5 New buildings: Planning means balancing and optimizing

5.1 Designing for energy optimization and integrated planning

The Energy Saving Regulation provides planning engineers with the option of integrated design in which the building is taken to be a holistic system.

A building with very good thermal insulation (with a low heating requirement) can make do with less complex heating engineering (high system energy requirement value). Conversely, a poorly insulated building can, at least theoretically, be compensated for by the installation of an appropriate heating system. Minimum thermal insulation in accordance with acknowledged good engineering practice (see Energy Saving Regulation § 6) has to be observed even with a particularly economical heating system.

The theoretical scope for decision-making by clients and planning engineers lies between the two "extremes" – maximizing the insulation or maximizing the heating system. The Energy Saving Regulation provides architects and planning engineers with more options for choosing among different designs and economic variations.

A clear rule applies however to the specific decisions: the building and its shell constitute a system with a long life and a correspondingly long-term energy-saving effect. The heating system of a building is subject to relatively rapid wear and therefore relatively short renovation cycles. The saving effect of the heating system should therefore be calculated for a relatively short time.

In general it may be said that, in the long term, a building with a low heating requirement is in any case optimally "equipped" for the anticipated energy shortage. Most architects and owners will therefore prioritize minimizing transmission heat losses by optimum thermal insulation of the building shell and reducing the ventilation heat losses, and only optimize the heating system in a second step. A solar energy future also requires superbly insulated buildings with a low heating requirement.

When it comes to balancing, optimizing and the necessary documentation procedures, planning engineers therefore have several possibilities for verifying the energy efficiency of their designs.

§ 3 of the Energy Saving Regulation sets out the method for calculating the annual primary energy requirement (Q_p) (see Chapter 4, page 18).

- In residential buildings whose window area does not exceed 30 %, the primary energy requirement can be calculated using a simplified method according to Appendix 1, no. 3 (heating period balancing method according to The Energy Saving Regulation, Appendix 1, Table 2 and at least the graph method in accordance with DIN 4701-10 for the system energy requirement value).
- The monthly balance method and one of the calculation methods should be used for the system energy requirement value (graph, table or detailed method) in non-residential buildings and buildings with a larger window area.

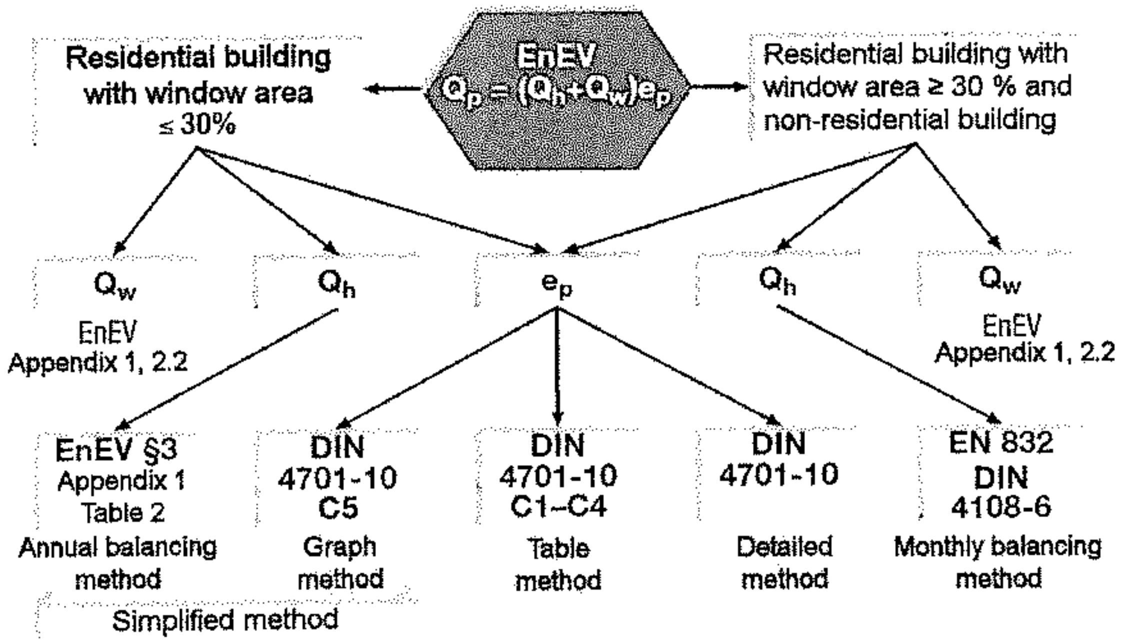

Fig. 14: Documentation procedure for the annual primary energy requirement according to the Energy Saving Regulation

This produces, for example, the following procedure in energy-related building design when the simplified method is used (heating period balancing method and graph method):

1. Determining the surface-area-to-volume ratio according to a preliminary draft

2. Calculating the maximum permissible annual primary energy requirement according to the Energy Saving Regulation, Appendix 1, Table 1

3. Calculating the annual heating requirement according to the Energy Saving Regulation, Appendix 1, Table 2

4. Accounting for the water heating requirement according to the Energy Saving Regulation: 12.5 k/Wh/(m^2·a)

5. Determining the energy requirement factor of the heating system in accordance with DIN V 4701-10, Appendix C.5 for a standard heating installation, for example low-temperature boiler with centralized water heating

6. Calculating the existing annual primary energy requirement, checking results with comparison

7. Carrying out the method again (optimization) if guidelines are not observed

HOAI service phases and Energy Saving Regulation design

These seven stages of the "Simplified method" for energy optimization of a building are new processes as far as the design activity of architects is concerned and should therefore be assigned to the service phases of the Fee Scale for Architects and Engineers (HOAI).

Fig. 15: HOAI service phases and Energy Saving Regulation design

Service phase 1: Clarification of design brief	Assess plot: building orientation, shading effects, preliminary clarification of legal constraints and funding programs
Service phase 2: Preliminary design	Outline energy and supply strategy, determine energy source. Clarify desired standard with owners: establish energy figures and documentation procedures. Agree requirement and financing of technology for using renewable forms of energy. Preliminary drafts for determining the surface-area-to-volume ratio. Preliminary draft statements with simple documentation procedures.
Service phase 3: Draft design	Calculating the energy requirements for the final variant. Several optimization loops. Determining building services engineering

	(ventilation, heating), floor plan organization.
Service phase 4: Approval planning	Drawing up the certificate of energy requirements. Applying for funding.
Service phase 5: Implementation planning	In the event of changes: heat balance calculation for final design (energy figures). Designing heating, ventilation and BWW system. Establish air-tightness and insulating strategy. Reduce thermal bridges, detailed design of non-conventional constructions. Energy-saving building services engineering, hot water connection for washing machine and dishwasher.
Service phase 6: Preparing the tender	Notifications in specifications in the case of new constructions. Promoting the n_{50} air exchange rate in accordance with DIN 4108-part 7. Note to craftsmen of possible Blower Door Test as control.
Service phase 7: Cooperation in tendering	Care in choosing craftsmen. General introductory talk if necessary.
Service phase 8: Site supervision	Site control: tightness, thermal bridges, careful execution of insulating work; set key dates. Possibly carry out Blower Door Test. Check whether any rectification work may be required.
Service phase 9: Site maintenance and documentation	Issue certificate of energy requirement. User manual with descriptions of the particular features of the building. Issue users with maintenance checklist for ventilation system. If required: clarify energy consumption (1^{st} + 2^{nd} years) with budgeted levels. Offer advice to building users (usage characteristics). Remedy defects.

It has been found that the classic design phases are particularly important. The "Energy" theme should be dealt with from the start. Owners and planning engineers must make the first fundamental decisions regarding energy sources and the type of building and building shell as early as the preliminary draft phase.

The compactness of the building, the building materials used and above all the selected insulating materials determine important energy reduction factors.

Actual optimization then takes place in the draft design stage and in greater detail in the implementation planning stage. The site supervision phase carried out by the construction management team is even more important than before. Quality assurance of construction (tightness of the building shell, avoidance of thermal bridges) is imperative from an energy point of view.

During utilization of the building a new area of site maintenance results from the certificate of energy requirements and associated planning engineers' service features. Additional services through to facility management are conceivable in this regard.

5.3 Computer tools

Several computer-aided methods have in the meantime become available for the documentation procedures and these facilitate both calculation of the annual heating requirement and assessment of the heating system in terms of energy by way of the system energy requirement value.

The insulation industry together with the heating and glass industries are preparing an Energy Certificate for Germany which contains all of the procedures of the most important standards and the requirements of the Energy Saving Regulation in a user-friendly format. There is a plan to integrate dynamic, expandable databases and product data in this computer program.

The IVPU, in collaboration with the Research Institute for Thermal insulation (FIW) in Munich, has developed a simple program that allows the test for energy reduction to be carried out quickly using the simplified documentation procedure for residential dwellings in accordance with The Energy Saving Regulation, Appendix 1, Section 2. The program is published on the IVPU website www.ivpu.de.

6 Old buildings: modernizing existing buildings for energy efficiency

6.1 Energy saving potential and types of building

Around 90 % of all existing residential dwellings were built before 1977, in other words, before the first thermal insulation regulation came into force. There is enormous potential for energy saving energy by minimizing heating losses in this area.

Existing buildings can be divided into types according to age and size. A building's age is an important feature because generally conventional constructions which influence the heating requirement may be found in every building period. The size of a building also plays a fundamental part. In relation to their usable volume, larger buildings have a smaller external area over which heat can escape to the environment.

Opportunities for savings may be found for every type of building by employing optimum thermal insulating measures in the walls, roof, basement and windows, and using ventilation measures as well. Thermal insulation of the roofs and external walls has the greatest energy-saving effect.

Which of these measures may be implemented so as to be economically viable depends on the type of building in each individual case. Almost all old buildings which are more than 20 years old have an energy consumption of at least 20 liters of fuel oil or 20 cubic meters of gas per m^2 living space and year. The anticipated saving as a result of thermal insulation measures is, on average, 50 %.

Energy-saving measures are already economical if the additional thermal insulation is linked with repairs and/or modernization that are pending anyway.

Overview of heat transfer limitation (according to the Energy Saving Regulation) Limiting heat transfer on the initial system, during replacement of and when renewing building components according to the Energy Saving Regulation, Appendix , Table 1 (extract)	
Component	**Maximum heat transfer coefficient in $W/(m^2 \cdot K)$**[1]
External walls generally	U_{max} = 0. 45 $W/(m^2 \cdot K)$
External walls where - **Claddings** are applied	

- **Insulating layers** are installed - **Framework infill panels** are replaced	U_{max} = 0.35 W/(m²·K) U_{max} = 0.35 W/(m²·K) U_{max} = 0.35 W/(m²·K)
Windows, French doors, roof windows	U_{max} = 1.75 W/(m²·K)
Ceilings, roofs, pitched roofs	U_{max} = 0.30 W/(m²·K)
Flat roofs	U_{max} = 0.25 W/(m²·K)
Walls and ceilings against unheated rooms or **against soil** - **general** - when **external cladding** is applied	 U_{max} = 0.50 W/(m²·K) U_{max} = 0.40 W/(m²·K)
[1] The heat transfer coefficient of the component can only be determined by allowing for the new and existing component layers. DIN EN ISO 6946:1996-11 should be used to calculate opaque components.	

Fig. 16: Requirements when changing external components of existing buildings

A measure is deemed economical if the costs for the saving of one kWh energy are lower than the future final energy price determined over the period of use. When a future energy price of for example 6.7 cents per kWh is considered, this produces potential savings of 53 % in the former West German states and 63 % in the former East German states.

6.2 Modernizing buildings for energy efficiency under the Energy Saving Regulation

The Energy Saving Regulation uses the enormous potential for savings in existing buildings and lays down particular requirements for the heat transfer coefficient of external components (U-value), when they are replaced, renovated or installed for the first time.

The Energy Saving Regulation, as a follow-up to the Energy Saving Law of 1976, is linked to the principle of cost-efficiency, so the new requirements only apply when more than 20 % of the area of a component is to be refurbished.

The legislation also places some obligations on retrofitting in the Energy Saving Regulation. They apply, in particular, to boilers that were put into operation prior to October 1, 1978. Uninsulated top floor ceilings, which cannot be walked on but are accessible, of heated rooms must be insulated before December 31, 2006 in such a way that their U-value is at least 0.30 W/(m²·K).

The provisions of Appendix 3 of the Energy Saving Regulation list the refurbishment procedures in question:

Renovation of external walls

- Application of cladding
- Lining on the interior
- Installation of insulating layers
- Renovation of the render
- Use of infill panels

Renovation of pitched roofs

- Replacement of the roof skin, external cladding
- Internal lining
- Installation of insulating layers

Renovation of flat roofs

- Replacement of the roof skin, external cladding
- Internal lining
- Installation of insulating layers

Renovation of walls and ceilings adjacent to unheated rooms and earth

- Renovation of external cladding, damp proof courses, drains
- Internal lining on walls
- Renovation of floor structures on the heated side
- Ceiling linings on the cold side
- Installation of insulating layers

Renovation of curtain walls

- Replacement of the entire component
- Replacement of the filling

Any architect or client must therefore follow this list when planning routine maintenance procedures and must adhere to the requirements of Table 1, Appendix 3 of the Energy Saving Regulation.

In the event of significant changes to existing buildings, a certificate of energy requirements is prescribed under certain conditions (cf. Energy Saving Regulation, § 13). A significant change exists if:

- at least three changes involving the replacement of a boiler or the conversion of a heating system to a different energy source take place within a year (cf. Energy Saving Regulation, Appendix 3, No. 1-5)
- the heated building volume is extended by more than 50 %.

6.3 The challenge for architects

The modernization of a building frequently offers a genuine second chance for good architecture. Architects are required here in two respects:

- for changes to the external styling of the building
- when planning the investment with respect to optimum energy saving

The modernization of existing buildings opens up a new field of activity for architects. Aspects such as optimum thermal insulation and energy saving must also be taken into account in their draft design in the future.