4. Calculation – no magic formula, just design aids

4.1 The decisive design parameters: heating requirement and installation engineering

The Energy Saving Regulation is based on the simple philosophy of a balancing concept using the following "magic formula":

$$Q = Q_h + Q_w + Q_t - Q_r$$

Q	heating energy supply
Q_h	heating requirement
Q_w	energy requirement for hot water
Q_t	heating system losses
Q_r	energy gains from the environment

The heating energy supply (Q) must compensate for the heat losses through the building shell and the energy losses in the heating system and cover the energy requirement for water heating (Q_w).

The building shell determines the heating requirement (Q_h). The solar heat gains and those from internal heat sources are offset against the transmission heat losses and the ventilation heat losses.

The energy gains from the environment (Q_r) result from the contribution made by renewable forms of energy for heating and water heating. The heating requirement is calculated in the Energy Saving Regulation using DIN V 4108-6 "Thermal insulation and energy saving in buildings; calculating the annual heating and heating energy requirements". This standard defines the national climate parameters and the standardized conditions of use, such as the average internal temperature of a building of 19 °C that is taken as a basis for normally heated buildings. These parameters are not set down in European standard EN 832 "Thermal performance of buildings – calculating the heating energy requirement; residential buildings".

The heating system losses (Q_t) are included in the system energy requirement factor (e_p). This value describes the ratio of primary energy used by the heating system to the useful heat that it outputs. The energy requirement value therefore tallies with the reciprocal of the conventionally employed level of use. It is determined in accordance with DIN V 4701-10 "Energy evaluation of heating and air conditioning systems; heating, water heating, ventilation". The use of renewable forms of energy is also considered accordingly. The factors which take account of the generation and distribution losses of the energy supply (oil, gas, etc.) outside of the "building" system are also included in the system energy requirement value as a primary energy characteristic.

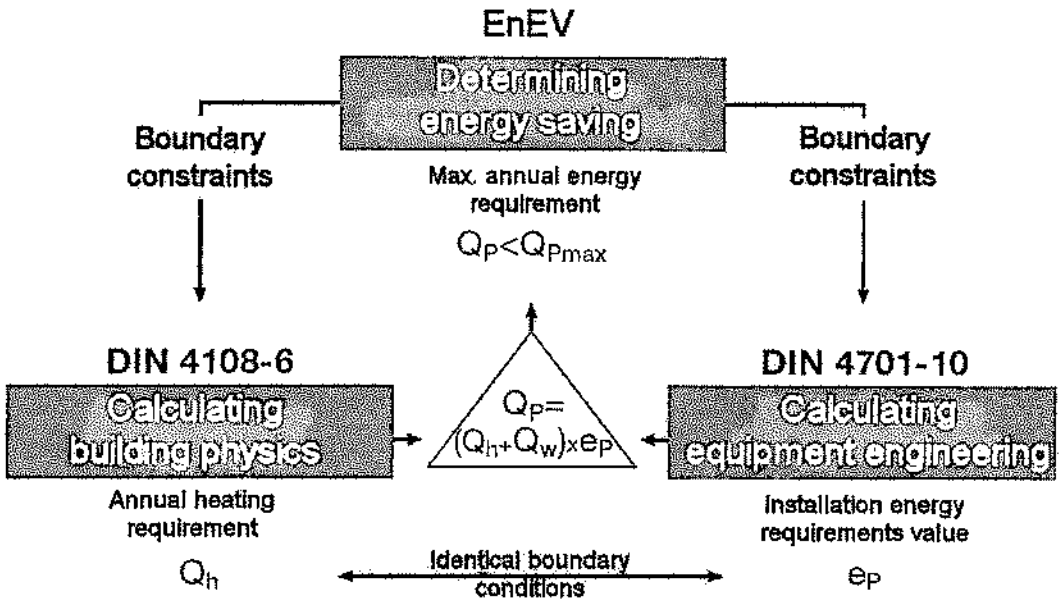

Fig. 13: Structure of the Energy Saving Regulation

The energy requirement for hot water (Q_w) is generally determined at 12.5 kWh/(m²·a) for residential buildings in the Energy Saving Regulation (see Energy Saving Regulation, Appendix 1, Section 2.2). As the heating system must firstly cover the heating requirement and secondly the energy requirement for water heating, both requirement values should be multiplied by the system energy requirement value, so the "magic formula" is simplified as follows and also provides the primary energy requirement (Q_p):

$$\mathbf{Q_p = e_p\,(Q_h + Q_w)\ kWh/(\,m^2 \cdot a)}$$

Q_p = primary energy requirement
e_p = system energy requirement value
Q_h = heating requirement
Q_w = energy requirement for hot water

If the energy requirement for hot water is excluded from the evaluation, it is found that the structural physics-related properties and, in particular, the heat-insulating properties of the building shell and the heating system, including the energy source, then become the decisive design parameters. The Energy Saving Regulation therefore follows the new approach. Building and installation engineering should not be designed separately but in an integrated manner.

4.2 The requirements of the Energy Saving Regulation

The Energy Saving Regulation was the first to introduce energy characteristics as a sole evaluation criterion for buildings. In § 3 of the regulation and the associated Appendix 1, the main requirement of the primary energy demand (Q_p) is given as a function of the surface area to volume ratio and the usable space A_N of the heated building. This is optimized to a single characteristic Q_p in kWh/(m^2·a), which increases the planning engineers' design scope. The calculation and testing procedure is determined by the areas of glazing (see Chapter 5, page 19).

A secondary requirement also applies, however, and this is the specific transmission heat loss H_T'. This is the U value of the external building components plus thermal bridge losses based on the heat-transmitting shell area in W/(m^2·K) (previously k_m value).

The following should be observed as further requirements of the Energy Saving Regulation:

- The tightness of the building shell and the minimum air exchange rate according to § 5 and Appendix 4. In this context, n_{50} values of at least 1.5 h^{-1} shall be observed when installing ventilation systems. In buildings with window ventilation this value must be 3.0 h^{-1} if a Blower Door Test is agreed between the architect and the client.

Energy Saving Regulation § 5:

Buildings to be constructed should be designed in such a way that the heat-transmitting enclosing surface, including the joints, is sealed in accordance with the state of the art so as to be permanently impermeable to air...

- Minimum thermal insulation and thermal bridges according to § 6. The thermal bridges are numerically included in the transmission heat losses.

Energy Saving Regulation § 6
(1) In buildings to be constructed, components which form an interface with ambient air, the soil or building components with significantly lower internal temperatures should be designed so as to meet the requirements of minimum thermal insulation according to acknowledged good engineering practice.
(2) Buildings to be constructed should be designed in such a way that the effect of structural thermal bridges on the annual heating requirement is kept to a minimum in accordance with good engineering practice and the measures that are economically feasible in each individual case.

There are a few exceptions in relation to the requirements level of the primary energy demand:

- In one-family and two-family houses with a monolithic external wall construction the Q_p values increase by 3 % if a low temperature boiler is installed. This regulation applies from February 1, 2002 for a period of five years.
- Only the secondary requirement H_T' applies in buildings that are heated using renewable forms of energy.
- In buildings which are heated by night storage heaters or in which heat is recovered from domestic ventilation systems, these systems are evaluated for 8 years with a primary energy factor of 2.0 instead of 3.0 in accordance with DIN V 4701-10.

4.3 The documentation procedures

The two decisive parameters for energy optimization of the design, and therefore the annual primary energy requirement (Q_p), are the heating requirement (Q_h) and the system energy requirement value (e_p):

$Q_p = e_p\ (Q_h + Q_w)$ kWh/(m^2·a)

Q_p primary energy requirement
e_p system energy requirement value
Q_h heating requirement
Q_w energy requirement for hot water

In the Energy Saving Regulation for residential buildings the energy requirement for hot water is generally set at 12.5 kWh/(m^2·a) (see Energy Saving Regulation, Appendix 1, Section 2.2).

The heating requirement can be determined in accordance with DIN V 4108-6 using two different methods:

- monthly balance method
- heating period balance method

The monthly balance method determines heat losses and usable heat gains for each month separately. This method is able to detect the respective parameters very accurately (for example heat storage effects of building components) and, for convenience, is best implemented using a computer.

The heating period balance method (also called annual balance method) balances heat losses and heat gains over the length of the heating period (185 days) and errs on the side of caution.

There are three methods to choose from when determining the system energy requirement value in accordance with DIN V 4701-10:

- graph method
- table method
- detailed method

The graph method involves graphically determining the system energy requirement value (e_p) and the final energy requirement using energy requirement value graphs as a function of

the area-based heating requirement and the heated usable space. Examples are shown in DIN V 4701-10, Annex C.5 for six common systems:

- Low-temperature boiler with centralized water heating
- Condensing boiler with centralized water heating
- Condensing boiler and solar water heating
- Condensing boiler and ventilation system with heat recovery
- Heat pump with centralized water heating
- Storage heating with ventilation system, decentralized water heating.

If the heating system has not yet been established, characteristics of the energy requirements value for standard products of the individual components in the heating system, such as boilers, are provided in the table method in DIN V 4701-10, Appendix C.1 to C.4. These standard values are geared to the lower energy average of the market level, however, and therefore do not lead to the lowest system energy requirement values.

If characteristics of specific products exist (for example the heat generator energy requirement value according to company statements), these characteristics may be used in the detailed method instead of the standard values in DIN V 4701-10, Appendix C.1 to C.4. This usually results in better system energy requirement values.