IBPC 2021 8th International Building Physics Conference Copenhagen Denmark

# The e-SAFE energy and seismic renovation solutions for the European building stock: main features and requirements

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*Figure 3. Possible renovation of the pilot building selected for demonstration in e-SAFE*

## Abstract

In the ongoing four-year EU-funded project called **e-SAFE** ("*Energy and seismic affordable renovation solutions*"), several solutions for the energy and seismic deep renovation of reinforced concrete (RC) framed buildings in the European countries are being developed and demonstrated. These solutions aim to be prefabricated, customizable, low-disruptive and sustainable in order to boost the decarbonisation of the largely inefficient European building stock. This paper presents the main features of the e-SAFE solutions for the building envelope, as well as the results of a preliminary analysis to verify their effectiveness and compliance with European legislation and standards. The outcomes will lay the foundations for the successive design and demonstration stage, by also identifying possible issues that need to be tackled.

## The e-SAFE solutions

In order to ensure energy and seismic retrofit of existing RC-framed buildings, e-SAFE will make use of:

(i) timber-based energy efficient panels (**e-PANEL**), including a wood-based insulating material
(ii) structural panels made of Cross Laminated Timber (**e-CLT**) that increase seismic performance through their connection to the existing RC beams with specifically designed friction dampers.

The CLT panels make available additional lateral stiffness, while the dampers dissipate seismic energy in case of moderate or strong ground motions. The e-CLT also includes an outer insulation, with a lower thickness than in the e-PANEL in order to get the same U-value (Figure 1). The two panels will clad the existing walls in a way that allows reaching the desired energy and seismic resistance.

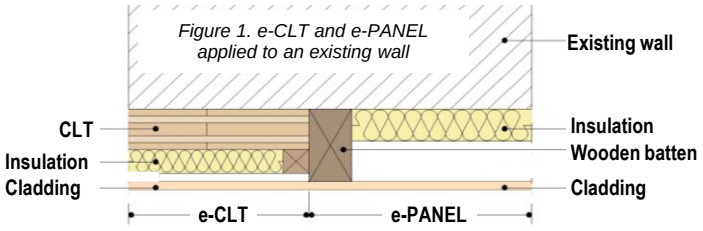


*Figure 1. e-CLT and e-PANEL applied to an existing wall*

Both panels are customizable (in terms of size – but keeping the same overall thickness – U-value and finishing material) and will be prefabricated through BIM-based design procedures. As a general rule, the e-PANEL will be applied on walls including openings, where e-CLT would not be effective (Figure 2). Both panels will be tested on a **pilot building in Catania** (Figure 3).

## Features of the proposed solutions

- **CLT panels**: $\lambda = 0.12$ W/(m·K), $\rho = 420$ (kg/m$^3$)
- **Wooden fibre**: $\lambda = 0.038$ W/(m·K), $\rho = 50$ (kg/m$^3$)
- **Insulation thickness**: 6 cm in e-CLT, 9 cm in e-PANEL
- **Vapour-open water-proof membrane** (6 mm) applied to the outer surface of the insulation (Sd = 0.30 m)

**Cladding**: Wooden Plastic Composites (WPC) slats


*Figure 2. Distribution of e-CLT and e-PANEL on the facades*

| Existing wall | Renovation solution | U [W·m$^{-2}$·K$^{-1}$] | $Y_{IE}$ [W·m$^{-2}$·K$^{-1}$] | φ [h] | $\kappa_i$ [kJ·m$^{-2}$·K$^{-1}$] | $R_w$ [dB] |
|---|---|---|---|---|---|---|
| **Double-leaf hollow clay bricks with non-insulated air gap (overall 30 cm)** | **e-CLT** | 0.28 | 0.02 | 15.3 | 47.4 | 58.0 |
| | **e-PANEL** | 0.28 | 0.06 | 12.0 | 48.3 | 56.0 |
| **Non-insulated solid bricks (overall 28 cm)** | **e-CLT** | 0.31 | 0.01 | 17.5 | 64.1 | 60.0 |
| | **e-PANEL** | 0.31 | 0.03 | 13.3 | 64.3 | 59.0 |

*Table 1. Thermal and acoustic performance for two traditional wall assemblies upgraded with the e-SAFE solutions*

## National regulations vs e-SAFE solutions

The **U-values** comply with all regulations in force in Southern European countries (e.g. Greece, Italy, Turkey), while at least 4 more cm of insulation would be necessary e.g. in Central and Northern Europe.

The **dynamic thermal transmittance** ($Y_{IE}$) is well below 0.10 W/(m$^2$·K), as required by national regulations in Italy when more than 50% of the building envelope is renovated.

All solutions show good **phase shift** (φ ≥ 12 h).

The **internal areal heat capacity** ($\kappa_i$) – i.e. the ability of a wall to accumulate heat when a periodic heat wave acts on its inner side – is always > 40 kJ/(m$^2$·K) and thus complies with a recent Italian regulation for public buildings.

According to EN Standard 13788:2013, no **internal or surface condensation** occurs in warm climates. In cold regions, vapour barrier is necessary on the inner side of the insulation.

The **acoustic performance** of building façades is commonly regulated either through their **apparent weighted sound reduction index** ($R'_w$), or through the **weighted standardized level difference** ($D_{2m,nT,w}$).

Both descriptors include the effect of glazed openings and lateral transmission: if double glazing windows with different glazing thickness are installed (e.g. 6-10-12), the weighted sound reduction index presented in Table 1 ensures that $D_{2m,nT,w}$ keeps between 42 dB and 46 dB, which is largely sufficient to comply with various national regulations, especially for residential buildings.

No further improvement stems from an increased thickness of insulation.

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.