TripleA-reno:

Demonstration of Combined Labelling Scheme

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Introduction: Demonstration buildings

This article is a follow up to the "TripleA-reno: Combined Labelling Scheme of dwellings" (p. 38), describing the demonstration cases of the labelling scheme. The validation of the combined labelling scheme on energy performance, IEQ and well-being was executed with real data from the TripleA-Reno project's demonstration buildings. The combined labelling template was applied to 14 dwellings in several European countries. The proposed combined labelling scheme was developed during the validation procedure according to the feedback from experts responsible for demonstration buildings. In the following sections, the main labelling results and experiences are presented for case studies located in Hungary, Italy, Spain and the Netherlands.

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Case study, Hungary

The Hungarian demo building is located in Szigetszentmiklos, 30 km from Budapest. The building was built in 1982 with prefabricated concrete panel construction technology. The building has a total of 60 apartments and the walls and roof have poor thermal characteristics. Most of the windows were replaced with new PVC framed windows. The building is connected to the district heating system, which provides thermal energy for heating and domestic hot water purposes. Within the building there is a 1-pipe heating system, the heating appliances are radiators equipped with a manual valve.

Two of the examined apartments have an energy efficiency class "F" while another has "D". The walls and roof of the building have very weak thermal insulation; therefore, the area-weighted average thermal transmittance (1.09–1.23 W/m²K), the delivered energy use (150–234 kWh/m²a) and the primary energy consumption (159–243 kWh/m²a) are high in the analysed dwellings. The renewable energy ratio was almost zero during the examination. The building has central heating control which often results in overheating in some apartments, while the indoor temperature was even beyond category III of the EN 16798-1 standard.

The well-being and IEQ indicators of the technical building systems were evaluated, and the result was weak for both apartments "1" and "2", and acceptable for "apartment 3". The better well-being and IEQ indicator in "apartment 3" is due to a local air conditioning system (split unit) in the living room, which provides room temperature control; therefore, the occupant in this apartment is at least able to control the indoor temperature in the cooling season. The pilot building is an old building; therefore, there is no radiant heating or cooling system. The main reason for the poor well-being and IEQ indicators is due central temperature control in the building, meaning that occupants cannot control the indoor temperature according to their needs which leads to inadequate thermal comfort.

Figure 1. The TripleA-reno Demonstration Building in Szigetszentmiklos, Hungary. A block of 60 apartments which was built in 1982.

The measured well-being and IEQ indicator was acceptable for "apartment 2" and very weak for apartments "1" and "3". The measurement was done during the heating season, in "apartment 2" the measured operative temperature met the EN 16798-1 category II, however apartments "1" and "3" – which are on the edge of the building – met Category IV or worse. The temperature was also measured in the apartments during the cooling season, and the indoor temperature of each apartment met the EN 16798-1 category III requirement. The measured CO_2 concentration was Category II in "apartment 1" and category III in the others. All these apartments have natural ventilation, which means the CO_2 concentration depends on how regularly and long the occupants leave the windows open. The relative humidity was out of the comfort range (25–70% RH) in each apartment. Also, the TVOC did not meet the 500 µg/m³ limit in the apartments. The measured formaldehyde figures were well below the WHO limit (100 µg/m³), except in "apartment 1". For the PM2.5 and PM10 figures: in "apartment 2" the PM2.5 was under the limit, while PM10 was over; in apartments "1" and "3" both PM2.5 and PM10 were over the limit.

Based on the combined labelling, thermal insulation of the walls and roof is recommended, which results in less use of heating and improves the IEQ (operative temperature: indicators 3.1 and 3.2). Installing thermostatic valves on the radiators is recommended, ensuring room control of the heating system, reducing heating energy use, and improving thermal comfort (no more overheating) and well-being (automatic operation). Installing a thermal solar collector system for the whole building is suggested, which reduces the energy use of domestic hot water production and increases renewable energy ratio. There is natural ventilation in the building; therefore, when the outdoor PM is high (during traffic hours or when there is heating of solid fuel in the area), the windows should remain closed if possible.

Case study, Italy

The Italian demo building is located in Concordia Sagittaria, which is 60 km from Venezia. The building was built between 1977 and 1978, is owned by ATER Venezia and hosts 21 apartments on four floors above ground. The external walls are made of a double layer of hollow bricks with thin thermal insulation. The heating system and the domestic hot water production are centralised: there is an oil-fired heating boiler, which provides thermal energy for heating and domestic hot water. The apartments have low performing window glasses and frames, and there is neither room thermostat, nor thermostatic radiator valves to control the indoor temperature.

The energy efficiency class is “F” or “G” for all the analysed apartments. The primary energy consumption (209–294 kWh/m²a), the delivered energy use (123–173 kWh/m²a) and the average thermal transmittance (1.12–1.66 W/m²K) are significantly high. The reason for variable calculated figures is the different apartment’s position inside the building. The measured delivered energy consumption is 20–25% higher than the calculated delivered energy use. This gap could be reasonably due to the central heating control that causes overheating in the apartments. Furthermore, the absence of thermostatic valves combined with the low energy performance of walls and windows increases this problem. The renewable energy ratio is zero in the current condition.

In all the surveyed dwellings the well-being IEQ indicators of the technical building systems highlighted a very weak performance, only the exterior shading indicator reached the maximum score. The heating system has central temperature control; therefore, occupants cannot control the indoor temperature. This is one of the most frequent complaints reported by residents. Windows and doors have really poor air-tightness resulting in draughts and infiltrations, which caused evident plaster blooming and mould presence on the external walls. Finally, the Concordia building is an old building; therefore, there is no radiant floor, wall or ceiling heating/cooling system. These characteristics provide little chance for the occupants to achieve well-being and create good indoor environmental quality.

Operative temperature, relative humidity, and CO_2 concentration were measured in four apartments in winter and summer. The operative temperature reaches only category III of EN-16798-1 standard in three apartments due to the central temperature control. The relative humidity was in the 25–70%RH comfort range in three apartments, and it was out of the comfort

Figure 2. The TripleA-reno Demonstration Building in Concordia Sagittaria, Italy. 21 apartments built between 1977–78.

range in one apartment. There is natural ventilation in the building; the measured CO_2 concentration was category II in two apartments and category III in the other two apartments. The windows' appropriate and regular opening results in better indoor air quality, which provides a better labelling outcome.

The tender of the energy renovation project for the Concordia building is in progress; the design specifications are in line with the combined labelling assessment recommendations for improved energy performance and comfort indicators. The renovation includes the thermal insulation of the walls and roof. All windows and doors will be replaced with thermal break frames and low emission glasses. The oil boiler will be replaced by a condensing gas boiler, improving the energy efficiency. The energy production will be supplemented by installing a photovoltaic system on the roof with 10 kW peak power. Thermostatic valves will be installed in the apartments in combination with the implementation of independent energy consumption accounting.

Case study, Spain

The Spanish demo case is located in Almoradí, a medium-sized town close to the Alicante Mediterranean shore (Costa Blanca). The demo case involves five multifamily buildings built in 1982, and is owned by the Regional Social Housing Company EVHA. The walls have poor energy performance. The apartments were initially constructed with wooden framed windows with single glass. There is electric heating in the rooms and air conditioning unit for heating and cooling in the living rooms. The lack of maintenance and few economic resources of the inhabitants have resulted in a degraded building complex, with an unattractive and outdated image.

Figure 3. TripleA-reno Demonstration Building in Almoradi, Spain. Five multifamily buildings built in 1982.

The energy efficiency class is "G" for the three examined apartments. The building walls have very weak thermal insulation; the original wood-frame windows also have poor energy efficiency; therefore, the area-weighted average thermal transmittance (1.09–2.08 W/m²K), and the primary energy consumption (284–301 kWh/m²a) are high in the analysed dwellings. The renewable energy ratio is zero in the current condition. The measured delivered energy consumption is lower than the calculated delivered energy consumption. The reason of this gap clearly turned out during the on-site visit and measurement, because the indoor temperature was even out of category IV of the EN 16798-1 standard in two apartments, i.e. the temperature and the occupant behaviour is significantly different from the standard user profile.

The well-being and IEQ indicators of the technical building systems were evaluated, and the results are acceptable. Indicators 2.1, 2.2 (control of heating, cooling system) and 2.5 (exterior shading) got the maximum scores, but for 2.2 it has to be noted that occupants installed local air conditioning split units only in their living rooms; therefore, occupants can control the living room's indoor temperature in the cooling season. In all apartments, 100% of windows from East to West orientation have exterior shading, but the windows and the doors are old and have very poor air-tightness. The building is old and there is no radiant heating or cooling system. These characteristics provide an acceptable chance for the occupants to achieve well-being and create good indoor environmental quality in their living rooms, but none in the rest of their homes.

The measured well-being and IEQ indicators were assessed, and the labelling result is acceptable (61–64%) for all the apartments. In "apartment 1" the measured operative temperature meets EN 16798-1 category III, while apartments "2" and "3" meet category IV. All apartments have and properly use, natural ventilation, resulting in adequate CO_2 concentration levels (EN 16798-1 category II). The relative humidity was within the comfort range most of the time. The TVOC was measured in the apartments and exceeded the 500 µg/m³ limit in all of them. On the contrary, the measured formaldehyde figures were well below the WHO limit (100 µg/m³). PM2.5 and PM10 figures were measured as well and were under the limits for apartments "2" and "3", while "apartment 1" was over the limit, which can be explained due to the position of the apartment on the ground floor with a façade facing a busy traffic road.

Thermal insulation of the walls and replacing the windows is recommended, which results in less cooling (and heating) energy use and will improve IEQ (Indicator 3.1 and 3.2, operative temperature). Sealing shutter boxes and perimeter of the windows will improve air-tightness. It is recommended that the home user have information on the indoor/outdoor conditions to make sound decisions regarding the on/off of their air conditioning equipment or open/close windows. Installing a thermal solar collector system for the whole building is suggested, which reduces the energy use of domestic hot water production and increases renewable energy ratio.

Case study, Netherlands

Two dwellings were assessed in the Netherlands, located in Eindhoven. Dwelling-1 is a typical Dutch style, 2-storeys, semi-detached house reflecting the architectural style of the 1930s, the era of its construction. The dwelling-2 is the second dwelling of a row house.

The energy efficiency class is "G" for dwelling-1, the calculated primary energy use is 413 kWh/m²a, and the area-weighted average thermal transmittance is 1.48 W/m²K, due to weak thermal insulation performance of walls and windows. The building structures of dwelling-2 have a slightly better thermal performance that results in lower area-weighted average thermal transmittance (1.28 W/m²K), while the primary energy consumption (145 kWh/m²a) is much lower compared to dwelling-1 because heated dwellings surround it on two sides.

The well-being and IEQ indicators of the technical building systems were evaluated, and the results are weak for both surveyed dwellings. The main reasons for the low level of well-being and IEQ indicator are the heating system's central control, the low air-tightness of windows and doors and the lack of exterior shading.

Operative temperature, relative humidity and CO_2 concentration were measured both in winter and summer period. The operative temperature reaches category III of EN-16798-1 standard in both dwellings in the heating season due to the central temperature control. The operative temperature in the summer period got the worst result, i.e. category IV of EN-16798-1 standard in both dwellings. In dwelling-1, the relative humidity was in the comfort range; however, the CO_2 concentration meets only category III of standard 16798-1. In contrast, the relative humidity in dwelling-2 was out the comfort range, but the CO_2 concentration was category II of standard 16798-1.

The measured temperature, CO_2 concentration and relative humidity values provide "very weak" result in dwelling-1 and "weak" result in dwelling-2, which means occupants may have issues to ensure good indoor environmental quality in their homes.

Based on the combined labelling assessment, the thermal insulation of walls and changing windows are recommended, which reduces heating and cooling energy use and improves comfort. In dwelling-1, it is recommended to install a CO_2 sensor and adapt the user behaviour by more often open windows to reduce the CO_2 concentration when the room is occupied by more than one person. In dwelling-1, the relative humidity should be reduced by installing an exhaust fan in the bathroom.

Conclusion

The TripleA-reno combined labelling scheme can inform people about the energy performance, IEQ and well-being of their homes. The energy performance indicators are essential to motivate occupants to renovate their homes. It has to be stressed out that, besides that calculated primary energy use, both calculated and measured delivered energy use are presented. The calculated delivered energy use is practical for objective comparison of different dwellings, while the measured delivered energy consumption is capable of presenting the realised energy performance especially before and after a renovation project and can also be useful to evaluate occupant behaviour.

Beyond the energy performance assessment, the evaluation of technical building systems in terms of well-being and IEQ can indicate which improvements are necessary to achieve better IEQ. If the rating of the technical building system provides a bad result, it does not always mean the actual indoor environmental quality is poor, but in such conditions, it is expected to be much more challenging to maintain good indoor environmental quality and well-being. The actual condition can be assessed with on-site measurements including temperature, relative humidity and indoor air pollutants. The TripleA-reno combined labelling is suitable for highlighting areas that need to be addressed to ensure better indoor environmental quality and well-being. ■