



CISBAT 2017 International Conference – Future Buildings & Districts – Energy Efficiency from Nano to Urban Scale, CISBAT 2017 6-8 September 2017, Lausanne, Switzerland

A load profile study of different buildings to identify neighborhood energy flexibility with exchange possibilities

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Abstract

Buildings are a key source of energy flexibility due to their high energy demand. Harnessing the energy flexibility of buildings, however, demands that buildings be considered collectively. This paper presents preliminary results to discover building's energy flexibility, from two different neighborhoods in the Netherlands. The energy demand profiles of three large buildings in each neighborhood are analyzed to identify possible useful simultaneous heating and cooling loads. Finally, the possibility for energy exchange between these buildings is explored.

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Peer-review under responsibility of the scientific committee of the CISBAT 2017 International Conference – Future Buildings & Districts – Energy Efficiency from Nano to Urban Scale

Keywords: Buildings; Energy exchange; Flexibility; Load profiles; Neighborhood; Simultaneous heating and cooling

1. Introduction

In recent years there has been great progress in energy management practices on the level of individual buildings. However, the energy consumption in most local communities, towns and cities, is still increasing instead of the necessary decrease to stay in-line with the targets of the sustainability policies [1]. The transition to a cleaner, greener

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energy infrastructure necessitates additional flexibility requirement due to the intermittent and high level of uncertainties associated with renewable energy sources [1]. There is a current focus on buildings as a potential source of achieving energy flexibility by using storage facilities or building services installations [1]. Buildings are considerable energy loads that can provide flexibility to the grid and could play a vital role to reduce uncertainty and provide stability to the grid in the future. According to IEA EBC Annex 67 [1], energy flexibility of a building is defined as “*the ability to manage its energy demand and generation according to local climate conditions, user needs and grid requirements*”.

Energy exchange between the buildings is an emerging concept which can provide flexibility in a decentralized neighborhood energy grid. Neighborhood-level energy exchange might be a practical solution which can reduce curtailment in the case of an over production or grid instability issues in the case of a prosumer sells the excess energy to the grid [2]. It is noted that not only electricity but also thermal energy exchange has a huge capacity for flexibility with well insulated commercial buildings [3]. This, in combination with a massive increase in energy efficient equipment and heightened use of renewables, will lead the way towards the energy and climate targets.

As part of a broader research on the possibility of energy exchange between buildings, neighborhoods and the smart-grid, this paper focuses on the potential for direct thermal energy exchange between neighboring buildings. By analyzing the cooling and heating demand profiles of different buildings in two distinct neighborhoods in the Netherlands, namely Princenhage located in Breda and Merwe-Vierhavens located in Rotterdam, the potential for exchange is outlined in this paper.

The content of this paper is as follows. Section 2 presents literature overview. Section 3 describes the methodology to select neighborhoods and the energy demand profiles of the selected buildings. Results, discussion and conclusions about the possibilities of energy exchange between buildings within a neighborhood are drawn in section 4 and 5.

Nomenclature

IEA	International Energy Agency	RC	Coefficient of resistance
EBC	Energy in Buildings and Communities Program		

2. Literature overview of similar studies

Literature search yield, relatively few studies for the topic “*thermal energy exchange between buildings*”. However, the terms “*smart thermal grids*”, “*energy exchange AND smart grids*” appear more popular than “*thermal energy exchange between buildings*”. The search terms were narrowed down to “*Simultaneous heating and cooling AND Buildings AND Heat pumps*” to align it with the paper objective. Ultimately, the revised search yielded 30 papers from Scopus and Web of Science databases (results are presented in Table 1). Out of these, four articles [4–7] are found to be more relevant for simultaneous heating and cooling loads in buildings. The rest of the research papers mainly focused on optimization, control and energy saving potential.

Table 1. Article search

Search Engine	Search Term	Search date	Number of articles
Scopus	Simultaneous heating and cooling AND Heat pump AND Buildings	05-04-2017 (All articles)	36
Web of Science	Simultaneous heating and cooling AND Heat pump AND Buildings		32

Buildings can demand to heat and cool simultaneously. Dairy plants [7], hotels [5], luxury dwellings, smaller office buildings [6], low-energy buildings, retails buildings [4] are some of the study cases used in the reviewed papers which demand simultaneous heating and cooling loads. Other than that, in spring and autumn seasons and buildings with several functions such as huge shopping complexes, demand heating and cooling at the same time. In such cases, energy exchange can create some flexibility by reducing the primary heating and (or) cooling demands. But the

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