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Multi–criteria optimization of the building energy efficiency: A simulation–based genetic algorithm

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Abstract

Iran is one of the largest energy consuming countries in the world. In Iran, buildings account for a significant proportion of the total energy consumption and carbon dioxide emission in which the energy used for the annual cooling, heating and lighting comprises up to 40%. This paper proposes a new approach for the simulation–based multi– criteria optimization problems, which overcomes important limitations of the optimization of the building energy performance. In this research, the multi-objective genetic algorithm (NSGA-II) method is coupled with EnergyPlus building energy simulation software to find optimum design parameters to increase the building energy productivity. To assess the capability and effectiveness of the purposed approach, the developed method is applied to a single room model, and the effect of building architectural parameters such as the building orientation, the shading overhang depth, the window size and the glazing material properties on the building energy consumption are studied in four major climate regions of Iran. In the result section, mono–criterion and multi–criteria optimization analyses of the annual cooling, heating, and lighting electricity consumption are studied to understand the interactions between the objectives and to minimize the total annual building energy demand. The results of the multi–objective optimization indicate that the annual heating electricity consumption may be increased 1.1 to 7.1%, however the annual cooling and lighting ones decreases 15 to 22% and 0 to 1.1%, respectively, in comparison with the baseline model. The optimum design leads to 1.8 to 9.2% decrease of the total annual building electricity demand for four different climate regions of Iran.

Keywords: Building energy performance, EnergyPlus, Weighted sum method, Multi–objective optimization, Genetic algorithm (GA)

Introduction

Iran is one of the largest energy consuming countries in the world, accounting almost 40% of the total energy consumption and 36% of the carbon dioxide emission [1]. Accordingly, improvement of the buildings energy efficiency has become a big deal for building energy engineers and designers. Building designers often use whole building energy simulation programs such as DOE–2, EnergyPlus, ESP–r, eQUEST and TRNSYS to analyze the thermal and energy behaviors of buildings. An approach known as “parametric study” may be used to investigate the building energy performance. As for the building simulation programs, it is necessary to construct a dataset including both inputs and outputs from hundreds of simulation runs by changing input values of the simulation model.