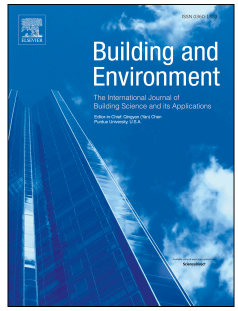

Energy-efficiency building retrofit planning for green building compliance

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Abstract

To promote sustainable development and expedite the progress on moving to a green building sector, the government of South Africa has developed an energy performance certificate (EPC) standard for buildings. A building is required to obtain a certain rating from the EPC in order to comply with the country's green building policy. Therefore, finding optimal retrofit plans for existing buildings are essential given the high investments involved in the retrofit of buildings that do not currently comply with the policy. This paper presents an optimization model to help decision makers to identify the best combination of retrofit options for buildings to ensure policy compliance in the most cost-effective way. The model determines optimal retrofit plans for a whole building in a systematic manner, taking into account both the envelope components and the indoor facilities. A roof top PV system is utilized to reduce the usage of electricity produced from fossil fuels. The model breaks down the long-term investment into yearly short-term investments that are more attractive to investors. Tax incentive program available in the country is taken into account to offset the long payback period of the investment. Economic analysis is also built into the model to help decision makers to make informed decisions. The retrofit of an existing office building is taken as a case study. The results show that 761.6 MWh energy savings and an A rating from the EPC can be obtained with a payback period of 70 months, which demonstrates the effectiveness of the model developed.

Keywords: Building retrofit, energy performance certificate, green building compliance, rooftop PV system, economic analysis.

Nomenclature

α_1 power load densities of people (W/m^2)

α_2 power load densities of lightings (W/m^2)

α_3 power load densities of appliances (W/m^2)

$\bar{C}_f(M)$ the absolute value of the cumulative cash flow at the end of the M-th month ($)

β_t budget allocated in year t for retrofit ($)

$\delta(t)$ coefficient taking the values from Table 1

$\Delta W(t)$ difference of humidity ratio between the inside air and outdoor air in year t (kg/kg)

η_p efficiency of the p-th solar panel alternative

η_s average solar energy to electrical power conversion efficiency

λ_j thermal conductivity of the j-th alternative of the external wall insulation materials (W/m°C)

λ_k thermal conductivity of the k-th alternative of the roof insulation materials (W/m°C)

ζ_a allowance rate set by the government

ζ_t tax rate for general businesses in South Africa

A_l^{pv} area of the l-th solar panel alternative (m^2)

A_p^{pv} area of one solar panel of the p-th alternative (m^2)

A_e available roof area for the PV power supply system installation (m^2)

A_{flr} areas of the floor of the building (m^2)

A_g gross area of the building (m^2)

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