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# HIGH EFFICIENCY PREFABRICATED RETROFIT MODULE DEVELOPMENT

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## KEYWORDS
Retrofit, prefabrication, energy efficiency, simulation tools.

## ABSTRACT

One of the main key sectors where it is vital to reduce the energy consumption is the existent building stock. The European Union has recognized this issue in 2002 with the entrance into force of the Directive on Energy Performance of Buildings where important measures to limit the buildings primary energy consumption are foreseen. Within this context, it was initiated a new project focusing the development of a new retrofit solution – a prefabricated façade retrofit module. This solution is, to some extent, a by-product of the authors' participation on the International Energy Agency project IEA ECBCS Annex50 and on the FCT funded project PTDC/ECM/67373/2006. In order to achieve a better support for the design of the retrofit solution and for the thermal optimization of the module, a measurement campaign has been performed to identify the existing building stock needs, and some computational tools were applied, like Google SketchUp® for 3D modelling to test the design options, and eQuest® tool to predict the energy performance of several construction options and to assure their compliance with the applicable regulations. Until the moment, a prototype was built and monitored in the Test Cells of Minho University and the modules' good thermal performance has been confirmed.

## INTRODUCTION

Taking into consideration the excessive energy consumption in recent years, it must be realized that the building sector is an extremely important sector to intervene. According to Balaras (2005), the European building stock stands for 33% of the final energy consumption and 50% of electricity use. There are also some predictions (Zimmerman 2006) pointing out that if a significant change of practice does not take place, in 2050 the building stock will represent 80% of the total energy consumption.

With the growing awareness of the European Union for this problematic, a regulative EU intervention was made with the entrance into force of the Energy Performance of Buildings Directive (EPBD 2002) whose objectives are to promote the sustainable development of the building sector reducing its excessive energy consumption. This Directive has been recently reinforced with the EPBD -Recast (EPBD 2009) whose main goal are the so called 20/20/20 targets, i.e., to reduce the greenhouse gases emissions in 20%, to reduce the community's energy consumption in 20% and increase the share of energy from renewable sources to 20% until 2020.

Conscious of the market needs, the LFTC – UMinho (Laboratory of Physics and Construction Technologies of the University of Minho) joined an IEA project – Annex 50 – that aims at promoting efficient energy retrofit strategies for residential buildings by gathering world specialists in this area and support their exchange of knowledge. In the scope of this project and also supported by the Portuguese project funded by FCT (PTDC/ECM/67373/2006), the LFTC – UMinho is developing an optimized prefabricated façade retrofit module for Portuguese residential buildings.

## BUILDING STOCK MEASURMENT CAMPAIGN

In order to develop retrofit modules that can efficiently respond to the building stock needs, a measurement campaign was carried out to identify the main energy pathologies (Silva et al. 2010). Thus, it was found that the overall needs are: to significantly reduce the coefficient of thermal transmission (U) applying levels of insulation far superior of existing ones; to reduce infiltrations with the use of more airtight windows frames and doors or use mechanical ventilation systems with heat recovery; to avoid thermal bridges applying a continuous exterior insulation layer or locally insulating by the interior.

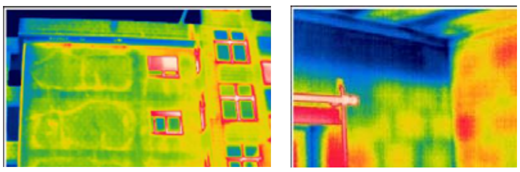

Figure 1: Identification of thermal bridges – pictures from infrared camera

## PREFABRICATED RETROFIT MODULE

The system under development is based on traditional discontinuous prefabricated insulating finishing, although with integrated ducts, optimized levels of insulation and with a mounting system that allows a simple application and removal.

Several design alternatives were executed and tested, and the final composition (from the outside to the inside) is: aluminium composite exterior finishing (6mm); agglomerated black cork insulation (60mm); steel U-profiles (1.5mm); extruded polystyrene insulation (XPS – 120mm) with or without moulded ducts for ducts and cables; smart vapour retardant.

This system was optimized for application on envelope walls of existing buildings; however it can also be applied in new buildings.

Figure 2: Retrofit module installation on the support structure

### Module performance optimization

For the prediction of the retrofit module performance, several simulation tools and tests were performed:

- Energy performance - a dynamic simulation tool was applied – eQuest® and the performance of an existing building was estimated considering the original envelope (U=1.9 W/m$^2$.ºC) and with the application of the retrofit module on the existing building walls (U=0.2 W/m$^2$.ºC). ). The results showed a significant reduction of the total energy needs of the original building that went from 320 kWh/m$^2$year to 86.8 kWh/m$^2$year with the application of the retrofit solution;
- Design optimization - a 3D modelling tool was applied – Google SketchUp® - in order to study and optimize the module application to the existing wall and the interaction between modules;
- Other issues - it was applied the tool THERM® to optimize the module in terms of thermal bridges and the tool Wufi® to confirm the inexistence of condensation inside the module, what is true when a vapour retardant is applied;
- Prototype - several module prototypes were built, applied to a partition wall of the Test Cells, and instrumented with heat flux sensors and thermocouples (superficial temperature) and confirmed the module thermal transmittance (U=0.23 W/m$^2$.ºC).

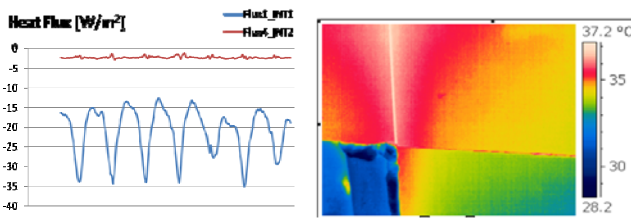


Figure 2: Measured heat flux of the module (Flux4) and partition wall (Flux1) and infrared picture

### CONCLUSIONS

As pointed out in the latest international policies, a drastic reduction of the current energy consumption is necessary. Thus, the development of a new prefabricated retrofit module for residential buildings is relevant. With the implementation of this type of solutions it can be obtained an overall reduction of the energy needs of about 70%, if the application of the module will be complemented with a systematic improvement of the building envelope. For the final validation of the retrofit module several prototypes were built and instrumented with monitoring equipment and their thermal performance certified.

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