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The effect of weather datasets on building energy simulation outputs

Silvia Erba[a]*, Francesco Causone[a], Roberto Armani[a]

[a]*Politecnico di Milano, Energy Department, via Lambruschini 4 – 20156 Milano, Italy*

Abstract

Results of dynamic energy simulations of buildings are affected by many uncertainties, which are the main reason of the performance gap registered between simulated and operational performance. They depend mostly on the incorrect modelling of building components and their properties, the inadequate characterization of operational schedules, the limitations in the simulation algorithms used by energy simulation software, the quality and reliability of data contained in weather files. The first three limiting factors are somehow under the control and capacity of the person in charge of the simulation, that, nevertheless, may not always be able to get detailed building specifications to identify the correct set-points and schedules, or to choose an alternative simulation software. The information contained in weather datasets are, however, completely out of the control of the person in charge of the simulation that may only assume them as a boundary condition. Unfortunately, not all the weather databases show the same level of data accuracy; moreover, they may refer to a climate that substantially changed in the last decades. The effects on building energy simulation results, played by different weather files referred to the city of Milan, is showed and discussed, highlighting the substantial performance difference depending on them.

Keywords: weather files; dynamic simulations; energy needs; thermal comfort; future weather scenarios

* Corresponding author. Tel.: +39 02 2399 3918
E-mail address: silvia.erba@polimi.it

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In the context of building renovations and new constructions, the objective to achieve the best comfort with minimum energy consumption is increasingly prominent. Stationary, semi-stationary and dynamic calculation methods are available for energy analyses but the growing awareness of building user needs, calls for enhancing the assessment of systems and components performance to guide the optimization of choices in the design phase [1,2]. In bioclimatic design and nearly Zero Energy Buildings (nZEB) projects, it is required to know the behaviour of the construction under the effect of specific drivers, or to explore the exact energy consumptions considering the presence of occupants and the exploitation of renewable energy sources, in order to avoid over-dimensioning of technical systems and consequent extra costs. Furthermore, there is a growing need to investigate passive techniques, to explore the potential of natural ventilation for cooling [3]. The concept of climate-adapted buildings is becoming crucial, due to the challenges launched by climate changes [4]. Moreover, building certification schemes provide incentives in terms of extra points when the optimization of building performance is carried out adopting advanced simulation tools. Building performance energy simulation software helps answering some of these requests, providing many information on how the building and its technical systems respond to different (indoor and outdoor) drivers.

The reliability of energy simulations depends, however, on many factors, such as the quality and detail of the model itself, the uncertainties linked to weather databases, the in-field measured parameters, and the parameters obtained from existing documentation [5,6]. Sensitivity analyses and calibration are essential tools to improve the accuracy, as confirmed by literature [7,8], nevertheless they cannot remove all the uncertainties, especially those implicit in the data source. Among the uncertainty factors, some researchers started investigating the effect of weather data quality on the final output of energy simulations. The creation of a more reliable building model is associated both to the choice of the most adequate weather dataset, which better represents the existing or future weather scenario [9-12] and to the construction method of the typical meteorological year, which requires continuous studies and improvements to overcome the limitations of the older methods [13-15].

The work summarised in the present paper, focuses on the effects that a not-adequate weather dataset may have on the analysis output of building energy simulations, that, to be reliable, should be coherent with the local climate changes experienced in the last decades. Nine of the ten warmest years on record have occurred since 2000 [16], showing their effects at a global and at a local scale. It is clear that a substantial underestimation of summer thermal loads and comfort conditions may occur, if a weather file based on data recorded more than half century ago is used.

Summer comfort is still poorly considered by the average design practice in Italy and EU, especially in the case of energy renovation of buildings for low-income families (e.g. social housing), where the attention is essentially placed on the energy savings for heating. However, the indoor environmental conditions of the buildings affect health, productivity and comfort of the occupants also during the cooling season, and may enhance or decrement people's wellbeing. Moreover, inadequate weather datasets may determine the overestimation of thermal loads during the heating season, and the consequent oversizing of technical systems. This may in the end, determine extra costs, lower efficiencies, and a higher energy consumption.

Using the energy retrofit of a public social housing unit in Milan as a reference study, in this paper we do compare the energy needs for space heating and cooling and the summer comfort conditions resulting from an energy model run with different weather datasets. Some of them, still commonly used, have been developed on the basis of weather data gathered between the 1950s and 1970s, other ones, instead, refer to data from recent years. Moreover, the mechanism of activation of shading devices and the schedule of bypass activation for ventilation, which can be both defined as a function of weather data, are investigated in detail, in order to offer a more comprehensive interpretation of the role played by weather datasets on building energy simulation outputs.

Nomenclature

TMY	Typical Meteorological Year
HDD	Heating Degree Day
CDD	Cooling Degree Day