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# Critical discussion of a shading calculation method for low energy building and passive house design

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**Abstract**

Solar energy gains are among the most important aspects in the design of very low energy buildings like passive houses. An optimization of solar gains reduces the required heating demand, however too high solar gains can lead to overheating issues.
Most methods for building energy ratings and building energy certificates use a monthly balance based calculation procedure. Also the current methodology for passive house assessment and certification is a monthly balance based one. To incorporate shading by fixed elements as an influence on solar gains into those methods, some simplifications are necessary.
This paper discusses the current implementation of the shading calculation in the passive house verification method. Based on comparison tests of the current method with an advanced shading calculation method shortcomings of the existing method are discussed. It is shown that the current algorithms for static calculation sometimes give erroneous and unreliable results. The impact on the different assessment criteria, energy demand and loads as well as overheating, exceeds acceptable margins of error.



*Keywords:* shading calculation; passive house calculation methodology; monthly balance method; solar gain;

## 1. Introduction

Solar energy gains are among the most important aspects in the design of very low energy buildings like passive houses. An optimization of solar gains reduces the required heating demand, however too high solar gains can lead to overheating issues [3],[4],[5]. Most methods for building energy ratings and building energy certificates use a monthly balance based calculation procedure. Also the current methodology for passive house assessment and certification is a monthly balance based one. To incorporate shading by fixed elements as an influence on solar gains into those methods, some simplifications are necessary. The current methodology for passive house assessment includes calculations for typical shading situations. Their development is based on dynamic building simulations [6], but a more


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detailed explanation of this method or its development isn't referenced. As it's stated that the shading algorithms were derived from dynamic building simulations, the idea behind this paper was a cross-validation with results of dynamic building simulation software.

## 2. Current Calculation Method

The current calculation according to PHPP [6] uses the reduction factor $r_S$ to calculate the shading influence. It is defined as the fraction of incident solar radiation onto a window with shading to the same window without shading. Thus, a high reduction factor represents high solar gains while a low factor means a high influence from shading objects. Shading reduction factors are divided into separate factors for winter and summer. The factor for winter is used for heating calculations, the factor for summer for cooling and overheating calculations. The shading reduction factor $r_S$ is calculated by combining typical shading situations (1). If a window is shaded from multiple objects, their shading reduction factors are multiplied. Further interference is not considered.

$$r_S = r_H * r_R * r_O * r_{other} \quad (1)$$

For landscape obstructions ($r_H$), window reveals ($r_R$) and window overhangs ($r_O$), calculation algorithms are available. These use the geographical latitude, window orientation and relevant geometry data, like for example the overhang depth and its vertical distance from daylight opening, to calculate the respective shading reduction factor. The algorithms use separate parameters for winter and summer factors and calculate shading reduction factors for the four cardinal orientations. In addition, a user-defined shading reduction factor $r_{other}$ can be also be taken into account. Due to their extent, the calculation algorithms aren't further explained in this paper. According to the PHPP user manual [6], they were derived from results of dynamic building simulations. A more detailed explanation of this method and the origin of the formulae aren't referenced. Furthermore, it isn't explained for what timespan the factors are divided into winter and summer.

## 3. Comparing the current method with results of dynamic building simulations

### *3.1. Shading calculation in dynamic building simulation WUFI® Plus*

The dynamic building simulation software WUFI® Plus includes shading calculation from direct and diffuse solar radiation. For every simulation time step the shading on building components and windows is calculated depending on solar position and the building's visualized 3D geometry, see Fig. 1. For this purpose, the building geometry is triangularized, i.e. all components are divided into small triangles, and the vector of direct solar radiation is calculated from the solar position [8]. Then the triangles from shading objects are projected on all other components and windows and it is checked, if the shading triangles overlap with component triangles. If component triangles are only shaded in parts, they're divided into smaller triangles. This process repeats until all shading triangles are considered. In the end, the solar heat gains from direct solar radiation through windows are calculated from the fraction of not-shaded glazing area for every simulation time step. In addition, WUFI® Plus also considers ground reflectance and diffuse radiation for this calculation, as long as this information is provided by the exterior climate data. The shading calculation was validated successfully with international standards DIN EN ISO 13791 [2] and ASHRAE 140 [1].

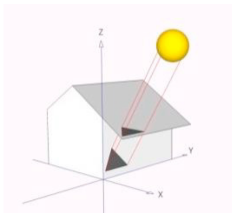

Fig. 1. Concept of shading calculation from direct solar radiation in WUFI® Plus.