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Method for probabilistic energy calculations – variable parameters

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Abstract

Building regulations in Sweden require that an energy calculation is done for every building to show that the building design meets the maximum specific energy use as outlined in the Swedish Building Code. The result of this energy calculation is always one number, for example a building might use 89 kWh/m^2 year when the building regulation requires 90 kWh/m^2 year. This level of reporting can lead to conflicts if the measured energy use is over the calculated energy use. With the current tools you need to do a time-consuming parametric study in order to see which risks are associated to the design and material properties.

This paper is part of a project called "Calculation method for probabilistic energy use in buildings" and is developing and testing the application of Monte Carlo simulations using two popular energy calculation tools developed in Sweden. The goals of the project are; to look at which input parameters have the largest influence on the result; to begin defining a realistic spread of the most significant parameters; to study the advantages and disadvantages of probabilistic energy calculations; and to look at the discrepancies between calculated and measured energy use.

This paper presents the results of the first stage of the study defining which input parameters should vary and defining a realistic spread of the values of these parameters. Out of all the input parameters in the case object, it was determined that the method should be tested with 16 parameters with variable values. This paper also presents the preliminary results of an energy calculation done on a real object using the variable parameters and 1000 iterations compared to the base calculation without Monte Carlo simulations.

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Keywords: Energy simulations, IDA-ICE, VIP Energy, statistical input, monte carlo

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1. Introduction

1.1. Swedish Code and Practice

Since July 1, 2006, building regulations in Sweden require that an energy calculation is done for every building to show that the building design meets the maximum specific energy use as outlined in the Swedish Building Code [1] [2]. The specific energy use is given in the units kWh/m^2 A_{temp} year. A_{temp}, according to BBR, is the floor area which is heated above 10 °C. The building code also requires that the energy use of the building be followed up within two years after delivery. Since then, various stake holders have been very interested in the actual performance of the building compared to the calculated energy use. This has resulted in a numerous studies looking at the calculated versus measured energy use. Some examples of these studies can be seen in: [3] [4] [5] [6] [7] [8].

The Swedish building industry had a difficult time after the implementation of the new building code based on the performance of a building. The new building code was very different and due to the lack of experience within the building sector, there were many failed projects in which the actual specific energy use was higher than the calculated specific energy use.

An interesting study was done by Annika Nilsson [3] of the Bo01 housing expo in Malmö three years before the building code change. This study gave an indication of the challenges that the building industry had to face if they were to be successful in accurately predicting the specific energy use of a building. In the Bo01 case, all the buildings had a specific energy limit set to 105 kWh/m^2 usable floor area per year so that all the energy used by the area would be covered by locally produced renewable energy sources. Unfortunately, the thesis showed that there was a large gap between energy calculations and measured energy use. None of the 10 buildings studied met their target. Most objects were between 40-60 % over their calculated values (pg 55). The worst case had an energy use of over 300 % higher than calculated. One of the biggest problems identified was the lack of good input data, pg 115. At this time there were not many studies about how much energy different aspects of buildings really used. Energy calculations before were not verified so it was difficult to find input data based on Swedish households. Additional weak points which were identified included problems with the solar gain calculations, lack of thermal bridges, wrong indoor temperatures, as well as a weak knowledge on how to make a building energy efficient by utilizing different components together. [3]

An organization eventually evolved with the purpose of standardizing user data. Sveby, short for Standardize and Verify Energy performance in Buildings, was created with financing from the Swedish Energy Agency and 15 stakeholders from the Swedish building sector with the purpose of defining different input data for energy calculations [9]. This has helped improve energy calculations greatly since the input data is based on measured input data.

Sveby has also held two Energy Calculation Competitions, one for a multi-family building and one for a school. The objects in the calculation were real objects which had extensive measurement data. The competition tried to simulate the Swedish building process and different energy calculations were done for different phases in the building process. The final energy calculation was compared to the object's real energy performance. The competition was used at a test for new input data. Their competitions have analyzed differences in energy calculations related to software, users, input data and methods used. The results varied about 11 % despite the same availability to input data and materials. The results also varied with different software. An important conclusion from the competitions is that the quality of the energy calculations depended on the individuals, and not the tools. Another important conclusion from the first energy calculation competition was that a safety margin of at least 10 % [10], pg 32] was recommended. The conclusion from the second energy competition was that, while the spread between submissions was less than the previous competition, the safety margin should be twice as high when compared to the first competition (i.e. 20 %) because the school used less energy than the residential building [11]. [10] [11]

1.2. Energy calculation programs

One of the earliest energy calculation programs to come out for a computer in Sweden was a program called ENORM 1000 in 1988. The purpose behind this program was to compare the actual building against a reference building defined by the Swedish building code. If the actual house had a lower calculated energy use then it was ok. [12]