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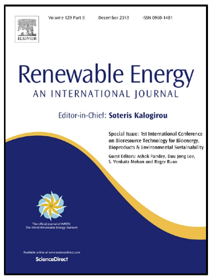

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Whole Building Optimization of a Residential Home with PV and Battery Storage in The Bahamas

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Abstract: In this paper a whole building optimization approach is used to assess the building performance and design of residential homes in The Bahamas with the goal of providing objective data for policy makers to achieve the sustainability goals in the country by minimizing carbon emissions and life cycle costs. This study accounts for the effects of building envelope improvements as well as a renewable energy system in the form of PV and battery electricity storage simultaneously in achieving the optimization objectives. EnergyPlus and jEPlus+EA provide the platform for this study, which implements the non-sorting genetic algorithm (NSGA-II) to find optimal solutions to building envelope design and renewable energy integration. Optimal design solutions are compared to a standard building model developed from audited data to provide an understanding of the interactions between the design objectives and optimal configurations. The results show that improvements to the thermal envelope and both the use of PV and battery storage are feasible and potentially advantageous to current building designs. Additionally, the results show a reduction in the NPV of up to 40%, with a net positive and carbon negative status, as well as a reduction in the yearly building energy consumption of up to 30%

Keywords: PV; Battery; Grid; Island; Optimization; Envelope; NSGA-II

1 Introduction

Building designers are often recommended to explore different energy conservation measures (ECMs) such as better use of insulation and low emissivity windows as well as reducing air leakage before resorting to technologies such as renewable energy and energy storage [1]. Unfortunately, in practice there are constraints that make the decision complicated since the design choices depend on each other, sometimes leading to contradictions [2]. For example, the use of window overhangs reduces the amount of heat gain to the building, but at the same time limits natural lighting in the interior. Hence, the design problem should find tradeoffs that satisfy the design constraints and objectives considering the use of alternatives as a whole system [3].

An important need in exploring design configurations relates to the issue of how to address climate change by reducing energy usage and greenhouse gas (GHG) emissions from fossil fuel consumption. The building sector contributes approximately 40% of the global demand for energy and is also a large producer of GHG emissions [4]. Additionally, the residential sector accounts for 25% of the global energy demand and 17% of the GHG emissions [5]. In developing countries, buildings are usually energy inefficient, but globally progress has been made where net zero energy and carbon negative buildings are possible. Although the challenge is apparent, there exists potential for improving building designs in the Caribbean, with over 30 active net zero energy buildings (NZEBs) worldwide [6]. Estimates for 2013 showed that buildings in the Latin American and Caribbean regions account for 25% of the total energy consumption and this value is likely to increase [7]. These countries have begun to implement and incorporate policy changes to address some of these energy consumption issues and to help overcome the barriers in achieving these goals. Strengthening of the existing research in these developing countries is key [8].