Energy performance assessment of buildings: a novel approach for model validation

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Abstract:

Among the existing calculation methods for the building energy performance assessment, the simplified dynamic models are considered to enable a sufficient level of accuracy while guaranteeing the simplicity of the calculation. To meet these goals, these methods are based on modelling assumptions and simplifications that may lead to inaccuracies in the building energy consumption prediction, both in design phases and in energy audits. The validation of the simplified dynamic models can therefore play a crucial role in fostering their application in the legislative framework, and eventually in addressing their implementation to increase their expected accuracy. However, ensuring a deep, rigorous, and correctly addressed validation is not straightforward. This is mainly due to the shortcomings of the existing validation procedures, which consist in: (i) difficulties in identifying the source of possible errors among uncertainties in the input data or inaccuracies in the calculation method, and (ii) inabilities in evaluating the effect of specific modelling simplifications, parameters, standard values, etc., on the accuracy of the model. Moreover, the validation is often carried out without any attempt to identify the sources of inaccuracies, or even without any theoretical fundamental on the calculation model under validation.

Within this framework, the Ph.D. research proposes a novel single-process comparative testing validation approach, intended at identifying at which extent, and for which conditions and purposes, specific modelling simplifications can affect the accuracy of the model undergoing validation. The proposed approach, named aware validation, is built on a robust and detailed knowledge of the theory behind the calculation model to be validated. This knowledge is achieved through the comparison map, a tool developed to catalogue and compare the existing modelling options, assumptions, and simplifications related to the modelling of the built environment. In the aware validation approach, an overall input equivalence is achieved, and the effect of given modelling assumptions is assessed by means of the variation in the accuracy of a reference model due to the implementation of each simplification, one-at-the-time.

The recently introduced EN ISO 52016-1 technical standard presents a (new) simplified dynamic calculation method, whose employment for legislative verifications is currently under discussion in Italy. In the present dissertation, the aware validation approach was therefore applied to the validation of the EN ISO 52016-1 dynamic method, as to provide a thorough knowledge of its limitations, problems, and peculiarities.

The research underlined important aspects as regard the building energy model validation, and the simplified dynamic model as well. Firstly, the research demonstrated the advantages of performing the validation separately for the different modelling assumptions, since it allowed different sources of inaccuracies to be distinctly identified in the simplified dynamic method. These consisted in (i) the definition of specific calculation parameters (e.g., definition of convective heat transfer coefficients), and

(ii) the simplification of specific heat transfer processes (e.g., shadowing of diffuse radiation, and back reflection of solar radiation). Therefore, the use of single-process validation approaches should be enhanced to guarantee rigorous validations. Moreover, the proposed approach allowed demonstrating that the EN ISO 52016-1 assumptions are suitable for defined conditions (e.g., levels of thermal insulation) and applications (e.g., code compliance checks, etc.); this result may also correctly address the choice of the level of modelling detail for eventual implementations of the method.

Considering these aspects, the outcomes of this Ph.D. research are intended contribute to the enhancement of the standardisation activity by providing a clear overview of the suitability of the EN ISO 52016-1 modelling simplifications and by addressing its implementation.