THE CONVERSION OF ENERGY EFFICIENCY REQUIREMENTS FOR BUILDINGS IN POLAND

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Summary

The paper describes new energy efficiency requirements for buildings in Poland, which are based on the EP indicator of the annual primary non-renewable energy use for the space heating, cooling, ventilation, domestic hot water and for the built-in lighting in case of public buildings. Some calculation results are presented to outline the influence of the energy-related parameters of the building envelope and systems on the energy performance of the typical residential buildings in the average climatic conditions.

Keywords: energy efficiency requirements, energy performance of buildings, energy quality of the building envelope

1 New energy efficiency requirements for buildings in Poland

1.1 The conversion of requirements

The buildings sector in Poland, similarly as in other countries with near climatic conditions, accounts for more than 40 % of the total energy consumption, mainly (up to 70%) for space heating. The use of fossil fuels necessary to fulfill the domestic needs of the residential buildings sector accounts for the CO_2 emission up to 15% of the current national limit. Mainly due to the fact that the major energy resource is a coal, which is used over non-urban areas in small individual heat sources (boilers) and in heat generation plants or combined heat and power generation plants over urban areas.

For the last decade the residential buildings sector in Poland have substantially decreased energy demand due to more rigorous energy requirements for new buildings, modernizations of existing buildings, usually by applying ETICS's for walls, thermal insulations of roofs, new heating systems and replacements of windows but also more economical energy management and inhabitants behavior. Even though, the current value of average energy use for regarding space heating of residential buildings still exceeds 200 kWh/m^{2}a. Such a level of the consumption causes serious economic, social and ecological consequences.

During the last century in Poland standards concerning the thermal protection of buildings were based on partial requirements by setting maximum U-values (thermal transmittance) of walls, roofs, windows, doors, and the like. Towards the end of the 20-th century the additional requirement was introduced – maximum values of $E_{0,max}$ – the indicator of seasonal net energy need for space heating depending on building compactness factor (A/V). Those energy requirements were obligatory for multifamily residential buildings and alternative for detached houses. At that time regulations weren't contained

system efficiency requirements and didn't take into account the use of different energy sources, particularly renewables.

Reformulation of the Building Regulations in 2008 [1] broadened requirements for all types of new buildings and existing buildings, which undergo major renovations. The way of expressing and the range of new requirements meet needs of the Energy Performance of Buildings Directive's implementation.

The main change consist in setting maximum values of the EP indicator of the annual primary non-renewable energy use for the space heating, cooling, ventilation, domestic hot water supply for all categories of buildings and also for the built-in lighting for public buildings.

Such a requirements have reached closer relationship with operational energy costs and the CO_2 emission indicators and in this way have become more suitable for use in economic evaluations or environmental assessment. The new approach leads to the holistic way of buildings design which enable to take into account the reduction of energy losses through building fabric and in building systems as well as appropriate utilization of heat gains or the heat recovery and the use of renewable energy sources on-site or nearby.

The partial requirements with extended new scope (maximum U-values, airtightness recommendations, minimum thermal insulations quality of heat distribution system elements, thermal protection for summer conditions and the like) have become optional to energy performance requirements based on EP-values.

The new energy efficiency regulations for building in Poland have been brought into force since 2009.

1.2 Determination of the EP values

The maximum permitted EP_{MAX} value, in kWh/m^2·a, is calculated from [2]:

$$EP_{MAX} = EP_{H,MAX} + \Delta EP_{W,MAX} + \Delta EP_{C,MAX} + \Delta EP_{L,MAX} \quad (1)$$

Fig. 1 sets out the maximum values of the EP_H indicator of the annual primary non-renewable energy use for the space heating depending on the building compactness factor (A/V).

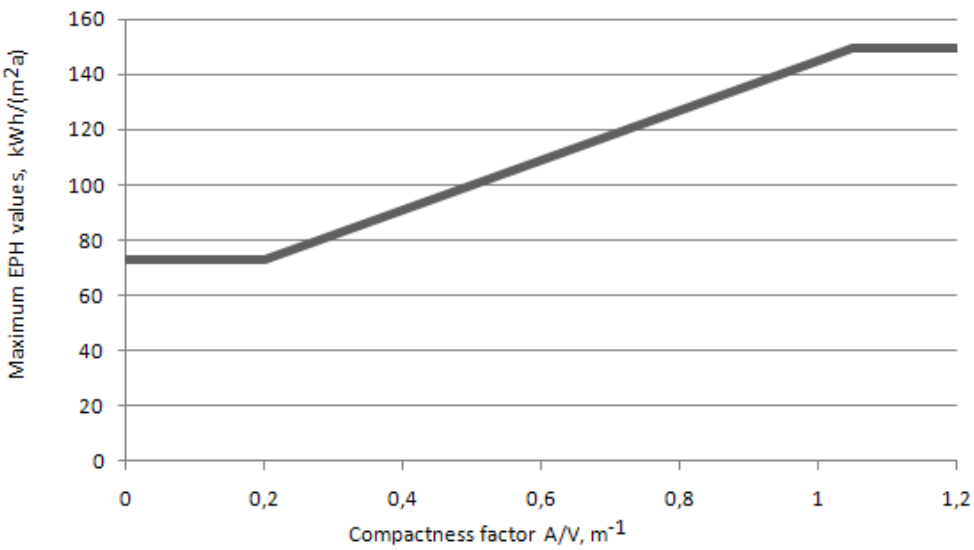

Fig. 1 The maximum permitted values of $EP_{H,MAX}$

The EP_{MAX} value is obtained by adding a correction terms $\Delta EP_{W,MAX}, \Delta EP_{C,MAX}, \Delta E_{L,MAX}$ to the $EP_{H,MAX}$ value.

The additional value for the domestic hot water supply depending on the floor area A_f of heated spaces or a part a_1 of this floor area per reference unit (usually per person) and dimensionless operating time b_t per year and daily consumption V_{CW} per reference unit is given by:

- for residential buildings

$$\Delta EP_{W,MAX} = 7800/(300 + 0{,}1 \cdot A_f) \tag{2}$$

- for non-residential buildings

$$\Delta EP_{W,MAX} = 1{,}56 \cdot 19{,}10 \cdot V_{CW} \cdot b_t / a_1 \tag{3}$$

The additional value for the space cooling depending on the total external walls area $A_{w,e}$ and the floor area of cooled spaces $A_{f,c}$ is given by:

- for residential buildings

$$\Delta EP_{C,MAX} = (5 + 15 \cdot A_{W,e} / A_f)(1 - 0{,}2 \cdot A / V_e) \cdot A_{f,c} / A_f \tag{4}$$

- for non-residential buildings

$$\Delta EP_{C,MAX} = (10 + 60 \cdot A_{W,e} / A_f)(1 - 0{,}2 \cdot A / V_e) \cdot A_{f,c} / A_f \tag{5}$$

The additional value for the built-in lighting in public buildings depending on the reference electric power P_N and operating hours t_0 is given by:

$$\Delta EP_{L,MAX} = 2{,}7 \cdot P_N \cdot t_0 / 1000 \tag{6}$$

For the existing building, which undergoes major renovation the maximum permitted EP_{MAX} value is 15 % higher than the value for the new building of the same type and the compactness factor value.

The EP value of the considered building is calculated from:

$$EP = \frac{Q_p}{A_f} \tag{7}$$

where:

Q_p - the annual primary non-renewable energy need for the space heating, cooling, ventilation, domestic hot water supply and the auxiliary energy consumption in building systems and also for the built-in lighting in case of public buildings, in kWh/a.

A_f - the floor area of conditioned spaces, in m^2.

The Q_p is obtained as follows:

$$Q_p = \sum_i w_i \cdot Q_{K,i} + \sum_i w_i \cdot E_{el,i} \tag{8}$$

where:
$Q_{K,i}$ - the annual delivered energy need with reference to the specific purpose: space heating, space cooling, ventilation, domestic hot water, lighting, in kWh/a.
$E_{el,i}$ - the annual auxiliary energy need in building systems, in kWh/a.
w_i - the non-renewable primary energy factor taking into account the energy required for any operations necessary for energy delivery to the building.

Tab. 1 Tab 1. The values of non-renewable primary energy factors according to regulations in Poland

Energy source		**Non-renewable primary energy factors w_i**
Fuels/ energy carrier	Oil	1,1
	Natural gas	1,1
	Liquid gas	1,1
	Hard coal	1,1
	Lignite coal	1,1
	Biomass	0,2
	Thermal solar collector	0,0
Heat form CHP	Hard coal/Natural gas	0,8/1,2
	Renewable energy sources (biogas, biomass)	0,15
District heating	Coal	1,3
	Gas/Oil	1,2
	Biomass	0,2
Electrical power	National mix	3,0
	PV systems	0,70

The annual delivered energy need $Q_{K,i}$ for space heating and ventilation or domestic hot water is calculated from:

$$Q_{K,i} = \frac{Q_{i,nd}}{\eta_{i,tot}} \tag{9}$$

where:
$Q_{i,nd}$ - the annual net energy need, in kWh/a,
$\eta_{i,tot}$ - the total average annual efficiency of a system.

The annual net energy need for space heating or cooling is calculated according to PN-EN ISO 13790 by means of the monthly method as follows:

$$Q_{H,nd} = \sum_{i=1}^{12} \left(Q_{H,ht,i} - \eta_{H,gn,i} \cdot Q_{H,gn,i} \right) \tag{10}$$

where:
$Q_{H,ht,i}$ - heat losses, in kWh/month,
$Q_{H,gn,i}$ - heat gains, in kWh/month,
$\eta_{H,gn,i}$ - dimensionless gain utilisation factor.

The annual net energy need for domestic hot water is given by:

$$Q_{W,nd} = V_{CWi} \cdot L_i \cdot c_W \rho_W \left(\theta_{CW} - \theta_O \right) \cdot k_t \cdot t_{UZ} / (1000 \cdot 3600) \tag{11}$$

where:
V_{CWi} - the daily use of hot water per reference unit L_i, in dm^3 per reference unit and day,
t_{UZ} - the usage days,
$c_W \rho_W$ - the specific heat and the density of water,
θ_{CW} - the temperature of domestic hot water (55 degC),
θ_O - the temperature of water,
k_t - the correction factor for temperature of hot water different then 55 deg C.

The annual delivered energy need for lighting is calculated from:

$$E_{K,L} = F_C \cdot P_N / 1000 \left[\left(t_D \cdot F_O \cdot F_D \right) + \left(t_N \cdot F_O \right) \right] \cdot A_f \tag{12}$$

where:
P_N - the electrical power consumed by the lamps, in W,
t_D - the usage hours during the days,
t_N - the usage hours during the nights,
F_C - the regulaion factor,
F_O - occupancy dependency factor,
F_D - daylight dependency factor.

2 Examples of EP_H-values calculations

The decisive effect on energy performance of buildings in climatic conditions of Poland has the energy need for the space heating including ventilation. Fig. 2 shows the examples of calculation results of EP_H-values of seven different residential buildings (no. B1-B7) which are characterised by:

- the A/V compactness factor which varies from 1,1 to 0,36 m^{-1} and the floor area of conditioned spaces A_f which varies from 60 to 3200 m^2,

- the arrangement of transparent elements of an envelope: 15 % of the N - elevation, 20 % of the E and the W - elevation, 60 % of the S – elevation,
- the non-renewable primary energy factor = 1,1,
- the total space heating efficiency = 0,95,
- the auxiliary energy need of 2% of the delivered energy for space heating,
- natural ventilation (air flow rates according to the regulations),
- climatic conditions for Warsaw – fig.2, 3, (most of other locations in Poland have similar conditions – usually differences less than 5% regarding temperature values and less 10% regarding solar irradiance, in extreme cases no more than 15 %).

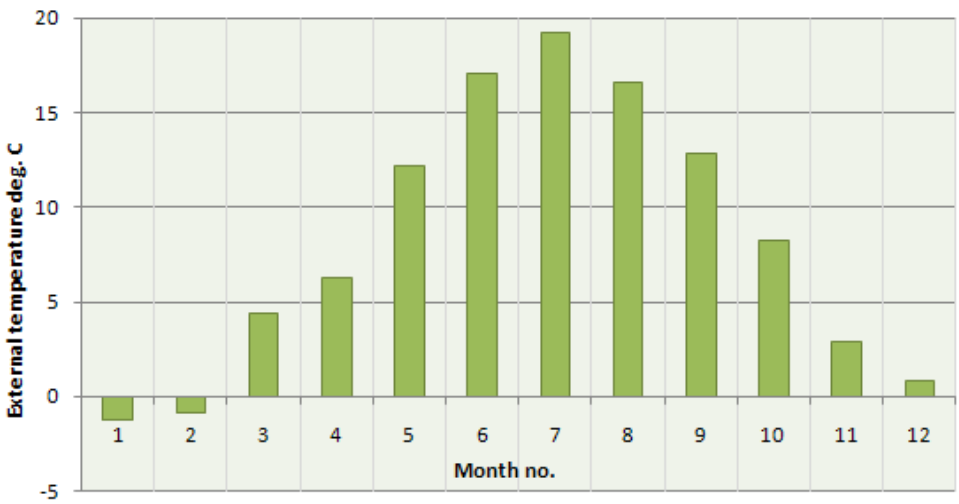

Fig. 2 The average climatic conditions for Warsaw – the temperature

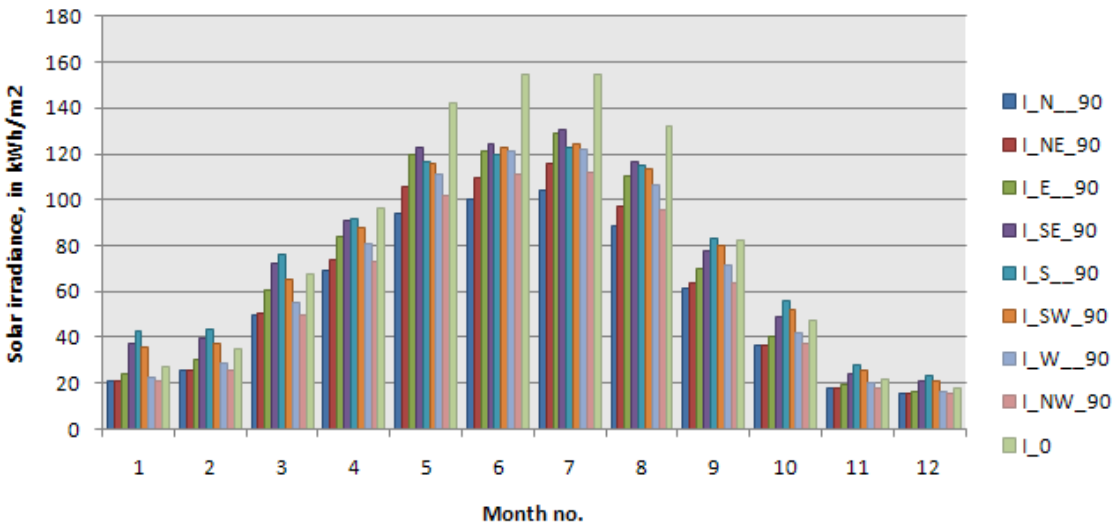

Fig. 3 The average climatic conditions for Warsaw – the solar irradiance

Similarly as for the energy quality assessment of construction products (e.g. windows [3] the energy performance of the envelope of the considered building is characterised by the equivalent value of thermal transmittance which is given by:

$$U_{eq} = U_{env} + \Delta U_{env,\inf} - \Delta U_{env,sol.gn} \tag{13}$$

where:
U_{env} - is the thermal transmmitance of the envelope depending on the U-values of opaque and transparent parts, taking account of thermal bridging effect, in W/m^2·K,
$\Delta U_{env,\inf}$ - is the correction for infiltration heat losses through the envelope of the considered building depending on its airtigtness which is characterised by n_{50} – value,
$\Delta U_{env,sol.gn}$ - is the correction for heat gains through the transparent part of the envelope of the considered building.

Fig 4 shows results of calculations of EP_H-values as functions of equivalent values of thermal transmittance for considered buildings and regressions lines [3].

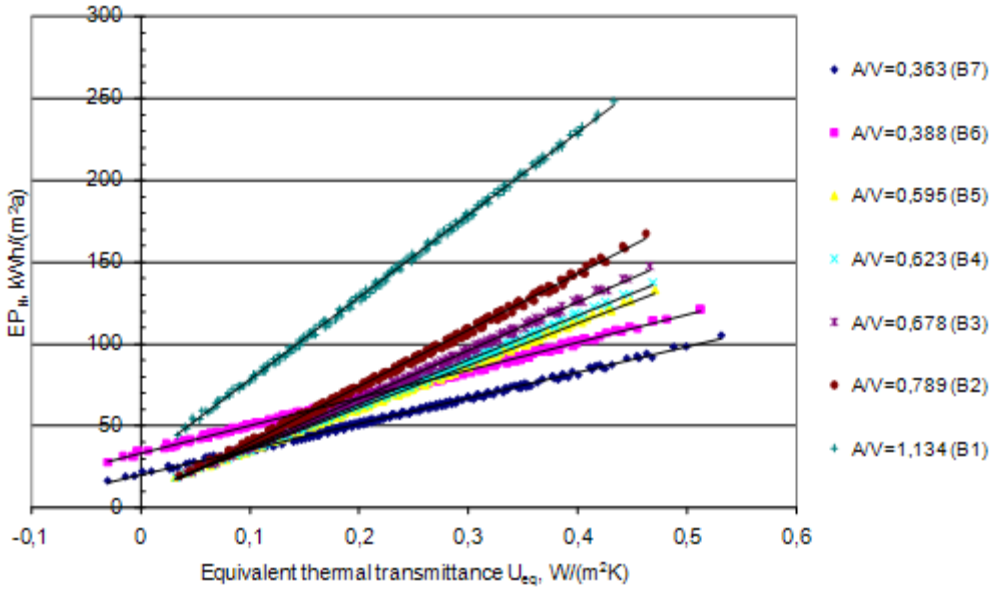

Fig. 4 Relationships between EP_H-values and U_{eq}-values of considered buildings

3 Conclusions

Economic, social and environmental reasons force significant reductions of energy use in buildings. The minimum energy efficiency requirements based on EP_{max}-values are one of the mechanisms through which these reductions are to be achieved. The latest revision of in the Building Regulations in Poland came into effect in January 2009.

The calculation method of the annual primary non-renewable energy use for the space heating, cooling, ventilation, domestic hot water supply and built-in lighting incorporates energy-related parameters of the building envelope and systems (including an use of renewables, a heat recovery and a heat gains utilization) and associates them with the overall energy performance of the building. The EP-values can be used as the input data for the cost-benefit evaluation or the environmental assessment over the estimated life-cycle of the building.

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