DIN V 18599 for residential buildings – improved evaluation approaches and review of application for the “Effizienzhaus-Plus” concept

Zukunft Bau - Research project

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Summary

Within the framework of this research project the application of DIN V 18599 for residential buildings characterized by a higher insulation standard than required following the German Energy Savings Regulation 2009 (EnEV 2009) is reviewed and assessed. At the start of the project there was no validated software available, which fully reflects the entire content of the DIN V 18599:2011-12. Therefore the calculations have been carried out using a Microsoft Excel tool developed and provided by the Fraunhofer Institute for Building Physics. This tool is designed for the evaluation at the level of net energy demands and offers the possibility to perform the energy balance either for the old version (2007) or for the new version (2011) of the DIN V 18599. Furthermore with this tool it is possible to assess single aspects of the standard revision regarding their energetic influences.

To assess whether and to what extent the unsteady thermal behavior of buildings characterized by a very high insulation standard can be described by DIN V 18599, which represents an energy balance method using average monthly climate data, building simulations (Software HAUSer) on an hourly basis have been carried out and compared to the results of DIN V 18599.

Starting from the evaluations regarding the influence of the insulation standard on the net energy demand, which have been performed for summer and winter separately, further investigations regarding the “Effizienzhaus-Plus-Standard” certification have been carried out. For calculations aiming for such a certification a specified meteorological dataset, representing typical average German climate is prescribed as reference boundary condition. The outcome of these investigations show the difference between taking this reference climate for certification compared to an assessment on the basis of the 15 different meteorological datasets that are available for different regions in Germany. In this context the energy output of photovoltaic systems has been determined on the basis of DIN V 18599-9:2011-12 as well as on the basis of hourly calculations using the software Polysun. Additional assessments of renewable energy generation by wind energy systems for the 15 climate regions in Germany have been carried out.

Evaluation of the winter period

Due to the revision of DIN V 18599 which led to the new version of this standard from 2011 changes in the results are caused by revised calculation methods on the one hand and by updated climate boundaries on the other hand. Corresponding calculations show that the main influences on the net heating demand are the introduction of a seasonal air exchange rate and the updated climate boundaries, which both lead to a heating demand reduction as single influences between 2 and 4 percent in case of the usage profile EFH (single family house with q_i = 45 Wh/(m²d)) and between 2 and 10 percent in case of the usage profile MFH (multi-family house with q_i = 90 Wh/(m²d)). It can be noted that higher insulations standards tend to higher reductions. Depending on the individual case that is examined, the heating demand is cut by 4 to 5 percent in case of the usage profile EFH and by 6 to 9 percent in case of the usage profile MFH when the whole net energy balance of DIN V 18599 from 2011 is compared to the old version from 2007.

The comparison of the results of DIN V 18599 (2011) and the simulation results for the single family house shows that the energy demands in case of the monthly energy balance are about 5 percent higher than the simulation results when the EnEV 2009 standard is regarded. The better the insulation standard gets the lower this deviation between monthly balance and simulation gets. Calculations regarding other model buildings led to different results. Within the scope of work for this research project it was not possible to identify clear dependencies regarding the deviations between DIN V 18599 and building simulations. For final clarification it becomes necessary to carry out appropriate and more detailed studies.

The objective of comparing DIN V 18599 with hourly building simulation was not in the first place a comparison of absolute energy demand values but rather the assessment whether the relative dependencies of single influences is reflected properly in DIN V 18599. In the light of the above, a detailed analysis of the following influences was examined:

- a direct comparison of lightweight and heavy building type whereby is has been distinguished between
- continuous heating and automatic lowering of temperature at night and between
- three different insulation levels

The analyses show that the calculated heating demand of DIN V 18599 is for heavy buildings always about 2 to 3 percent lower compared to lightweight buildings. This is contrary to the results of simulations that show for the case with automatic lowering of temperature at night about 2 percent higher energy demands in case of heavy buildings. In case of continuous heating during the night simulations lead to about 2 percent lower energy demands compared with lightweight buildings, which matches with the results of DIN V 18599.

Furthermore the results show that the estimated reduction of heating energy demand when increasing the insulations level is lower in case of DIN V 18599 than in case of simulation. This means that the monthly calculation delivers results “on the save side” compared to the more detailed hourly based simulations.

For the evaluation of the winter period it can be summarized that the only task for further revision of DIN V 18599 is to correct the incorrect valuation of heating demand estimated for lightweight buildings in case of heating operation with automatic lowering of temperature at night, which is the relevant case for any energy balance according to the EnEV.

Evaluation of the summer period

Initial point for the investigation regarding the summer period is, that the monthly energy balance of DIN V 18599 leads to higher net cooling energy demands when the insulation level of (residential) buildings is increased. This is contrary to the findings out of previous investigations where building simulations have shown that increasing the insulation level leads to an improvement of the thermal situation and therefore to a reduction of the net cooling energy demand. In this context it has to be mentioned that the basis of these previous investigations was a significantly lower insulation level compared to the actual requirements given by the EnEV, what determines the initial insulation level in this research project.

Within the framework of this report results out of DIN V 18599 and building simulations are compared for the insulation levels EnEV 2009 (equivalent to 100 % $H_{T,Ref.\ EnEV\ 2009}$), EnEV 2009+ (equivalent to 70 % $H_{T,Ref.\ EnEV\ 2009}$) and EnEV 2009++ (equivalent to 55 % $H_{T,Ref.\ EnEV\ 2009}$). Main outcome of this comparison is that it is less the insulation level, defined by the average heat transfer coefficients, than the individual solar heat gain coefficient (g-value, SHGC) that mainly impacts the estimated net energy demand for cooling. In contrast to the results of the previous investigations for lower insulation levels, the building simulations carried out in the framework of this project show an increasing energy demand for cooling when the insulation level is increased starting from the level EnEV 2009 (same

SHGC of glazing for all levels). This outcome can be explained by analyzing the transmission heat flow which results as average heat sink for the regarded cooling period. Inevitable consequence of increasing the insulation level is a decreasing transmission heat flow and therefore an increasing cooling demand. Regarding the comparison of DIN V 18599 and building simulations it can be noted that the dependency of the net cooling energy demand is broadly right described in DIN V 18599. However, the evaluation shows also, that the influence of solar heat load is underestimated by DIN V 18599.

Regarding the calculation of the net cooling energy demand in DIN V 18599, which is based on the amount of heat sources that cannot be used for heating purposes, the comparison between DIN V 18599 and building simulation shows, that major impacts on the cooling demand are actually not considered in DIN V 18599. On the one hand this concerns the influence of a sun shading system, which is only allowed to be considered in case of it is a fixed sun shading system (for residential buildings only). On the other hand the present algorithms in DIN V 18599 are not able to reflect the positive influence of increase air change rates during day and night on the thermal situation in summertime. Although the introduction of a seasonal air change rate in the new version of DIN V 18599 from 2001 leads to a 50 percent decreased cooling energy demand compared to the version of 2007, it is not reflected that the net cooling energy demand can be reduced close to zero when reasonable ventilation behavior comes together with a good sun shading system.

One possible approach to take a variable sun shading system into account is to adapt the already established approach for non-residential buildings on the basis of the level of activity for different systems. To be able to derive suitable approaches for DIN V 18599 to reflect the positive influences of increased air change rates during the day and during the night, more detailed investigations are necessary and should be taken into account for further updating the DIN V 18599.

Overall it is underlined at this point, that it should be assumed that the application of cooling units for residential buildings is not a common practice. No matter of this, calculating the cooling energy demand should take into account the main influences on this value. Especially in case of non-residential buildings, which are not subject to this investigation, whereas the influence of sun shading systems is reflected but not the positive influence of increased air change rates during the day and during the night, taking into account these effects is highly important because of the application of cooling units is not an exceptional case in the whole field of non-residential buildings.

Results regarding the “Effizienzhaus-Plus” standard

When proofing a building as an “Effizienzhaus-Plus”, the calculations for certification have to be done on the basis of DIN V 18599. Independently of the building location hereby the German reference climate has to be taken into account. Following the regulations of EnEV 2009, for certification the 2007 version of DIN V 18599 is relevant. Investigations in the framework of this study show on the one hand a comparison between the old and new German reference climate. On the other hand calculations basing on the 15 available climate datasets for Germany are compared to the general certification on the basis of the reference climate.

This aforementioned evaluation regarding the “Effizienzhaus-Plus” standard based on individual local climate data leads to the conclusion that only in case of 3 (including the reference climate) out of the 15 climate regions the PV-layout on the basis of the reference climate fulfills the requirement to result in a positive final and primary energy balance over the year. Conversely this means, that proofing an “Effizienzhaus-Plus” is not possible in 12 out of 15 climate regions when local climate data is used instead of the German reference climate. For planners of buildings that are intended to be designed as an “Effizienzhaus-Plus” this leads to the recommendation to always add the results of an energy balance based on local climate data in addition to the formal proving based on the German reference climate.