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New simulation platform for the rehabilitation of residential buildings in Madrid

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Abstract

A new simulation platform has been created to quantify the energy response of existing residential buildings with different refurbishment strategies. This tool has been developed as a multi-step form wizard to select the simulation options. The energy improvements have been calculated through the coupling between TRNSYS and GenOpt. Output information is: annual thermal loads, monthly loads reductions and cost estimations. Four refurbishment options have been evaluated considering different combined actions. The renovation of the building envelope is the most expensive action with the highest annual savings while the behavior of inhabitants is the cheapest option with the lowest annual savings.

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Keywords: Monitored buildings, thermal comparison, comfort quantification

1. Introduction

According to the 2010 European Directive related to the energy performance of buildings, this sector represents one of the main energy consumers with more than 40% of the final energy consumption and 33% of the low carbon emissions in the Union [1]. Residential buildings accounts for over 60% of total energy consumption in the

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buildings sector [2]. In Spain, the energy consumption for thermal conditioning residential buildings is about 48% of the total energy use [3]. Most of these dwellings have registered poor energy performances, so the application of refurbishment options has a great potential for increasing the energy savings and reducing their environmental impact [4, 5, 6]. Therefore, at the citizen level, a lower energy demand not only leads to economical savings but also contributes to the sustainable development of their cities. With this aim, the research Spanish project PRENDE [7] has been carried out a citizen-oriented service based on Information and Communications Technologies at neighbourhood scale. As a part of this service, a software tool which gathers the initial simulation options, queries the simulation database and generates a simulation report, has been developed. The energy savings have been obtained through the coupling between TRNSYS [8] and GenOpt [9]. This platform promotes the benefits of the refurbishing existing buildings in Madrid to improve the energy efficiency and recommends the best practices to reduce the energy demand.

2. Description of the tool

2.1. Internal database

The studied dwellings are placed in Madrid, characterized by semi-arid climatic conditions (Köppen-Geiger coefficient: Csa) with mild cool winters and hot summers. To analyse the energy performance of them, representative models that symbolize the main typologies of Madrid were selected. Different criteria related to shape, year of construction, constructive parameters, ratio opaque walls and windows, outdoor facades, shadings, conditioning area or end-uses were considered. This information was provided by the public centre Empresa Municipal de la Vivienda y Suelo de Madrid, dependent of the city hall of Madrid; and the construction company Ferrovial Agroman. Four building cases and three boundary conditions (position of dwelling: ground, middle and roof floor) were selected. According to the Spanish Building Code requirements for the residential buildings [10], twelve TRNSYS [8] models were developed considering the following hypotheses:

- Contact with other conditioned dwellings is considered as boundary condition with identical temperatures.
- Ground is modelled as adiabatic zone (monthly temperature variation provided by [10]).
- Free running conditions: no internal gains but set points temperatures have been fixed.
- Constant infiltration rate set to 0.8 ac/h [10].
- Two conditioned periods: summer (June to September) and winter (from January to May and October to December).

One existing meteorological year was selected as the representative weather of Madrid [12]. This file was used to identify the proper refurbishment actions by means of Givoni bioclimatic charts [13]. Once these actions were selected, several series of simulations were executed to analyse the energy performance of dwellings. This assessment was done through the coupling between TRNSYS and GenOpt. The base cases of each dwelling were modelled with TRNSYS, indicating the refurbishment variables and the objective functions to be studied. The analysed variables are: azimuth, envelope characteristics, insulation, windows, shade, ventilation and set point. Three objective functions were calculated: heating, cooling and annual loads (conditioning thermal loads throughout the year). GenOpt [9] was used to parametrize the energy response of the TRNSYS models to fluctuations of the refurbishment variables, varying only one of them while the rest remain constant. The thermal needs obtained by each case feed the database that is going to be the engine of the new tool.

2.2. Architecture of the new tool

The simulation tool consists of two modules: 1) a RESTful [14] web service which exposes the content of the simulation database through and Application Programming Interface (API) and 2) a web application which acts as a front-end, gathering input data from users and interacting with the web service to collect the information needed to generate a simulation report as an output.