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ScienceDirect

Energy Procedia 104 (2016) 281 – 286

Energy Procedia

CUE2016-Applied Energy Symposium and Forum 2016: Low carbon cities & urban energy systems

A feasibility study of low carbon energy systems for a tower block in London

Yifu Feng[a]*, Hang Yu[b], Yechen Yu[a]

[a]Institute for Environmental Design and Engineering, UCL, 14 Upper Woburn Place, London WC1H 0NN, United Kindom
[b]School of Mechanical Engineering, Tongji University, Caoan Road No. 4800, 201804 Shanghai, China

Abstract

Low carbon energy (LCE) systems have played an essential role in minimizing building energy usage and carbon emissions. Early considerations of feasibility and integration for different types of LCE systems are beneficial for the building design process. In this study, an office building located in London was taken as an example, in which seven potential low carbon energy solutions were analysed qualitatively based on the 'RESET' tool provided by CIBSE. Four feasible options were narrowed down including: solar thermal, photovoltaics, ground source heat pump (GSHP) and combined heat and power (CHP) systems. 'RETScreen4' was then used to perform a quantitative analysis to select the appropriate solution. The results indicate that the CHP system gave the best performance environmentally and economically with the relevant assumptions.

Peer-review under responsibility of the scientific committee of the Applied Energy Symposium and Forum, CUE2016: Low carbon cities and urban energy systems.

Keywaords: Low carbon energy; Solar thermal; Photovoltaics; Ground source heat pump (GSHP); Combined heat and power (CHP)

1. Introduction

The UK is required to reduce 12.5% of greenhouse gas emissions by 2008 due to the Kyoto Protocol, followed by the intention to reduce 60% of carbon emissions by 2050 [1-3]. With the growing need to conserve energy, there is a trend for LCE technologies to be considered at an early stage of the design process in order to successfully integrate into buildings [3]. In this report, to achieve energy conservation and carbon emissions reduction for an office building located in central London, appropriate LCE technologies are proposed and analysed qualitatively and quantitatively. Actually, many comprehensive case studies have analyzed the feasibility of LCE systems for different types of functional buildings. Zhang and Zhang [4] presented a feasible development scheme of a micro-grid PV system in a high-rise building. Bakos and Soursos [5] also reported successful installations of large grid-connected PV systems

* Corresponding author. Tel.: +8615601692058.
E-mail address: yifu.feng@ucl.ac.uk (Y. Feng).

Peer-review under responsibility of the scientific committee of the Applied Energy Symposium and Forum, CUE2016: Low carbon cities and urban energy systems.
doi:10.1016/j.egypro.2016.12.048

in Greece. Passos et al. [6] proved solar energy for domestic hot water to be feasible economically to reduce electricity peak demand in Brazil.

Payback time analysis for LCE systems has been conducted in many previous studies. A simple payback time of 8.5 years for a PV system is quoted in the Greek study [5] and 6-7 years for PV/ hybrids in a study of small to medium-sized tourist accommodation in Australia [7]. The Brazil study quoted a payback time of 5-8 years for a solar hot water system. Further studies of CHP systems quote payback times from 5.8 to 21 years depending on the gas price [8].

The software tool, 'RESET' introduced by CIBSE TM38, can rate various low carbon energy technologies, thereby helping to identify the appropriate solution at an early design stage. Additionally, 'RETScreen4' developed by Natural Resources Canada, is an efficient tool for quantitative analysis of low carbon technologies. In this study, both tools were used to analyse the technical feasibility and economic viability of LCE systems for a high specification tower block located near Aspen Way, Poplar in London.

2. Qualitative analysis of low carbon energy supply options

This qualitative analysis of seven LCE systems is based on the 'RESET' tool introduced by CIBSE TM38 [3]. The relative importance of the factors shown in Table 1 is ranked from 1 to 5. For this project, cost effectiveness and carbon saving are prioritized with a top ranking of 5. Based on the comparison of relative performance illustrated in Fig. 1, solar hot water, photovoltaics, CHP and ground source heat pumps (GSHP) are feasible for this office building.

The year-round demand for hot water and reliable power load can improve the viability of a solar thermal installation or a CHP system. Furthermore, flat plate collectors can be installed on the flat roof of the building. Additionally, the hot water tank can be installed at a higher level of the building close to the source of heat - the collectors on the roof. Therefore, the additional cost of can be reduced with the added benefit of less heat loss of the pipework. As for the CHP system, it would be efficient if it could supplement the grid during the daytime [9].

Addressing the issue of space utilization, the unshaded south facing wall and the unshaded flat roof (approximately 300 m^2 in total) are available for the installation of photovoltaics. Additionally, sufficient ground space is accessible for the installation of a horizontal or vertical closed loop GSHP system. Other options are not feasible due to the lack of space or insufficient natural resources.

Table 1. Importance grades of factors

Parameters	Ranking
Cost effectiveness	5
Carbon savings	5
Marketing/ image	3
Technology risk	3

Scale of 0-5 (5 being most important)

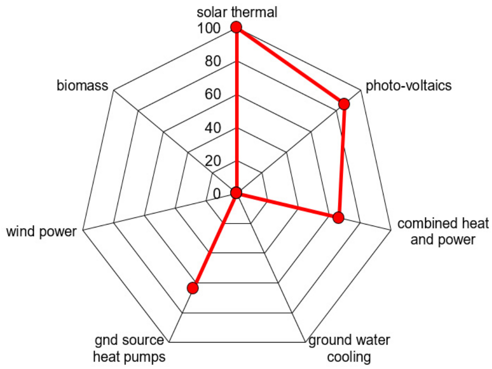

Fig. 1. Performance of low carbon options