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Energy efficient building block design: An exergy perspective

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ABSTRACT

This study introduces the exergy analysis method into the field of urban planning, in order to find out the amount of energy that can be conserved in a building block when an energy efficient construction design is applied. This was done in four steps. First, energy efficient design parameters were derived from the literature and design alternatives were developed accordingly. Second, data was gathered from the case area for the exergy calculations. Third, exergy analysis of existing building blocks and proposed design alternatives were separately carried out. Finally, the amount of decrease in the exergy loss due to suggested energy efficient design was found out. The results show that the exergy efficiency of the existing building blocks is about 2%, while the proposed design alternatives will be around 10–11%. The overall exergy loads of the alternative plans were found as 166.3 W, 225.1 W, 142.5 W and 137.8 W respectively for winter and 105.4 W, 140.0 W, 89.9 W and 86.3 W respectively for summer, on a housing unit basis. As a result, the suitability and importance of the exergy analysis on the built environment was proven, by revealing actual and considerable energy conservation and sustainable use of energy through application of energy efficient design parameters.

1. Introduction

In recent years, global environmental problems, increasing population, limited nonrenewable energy sources and global climate changes have emphasized that the connection between energy and environment is very strong and relevant. Furthermore, the cost of energy—whether for the end-users or multinational companies-is another major problem, when the global economic positions of the countries and the companies are taken into account. With these in mind, there are various attempts to decrease energy production costs and reduce emissions for environmental preservation. Attempts to decrease total energy consumption is amongst the major discussions, along with construction of energy efficient devices and systems. In addition to these, cheap, sustainable and renewable energy production is another major study in today's world [21].

When the global energy consumption is investigated for each the sectors, it is seen that 51% of total energy production is used in industry, 20% in transportation, 18% in residential and 12% in commercial sectors [4]. Globally 50% of the total energy consumption and 42% of the total water consumption take place in the construction and usage period of buildings. Furthermore, 50% of the greenhouse gases, 40% of the water pollution and 24% of the air pollution arises from the activities in the built environment [5]. It is interesting that 81% of the residential energy demand is used in the heating of buildings [19].

When “energy efficient planning and design” is considered, what comes to mind is basically a relationship of “land use” and “building design” (Fig. 1) [10,16,17]. Energy efficient planning principles systematically investigate a city at three different scales, which are: the settlement's properties, the building block's properties and the building's properties [13]. While making decisions about land use, the ideas to reduce the effects of climate changes should be considered, ensuring efficient and effective use of energy. It is concluded by Ovalı [16] in her study that 50% of energy consumed in buildings can be conserved in case a climate friendly building and built environment design is applied.

Previous studies have documented investigations of two different scales in the literature from an energy efficiency perspective: building scale and building block scale. Numerous studies have also focused on “physical environment design parameters” and “building design parameters.” (Fig. 2) However, there has been relatively little literature published on the use of

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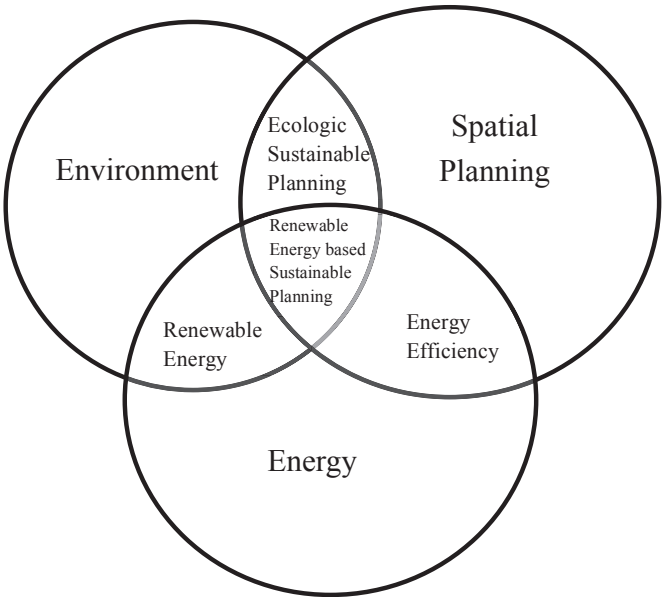

Fig. 1. The relation between planning, environment and energy. (Source: Bayındırlık ve İskan Bakanlığı [2], 766).

renewable energy, such as energy production and conservation based on renewable energy sources.

Much research on exergy focuses on building scale while a great portion of the literature has not utilized all of the parameters that are factors in performance, effectiveness and efficiency of energy in settlement areas.

The studies that only take the building scale parameters into account do not take the relation of the buildings with each other and surrounding environment into account. Only a limited number of studies [1,3,8,16,18] evaluated the energy performance, using only some of the parameters, and they still only conducted a quantitative research.

Furthermore, the studies on exergy related topics which deal with the properties of the buildings and construction materials only focus on building scale, rather than the neighborhood or settlement scales.

Most of the literature efforts did not take the use of renewable energy sources into account and none of them considered local renewable energy resources (solar radiation, wind energy, geothermal and biomass) which should be identified and integrated in the planning policies.

Differing from the literature, this study aims to find out the amount of energy conservation -using exergy analysis in a building block, when “energy efficient design” is applied according to the predefined parameters. In other words, it aims to determine the amount of energy-exergy that can be saved -by means of exergy analysis-for the sake of sustainability when energy efficient design parameters are applied. In addition to the construction materials, orientation and location properties, solar radiation and wind effects are also taken into account in the exergy analysis in this attempt.

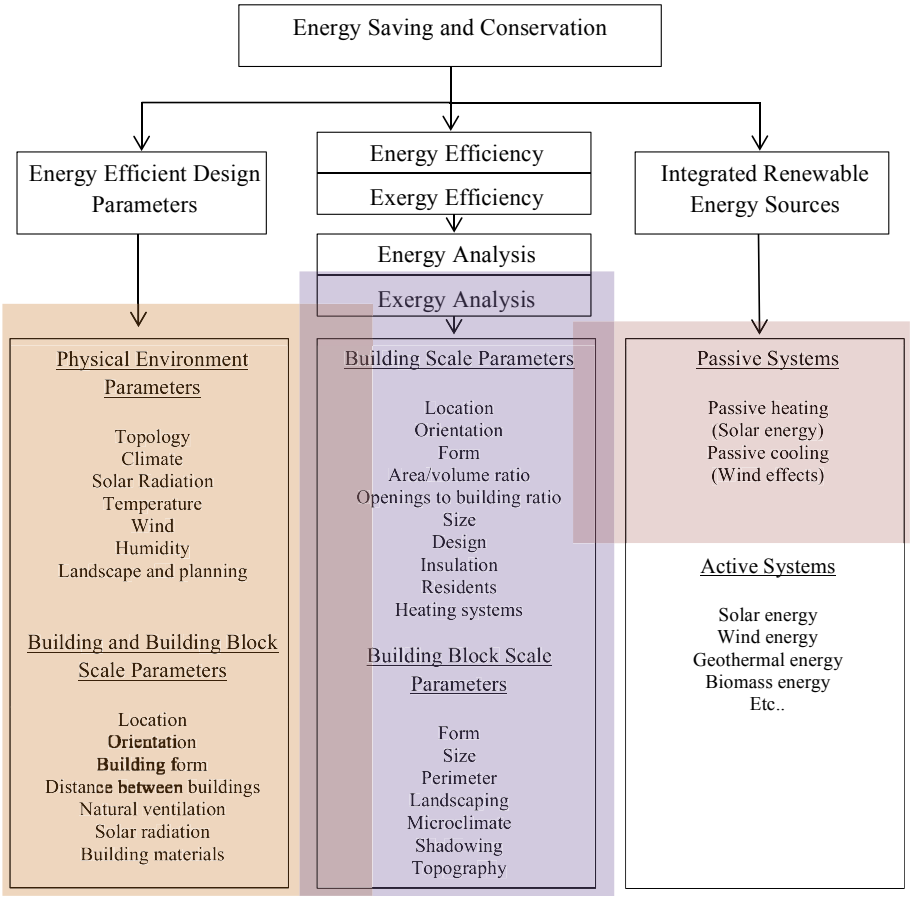

Fig. 2. Structure of the literature.