TripleA-reno:

Combined Labelling Scheme of Dwellings



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Introduction

The overall objective of the TripleA-reno project is to increase acceptance of - and facilitate decision making on - deep and nZEB renovation for consumers and end-users of residential buildings. As part of the project, the aim was to develop a combined labelling scheme for dwellings, which includes energy performance, indoor environmental and well-being indicators. The excel template of the combined labelling scheme can be downloaded in the references list [1], the webtool of the combined labelling scheme will soon be available on the TripleA-reno website [2]. This article is based on a conference paper from Cold Climate 2021 which introduced the Combined Labelling Scheme of dwellings [3].

Why is the combined labelling scheme necessary?

The renovation of building stock plays a major role in meeting the energy efficiency targets set in the EU Member States. This weighted annual energy renovation rate is calculated to be about 1%. If this rate persists, the building sector will clearly and significantly fail to deliver its share of the overall need for primary energy reduction and, consequently, reduce greenhouse gas emissions [4].

After performing an assessment on the existing certification schemes, we found that there is no combined labelling scheme available yet with a focus on dwellings which combines indicators on energy performance, indoor environmental quality and well-being together. M.A. Ortiz et al. studied [5] the well-being and the interaction between influencing factors and concludes the energy use is a consequence of trying to attain homeostasis (comfort, neutral state, lack of stress). This means that people use energy to satisfy their needs and to achieve well-being. In line with this result, the TripleA-reno combined labelling focuses on end-users and informs them about the energy performance and well-being aspects of their homes. The well-being and IEQ indicators label the technical building systems' capabilities from well-being and IEQ point of view. However, in order to know what figures are realised in the analysed residential building or apartment, a series of on-site measurement of parameters that influence IEQ and well-being is also necessary.

TripleA-reno combined labelling: energy performance, indoor environmental quality, well-being

The methodology used of the most important certification schemes was reviewed, including regulations and standards, in order to determine the relevant indicators and requirements. As a result of the assessment, the TripleA-reno combined labelling scheme was developed, which includes the following indicators:

Table 1. *Combined labelling indicators and main features.*

Indicators	Main features
Energy performance	Both calculated and measured energy uses are presented.
Indoor environment and well-being	IEQ and well-being capability of the building and technical building systems.
Measured indoor environment and well-being	Based on measured figures, related to the specific dwelling and dependent on occupant habits.

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Energy performance indicators

The calculated total primary energy use is included in the TripleA-reno labelling scheme. According to the EPBD, the primary energy consumption for dwellings takes into account only the energy consumption of heating, cooling, domestic hot water and ventilation. Household electricity is not considered when primary energy consumption of different residential buildings or building units is compared. However, from the end-user point of view, the calculated total primary energy consumption may be too difficult to understand; furthermore, there are significant differences among primary energy factors of different energy sources. Therefore, it makes sense to show the delivered energy use besides the total primary energy use.

Regarding the type of energy use, both the calculated and measured delivered energy uses are included in the TripleA-reno labelling. The calculated delivered energy use is an objective way to evaluate the energy performance, while measured energy can be a useful indicator to compare energy consumption before and after deep renovation. The energy consumption monitoring can be implemented based on measurements from power and gas meters and thermal flow meter for district heating/cooling or consumption bills (e.g. oil, biomass).

There are several different building structures with varying thermal transmittances (U-values) in buildings, e.g. walls, roofs, windows. The area-weighted average is a simple mathematical technique for combining different amounts of various components into a single number. The area-weighted average thermal transmittance is included as an energy performance indicator in the TripleA-reno combined labelling as it is useful when comparing building structures before and after the renovation, or when one compares the energy characteristics of structures in different buildings. The area-weighted average thermal transmittance regards only the above-ground structures.

The EPBD recast defines that the energy requirements of nearly zero energy building should be covered to a significant extent from renewable sources [6]. The share of renewable energy use in the total primary energy use is included in the TripleA-reno combined labelling.

Table 2. *Features of the energy performance indicators of TripleA-reno combined labelling.*

Nr.	Name, unit	Reference/ description	Source
1.1	Energy efficiency class [-]	Align with national energy performance certification (EPBD) and EN ISO 52003-1.	EPBD
1.2	Calculated total primary energy use, [kWh/m^{2}a]	EN ISO 52000 standard series.	Level(s)
1.3.1	Calculated delivered energy use (fuel), [kWh/m^{2}a]	EN ISO 52000 standard series.	Level(s)
1.3.2	Calculated delivered energy use (electricity), [kWh/m^{2}a]	EN ISO 52000 standard series.	Level(s)
1.3.3	Calculated delivered energy use (district energy), [kWh/m^{2}a]	EN ISO 52000 standard series.	Level(s)
1.3	Calculated delivered energy use, [kWh/m^{2}a]	Sum of all calculated delivered energy use.	Level(s)
1.4.1	Measured delivered energy use (fuel), [kWh/m^{2}a]	Based on measurement or energy bills. Energy consumption without any correction.	–
1.4.2	Measured delivered energy use (electricity), [kWh/m^{2}a]	Based on measurement or energy bills. Energy consumption without any correction.	–
1.4.3	Measured delivered energy use (district energy), [kWh/m^{2}a]	Based on measurement or energy bills. Energy consumption without any correction.	–
1.4	Measured delivered energy use, [kWh/m^{2}a]	Sum of all measured energy use.	–
1.5	Share of renewable energy sources, [%]	Renewable primary energy use divided by total primary energy use: $RER_P = \frac{\sum E_{Pren}}{\sum E_{Ptot}}$	N ISO52000-1 equation 17
1.6	Area weighted average thermal transmittance, [W/m2K]	Regarding the above- ground structures: $\overline{U} = \frac{\sum Ai \cdot Ui}{\sum Ai}$	–

Well-being and IEQ indicators

In the developed TripleA-reno combined labelling, the well-being and IEQ indicators focus on the most critical features of the technical building systems, which on the one hand influence IEQ and occupant well-being in residential buildings, and on the other these can be improved through renovation. The following indicators are included:

- The first two indicators are control over both heating & cooling systems. Having control over the room temperature is more effective than at apartment or building-level to adapt the indoor temperature according to the specific needs of the occupants. As opposed to a central building system where occupants only have limited influence.
- The third indicator to measure is the supply of airflow per person with mechanical ventilation. If the air change rate is inadequate, the concentration of indoor contaminants, such as CO_2 and VOC, will increase, which reduces the indoor air quality and occupants' well-being which in turn has a negative influence on the occupants' health. Natural ventilation is not within the TripleA-reno labelling scope as the project focuses on existing buildings.
- Air-tightness of windows and doors is the fourth indicator, which is not directly included in the labelling schemes we've reviewed. Low air-tightness of windows can cause discomfort for occupants, especially during winter when a draft can occur. Furthermore, low air-tightness increases infiltration, which results in higher heating and cooling energy consumption.
- Exterior shading is the fifth indicator of the TripleA-reno combined labelling. The exterior shading can provide better thermal comfort, since the temperature of indoor spaces and the glass of windows will be limited, and on the other hand the same indoor temperature can be kept with lower energy use in the cooling season when using exterior shading.
- The sixth indicator of the TripleA-reno combined labelling provides information to the occupant on the radiant heating/cooling systems to asses if they operate in at least 50% of the conditioned floor area.

Table 3. *Well-being and IEQ indicator of TripleA-reno combined labelling.*

Nr.	Name, unit	Reference/categories	Source
2.1	Control of the heating system	1. No heating system 2. No control 3. Central (building) temperature control 4. Apartment temperature control 5. Room temperature control	–
2.2	Control of the cooling system	1. No cooling system 2. No control 3. Central (building) temperature control 4. Apartment temperature control 5. Room temperature control	–
2.3	Supply air flow per person (in case of mechanical ventilation) [l/s, pers]	EN 16798-1 category I, II, III fresh air flow per number of occupants	Level(s)
2.4	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	–
2.5	Exterior shading [%]	Percentage of the windows with exterior shading. Windows are taken into account only from East to West.	–
2.6	Radiant heating and/or cooling system [%]	Radiant heating and/or cooling system (floor, wall, ceiling) operates in rooms at least 50% of the conditioned floor area	WELL
2.7	Radiant temperature asymmetry	Radiant temperature asymmetry meets ISO 7730 Category B requirement	ISO 7730

Measured well-being and IEQ indicators

TripleA-reno focuses on motivating the renovation of residential buildings; therefore, parameters have been collected that significantly affect the occupants' well-being and IEQ in residential buildings which can be improved through renovations. Operative temperature, relative humidity and CO_2 concentration are the parameters that people are most sensitive about. The operative temperature and CO_2 have to be evaluated through categories of the EN 16798-1 standard. They can be placed within a certain category if 85% of the measured data falls within the range of that category. The relative humidity has to be in the comfort range, which is between 25 and 70%RH.

The most common air contaminants, such as TVOC and formaldehyde, are taken integrated in the TripleA-reno labelling. Building materials, furnishings, fabrics, cleaning products, personal care products and air fresheners can all emit volatile organic compounds (VOCs) into the indoor environment. Owing to VOCs' complexity, the individual health effects can vary greatly in different cases. Long-term exposure to even low TVOC concentrations can lead to a variety of symptoms including increased perception unpleasant odours and tastes, irritation of eyes/nose/throat, dry skin and itching, increased sensitivity to infections of the respiratory tract, neurotoxic symptoms (fatigue, headaches, reduced mental performance).

Formaldehyde (HCHO) can be released from plastics, furniture, and adhesives in homes, which can be further concentrated in the living space during the winter. Formaldehyde is a colourless aldehyde gas and, similar to TVOC, even small quantities of formaldehyde in the room air may affect human health. The symptoms include concentration disorders, nervousness, headaches, dizziness, but also nausea, swelling of the mucosa, conjunctival irritations and lacrimation [7].

In the TripleA-reno labelling, the allowed concentration of TVOC for the well-being limit was taken from the WELL [8] and LEED [9] labelling schemes and is set at 500 µg/m³. However, the costly and complex laboratory analysis (ISO 16000-6) is not required because the TVOC measurement is only informative. The allowed concentration of formaldehyde was taken from the WHO and is set at 100 µg/m³. The laboratory analysis (ISO 16000-3) is not a requirement because the formaldehyde measurement is informative. The allowed concentration of PM2.5 and PM10 was taken from WELL labelling scheme: PM2.5 = 15 µg/m³, PM10 = 50 µg/m³. The measurement can be implemented with a light-scattering airborne particle counter in accordance with ISO 21501-4.

Table 4. *Measured well-being and IEQ indicators of TripleA-reno combined labelling scheme.*

Nr.	Name, unit	Reference/categories	Source
3.1	Operative temperature – heating* [°C]	Measured data compared to EN 16798-1 temperature ranges.	–
3.2	Operative temperature – cooling* [°C]	Measured data compared to EN 16798-1 temperature ranges.	–
3.3	Relative humidity of indoor air is between 25% and 70% [%RH]	Measured data compared to 25 to 70%RH	–
3.4	CO_2 concentration [ppm]	Measured data compared to EN 16798-1 categories.	–
3.5	TVOC [µg/m³]	Measured data compared to the limit (500 µg/m³)	Well-being limit adapted from WELL, LEED
3.6	Formaldehyde [ppb]	Measured data compared to the limit (100 µg/m³)	WHO IAQ guideline 2010, 30 min mean value
3.7	PM2,5 [µg/m³]	Measured data compared to the limit (15 µg/m³)	Well-being limit adapted from WELL (The WHO annual mean is 10 µg/m³)
3.8	PM10 [µg/m³]	Measured data compared to the limit (50 µg/m³)	Well-being limit adapted from WELL (The WHO annual mean is 20 µg/m³)

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

Required measurements

The requirements of the measurements are summarised shortly in this section. The measurement place is the living room. The operative temperature, the relative humidity and the CO_2 concentration of indoor air should be measured for at least one week by 5-minute time series. The measured data of indoor temperature and CO_2 concentration has to be compared to the ranges of EN 16798-1 standard, while the relative humidity has to be compared to the comfort range that is from 25 to 70%RH. The TVOC and the formaldehyde measurements should be completed two times on the spot, at the beginning and the end of one-week measurements of temperature, relative humidity and CO_2 concentration. The measurement of PM2.5 and PM10 should also be completed two times on the spot, but it requires at least 30-minute-long measurements, at the beginning and the end of one-week measurements of temperature, relative humidity and CO_2 concentration. During the evaluation of the measured figures, the category satisfied by at least 85% of the measured figures must be chosen.

Labelling

The energy performance indicators express the energy characteristic of the building, which contains the energy efficiency class, the calculated and the measured energy use, which are displayed to the end-user one by one. The energy efficiency class (A+, A, B, C, ...) of the analysed dwelling clearly conveys the energy efficiency

Table 5. *Scoring of the well-being and IEQ indicators.*

Nr.	Name	Scores
2.1	Control of the heating system	Room temperature control: 20 points Apartment temperature control: 10 points Central (building) temperature control: 5 points No control: 0 point
2.2	Control of the cooling system	Room temperature control: 20 points Apartment temperature control: 10 points Central (building) temperature control: 5 points No control: 0 point
2.3	Supply air flow per person (in case of mechanical ventilation)	Fresh air flow per number of occupants meets EN 16798-1 category I, II: 20 points Fresh air flow per number of occupants meets EN 16798-1 category III: 10 points Less than EN 16798-1 category III: 0 points
2.4	Air-tightness of windows and doors	Good air-tightness: 10 points Medium air-tightness: 5 points Poor air-tightness: 0 point
2.5	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% 7 points for 70-79% 6 points for 60-69% 5 points for 50-59% 4 points for 40-49% 3 points for 30-39% 2 points for 20-29% 1 point for 10-19% 0 point for 0-9%
2.6	Radiant heating and/or cooling system operates in rooms at least 50% of the conditioned floor area	Radiant heating and/or cooling system operates in rooms at least 50% of the conditioned floor area: 10 points Radiant heating and/or cooling system operates in rooms less than 50% of the conditioned floor area: 0 points
2.7	Radiant temperature asymmetry	Radiant temperature asymmetry meets ISO 7730 Category A or B: 10 points Radiant temperature asymmetry meets ISO 7730 Category C or worse: 0 points

of the current condition. The calculated figures, such as total primary energy use, delivered energy use per energy sources, measured energy use per energy sources, the share of RES and the area-weighted average thermal transmittance provide information on the main energy characteristics of the analysed dwelling.

Concerning the joint assessment of well-being and IEQ, the labelling output is put in one class to ensure a user-friendly output. However, the labelling presents not only the result (the achieved class) but also all indicators with their gained and theoretical maximum points, which details the result and provides information on what should be improved. The steps to label the well-being and IEQ indicators are:

1. Score calculating: the relevant well-being and IEQ indicators gain points according to **Table 5** and **Table 6**.
2. Sum the gained scores of the relevant indicators.
3. Sum the theoretical maximum scores of the relevant indicators. These include maximum points for all the relevant indicators. For example, if there is no cooling system or mechanical ventilation system in the building, those will not 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 according to **Table 7**.

Table 5 demonstrates the well-being and IEQ indicators scoring, **Table 6** introduces the measured well-being and IEQ indicators, and **Table 7** shows the labelling. ■

Table 7. *Labelling results in the TripleA-reno combined labelling.*

Calculated percentage of total and theoretical maximum points	Labelling
90-100%	Excellent
80-89%	Good
60-79%	Acceptable
50-59%	Weak
0-49%	Very weak

Table 6. *Scoring of the measured well-being and IEQ indicators.*

Nr.	Name	Scores
3.1	Operative temperature – heating	30 points - EN 16798-1 Category II 15 points - EN 16798-1 Category III 0 point - EN 16798-1 Category IV
3.2	Operative temperature – cooling	15 points - EN 16798-1 Category II 8 points - EN 16798-1 Category III 0 point - EN 16798-1 Category IV
3.3	Relative humidity of indoor air is between 25 and 70%	5 points if RH is between 25 and 70%RH
3.4	CO_2 concentration	20 points - EN 16798-1 Category II 10 points - EN 16798-1 Category III 0 point - EN 16798-1 Category IV
3.5	TVOC	10 points - TVOC is under 500 µg/m^3 0 point - TVOC is 500 µg/m^3 or more
3.6	Formaldehyde	10 points - Formaldehyde is under 100 µg/m^3 0 point - Formaldehyde is 100 µg/m^3 or more
3.7	PM2,5	5 points if PM2.5 is under 15 µg/m^3 0 point if PM2.5 is 15 µg/m^3 or more
3.8	PM10	5 points if PM10 is under 50 µg/m^3 0 point if PM10 is 50 µg/m^3 or more

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