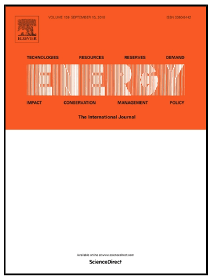
# Accepted Manuscript



A robust design of nearly zero energy building systems considering performance degradation and maintenance

Pei Huang, Gongsheng Huang, Yongjun Sun

PII: S0360-5442(18)31719-5

DOI: 10.1016/j.energy.2018.08.183

Reference: EGY 13659

To appear in: *Energy*

Received Date: 18 April 2018

Accepted Date: 24 August 2018

Please cite this article as: Pei Huang, Gongsheng Huang, Yongjun Sun, A robust design of nearly zero energy building systems considering performance degradation and maintenance, *Energy* (2018), doi: 10.1016/j.energy.2018.08.183

# A robust design of nearly zero energy building systems considering performance degradation and maintenance

Pei HUANG[1], Gongsheng HUANG[2], Yongjun SUN[1,3*]

[1]Division of Building Science and Technology, City University of Hong Kong, Kowloon, Hong Kong

[2]Department of Architecture and Civil Engineering, City University of Hong Kong, Kowloon, Hong Kong

[3]City University of Hong Kong Shenzhen Research Institute, Shenzhen, P. R. China

[*]Corresponding author. Tel.: 852-34422672; fax: 852-34420443

E-mail: yongjsun@cityu.edu.hk

**Abstract:** Nearly zero energy buildings (nZEBs) are considered as a promising solution to mitigate the energy and environmental problems. A proper sizing of the nZEB systems (e.g. HVAC systems, PV panels, wind turbines and batteries) is essential for achieving the desirable level of thermal comfort, energy balance and grid dependence. Parameter uncertainty, component degradation and maintenance are three crucial factors affecting the nZEB system performances and should be systematically considered in system sizing. Until now, there are some uncertainty-based design methods been developed, but most of the existing studies neglect component degradation and maintenance. Due to the complex impacts of degradation and maintenance, proper sizing of nZEB systems considering multiple criteria (i.e. thermal comfort, energy balance and grid dependence) is still a great challenge. This paper, therefore, proposes a robust design method of nZEB systems using genetic algorithm (GA) which takes into account the parameter uncertainty, component degradation and maintenance. The nZEB life-cycle cost is used as the fitness function, and the user' performance requirements on thermal comfort, energy balance and grid dependence are defined as three constraints. This study can help improve the designers' understanding of the impacts of uncertainty, degradation, and maintenance on the nZEB life-cycle performances. The proposed method is effective in minimizing the nZEB life-cycle cost through designing the robust optimal nZEB systems sizes and planning the optimal maintenance scheme, meanwhile satisfying the user specified constraints on thermal comfort, energy balance, and grid dependence during the whole service life.

**Keywords:** Nearly Zero Energy Building, Robust design, Uncertainty, Degradation, Maintenance, Life-cycle Performance