Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 103 (2016) 64 – 69

Energy Procedia

Applied Energy Symposium and Forum, REM2016: Renewable Energy Integration with Mini/Microgrid, 19-21 April 2016, Maldives

Optimal Design of Active Cool Thermal Energy Storage Concerning Life-cycle Cost Saving for Demand Management in Non-residential Building

Borui Cui, Fu Xiao*, Shengwei Wang

Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong

Abstract

This research provides a method in comprehensive evaluation of cost-saving potential of active cool thermal energy storage (CTES) integrated with HVAC system for demand management in non-residential building. The active storage is beneficial to building demand management by shifting peak demand as well as providing longer duration and larger capacity of demand response (DR). In this research, it is assumed that the active CTES is under control of the fast DR strategy during DR events and storage-priority operation mode to shift peak demand during the normal days. The capacity of active CTES is optimized under the incentives of both modes.

Peer-review under responsibility of the scientific committee of the Applied Energy Symposium and Forum, REM2016: Renewable Energy Integration with Mini/Microgrid.

Keywords: Active cool thermal energy storage; Building demand management; Demand management; Life-cycle cost saving

1. Introduction

Building sector is one of the major sectors of the energy consumption. According to the 2009 buildings energy data book provided by the U.S. Department of Energy, the buildings sector consumed 74% of U.S. electric energy consumption [1]. In Hong Kong, the energy consumption of buildings occupied 90% of the total electric energy consumption in 2008 [2]. Therefore, proper management of the building energy use will be not only essential for the reliable operation of the whole grid but also beneficial in cost saving for the building owners.

Building demand management has been adopted and it includes two main parts: the peak load management (PLM) and the demand response (DR) [3].

*Corresponding author Tel: +852-2766-4194;
Email address: linda.xiao@polyu.edu.hk

Peer-review under responsibility of the scientific committee of the Applied Energy Symposium and Forum, REM2016: Renewable Energy Integration with Mini/Microgrid.
doi:10.1016/j.egypro.2016.11.250

The former one is usually motivated by high charges for peak demands or time-of-use rates based on the electricity price structure which considers the time and the quantity of electricity used. The later one refers to event-driven and can be defined as short-term modifications in customer end-use electric loads.

Within the building sector, the heating, ventilation and air conditioning (HVAC) systems are the major contributors to the energy consumption of buildings, which even consume 60% of the building energy in hot climate locations [2]. In recent year, cool thermal energy storage (CTES) has been widely used by integration with HVAC system to shift cooling load in buildings**.** It can bring considerable cost saving by reducing peak demand for PLM. Meanwhile, it can also enlarge the demand response capacity by discharging cooling [4]. CTES systems can be further divided into "active" and "passive" systems. "Active" denotes that CTES systems require an additional fluid loop to charge and discharge the storage tank [5]. The passive means that the use of CTES as well as melting and freezing of CTES medium are realized without resort to mechanical equipment [6].

This study aims to provide a guidance in comprehensive evaluation of cost-saving potential of CTES integrated with HVAC system for building demand management, including both PLM and fast DR. During the DR event, income from fast DR can be achieved through activation of the active CTES. During the normal days, the active CTES can be also used to shift peak load for reducing the high charge of peak demand. The law of marginal decision rule is used to optimize the capacity of active CTES and to determine the corresponding life-cycle cost saving potentials.

2. Research flowchart and optimization method introduction

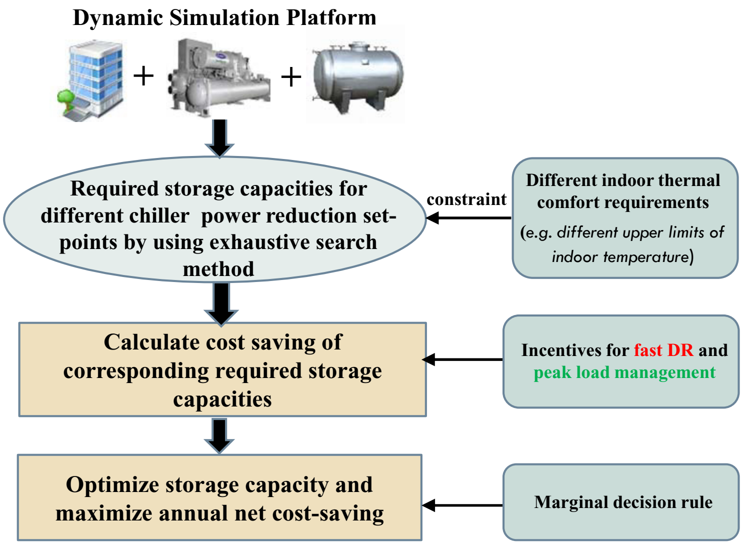

Fig.1 Methodology flowchart

As shown in Fig.1, a dynamic simulation test platform is built first, which include different dynamic models, such as chiller, PCM storage tank, building and et al. The required capacities of CTES for different chiller power reduction set-points by using exhaustive search method are resulted under control of the developed fast power demand response strategy using active and passive building CTES [7]. The different indoor thermal comfort requirements from building users, i.e. different upper limit of indoor temperature, are assumed to be the constraint. In the next step, the cost saving of the resulted storage capacities are calculated by introduction of incentives for both fast DR and PLM. A optimal design method by using marginal decision rule is introduced from [8] to optimize the capacity of active CTES and to determine the corresponding maximum annual net cost saving. As shown in Fig.2, the effects of