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ENERGY EFFICIENCY OF PUBLIC BUILDINGS TOWARD NZEB
POSSIBILITIES AND CONSTRAINTS

BY

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Abstract. Energy efficiency is one of the main targets of Europe 2020 Strategy. As buildings account for approximately 40% of final energy consumption, investing in measures in buildings can yield substantial energy savings. In this context, public buildings must be an example for the measures taken in order to decrease the energy consumption. More than that, European Directive 31/2010 states that all new public buildings after 31 December 2018 bust be "nearly zero energy buildings". This paper presents the possibilities to save energy in some education buildings belonging to the Technical University "Gheorghe Asachi" from Iaşi, by adopting some different additional thermal insulation measures on the envelope elements and photovoltaic panels placed on the opaque areas of external walls and terrace roofs. The results highlights that for existing buildings there are some constraints and the NZEB means a target very difficult to be achieved.

Key words: energy efficiency; thermal insulation; nearly zero energy building.

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1. Introduction

The most important issue of the latest decades is *energy*. Worldwide energy consumption is increasing due to population ever more numerous and more advanced technology. Because of that, scientists are concerned that the content of carbon dioxide into the atmosphere is increasing causing the global warming phenomenon. Most of the recent efforts have been directed toward new and better sources of energy that have a low impact on the environment. As the buildings sector is the most important consumer, representing 40% of the European Union's total energy consumption, reducing energy consumption in this area is therefore a priority.

Along with the increased use of renewable energy, measures taken in order to reduce the energy consumption in the EU would allow it to comply Kyoto Protocol to the Framework Convention Organization United Nations Climate Change (UNFCCC) and to meet its commitment to long-term keeping global warming below 2°C, and its commitment to reduce, by 2020, global emissions of greenhouse gases by at least 20% below 1990 levels and by 30% in case of international agreement.

Reduced energy consumption and increased use of renewable energy also have an important role in promoting security of energy supply, technological developments and in providing opportunities for employment and regional development.

Management of energy demand is an important tool enabling the European Union to influence the global energy market and hence the security of energy supply in the medium and long term.

On May 19, 2010, a recast of the Energy Performance of Buildings Directive was adopted by the European Parliament and the Council of the European Union in order to strengthen the energy performance requirements and to clarify and streamline some of the provisions from the 2002 Directive it replaces.

Major points of the Recast Directive include:

1º As of December 31, 2020 new buildings in the EU will have to consume 'nearly zero-energy'.

2º Public authorities that own or occupy a new building should set an example by building, buying or renting such 'nearly zero-energy building' as of December 31, 2018.

3º The definition of nearly zero-energy building was agreed as: "*nearly zero-energy building* means a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby".

4º Member States shall draw up national plans for increasing the number of nearly zero-energy buildings.

5º Member States shall furthermore, following the leading example of the public sector, develop policies and take measures; *i.e.* the setting of targets, in order to stimulate the transformation of buildings that are refurbished into nearly zero-energy buildings, and inform the Commission thereof in their national plans.

6º The Commission shall, by December 31, 2012 and every three years thereafter, publish a report on the progress of Member States in increasing the number of nearly zero-energy buildings. On the basis of that report the Commission shall develop an action plan and, if necessary, propose measures to increase the number of those buildings and encourage best practices as regards the cost-effective transformation of existing buildings into nearly zero-energy buildings.

7º The 1000 m^2 threshold for major renovation has been deleted and this will take effect when the national regulations have been implemented and applied.

8º Minimum requirements for components are introduced for all replacements and renovations, although for major renovations, the holistic calculation methodology is the preferred method with performance calculations based on component requirements allowed as a complement or alternatively.

9º A harmonized calculation methodology to push-up minimum energy performance requirements towards a cost-optimal level is set out in the Directive.

10º Member States will have to justify to the Commission if the gap between current requirements and cost optimal requirements is more than 15%.

11º A more detailed and rigorous procedure for issuing energy performance certificates will be required.

12º Control systems will be required by Member States to check the correctness of performance certification.

13º Member States will be required to introduce penalties for non-compliance. Member States shall lay down the rules on penalties applicable to infringements of the national provisions adopted pursuant to this Directive and shall take all measures necessary to ensure that they are implemented. The penalties provided for must be effective, proportionate and dissuasive.

14º Member States shall ensure that:

a) until December 31, 2020, all new buildings will be building whose energy consumption is nearly zero; and

b) after December 31, 2018, new buildings occupied and owned by public authorities are buildings whose consumption of energy is nearly zero.

15º Member States shall develop national plans for increasing number of buildings whose energy consumption is almost zero. These national plans may include targets differentiated according to the category of building.

16º Member States shall issue a certificate of Energy Performance for:

a) buildings or building units which are constructed, sold or rented to a new tenant; and

b) buildings where a total useful floor area over 500 m^2 is occupied by a public authority which is visited by public frequently. On July 9, 2015 the threshold of 500 m^2 will be reduced to 250 m^2.

17º Member States shall take the necessary measures to ensure that, if the total useful area over 500 m^2 of a building for which a certificate of energy performance is occupied by public authorities and frequently visited by the public, the energy performance certificate is displayed in a place where it can be seen by the public. On July 9, 2015 this threshold of 500 m^2 will be reduced to 250 m^2.

2. Thermal Rehabilitation Measures of Public Buildings. Case Study.

The analysed buildings belonging to the Technical University "Gheorghe Asachi" from Iaşi have different geometrical characteristics and different thermal insulation levels.

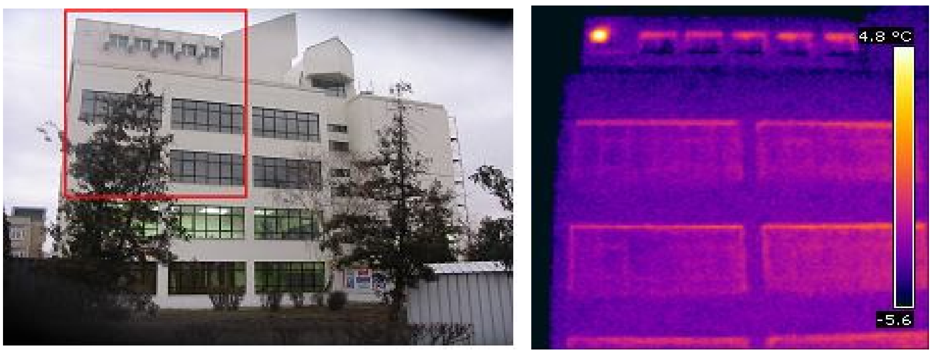

Fig. 1 – The "R" building: photo and IR image.

The building made in 1973 and named "R" has four floors, and at the upper level is an amphitheatre. The bearing structure is made of reinforced concrete diaphragm walls with pillars in the façades plans. The external walls are protected on the exterior side with masonry units with vertical holes. The building has a useful area of 2,931 m^2, a heated volume of 12,185 m^3, and a floor area on the ground of 826 m^2. In 2,007, the building was thermal rehabilitated, the measures consisting in adding a 5 cm layer of expanded polystyrene on the external walls, 10 cm of extruded polystyrene on the upper and lower floors and changing the old wooden windows with new ones of aluminium frames and insulated glazing (Fig.1).

Another one, which belongs to the Building Services Department was made in 1990, has five levels and a constructive structure made of reinforced concrete frames and closing elements made of autoclaved aerated concrete of 30 cm. The useful area is 5,328 m^2, the interior volume is 30,987 m^3 and the floor area on the ground is 1,744 m^2 (Fig.2).

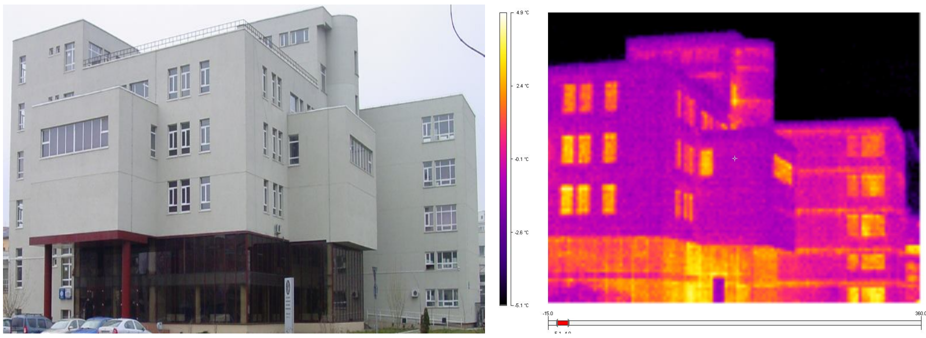

Fig. 2 – The Building Services Department: photo and IR image.

The third analysed building belongs to the Energetics Department. It was built in 1980, has four levels and a constructive structure made of reinforced concrete frames and closing elements made of autoclaved aerated concrete of 25 cm. The useful area is 4,524 m^2, the interior volume is 18,760 m^3 and the floor area on the ground is 1,773 m^2 (Fig.3).

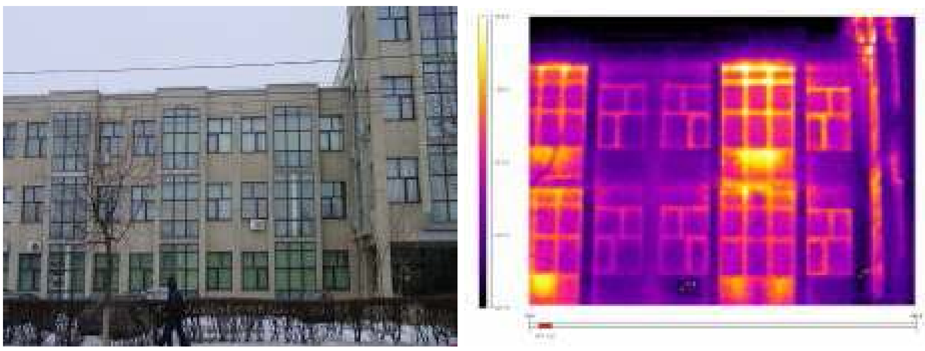

Fig. 3 – Building of Energetics Department: photo and IR image.

The three buildings described above have been submitted to a thermo-energetical audit/expertise. Firstly, the energy performance of buildings was assessed in the initial stage, according to the Romanian methodology Mc 001/1, 2, 3-2006 and Mc 001/4-2009. The resultant specific annual energy consumption for heating is between 100…150 kW.h/m^2.a for each building and this situate them in the class B or C, on a scale from A-G of the certification of new or existent buildings, which has to be implemented as part of the Energy Performance in European Buildings Directive.

Than, some constructive measures were proposed to improve the energy efficiency of the building and to bring it close, as much it is possible, to the condition of “Nearly Zero-Energy Building (nZEB)”.

To increase the resistance to heat loss of the building envelope, were proposed additional layers of efficient insulation with the specific value of the thermal conductivity coefficient $k \leq 0.04$ W/mK (materials such as expanded or extruded polystyrene, polyurethane foam, or mineral wool). The thickness of the insulation is 20 cm for wall, 30 cm to the terrace and a thickness of 10 cm for the ground floor slab. The ground floor insulation thickness was limited by conditions of buildings already constructed and the fact that none of these does not have technical underground, to accommodate a thicker layer on the ceiling of the basement.

For the doors and windows openings are proposed modern plastic and wooden window profiles with insulated glazing triple glass window panes separated by monatomic gas (argon, krypton or xenon) filled space to reduce heat transfer across that part of the building envelope.

Then the energy performance of buildings was assessed in the hypothesis that the building is retrofitted in the proposed conditions. The results are presented in Table 1.

Furthermore, in the context of Nearly Zero Energy Buildings, according to the concept of ‘building’s energy footprint’ introduced by Scognamiglio and Røstvik, (2012), the space required to provide for electrical and thermal energies from renewable sources (*i.e.* the surface necessary for placing the energy generation devices) was provided for each building (on the roof and walls) in order to be covered by photovoltaic panels (see Tabel 2).

After building retrofitting by the thermal insulation of the envelop elements and the addition of the photovoltaic cells integrated into the building envelope, the specific annual energy demand for heating is between 19… 63 kW.h/m^2.a classifying the buildings in class A of energy consumprion. A comparative representation of the heating demand values of buildings before and after retrofitting is presented in Fig. 4.

Table 1
Characteristic Data for Analysed Buildings

Nr.	Building parameter	Symbol	Unit	R building		Building services department		Electrical energy manag.dept.	
				Initial	Retrofit-ted	Initial	Retrofit-ted	Initial	Retrofit-ted
1	Building envelope area	$A_{env.}$	m^2	4,315.7	4,315.7	6,986	6,986	6,076	6,076
2	Corrected mean thermal resistance	R_{med}	$m^2.K/W$	0.71	2.47	0.979	2.526	0.982	2.912
3	Global factor of thermal insulation	G_1	$W/m^3.K$	0.498	0.143	0.4	0.259	0.534	0.281
4	Annual specific heat consumption	$q_{heat.}$	$kWh/m^2.a$	151.34	43.5	102.5	66.4	150.7	79.3
5	Index of building compactness	$A_{env.}/V_{heat.}$	m^{-1}	0.35	0.35	0.23	0.23	0.32	0.32
6	Glazed area / Walls area	$A_{gl.}/A_{wall}$	–	0.44	0.44	0.76	0.76	0.56	0.56
7	Annual specific heating demand	q_a	kWh/a	487,786	140,067	648,800	420,098	685,732	360,844

Table 2
The Balance Between the Heat Energy Demand and Energy Production from Renewable Source for Each Analysed Building

Nr.	Building parameter	Symbol	Unit	R building	Build. services dept.	Electrical energy manag. dept.
				Retrofitted	Retrofitted	Retrofitted
1	PV panels area	A_{PV}	m^2	1,966.8	2,032.98	1,845.58
2	PV annual potential	Q_{PV}	kWh/a	78,672	81,319	73,823
3	Annual heating demand	Q_a	kWh/a	140,067.06	420,098.26	360,844.16
4	Uncovered annual demand of energy for building heating	$Q_a - Q_{PV}$	kWh/a	61,395.06	338,779.06	287,020.96
5	Uncovered annual specific heat consumption	q'_a	$kWh/m^2.a$	19.05	53.52	63.07

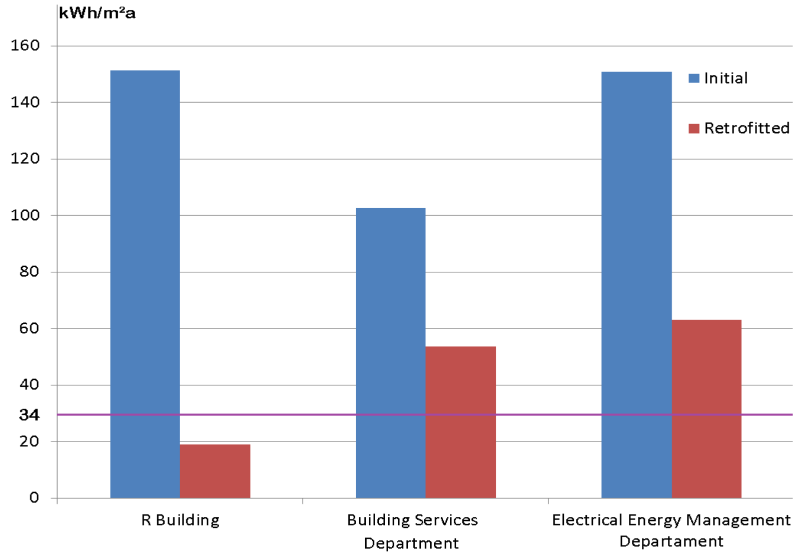

Fig. 4 – Specific annual energy consumption for building heating.

Considering the concept of Three-Liter-House-Schools denoted as "beacons" by the research project EnEff:Schule (Wollensak, 2009), becouse their primary energy demand for heating and ventilation and related auxiliary energy accounts to only 34 kW.h/m².a which corresponds to 3 L mineral oil or 3 m³ natural gas, the R building, meets this condition.

3. Discussion

Applying supplementary thermal insulation measures for all components of the building envelope will determine significant reduction in building annual demand of energy for heating, from 35.25% in case of Building Services Department up to 71.28% for "R" building. The difference could be explained taking into account the report Glazed area/Walls area, which has a greater value in case of Building Services Department. In spite of these insulation measures, the specific annual heating demand is still high for all analysed building. For example, the Passive House Institute's EnerPHit for certified energy retrofits requires a maximum heating demand of 25 kWh/m^2.a (EnerPHit, 2001).

Just the passive measures of energy efficiency for buildings (*i.e.* the supplementary thermal insulation) are not strong enough to fulfil the more restrictive conditions for Passive Building or Nearly Zero Energy Buildings

(NZEB). For this active green, renewable source, energy generators (like photovoltaic panels, solar panels, or wind turbines) must be combined with the passive constructive solutions to increase the building energy efficiency.

By using renewable energy sources, *i.e.* covering buildings' roof and facades with photovoltaic panels, the building energy demand could be further decreased, but the NZEB is a very difficult target to be achieved through energy retrofit of existing building.

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EFICIENŢA ENERGETICĂ A CLĂDIRILOR PUBLICE SPRE NZEB
Posibilitaţi şi limite

(Rezumat)

Eficienţa energetică reprezintă unul dintre cele mai importante ţeluri cuprinse în strategia europeană în perspectiva anilor 2020. Întrucât sectorul clădirilor este responsabil de 40% din consumul total, investiţiile în acest domeniu pot conduce la economii substanţiale de energie. În acest context, clădirile publice pot constitui un exemplu în ce priveşte măsurile de reducere a consumurilor de energie. Mai mult de atât, Directiva Europeană 31/2010 stabileşte ca toate clădirile publice noi, realizate după 31 decembrie 2018, trebuie să fie clădiri "aproape zero energie". Lucrarea prezintă posibilităţile de reducere a energiei în clădiri de învăţământ aparţinând Universităţii Tehnice "Gheroghe Asachi" din Iaşi prin adoptarea de măsuri de izolare termică suplimentară şi prin prevederea de panouri fotovoltaice amplasate pe faţade şi terase. Rezultatele evidenţiază faptul că pentru clădirile existente, atingerea deziderratului de NZEB este dificil de atins.