Derivation of algorithms for the climate correction of heating energy parameters

- short report -

The research report has been sponsored with funds of the Bundesamt für Bauwesen und Raumordnung (German Federal Office for Building and Regional Planning)

(Reference: Z 6 – 10.07.03-04.15/ II 13 – 80 01 04-15)

Size: 5 pages

1 Objective of the research project

In the present paper on the research project “Derivation of Algorithms for the Climate Correction of Heating Energy Parameters” an approximation approach is identified which, aside from correcting the heating energy consumption as per VDI 3807 part 1 with regard to temperature data also provides a correction taking into account variations in the solar radiation.

Up to now, the procedure described in VDI 3807 has typically been used for the climate correction of energy parameters. It had been developed for buildings with a comparatively low level of thermal insulation resulting in large deviations when applied on today’s building design with its significantly reduced thermal losses. For buildings with high thermal losses, the outside ambient temperature constitutes the main climatic factor determining the heating energy requirement. The procedure is based on the determination of heating degree days as a climatic reference which is solely based on the outside air temperature. VDI 3807 delivers sound results for the climate correction of the energy parameters of older buildings with a moderate thermal protection.

In the building sector, the need to save energy has led to a change in the way buildings are constructed. Through better insulation standards, improved air tightness and an increased application of controlled ventilation, the heat losses of today’s buildings are much lower than in the past. As a result, the calculation approach to VDI 3807 does no longer produce realistic results for today’s buildings. The calculation of heating energy days is made for a heating temperature limit of 15 °C. This value does no longer correspond to the heating temperature limit of today’s buildings. The calculation approach of VDI 3807 accounts for the influence of radiation in an indirect manner only. For an increased accuracy, the solar heat gain has to be taken into account.

2 Conducting the research project

2.1 Research methodology

In order to derive a basis for calculating the climate correction of heating energy parameters, simulations are performed in order to determine the heating energy requirement of different building types depending on outside ambient temperature and solar radiation. The input data used in the simulation are building and component data, the profile of usage and the meteorology.

The buildings analysed comprise four single-room / single zone modules as well as four multi-zone modules. These are described below:

Single zone modules

- central room
- corner room
- corner room in attic storey
- Single zone house

Multi-zone modules

- Single family detached house
- Mid-terrace house
- End-of-terrace house
- Central storey of an apartment house

For single room modules calculations are made for varying window area ratios. For the single family house (multi-zone module), the initial state as well as an increased window area ratio are analysed.

Two different insulation levels are investigated. This covers the standard requirement as per “Energie-Einspar-Verordnung” (EnEV, German Energy Saving Directive) as well as the insulation standard of so-called “passive houses”. The utilisation varies according to these standards. Internal heat sources are incorporated by means of fixed values, and a distinction is made for the modules between the utilisation for normal buildings and an increased utilisation. For multi-zone buildings, the internal heat sources are multiplied with the factors 0,5 and 1,5.

The simulations use the meteorological data of the test reference years (TRY) provided by the German Meteorological Service (Deutscher Wetterdienst). The town of Würzburg represents the reference location. For the temperature-dependent correction of the heating energy requirement, the temperature data of Freiburg and Hof are used. The effect of the solar radiation on the heating energy requirement is taken into account by varying the solar radiation of the Würzburg TRY by additional radiation factors of 0,5; 0,8; 1,3; 1,5 and 2,0. The combination of modified radiation and temperature data is investigated against measured climate data of the town of Würzburg.

2.2 Calculation and evaluation

With the above parameters simulations are carried out to calculate the heating energy required in the different cases. The values showing deviating climate data are compared with the respective reference value of Würzburg.

Based on the simulation results, separate correction approaches are initially investigated for calculating the heating energy requirement with modified temperature data and with varying radiation factors. A procedure for the correction of heating parameters with respect to temperature and radiation is developed on the basis of the climate data of Kassel.

The temperature-related correction approach is modelled after the procedure of VDI 3807 part 1. However, the degree day figure takes the place of the heating days as a reference for the correction.

For correcting the heating energy requirement with respect to the solar radiation, three different approaches are analysed. The first approach analyses, along the lines of a purely temperature-related correction, an approximation formed by the product of radiation factor and heating energy requirement. The second approximation approach has also been derived empirically and relates the radiation factor to the ratio of solar gains to the total energy losses. A third correction approach is developed analytically in order to achieve a better alignment to the reference values.

For the climate correction with regard to radiation and temperature, this calculation approach is expanded incorporating a degree day figure correction. The resulting approach which, in the first instance, describes the climate correction of the heating energy requirement is illustrated by means of an example. This correction approach is simplified taking into account the solar radiation only and remodelled for the application on the heating energy requirement.

3 Summary of results

Based on comprehensive simulations the influence of temperature and solar radiation on the heating energy requirement is analysed.

The evaluation of climate data shows that the maximum radiation sum (location Stötten) exceeds the Würzburg values by 8,8 %. The lowest radiation sum is found in Hannover. It falls short of the Würzburg values by 17,1 %. The deviation from the temperature values of Würzburg is described by means of the degree day figure factor $f_{Gt20/20}$. For Hof, the location with the lowest annual mean outside air temperature, this factor amounts to 0,8. Freiburg reaches the highest annual mean outside air temperature, and the degree day figure factor is 1,13.

The analysis of the various approaches for correcting the heating energy requirement shows that the approach based on degree day figures only as well as the two empirical approaches for the radiation correction are inadequate procedures for the climate correction. The analytically developed approach for a correction with respect to solar radiation and temperature also takes into account the internal heat sources and their variation. It produces excellent results.

This approach is as follows:

$$E_{V,ber} = f_{s,Gt} \cdot E_{V,g} \qquad (1)$$

with

$E_{V,ber}$	[kWh/(m^{2}a)]	corrected energy consumption
$f_{s.Gt}$	[-]	factor to correct the heating energy requirement with respect to solar radiation and temperature according to equation (2)
$E_{V,g}$	[kWh/a]	measured energy consumption

and

$$f_{s,Gt} = f_{Gt} + \frac{\left(f_{Gt} \cdot \eta - \eta_{ref}\right) \cdot \left(Q_{i,ref} + Q_{s,ref}\right) + f_{Gt} \cdot \eta \cdot \left(\Delta Q_i + \Delta Q_s\right)}{Q_h} \qquad (2)$$

with

f_{Gt}	[-]	degree day figure factor, ratio of degree day figure of reference case to degree day figure of analysed case
η	[-]	degree of utilisation of heat gains for analysed case

η_{ref}	[-]	degree of utilisation of heat gains for reference case
Q_i	[kWh/a]	internal heat sources for analysed case
Q_s	[kWh/a]	solar heat gains for analysed case
ΔQ_i	[kWh/a]	difference of internal heat gains
ΔQ_s	[kWh/a]	difference of solar heat gains
Q_h	[kWh/a]	heating energy requirement for reference climate

When applied on the climate data of Kassel, the corrected heating energy requirement shows a standard deviation of 0,03 for multi-zone buildings with EnEV level, and a standard deviation of 0,2 is found for the passive house standard.

This approach offers, therefore, the opportunity to correct climatic i.e. temperature and radiation-related variations of energy consumption data.

Since the application of this approach is rather complex, it is simplified by analysing the variation of solar radiation only. Equation (3) represents the simplified approach:

$$Q_{H,ber} = Q_H \cdot \left[1 - c \cdot \frac{Q_{s,ref}}{A_N} \cdot \left(1 - f_{str}\right)\right] \qquad (3)$$

$Q_{H,ber}$	[kWh/a]	corrected annual heating energy requirement
Q_H	[kWh/a]	analysed annual heating energy requirement
c	[-]	coefficient depending on building type, window area ratio and insulation standard
$Q_{s,ref}$	[kWh]	solar gains for reference case
A_N	[m^2]	net floor space of heated room
f_{str}	[-]	radiation factor, ratio of radiation of analysed case to reference case