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ScienceDirect

Energy Procedia 122 (2017) 325–330

Energy Procedia

www.elsevier.com/locate/procedia

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

Localized meteorological variables influence at the early design stage

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Abstract

A measurement campaign was set up in Lausanne. The objective of this study is to define the importance of using local meteorological variables in the design of urban spaces and in the evaluation of building energy use. Urban simulation tools typically use average climatic data to calculate the convection coefficient, the building thermal balance and the pedestrian comfort. For this purpose, two simulation tools, a CFD model and CIM (Canopy Interface Model) are used to simulate the meteorological variables on the EPFL campus, Lausanne, Switzerland. The simulation results from the CFD model and the CIM are compared with the experimental data and both models provide trends that are in very good agreement with measurement. CIM can provide high resolution vertical profiles without significant computational resources and thus be used at an early stage in the design phase. The CFD should be used when a more precise local evaluation is needed.

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: Building energy demand; CFD models; CIM; Early stage design; Urban climate; Turbulence parameterization

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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
10.1016/j.egypro.2017.07.331

1. Introduction

The IPCC (Intergovernmental Panel on Climate Change) in their Fifth Assessment report in 2013 [1], stressed on the fact that there is clear proof that the current climate change is being caused by human activities. There is compelling evidence this is due to the release of greenhouse gases (GHG) such as carbon dioxide (CO2) from the combustion of fossil fuels to produce energy [1]. A large proportion of global energy demand has been related to buildings which, therefore, are one of the main sources of air pollution. Approximately half of the primary energy use in Switzerland occurs in buildings. Of this energy, about 30% is consumed by space heating, cooling, and water heating; 14% through electricity use, and 6% through construction and maintenance [2]. In addition, the building sector accounts for more than half of the CO2 emissions in Switzerland, which shows that it is among the most significant contributors to carbon emissions. This implies also that the building sector provides a real opportunity for a large improvement with regards to energy efficiency and reduction of CO2 emission.

For the efficient planning of future buildings and districts urban planners need to have access to appropriate tools and information. For example, the future development of the EPFL campus will imply densifying the existing building stock [3], but the question still remains how to design the space in order to reduce the energy consumption while at the same time increasing the liveability of the outdoor environment [4].

It is now well known that the urban climate depends on a series of processes taking place at different spatial (from global to local) and temporal scales [5]; building energy demand and urban climate are also closely related and interdependent [6]–[8]. It is thus essential to have access to tools, which can evaluate - with precision - the interactions that exist between buildings, their energy use as well as the local climate. Several models have been developed in recent years to better represent the various phenomena influencing energy use and urban climate [9], [10]. Besides these models, CFD tools have been used to evaluate with more precision the turbulent processes in urban areas [11]–[13]. One of the major drawbacks with these models is the lack of data to validate and the lack of comparison with real data from urban areas.

Acronym

CIM	Canopy Interface Model
CFD	Computational Fluid Dynamics
CO2	Carbon dioxide
EPFL	Ecole Polytechnique Fédérale de Lausanne
GHG	Green house Gases
MoTUS	Measurement of Turbulence in an Urban Setup

For this purpose, a project (MoTUS) to monitor high resolution vertical meteorological profiles was set up. The aim is to determine the impact of urban areas / buildings on meteorological variables (such as wind or temperature) and to represent these effects when evaluating building energy use, air pollutant dispersion and renewable energy potential in urban planning scenarios. Such monitored meteorological data are scarcely available with high vertical resolution. Campaigns such as the BUBBLE (Rotach et al. 2005) observation period provided useful information and data to develop and generalize new parameterization schemes. However, there is a strong need for such data in multiple configurations in order to develop new tools and methodologies which can then be used in the evaluation of building energy use.

In the current study, we use two different modeling tools and compare them with data from the monitoring tower. We then define the most useful parameters influenced by the presence of buildings and how they can be simulated. We first give an overview of the two models used. In Section 3 we briefly explain the experimental setup, the type of instruments that have been installed and details related to their configuration. We then describe and discuss the results