Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 105 (2017) 88 – 93

Energy Procedia

The 8th International Conference on Applied Energy – ICAE2016

Building integrated photovoltaic thermoelectric wall system: balancing simulation speed and accuracy

Yongqiang Luo[a], Ling Zhang[a,b]*, Zhongbing Liu[a], Jing Wu[a], Xiliang Wang[a], Lei Xie[a], Xiu Xu[a], Xiaohui Lv[a]

[a]*College of Civil Engineering,Hunan University, Changsha 410082, PR China*
[b]*Collaborative Innovation Center Building Energy Conservation & Environmental Control, Hunan 412007, PR China*

Abstract

A proper parameters setting is crucial to both simulation speed and accuracy. This is particularly true for the simulation of complicated systems. Building integrated photovoltaic thermoelectric wall system (BIPVTE) is an effective and innovative active building envelope system which can largely cut building energy consumption. The basic thermal model of BIPVTE wall system was established and two important model parameters were optimized to provide useful guide for further investigation of this active wall system. The numerical study in terms of time step Δh and superposition number N in model integral calculation were conducted and analyzed to balance simulation speed and accuracy. It is concluded that time step should be set around 10 min to 30 min and parameter N around 6 to 8 for the annual thermal performance simulation of BIPVTE wall system. But if the simulation task is typical day calculation, time step should be set as around 1 min.

Peer-review under responsibility of the scientific committee of the 8th International Conference on Applied Energy.

Keywords: Active wall system; photovoltaic; thermoelectric; calculation speed; simulation accuracy

1. Introduction

Global energy shortage is a crucial problem confronting all nations. On one hand, scientists are trying to explore new energy to solve the problem, while on the other side, different innovative technologies are proposed to enhance energy efficiency. Among all the energy consumption systems in our world,

* Corresponding author. Tel.: +86-0731-885228641; fax: +86-0731-88822610.
E-mail address: lingzhang@hnu.edu.cn

Peer-review under responsibility of the scientific committee of the 8th International Conference on Applied Energy.
doi:10.1016/j.egypro.2017.03.284

buildings should be blamed as the top energy consumer. One reason behind this fact is that building envelope contributes about 1/3 of air conditioning load throughout entire year [1]. Therefore, improving energy efficiency of building envelope system becomes quite important.

Building envelope refers to the structure like brick wall, glazing façade and windows. According to different functionality, envelope can be divided into passive building envelope [2] and active envelope [3]. The passive envelope takes advantages of its designed structure to realize building energy efficiency, while the active envelope can otherwise largely cut air conditioning load and control indoor thermal environment with input power. The integration of PV panels into building envelopes is a kind of passive structure received extensive attentions. Besides, thermoelectric (TE) cooling/heating is another promising tech which has been integrated into building systems like TE air conditioner [4, 5] and TE radiant ceiling panel system [6, 7].

Based on the characteristics of both PV and TE tech, a novel active wall system that integrates PV and TE modules [8] was proposed to enhance energy performance of building envelopes. This system is called building integrated photovoltaic thermoelectric wall (BIPVTE) and the experiment was firstly conducted in both summer and winter conditions [8]. In addition, the system heat transfer model was established to investigate the thermal performance [3] to conclude that this active envelope can save about 70% energy comparing traditional wall. In addition, for any system modeling and simulation, the calculation speed and accuracy are two vital elements in evaluation. However, for most system model simulation, using finite difference method or finite volume method usually require small time step [3]. This dilemma has to be handled for BIPVTE wall system as well. This study optimized the model parameters of time step and superposition number in integral calculation formula, which are key model parameters for system simulations.

Nomenclature

Abbreviations

BIPVTE	building integrated photovoltaic thermoelectric
PV	photovoltaic
TE	thermoelectric

Symbols

I_{PV}	output current of PV module (A)
N	number of superposition of time
R_c	thermal resistance between cold side of TEM and backside of aluminum panel (K/W)
R_h	thermal resistance between hot side of TEM and air duct (K/W)
V	voltage (V)
α	Seebeck coefficient (V K^{-1})
α_{PV}	absorption factor of PV module
λ	thermal conductivity (W/m K)
λ_b	thermal conductivity of insulation (W/m K)
ρ	density of aluminum panel (kg/m^3)