Final Report

Project acronym: *CTB Basics*
Project number*: 4314*
M-ERA.NET Call 2016

Period covered: 01/08/2017 to 31/08/2020

Refer to beneficiaries when filling out this report.
To be completed by the project coordinator only.
Minimum font size is 11 pt.

2. Publishable project summary

The building sector contributes about 40% of the total energy consumption in Europe. The building envelope plays an important role in the energy balance. In order to meet the EU-wide and global challenges, a new approach has to be used to prepare a building solution that will be sustainable, economical and widely applicable. The CTB Basics focused on the insulation performance and the adaptability of a new building block – CleanTechBlock (CTB), a multifunctional sandwich-block solution with integrated thermal insulation—foamed glass in line with the passive building regulations.

In the project we investigated the contributions to the effective thermal conductivity in foamed glass through the analysis of open- and closed-porous foamed glass samples. For these purpose we used the knowledge on the foaming mechanism to tune the foaming process and prepare foamed glass samples with different composition of the solid and gaseous phase, different porosity degree and type, as well as dense glass samples with the same solid composition as the solid composition of the foamed samples. All the samples were prepared by direct use of waste glass, thus improving the sustainability of the product. The detailed characterization enabled us to quantify the contributions of the solid and gas conduction, and radiation to the effective thermal conductivity. The results show that inhibition of crystallization and control of the composition of the gaseous phase are crucial for achieving a thermal conductivity below 40 mW m^{-1} K^{-1}. The radiation also becomes important as the density decreases below 110 kg m^{-3}. The lowest thermal conductivity achieved is 37 mW m^{-1} K^{-1}. Even more important is the conclusion that the thermal conductivity can be decreased further. The developed, experimentally validated model of heat-transfer in foamed glass revealed that it is possible to reach values down to 33 mW m^{-1} K^{-1}.

With the input of the insulation properties of foamed glass, the insulation performance of the CTB wall was calculated. The optimized CTB block geometry and assembly effectively prevents penetration of water and capillary damp, as required in humid climates. Moreover, the easily adaptable thickness of the insulation layer enables full adjustment to the required building code in different climatic regions. The use of a foamed glass with the lowest thermal conductivity, as required in a passive house standard and cooler climates, saves on the thickness of the wall construction in comparison to conventional constructions. Moreover, the full stability of the insulation properties ensures unchanged thermal effort and energy efficiency throughout the life span of the building. In warmer climates, the importance of a high thermal mass out passes the insulation requirements, which can be achieved by the use of a thicker inner shell of the CTB element. Moreover, the foamed glass prepared from waste glass of a lower quality and lower environmental impact can be used.

A life cycle assessment of the foamed glass production, the CTB element and the CTB building solution was performed using input data from the laboratory and data from life cycle inventory databases. A cradle-to-gate life-cycle model was implemented for two options, foamed glass with λ=37 mW m^{-1} K^{-1} from CRT panel glass and foamed glass with λ=45 mW m^{-1} K^{-1} from flat glass, and compared with conventional thermal insulation materials for a functional unit based on thermal resistance. The results show that both foamed glass options present lower environmental impacts for climate change, eutrophication and acidification. This is mainly due to the direct use of waste glass in production. Further improvements can be achieved with the use of alternative glass wastes and by applying the latest production process (continuous conveyor belt). Additionally, a circular economy assessment of the CTB using a consequential LCA approach remains under assessment.