Energy performance indicator and energy performance requirements: a Polish approach to implementation of EPBD

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SUMMARY

The EC Directive on Energy Performance of Buildings created a challenge for all Member States, especially in sense of adoption of new requirements and calculation methodology. This paper describes the Polish experts' solution. It has been suggested that the distinction between energy performance requirements and determination of building energy class should be introduced to Polish regulation. Two levels of requirements are considered: first regulation of gains and losses and second regulation on efficiency of hot water preparation and lighting efficiency. Assignment of energy class for particular building is proposed in relation to reference building and expressed by dimensionless integrated energy performance indicator WZE. The WZE is normalized in a sense that its value equal to 1 represents the building energy performance identical to the reference building. The methodology takes into account different impact of energy sources on environment by utilization of weightings representing specific energyware.

INTRODUCTION

All the Member States have faced a challenge related to implementation of the Directive EC/91/2002 on energy performance of buildings (EPBD) [1]. The implementation deadline has been met by some of the countries, whereas the others were delayed due to the different reasons. Poland is among the countries which asked for an extension time.

Implementation of requirements settled by European Directives is obligatory for all the member states but the way chosen is entirely left for the national decisions. To support harmonization of implementation towards Europe the Commission mandated CEN to prepare set of new standards supporting objectives of Directive.

In Poland, works on implementation of EPBD have been voluntarily undertaken by Association of Energy Auditors (non-profit organization of public benefit) in 2004. Five working groups have a structure reflecting typology of energy performance problems identical as in the CEN Umbrella document [2]. The idea was to follow the new CEN standards (also on a stage of project) as close as it was possible in order to facilitate harmonization with EU standardization in a future. The final proposal of the scope and form of energy certificate was a compromise between requirements of the drafts of standards and ability of its adaptation (lack of energy inventory of buildings and related metrological data). Once, after few years of assessment system operation, such a data will become available this fact should be easily taken into account in a process of updating the regulations. The method proposed [3] - has an additional advantage – it can be used along with changing energy performance requirements. It uses concept of reference buildings and introduces dimensionless indicator for the assessment which is not entirely in line with recommendation of the indicators proposed by prEN 15217 Energy performance of buildings - Methods for expressing energy performance and for energy certification of buildings [4]. Further, there was a clear agreement of the stakeholders that the assessment should follow asset rating instead the operational rating.

METHODS

Requirements and Energy Performance

Among the others the basic Directive aims are:

1. Establishment of new (more demanding) energy performance requirements, taking into account their updating according to changes in technological and economical circumstances;
2. Adoption of calculation methodology comprising elements of energy balance described in the Annex to the Directive.

These aims are obligatory for all member states both old and new ones. In spite of acceptance of the Directive before the extension of EU there was no any additional transition period foreseen for new members. However there are many projects financed by EIE program focused on different issues of EPBD. Concerted Action, the project dedicated to information exchange among the national experts working on Directive implementation is the example of the EC help to MS. All these projects showed a variety of approaches taken by the countries, but they also are indicating European efforts towards harmonization of setting requirements procedure and methodology of calculation. For illustration of the span of approaches, the energy performance as the term is differently understood across the Europe. Some of the countries are assigning to this term energy delivered or equivalent emission whereas the others are taking heat losses or gains. Detailed description of the approaches is provided in report of ENPER [5], the Proceedings of International Conference on the Energy Performance of Buildings, Brussels, September, 2005 [6].

Determination of Energy Performance Indicator

The distinction between energy performance requirements and determination of building energy class was introduced in Polish regulation. In regards to requirements, two levels are considered: first regulation of gains and losses and second regulation on efficiency of hot water preparation and lighting efficiency. Assignment of energy class for particular building is proposed in relation to so called reference building and expressed by dimensionless indicator called integrated energy performance indicator *WZE*. The *WZE* is not a subject of regulation - requirements; it is a result of application of partial lower level requirements. Integrated energy performance indicator (*WZE*) is described by Eqn.1.

$$WZE = N_g \cdot f_g + N_w \cdot f_w + N_o \cdot f_o + N_{ch} \cdot f_{ch}, \quad (1)$$

where coefficients N represents a level of requirements fulfilment (ratio of energy use in analyzed building to reference building) according to heating and ventilation, hot water, lighting and cooling that is denoted respectively by subscripts “*g*”, “*w*”, “*o*” and “*ch*”. The coefficients *f* describe share of energy use for specific purposes versus an overall energy use *Q*, taking into account whole building or analyzed operational zone (e.g. apartment) (eqn 3).

$$f_g = \frac{\sum_i \left(w_i \cdot \sum_j E_{gi,\,j} \right)}{Q} \qquad \text{(2a)}$$

$$f_w = \frac{\sum_i \left(w_i \cdot \sum_j E_{wi,\,j} \right)}{Q}, \qquad \text{(2b)}$$

$$f_o = \frac{\sum_i \left(w_i \cdot \sum_j E_{oi,\,j} \right)}{Q}, \qquad \text{(2c)}$$

$$f_{ch} = \frac{\sum_i \left(w_i \cdot \sum_j E_{chi,\,j} \right)}{Q}, \qquad \text{(2d)}$$

$$Q = \sum_i \left(w_i \cdot \sum_j E_{gi,\,j} \right) + \sum_i \left(w_i \cdot \sum_j E_{wi,\,j} \right) + \sum_i \left(w_i \cdot \sum_j E_{oi,\,j} \right) + \sum_i \left(w_i \cdot \sum_j E_{chi,\,j} \right), \qquad (3)$$

Summation by "*i*" is related to different sources of energy supplied to analyzed building. This summation takes into account different impact of energy sources on environment, weightings representing specific energyware w_i , are presented in table 1. Summation by "*j*" is related to a number of zones of specific operation (e.g. in case of heating "*j*" can indicate different temperature zones, in general number of zones within specific energy use can be different e.g. number of temperature zones can be different then the lighting zones). Symbols $E_{gi,j}$, $E_{wi,j}$ $E_{oi,j}$ $E_{chi,j}$ are denoting energy use for specific purposes in specific zone that is related to specific energy source.

Table 1. Weights assigned to energyware

Energyware	Weights (*w*)
Electricity (in Poland basically from coal burning)	2,5
Biomass	0,5
Solar, wind and geothermal energy	0
Other energywares	1

Table 2. Values of WZE indicator and related energy classes

	Values of *WZE* indicator	Energy class of building
	from 0 to 0,25	A
	from 0,26 to 0,50	B
	from 0,51 to 0,75	C
	from 0,76 to 1,00	D
	from 1,01 to 1,25	E
	from 1,26 to 1,50	F
	over 1,51	G

The *WZE* is normalized in a sense that its value equal to 1 represents the building energy performance identical to the reference building. The reference building is the building similar to assessed one in terms of shape, operational areas and, profiles of use but with components fulfilling minimum requirements for newly constructed building (e.g. *U* values), referenced system efficiencies, and energy weights equal to 1, except those used for media transport (eg. energy used for circulation pumps in heating system). To some extent *WZE* value indicates cost of energy in relation to the reference building. The *WZE* is divided by intervals representing the energy performance class of the building, table 2. Number of classes depends on marketing assumptions of energy assessment scheme. The values presented in table 2 are the proposals for case of Poland.

Determination of heating and ventilation component

Construction of heating and ventilation component in Eqn.1 can be done in the following steps:

1. Calculation of delivered energy demand E_g for each operational area of assessed buildings with respect to energyware, installation efficiencies, under standard use and weather. Calculation of net energy is performed according to Polish standard, but the intention is to use CEN EN 13790 [7] after its adaptation to Polish building stock features
2. Same as in p.1 but done for reference building E_{gr} with defined installation efficiencies in regards to production, distribution and regulation, as well as reference weights (basically equal 1).
3. Finally, the component N_g of Eqn.1. can be calculated according the formula:

$$N_g = \frac{\sum_i \left(w_i \cdot \sum_j E_{gi,j} \right)}{\sum_i \left(w_{r,i} \cdot \sum_j E_{gri,j} \right)} \qquad (4)$$

Energy demand for hot water preparation

Use of hot water depends on particular needs and therefore is not regulated in requirements. The only regulated requirements are efficiencies of 1 m^3 of hot water preparation and distribution, [8]. Calculation of hot water component of Eqn. 1:

$$N_w = \frac{\sum_i \left(w_i \cdot \sum_j E_{w1\,i,j} \right)}{\sum_i \left(w_{r,i} \cdot \sum_j E_{w1r\,i,j} \right)} \qquad (5)$$

where: *w* is energy weights, E_{w1} and E_{w1r} energy for m^3 of hot water preparation in assessing and in reference buildings. Equation 5 shows the level of fulfilment of energy performance requirements expressed in energy needed for 1 m^3 of hot water.

Moreover, for the purpose of energy class assignment some averages of hot water demands are listed in regulations as but just for use in calculation procedure of f_w coefficient. At the same time, for information purposes it is possible to estimate energy used for hot water in reference building.

Lighting component

Basic mean of energy reduction for lighting is application of energy efficient hardware. Thus, as the measure of lighting system efficiency for regulation purposes the specific corrected capacity of lighting unit W/(m^2·100 lx) is proposed, [9]. Again, the same approach as for hot water is applied, the regulation refers to technical solutions not to the use of lighting.

The coefficient of fulfilment of lighting energy requirements N_o for Eqn.1 is the ratio of weighted averages of the specific capacity of assessed and referenced lighting systems in the whole building. The averages are weighted by areas of different lighting demands. The referenced specific capacities vs. light fluxes for different lighting purposes are listed in the regulation.

Determination of coefficient f_o requires estimation of energy use for lighting. This can be done if a capacity of the unit and the operating time are known. The basic formula applied for this purpose is taken from the PrEN 15193: Energy performance of buildings — Energy requirements for lighting, [10] in GJ/year:

$$E_O = 3{,}6 \cdot 10^{-6}\left(\sum_j \left(P_{p,j} \cdot t_{p,j}\right) + \sum_j \left(P_j \cdot t_{u,j}\right)\right), \quad (6)$$

where $P_{p,j}$ is total installed capacity of emergency lighting units, W; $t_{p,j}$ is time of operation of emergency lighting units in a year, h/r; P_j is total installed capacity of built in lighting units W; $t_{u,j}$ is time of operation of built in lighting units in a year, h/r ; Summation on „j" goes over lighting zones.

RESULTS

Some analysis of buildings using energy performance indicator *WZE* has already been done. Very interesting study analysed school buildings in one of the towns in southern Poland [11]. The figure 1 presents the comparison of estimations of *WZE* with integrated energy characteristics EA according to Display campaign [12]. The figure presents pretty good correlation between these two methods (R^2= 0.6935). *WZE* indicator turned to be more generous for buildings that used renewable energy. Figure 2 presents changes of energy performance indicator *WZE* due to thermomodernization of schools. The modernization of schools reduced initial values of *WZE* by 10 to 70 % and in vast majority of cases reduced values of *WZE* below 1.

The proposal of Polish certificate counts four pages and covers information on energy use for all purposes for the assessed and reference buildings along with recommendation about potential improvements as well as graphical presentation of energy performance indicator WZE. The example for thermomodernized apartment building (no air conditioning) is presented below on Figure 3.

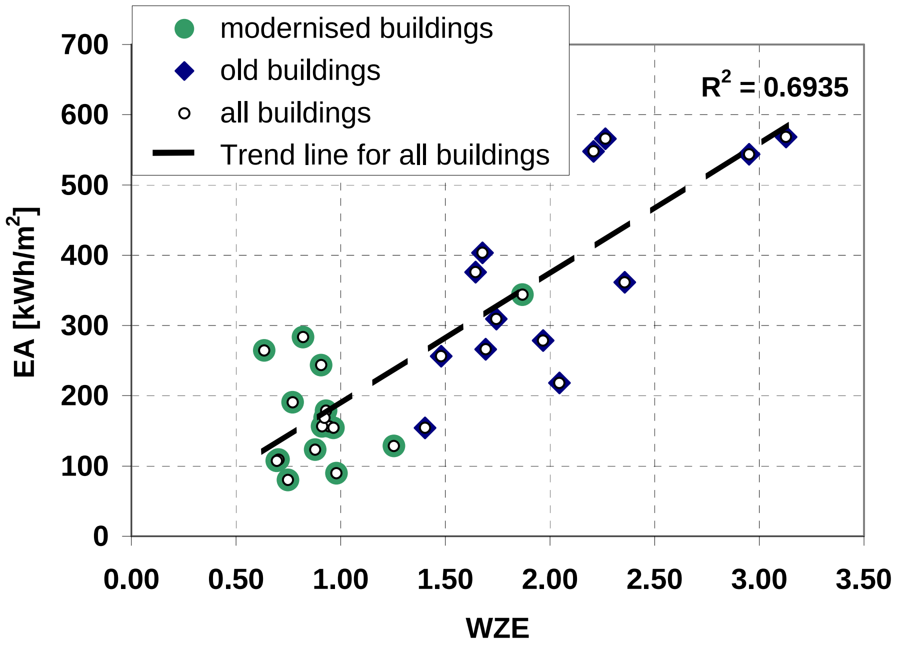

Figure 1. The comparison of energy performance of building evaluated using energy performance indicator *WZE* and integrated energy characteristics EA according to Display campaign [11].

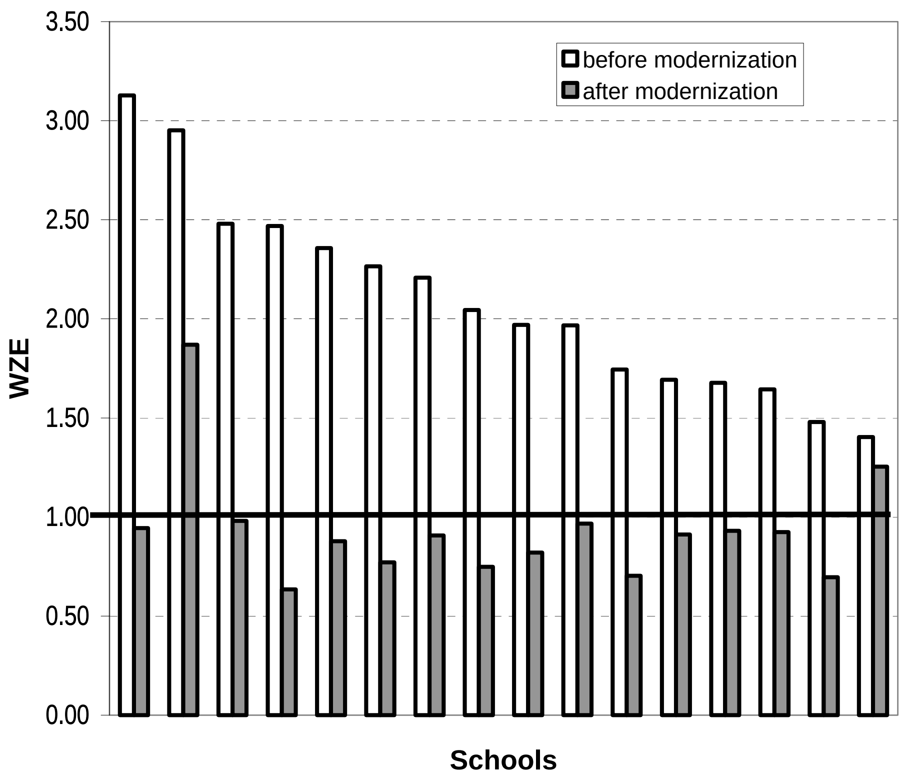

Figure 2. The change of energy performance indicator *WZE* for thermodedernized schools [11].

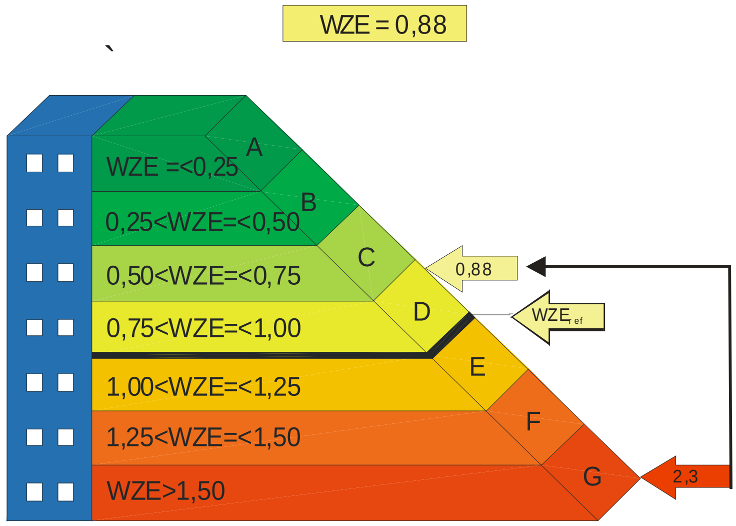

Figure 3. Label from energy certificate showing improvement of energy standard

The label on Figure 3 indicates strong improvement of building standard due to thermomodernization. *WZE* value has been changed from 2,3 to 0,88 that means the energy cost in building after investment is reduced approximately 2,6 times and finally is 12% lower then maximum normalized cost in similar newly constructed building (the reference building). Concept of reference buildings requires that reference values of all components influencing energy performance of buildings are specified.

DISSCUSSION

Presented method of determining integrated energy performance indicator and related to it energy class assignments are the basis for preparation of energy certificate according to the directive on energy performance of buildings. It is important that energy certificate can be elaborated for every type of building for which delivered energy and hot water requirements are estimated. For others types of building than apartment one the components of Eqn.1 related to lighting and cooling can be easily taken into account. Reference building concept made this approach general and easy to interpret (*WZE*=1 denotes the building fulfilling maximum/minimum permissible values with energy supplied from reference source).
Low values of *WZE* (< 1) indicates that buildings components have better parameters than reference ones or/and efficiencies of the systems are better than reference ones or/and energy source is more ecological than reference one. The *WZE* concept has moved the regulation requirements towards partial regulations (building components oriented). Energy class of a building is a resultant of partial requirements and technological solutions of installations.
Of course some Polish energy engineers are afraid that WZE calculations are more time consuming (analysed building is evaluated twice), however special software with data reference values base could solve this problem. Other doubts are associated with the fact that energy performance indicator *WZE* is not sensitive to building shape and allow architects to design buildings with low area to volume ratio.

The contradictory approach where the energy performance requirements are expressed in terms of energy or emissions normalised over the building area is undertaken is some countries. This gives even more freedom in architectural, constructional and material choices in extreme it would be acceptable to erect poor buildings entirely supplied by renewable.

Therefore, energy performance requirements are usually accompanied by additional regulations related to building components. Moreover, the requirements using energy terms needs detailed database of energy use along with coincident weather and profile of building use to decide about the energy class. In the absolute scale school without pool will be better ranked that one with it. Thus, very often, the typology of buildings is introduced, which means necessity of preparing number of scales related to number of identified building types and their equipments. In case of multi purpose buildings (eg. multifamily residential building, with shops on the first floor and restaurant on the roof level) the situation is extremely difficult to solve. Moreover as new CEN standards introduce the concept of different indoor environment categories the number of scales should by multiplied by number of indoor environment categories e.g. 3. If not buildings that use additional energy for creation of higher level of indoor environment would be punished by low energy performance category.

ACKOWLEGEMENT

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