Simulation-based support for integrated design of new low-energy office buildings - DTU Orbit (28/12/2018)

Simulation-based support for integrated design of new low-energy office buildings
This thesis reports on four years of research with the aim to contribute to the implementation of low-energy office buildings with high quality of indoor environment and good total economy. Focus has been on the design decisions made in the early stages of the building design process. The objective is to contribute to a development where simulations of building energy performance and indoor environment is used for generating an input to the overall building design process prior to any actual form giving of the building. This input should be considered as one of several similar inputs from other building design disciplines (structural, fire, architecture etc.) to the integrated building design process. The research therefore revolves around the hypothesis that parametric analyses on the energy performance, indoor environment and total economy of rooms with respect to geometry and characteristics of building elements and services can be used to generate a useful input to the early stage of an integrated building design process. To pursue a corroboration of this hypothesis, a method for making informed decisions when establishing the input to the overall building design process is proposed. The method relies on the use of building simulation to illustrate how design parameters will affect the energy performance and the quality of the indoor environment prior to any actual design decision. The method is made operational in a simple building simulation tool capable of performing integrated performance predictions of energy consumption, thermal indoor environment, indoor air quality, and daylight levels. The tool has been tested extensively throughout the four year period of this project. The feedback from these tests has been used to develop the operability and usability of the tool. The end result is a tool which, with minor reservations, has proved to be operational and useful in the design of low-energy office buildings with good indoor environment. The conducted research is reported in the main body of this thesis and in three papers for scientific journals. An abstract of these is given in the following. Article I The early stages of building design include a number of decisions which have a strong influence on the performance of the building throughout the rest of the process. It is therefore important that designers are aware of the consequences of these design decisions. This paper presents a method for making informed decisions in the early stages of building design to fulfill performance requirements with regard to energy consumption and indoor environment. The method is operationalised in a program that utilises a simple simulation program to make performance predictions of user-defined parameter variations. The program then presents the output in a way that enables designers to make informed decisions. The method and the program reduce the need for design iterations, reducing time consumption and construction costs, to obtain the intended energy performance and indoor environment. Paper published in Energy and Buildings 42 (7) (2010), 1113-1119. doi:10.1016/j.enbuild.2010.02.002 Article II A method for simulating predictive control of building systems operation in the design stage is presented. The predictive control method uses building simulation based on weather forecasts to predict whether there is a future heating or cooling requirement. This information enables the thermal control systems of the building to respond proactively to keep the operational temperature within the thermal comfort range with the minimum use of energy. The method is assuming perfect weather prediction and building modelling because of the design situation. The method is implemented in an existing building simulation tool. A test case featuring an office located in Copenhagen, Denmark, shows that the suggested method reduces the energy required for heating and ventilation compared to more conventional control systems, while improving thermal comfort for building occupants. The method furthermore automates the configuration of buildings systems operation. This eliminates time consuming manual configuration of building systems operation when using building simulation for parametric analyses in the design phase. Applied Energy 88 (2011) 4597–4606. doi:10.1016/j.apenergy.2011.05.053 Article III Increasing requirements for energy performance in new buildings mean the cost of incorporating energy-saving in buildings is also increasing. Building designers thus need to be aware of the long-term cost-effectiveness of potential energy-conserving measures. This paper presents a simplified and transparent economic optimisation method to find an initial design proposal near the economical optimum. The aim is to provide an expedient starting point for the building design process and more detailed economic optimisation. The method uses the energy frame concept to express the constraints of the optimisation problem, which is then solved by minimising the costs of conserving energy in all the individual energy-saving measures. A case example illustrates how the method enables designers to establish a qualified estimate of an economically optimal solution. Such an estimate gives a good starting point for the iterative design process and a more detailed economic optimisation. Furthermore, the method explicitly illustrates the economic efficiency of the individual building elements and services enabling the identification of potentials for further product development. Paper published in Renewable Energy 38(1) (2012) 173-180. doi:10.1016/j.renene.2011.07.019

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