



Journal Homepage: - [www.journalijar.com](http://www.journalijar.com)

## INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/11049

DOI URL: <http://dx.doi.org/10.21474/IJAR01/11049>



### RESEARCH ARTICLE

#### INTERNAL HEAT GAINS IN RESIDENTIAL BUILDINGS IN GERMANY

F. Ziegler

Mendel University, Faculty of Business and Economics in Brno, Czech Republic.

#### Manuscript Info

##### Manuscript History

Received: 25 March 2020

Final Accepted: 30 April 2020

Published: May 2020

##### Key words:-

Internal Heat Gains, DIN 4108-6, KfW  
Efficiency House

#### Abstract

Internal heat gains by people and equipment contribute to the heat demand of residential buildings. They increase the lower the energy requirement of a building and can account for about a quarter of the heating requirement of a KfW-55 efficiency house. They thus make a considerable contribution to reducing heating requirements, which KfW takes into account indirectly as part of its financial support. In Germany, a constant value of 5 W/m<sup>2</sup> energy reference area is assumed for residential buildings - when applying DIN V 4108-6 and DIN V 4701-10. This value has remained constant since the standards were introduced (2003), although energy-saving devices have now penetrated the market. Other calculation models and authors also assume lower profits in Europe, so that it seems justified to adjust this value. In this study, the - internal heat sources in apartment buildings in Germany - are calculated in relation to the degree of equipment, a heat loss factor and the eco-design requirements, among other things, in order to obtain a modern basis for the calculation of energy balances.

Copy Right, IJAR, 2020,. All rights reserved.

#### Introduction:-

Internal gains emergence by the heat levy of the human or animal's body, depending on many factors like activity grade (metabolic rate), clothing grade (clo), indoor operative temperature, air moisture. The use of technical equipment also provides a contribution to the latent heat gains in the thermal zone as the efficiency contributes to what "waste energy" is emitted as thermal energy and transported to the room. Also, goods which are brought into the heated building, which have a different temperature in relation to the room temperature or heat gains through cooling or heating facilities, contribute to heat gains or losses within the thermal zone, see part -2 section 5.4.5 (DIN V 18599-1 to -10, 2016, p.35).

#### Literature Research:

During the last years, the efficiency of electrical appliances and the energy awareness has risen (Osterhage, 2018, p.85) (Mills; Joachim Schleich, 2010), but also the use of more and more electrical appliances. So the real consumption of electrical energy has stayed nearly the same since (Bissiri et al., 09.2019, p.559).

There are several accounting approaches for internal gains.

The heat levy of People is set to different values regarding what technical pamphlet looking for. ASHRAE, for example, assumes 80 W/Person, the passive house institute uses 60 W/Person whereas (Elsland et al., 2014) notes 70 W/Person for calculating the heat gains. Other regulations (DIN V 18599-10, 2018, p.16 ff) specify 90 W/(m<sup>2</sup>d) for

multi-family houses with a time of use of 24 h per day. The living space reference is the net space area. (In the DIN V 4108-6) it is the energy reference area, which is the gross volume multiplied with 0,32.)

In research commissioned by the 'Bundesministerium für Verkehr, Bau und Stadtentwicklung– BMVBS' - the deviations of the Version 2011 compared to 2007 were shown, where the energy level and size was equal to the investigated buildings in this thesis (KfW70, KfW55); (Maas and Schlitzberger, 2013).

In DIN V 4108-6 the mean whole internal gains are set to 5 W/m<sup>2</sup> energy-related area (ERA). This seems to be a small amount of power, but multiplying it with the ERA and the time it is about 20 % of the net heating demand. The heat levy is well known since Ole Fanger experienced a lot at thermal comfort (Fanger, 1970).

Compare those terms of use is shown in the following table:

**Table:-** Internal heat gains from different literature sources; Nr. 6 only informative (4 occupants were assumed); HDD: heating degree days; A,LS: Area, living space.

source	date	internal heatgains (IHG)	IHG x 100 m <sup>2</sup>	comment
DIN V 4108-6	2003	5 W/m <sup>2</sup>	500 W	During heating period; m <sup>2</sup> ERA; equal 0,32Ve
DIN V 18599-10	2018	90 Wh/(m <sup>2</sup> d)	375 W	m <sup>2</sup> energy reference area (ERA)
(Maas and Schlitzberger, 2013)	2013	45 Wh/(m <sup>2</sup> d)	206 W	m <sup>2</sup> ERA (optimized calculation approach)
(PASSIPEDIA, 2015)	2015	2,1 W/ m <sup>2</sup> +50/A,LS	260 W	m <sup>2</sup> living space (LS); valid for passive houses (R)
(Eisland et al., 2014)	2014	1228 kWh to 1676 kWh/dwelling	305 W	value 2008 to 2050; interpolated 2020) related to 185 HDD
(ASHRAE, p.197)	2017	532+1,4 A,LS+116 occup. (Btu/h)	530 W	valid for US homes

The reference area differs when using the "DIN V's" or the passive house (R) - the living space is the real tempered space whereas the energy-related area (ERA) is a part of the volume of the building.

Internal heat or solar gains (IHG, SG) reduce the heating demand and are for that reason monetary important support. At the same time, electrical energy is high-quality energy and more expensive.

### Methodology:-

Internal heat sources are generated by people and animals, heat emission from lighting and equipment, and the throughput of materials (incoming and outgoing goods).

The idea is to link the heat sources to a device equipment factor and multiply the energy demand of modern, less energy consuming devices by a heat loss factor. At the same time, two usage situations exist: Use and non-use or with persons: presence and absence.

In general, this can be described with equation 1:

$$IHG = \frac{1}{NFA \cdot T} \sum_{i=1}^k F_{R,i} \eta_{body,i} (P_{work,i} t_{pres} + P_{non-work,i} (1-t_{pres})) \left[ \frac{W}{m^2} \right] (1)$$

NFA: net floor area [m<sup>2</sup>]

T: 24 h

F<sub>R,i</sub>: Radiation or heat waste factor of the i<sup>th</sup> body or appliance

η<sub>body,i</sub>: saturation of the i<sup>th</sup> body or appliance

P<sub>work,i</sub>: Power of the i<sup>th</sup> body or appliance

P<sub>non-work,i</sub>: Power if no of the i<sup>th</sup> body or appliance

t<sub>pres,i</sub>: daily presence or duration of use [h/d] of the i<sup>th</sup> body or appliance

Representative for 'body' is either the human body or that of an object.

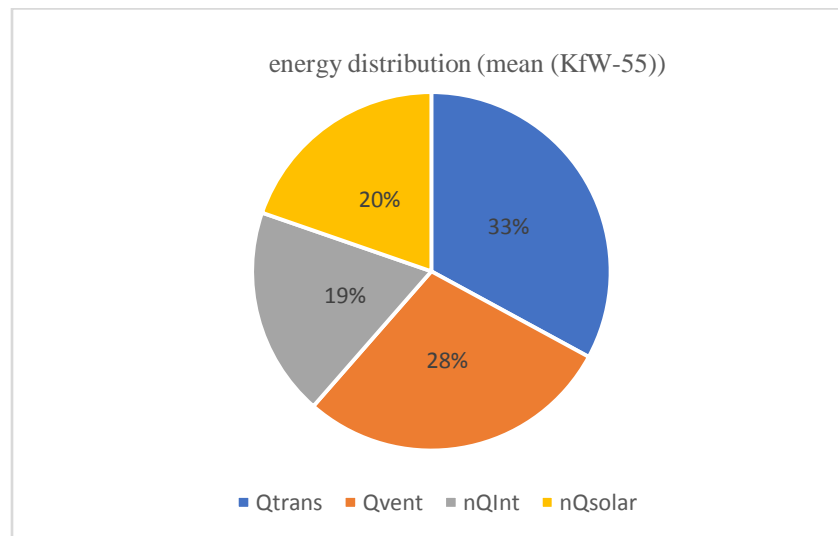
Some radiation factors are given in ASHRAE-Handbook. Here the usage factor is equivalent to the usability factor, which is given in (DESTATIS, 2019) "...AusstattungprivaterHaushalte...". But the radiation factors (FR) are those from American appliances. But they can be used for orientation as in the USA the EnergyStar is the pendant to the EU-Energy label but the energy consumption is much more less than in the EU.

If the medium to most efficient appliances with an efficiency class of A++ or A+++ are taken into account, the degree of appliance equipment in German households, the useful life and standby time or the presence of persons, the IHGs are reduced to approx.  $3 \text{ W}/(\text{m}^2\text{K})$ . This corresponds to a reduction of 40%. Multiplied by the ERA, the correlation for the IHG is:  $Q_i = 0.96 V_e$ , i.e. approximately  $Q_i \approx V_e$  in Watt.

In the case of heating requirements, the reduced proportion of internal heat sources results in a loss that must be substituted by fossil or renewable energies.

### Results:-

In our own calculations, a distribution of the heat flows was calculated for 8 apartment buildings with 7 to 98 residential units as shown.



The proportion of usable internal heat sources was on average 19% and would logically increase with lower transmission and ventilation heat losses in future buildings - with the same heat flow.

In the near future (possibly 2021), buildings will comply with the requirements of the German Building Energy Act (Gebäude-Energien-Gesetz - GEG) and meet the energy requirements of a low-energy building (equivalent to a KfW-55 efficiency house or an annual primary energy requirement of max.  $40 \text{ kWh}/(\text{m}^2\text{a})$  (reference EnEV 2009) and specific transmission heat loss max.  $28 \text{ W}/(\text{m}^2\text{K})$ .

### Conclusion:-

The underlying internal heat sources are assumed to be considered too high, at least in the currently valid DIN V 4108-6 (2003). This is due to the EU measures concerning more effective and thus more climate-friendly appliances that require considerably less energy. However, the energy requirement also depends on the needs of the users, which are reflected in the degree of equipment.

(Maas and Schlitzberger, 2013) set a value for DIN V 18599 of the equivalent of approx.  $2.1 \text{ W}/\text{m}^2$ , (Elsland et al., 2014) a value of approx.  $3.1 \text{ W}/\text{m}^2$ . Somewhat more recent studies assume a value of  $2.6 \text{ W}/\text{m}^2$  in relation to living space (PASSIPEDIA, 2015). Own calculations come to IHG of approx.  $3 \text{ W}/\text{m}^2$  (appendix). This means that the internal heat sources are 40 % lower than assumed according to DIN V 4108-6.

In order to be able to live more resource-efficiently and cost-effectively in the future, energy generation systems are needed that are well adapted to the demand. Therefore, the assumption of internal heat sources is of crucial importance, especially for energy self-sufficient systems. In future, IHG should therefore be (continuously) adapted to energy efficiency and the degree of equipment. It makes sense to distinguish here between single-family homes, two-family homes and apartment buildings.

Since lighting and the number of occupants have the main influence on internal profits, these variables (number of persons per accommodation unit, specific illuminance, duration of lighting including pre- and post-operating time) should be determined as accurately as possible. In our own calculations, 47 m<sup>2</sup> living space per person according to (DESTATIS, 2019) and for the irradiance 10 W/m<sup>2</sup> area (ERA) as well as the irradiation time between sunrise and getting up and going to bed and sunset plus 10 minutes each were taken into account. For the duration, a uniform average geographical location for Germany would have to be assumed.

### Literature:-

1. Bissiri, M., Reis, I. F. G., Figueiredo, N. C. and Pereira da Silva, P.: An econometric analysis of the drivers for residential heating consumption in the UK and Germany, *Journal of Cleaner Production*, 228, 557--569, doi:10.1016/j.jclepro.2019.04.178, 09.2019.
2. DESTATIS: Wirtschaftsrechnungen - Laufende Wirtschaftsrechnungen Ausstattung privater Haushalte mit ausgewählten Gebrauchsgütern, Statistisches Bundesamt DESTATIS, Wiesbaden., 2019.
3. DIN 4108-6: DIN V 4108-6:2003-06: Thermal protection and energy economy in buildings — Part 6: Calculation of annual heat and annual energy use, , 110, 2003.
4. DIN V 18599-1 to -10: DIN V 18599 Energetische Bewertung von Gebäuden, 2016.
5. Elsland, R., Peksen, I. and Wietschel, M.: Are Internal Heat Gains Underestimated in Thermal Performance Evaluation of Buildings?, , 60, doi:10.1016/j.egypro.2014.12.364, 2014.
6. Fanger, P. O.: Thermal Comfort: Analysis and Applications in Environmental Engineering, Danish Technical Press., 1970.
7. Maas, A. and Schlitzberger, S.: DIN V 18599 für Wohngebäude - verbesserte Bewertungsansätze und Überprüfung der Anwendungsmöglichkeiten auf das Effizienzhaus Plus Konzept, Fraunhofer IRB-Verlag., 2013.
8. Mills; Joachim Schleich, B.: What's driving energy efficient appliance label awareness and purchase propensity?, 2010.
9. Osterhage, T., Calì, D., Streblow, R. and Müller, D.: EVALUATION OF DIFFERENT ENERGY-EFFICIENT REFURBISHMENTS, CISBAT, Lausanne. [online] Available from: [https://www.researchgate.net/publication/306056698\\_Evaluation\\_of\\_different\\_energy-efficient\\_refurbishments](https://www.researchgate.net/publication/306056698_Evaluation_of_different_energy-efficient_refurbishments)
10. PASSIPEDIA: Internal heat gains related to the living area, [online] Available from: [https://passipedia.org/planning/calculating\\_energy\\_efficiency/phpp-\\_the\\_passive\\_house\\_planning\\_package/internal\\_heat\\_gains\\_in\\_relation\\_to\\_living\\_area](https://passipedia.org/planning/calculating_energy_efficiency/phpp-_the_passive_house_planning_package/internal_heat_gains_in_relation_to_living_area), 2015.