutions

Outer walls – large panels, [$m^2 \cdot K/W$]	$R' = 1.47$
Inner walls towards staircase, [$m^2 \cdot K/W$]	$R' = 1.49$
Joining walls, [$m^2 \cdot K/W$]	$R' = 1.8$
Roof terrace floor, [$m^2 \cdot K/W$]	$R' = 3.28$
Basement floor, [$m^2 \cdot K/W$]	$R' = 1.8$
Outer carpentry works, [$m^2 \cdot K/W$]	$R' = 0.5$
Inner carpentry works, [$m^2 \cdot K/W$]	$R' = 0.39$
$n = 0.5$ h^{-1}	
G = 0.502 [$W/m^2 \cdot K$]	
G_N = 0.567 [$W/m^3 \cdot K$]	
Heating – annual consumption, [$kWh/m^2 \cdot year$]	60.0
Energy class	*A*
CO_2, [kg/year]	31,633

5. New Buildings. Design Implementation Trends and Performances

New investments in building for collective residential homes are increasing because of the high demand on the housing market.

Meeting such performance exigencies as achieving a hygrothermal comfort and decreasing the impact on environment have become major objectives for decision makers.

The present-day trends in residential buildings in Romania have in view the followings aspects:

a) meeting performance exigencies (compulsory, as specified in the law on quality);

b) achieving large glazed areas, due to the quality of joinery materials used;

c) reducing the building compactness as a result of the play of volumes in order to create a remarkable exterior façade;

d) building very large balcony areas.

In these cases, the energy consumptions will exceed the maximum admissible limits because:

a) the glazed areas cannot reach, at today's level of technology in the field, thermal performances that would be similar to the opaque part of the outer walls (R'_{max} = 1.2 $m^2 \cdot K/W$ in PVC windows with 8 chambers, 4 glass plates and 2 layers e – low);

b) the play of volumes introduces new elements into the envelope surfaces (floors over the exterior space, terraces or outer walls) as well as a series of geometric thermal bridges which are hard to correct

c) the balconies introduce important thermal bridges into the envelope and they cannot be corrected irrespective of the thickness of the thermal insulation applied.

In this context, the thermal protection through the envelope is much harder to achieve because of the great influence exerted by the thermal bridges (approx. 50%).

Introducing new measures of using the unconventional energy sources is not feasible for the time being because of the lack of a legislative framework, or of a very large initial investment (approx. 10,000 € for a 100 m^2 building) which is not easily accepted by beneficiaries (Radu & Vasilache, 2007).

6. Conclusions

Romania's climate is tending towards reducing the winter minimum and increasing the summer maximum temperatures. Thus, there are winters when the outer air temperature drops down to –20°C (minimum), while in summer it exceeds +40°C.

The air humidity is greatly modified. The rainfall and dominant winds regime is continuously changing.

The adjusting of the existing buildings to the exigencies of Sustainable Development may be achieved by saving the unused energy which thus becomes the main energy saving source.

Burning fossil fuels to produce energy (1 kWh) gives way to an emission of 0.19...0.40 kg CO_2/kWh, depending on the fuel. At today's level of thermal protection exigency it is possible to obtain energy savings of 55%…65% in the buildings erected until 1997.

Building houses with a very low energy consumption, such as 3 L house (30 kWh/m^2·year), the passive house or the active one requires at a first stage the involvement of the factors concerned, *i.e.*: engineers in construction works, in services, architects, legislative factors, banks, manufacturers of energy production systems from accessible reclaimable sources, national distributors of energy for the taking over of the exceeding in electric energy and users who would become aware of the necessity of such projects. The initial specific investments are higher and will be written off on a longer term basis.

Only an adequate thermal protection and a minimum rate of ventilation cannot minimize to zero the energy consumptions of a dwelling house. This solution should be correlated with using the reclaimable energy sources that are locally available.

The next stage is going to be extremely important for the engineers in constructions and architects because, besides the general objectives aimed at in designing and erecting a residential home, it is absolutely necessary to know and apply the Sustainable Development principles.

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METODE DE REDUCERE A IMPACTULUI CLĂDIRILOR DE LOCUIT ASUPRA MEDIULUI ÎNCONJURĂTOR

(Rezumat)

Schimbările climatice majore cu fenomene extreme la nivel global au impus reconsiderarea politicilor de mediu şi aplicarea exigențelor pentru o dezvoltare durabilă.

România este una dintre primele ţări care a aprobat Protocolul de la Kyoto. Standarde specifice care stabilesc economisirea de energie primară sunt utile pentru clădiri noi şi existente şi va fi implementat în viitorul apropiat. În acelaşi timp, o serie de clădiri vechi, care sunt reabilitate termic şi structural, sunt deja în faza de implementare a măsurilor pentru reducerea consumului de energie. Scopul este de a reduce dependența de energie cu combustibilii fosili şi de a reduce impactul asupra mediului, asigurând în acelaşi timp un confort adecvat. Cantități mari de energie sunt consumate pentru încălzire, în timpul iernii, şi de răcire sau de aer condiționat , în timpul verii. Pe lângă toate, energia termică este necesară pentru a asigura apa caldă menajeră şi energie electrică pentru iluminatul artificial. Se analizează efectele asupra clădirilor de locuit din a treia zonă climatică produse de aplicarea unor măsuri de reabilitare termică asupra înfăşurătorii.