BestFacade

Best Practice for Double Skin Facades

supported by

Intelligent Energy Europe

Agreement No: EIE/04/135/S07.38652

A ventilated double facade can be defined as a traditional single facade doubled inside or outside by a second, essentially glazed facade. Each of these two facades is commonly called a skin (whence the widely-used name "ventilated double-skin facade"). A ventilated cavity – having a width which can range from several centimetres at the narrowest to two metres for the widest accessible cavities – is located between these two skins.

BestFacade – Introduction

Best Practice for Double Skin Facades

Innovative facade 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 facade should allow for a comfortable indoor climate, sound protection, good lighting and a minimum demand for auxiliary energy input. Double skin facades (DSF) have become a major architectural element in office buildings over the last 15 years.

Description

Commercial buildings with integrated DSF can be very energy efficient buildings with all the good qualities listed above. However not all DSF 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 BestFacade project has aimed to create a best practice guideline to actively promote the energy efficient concepts of DSF. It is based on a comprehensive survey of DSF in Europe. Information on built examples of DSF in European office buildings has been collected, investigated and assessed. Using this guideline designers and investors can avoid application of non relevant concepts of DSF performing worse than traditional facades. The investor confidence concerning operating performance, investment and maintenance costs will thus increase.

A simple calculation method for national guidelines to estimate the energy demand and comfort parameters is developed. This method has been evaluated using measured and simulated data sets. Its aim is to be presented to the relevant CEN committees and to be integrated into assessment methods of the EBPD.

Target group

The project has a wide target range: different sectors and stakeholders of the building branch like owners, users, architects, engineers, manufacturing, production, management, design and consultant experts, the facade industry, HVAC industry, investors, contractors, standardisation bodies, authorities, knowledge providers (Universities, Research Centers).

Deliverables

The outcomes of the BestFacade project are miscellaneous. A project database of DSF in the European Union has been established. A design guide including best practice examples has been compiled, providing the target group with a common basic scientific, technical and economic knowledge on DSF. An assessment method has been developed, that offers sufficient accuracy of the thermal behaviour and the energy performance of the system and that is harmonised with the currently developed CEN-Standards for the implementation of the EPBD.

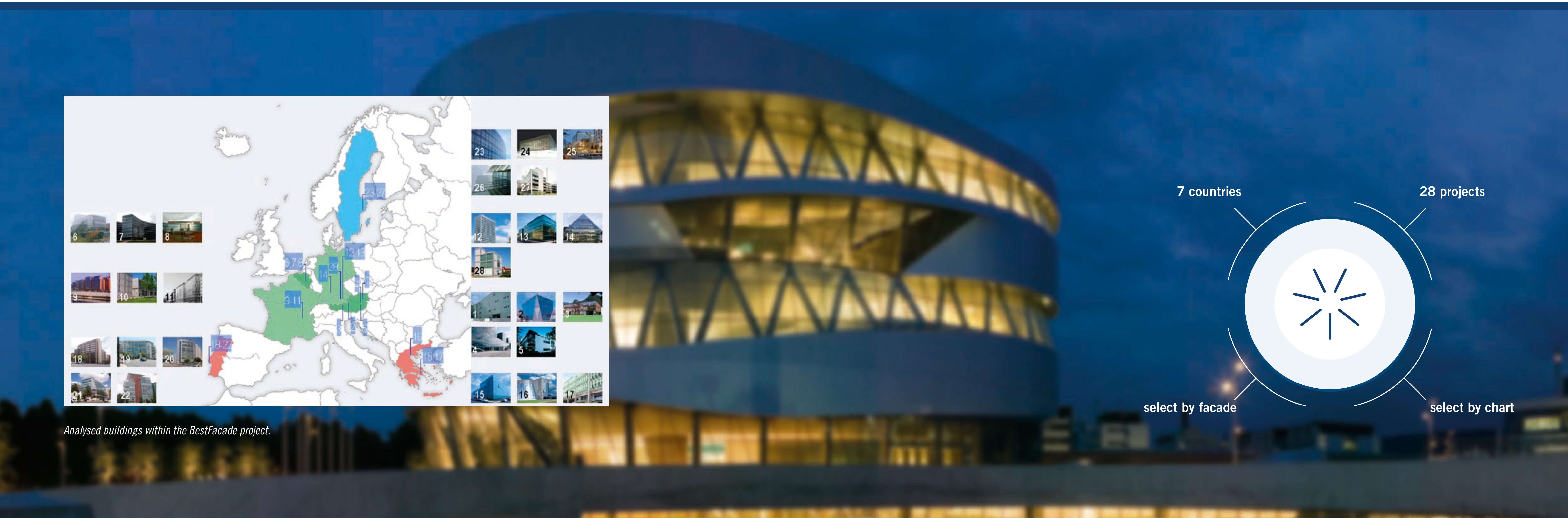
Benchmarks have been made available allowing users and operators to compare their energy consumption levels with others in the same group, set future targets and identify measures to reduce energy consumption.

Non-technological barriers and solutions to overcome them have been identified.

The dissemination strategy of the deliverables consits of a website, CD-Roms, workshops and presentations at conferences.

Tasks

The project is structured along eight main work packages (WP). WP1 "State of the Art" collects information on double skin facades (DSF) and issues like energy consumption, user acceptance, etc in different countries and climatic regions. In WP2 "Cutback of non-technological barriers" obstacles towards DSF are evaluated and strategies to overcome them are given. In WP3 "Benchmarks & Certification" benchmarks are created to compare different DSF. In WP4 a simple calculation method has been developed. WP5 "Best Practice Guidelines" provides a guidebook for the target group. WP6 "Dissemination" and WP 7 "Common dissemination activities" comprise publications of the outcomes and presentations on conferences, study days, etc.



Analysed buildings within the BestFacade project.

BestFacade – State of the Art

Best Practice for Double Skin Facades

WP1 was proposed as a starting point for the following work packages. Thus all partners have been involved into the design of the questionnaires according to the special needs of their work packages and have used their good contacts within the building scene to get data on implemented facades in their countries.

The architectural aspects of double skin facades (DSF) in Europe are discussed for their conception and glass architecture in general, the need of an integrated planning approach, lighting, the multitude of the city, environmental architecture, the facade as communication and sound attenuation.

Literature database

A centralised database containing literature about DSF has been extended in the framework of the WP1 serving as the knowledge base for further work in the BestFacade work packages such as non technological barriers, benchmarks, calculation method up to the dissemination activities.

After a first round in WP1 more than 360 articles, books, proceedings, diploma thesis and PhD thesis about DSF are available within the literature database.

A special four-language keyword list (English, French, Dutch and German) was developed to classify the literature by reducing and completing an existing list from the Belgian Building Research Institute (BBRI). This keyword list is the main feature for finding and using the literature database. The documents are sorted and evaluated by their authors, keywords, language and publication type, with the objective to make it as easy as possible to find a special document or documents about a special aspect of DSF.

The main function and advantage of this database is the possibility to get an efficient overview about the literature, ranked by keywords and their relevance in this document.

Analysis of 28 DSF in Europe

The main goal of WP1 was to analyse implemented DSF all over Europe.

Twenty-eight facades of different buildings in all partner countries of BestFacade have been studied by means of a standardized questionnaire.

The questionnaire comprises data on location, information about the building and the facade, construction and route of air flow in the facade as well as maintenance and costs. The analysis has been drawn for the aspects, types of facade in different countries, DSF in different climatic regions of Europe, existing simulations and measurements, thermal behaviour, indoor air quality, comfort, user acceptance, energy demand and consumptions, control strategies, integrated building technology, costs (investment, maintenance, operation), resource conservation, environmental impact, comparison to conventional glass facades, integration of renewable energy sources into DSF, and non-energy related issues: acoustics, aesthetics, fire protection, moisture, corrosion, durability, maintenance, and repair.

Most of the buildings are office buildings followed by schools and service buildings. Nearly all of the buildings have mechanical ventilation systems and the heating and cooling are performed most often by air heating/cooling systems. The types of facades are mainly multi-storey and corridor type, in Belgium juxtaposed modules are frequently used. The facade gaps are mostly naturally ventilated (except for Belgium, where the indoor air is led by mechanical ventilation via the gap to the centralized air handling unit).

The shading is performed mainly with Venetian blinds located in the gap. The cleaning of the outer shell is done mainly via a cradle or a lifting platform, the glazing of the gap is most often cleaned from the gap or from the interior.

Despite the fact that costs were not given for the buildings, investigated literature reviews and experiences of the participants show that DSF have about 400–800 €/m² higher cost compared to conventional single skin facades and about 300–500 €/m² compared to single skin glazed facades. Box window facades are not significantly more expensive compared to single skin facades.

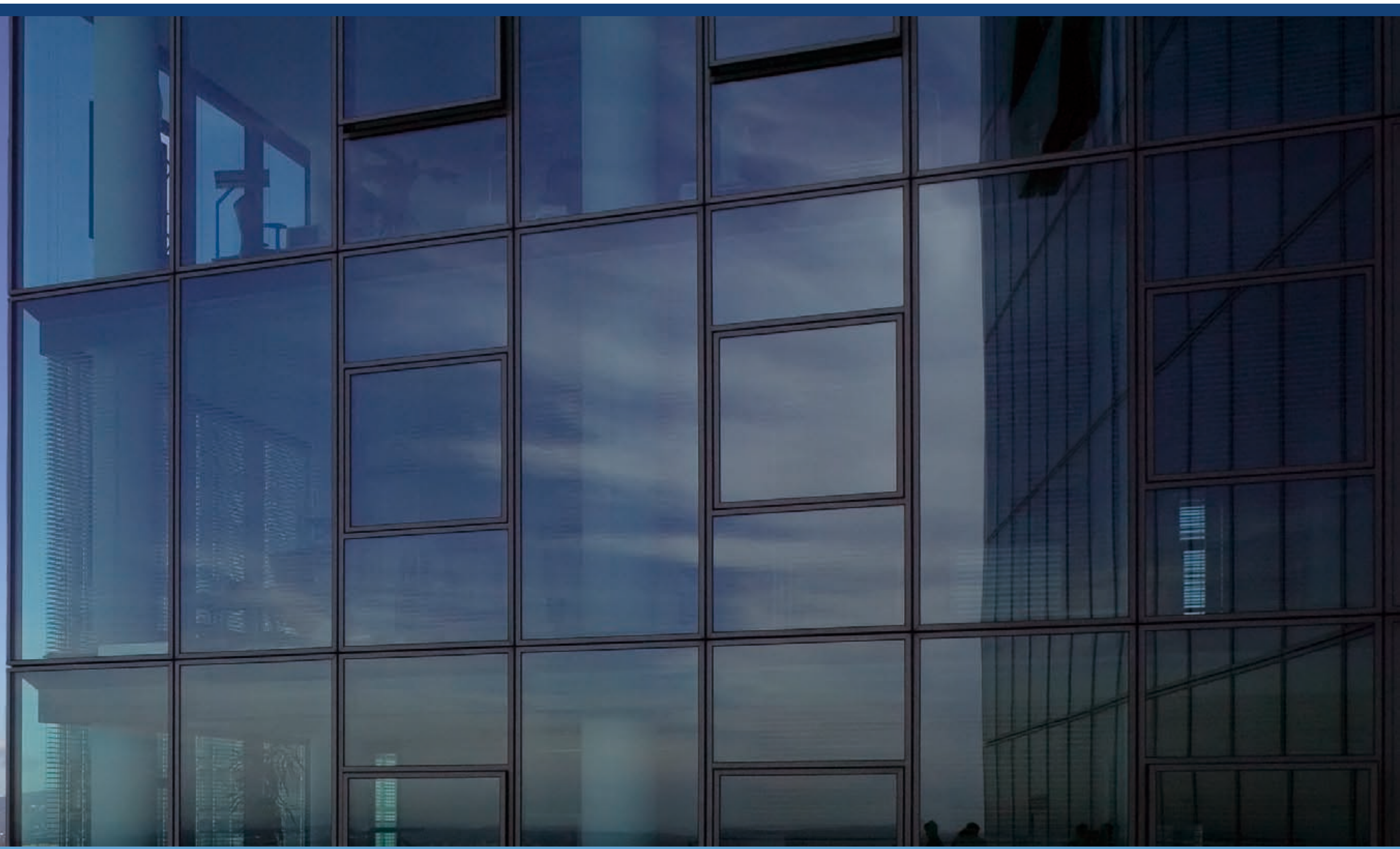
Unfortunately only little measured data of energy demand and temperatures in the gap and the rooms behind was available, because building managers are not easily willing to give away such sensible data. Nevertheless WP1 gives a comprehensive overview on the state of the art of double skin facades.

Summary

WP1 has provided input for most the other work packages.

By means of questionnaires all 7 partners have collected data from DSF in their country.

A database of buildings thus has been established, including existing simulations and measurements, thermal behaviour, indoor air quality, comfort, user acceptance, energy demand and consumptions, control strategies, integrated building technology, costs, acoustics, aesthetics, fire protection, moisture, corrosion, durability, maintenance, etc.



Best**Facade – Non-technological Barriers**

Best Practice for Double Skin Facades

The non-technological barriers to the application of double skin facades (DSF) were analysed in WP2 of the BestFacade project. These non-technological barriers are more difficult to overcome than technological barriers as they are not objective and differ from country to country.

In search of reasons

A questionnaire was developed in order to define the non-technological barriers and the factors that hinder or, in some cases, support the development of DSF in the different countries. The questionnaire forms the basis for a 'SWOT' analysis ('Strengths', 'Weakness', 'Opportunities' and 'Threats') – a methodology that analyses the barriers and limitations of a product in the market and identifies the advantages and disadvantages by comparing it with products of similar use. The investigated barriers concern aspects like legislation, finance, education, institutional and sociological behaviour. The results showed that due to the high number of different DSF concepts, some elements and legislation issues can be positive in a specific DSF design, and not for other.

It can be concluded that many 'non-technological barriers' prevent the application and development of DSF in the European market like the lack of legal standardized schemes, of knowledge regarding the design, performance, construction of the system, the lack of documented data on the built DSF buildings and the lack of financial support from the government and regional institutions.

The study also showed that there is skepticism in the scientific field concerning the energy efficiency of the system. Among the majority of the architects the reputation of the system is good mainly because of aesthetics reasons. Also, the reputation of the system is good in the building industry that tries to promote this type of facade but there is also concern because of the high investment cost. Although the benefits that DSF could provide in the energy and environmental performance of buildings via an appropriate design, it seems that their use is offset by the use of conventional facade systems because of the above mentioned reasons and the increased investment cost. Therefore, the study shows the need for the dissemination of knowledge on the system and its advantages and disadvantages, the documentation of best practice examples and the reduction of the construction cost.

Strategies to overcome

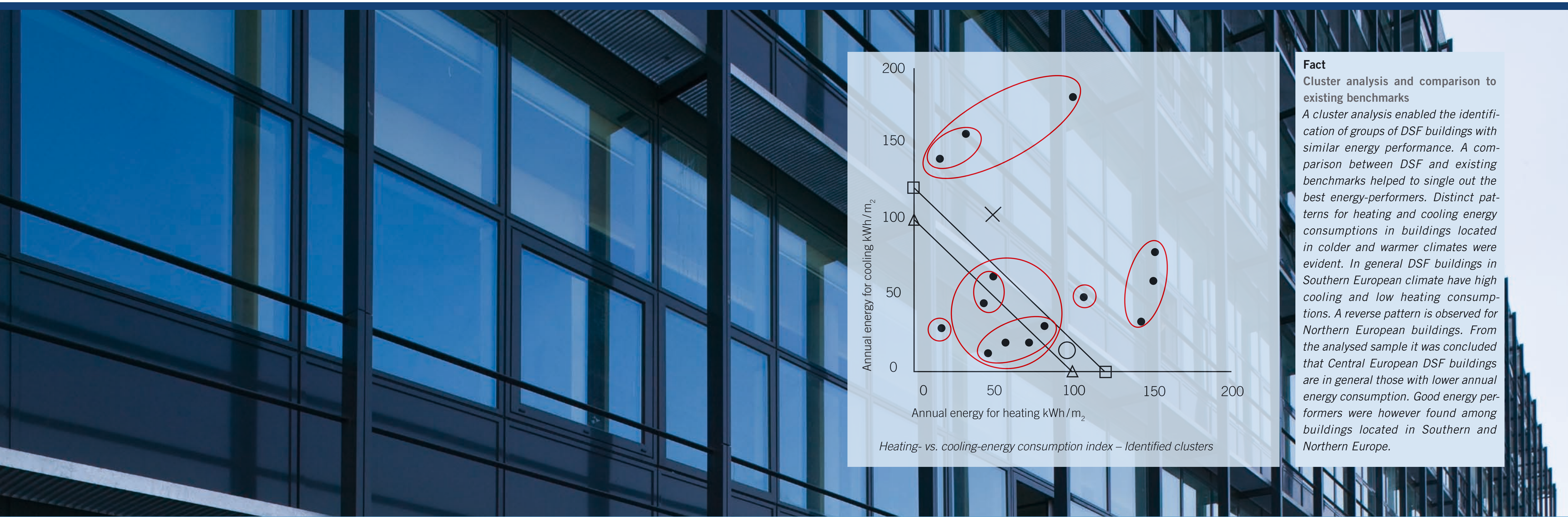
Further to the analysis, strategies to overcome these barriers are suggested, based on the answers of the questionnaires. It is suggested to follow a policy distinguished into 2 stages: the pre-assessment and post-assessment stage. In the pre-assessment stage the policy aims at providing the different target groups with all the necessary information on DSF to be able to define and check the performance of the system. Additionally, introducing homogenous legal schemes and simple calculation methods concerning DSF in all countries based on the EN standards. It also suggests the dissemination of the EN standards 13830 'Product Standard – Curtain Walling' and EN 13119:2004 that currently is the official legal document for DSF in use that specifies the characteristics of the system and provides technical information on the varying performance requirements throughout Europe. According to EN 13119:2004, a DSF is defined as: 'a curtain wall construction comprising an outer skin of glass and an inner wall constructed as a curtain wall that together with the outer skin provide the full function of a wall'. The EN standards list the facade specifications according to the requirements of the Construction Products Directive (CPD) leading to the CE marking for curtain walling (since 2005). Reliable documentation of good built DSF examples is important. Additionally, its dissemination can be performed in various ways, through seminars on national level, the internet, education at university level, publication of best practice examples in journals and the distribution of a best practice guideline with illustrations of built examples.

The post-assessment policy includes all actions that have to be taken into consideration after the DSF dissemination in order to support the product in the market. An appropriate marketing from the involved associations is essential. The documentation of DSF examples including real data of their energy and environmental performance along with operational and investment costs is necessary to increase reliability of the product and awareness among the target group.

Finally, support from the public and the government is always important in developing the DSF market; funding also is an essential motive for the promotion of the system.

Summary

The non-technological barriers to the double skin facade (DSF) are identified and analysed. These barriers concern aspects as legislation, finance, education, institutional and sociological-behavioral aspects. Further to the analysis, strategies to overcome these barriers are suggested. It is suggested to follow a policy that will be distinguished into two stages: the pre- and post-assessment stage.



Heating- vs. cooling-energy consumption index – Identified clusters

Fact

Cluster analysis and comparison to existing benchmarks

A cluster analysis enabled the identification of groups of DSF buildings with similar energy performance. A comparison between DSF and existing benchmarks helped to single out the best energy-performers. Distinct patterns for heating and cooling energy consumptions in buildings located in colder and warmer climates were evident. In general DSF buildings in Southern European climate have high cooling and low heating consumptions. A reverse pattern is observed for Northern European buildings. From the analysed sample it was concluded that Central European DSF buildings are in general those with lower annual energy consumption. Good energy performers were however found among buildings located in Southern and Northern Europe.

BestFacade – Benchmarks & Certification

Best Practice for Double Skin Facades

In spite of the acceptance gained among certain architects and promoters, and of the number of European buildings that were built using double skin facades (DSF) technology, the actual energy performance of DSF buildings is still lacking a more in-depth evaluation. The knowledge of actual energy performance of DSF buildings in most cases is limited and resides mainly within specialized organisations.

Energy benchmarking studies

The great variety in DSF typologies can justify wide variations in energy performance between different DSF buildings, and a typology that proves to be efficient for a certain climate can be inadequate for a different climate. Energy benchmarking studies enable highlighting the performance of different technologies. Benchmarking applied to DSF buildings not only identifies differences in the performance of facades, but also helps in the identification of the underlying causes of this difference and thus enables the identification of best practices. The work carried out within WP3 focuses on energy benchmarking and facade certification methods.

Planning phase

The necessary building data were defined during the early planning phase of the benchmark study. Questionnaires were prepared that enabled the collection of data on overall building characteristics, the HVAC system, internal gains, user comfort, detailed characteristics of the facade (shading devices, daylight control, etc.) and energy consumption. Having in mind the need to compare buildings of different dimensions, located in different climates and having a different HVAC system, typical energy performance indicators normalized per floor area, per climate and per primary to net energy efficiency were considered. Each participating country selected buildings, giving priority to "best performers" and with a wide range of DSF typologies.

Search & observation phase

The search for DSF buildings willing to participate in the energy benchmark study was a task much harder than initially thought. This fact was attributed to the building managers fear for loss of confidentiality. From the initial participating buildings, only about 50% returned energy consumption data (mostly energy bills), and only about 15% presented detailed energy consumption (heating, cooling, ventilation and lighting). Often it was simply impossible to split the costs for cooling, ventilation and lighting energy from the total costs for electricity.

Analysis phase

The lack of detailed energy consumption data led to the adoption of cluster analysis techniques. This methodology and comparisons between existing DSF energy consumptions data, existing European energy benchmarks and energy consumption data for single facade office buildings enabled the identification of the best-performing DSF buildings. Regarding the energy performance indicators, it was decided to normalize only per building floor area and to only compare buildings from the same climatic region.

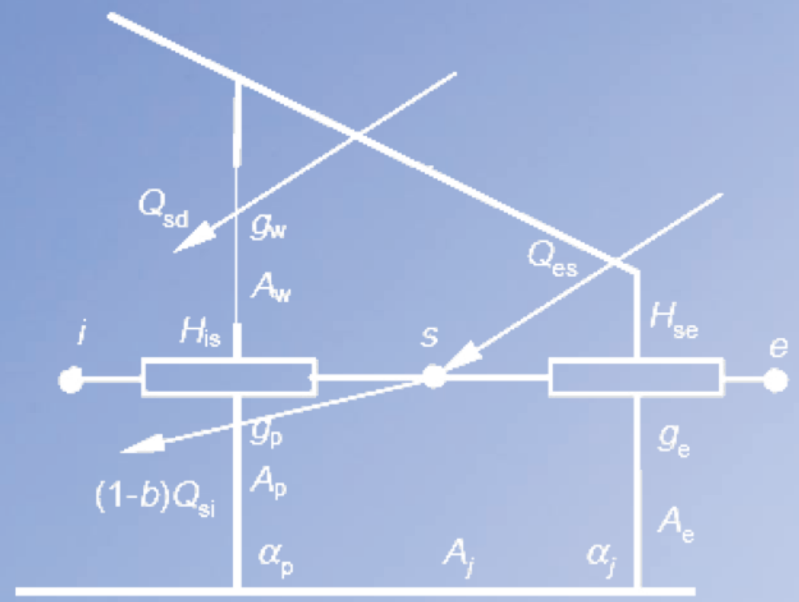
Certification method

The energy certification of office buildings, including DSF buildings, is defined by each European Member State based on the EPBD. In some European countries there is already a method implemented that considers the existence of designers and building owners on one side, experts responsible for the rating of the façade on the other side, and finally, at Member-State level, an overall supervision entity. The rating is based on a Reference Facade Method, which consists of the comparison of numerical energy performance results for the actual building, with the actual facade, and numerical energy performance results for the same building but considering a reference facade. The reference facade (or typical facade) is defined at Member State level.

Summary

Careful design can make double skin facades (DSF) buildings good energy performers.

Work performed within WP3 enabled the identification and the detailed analysis of DSF buildings with good energy performance. From these exemplary buildings best practices and energy benchmarks for Southern and Northern European climates were derived. A certification method for façades designated Reference Façade Method, is proposed. This method can be used to rate DSF and contribute to in the selection of better energy performing DSF.



The winter garden model out of EN/ISO 13790 was adapted for the calculation of the energy performance of double skin facades within the BestFacade project.

The VERU test facility for facade and building service systems and their components.

BestFacade – Simple Calculation Method and Energy Design Guide

Best Practice for Double Skin Facades

A Simple calculation method?

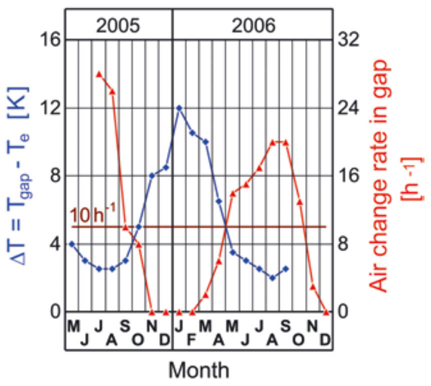
Presently the assessment of the thermal behaviour and the energy efficiency of naturally and mechanically ventilated double skin facades (DSF) is only possible by using complex simulation tools, which allow interconnections between fluid dynamics, energy balances and optical transport mechanisms. This makes it impossible to have reliable predictions in the early planning phase and to reduce uncertainties at designers and investors.

Analysis of existing approaches

The project group has reviewed the following existing approaches: EN/ISO 13790, ISO/FDIS 13789, DIN V 18599, the Platzer Double Skin Facade Guideline, the WIS approach, EN 13830, EN 13947, ISO 15099, ISO 18292. Most of the mentioned standards and guidelines could not be used because they either did not yet foresee the calculation of the system DSF, did not cover either the solar radiation or the energy calculation, are not coupled to the building, include only definitions or focus on a rating system. Others showed weaknesses in the calculation of the solar gains. The group decided to use the approach of the DIN V 18599, the national German application of EN/ISO 13790, with an useful extension for DSF. The facade system is regarded similar to the winter garden model.

Focus on air change rate

The chosen German standard uses a constant air change rate of 10 h^{-1} for naturally ventilated DSF 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 facade types, temperature, etc.



Measured monthly average data: VERU

Temperature/ventilation rates

Calculation of the temperature in the facade gap (according to DIN V 18599):

$$\vartheta_s = \frac{\Phi_{gain} + \vartheta_i(H_{T,is} + H_{V,is}) + \vartheta_e(H_{T,se} + H_{V,se})}{H_{T,is} + H_{V,is} + H_{T,se} + H_{V,se}}$$

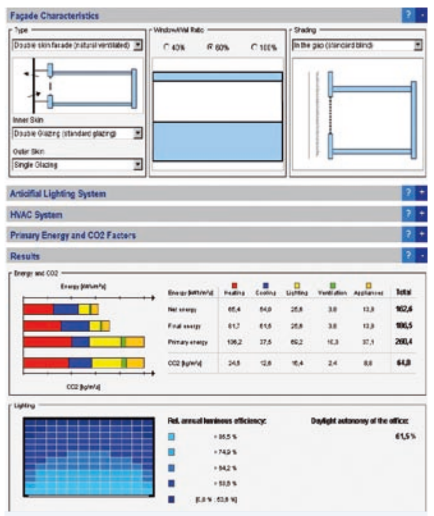
	(Default) air change rate h^{-1}	
	Summer (April – Oct.)	Winter (Nov. – March)
Facade control strategy		
Open at all times	25	25
Adjustable flaps	25	4

Table of default air change rates for naturally ventilated facades.

The simple calculation model has been validated with simulation tools such as Energy plus, Parasol and WIS.

Energy design guide

The simple calculation method using the approximation of the air change rates have been applied in an energy design guide, an internet-based tool for different facade types at an early planning stage. Unlike a design tool it is simple to use and it gives information on the influence of different facade strategies on the net, final and primary energy as well as the CO_2 emissions and more specific lighting results.

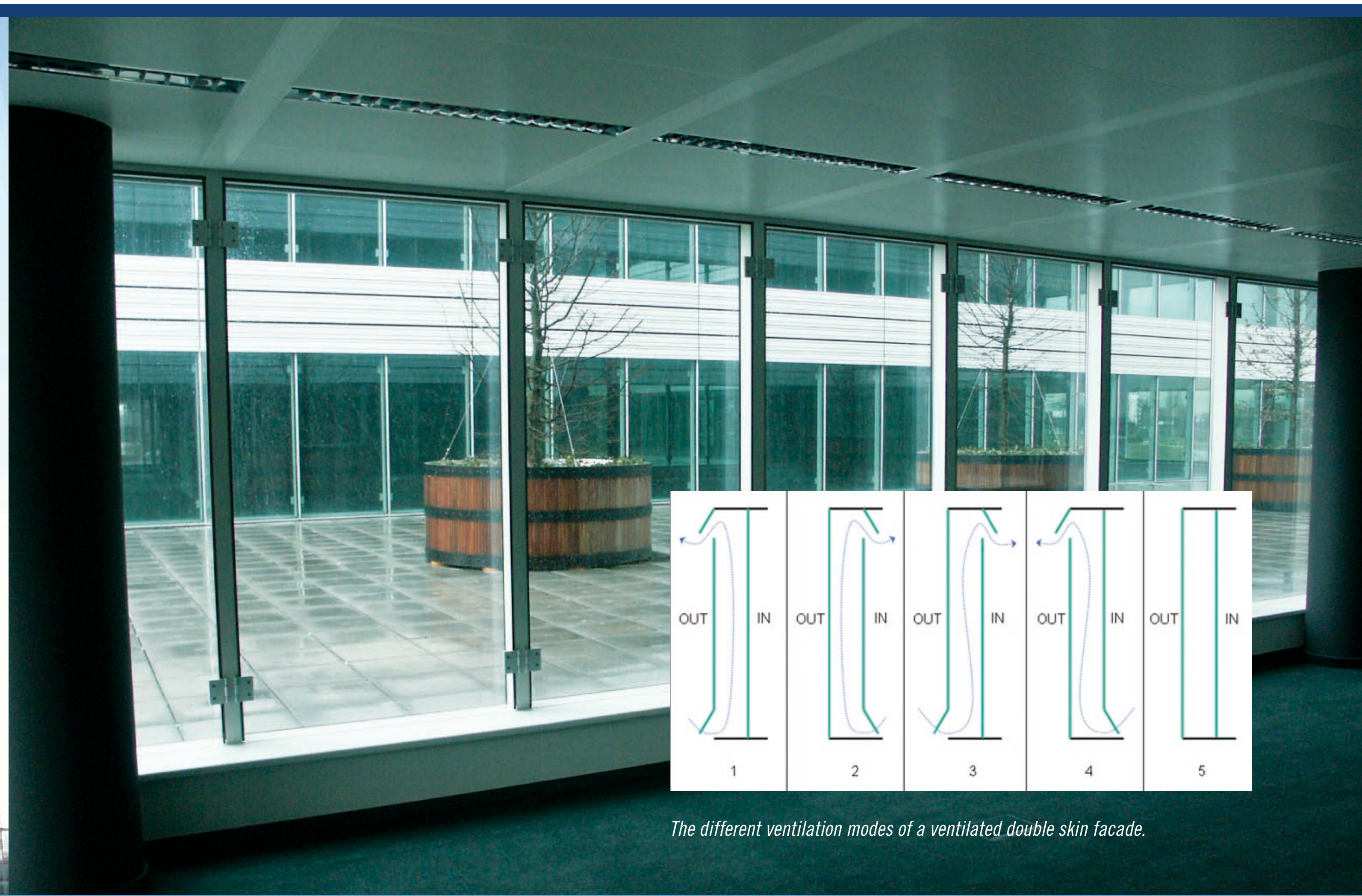


Screenshot of the energy design guide tool.

Summary

The BestFacade project analysed various approaches for the energy performance assessment of double skin facades (DSF). 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 major influence factor, the air change rate, was approximated for different facade types and temperatures based on measured data. The simple assessment method was validated with simulation tools and applied at an internet-based, simple to use, energy design guide for different facade systems during the early planning stage.

All results are described in detail in the WP4 report and are available on the project website.



The different ventilation modes of a ventilated double skin facade.

BestFacade – Best Practice Guidelines

Best Practice for Double Skin Facades

Many modern office buildings have highly glazed facades. However, their performance is being questioned, especially in terms of energy use and indoor climate.

Therefore more and more of these buildings are being built with double skin facades (DSF), which can provide improvements such as a thermal buffer zone, energy savings, wind protection with open windows, fire protection, aesthetics, solar preheating of ventilation air, sound protection, night cooling and a site for incorporation of PV cells.

However not all DSF built perform well. Far from it, in many cases large air conditioning systems have to compensate for summer overheating problems and the energy consumption 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.

Objectives of the guidelines

The best practice guidelines aim at offering information supporting in the design, choice, implementation and management of energy efficient and healthy office buildings with DSF.

The guideline consists of three parts:

1) Fundamentals: common basic scientific, technical and economic knowledge on DSF is provided.

2) Applications: detailed practical information in order to design, choose, manage, use and maintain first of all DSF but also buildings with DSF is provided.

3) Tools: general information on tools, review of simulation tools and existing standards is given. The simple calculation method is described.

1. Fundamentals

1.1. Architecture

No other building material has during the last two decades experienced such an innovative increase as glass. It has evolved into a high-tech product that in its right use can create slender and bold constructions. Architecturally an airy, transparent and light building is created, where the access to daylight is higher than in more traditionally built office buildings. The idea is often to create a building with openness and to give an impression of the future. The complete transparency also shows a corporate will of communication and openness towards society outside.

The daylight and its positive effects on humans have always been a main ingredient in architecture. However, careful planning is necessary for a glazed facade with the amount of light that is allowed into the building. If glass architecture is to survive it must limit its influence on energy losses by new innovative solutions.

1.2. Technology

Classification

A ventilated DSF can be defined as a traditional single facade doubled inside or outside by a second, essentially glazed facade. A ventilated cavity – with a width from 10 centimeters at the narrowest to 2 meters for the widest accessible cavities - is located between these two skins.

The cavity can be ventilated with natural, mechanical or hybrid ventilation.

The DSF can be classified as follows:

- Ventilated double window
- Facade partitioned per storey with juxtaposed modules
- Facade partitioned per storey-corridor type
- Shaft-box façade
- Multi-storey façade
- Multi-storey louver façade

The application is often new construction, but can also be refurbishment.

Glass type

The choice of the glass type for the interior and exterior panes depends on the type of facade. In case of a facade ventilated with outdoor air, an insulating pane (=thermal break) is usually placed at the interior side and a single glazing at the exterior side.

In case of a facade ventilated with indoor air, the insulating pane is usually placed at the exterior side, the single glazing at the interior side.

Shading device

The shading device is placed inside the cavity for protective reasons. Openings in the external and internal skin allow the ventilation of the cavity. The choice of pane type, shading device, geometry of the cavity, and type, size and positioning of interior and exterior openings of the cavity and ventilation strategy is crucial for the performance of a DSF system.

Daylight

The high daylight access for a building with DSF, combined with an intelligent lighting control system, may lead to important savings in use of electricity for lighting.

However this high daylight availability can cause glare problems and be responsible for visual discomfort.

1.3. Costs

An important factor when choosing a facade system is the cost of the facade and the entire building. Today usually the investment cost and not the life cycle cost is considered. Only taking into account the investment cost often results in a facade system and building that just fulfils the requirements of the building code at the lowest investment costs.

A DSF is usually more expensive than a single skin, at least considering the investment cost.

Justification of its inclusion in a building design can be based on energy efficiency and associated cost savings. Qualitative benefits of solar control, moderated surface temperatures, noise reduction, reduced glare, reduced heating/cooling demand, aesthetic purity and increased daylighting are generally seen only as intangible 'bonus' benefits. Preferably the cost of the entire building is taken into consideration, in order to avoid sub optimisation. A well designed DSF can result in lower operating cost (mainly lower energy costs compared with a glazed single skin facade). The cleaning costs for the facade can be higher.

The great challenge for a glazed office building (single and double skin) is to optimise energy use, use of daylight, visual and thermal comfort at a reasonable investment and life cycle cost. Office buildings with glazed facades risk having a higher use of energy for cooling and heating than an office with a traditional façade. A single glazed facade increases the risk for an unsatisfying thermal comfort close to the facade and glare further inside the building. A DSF will lower these risks. Glazed buildings require more planning and have less tolerance for design and construction errors.

DSF can provide: a thermal buffer zone, energy savings, wind protection with open windows, fire protection, aesthetics, solar preheating of ventilation air, sound protection, night cooling and a site for incorporation of PV cells.

2. Applications

In order to arrive at a glazed DSF office building with a reasonable energy use, good thermal and visual comfort the following actions are required during the building process:

- a comprehensive view must be applied to the building.
- energy and indoor climate simulations are carried out starting already during the brief phase and then being refined during the building process.
- energy use and environmental requirements as performance specifications are drafted in the brief.
- there is an energy and environmental coordinator from the brief phase until the first year of operation.
- a governing quality and environmental program with performance requirements is worked out starting already during the brief phase, and is refined during the building process.
- good cooperation between designers to ensure a well performing system: architecture, HVAC, structural engineering, electrical engineering and building physics.
- good cooperation between client, designers and contractors.
- a life cycle cost analysis is carried out to avoid prioritising investment costs and neglecting operating, maintenance and energy costs.
- a separate performance specification is worked out for the DSF based on analysis of the entire building, to avoid sub optimisation and then refined during the design.

Best**Facade – Best Practice Guidelines**

Best Practice for Double Skin Facades

Case studies – predicted performance

The energy and indoor climate performance is very dependant on the climate. A design of an highly glazed DSF building, which is optimal for Sweden will not work very well in e.g. Portugal and the contrary. However, for a highly glazed office a DSF is usually preferable to a single skin.

Performance specifications

The performance specifications for the DSF must cover the following aspects:

Building physics

- Influence of the climate on inner and outer skin
- Energy conservation
- Thermal comfort
- Sound insulation
- Fire protection
- Light

Technology

- System – method of production
- Material in outer and inner skin
- Glazing
- Safety
- Shading devices
- Air cavity
- Cleaning and service devices
- Costs

Building process planning

Operation and maintenance

To ensure optimal operation of a building with a DSF, it is crucial to have an intelligent control system for the DSF and the installations of the building, and a usable and user friendly building energy management system (BEMS).

Some remarks on how to succeed

How to succeed during design:

- The internal gains must be minimized.
- Increasing the glazed area results in increased risk and lowered tolerance for errors.
- Special attention has to be paid to corner rooms with two glazed facades.
- U- , g- and τ_v -values have to be chosen correctly. These values do of course depend upon many factors e.g. the climate, the size and shape of the building, the size, type and orientation of the glazed areas and the geometry and ventilation of the cavity of the DSF. A thorough analysis is required to determine these values.
- An appropriate control strategy for ventilation and solar shading of the DSF has to be chosen.

3. Energy indoor climate tools

The modelling of ventilated DSF or a building with a DSF is a complex task. The choice of the most appropriate software for simulation depends on the objective of the simulations. For the pre-design the simple calculation method developed within the BestFacade project can be used to make a first decision concerning the type of facade and to make an energy performance certificate. There are tools for simulation of the DSF and there are building energy simulation programs capable of simulating a ventilated DSF. During the detailed design the role of simulation is important. Simulation represents the only method to predict the yearly energy consumption to dimension a building equipped with a ventilated DSF and to assess the impact of different control systems and control strategies on the building performance.

Conclusions

There is a high interest to design and build glazed office buildings with DSF. The buildings can be high-rise and low-rise, mainly office buildings. The buildings usually have highly glazed facades. The application is often new construction, but can also be refurbishment of existing facades. If the starting point is a glazed building, then with proper design adding a second skin can result in energy savings (heating and cooling) and improved thermal and visual comfort, improved sound attenuation and protected "exterior" solar shading. However, the DSF are often more expensive than single skin facades, which can be compensated for by a reduction in use of energy. For a building, which is not highly glazed and with a high level of thermal insulation, the energy use for heating and cooling is likely to be lower, than for a highly glazed building with a DSF.

In order to ensure a well performing, in terms of energy use and indoor climate, building with a DSF, simulations of the DSF and building using a validated tool are necessary. The best practice guidelines for DSF provide information supporting in the choice, design, implementation and management of office buildings with DSF.

Summary

WP5 provides the Best Practice Guidelines divided into 3 main parts: fundamentals, applications and tools. The first part handels architectural and technological issues. The 2nd part covers the performance specifications of the double skin facade (DSF). The final part discusses the modelling of the energy consumption and the indoor climate.

The aim of the guidelines is to enable/promote the design of well performing DSF in accordance with the building that compensates the higher investment costs by a reduction in the use of energy.

BestFacade – Partners

Best Practice for Double Skin Facades

MCE Anlagenbau Austria

Graz University of Technology – Institute of Thermal Engineering

Fraunhofer Institute of Building Physics

National and Kapodistrian University of Athens

C.Kiossefidis S.A.

Instituto de Soldadura e Qualidade

ENTPE-Laboratoire Sciences

Lund University

Belgian Building Research Institute

Reynaers Aluminium NV

WSP Sverige AB

Skanska Teknik AB