DIN 18599 – ACCOUNTING FOR PRIMARY ENERGY
NEW CODE REQUIRES DYNAMIC SIMULATION

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ABSTRACT

The new standard DIN V 18599 for Energy Efficiency of Buildings, which implements the European Energy Performance of Buildings Directive (EPBD) in Germany, requires to calculate a comprehensive energy balance for buildings, including the building envelope, building services for heating, cooling and air conditioning, lighting with all their primary or source and site energy consumption.

This new calculation methodology with holistic energy balances results in an overall annual primary energy demand of buildings – already in early phases of the building design. This information at that stage offers a real opportunity to evaluate and compare different energy concepts and improve the energy performance of buildings significantly.

The simulation software *ennovatis* uses a 3D building model for a practicable implementation. The simulation tool calculates all energy flows, makes them visible, and generates the energy performance certificate according to DIN V 18599.

This paper gives an introduction to the EPBD and the German standard DIN V 18599 and documents how this new standard is integrated in the design process using the simulation tool *ennovatis*.

INTRODUCTION

The development of new technologies and the improvement of existing technologies to higher energy efficiency is one option for counteracting worldwide climate change, environmental pollution and the consumption of resources. Numerous studies report high energy-saving potentials in both, existing and new buildings. However, the knowledge of such saving potentials as well as the knowledge of existing technologies is not necessarily leading to their substantial exploitation. The reasons for the failing are manifold and based on complex structures, but the high energy demand of buildings is continuing.

The growing consumption of electricity for the operation of buildings, especially air conditioning, was causing worries in Europe - and Germany in particular - that the climate protection targets would not be achieved. Within the framework of the Kyoto Protocol, Germany committed to reduce the emissions of Greenhouse Gases from 2008 to 2012 by 21% in comparison to 1990 levels. Similar targets apply to other EU states. The increase in the energy efficiency of buildings plays a significant role in reaching these targets. It was therefore important to develop strategies to counteract the growing consumption of electricity in the building sector. There was increasing awareness that it is not sufficient to restrict the energy efficiency of buildings and according codes to the topic of heating alone, but that the major consumers of electricity, namely lighting and air conditioning, have to be included as well. Six years ago the European Parliament therefore decided within the European Energy Performance of Buildings Directive (EPBD) (EU_RL) that the mandatory requirements placed on the energy efficiency of buildings have to be based on the primary energy demand of the whole building. The total primary energy demand includes the energy for heating, air conditioning, ventilation, lighting and hot water, as well as all auxiliary energy. However, there was no method or code available to determine the total primary energy demand, particularly including air conditioning and lighting. For this reason the EU states supplemented existing calculation methods and developed new ones.

The aim of the assessment procedure in Germany was to develop a comprehensive calculation methodology which incorporates all energy-relevant systems and the interactions between them. The result was the new standard DIN V 18599 (DIN V 18599) "Energy Efficiency of Buildings". For the first time in Germany a procedure was available, which enabled the calculation of the energy demand for heating, hot water generation, air conditioning, cooling and illumination of buildings in an integrated procedure (see Figure 1).

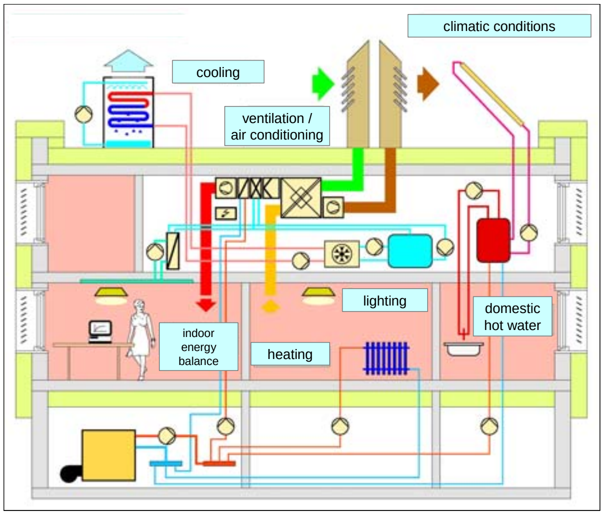

Figure 1 Energy Balance Method (DIN V 18599)

THE EVALUATION PROCEDURE

The newly developed calculation algorithms can be applied to all residential and non-residential buildings, as well as new and existing buildings. The special conditions applicable to non-residential buildings are taken into account by means of a breakdown according to use zones and the specific balancing of weekend operations. Through the various use zones, it is also possible to model non-residential buildings with very complex and different uses. A simple example is an office building with a canteen.

The calculation method follows the supply of heating and cooling energy from the demand in the room to the energy generation. This means the path leads from the demand and, thus the loads in the rooms, over the terminal units and distribution systems in the building, central mechanical and electrical systems, to the generation systems on-site. Eventually, the energy supply from central plants on- or off-site is rated with primary energy factors.

The procedure begins with an assessment of the daylight and therefore a calculation of the electricity requirement for artificial lighting. At the same time, the heat gains into the room from the artificial lighting are calculated. This is subsequently included in the energy balance for heating and cooling.

Although the calculation method is structured in ten specific parts that reflect different systems or disciplines, the individual sections are linked together by defined interfaces and common specifications for standard values, as the previous example of the energy calculation of lighting demonstrates. Thus, interactions are mapped and it is guaranteed that the same or corresponding values are used in all different parts of the evaluation. For example, the effects of sunscreens on illumination and cooling requirements are evaluated on a uniform basis.

A consequence of the aim of providing better protection for the environment is that the primary energy demand has to be calculated (see Figure 2). This is the only way to asses the damage potential to the environment. For the conversion of the site energy to primary energy there are factors stipulated for the calculation method which reflect the quality of the energy generation and distribution based on the typical energy-mix in Germany.

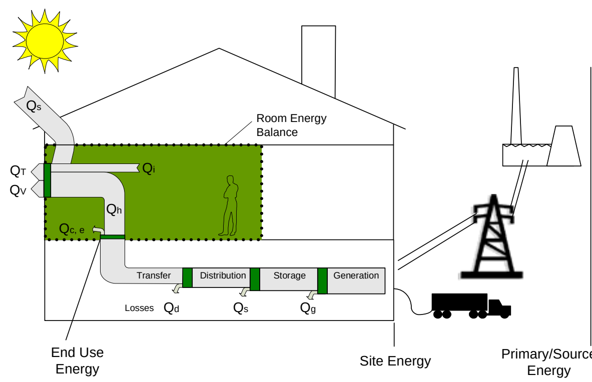

Figure 2 Different Forms of Energy

The following table gives examples of primary energy factors for various energy sources in Germany. The factor 2.7 for electricity illustrates in particular how significant the electricity use affects the primary energy and the environment. This high factor reflects the relatively high rate of coal-fired power plants in Germany.

Table 1 Primary Energy Factors for Germany (DIN V 18599)

ENERGY SOURCE	PRIMARY ENERGY FACTOR
Natural gas	1.1
Heating oil	1.1
Local and district heating from renewable energies	0.7
Electricity	2.7

The final energy efficiency evaluation is carried out by a "reference building procedure", analogous to the baseline model of ASHRAE 90.1 Appendix G. Limiting values of energy consumption are no longer determined by stipulated factors depending on the ratio between the envelope surface and the building volume as in former regulations, but by representation of the actual building itself. Parallel to the calculation of the primary energy demand of the actual building, a so-called reference building is calculated which defines the required minimum energy efficiency. The reference building is characterized by identical area distribution and identical use, but is calculated with reference values, which represent minimum standards for the envelope (heat transfer), mechanical and electrical systems (efficiency factors), etc. The primary energy demand of the reference building then defines the required energy efficiency of the designed building.

The reference values used for the calculation of the primary energy requirement $Q_{P,max}$ of the reference building are stipulated by law. However, single values may exceed reference values if the overall maximum primary energy requirement is still met.

THE DIFFICULTY

Dealing intensively with the individual sections of DIN V 18599, documented on around 800 pages, the extent and level of detail required gets obvious. The procedure remains transparent, since all calculation steps are thoroughly described and could be done manually. However, due to the large amount of calculations a manual approach would be extremely time-consuming and an error-free application is unrealistic. Without corresponding software, the calculation of variants is doomed to fail also due to time and resources available in common building design practice.

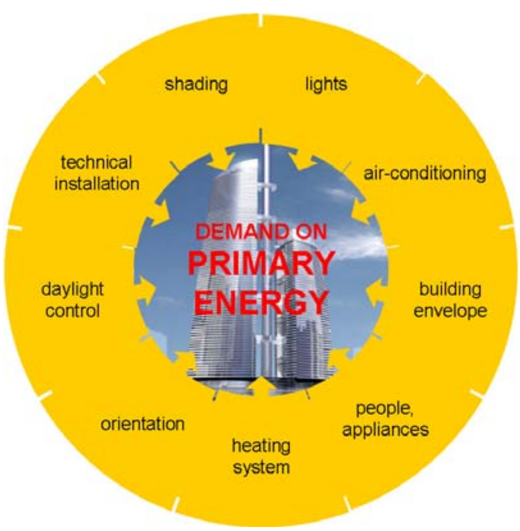

Figure 3 Main Influences on Energy Demand

The energy balance of a building includes all energy systems. Due to manifold interactions between the various systems, a realistic prediction of the energy consumption without calculation is not possible (see Figure 3).

A change in one individual system has effect on several other systems and, thus, the overall energy consumption of the building.

THE SOLUTION

The solution is an evaluation and calculation software based on an object oriented 3D building model (see Figure 4). With the aid of the building model it is possible to carry out the evaluation of the energy performance and to optimize subsequently step by step. In this manner the energy demand of the planned building can be reduced to a minimum with comparatively small effort and a high degree of transparency.

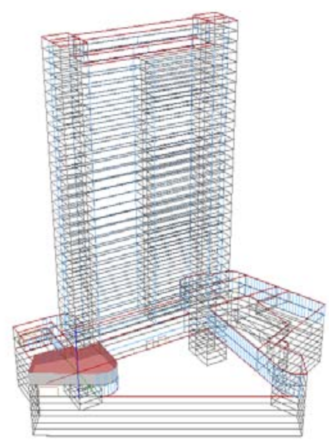

Figure 4 3D Building Energy Model (Ennovatis)

The *ennovatis* software allows the analysis of variations in building envelopes, room conditioning concepts, schedule of building use and zoning, energy generation and distribution systems. The impact on the annual energy demand and operating costs is calculated. Even different control strategies of technical systems can be modeled to a limited extend. This is very important as the quality of the system control and operation is of high significance for the energy consumption of the building.

The object oriented 3D building model allows for modifying technical data, e.g. increasing the window to wall area ratio by changing one single value very quickly. This allows an evaluation and optimization of the energy performance in a convenient manner with a minimum of effort. During the design process, changes in building plans can be quickly analyzed and evaluated in regard to their effects on the energy balance.

For each of the variants a total energy balance calculation is performed over a period of one year. The result obtained is a detailed list of all energy fluxes for all systems and zones (see Figure 5). The calculated energy demand for heating, cooling, ventilation and air conditioning as well as lighting allows estimating subsequent costs for the potential occupant at an early stage.

Furthermore, an object-oriented building model provides data which are consistent and available to all parties involved in the planning process. In the building model the planning status over all disciplines is documented and can be communicated to the design team easily and transparently.

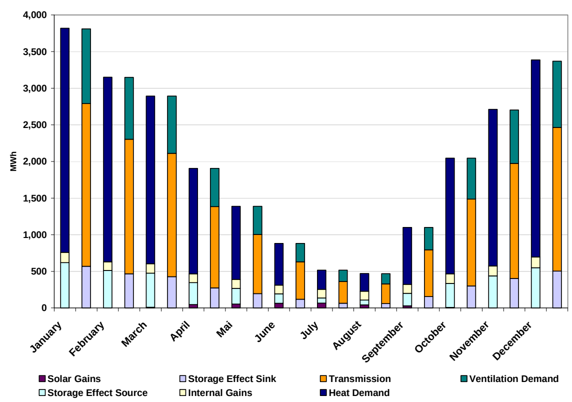

Figure 5 Monthly Energy Demands (Ennovatis)

CONCLUSION

The new German standard DIN V 18599 provides a methodology which calculates the primary energy demand of all systems within a building, including system interactions. The algorithms that have been developed for the calculation of a holistic energy balance can be used for residential and non-residential buildings, as well as for new and existing buildings. DIN V 18599 allows estimating and evaluating the energy demand of buildings and the use of renewable energy in early stages of the planning process and support decisions appropriately. In order to guarantee cost-effective and error-free application in the actual planning process, a 3D building model is required. This is the only way to carry out changes to the geometry and zoning of the building in a transparent manner. Subsequently the model can be used for many other planning tasks like building operation.

Many building owners have already recognized that by means of slight increases in planning costs it is possible to reduce the recurrent annual operating costs and therefore also the life cycle costs of a building. In order to achieve this, it is important that the building owner precisely defines the corresponding requirements on rooms and the building itself (e.g. use, air conditioning) prior to the start of the planning process. In the "Integrated Planning Process" an optimum energy and technical concept can then be formulated and achieved, which is conform to the above mentioned requirements. In order to design and build an energy-efficient building it is not possible to simply apply an existing technical concept to the new building. On the one hand the collaboration with all of those involved is required; on the other hand, each concept has to be precisely adjusted to the project's requirements. Integrated planning with the application of DIN V 18599 is becoming a valuable asset for the construction of energy-efficient buildings.

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