INTEGRISANO ODRŽIVO PROJEKTOVANJE ZGRADA

INTEGRATED SUSTAINABLE BUILDING DESIGN

Zoltan MAGYAR*

Budapest University of Technology and Economics, Hungary

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Rad prikazuje kombinovano označavanje zgrada koje obuhvata aspekte energije, kvalitet unutrašnje sredine i ugodnost. Razvoj predloženog kombinovanog označavanja odvija se kroz projekat TripleA-reno, čiji je cilj podsticanje dubinskog obnavljanja stambenih zgrada

Ključne reči: unutrašnja sredina; ugodnost; kombinovano označavanje

The paper demonstrates combined labelling of buildings, which includes energy, indoor environmental and well-being aspects. The development of the proposed combined labelling is in progress in TripleA-reno project, which aim is to encourage the deep renovation of residential buildings.

Key words: indoor environment, well-being, combined labelling

1. The TripleA-reno combined labelling scheme

The TripleA-reno is a EU funded project, running from May 2018 until April 2021. The main objective of the project is to encourage the deep renovation of residential buildings, making the renovations attractive and affordable for the users. To this end, the project will develop a user-centered platform which helps users in the decision-making, in the implementation and even in the in-use phase of the renovation.

As part of the project, the aim is to create a combined labelling scheme, which includes energy, indoor environmental and well-being indicators. The indicators of the combined labelling scheme were defined according to the purpose of the project, therefore those energy and comfort characteristics of a residential building were focused that can be changed by (deep) renovation. The methodology used in the main existing certification systems (LEED, BREEAM, WELL) and reporting framework (LEVEL(s)) was reviewed [1, 2, 3, 4, 5, 6, 7], including regulations and standards, in order to determine the relevant indicators and requirements. As a result of the assessment the “Energy indicators”, the “Qualitative well-being and IEQ indicator (Related to the building system)” and the “Measured well-being and IEQ indicator (Related to the

apartment and depending on occupant habits)” is being developed, which altogether results the combined labelling.

The qualitative well-being and IEQ rating include those indicators that characterize the building regardless of occupant habits. These indicators are evaluated based on the designed or implemented technical systems. The measured well-being and IEQ rating is related to the apartment and most of it depends on occupant habits and can be evaluated by on-site measurement.

The proposed combined labelling will give occupants insight not only into the energy efficiency, but also the indoor environmental and well-being aspects.

1-1- Energy indicators

The Energy Performance Certificate (EPC) has been introduced in EU countries according to the requirements of the EPBD. The EPC shows the characteristics of the building envelope and the HVAC systems and demonstrates the primary energy use of the building in a transparent manner. It is very useful when one would like to label the energy consumption. The EPC is an objective assessment, which helps end-users to get information on energy efficiency, therefore it makes sense to use EPC as energy performance indicator and complement it with IEQ and well-being performance indicators. In addition

* Autor: magyar@egt.bme.hu

to the EPBD energy performance calculation, the delivered energy use (both calculated and measured) and the area weighted average thermal transmittance is shown in the labelling. The calculated total primary energy and the calculated delivered energy use is align with Level(s) reporting framework. The energy indicators, the units and the references are shown in Table 1 below:

Table 1 Energy indicators

Energy indicators	Unit	Reference / Description
Energy Class	-	Align with national energy performance certification (EPBD)
Calculated total primary energy use	kWh/m ² a	Align with EN 15603 and EN ISO 13790, or EN ISO 52000 standard series.
Calculated delivered energy use (fuel)	kWh/m ² a	Align with EN 15603 and EN ISO 13790, or EN ISO 52000 standard series.
Calculated delivered energy use (electricity)	kWh/m ² a	Align with EN 15603 and EN ISO 13790, or EN ISO 52000 standard series.
Calculated delivered energy use (district energy)	kWh/m ² a	Align with EN 15603 and EN ISO 13790, or EN ISO 52000 standard series.
Calculated delivered energy use	kWh/m ² a	Sum of all calculated delivered energy use.
Measured delivered energy use (fuel)	kWh/m ² a	Based on measurement or energy bills. Energy consumption without any correction.
Measured delivered energy use (electricity)	kWh/m ² a	Based on measurement or energy bills. Energy consumption without any correction.
Measured delivered energy use (district energy)	kWh/m ² a	Based on measurement or energy bills. Energy consumption without any correction.
Measured delivered energy use	kWh/m ² a	Sum of all measured energy use.
Share of RES	%	Calculated renewable primary energy use divided by calculated total primary energy use.
Area weighted average thermal transmittance	W/m ² K	Regarding above ground structures.

For residential buildings according to EPBD, the primary energy consumption takes into account only the energy consumption of heating, cooling, DHW and ventilation. Household electricity (plug load) is not taken into account when primary energy consumption of different residential buildings or building units are compared, because there can be many differences between one and another dwellings' household appliances and the operation of them.

However, from end-user point of view the primary energy consumption may be too difficult to understand, furthermore there are big differences among primary energy factors of different energy sources. Therefore it makes more sense to show also the delivered energy use. The delivered energy is a very useful indicator especially in case when somebody would like to monitor their energy consumption and the behaviour of a selected residential building (or building unit) and would not like to compare with other buildings (flats), only with itself – when the occupant of the residential building does not change. Typically, the energy sources in residential buildings are natural gas, oil, biomass, electricity and thermal energy from district heating. The energy consumption monitoring can be implemented based on measurements from the power and gas meters (gas and electricity) and thermal flow meter for district heating/cooling, or based on consumption bills (e.g. oil, biomass).

There are several types of building structures and U-values within a building: e.g. wall, floor, roof, windows, etc. The area-weighted averaging is a simple mathematical technique for combining different amounts of various components into a single number. The area-weighted average thermal transmittance for above ground structures is included as energy indicator in the labelling, because it is useful when comparing building structures as a whole before and after the renovation, or when comparing energy characteristic of building structures of different buildings.

1.2. Qualitative well-being and IEQ indicators

The combined labelling includes not only energy use but other parameters, because the aim is to create an end user centric certification, which is easy to understand and expresses not only the sustainability of a building but also qualitative parameters as well. The well-being and the indoor environmental quality very much depend on the features of the technical building systems. For example, the central heating control in a building is worse than an apartment control or room control, because in the latter cases the occupant has the chance to control the indoor temperature according to her/his specific needs. Therefore qualitative features of the technical building

systems shall be rated as well. The most important features of the technical building systems were collected which on one hand influence IEQ and occupant well-being in residential buildings, and on the other hand these can be improved by renovation. The qualitative well-being and IEQ indicators, the units and the references are shown in Table 2 below:

Table 2 Qualitative well-being and IEQ indicators

Qualitative well-being and IEQ indicators	Unit	Reference / Description
Control of heating system	-	1. No control 2. Central (building) temperature control 3. Apartment temperature control 4. Room temperature control
Control of cooling system	-	1. No control 2. Central (building) temperature control 3. Apartment temperature control 4. Room temperature control
Fresh air flow (mechanical ventilation) per number of occupants	l/s	In case of mechanical ventilation the fresh air flow per number of occupants meets EN 16798-1 category I or II, or III.
Air tightness of windows and doors	-	1. Poor air-tightness: warped, poorly fitted or unsealed windows and doors. 2. Medium air-tightness: windows and doors with well fitted sealings. 3. Good air-tightness: factory-fitted shaped sealing profiles or certification document according to EN 12207 Class 4.
Exterior shading	%	Rate of the glazed building openings' surfaces with exterior shading to total surfaces of glazed building openings. Openings are taken into account only from East to West, the Northern openings are not considered.
Radiant heating and/or cooling system	%	Adapted from WELL labelling scheme. Radiant heating and/or cooling system operates in rooms at least 50% of the conditioned floor area.
Radiant temperature asymmetry	-	ISO 7730 Category II

1.3. Measured well-being and IEQ indicators

The qualitative well-being and IEQ indicators give feedback to the end user about the technical building systems and its capabilities from well-being and IEQ point of view, but do not give information on what figures are realized in the analysed residential building or apartment. Therefore, onsite measurements are needed to evaluate the realized status, giving information to the end-user which parameters are good and which should be improved in order to improve IEQ and well-being.

Those essential parameters are collected that have significant effect on occupant well-being and IEQ in residential buildings and on the other hand these can be improved by renovation. The measured well-being and IEQ indicators, the units and the references are shown in Table 3.

1.4. Labelling

The energy indicators express the energy characteristic of the building one by one, therefore aggregating them into a single energy indicator is not recommended, but it is proposed to be shown to the end user one-by-one. The energy class (A B, C, ...) of the analysed building provides clear view on the energy efficiency of the actual status. The calculated figures, such as total primary energy use, calculated and measured delivered energy use, share of RES and area weighted average thermal transmittance, provide information on the main energy characteristics of the analysed building or building unit. The energy indicator contains both the energy class and the calculated or measured figures, which are displayed to the end user.

Concerning the joint assessment of well-being and IEQ, the output of the labelling should be one class in order to ensure easy understanding. However, the labelling should present not only the result (the achieved class), but all of the sub-indicators with its gained and theoretical maximum points,

which details the result and provide information on what should be improved.

Table 3 Measured well-being and IEQ indicators

Measured well-being and IEQ indicators	Unit	Reference / Description
Operative temperature – heating season*	°C	Measured data compared to EN 16798-1 temperature ranges.
Operative temperature – cooling season*	°C	Measured data compared to EN 16798-1 temperature ranges.
Relative humidity of indoor air is between 30 % and 70 %	%	Measured data compared to CEN CR 1752 range (30 to 70 %RH).
CO ₂ concentration	ppm	Measured data compared to EN 16798-1 categories.
TVOC	µg/m ³	Measured data compared to the limit (500 µg/m ³). Adapted from WELL labelling scheme.
Formaldehyde	ppb	Measured data compared to the limit (100 µg/m ³). Adapted from WELL labelling scheme.
PM _{2,5}	µg/m ³	Measured data compared to the limit (15 µg/m ³). Adapted from WELL labelling scheme.
PM ₁₀	µg/m ³	Measured data compared to the limit (50 µg/m ³). Adapted from WELL labelling scheme.

* During the site survey operative temperature in the heating season or in the cooling season has to be measured according to the actual season.

The steps of the labelling of the well-being and IEQ indicators are as follows:

1. Score calculating: the relevant well-being and IEQ sub-indicators gain points according to the Table 4 and Table 5.
2. Sum the gained scores of the relevant sub-indicators.
3. Sum the theoretical maximum scores of the relevant sub-indicators. These include maximum points for all the relevant sub-indicators. For example if there is not cooling system, or mechanical ventilation system in the building, those won't be concerned when calculating maximum points that can be achieved.
4. Calculate the percentage of total gained points / total theoretical maximum points.
5. Labelling based on the calculated percentage of total and theoretical maximum points:
 - Excellent 90-100 %

- Good 80-89 %
- Acceptable 60-79 %
- Weak 50-59 %
- Very weak under 50 %

Table 4 Scores for Qualitative well-being and IEQ indicators

Qualitative well-being and IEQ indicators	Scores
Control of heating system	Room temperature control: 20 points Apartment temperature control: 10 points Central (building) temperature control: 5 points No control: 0 point
Control of cooling system	Room temperature control: 20 points Apartment temperature control: 10 points Central (building) temperature control: 5 points No control: 0 point
Fresh air flow (mechanical ventilation) per number of occupants	Fresh air flow per number of occupants meets EN 16798-1 category I or II - 20 points Fresh air flow per number of occupants meets EN 16798-1 category III - 10 points Fresh air flow is less than EN 16798-1 category III – 0 point
Air tightness of windows and doors	Good air-tightness: 10 points Medium air-tightness: 5 points Poor air-tightness: 0 point
Exterior shading	10 points for 100% of windows from East to West have exterior shading 9 points for 90%-99% 8 points for 80-89% ... 1 point for 10-19% 0 point for 0-9%
Radiant heating and/or cooling system	Radiant heating and/or cooling system operates in rooms at least 50% of the conditioned floor area: 10 points
Radiant temperature asymmetry	Radiant temperature asymmetry meets ISO 7730 Category II: 10 points

Table 5 Scores for Measured well-being and IEQ indicators

Measured well-being and IEQ indicators	Scores
Operative temperature – heating season*	30 points - EN 16798-1 Category II 15 points - EN 16798-1 Category III 0 point - EN 16798-1 Category IV
Operative temperature – cooling season*	15 points - EN 16798-1 Category II 8 points - EN 16798-1 Category III 0 point - EN 16798-1 Category IV
Relative humidity of indoor air is between 30 % and 70 %	5 points if RH is between 30 and 70%RH
CO ₂ concentration	20 points - EN 16798-1 Category II 10 points - EN 16798-1 Category III 0 point - EN 16798-1 Category IV
TVOC	10 points - TVOC is under 500 µg/m ³
Formaldehyde	10 points - Formaldehyde is under 100 µg/m ³
PM _{2,5}	5 points if PM _{2.5} is under 15 µg/m ³
PM ₁₀	5 points if PM ₁₀ is under 50 µg/m ³

* During the site survey operative temperature in the heating season or in the cooling season has to be measured according to the actual season.

2. Examples of combined labelling

In the TripleA-reno project there are 8 demo buildings located in Hungary, Spain, Italy, Netherlands and in Greece. In all demo buildings a monitoring activity and an ethnography research were performed in the existing status (before deep renovation). On the one hand, the aim was to collect information on user habits, energy practices, motivation factors and barriers regarding deep renovation. On the other hand, indoor environmental parameters and energy use was measured for analysis and for feeding them into the combined labelling scheme. The testing of the combined labelling has been started recently. An excel sheet was developed in which the user has to give administrative data (name of the building, date), the calculated and the measured energy parameters, furthermore the user has to select the qualitative parameters of the residential unit from a drop down menu, and finally has to evaluate the measured parameters also from a drop down menu.

The results of first tests of the combined labelling can be seen on the following figures:

- Figure 1 and 2: apartment 2 in the Hungarian demo building (condominium, built in 1982)

- Figure 3 and 4: apartment 3 in the Hungarian demo building
- Figure 5 and 6: new family house (built in 2017)

TripleA-reno

Combined performance label on energy, IEQ and well-being									
Building name / Apartment		Condominium, Szécszentmiklósi, apartment 2						DATE: 22.08.2019	
COMBINED PERFORMANCE LABEL									
Season of measurements	Energy Class	Calculated total primary energy use	Calculated delivered energy use	Measured delivered energy use	Share of RES	Average U	Qualitative well-being and IEQ		Measured well-being and IEQ
Both heating and cooling season	F	201 kWh/m ² a	158,85 kWh/m ² a	185 kWh/m ² a	0,04 %	1,23 W/m ² K	58%	Weak	63% Acceptable
Energy Indicator									
Number	Name	Unit	Reference / Description				Value		
1.1	Energy Class	-	Align with national energy performance certification (EPBC)				F		
1.2	Calculated total primary energy use	kWh/m ² a	Align with EN 15603 and EN ISO 13790 or EN ISO 52000 standard series				201		
1.3.1	Calculated delivered energy use (fuel)	kWh/m ² a	Align with EN 15603 and EN ISO 13790 or EN ISO 52000 standard series				0		
1.3.2	Calculated delivered energy use (electricity)	kWh/m ² a	Align with EN 15603 and EN ISO 13790 or EN ISO 52000 standard series				0,85		
1.3.3	Calculated delivered energy use (district energy)	kWh/m ² a	Align with EN 15603 and EN ISO 13790 or EN ISO 52000 standard series				158		
1.3	Calculated delivered energy use	kWh/m ² a	Sum of all calculated delivered energy use				158,85		
1.4.1	Measured delivered energy use (fuel)	kWh/m ² a	Based on measurement or energy bills. Energy consumption without any correction				0		
1.4.2	Measured delivered energy use (electricity)	kWh/m ² a	Based on measurement or energy bills. Energy consumption without any correction				22		
1.4.3	Measured delivered energy use (district energy)	kWh/m ² a	Based on measurement or energy bills. Energy consumption without any correction				163		
1.4	Measured delivered energy use	kWh/m ² a	Sum of all measured energy use				185		
1.5	Share of RES	%	Renewable primary energy use divided by total primary energy use				0,04		
1.6	Area weighted average thermal transmittance	W/m ² K	Regarding above ground structures. U _{aver} < 24W ² /24K				1,23		

Figure 1 Combined labelling of an apartment 2 in the Hungarian demo building (Part 1)

Qualitative well-being and IEQ indicator					
Number Name	Unit	Classif.	Reference / Description	Points	Maximum
2.1 Control of heating system	-	5 cat	Central (building) temperature control	5	20
2.2 Control of cooling system	-	5 cat	No cooling system	-	-
2.3 Fresh air flow (mechanical ventilation) per number of occupants	l/s	3 cat	No mechanical ventilation	-	-
2.4 Air tightness of windows and doors	-	3 cat	Good air tightness: factory-fitted shaped sealing profiles or certification document according to EN 12207 Class 4	10	10
2.5 Exterior shading	%	11 cat	100% of windows from East to West have exterior shading	10	10
2.6 Radiant heating and/or cooling system	%	2 cat	< 50% of the conditioned floor area	0	10
2.7 Radiant temperature asymmetry	-	2 cat	ISO 7730:2005 Category A or B	10	10
Total				35	60
Measured well-being and IEQ indicator					
Number Name	Unit	Classif.	Reference / Description	Points	Maximum
3.1 Operative temperature – heating season	°C	3 cat	EN 16798-1 Category II	30	30
3.2 Operative temperature – cooling season	°C	3 cat	EN 16798-1 Category III	8	15
3.3 Relative humidity of indoor air is between 30% and 70%	%	11 cat	RH < 30% or RH > 70%	0	5
3.4 CO ₂ concentration	ppm	3 cat	EN 16798-1 Category III	10	20
3.5 TVOC	µg/m ³	2 cat	TVOC < 500 µg/m ³	0	10
3.6 Formaldehyde	ppb	2 cat	Formaldehyde < 100 µg/m ³	10	10
3.7 PM _{2,5}	µg/m ³	2 cat	PM _{2,5} < 15 µg/m ³	5	5
3.8 PM ₁₀	µg/m ³	2 cat	PM ₁₀ < 50 µg/m ³	0	5
Total				63	100
Recommendations:					
Thermal insulation of the walls and roof is recommended, which results less heating energy use and improves IEQ.					
Installing thermostatic valves on the radiators is recommended, which provides room control of the heating system, reduces heating energy use and improves thermal comfort (no more overheating) and well-being (automatic operation).					
Installing thermal solar collector system for the whole building is suggested, which reduces energy use of domestic hot water production and increases share of renewable energy sources.					

Figure 2 Combined labelling of an apartment 2 in the Hungarian demo building (Part 2)

Figure 3 Combined labelling of an apartment 3 in the Hungarian demo building (Part 1)

Figure 4 Combined labelling of an apartment 3 in the Hungarian demo building (Part 2)

Figure 5 Combined labelling of a new family house built in 2017 (Part 1)

Figure 6 Combined labelling of a new family house built in 2017 (Part 2)

3. Conclusion

The TripleA-reno project has end-user centric approach. The main goal of the project is making the deep renovation of residential buildings attractive and affordable for the occupants. As part of the project, a combined labelling scheme is being developed for residential buildings and building units, which includes energy, indoor environmental and well-being indicators that can be changed by (deep) renovation. The proposed combined labelling will give feedback to the occupants about their energy efficiency, indoor environmental and well-being parameters. The labelling provides information on which parameters are good and which should be improved in order to improve energy efficiency, IEQ and well-being.

The validation of the proposed combined labelling is still in progress. The aim of the validation procedure is to test the effectiveness of the proposed scheme. Modifying or final tuning of the combined labelling process is planned based on the experiences of feeding the combined labelling scheme with real data of residential demo buildings located in several countries.

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