LOW ENERGY CERTIFICATE - PROPOSAL FOR A BUILDING ENERGY EFFICIENCY CERTIFICATE

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SUMMARY

The objective for the next years must be a significant reduction of energy consumption, together with an increasing awareness for the continuing rise of energy costs, increasing population and the need to save energy in order to reduce emissions. In a first step, it is essential to avoid not only an extreme increase of energy demand for heating and cooling, but also extreme peak loads, which can lead to a supply shortfall. Correct consideration of the requirements while planning the building's envelope, especially the façade is essential.

Therefore, a planning and control instrument including a certification system will be developed, which will enable both the architect and the authorising authority to apprise and assess the energetic behaviour of buildings using average technical expertise and at reasonable cost. For this, it is vital that that the basic physical structure of buildings be considered exclusively in respect to regional climatic conditions. Calculations must be based solely on the results of thermal balance equations. The assessment must be made unaffected by political and lobby influences, which often play a role: e.g. primary energy sourcing. This of course includes economic considerations, in which the investment costs for additional insulation are set against operating and maintenance costs.

The planning tool –LowEnergyCertificate- LEC provides architects and engineers to describe the energy demand for heating (only), heating and cooling and cooling (only) for different kind of buildings (residential, office and commercial buildings; new and existing buildings). Therefore they have the possibility to optimize the building envelope during the planning stage for the regional climatic conditions (actual available climate data are Europe, Turkey, USA, Russia, China; more climatic regions are in preparation). Additionally, a world wide comparability of the building energy standard is now possible by using LEC.kurzfassung

THE NEED FOR BEES (BUILDING ENERGY EFFICIENCY CERTIFICATES)

The urgent need for buildings resulting from economic development has led to impressive and remarkable forms of architecture, many of which have been designed and planned by architects with the regional perspectives.

Even so, it is often the case that neither prevailing climate conditions nor the availability of particular building materials have been properly accounted for.

This often stands in sharp contrast to the traditional development of structural design and construction methods, which are adapted to end use, locally available construction materials and building traditions.

Important aspects of housing and living traditions may be completely ignored. People often aspire to western models in terms of quality of life and lifestyle. This also applies to their living space and the architectural environment.

FIG. 1: Architecture and lifestyle in China

Problematically, the possibilities for the realisation of buildings and apartments differ.

Though buildings may conform externally to western models, they lack essential elements which account for the quality and serviceability of a building or apartment.

Often flats and offices are sold in a basic configuration, frequently without taking into account functionally important details such as

- adequate moisture proofing,
- sufficient drainage of roofs and façades,
- thermal insulation adapted to the climate conditions,
- measures to limit overheating in summer,
- a 100 % airtight building envelope,
- adequate sound insulation, especially for structure-borne sound,
- acoustic damping in rooms.

An example may help to illustrate this: according to western tradition, it is expected that a house, apartment or office will be equipped with central heating and can be cooled if necessary. In China, however, the installation of technical systems for heating and cooling is the responsibility of the tenant/buyer.

Thus individual, decentral air-conditioning units are generally used, and both heating and cooling are powered by electricity only, leading to extremely high peaks in power consumption.

The eyesores resulting from construction had done too hastily and under pressure also reveal substantial flaws in the quality of planning and execution. Energy-saving thermal insulation is often not taken into account or cannot be taken into consideration because of a lack of calculation models, which can be applied pragmatically.

Energy-saving thermal insulation ultimately helps to reduce energy demand for heating and cooling to an economically acceptable level.

With regard to operational costs, two objectives need to be addressed:

- energy demand for heating and cooling must be minimised (kWh price)
- it is vital to avoid extreme demand peaks (costs of providing capacity for peak usage)
- The energy demand for heating and the connection capacity requirement are mainly influenced by:
- heat loss by transmission through the building's envelope
- ventilation heat loss due to air exchange (airing of rooms)
- heat losses due to air leakage through gaps in the building's envelope

The energy and connection power required for cooling of a building are influenced by:

- internal loads
- heat gain by transmission
- solar heat gain
- latent heat due to condensation in the air-conditioning unit

One must bear in mind that inappropriate use can substantially increase demand and power required.

The objective for the next years must be a significant reduction of energy consumption per capita, together with an increasing awareness for the continuing rise of energy costs, increasing population and the need to save energy in order to reduce emissions.

The United Nations Framework Convention on Climate Change of 1992 [1], and the Kyoto Protocol to the United Nations Framework Convention on Climate Change of 1998 [2] are the groundwork for the reduction of greenhouse gases in CO2-equivalents for

- industrialized countries ('Annex B countries')at least 5 %
- EU-15 8 %
- Germany (EU burden sharing) 21 % by 2008 - 2012.

The year of reference for CO2, CH4, N2O, is 1990; for CFC, HCFC and CF6, it is either 1990 or 1995.

A further reduction of the emissions of greenhouse gases in CO2-equivalents by 2020 compared to 1990 is expected as a result of the follow-up agreement to the Kyoto Climate Protocol of the UN conference of Copenhagen in 2009.

This step was politically implemented by the on the total energy efficiency of buildings. In this time, different Building Energy Efficiency Certificates are used. For example:

LEED [3] - certificates by Platinum, gold, silver Levels. Basis is the Evaluation of buildings based on a credit system. The focusing on energy efficiency based on ASHRAE [4], with building guidelines but no calculation. The main focus is based on water and waste management, building materials, etc.

EnEV [5] - certificates by Energy Passport. This Certification system is used in Germany for the promotion of energy efficiency in buildings based on the guideline 2002/91/EG of the European Parliament and Council dealing with energy efficiency of buildings. The calculation tool is based on DIN 18599 [6], uses German climate conditions and regards the energy consumption of heating and cooling by HVAC Systems and lighting. A noticeable strengthening of requirements over EnEV 2001 is already being discussed. The requirements expected in EnEV 2009 are expected to be 30 % under those of EnEV 2007.

Based on experience, it is shown that the highly complex approach of the evaluation methodology involves extensive calculation work and, in the meantime, requires very specific knowledge in the fields of building physics and mechanical services.

In the process, the relation with the building and the optimisation of the building's envelope are often forgotten.

According to EnEV 2007, the energy balance for new buildings must be established first. From this, energy demand for the heating and cooling of rooms is determined. This process must take into account the efficiencies of heating, cooling and ventilation systems along with hot water provision and lighting. These calculations result in a figure for the building's power demand. Taking into account energy production with respect to CO2 emissions per kWh, this energy demand is declared to be the building's annual primary energy demand Qp,vorh and is compared with the maximum permissible annual primary energy demand Qp,max.

It's difficult for users, architects and engineers to ascertain directly possible improvements from the multitude of input parameters and to derive energetically and economically appropriate modifications.

What improvements are needed?

In a first step, it is essential to avoid not only an extreme increase of energy demand for heating and cooling, but also extreme peak loads, which can lead to a supply shortfall. Correct consideration of the requirements while planning the building's envelope, especially the façade is essential.

So a new planning and control instrument including a certification system will be developed, which will enable both the architect and the authorising authority to apprise and assess the energetic behaviour of buildings using average technical expertise and at reasonable cost. Nevertheless, this is definitely not possible by using the actual existing Building Energy Efficiency computer programs.

For this, it is vital that that the basic physical structure of buildings be considered exclusively in respect to regional climatic conditions. Calculations must be based solely on the results of thermal balance equations. The assessment must be made unaffected by political and lobby influences, which often play a role: e.g. primary energy sourcing.

This of course includes economic considerations, in which the investment costs for additional insulation are set against operating and maintenance costs.

An established method of verifying, ensuring and if necessary improving the quality and durability of buildings including building services is the use of quality control systems, which should include:

Step 1. Exclusively the building's envelope

Step 2. Exclusively the HVAC equipment

Step 3. Assessment of the quality of planning

Step 4. Assessment of the quality of execution

For the assessment and optimisation of the building's envelope (Step 1), a possible assessment system is proposed below, which comparatively easily, yet relatively accurately reflects the energetic quality of the building with respect to heating and cooling.

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The assessment for the heating period is based on a comparison with reference buildings built according to the standard of the 'eighties. Assessment of the cooling period is made by a comparison with an optimal façade, for which the criterion 'zero energy façade' has been defined.

Then, taking into account specified rating criteria, the results of the assessment of the energy demand for heating and cooling are summarised and attested. The certification of a building is in the form of a simplified star rating system.

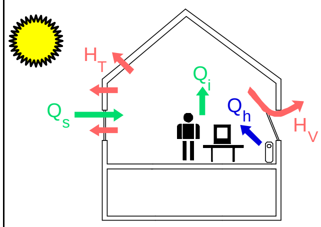
An increasing number of stars, analogue to the assessment criteria for hotels and gastronomy, instantly visualises the energetic quality of the building.

TABLE. 1: Certification - Standard of Buildings

1 *	Standard: very poor upgrades for Energy consumption in winter and/or summer obligatory
2 * *	Standard: poor upgrades for Energy consumption in winter and/or summer necessary
3 * * *	Standard: good upgrades for Energy consumption in winter and/or summer recommended
4 * * * *	Standard: very good Standard according to Building Standard in Europe 2007
5 * * * * *	Standard: excellent Standard according to *Low Energy* Buildings in Europe 2009

THE CERTIFICATION PROCEDURE

TABLE. 2: certification procedure

Object	Proof of the energy efficiency of buildings 
Calculated parameters	Service energy demand Qp - Energy demand of a building, needed to maintain the specified thermal conditions (heating, heating and cooling, cooling). The energy demand is a parameter of the building solely influenced by its structure and use, without consideration of the building services.
Assessment criteria	q_h - normalised thermal heat demand of the building q_{fc} - normalised energy demand of the building for cooling
Boundary conditions	Bases: DIN 4108 [7] – parts 2 + 6 and DIN V 18599 [6], with - climate (reference climate of the world climate regions) - geographic position (azimuth, surface normal) - use

	- construction method - thermal balance model with reasonable simplifications

Here, the energy balance of the building must be established, taking into account whether the building is heated only, heated and cooled, or cooled only.

TABLE . 3: boundary conditions

Type of building	Residential building; office and commercial buildings; other buildings
Age of the building	New buildings; existing buildings
Size of the building	V_e – Volume of the building – exterior dimensions
Construction	Lightweight construction: Buildings with suspended ceilings, lightweight partitions, hollow floors. This includes rooms with at least four of the six limiting surfaces (walls/floor/ceiling) separated from massive structural elements by cladding. Heavy construction: Buildings with solid concrete ceilings, heavyweight partitions, screed floors without cladding. This includes rooms mainly without cladding of the heavy internal structural elements. Structural elements, such as solid concrete ceilings, heavy partitions and screed floors must be in direct contact with the ambient air.
Air exchange	Residential buildings: venting day and night Office and commercial buildings: day venting with or without night venting
Construction materials	Construction materials are chosen according to Standards with respect to their density and thermal conductivity, with special consideration of their absorption, thermodynamic storage capacity, absorption, reflection and transmission behaviour with respect to radiation (transparent elements of the building's envelope)
Energy systems	Heating; heating and cooling; cooling
Climate Regions	Europe, Turkey, USA, Russia, China

THERMAL CALCULATIONS FOR THE BUILDING UNDER CONSIDERATION

Annual thermal heat demand

In the calculation of the annual thermal heat demand, the balance between heat losses and heat gains over the heating period (HP) is established.

A balance of the following energies is drawn up:

Heat losses:

- transmission heat losses through the building's envelope
- venting losses

- Heat gains:
- solar heat gains
- internal loads

Certification procedure Low Energy Certificate – heating period

The assessment of the considered building is made on the basis of a specified reference building. Geometry, climate region, orientation, azimuth, surface normal and use of the reference building correspond to those of the considered building, and to the Chinese building standard of the 'eighties with respect to structural design and construction elements.

For assessment and certification, the reduction of energy demand for heating is calculated from the difference between the annual thermal heat demands of the considered building and the reference building.

Annual energy demand for cooling

Estival temperature behaviour inside buildings

Requirements concerning thermal protection in summer aim at being able, as far as possible, to do without building services for cooling in non air-conditioned living and working spaces, and/or to reduce as far as possible the energy demand for cooling in rooms air-conditioned because of their utilisation. In particular, it should be ensured that the ambient temperature in non air-conditioned rooms does not significantly exceed physiologically bearable ambient air temperatures.

The comfort level defined for the summer in the German Standard DIN 4108-2 has proven to be sensible and reflects the region of barely tolerable indoor climate in the summertime very well.

The estival thermal protection implies high construction requirements, especially with regard to the type and size of façade glazing, and the shielding quality of shading devices. The so-called solar gain factor S’ is used to assess the estival thermal protection of a room.

TABLE. 4: Solar heat gains in Rooms

$S' = A_G \cdot g \cdot F_C$	S’… = solar gain factor A_G… = glazed surface area g... = total energy transmission coefficient of the glazing F_C... = reduction factor for the schading

Certification procedure Low Energy Certificate – cooling period

The assessment and certification of the estival behaviour of buildings is based on a simple method derived from the requirements of the German Standard DIN 4108-2 and specifically developed for China.

The criterion ‘zero cooling energy’ is defined for façades. A façade construction is described, whose interacting size of window, glazing properties, shading devices and glare shield limit the time in which given maximum temperatures are exceeded to a few hours per year. Increased internal loads and the possibility of reducing ambient air temperature by increased venting are not considered.

The threshold values were determined bearing in mind that this criterion should not lead to too great a reduction in daylight due to an unacceptably small area of window or reduced light transmission coefficients of special anti-sun glass.

A ‘zero cooling energy’ façade thus ensures that the rooms behind them do not overheat when not in use and therefore need not be cooled whether they are in use or not.

The product of the temperature excess and the corresponding time is used as a criterion for the threshold value for the ambient temperature (cf. DIN 4108 T2).

At this, one must bear in mind that in regions with low outside temperatures, e.g. the Harbin region, due to low nocturnal temperatures, cooling down, and therefore a lower mean daily temperature are more easily achieved than in regions with more constant climate, such as the Guangzhou region, where daytime and night-time temperatures are nearly equal.

The following parameters are calculated for a reference room, using a dynamic climate simulation. This is done with by a raddy state computermodel , for the calculation of heating and cooling performances and air temperatures..

TRNSYS [8] is a modular simulation software and can account for dynamic effects, for which the data can be taken from actual records. Special attention is paid to the ambient temperature resulting naturally, i.e. under the sole influence of inner and outer thermal influences, without heating and cooling. These form primarily an rating criterion for the thermal design of buildings with respect to energy saving and climate adapted building techniques.

Procedure

With this simulation model, the cooling energy demand for rooms that just meet the threshold criteria without cooling is determined for different solar gain factors: S', lightweight and heavyweight constructions, all four cardinal directions and each climate region in China.

The result of the calculations is the optimum solar gain factor S'_{opt}, parameter for the "zero cooling energy" façade.

The certificate is based on the factor S'_{opt}. An optimal design can be realised with its help.

Further, the specific energy demand for cooling per unit area respectively the specific cooling power per unit area required to dissipate solar heat gains can be determined from the difference between the actual S'_{act} value of the building and the optimal S'_{opt} values for the individual façades

Energetic assessment and/or classification of façades with respect to the total energy demand for cooling

The energetic quality of a façade is assessed using the following parameters:

- Specific energy demand for cooling of the façade per unit area (q_{FC} in kWh/m²a)
- Max. specific cooling power/connection power of the equipment, per unit area ($\dot{q}_{FC}$ in kWh/m²)

Energy demand for cooling and the cooling power are determined for different solar gain factors by a parameter study performed with the simulation model.

From these calculated values, a function describing q_{FC} and $\dot{q}_{FC}$ as a nearly linear function of the difference S'_{act} - S'_{opt} can be derived for the different climate regions of China and varying façade orientations. The gradient of this function is called *L* in the following. A negative factor *L* reduces the thermal storage behaviour of the building and, subsequently, the cooling energy demand in rooms with high internal loads.

Assessment of the building according to the Low Energy Certificate

Assessment is made for

- thermal insulation standard for winter
- estival thermal insulation

TABLE. 5: Standard of Buildings – Winter

1 * Building Standard before BEE - Requirements	= Energy consumption for heating MAX 100 – 69 %
2 * *	= Energy consumption for heating 70 - 49 %
3 * * *	= Energy consumption for heating 50 - 31 %
4 * * * * Building Standard Europe 2007	= Energy consumption for heating 30 - 21 %
5 * * * * * Low Energy Building Standard Europe 2009	= Energy consumption for heating MIN ≤ 20 %

TABLE. 6: Standard of Buildings – Summer

1 *	= Energy consumption for cooling MAX ≥ 170 %
2 * *	= Energy consumption for cooling 150 - 169 %
3 * * *	= Energy consumption for cooling 130 - 149 %
4 * * * *	= Energy consumption for cooling 115 - 129 %

5 * * * * * Standard Europe 2007/2009	= Energy consumption for cooling MIN ≤ 110 - 114%

Both standards are given in a summary and in the certificate.

Duration of heating and cooling periods is not considered here. This is done to avoid that, for example, a building with a poor standard for the cooling period gets a negative assessment although the cooling period is very short compared with the heating period.

TABLE. 7: Assessment - Standard of Buildings

Heating period	Q_G in $\frac{kWh}{a}$
Cooling period	Q_{FC} in $\frac{kWh}{a}$

TABLE. 8: Certification - Standard of Buildings

Certification - Result Example	Standard of Buildings Winter	Standard of Buildings Summer
3 * * *	3 * * *	4 * * * *
3 * * * etc.	5 * * * * *	3 * * *

FIG. 2: LEC – Low Energy Certificate

In arriving at the annual standard for the building, the lowest assessment / number of stars for the heating period and cooling period is decisive! The evaluation is done with interactive software.

CONCLUSION

The planning tool –LowEnergyCertificate- LEC provides architects and engineers to describe the energy demand for heating (only), heating and cooling and cooling (only) for different kind of buildings (residential, office and commercial buildings; new and existing buildings). Therefore they have the possibility to optimize the building envelope during the planning stage for the regional climatic conditions (actual available climate data are Europe, Turkey, USA, Russia, China; more climatic regions are in preparation). Additionally, a world wide comparability of the building energy standard is now possible by using LEC.

REFERENCES

[1] United Nations Framework Convention on Climate Change of 1992 - http://unfccc.int/resource/docs/convkp/conveng.pdf)

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