

LITERATURE

References

- [1] Nationales Klimaschutzprogramm 2000. In: Umwelt 11/2000, p. 571 ff.
- [2] Bott, Helmut: Zur Ästhetik der Energie-einspar-Architektur. In: Kongressdokumentation NiedrigEnergieBau Hamburg 1999, p. 65.
- [3] Sauerbruch, Matthias: Architektur beflügeln. In: Baumeister 2/2000, p. 31.
- [4] Eicke-Hennig, Werner: Niedrigenergiehäuser. Mehr gestalterische Qualität – mit weniger Energie. In: Deutsches Architektenblatt 6/1998, p. 806.
- [5] Herzog, Thomas: Wohlt temperierte Bunker. Über ökologisches Bauen und intelligente Gebäude. In: Deutsches Architektenblatt 5/98, p. 592.
- [6] Ingenhoven, Christoph: Die Eleganz der logischen Systeme. Die Architektur in einem ökologischen, ökonomischen, sozialen und kulturellen Netzwerk. In: Frankfurter Rundschau 27.03.99.
- [7] Kohler, Niklaus: Ist die Wärmeschutzverordnung wirklich das Ende der Baukunst, Herr Kohler? In: Baumeister 6/97, p. 5.
- [8] Fachregel für Dächer mit Abdichtungen – Flachdachrichtlinien. Compiled and published by the Zentralverband des Deutschen Dachdeckerhandwerks, the Fachverband Dach-, Wand- und Abdichtungstechnik e.V. and the Hauptverband der Deutschen Bauindustrie e.V. – Bundesfachabteilung Bauwerksabdichtung, September 2001.
- [9] Anforderungen für hinterlüftete Außenwandbekleidungen, see "Regelwerk des Deutschen Dachdeckerhandwerks, Hinweise für hinterlüftete Außenwandbekleidungen". Published by the Zentralverband des deutschen Dachdeckerhandwerks and the Fachverband Dach, Wand- und Abdichtungstechnik e.V., Cologne, March 1993.

[10] Loga, Tobias: PUR-Dämmung im Neu- und Altbau. Modellrechnungen zur neuen Energieeinsparverordnung. Published by IWU, Darmstadt, 2002.

[11] Ebel, Witta; Feist, Wolfgang; Loga, Tobias: Nachweisverfahren für den Passivhaus-Standard auf der Basis von Energiekennwerten LEG/Ph. Beschreibung des Verfahrens, Handrechenblätter. Published by IWU, Darmstadt, 1995.

[12] Industrierverband Polyurethan-Hartschaum e.V. (publisher): Ökobilanz von PUR-Hartschaum-Wärmedämmstoffen. Stuttgart, 2002.

Further reading

ASEW: Energiesparmaßnahmen an bestehenden Wohngebäuden. Publisher: Umweltbehörde Hamburg, Fachamt für Energie und Immissionsschutz, Hamburg, 1999.

ASEW: Das NiedrigEnergieHaus. Cologne, 1996.

Bundesministerium für Wirtschaft und Technologie: Energiepolitische und gesamtwirtschaftliche Bewertung eines 40%-Reduktionsszenarios. BMWi Documentation No. 492. Bonn, July 2000.

Burger, Helmut: Energieeinsparverordnung (EnEV 2000): Auf dem Weg zum großen Wurf. In: GREinform No. 22/February 2000, pp. 14-20.

Deutscher Bundestag, Referat für Öffentlichkeitsarbeit (publisher): Konzept Nachhaltigkeit. Vom Leitbild zur Umsetzung. Final report of the Enquête Commission "Protection of mankind and the environment" by the 13th German Bundestag. Bonn, 1998.

Eicke-Hennig, Werner: Energieeinsparverordnung 2001 – und Stand der Niedrigenergiebauweise. In: WKSB, new series 44/1999, pp. 1-16.

Gesellschaft für rationelle Energieverwendung e.V. (publisher): Energieeinsparung im Gebäudebestand – Bauliche und anlagentechnische Lösungen. Berlin, 2002.

Ders.: EnEV "2000" Verordnung in Gefahr? Ein GRE-Diskussionsforum. In: GREinform No. 27/June 2001, pp. 14-15.

Hausladen, Gerhard: Energieeinsparverordnung 2000. In: Isoliertechnik 3/2000, pp. 12-17.

Hegner, Hans Dieter: Die Energieeinsparverordnung 2000 – neue Perspektiven für Planung und Ausführung. In: Kongressdokumentation Fachkongress, NiedrigEnergieBau 99. Hamburg 1999.

Industrieverband Polyurethan-Hartschaum e.V. (publisher):
– Eigenschaften von PUR-Hartschaum-Wärmedämmstoffen. Stuttgart, 1998.

- Ökobilanz von PUR-Hartschaum-Wärmedämmstoffen. Stuttgart, 2002.
- Sommerlicher Wärmeschutz. Die wichtigsten Einflussfaktoren. Stuttgart, 2000.
- Verwertung (Recycling) und Entsorgung von PUR-Hartschaum-Abfällen. IVPU Nachrichten No. 54. Stuttgart, 1996.
- Starter Haus '98. IVPU reports No. 62. Stuttgart, 1998.
- „Werkzeuge“ für die energetische Optimierung eines Gebäudes. IVPU reports No. 68. Stuttgart, 1999.
- IVPU Resource architecture prize 2000 – documentation. Stuttgart, 2000.

IWU (publisher): Einsparungen beim Heizwärmebedarf – ein Schlüssel zum Klimaproblem. Darmstadt, 1995.

Kalksandstein-Information GmbH + CoKG (publisher): EnEV – Verordnung über energiesparenden Wärmeschutz und energiesparende Anlagentechnik bei Gebäuden (Referentenentwurf; Stand Juni 1999). Hannover, 1999.

Lenz-Architekten-Stuttgart: Wege zu einem nachhaltigen Bauen. Published by Industrieverband Polyurethan-Hartschaum e.V., Stuttgart, 1998.

Oertel, Günther: Polyurethane. In: Kunststoffhandbuch, vol. 7, 1993.

Oswalt, Philipp (publisher): Wohltemperierte Architektur: neue Techniken des energiesparenden Bauens. Heidelberg, 1994.

Tuschinski, Melita: Wärmetechnische Analysen zum Drei-Liter-Heizöl-Haus. In: IVPU reports No. 58. Published by Industrieverband Polyurethan-Hartschaum e.V., Stuttgart, 1998.

Wirtschaftsministerium Baden-Württemberg (publisher): Energiesparendes Bauen und gesundes Wohnen. Stuttgart, 1996.

LIST OF ILLUSTRATIONS

- Fig. 1* *Change in the maximum permissible heating requirements of buildings*
Source: GDI
- Fig. 2* *End-user energy consumption by sector*
Source: Arbeitsgemeinschaft Energiebilanzen: Nationales Klimaschutzprogramm verabschiedet. In: Umwelt 11/2000, p. 571 ff.
- Fig. 3* *CO₂ emissions by sector*
Source: Damit weniger in die Luft geht: Das neue Klimaschutzprogramm der Bundesregierung. (Publisher) Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit. Berlin, 2000.
- Fig. 4* *CO₂ reduction target of -25 %.*
Source: BMWi: Energie mit Zukunft
- Fig. 5* *Principle of balance between energy gains and energy losses in the Thermal Insulation Regulation 1995*
Source: IMPULS Programm Hessen, IWU
- Fig. 6* *Principle of balance between energy gains and energy losses in the Energy Saving Regulation*
Source: IMPULS Programm Hessen, IWU
- Fig. 7* *Different insulating materials and their insulating effect*
Source: IVPU
- Fig. 8* *SOLAR-LOFT, Braunschweig 2000*
Draft: D. E. Frahm and C. Neunzig, Architects, Braunschweig
Source: IVPU Architektur Preis 2000 ressource architektur – Dokumentation. Stuttgart, 2000
- Fig. 9* *Sport Toto, Basel*
Source: OKALUX GmbH, Marktheidenfeld
- Fig. 10* *Different requirement levels: Thermal Insulation Regulation and the Energy Saving Regulation*
Source: Hans Dieter Hegner: „Die Energieeinsparverordnung 2000 – neue Perspektiven für Planung und Ausführung“. In: Kongressdokumentation Fachkongress, NiedrigEnergieBau 99, Hamburg 1999
- Fig. 11* *Types of energy and balance boundaries*
Source: IMPULS Programm Hessen, IWU
- Fig. 12* *Primary energy evaluation of the energy sources (e_p values)*
Source: DIN V 4701-10, Section C 4.1 and EnEV, Appendix 1, Section 2.1.2
- Fig. 13* *Structure of the Energy Saving Regulation*
Source: Helmut Burger: "Handeln-Jetzt". In: GRE-inform 22/2000, p.15.
- Fig. 14* *Documentation procedure for the annual primary energy requirement according to The*

Energy Saving Regulation

Source: Feldhusen

- Fig. 15 *HOAI service phases and Energy Saving Regulation design*
Source: Eicke-Hennig, IMPULS Programm Hessen
- Fig. 16 *Requirements when changing external components of existing buildings*
Source: EnEV § 8, Appendix 3, Table 1
- Fig. 17 *Cell structure of polyurethane rigid foam*
Source: "Eigenschaften von PUR-Hartschaum-Wärmedämmstoffen". Stuttgart, 1998.
- Fig. 18 *Insulating material thicknesses as a function of thermal conductivity for a U-value of 0.20 W/(m² · K), ignoring heat transfer resistance*
Source: IVPU
- Fig. 19 *IVPU U-value recommendations for various components with corresponding polyurethane insulating material thicknesses*
Source: IVPU
- Fig. 20 *Polyurethane pitched roof insulation with air-tight layer on visible cladding*
Source: IVPU
- Fig. 21 *Polyurethane pitched roof insulation with an air-tight layer above the rafters*
Source: IVPU
- Fig. 22 *Polyurethane pitched roof insulation with an air-tight layer below the rafters*
Source: IVPU
- Fig. 23 *Polyurethane pitched roof insulation with plasterboard below the rafters*
Source: IVPU
- Fig. 24 *Thermal bridges caused by materials*
Source: IVPU
- Fig. 25 *Thermal bridges caused by geometry*
Source: IVPU
- Fig. 26 *Total cost (units for labor and material costs) of polyurethane rigid foam insulation over the rafters compared with WLG 040 insulation using a combination of between-rafter and under-rafter insulation*
Source: IVPU
- Fig. 27 *Flat roof with polyurethane rigid foam insulation*
Source: IVPU
- Fig. 28 *Laying polyurethane rigid foam insulating panels on a flat roof*
Source: IVPU
- Fig. 29 *Polyurethane composite thermal insulation system*
Source: IVPU
- Fig. 30 *Polyurethane passive house with a rear-ventilated façade*
Source: IVPU

- Fig. 31 *Core insulation with polyurethane rigid foam*
Source: IVPU
- Fig. 32 *Floor insulation with polyurethane rigid foam insulating boards*
Source: IVPU
- Fig. 33 *Laying polyurethane perimeter insulating boards*
Source: IVPU
- Fig. 34 *Perimeter insulation with polyurethane rigid foam*
Source: IVPU-Konstruktionsblatt 13, "Perimeter-Dämmung mit PUR-Hartschaum". Stuttgart, 2000
- Fig. 35 *Over-rafter insulation with polyurethane rigid foam insulating boards*
Source: IVPU
- Fig. 36 *Retrofitted insulation of the top floor ceiling with polyurethane rigid foam*
Source: IVPU
- Fig. 37 *Internal insulation with polyurethane rigid foam*
Source: IVPU
- Fig. 38 *Insulation of the basement ceiling with polyurethane rigid foam*
Source: IVPU
- Fig. 39 *Three-liter house of timber construction with polyurethane rigid foam insulation*
Source: IVPU Nachrichten No. 62
- Fig. 40 *Three-liter house with concrete wall panels as heat stores*
Draft: Prof. Josef Lenz, Stuttgart
Source: IVPU Nachrichten No. 62
- Fig. 41 *Paderborn single-family house (NEH standard)*
Architect: Prof. Josef Lenz, Stuttgart
Source: IVPU/IWU
- Fig. 42 *Terraced housing development – a low building with the quality of a single-family house*
Draft: Franz Xaver Lutz and Silvia Roos, Konstanz, Architects
Source: IVPU
- Fig. 43 *Polyurethane passive house in Schorndorf*
Architect: Prof. Josef Lenz, Stuttgart
Source: IVPU/IWU
- Fig. 44 *Semi-detached house in Bexbach (existing building)*
Source: IVPU/IWU
- Fig. 45 *Multi-family house in Frechen (existing building)*
Source: IVPU/IWU
- Fig. 46 *Paths to sustainable building*
Source: IVPU
- Fig. 47 *Stages in production and their contribution to the total energy consumption (in %)*
Source: "Ökobilanz von PUR-Hartschaum-Wärmedämmstoffen". Stuttgart, 2002

Fig. 48 Polyurethane particle board production

Source: IVPU Nachrichten No. 54

Fig. 49 Energy recovery from polyurethane rigid foam

Source: IVPU

DESIGN AIDS

Regulations

Act on Energy Saving in Buildings (Energieeinsparungsgesetz – EnEG) of July 22, 1976, amended by First Amending Act to the Energy Saving Act of June 20, 1980

Regulation on Energy-Saving Thermal Insulation for Buildings (Wärmeschutzverordnung – WärmeschutzV) of August 16, 1994

Regulation on Energy-Saving Requirements of Heating Systems and Hot Water Systems (Heizungsanlagen-Verordnung – HeizAnIV) of May 4, 1998

Act on the Priority of Renewable Energies (Erneubare-Energien-Gesetz – EEG) of April 1, 2000

Regulation on Power Generation from Biomass (Biomasse-Verordnung – BiomasseV) of June 21, 2001

Regulation on Energy-Saving Thermal Insulation and Energy-Saving Installation Engineering in Buildings (Energieeinsparverordnung – EnEV) of November 16, 2001

Standards

DIN EN 832, 1998-12 edition

Thermal performance of buildings – Calculation of energy use for heating; residential buildings; German version of EN 832:1998

DIN 1053-1, 1996-11 edition

Masonry – Part 1: Design and construction

DIN 4108-1, 1981-08 edition

Thermal insulation and energy saving in buildings; quantities and units

DIN 4108 supplement 2, 1998-08 edition

Thermal insulation and energy saving in buildings – thermal bridges – examples of design and construction

DIN 4108-2/A1 (draft standard), 2002-02 edition

Thermal insulation and energy saving in buildings – Part 2: Minimum thermal insulation requirements, amendment A1

DIN V 4108-4 (pre-standard), 2002-02 edition

Thermal insulation and energy saving in buildings – Part 4: Characteristics relating to thermal insulation and moisture protection

DIN V 4108-6 (pre-standard), 2000-11 edition

Thermal insulation and energy saving in buildings – Part 6: calculating the annual heating and heating energy requirement

DIN 4108-9 (draft), 2001-11 edition

Thermal insulation and energy saving in buildings – Part 9: Methods for calculating thermal insulation in summer – reducing solar heat contributions to buildings

DIN V 4108-10 (pre-standard), 2002-02 edition

Thermal insulation and energy saving in buildings – application-related requirements for thermal insulating materials – Part 10: factory-made thermal insulating materials

DIN V 4701-10 (pre-standard), 2001-02 edition

Energy efficiency of heating and ventilation systems – Part 10: Heating, drinking water heating, ventilation

DIN EN 12207, 2000-06 edition

Windows and doors – Air permeability – Classification; German version of EN 12207:99

DIN EN 13165

Thermal insulation materials for buildings – factory-made rigid polyurethane foam products

DIN 18195-1, 2000-08 edition

Water-proofing of buildings – Part 1: Principles, definitions, classification of types of sealing

Documentation procedures

The Energy Saving Regulation

Several computer-aided methods are now available. 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 IVPU, in collaboration with the Research Institute for Thermal Insulation (FIW), Munich, has developed a simple program that allows the test for energy reduction to be carried out quickly. The simplified documentation procedure is used 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.

Thermal insulation in summer

To limit solar heat contributions in summer, the IVPU has drawn up a form that facilitates calculation of the maximum permissible value and the actual value of solar contributions according to DIN 4108-9 (draft 1999-10) using the simplified documentation procedure. The form is published on the IVPU website at www.ivpu.de or can be ordered free of charge from the IVPU.

Construction drawings

The IVPU has published a number of construction drawings that provide specific information on the use of polyurethane rigid foam as thermal insulation in various components:

Construction drawing

- No. 4 Flat roofs
- No. 5 Terrace roofs
- No. 6 Parking areas
- No. 7 Floors, including floors with panel heating
- No. 8 Pre-insulated pipes
- No. 9 Pipe and tank insulation
- No. 12 Green flat roofs

No. 13 Perimeter insulation

The construction drawings are published on the IVPÜ website www.ivpu.de or can be requested free of charge from the IVPÜ. Further information and construction aids (texts for invitations to tender, heat insulation calculations, prices and delivery details) can be obtained from the IVPÜ member firms.

ISBN 3-932500-21-0

IVPÜ · Industrieverband Polyurethan-Hartschaum e.V. · Kriegerstrasse 17 · 70191 Stuttgart

Telephone +49 (0) 7 11 29 17 16 · Fax +49 (0) 7 11 29 49 02

E-mail: ivpu@ivpu.de · Website: www.ivpu.de