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Energy Audit and Renewable Integration for Historic Buildings: The case of Craiglockhart Primary School

Dimitrios I. Doukas[a,*], Tom Bruce[b]

[a]*Department of Electrical and Computer Engineering, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece*
[b]*Institute for Energy Systems, School of Engineering, The University of Edinburgh, Edinburgh EH9 3JL, United Kingdom*

Abstract

Energy Audit and Planning for both existing and new-to-build buildings has been of increasing interest during the last years due to growing environmental concerns. Especially historic buildings, such Craiglockhart Primary School, which are of great importance because of their special architectural characteristics, are energy-demanding structures of incomplete and outdated technology. Improving the energy efficiency of such buildings would mean environmental and financial benefits as well as retaining of the historical heritage of Edinburgh. Additionally, integration of renewable sources in such buildings would result in a further gain from renewable heat incentives and in greener building as well. Firstly, this paper summarizes a study of possible actions for improving the energy efficiency of such buildings. Secondly, assuming that the proposed measures have been applied, possibility of renewables' integration is assessed. Heat pumps and biomass integration is investigated and a hybrid system is finally proposed. This paper evaluates level of improvement and cost for all scenarios explored after considering possible constraints.

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Keywords: energy audit; energy efficiency; historic buildings; renewable integration; sustainable buildings

1. Introduction

Energy demand has been increased considerably, and building sector is one of the leading sectors in energy consumption. In the UK particularly, approximately 30% of emissions are strictly combined with buildings. [1] Because of the global awareness about climate change and towards a sustainable future, many governments adopted

* Corresponding author. Tel.: +302310996325.
E-mail address: doux@auth.gr

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policies to improve the efficiency of building and therefore decrease pollution coming from them. Researches have indicated that 80% of the buildings in 2030 will have been at least 25 years old. [1] Many of these buildings would have a historical importance, therefore careful refurbishment would be necessary, since retaining of their historic fabric is equally important to their energy profile upgrading.

Energy efficiency could be achieved after applying a process called energy audit and planning. According to this process all energy consumptions would be defined and possibilities to reduce them would be explored. [2] Overview of input data, such as bills, architectural plans, meteorological data and occupants' profile in combination with scholastic exploration and comparison of different actions to improve the building's efficiency would lead to a proposed solution of the minimum cost and the maximum gain at the same time. An energy audit process could be described as following: a) commitment on energy conservation with respect to environment, b) exploring ways to reduce consumption and c) further improvements, and promoting of energy efficiency. [3]

Buildings of historical heritage exist during many years and were built with significantly different construction characteristics. Their complexity and age, the absence of modern technology and the out of date techniques and materials used for them make improving their energy efficiency really difficult. [4] The most difficult case would be, achieving a balance between retaining their architectural and historic profile, improving their efficiency by decreasing their energy demand and meeting the needs of nowadays householders. [4] Additionally, integration of renewable sources is proposed as an alternative way to succeed reduced pollution and financial profit. Renewables' integration has additional advantages to indicate, such as additional financial profit because of incentives or energy independency. Since, renewable sources most of the times are combined with noticeable visual impact, loss of building's special interest and visual intrusion and damaging of historic fabric may occur and should be avoided. [5]

Craiglockhart Primary School is housed in a 107-year-old sandstone building. It is an energy demanding building of outdated technology. High levels of energy and thermal losses because of high ceilings, lots of single-glazed window area and incomplete insulation make the building energy inefficient. Close look of the existing situation and energy usage, in order to investigate ways to improve energy consumption and efficiency of the building was necessary and the need to explore options for alternative energy sources, including renewable generation was evident.

The contribution of this paper is to build a model that describes realistically the energy profile of the Craiglockhart Primary School and explore several possible solutions that could improve the building's efficiency as a further step. Architectural, historical and energy usage data are collected, areas and volumes are calculated, while activities within the building are considered. Thermal losses are calculated and mapped while influence of the building characteristics to the overall consumption is discussed. The analysis will calculate savings, payback periods and ability of implementation in such a building for any explored scenario. The result would be a proposal of a realistic series of actions with a payback period less than 10 years. Furthermore, integration of renewables that does not affect its appearance is examined and a system (hybrid or not) would be proposed as well.

2. Efficiency Improvements

According to a Building Research Establishment: "The challenge is to refurbish the homes of the past as the homes of the future". [4] Especially for aged historic buildings, a variety of measures are recommended. Improving the efficiency of a building is fully related with the reduction of the building's heat losses as much as possible. [6]

Firstly, considering insulation improvements, walls are an important factor of fabric losses, since they are the biggest part of the building's surrounding surfaces; some time heat losses through walls reach 35% of the total building's heat losses [4]. Level of improvement depends on the building's characteristics and on the main wall material used, because different insulation measure should be taken for different masonry materials and thickness. Walls insulation could be added both interiorly or exteriorly. [1,4] External works would be most of the times ignored, since external view of the building's walls is of the most important building's fabric characteristics, but even interior insulation works should be made with great attention and after considering the interdependence between the pre-used material and the added one. [1,4] Upgrading walls insulation is important since it leads to significant reduction of heat losses. However, there are aspects that should be carefully examined are loss of space, possibility of thermal bridges or problems at windows and openings [7,8] Secondly, poor roof's insulation may be responsible for 25% of total building's heat losses. [4] Insulating the roof does not affect the activities within the