A simple calculation method for the energy performance of double skin facades

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ABSTRACT

Presently the assessment of the thermal behaviour and the energy efficiency of naturally ventilated double skin facades (DSF) is only possible by using complex simulation tools, which allow inter-connections between fluid dynamics, energy balances and optical transport mechanisms. The performance assessment of mechanically ventilated DSF is slightly easier but still requires simulation tools. Because of the interaction of separate calculation results, extensive iterations are often necessary. This makes it impossible to have reliable predictions on energy efficiency and impacts on comfort in the early planning phase and to sizable uncertainties at designers and investors.
Therefore an assessment method was developed in the IEE project BESTFACADE, which on the one hand can be integrated in the assessment methods of the EPBD and on the other hand offers sufficient accuracy of the thermal behaviour and the energy performance of the system. Similar to the standardised approach for the winter gardens, trombe walls and the ventilated building envelope parts of the ISO 13790, annex F, a monthly balanced calculation procedure was developed and evaluated based on sensitivity studies performed in earlier projects of the consortium partners. This calculation procedure harmonises with the currently developed CEN-Standards for the implementation of the EPBD. The main work consisted of the approximation of the airflow in the façade interspace and the adaptation of the utilisation factor of the solar gains to the different facade systems.

1. INTRODUCTION

Innovative façade concepts are today more relevant than ever. The demand for natural ventilation in commercial buildings is increasing due to growing environmental consciousness while at the same time energy consumption for buildings has to be reduced. An advanced façade should allow for a comfortable indoor climate, sound protection and good lighting, while minimising the demand for auxiliary energy input. Double skin façades (DSF) have become an important and increasing architectural element in office buildings over the last 15 years.

Figure 1. Example for a double skin façade building: The central library in Ulm, Germany.

Commercial and office buildings with integrated DSF can be very energy efficient buildings with all the good qualities listed above. However not all double skin façades built in the last years perform well. Far from it, in most cases large air conditioning systems have to compensate for summer overheating problems and the energy consumption badly exceeds the intended heating energy savings. Therefore the architectural trend has, in many cases, unnecessarily resulted in a step backwards regarding energy efficiency and the possible use of passive solar energy.
The EU IEE project BESTFACADE promotes the concept of well-performing double skin façades both in the field of legislation and of construction thus increasing investor's confidence in operating performance, investment and maintenance costs.

2. WHY A SIMPLE CALCULATION METHOD FOR THE ENERGY ASSESSMENT OF DOUBLE SKIN FACADES?

Presently the assessment of the thermal behaviour and the energy-efficiency of naturally ventilated double skin facades is only possible by using complex simulation tools, which allow interconnections between fluid dynamics, energy balances and optical transport mechanisms. The performance assessment of mechanically ventilated double skin facades is slightly easier but still

requires simulation tools. Because of the interaction of separate calculation results, extensive iterations are often necessary. This makes it impossible to have reliable predictions on energy efficiency and impacts on comfort in the early planning phase and to reduce uncertainties at designers and investors.
Therefore the goal of the BESTFACADE work package 4 was to develop an assessment method, which on the one hand can be integrated in the calculation methods of the EPBD (Energy Performance Building Directive) and on the other hand offers sufficient accuracy of the thermal behaviour and the energy performance of the system. Experience from innovations in the past has shown that it is helpful for the increased implementation of new technologies (to which the double skin facades still can be counted) to be assessable within the national energy performance assessment methods. An assessment method for the very early planning stage contributes to the reliability and therefore also the trust of the architects and clients into the technology.
The work in the BESTFACADE project foresaw the development of a method similar to the standardised approach for the wintergardens, trombe walls and the ventilated building envelope parts of the ISO 13790, annex F, which is a monthly balanced calculation procedure. It had to be evaluated based on sensitivity studies performed in earlier projects of the consortium partners. The calculation procedure had to harmonise with the currently developed CEN standards for the implementation of the EPBD. The results of the developed methods had to be compared to results from simulations.
The method shall then be applied in an energy design guide, an interactive usable internet tool for giving impressions on the influence of different façade types on the energy performance the zone behind the façade.

2. ANALYSIS OF EXISTING APPROACHES

The work started with the analysis of standards or guidelines, that are covering certain approches which may allow to be extended for calculating the energy performance of buildings with DSF systems. The analysis gave the following strengths and weaknesses for the choice of an appropriate standard for the BESTFACADE aproach.
- EN/ISO 13790: no DSF approach forseen so far, but as shown in the German DIN V 18599 the wintergarden approach in Annex F can be sufficient applied to DSF systems. A DSF extention is strongly recommended for this standard.
- ISO/FDIS 13789: this standard is not applicable to energy performance calculation as solar radiation is not considered in the calculation.
- DIN V 18599: the national German application of EN/ISO 13790 with an useful extention for DSF. The approach is recommended to be transferred as general method for DSF to EN/ISO 13790 (DIN Standard Committee, 2007).
- Platzer guideline: Comparable to the DIN V 18599 DSF approach but some physical weaknesses in the calculation of the solar gains through the outer façade. No added value compared to the DIN V 18599 approach. Therefore not recommended.
- WIS approach (EU project WIS): only steady state conditions are foreseen for the calculation, no whole year aproach with dynamic characteristics of façade systems. More a tool for calculating product characteristics. Therefore not applicable.
- EN 13830: this standards contains only definitions, no calculation procedures.
- EN 13947: this standard covers only procedures for calculating thermal characteristics; no solar, no energy. Therefore not applicable.
- ISO 15099: this standard covers calculation procedures for thermal, solar and optical characteristics for façade elements, but no energy nor coupling with building behaviour is foreseen. Therefore not applicable.
- ISO 18292: façade rating system on the base of the EN/ISO 13790 philosophy, but only for façade related paramenters of the energy balance. DSF applications can be used in the same way as in EN/ISO 13790.

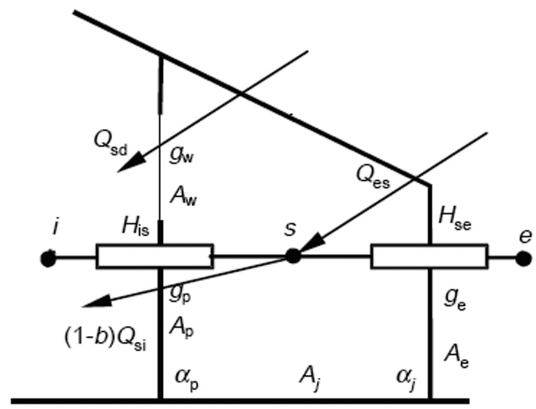


Figure 2. Wintergarden model out of EN/ISO 13790 and DIN V 18599.

The analysis made evident, that the BESTFACADE approach should be applied in EN/ISO 13790 in the way as done in DIN V 18599, but extended to all kinds of DSF systems. The facade system is regarded similar to the winter garden model (see figure 2). The influence factors have to be updated by the further work in the BESTFACADE project.

3. ANALYSIS OF EXISTING MEASUREMENTS

The chosen German standard generally uses a constant air change rate of 10 h^{-1} for naturally ventilated double skin facades throughout the year in order to be on the safe side for both heating and cooling issues. The next step was to analyse existing measurements and adapt the ventilation rate to different façade types, temperature, etc. The project partners could provide the following in detail measurements of double skin façade buildings:

- BiSoP Building in Baden, Austria
- VERU test facility in Holzkirchen, Germany
- Postcheque building, Vliet test building, Aula Magna building in Belgium

An example of the analysed data is given in figure 3 for the VERU test facility (see figure 4). Figure 5 presents the comparison of the net energy demand for heating, cooling and lighting between the measurement, the calculation with the DIN V 18599 approach with an air change rate of 10 h^{-1} and with the measured monthly average air change in the façade gap. The graphic shows that by using correct air change rates, the calculation with the German standard gives results very close to the measurements.

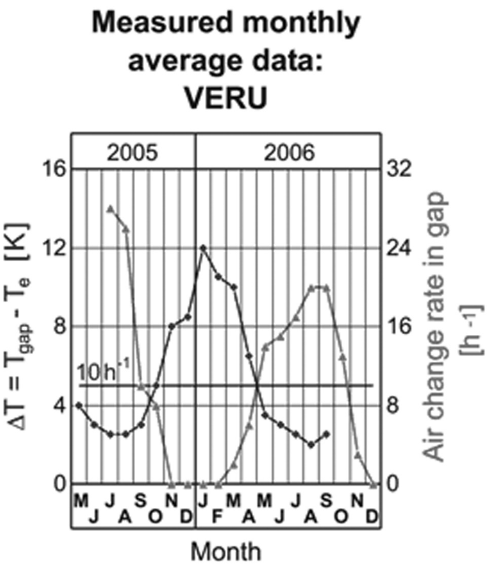


Figure 3. Measured monthly average data of the excess temperature and the air change rate in the façade gap at the test facility VERU.

Figure 4. Photo of the test facility VERU in Holzkirchen, Germany.

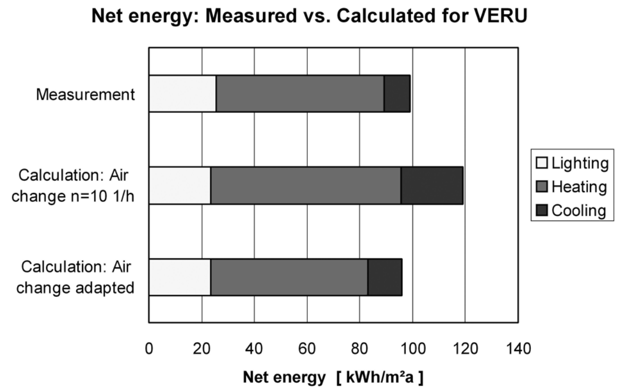


Figure 5. Comparison of the measured and calculated net energy demand according to DIN V 18599 with a standard ventillation rate and with monthly adapted ventilation rates.

4. DEFAULT VENTILATION RATES

The developed default values for ventilation rates in winter and summer for open and closed gaps are presented in table 1 and can be used for monthly calculation in middle European climates. As there were no monitoring results available from Northern and Southern European double skin façade buildings additional default values for these climate zones were not possible.

The project group has also prepared default values for the excess temperatures in the double skin facades which are included in the BESTFACADE WP4 report (Erhorn, 2007).

Table 1: Default air change rates for naturally ventilated façades.

Façade control strategy	(Default) air change rate [h^{-1}]	
	Summer (April–Oct.)	Winter (Nov.–March)
Open at all times	25	25
Adjustable flaps	25	4

Additionally there was a more detailed approximation of the ventilation heat transfer coefficient developed, which is dependant from various construction parameters like inlet and outlet characteristics and obstacles in the cavity (Hellström, B., 2007).

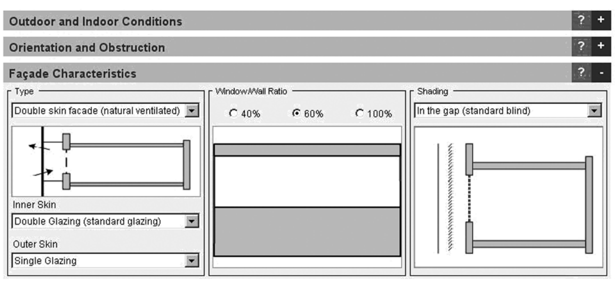
The simple method was validated by using simulation tools such as Energy Plus, Parasol and WIS.

5. APPLICATION OF THE METHOD IN AN INTERNET-BASED INFORMATION TOOL

The simple calculation method developed in the project is the basis for the BESTFACADE tool for the energy need and lighting autonomy in office rooms with different façade types. The simple to use tool is not thought for in detail calculative assessment but for giving first indications on the impact of different façade types on the heating, cooling and lighting energy demand. It is based on a lighting information and decision tool developed at Fraunhofer Institute of Building Physics for assessing the daylight availability and the electrical lighting demand for different façade types and was extended to heating and cooling energy demands in the participating European regions within the BESTFACADE project.

After choosing the European region (North, Central, South), the internal gains (standard, extended), the façade orientation and the possible linear obstruction, the user has to define the façade characteristics as presented in figure 7. This includes the façade types (single façade, double skin façade naturally ventilated and double skin façade mechanically ventilated), different types of glazings, different window wall ratios and various shading systems.

Figure 6. Screenshot of the start page of the BESTFACADE information tool.



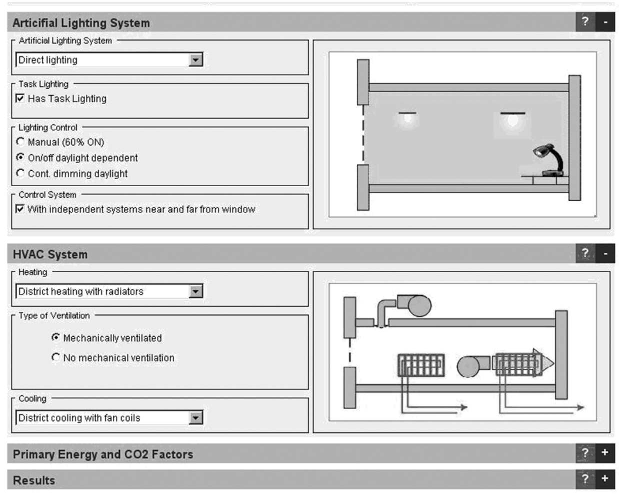


Figure 7. Screenshot of the BESTFACADE tool part definition of facades, lighting and HVAC systems.

The next step is the choice of the artificial lighting system (direct, indirect or direct/indirect, task lighting) and the lighting control (manual, daylight dependent, dimming, independent control near and far from the window). The offered HVAC systems include district heating with radiators or fan coils, mechanical or natural ventilation only and district cooling with fan coils or with cooling ceiling. The results are based on the simple calculation method developed within the BESTFACADE project and include net energy, final energy and primary energy demands for heating, cooling, lighting, ventilation and appliances as well as the CO_2 emissions. The lighting results are further elaborated by giving the relative annual luminuous efficiency at each point of the room plus the minimum and the maximum and the daylight autonomy of the office.

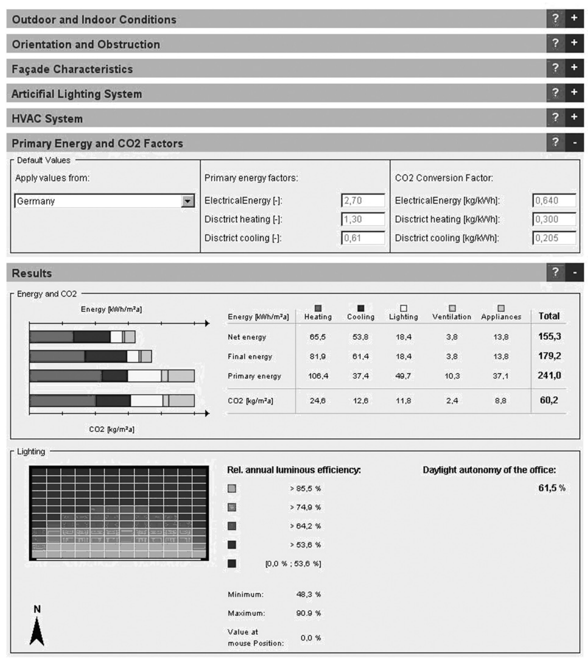


Figure 8. Screenshot of the BESTFACADE tool part definition of

the primary energy and CO_2 factors and results for energy, CO_2 and luminous efficiency and daylight autonomy.

6. CONCLUSIONS

The EU IEE BESTFACADE project has analysed various approaches for the energy performance assessment of double skin facades. The analysis made evident, that the BESTFACADE approach should be applied in EN/ISO 13790 in the way as done in DIN V 18599, but extended to different kinds of DSF systems. The major influence factor, the air change rate, was approximated for different façade types and temperatures based on measured data. The simplified assessment method was validated with simulation tools and applied at an internet based simple to use energy design guide for different façade systems during the early planning stage.
All results are described in detail in the BESTFACADE WP4 report (Erhorn, H., 2007) and are available on the project website.

ACKNOWLEDGEMENTS

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REFERENCES

All mentioned international and national standards are available at the national standardisation bodies.
DIN standard committee (2007). *DIN V 18599. www.beuth.de*
Erhorn, H. (ed.) (2007). *BESTFACADE WP 4 Report "Simple calculation method". www.bestfacade.com*
Energy need and lighting autonomy in rooms with different façade types. Internet-based information tool. www.bestfacade.com
Hellström, B. (2007). *Detailed ventilation heat transfer coefficient of a double skin façade.* Included in BESTFACADE WP4 Report "Simple calculation method". www.bestfacade.com.