BESTFAÇADE

Best Practice for Double Skin Façades

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WP2 Report 'Cut back of non-technological barriers'

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1 Introduction

This report is the deliverable of work package 2 of the "Best Practice for Double Skin Facades" project. The aim of the report is to describe the cut back of non-technological barriers to the application of Double Skin Facades (DSF). These non-technological barriers are more difficult to overcome than technological barriers due to the fact that the factors which govern them are not objective and differ from country to country.

The report comprises two parts:

In the first part the non technological barriers are identified and analysed. These concern aspects as legislation, financial aspects, institutional aspects sociological-behavioral aspects, educational aspects and institutional aspects. As part of this action a questionnaire was completed by each partner describing the above factors that hinder or, in some cases, promote the development of double skin facades in their countries respectively.

The analysis aimed at a broad approach, however, there is not always easy to summarize the advantages and disadvantages of DSF in a questionnaire. This is due to the high number of different DSF concepts, some elements can be positive in a specific DSF design, and not for other. The questionnaire with all answers from the partners is included in the appendix.

Also, the architectural and engineering aspects of double skin facades are presented.

In the second part of the report strategies to overcome these barriers are suggested. The proposed strategies are based on the answers of the questionnaires. It is suggested to follow a policy that will be distinguished into two stages: the pre-assessment and post-assessment stage in order to cover all issues defined in the first part of the analysis.

2 PART 1- Description of the questionnaire

A questionnaire was developed within the first part of work package 2 identifying the non-technological barriers to DSF. The questionnaire forms the basis for a SWOT analysis. SWOT analysis is a methodology that analyses the barriers and limitations of a product in the market. It is a means to identify the advantages and disadvantages of the product and thus the range of its applicability.

SWOT is an abbreviation of 'Strengths', 'Weakness', 'Opportunities' and 'Threats'.

The issues 'Strengths' and 'Weaknesses' study *internal* resources of the product (in this case double skin façade systems) by comparing it with other products of the same type (in this case with conventional façade systems)
Key questions of this group of questions are the following:
What are the main advantages of double skin facades compared to conventional façade systems?
What are the main disadvantages of double skin facades compared to conventional façade systems?

The issues 'Opportunities' and 'Threats' analyse *external* resources that have an impact on the applicability and use of the product like as sociological and behavioral aspects, legislation etc.
Key questions of this group of questions are the following:
What are the major opportunities posed by the outside world for double skin façade systems?
What are the main threats to double skin façade systems from the outside world?
The 'SWOT' principle could be presented in the following scheme:

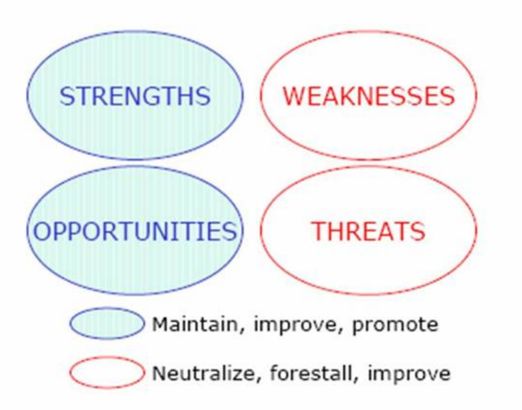

Figure 1: SWOT analysis principle Source: European programme 'RESHYVENT' Work package 2

The questionnaire, developed within WP2 of the BESTFAÇADE project, studies whether the investigated issues consist of an opportunity/strength or threat/problem for double skin facades in the BESTFACADE participating countries. The questions are split into the following five categories:

- Legislation
- Knowledge
- Financial aspects
- Sociological and Behavioral aspects
- Institutional aspects

More specifically:
The 'Legislation' section includes questions regarding the existence of legislation in each participating country for double skin facades in terms of sound and fire protection, ventilation requirements, thermal requirements and energy issues.
The 'Knowledge' section includes questions on the level of knowledge on the typology, design and construction of double skin facades. Additionally, the participating countries are asked to comment on the level of knowledge on the advantages and disadvantages of double facades compared to conventional facades and on the availability of built examples in their countries.
The 'Financial aspects' section includes questions regarding the level of knowledge on the cost of double skin facades compared to traditional facades and the availability of funding schemes.
The 'Sociological and Behavioral aspects' section includes questions regarding the applicability of double skin facades in each country according to their climatic conditions, local architecture, the use of buildings and the significance of the occupant control for ventilation in specific climatic conditions. Additionally, the reputation of double skin facade is investigated in each country-member.
The questions of the 'Institutional aspects' section investigate the existence of governmental and regional support and the required bureaucracy for the double skin facade technology.

The questions are distinguished into 2 types:
Questions dealing with objective issues, i.e. legislation, and
Questions dealing with subjective issues i.e. level on knowledge.
As the investigation aims at identifying the non-technological barriers in the whole of each country, at first stage, the questionnaire circulated within the bestfaçade members and then additional feedback was provided by external group according to the nature of questions.
The questions dealing with subjective issues were addressed at a target group that in overall was split into:

- scientific group/educational institutions (mainly with the members of the Best Facade project)

- building industry/ construction
- architects
- any other group (optional , i.e. investors, building owners)

Following all questions of each category are described along with the answers of each partner regarding the status of the double skin façade in their country.

3 Legislation

The first factor to be studied is the legislation on double skin facades in each country. The legislation is divided into 13 sub-categories concerning:

1. Basic legislation on double skin facades (whether this is an opportunity or threat to double skin facades)
2. Existence of legislation on fire protection (opportunity or threat)
3. Existence of legislation on sound protection (opportunity or threat)
4. Existence of legislation on energy issues – savings (opportunity or threat)
5. Existence of legislation on environmental issues (lighting, glare, indoor comfort, air quality)-(opportunity or threat)
6. Existence of legislation on ventilation requirements (opportunity or threat)
7. Current legislation on the percentage of glazing (opportunity or threat)
8. Current legislation on thermal insulation – achieved U-values (opportunity or threat)
9. Requirements for the integration of renewable energy – PV cells (opportunity or threat)
10. Requirements on thermal and energy modeling of buildings (opportunity or threat)
11. Requirements on thermal and energy modeling of double skin façade performance (opportunity or threat)
12. Safety regulations influencing double skin facades (opportunity or threat)
13. Other legislation with an impact on double skin facades (opportunity or threat)

3.1 Basic legislation on double skin facades

Currently the EN Standards 13830 and CE marking of curtain walling is the official document that specifies the characteristics of curtain walling and provides technical information on the varying performance requirements which apply throughout Europe.
However, in all countries that completed the questionnaire apart from one there is NO awareness of any specific legislation on double skin facades. All existing legislations applicable to the conventional façade systems and buildings are also applied to the case of double skin facades. It is also important to note that in Germany there is no special legislation on facades but only legislations for buildings. However, in the case of Portugal the general Portuguese building construction regulation is written so that all technologies are legislated. There is an article that states that every technology has to be certified. This certification is usually made by Portuguese Building Research Laboratories (LNEC). The fact remains that no specific legislation for DSF buildings exists, and no certification by LNEC exists. There is also no threat to the application of double skin facades because there is poor control in the building industry.

3.2 Existence of legislation on fire protection

In general legislation in fire protection exists on all countries and poses a threat to double skin facades since the fire transfer between rooms and levels has to be reduced. Specific legislation on double skin facades regarding fire protection exists in Germany and poses a threat because fire men face more difficulties in the case of double skin facades since a second escape route via the façade is not possible. In Belgium the fire safety aspects are always integrated in the case of the construction of buildings. Special rules are applicable to the façade. At the beginning of a national project on DSF in year 2000, no specific rules were available to treat the case of the DSF. This did pose a problem since each project had to be evaluated by the local responsible fireman. Accepted solution somewhere could be rejected elsewhere. During this national project, specific rules have been proposed to handle the case of DSF. A working group including the authorities has been constituted. These rules should be approved and applicable at the national level in the coming months. Similarly, in Portugal, the legislation on fire protection makes no reference to double skin facades. It poses problems to DSF buildings, and architects have experienced difficulties in the past because licensing can be denied by fire brigades, due to the fact that some times different fire brigades have different opinions, so a clarification of this subject would certainly help the licensing of DSF buildings. In Sweden there is also no specific legislation on fire protection for double skin facades. The building code states that the risk of fire spread between fire cells should be limited and therefore the requirements on double skin facades vary from design to design. In Greece although there is no specific legislation on fire protection for double skin facades, the existing legislation may be a threat due to restrictions in the design of the façade concerning the distance between the escape routes.

3.3 Existence of legislation on sound protection

In general legislation on sound protection poses no threat to double skin facades. Instead, because double skin facades perform better than single skin buildings in terms of sound protection, legislation might seem as an opportunity for double skin facades even in the case of Greece where there is no legislation on sound protection. Austria, Belgium, Germany and Portugal state this is an opportunity. Germany, Belgium and Portugal concern the propagation of sound between adjacent spaces through the DSF cavity due to the telephony effect as a possible threat. In Sweden the building code states certain level of sound reduction of the façade related to traffic. In Portugal although there is no legislation on acoustical insulation rules are available within standards for the airborne acoustical protection of facades. These rules are applicable to all kind of facades and not only to DSF.

3.4 Existence of legislation on energy issues – savings

All countries except Greece have legislation on energy issues. Specifically, in Austria promotion money for residential use is mostly linked to calculated energy performance values (kWh/m²a). The software which has to be used is simple and not able to calculate double skin facades and therefore there can be no preference to use these systems.
Thermal regulations are also applicable in the three regions of Belgium. These regulations have been or are under revision to fulfill the requirements of the EPBD. To summarize, the buildings have to fulfill a maximal thermal transmittance (U-value) and a maximal average U-value (via the so-called K-level). Since the1st of January 2006, requirements about the energy performance at the building level (primary energy consumption of buildings) have been entered into force in the Flemish region; the two other regions will follow this last step in the coming months. The legislation could be an opportunity if the designed DSF is performing well (due to the presence of two glazed skins), but could be a threat if badly designed (due to overheating in summer for example).
In Germany Energieeinsparverordnung (a legislation that defines a maximum primary energy demand of buildings depending on the A/V ratio) defines the legislation on energy issues. For buildings with large glazed facades (therefore also the DSF case) it includes another requirement on the maximum thermal transmittance through the building envelope. This will be replaced by a new legislation soon that includes a new calculation standard (DIN V 18599). In this case the legislation poses both a threat and an opportunity to double skin facades. A threat because not every glazed façade can meet the requirement of the maximum thermal transmittance and an opportunity due to the fact that the second layer is regarded as a buffer zone, and therefore reduces the U-value of the façade.
In Portugal until now, energy legislation has never proved to be a threat to DSF buildings. This could mean that no particular problems arise in the specification of materials and DSF technology, or could simply result from the fact that in most cases the energy regulation is not subject to a demanding control. If it is proved that DSF buildings have poor performance due to DSF technology, namely, overheating problems, then, for cooled DSF buildings the Energy legislation will be an obvious threat to DSF buildings.
In Sweden the energy requirements of the building code are being revised to fulfill the EPBD. The current building code has heat recovery on ventilation (unless renewable district heating) and U-value requirements. The last requirement is often difficult for a glazed building to meet. There is always the possibility to establish a reference building and carry out energy simulations for the reference and the actual building. The revised requirements will also have the alternative with a required energy use of the building, which might facilitate for glazed buildings.

3.5 Existence of legislation on environmental issues (lighting, glare, indoor comfort, air quality)

The performance related to the lighting issues of a DSF is quite similar to this of a conventional single glazed façade. However, the legislation on lighting can be seen as an opportunity since buildings with double skin facades can usually achieve desirable visual comfort conditions.

Specifically, in Austria the use of efficient lighting is often suggested but no regulated by Law. Occupational medicine has a look at each workplace and gives comments to glaring conditions at the workplace. Discussion on overheating temperatures in working places and the influence on lease prices of office buildings is disputed, but no general regulation exists until now. The indoor air quality is only touched by the regulations dealing with ventilation and the Employee Protection Law which deals with smoking regulations. In industrially used buildings (for example paint shops) there are special regulations for air quality.

In Belgium the energy impact of the lighting in office buildings will be included in the new regulation about the energy performance of buildings .The RGPT ("Règlement Général pour la Protection du Travail") specifies values about the lighting (lux) level reaching into offices and deals with the availability of natural light. European standards are also specifying lux-level in office buildings. No quantitative specifications about glare exist today. The RGPT specifies rules about acceptable indoor air temperature in function of the activity realised (and not in function of the type of room). No requirements exist about the air quality except rules concerning smoking areas in office buildings. For new constructed buildings, there exist regulations related to ventilation requirements.

In Germany legislation for lighting exists and minimum requirements for daylight factors may pose a threat to double skin facades. Indoor comfort and air quality have no special legislation for double skin facades; however, if there is an air conditioning system included, the maximum indoor temperature has to be 26°C which could pose a threat to double skin facades. To avoid overheating there is a maximum solar transmittance factor defined that has to be met by all facades, which consists an opportunity for double skin facades because the solar transmission factor is usually lower in spite of usually higher temperatures behind double skin facades. Concerning glare, offices should have a glare protection which is considered as an opportunity for double skin facades.

In Greece, there is no legislation governing environmental issues. However, there are guidelines for lighting based on the guide “Ergonomic Problems of Employers”, ELKEPA, 1987. In addition in special cases of buildings whose design may surpass the permissible built area by law, lighting and ventilation conditions are required as part of the design process.

In Portugal there is a general regulation, which is not specific to double skin facades and until now has not produced any relevant threat to double skin façade buildings.

In Sweden the energy impact of the lighting in office buildings will be included in the new regulation about energy performance of buildings. The National Swedish Board of Occupational Safety and Health standards state that for working environments there should be satisfactory daylight and possibility to view the outside. There should also be adequate lighting and glare should be avoided. The indoor climate must be suitable and adapted to the character of the activity. Finally, the CO_2 content of the air should be below 1000 ppm, assuming that the other pollutants are at an acceptable level.

3.6 Existence of legislation on ventilation requirements

In the case of legislation on ventilation requirements all countries have legislations and airflow recommendations in the building code.

In Austria for some building usage, like as laboratories, commercial kitchens etc., mechanical ventilation is mandatory. If a mechanical ventilation is implemented it has to be proven that the asked hygienic rate of air change is provided. If window ventilation is implemented the planner has to account for the asked minimum openable window area. Hygienic flow rates and openable window areas are specific to the utilisation and given by the national standards.

In Belgium the RGPT specifies minimal airflow to realise a.o. within office buildings. The new regulation, entered into force in 2006 in the Flemish region, defines an extended set of rules applicable to office buildings. These rules could also become valid in the future into the two other regions. There are however no rules defining the type of ventilation (natural or mechanical) nor the size of the openable windows to be realised.

In Germany legislation exists only for assembly rooms (30 m^3/ph), while in the case for mechanical ventilation the requirements are 30m^3/ph and 0.5 air changes h^{-1}.

In Greece legislation for ventilation requirements exists since 1987 (according to T.O.T.E.E. 24/23, 2425/86) and poses no threat to double skin facades.

In Portugal there is legislation on ventilation, but none to openable windows. The legislation on ventilation is general, not specific to double skin facade buildings and, until now, has not produced any relevant threat to DSF buildings.

In Sweden legislation exists for ventilation requirements and poses no threat, but also no opportunity for double skin facades. A minimum outdoor air ventilation rate is specified in the building code 0.35 l/ (sm^2).

3.7 Current legislation on the percentage of glazing

On the percentage of glazing of a building, Belgium, Greece and Sweden have no legislation. However, in Belgium and Sweden, indirect requirements are set by imposing a maximal

average U-value to the building and indirect minimum requirements exist by imposing daylight availability into the office.
In Greece legislation exists only for preserved traditional settlements and poses no threat to double skin facades since it is not possible to build such buildings in those areas.
In Austria national standards dictate the minimal account of glazing for living spaces to guarantee enough sunlight, while there is no regulation for the maximum.
In Germany legislation exists and the minimum requirement of window size depends on the room floor area for dwellings (Landesbauordnungen). For offices, window size is dependent on room width (DIN 5034), which is rather an opportunity for double skin facades since there is no maximum size, but only recommendations. A possible threat could be the Energiesparverordnung, which requires a calculation that proves that there are no overheating problems in the case of not air-conditioned buildings and thus large glazed areas without good shading devices have problems to meet the requirements.
In Portugal legislation poses no threat to double skin facades. It is actually a general regulation, not specific to DSF buildings and until now has not produced any relevant threat to DSF buildings.

3.8 Current legislation on thermal insulation – achieved U-values

All countries have legislation on thermal insulation and achieved U-values; this is considered from most countries as an opportunity for double skin facades since the U-value is usually lower in the case of double skin facades than for other glazed façade types.
In particular in Austria there are 9 federal states each administrating its building codes. Each federal state government legislate a set of U-values that are not allowed to exceed. The Harmonizing of these standards between the provinces is currently under examination.
In Belgium the buildings have to fulfill a requirement concerning a maximum U-value of each building component and a maximum averaged U-value (via the so-called K-level). Since January 2006, requirements about the energy performance at the building level have been also entered into force in the Flemish region; the two other regions will also be obliged to perform this last step.
In Germany specific requirements exist for non-residential buildings with high window to floor area ratio, maximum thermal losses (Energieeinsparverordnung), while the calculation of the U-Value of facades according to ISO standards.
In Greece the Thermal Regulation of 1981 is used and could pose a threat only if the double skin façade construction does not meet with the Regulation.
In Portugal with the recent transposition of the EPBD to the Portuguese legislation, stricter U-values exist. These can contribute a threat to DSF buildings.
In Sweden the legislation could pose a threat as it makes it difficult to get a building permit, because it is difficult to meet the requirements of the building code i.e. the requirements on the overall U-value.

3.9 Requirements for the integration of renewable energy – PV cells

In all countries apart from France there are no requirements for the integration of renewable energy sources. Specifically, In Austria such installations are eligible for government aid and tax relieves depending on the federal states. In case of installation, technical requirements are to be met. In Belgium the technology of renewable energy sources is taken into account into the new energy performance regulation entered into force in 2006 in the Flemish region. The regulation is specifying that in case of construction of large buildings (>1000m²), a feasibility study has to be made to assess the interest of such technologies. Finally, in Germany the incorporation of such technologies is seen as an opportunity since the Energieeinspeisungsgesetz (not on DSF, but on DSF in combination with PV-Systems and other renewable energies) fixes high prices for PV-electricity if fed into the power grid.

3.10 Requirements on thermal and energy modeling of buildings

All countries apart from Belgium and Greece have requirements on thermal and energy modeling of buildings, however in Greece requirements have been specified with the EPBD implementation. Threats for double skin facades will then depend on their actual performance. In Belgium there are no requirements except that reference is made to the existing Belgian standards. These standards have to be applied; however, none of these standards are giving satisfactory answers on how to handle double skin facades because there is a lack of rules for these facades. As for the other countries that have requirements on thermal and energy modeling of buildings in Austria heat demand calculations are requested by all provinces (according to a simplified EN 832 approach) for residential buildings for the subsidy schemes. Only some provinces have this request in the building code and there are no special requirements for double skin facades. In Germany the new DIN V 18599 gives a conservative approach for double skin facades and could pose a threat for good double skin façades that might provide better results than calculated with the DIN. In Sweden the requirements on thermal and energy modeling could also pose a threat to double skin facades since it is difficult to make calculations for such types of facades.

3.11 Requirements on thermal and energy modeling of DSF performance

In all countries there are no requirements on thermal and energy modeling of double skin facade performance. Specifically, in Belgium since there is no specific legislation for double skin facades there are no requirements on thermal and energy modeling. In Belgium for the moment, compliance has only to be demonstrated with the maximum U-value criteria. This has changed since January 2006 with the EPBD implementation and the energy performance of the whole building has to be calculated. As a result an appropriate modeling of double skin facades is necessary in order to be able to determine the real energy performance of the facade. In Germany there are no requirements for simulation tools. There is a new CEN norm that demands a proof that the used simulation tool is accurate enough for the simulation performed. For calculation with the new German standard DIN V 18599: conservative approach, a ventilation rate of 10 h-1 (in relation to the cavity) and the frame size of outside skin are defined. Thermal transmittance and solar irradiation into the room behind are calculated similarly to the wintergarden principle of EN 832. In Greece requirements exist with the EPBD implementation from January 2006. In Portugal due to the transposition of the EPBD, thermal modeling of double skin facades is considered. Simple or detailed modeling tools can be used for the thermal modeling of double skin facades. In Sweden there are no requirements on thermal and energy modeling of double skin facades.

3.12 Safety regulations influencing DSF

In Austria the safety regulations can prove as an opportunity for double skin facades since the cavity can be used as a fire escape route and night ventilation is possible without safety risk. In Belgium and Germany in terms of stability, safety of the occupant or of the pedestrians, the same criteria as those applicable to traditional single façades are applicable to DSF. In Portugal and Sweden safety regulations exist but pose no threat to the double skin façade, while in France and Greece no relevant regulations exist.

3.13 Other legislation with an impact on DSF

In Austria regulations on air traffic in some cases demand the implementation of radar damping systems on double skin facades.

4 Knowledge

The second aspect to be studied from this questionnaire is the level of knowledge that each country has on double skin facades. The questions are addressed at 4 target groups: scientific – educational institutions, the building industry – construction, architects and others such as building owners and investors. Subsequently, the level of knowledge in each country is analysed according to 5 factors:
1. The level of knowledge on the typology and performance of double skin facades (high or low level of knowledge)
2. The level of knowledge on the design, construction and technology of double skin facades (high or low level)
3. The dissemination of knowledge on double skin facades (through University, Internet, Seminars, Other Methods)
4. The level of knowledge on the advantages and disadvantages of the double akin facade compared to a conventional façade (high or low level)
5. The availability of double skin facade built examples in each country

4.1 The level of knowledge on the typology and performance of double skin facades

4.1.1 Scientific – educational institutions

In Austria the level of knowledge on the typology and performance of double skin facades is high only in a small range of institutions – mainly scientific – in the aspects of building physics and resistance. However, nearly no information on construction, costs and the performance of double skin facades is provided at educational institutions. In Belgium, the BBRI has a good level of knowledge and set up a specific document about the typology of double skin facades. Performances (thermal, acoustics, etc) of DSF have been determined. PhD's in Belgian universities have been performed. The main difficulty lies in determining the thermal performances at the building level (and not only at the façade level).In Germany the IBP also has a high level of knowledge on the subject which is depicted in literature studies, simulation and measurements at VERU. In France, Greece, Portugal and Sweden there is a low level of knowledge on the typology and performance of double skin façades, however, in all the BESTFACADE participants some educational institutions (i.e. NKUA, BBRI, VERU, FhG-IBP) participate in research programs that offer knowledge on DSF issues and awareness on the respective level of knowledge in other countries. In Sweden also there is an ongoing research project on glazed office buildings, at the University of Lund.

4.1.2 Building Industry – Construction

In Austria and Belgium the level of knowledge is high with big construction companies, which work at an international level, having their own systems of proved construction typology. Big facility management firms know about the performance of double skin facades quite well. In Germany, the level of knowledge is also high in the façade industry. In Greece a few construction companies have already participated in the design of double skin facades. In Portugal the knowledge is low since most of the double skin façade technology is imported and installed by foreign companies. However, recently Portuguese construction companies started developing their own DSF products. In Sweden the level of knowledge is also low among clients and engineers, apart from some major property owners and developers with some knowledge on the typology and performance of DSF. However, the knowledge on the energy performance of DSF is rather low in all countries.

4.1.3 Architects

In Austria, there is just minimal knowledge about double skin facades in the bulk of architects practicing in the country. In Belgium, the majority of architects are not really aware about the real performances of DSF (apart from specialized architects). In Germany, while conventional architects do not know much about double skin facades and further education of engineers is not very common, some architects and consultant offices are specialized in DSF buildings. In Greece the majority of architects are not aware of double skin facades, however limited architectural practices have participated in the design of double skin facades. In Portugal there is high knowledge about the typology of DSF between architects. There are several DSF buildings in Portugal – more than 10 only in Lisbon – and some architects have designed more than one. However, there is scarce knowledge in thermal and energy performance of double skin facades and architects do not actually know on the design stages how the building will perform. In Sweden, the knowledge on the typology and construction of DSF is low apart from some major architects with some knowledge on typology.

4.1.4 Building owners – Investors

In Germany building owners and investors do not know too much about double skin facades and this encourages architects to sell them this feature with arguments that it solves all the problems of the building. However, investors are aware that double skin facades cause higher investment costs and therefore the systems are mostly used for high-representative buildings.

4.2 The level of knowledge on the design, construction and technology of double skin facades

4.2.1 Scientific – educational institutions

In Austria, Belgium and Germany the level of knowledge on the design, construction and technology of double skin facades is high. Specifically, in Belgium the BBRI, while not specializing in the design, it followed some work on the construction work of buildings equipped with DSF and in Germany the IBP has the case studies of the Ulm Library and the Fraunhofer central building. In Greece and Sweden the level of knowledge is low, however in all BESTFACADE participants some educational institutions participate in research programs, mainly at the research level and not so much at the design and construction level.

4.2.2 Building Industry – Construction

In Austria the level of knowledge is high only on a small range of companies in terms of construction knowledge and costs. In Belgium, specialized façade constructors have a high knowledge on the design, construction and technology of DSF. In Germany the façade industry has a high knowledge on the design, construction and performance of double skin facades. However, reality proves that often the wrong type of DSF is applied in buildings resulting in bad comfort and/or high energy consumption. There is also a big interest to improve the reputation of double skin facades. In Greece and Portugal the knowledge is low for the building industry, however for Greece it is high in specific cases of companies that have participated in the construction of double skin facades; for Portugal knowledge is increasing with the recent development of DSF product by the Portuguese construction.

4.2.3 Architects

In Austria there is minimal knowledge about double skin facades among architects, which is also the case in Belgium, France, Greece and Sweden. Specifically, in France buildings are designed without calculation methods applied. The case is not the same for Germany, where some architects and consultants are specialized in DSF buildings and in Portugal for architects who have designed DSF buildings.

4.2.4 Building owners – Investors

In Germany building owners do not know too much about double skin facades since design, construction and technology is not of much interest to them. The same applies for investors since they have to depend on the architect/engineers for the design, construction and technology of double skin facades.

4.3 The dissemination of knowledge of double skin facades

Four methods were considered for the dissemination of knowledge of DSF: University level, internet, seminars or any other method. More specifically, in Austria explicit DSF knowledge is not included in any education system. Because of the lack of other sources the internet could be considered the best source to get information but the quantity of high quality information is rather small. In Belgium and France the dissemination comes through universities, the internet and seminars and in Germany through other methods as well. In Greece dissemination comes through the internet, seminars and indirectly through educational institutions that may participate in research programs concerning double skin facades. In Portugal dissemination comes mainly through universities (graduate students) and scientific papers and not through the internet or seminars, while in Sweden mainly through internet, specifically the Website of Lund University.

4.4 The level of knowledge on the advantages and disadvantages of the double skin facade compared to a conventional façade

4.4.1 Scientific – educational institutions

In Austria the knowledge is low. The best source until now comes out of self done projects or projects that the scientific institutions are close to, however reliable comparative studies are missing. In Belgium and Germany the knowledge is high; in Belgium the BBRI and some universities have written documents dealing with these topics. The main uncertainty is related to the thermal performances, at the level of the building, of a DSF compared to these of a traditional glazed façade. In all other countries the level of knowledge is low. Specifically in Greece educational institutions participate in research programs in order to assess the advantages and disadvantages if DSF compared to conventional construction. Similarly in Portugal universities and research centres are starting to work on these subjects, and in Sweden the level of knowledge is rather low apart from some research institutions (i.e. Lund University).

4.4.2 Building Industry – Construction

In Austria, Belgium and Germany the façade industry has a high level of knowledge. In Greece, while the level of knowledge is low, companies that participate in the design of DSF can investigate the advantages and disadvantages through their built examples. Similarly, in Sweden the level of knowledge is low apart from some engineering firms.

4.4.3 Architects

In all countries the level of knowledge is low, apart from specialized architects and consultants in Germany and Belgium who have done further education courses concerning DSF and have taken part in information seminars. In Austria the architects often see only the design advantages, while in Greece, Portugal and Sweden the level of knowledge is low even for those who have participated in the design of DSF and these are the ones with the most knowledge in the building industry.

4.4.4 Building owners – Investors

In Germany both buildings owners and investors have a low level of knowledge on the advantages and disadvantages of DSF compared to conventional facades.

4.5 The availability of double skin facade built examples in each country

In all countries participating in this questionnaire buildings that use double skin facades exist. Specifically, in Austria several examples of buildings with DSF exists however the availability of reliable data is low. In Belgium these types of buildings are more often being built since the 90's. It has to be noted that the concepts applied in Belgium are rather different from those applied in other countries such as Germany, since the applied façade concepts in Belgium are mostly mechanically ventilated. In Germany there are a lot of such types of buildings but the energy consumption in most cases is not published, while in Greece there are a few office buildings in Athens and Thessaloniki already built and 2 more are currently under construction – an exhibition centre and a hotel - in these two areas as well. In Sweden approximately ten buildings are in operation but for a short period to have concrete results.

5 Sociological – Behavioral aspects

Following the knowledge on double skin facades, sociological and behavioral aspects of double skin facades were studied in each country. Specifically, these aspects were divided into 6 categories:

1. Local climatic conditions (if these are appropriate or not appropriate to DSF)
2. Local architecture and the aesthetics for full transparency (if this is a problem or not a problem for the use of DSF)
3. Aspects on the double skin façade cavity, concerning the calculation of its area in the total net floor area of the building and the reduction of rentable Office space (a problem or not a problem)
4. The appropriateness of double skin facades in each country and the non-appropriateness of buildings in each country (a problem or not a problem)
5. The importance, under specific climatic conditions, of occupant control for ventilation and the possibility that such controls could pose a problem the operation of double skin facades (a problem or not a problem)
6. The reputation of double skin facades according to different target groups such as scientific – educational institutions, the building industry – construction, architects and others such as building owners and investors. (Good reputation or bad reputation)

5.1 Local climatic conditions

The local climatic conditions favor double skin facades in most all countries if the façade is constructed according to its initial design. Specifically, in Austria the climatic conditions usually can be controlled by DSF related technical equipment. However, it is not proven yet if this justifies enormous additional investment. In Belgium several concepts of facades exist. Each of them is more appropriate for a specific type of climate. In general, naturally ventilated double skin facades are not very appropriate in warm climates, in which mechanical ventilation could be adapted. In France the climate is also appropriate for double skin façades, as well as in Germany depending on the building usage and type of DSF. In Greece, if the double skin façade is not well designed and shaded, an overheating problem could arise in the summer because of the high temperatures inside the air cavity. In Portugal the architects that design DSF buildings state that double skin facades are appropriate for the climatic conditions. They also state that this is in the case that the initial design is actually followed, because some times, mainly due to costs, the actual façade differs from the designed one (i.e. the building owner decides not to include shading devices). The same applies in Sweden where according to some architects the local climatic conditions are appropriate for double skin facades.

5.2 Local architecture and the aesthetics for full transparency

In most countries local architecture and aesthetics for full transparency do not pose a problem in the implementation of double skin facades. However, in Austria the outward looking transparency is usually not a problem, while the inward looking transparency is disputed and causes opposition by the users. This depends on the clientele since many architects like full transparency, while many users do not. In Belgium there is a tendency to adopt more and more transparent buildings and it is often one of the elements to consider when adopting a DSF. In Germany, it also poses no problem since double skin facades have become an architectural trend in high-level, high-rise buildings in the last 15 years, however some provisos exist in the use of such buildings. In Greece also it does not pose a problem; however there are some inhibitions concerning overheating issues in full transparent buildings since the performance of double skin façade technology is not widely known. In Portugal and Sweden, full transparency does not pose a problem to the selection and use of double skin facades.

5.3 Aspects on the double skin façade cavity, concerning the calculation of its area in the total net floor area of the building and the reduction of rentable office space

In all countries, the area of the cavity of the double skin façade is calculated in the total net floor area of the building and thus reduces the rentable office space. In Austria, specifically, the ecological impact of double skin facades and the need for energy and cost cannot be compared to the usefulness of a building. Therefore, the space of the cavity, since it is a means of designing a more ecological building, cannot be seen equal to floor space. In Germany, while the net floor area never includes the interspace, the reduction of the net floor area by the double skin façade is a problem because of smaller rented net floor area. The maximum size of the buildings is defined by taking the length of the external façade. In Greece it also poses a problem concerning a possible reduction of office space, as well as Sweden where it is not clearly specified in the Swedish standard for the calculation of building areas, the risk is that the development rights can be reduced. In Portugal, since most of the DSF buildings are owned by financial and technological institutions, the reduction of the rented space has not been a problem when compared to the benefits of the aesthetic factors.

5.4 The appropriateness of double skin facades for all types of buildings

In Austria the concept of double glazed spaces is often used in the 'wintergarten' concept, which is popular in single family houses. In multi storey residential buildings it is not common to use double skin facades. In general, double skin facades can be used for all building types in Austria, but due to the costs their main field of application is in office buildings. In Belgium the diversity of DSF is so high that in principle such types of facades seem to be applicable to all types of buildings apart from residential buildings. In Germany double skin facades are mostly used in high-level office buildings because of the high investment costs. In Greece, double skin facades can be used for offices and public buildings because of the high costs, however, not in residential buildings. In Portugal until now DSF buildings are mainly office buildings and shopping centers. The same applies for Sweden where DSF buildings are so far mainly new office buildings.

5.5 The importance, under specific climatic conditions, of occupant control for ventilation and the possibility that such controls could pose a problem the operation of double skin facades

The discussion about open able windows is a very emotional one in Austria. There have been many discussions that the pure possibility to open the window, to contact the outside, is a value the most people do not want to miss. Complete control by the occupants is not necessary but the possibility to influence the indoor climate at their own working place in a small range is needed for high user acceptance. Therefore, if a facade (ventilation system) does not allow at least a small range of user control it will not be accepted and if the technical concept is not able to handle this, it will be considered as the wrong concept. In Belgium it has been often observed that occupants need to have a certain control of their environment, such as the control of the solar shading, the temperature levels or opening of the windows. Adapted concepts of DSF could take advantage of this offering such control systems. Otherwise, that could be a problem for the use of DSF. In Germany, the automatic control for ventilation is a problem since most people prefer an indoor comfort that they can influence themselves, for example by opening the windows at their choice. This type of control is most of the times not possible with double skin facades and their linked technical systems like air conditioning or mechanical ventilation. The same applies for Greece where the use of openable windows is desirable and therefore could pose a problem id the DSF design does not permit this type of flexibility. In Portugal such controls pose problems for occupants; however they pose no problems for office managers who are responsible for the management of the building. In Sweden most people prefer being able to influence the indoor comfort (e.g. by opening the windows at their choice). In office buildings the users can most of the time not control the mechanical ventilation but can usually at least open some windows. This is most of the times not possible to the same extent in existing office buildings with DSF.

5.6 The reputation of double skin facades according to different target groups

In Austria the reputation of double skin facades in the group of experts in the field of building physics and energy is rather skeptic but never the less interested. The same applies for architects where the reputation regarding aesthetics is good because it gives new possibilities to design the building envelope. In Belgium the authors assume that in general the DSF have a rather good reputation since more and more buildings are built with these types of facades. However, there are some examples of bad working buildings equipped with DSF. For many actors, the reputation of DSF is a confused subject due to the lack of knowledge about the energy performances of buildings equipped with DSF. In Germany the reputation of double skin facades is generally good but in some expertise positions bad. For scientific and educational institutions, however, most articles on the energy consumption of buildings that incorporate double skin facades show that the consumptions are much higher than in conventional buildings. For architects the double skin façade is the solutions to most problems for high rise buildings and architectural papers often praise the designs of double skin façade buildings and sell the idea that this type of façade solves all problems. However, it has a bad reputation for engineers since they exchange information on technology related Symposia and every consultant tries to develop a more efficient system. Concerning building owners the reputation is good if they are reading architectural papers and bad if they are reading publications on real energy consumption and comfort. Finally, the investors have a good reputation for double skin facades applied to high level office buildings. In Greece there is mostly no reputation for double skin facades. Scientific and educational institutions are still investigating DSF reputation through research work and the majority of architects are not aware of DSF technology. However, a few companies that try to promote double skin facades and improve their performance have a good reputation for DSF. Finally, in Sweden the reputation of DSF in scientific and educational institutions is generally bad since there is a skepticism concerning energy efficiency and the quality of the indoor climate since the level of knowledge is not yet high. The same applies for the building industry but for the reason of high investment costs. However, the reputation is good among many architects, as well as investors in high profile office buildings.

6 Financial aspects

For the financial aspects of double skin facades three main factors were examined:
1. The cost of double skin facade buildings compared to buildings with traditional facades (high or low cost)
2. The level of knowledge on the cost of double skin facades (investment, operational, maintenance), depending on target groups such as scientific – educational institutions, the building industry – construction, architects and others. (if there is high or low level of knowledge)
3. The availability of funding grants for double skin facades (available or not available grants)

6.1 The cost of double skin facade buildings (investment, operational, maintenance) compared to buildings with traditional facades

In all countries taking part in this questionnaire the cost of double skin façade buildings compared to buildings with traditional facades is considered higher. Although based on very few data available, the cost of DSF buildings is compared to this of traditional facades and considered mostly higher in Austria. Belgium considers that it is not generally possible to give any general rule about the difference in cost between DSF and traditional façade buildings since high and low cost are subjective concepts and extremely variable from one building to another. As a general rule, it can be said that DSF should cost more than traditional facades and that the operational costs should be reduced. It is however observed that in some buildings the cooling consumption can be higher than in traditional buildings. In Portugal the cost is high but identical to that of common skin buildings with identical typology (Portuguese DSF buildings are usually multistory buildings owned by banks, technology companies and shopping centers), however, since DSF technology is imported, the cost depends very much on the contract. Finally, in Sweden DSF buildings are considered to have a higher investment cost compared to traditional façade buildings.

6.2 The level of knowledge on the cost of double skin facades (investment, operational, maintenance), depending on target groups

In all countries apart from Germany the level of knowledge on the cost of double skin facades concerning the investment, operational and maintenance cost is low in scientific and educational institutions, as well as architects due to the difficulty of getting data and the fear of bad reputation, which blocks dissemination. In Germany on the other hand, there is high level of knowledge for investment and operational cost and low on maintenance cost among scientific and educational institutions, and a high level of knowledge in all fields in the façade industry. Among architects and investors the level of knowledge on investment cost could be high, but in all other fields it is low. The level of knowledge on the cost of DSF is low on all fields among building owners as well. In Greece, while the level of knowledge is mainly low, companies that have participated in the construction of DSF could have a high knowledge on investment cost. In Sweden the level of knowledge on the cost of the façade –investment, operational, maintenance- is low mainly due to the lack of data as the few existing buildings are recently constructed. However, among architects and building industry there is high level of knowledge on the investment costs.

6.3 The availability of funding grants for double skin facades

In all countries there are no available grants for double skin facades

7 Institutional aspects

The study of institutional aspects of double skin facades concern the possible support that this kind of technology could have, as well as institutional drawbacks, such as bureaucracy. Thus, the questionnaire was divided into three sub-categories, namely:
1. Support from the Government or Professional institutions
2. Regional Support-Planning policy
3. Required bureaucracy-authorisation for the new technology (increased or decreased bureaucracy)

7.1 Support from the Government or Professional institutions

In consideration of the institutional aspects, nearly all the countries that filled in the questionnaire replied that there is no sufficient support by the government or professional institutions either. It is noticeable, though, that on Belgium's part there is indirect support via the financing of research projects like a national project (2000-2004) on DSF coordinated by the BBRI. In the case of Germany, also, support is provided only for integrated PV glass systems. In Greece also there is indirect support through the financing of research programs. As for Austria, France and Portugal support in these countries does not exist. In Sweden there is at least one research project supporting the building design funded mainly by the Swedish Energy Agency.

7.2 Regional Support-Planning policy

No specific planning policy is remarked in any of the participant countries and regional support is apparently non-existent.

7.3 Required bureaucracy-authorisation for the new technology

Bureaucracy is shown to have increased to a great extent in the countries mentioned. In Belgium, specifically, the future energy regulation implies that technology not covered by the standard calculation procedure will have to be assessed by the so-called principle of equivalence. Unfortunately, the exact way to fill in this remains unknown and this eventually leads to the quest of complementary studies in order to be able to evaluate the energy performance of this kind of technology (as DSF). In France, Greece and Portugal there are high levels of bureaucracy. In Portugal, due to the huge bureaucracy, new technologies such as DSF are used without specific authorization. Fire protection, in particular, is the main cause of problem for DSF buildings in this country. Germany retains an increased level of bureaucracy at least the same as for other types of facades. In Sweden there is a risk for increased bureaucracy, especially with the new building code stating the energy performance but not any recommendation is given on how to take into account DSF.

8 Additional comments

The additional comments section of the questionnaire provides each country the opportunity to specify any other comments on the non-technological barriers for double skin facades not covered in the previous sections, as well as initial comments-proposals on the barriers to overcome the non technological barriers.

8.1 Other comments on the non technological barriers

Austria is among the countries that have commented sharply on the non technological barriers, claiming that sometimes the needed additional space is simply not available. Austria's argumentation is that if you are limited with the space and you have to downsize the floor space, DSF is getting extremely expensive because you loose floor space for renting or selling actually. Sweden commented on the space covered by the DSF cavity in the case where the development rights can be reduced and this will pose a problem to the application of DSF. France, Greece, Portugal did not make any remarks upon on the subject.

8.2 Initial comments-proposals on the barriers to overcome the non technological barriers

Initial thoughts on the strategies to overcome the non-technological barriers suggested by the participating countries include:

Austria highlights the need of a centralized information network database that would be performed by professionals of all sections of the design-, construction- and maintenance process of DSF. National legislation should act on the topic and provide standardisation schemes to easily evaluate projected DSFs.

Belgium, France and Germany have three proposals:
1. Better knowledge of DSF concerning the advantages, inconveniences, real performances (energy but also acoustics etc) at the level of the facade and also at the level of the building.
2. Knowledge of the most appropriate applicable concept of DSF (for example different concepts are possible in function of the type and/or the use of the building) and also knowledge of the best control system and strategy.
3. Reduction of the cost of the façade.

In the case of Greece, the non technological barriers could be overcome through workshops and seminars in order to introduce best practice of DSF, as well as through the publication of

bad practice examples and solutions to the problems (including technical and mechanical solutions).
Finally Sweden proposes the dissemination of best practice and advantages/disadvantages to clients and architects.

9 Architectural and engineering aspects of DSF

There are numerous scales that double skin facades can affect the use and perception of space. Both interior and exterior factors must be considered.
Glass as material can be extremely transparent as well as reflective, depending on light condition, surface properties and design.
The openness of the double skin façade has advantages and disadvantages, contextual issues are important to handle the potential transparency and reflectivity. This is also to consider when programmatically handling the expression of the building, the level of openness must correspond with intentions of the use and desired manifestation.
DSF facades limit the way of dividing the interior space, as well as ways if furnishing the space. The direct light must be handled to avoid temperate variations or too much light.
A building with a large homogenous, glazed façade can create a sense of anonymousness for the users, like sitting in a large fish tank with no defined interior places. The glazed façade offer no traditional spatial arrangement for furnishing, so planning is of great importance in these interiors.

It is obvious that all this together makes greater demands on engineers, the larger the glazed areas in a building. The engineer has to make sure, together with the architect, that a low energy use, good thermal comfort and good visual comfort are obtained in the finished building. Glazed buildings, especially with double skin facades, can also be challenging for an engineer from a structural point of view, especially if the knowledge is lacking.
Also challenges for the engineers appear to solve the issues of thermal and visual properties together with the architect.

To conclude, the use and the user of a DSF office building must be well defined to ensure the best architectural use and design of the building. The choice of transparent or reflective surface is a way of deciding the exterior expression. Together with the interior layout, the level of openness can fit with the corporate intentions as well as the well-being of the users. The architectural and mostly technological-structural aspects make technological demands on engineers. Team work between architects, engineers, clients and users are required from the very early design stage.

10 PART 2 - Strategies to overcome the non-technological barriers

The analysis on the non-technological barriers to DSF, based on the WP2 questionnaire, showed the significance of the following issues:

- Lack of specific legislation and standardised schemes on DSF
- Lack of knowledge on DSF (advantages/disadvantages, cost of DSF)
- Not documentation of reliable best practice examples of DSF
- Not available funding

In order to overcome the non-technological barriers it is suggested to follow a policy that will be distinguished into two stages: the pre-assessment and post-assessment stage in order to cover all issues defined in the WP2 questionnaire.
The pre-assessment stage deals mainly with legislation and standardized schemes on DSF, harmonisation of the standardized schemes to the national market industry and dissemination of DSF to the target group and beyond it.
The post-assessment stage deals with adequate and reliable documentation of good examples along with an aggressive marketing policy from the relevant associations and the provision of funding schemes.
The policy targets could be illustrated in the following graph:

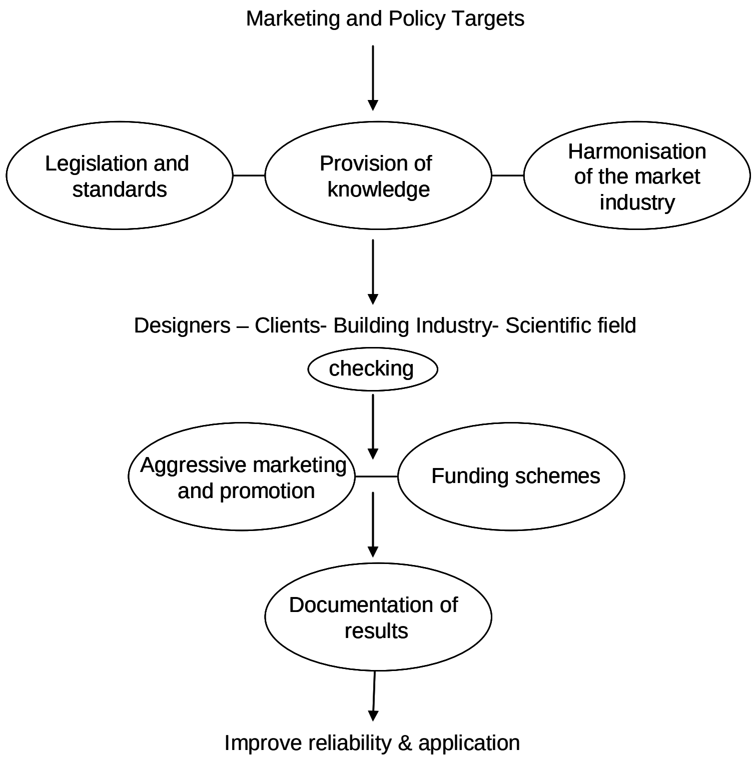

Figure 2: Policy target to overcome the non-technological barriers

10.1 Pre - assessment

The pre-assessment phase aims to provide the target group with all necessary information on DSF to be able to check the performance of the suggested technology. Specifically, the following actions are suggested:

- Provide information on DSF legislation

Introduce EN standards
Introduce homogenous calculation issues, marking and predictive tools

- Enhance harmonisation of the market and the calculation methods

To meet national legislation and fit EN standards
To meet local climatic conditions

- Increase dissemination of DSF regarding

The characteristics of DSF
The advantages/disadvantages of DSF
Cost of the façade system
Better-documented examples

Legislation/Standardized schemes: Currently there is legal regulation for DSF in use covered by the EN- standards, EN 13830 'Product Standard - Curtain Walling'. According to EN 13830: 2003-11 **a curtain walling** is defined as: '*external building façade produced with framing made mainly of metal, timber or PVC-U, usually consisting of vertical and horizontal structural members, connected together and anchored to the supporting structure of the building, which provides by itself or in conjunction with the building construction all the normal functions of an external wall but does not contribute to the load bearing characteristics of the building structure'.*
According to prEN 13119:2004, **a double skin façade** 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 façade specifications according to the requirements of the Construction Products Directive (CPD) leading to the CE marking for curtain walling, that is in enforcement since the year 2005 (figure 3).
The EN standards were presented to the participating countries of the BEST FACADE project by the EU association of the window and curtain wall industries, EuroWindoor. The standards cover the thermal resistance, acoustic, air tightness, water permeability and wind protection issues for DSF systems. However, only one of the participating countries was aware of these specific standards.

CE	*CE conformity marking, consisting of the "CE" symbol given in directive 93/68/EEC*
01234	*Identification number of the certification body (where relevant)*
Any Co. Ltd, PO Box 21, B-1050	*Name or identifying mark and registered address of the producer*
02	*Last two digits of the year in which the marking was affixed*
01234 –CPD-00234	*Certificate number (where relevant)*
EN 13830	*Number of European standard*
Curtain wall product Intended to be used in City Office application	*Description of product*
Reaction to fire - Classes Fire resistance - NPD Watertightness - class R6 Resistance to own dead load - kN Wind load resistance - 1200 kN/m² Impact resistance - Technical classes Thermal shock resistance - Glass type Resistance to horizontal load - kN at m sill height Thermal transmittance - NPD Air permeability - class A3 Airborne sound insulation - dB	*Information on regulated characteristics*

Figure 3: Example from product standard EN 13830: 2003 – 11, presented by Mr Koos (EuroWindow) during the BEST FAÇADE meeting in Delphi

U-value calculations for DSF: A homogenous procedure for the U-value calculation and performance of DSF is necessary as a means to compare different projects in different countries; this could be covered by the procedure suggested by prEN 13947:2005 in conjunction with the calculation method that will be developed within work package 4 of the

BEST FAÇADE project. A simple calculation method will be developed in accordance with the CEN standards to be used by all European countries for the thermal and visual performance of DSF.
According to prEN 13947:2005 Annex D, the U-value of curtain walls can be calculated by the equation:

$$U_{cw} = \frac{1}{\frac{1}{U_{cw,1}} - R_{si} + R_s - R_{se} + \frac{1}{U_{cw,2}}}$$

where $U_{cw,1}$: U-value of the primary (internal) curtain wall and
$U_{cw,2}$: U-value of the secondary (external) curtain wall

Harmonization of the EN standards and calculation methods to meet all national legislations is important to meet different climatic conditions and market needs. It should be noted that the participating countries in the BESTFACADE project belong in 3 different climatic regions all over Europe: the ‘Nordic region’ represented by Sweden, the ‘temperate region’ represented by Austria, Belgium, France and Germany, and the ‘Mediterranean’ region with Greece and Portugal (BESTFACADE WP1 report). This climatic variation results in different ventilation concepts and energy demand thus different façade concepts. Additionally, variation in knowledge and needs on simulation methodologies and legal requirements are noted among the participating countries.
Knowledge/dissemination: Dissemination of DSF is important in conjunction with reliable documentation of good built examples. A broad dissemination of the BEST FAÇADE project, i.e. through seminars on national level, and BEST FAÇADE workshops within the target group and beyond is necessary to overcome the lack of information. Additionally, training of architects and engineers at university level on the DSF system would increase the consciousness of the students and future professionals. The use of complementary methods like as internet and journals would support the promotion of this training process.
Within the dissemination procedure, a best practice guideline including good examples already built in the participating countries will be prepared with the initiative of the BEST FAÇADE members and distributed to the target group, engineers, architects, building owners and construction industry. The guideline will be prepared within work package 5 of the BEST FAÇADE project and aims to include common basic scientific, technical and economic knowledge of the DSF projects that will be published.
The analysis showed that the majority of the built DSF examples concern office buildings. For financial and commercial reasons, it is essential to show the applicability and expansion of DSF use also in other type of buildings like school, malls and other public buildings. The publication of existing public buildings and research on this level could support this action.

10.2 Post- assessment

The post assessment stage includes all actions that have to be taken into consideration after the DSF dissemination in order to support the product in the market. The following actions are suggested:

- Aggressive marketing from involved associations
- Better definition of targets by the façade industry
- Increased and reliable documentation of best practice
- Provision of funding

The information provided on DSF during the pre-assessment stage in conjunction with the aggressive policy from the building industry and the well documented best practice examples would increase the awareness and the reliability of the product in the market.

Aggressive marketing: The advertisement of the DSF is also dependent on the company level policy: the national markets and involved associations should follow an aggressive policy for the promotion of the product. EuroWindoor could play a driving force to this on EU level in collaboration with the national markets by creating a functioning market environment for DSF. They could make public the advantages of the system as well as the fact that funding is important to enhance the spread of the use of DSF. Political pressure should be applied both on national level (i.e. DIMGLASS in Greece and relevant glass companies in the other participating countries) and on EU level (i.e. EuroWindoor). Additionally, companies could play an active role on legislation issues, for example by promoting DSF products as 'green' products that are adequate to comply with the EPBD, thus to reduce emissions especially CO_2 and the building energy consumption.
Additionally, the analysis showed the lack of a board/institution to be the link between the designers and the construction industry and to set specific targets/standards for the façade industry. It is essential to establish a clear set of specific objectives: nowadays, with the implementation of new regulations, science should be considered to deal with construction and particularly with façade performance and energy conservation. A society of façade engineering on national and EU level in conjunction with the façade industry could play a driving force for the development of the glazing systems and the promotion of the DSF products. The society should aim to ensure that, all those associations involved in façade, work more closely together and to develop, evaluate and disseminate information on regulations and standards and the product performance specifications. Proposed actions of the society should include the preparation on 'technical' and 'physics' aspects of high-technology facades, the organization of regular technical meetings aiming at informing technicians and engineers on the update of the legislation and market. In this action,

EuroWindoor could also play an active role due to their experience in European level and their cooperation with global key players at international level.

Documentation of results: The publication of the good examples along with the documentation of their energy and environmental performance including operational and investment costs in engineering and architectural journals is important to increase reliability of the product and awareness among the target group. The provision of real data (i.e. monitoring data on energy and indoor comfort along with the users' satisfaction after the building construction and occupancy) and advertisement of the results would encourage the use of DSF and the public confidence in the product. The monitoring policy and the documentation of the results are effective in showing of how the DSF construction is meeting or not the various thermal and energy requirements. It is always necessary to cross the results of the theoretical and simulation analysis by monitoring the efficiency of the applied techniques that were studied. In this way, the difficulty levels in integrating the proposed systems and the efficiency of the applied strategies can be checked and improved. On the other hand, the lack of documentation on the real performance of DSF, i.e. lack of energy data and thermal comfort could be considered and as an indication of the negative aspects and malfunction of the product.
'Demonstration' projects could also be used to demonstrate the best technology, such as DSF, document the whole procedure from the pre-design stage until the occupancy of the building to indicate the performance of the technology.

Financial: The main competitor to the DSF is the conventional glazed systems due to their simpler technology and their reduced investment and lower construction costs.
It should be noted that the driving force for the application of DSF should not be the cost but the advantages of the technology and the system selected.
The reduction of the cost of the façade would promote the use of the product in the market. However, because of the high initial construction cost of the DSF and integrated shading systems, the DSF buildings could be assessed as cost-effective through the life-cycle cost method, assessing the total building cost over time. This include the initial costs (design and construction) in conjunction with operating costs, maintenance and environmental or social benefits (indoor environmental conditions, worker productivity etc)
The analysis showed that currently there are no financial incentive schemes for DSF. On national and EU level, there should be established short and long term funding to support both research and construction. It is also shown that public support and support from the Government is always important in developing the DSF market, thus the Government and relevant professional institutions should enhance the participation in projects relevant to DSF both in research and construction level with adequate subsidies.

11 Conclusions

The analysis on the non-technological barriers to DSF regarding the legislation issues shows that in the participating countries apart from one there is no awareness of the EN 13830 standards. This European Standard specifies characteristics of curtain walling and provides technical information on the varying performance requirements. Also, the document provides guidance to the curtain wall manufacturer on how to meet the requirements of the European Construction Products Directive (CPD). The CE marking is in force from 2005.
All existing legislations applicable to conventional facades (legislation on fire and sound protection, lighting issues etc) are also applied to double skin facades, since there are no specific ones for this type of facades.
Legislation on fire protection may be a threat to DSF since the fire transfer between the rooms and levels has to be reduced. Additionally sound legislation can be a threat when considering sound transfer between adjacent spaces through the DSF cavity. On the other hand, sound legislation can also be an opportunity to DSF as this type of façade provides better sound insulation than single skin systems. Legislation on lighting issues could pose a threat to DSF since the inner layer of glazing in conjunction with the internal blinds can lower significantly the daylight factors in the occupied spaces; however a proper design can result in adequate visual comfort; and then the legislation is considered as an opportunity to the use of DSF.
All countries have legislation on thermal insulation and achieved U-values; this is considered from most countries as an opportunity for double skin facades since the U-value is usually lower than for other glazed façade types. However, maximum indoor temperatures could pose a threat to DSF if limits of indoor temperature are to be observed.
The EPBD implementation could be an opportunity if the designed DSF is performing well (due to the presence of the two glazed skins), but it could be a threat if the system is badly designed and cannot meet the thermal and energy requirements (for example overheating is observed in summer).
In the case of ventilation requirements, these exist in all countries but do not pose any threat to the application of DSF.

The analysis showed that in all countries there are built examples; the majority of them have been constructed recently; however there is no documentation of their energy and environmental performance. In terms of the level of knowledge concerning the typology, performance, design and construction of DSF, educational /research institutions and big constructions companies usually working at an international level have good knowledge of the DSF systems. On the other hand, low level of knowledge is noted in the group of architects, building owners and investors. In the case of the advantages and disadvantages of the double skin facades compared to the conventional systems, it seems that the

knowledge is low in all target groups apart from several educational/research institutions that are working in relevant projects.
Climatic conditions do not seem to pose any obstacle in the application of DSF. Different systems can be applied in different countries; further design considerations should be applied in extreme climatic conditions i.e. excessive hot periods.
Full transparency do not seem to pose any threat to the application of DSF, it seems that architects desire full transparency while users might not like it.
Although DSF can be applied in all type of buildings, until now they have been used mainly for office buildings and not so much for residential and other type of buildings because of their increased construction and capital cost. The occupant control for ventilation may be a threat to DSF if their design does not allow user control.
Regarding the reputation of DSF in all countries, it seems there is skepticism in the scientific field concerning the energy efficiency, the indoor air quality and thermal comfort levels that this type of façade can provide. The reputation is good in the building industry that tries to promote this type of façade but there is also concern because of the high investment cost. Among the majority of the architects the reputation is good mainly because of aesthetics reasons. However, there is rather low level of knowledge on the energy performance of DSF among all target groups
The analysis also showed the lack of regional support, support from the government and the lack of a planning policy regarding DSF.

Finally, the analysis showed that the choice of glass as a material to be applied in large glazed areas and in double skin façade buildings poses architectural and engineering issues that concern both internal and external factors. The exterior expression of the building, the level of openness, the internal layout, the dividing of the interior and furnishing as well as structural issues have to be taken into consideration when designing a double skin facade building.
Team work between architects, engineers, clients and users are required from the very early design stage.

It can be concluded that many ‘non-technological barriers’ prevent the application and development of DSF systems in the EU market mainly because of the lack of legal standardized schemes, the lack of knowledge and the lack of financial support from the government and regional institutions. 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 façade systems.

Initial comments on strategies to overcome the non-technological barriers suggest:

- Legislation and standardization schemes for the evaluation of DSF
- Better knowledge of DSF (regarding their advantages/disadvantages, concept, etc)
- Reduction of the cost of the DSF

- Dissemination of best practice examples

The following table summarises the results of the analysis of the 'non-technological barriers' on DSF, based on the 'SWOT' principle.

DSF/ASPECTS	THREAT /WEAKNESS/PROBLEM/NOT APPROPIATE	OPPORTUNITY/STRENGTH/NOT A PROBLEM/APPROPIATE
Legislation on	fire protection	
	sound	sound
	energy issues	energy issues
	lighting	lighting
		U-Values
	thermal comfort (if overheating is experienced)	
Requirements	on thermal & energy modeling of buildings	
	on thermal & energy modeling of DSF if comfort requirements cannot be met	
Knowledge	low level of knowledge of advantages/disadvantages compared to conventional glazed systems in all target groups	
	low level of knowledge typology-design-construction among architects and building owners	high level of knowledge typology-design-construction among research institutions and big construction companies
	no available-published data of the built examples (performance, energy)	
Sociological aspects	full transparency	full transparency
	occupant control for ventilation	
		climatic conditions
	type of building (mainly for office buildings)	
	reputation - scepticism in the scientific field	good reputation in the building industry
Financial aspects	high investment costs	
	high cleaning costs	
Institutional aspects	no support from Government	
	not available funding	

Table 1: Table summarizing the non-technological barriers to DSF based on the 'SWOT' principle

In order to overcome the non-technological barriers to DSF a policy with a pre-assessment and post-assessment stage is suggested to cover all issues defined in the first part of the analysis.

In the pre-assessment stage the policy aims at providing the different target groups with all necessary information on DSF to be able to define and check the performance of the system. The pre-assessment policy aims at introducing homogenous legal schemes concerning DSF in all countries based on the EN standards. It is suggested that all countries would comply with the EN standards (EN 13830 'Product Standard - Curtain Walling) and fit these to their market and needs. It is also important to have a comprehensive approach for the calculation of the energy and environmental performance of DSF. This can be covered by the standards prEN 13947:2005 Annex D that gives the equation for the calculation of the U-value of curtain walls. Additionally the simple calculation method that will be developed within work package 4 of the BESTFACADE project could be used by all European countries for the thermal and visual assessment of DSF.
Dissemination of DSF is important in conjunction with reliable documentation of good built examples. Dissemination of the DSF buildings and the BESTFACADE project can be promoted in various ways, through seminars on national level, BESTFACADE workshops, education at university level, the use of complementary methods like as internet and publication of best practice examples in journals, the distribution of a best practice guideline with illustrations of DSF built examples.

The post-assessment policy includes all actions that have to be taken into consideration after the DSF dissemination in order to support and promote the product in the market. An aggressive marketing from the involved associations is essential as the advertisement of the DSF is dependent on the company level policy. Companies with experience on international level, i.e. EuroWindoor, could play a driving force to this on EU level in collaboration with the national markets by creating a functioning market environment for DSF. Additionally, the establishment of a board/institution of façade engineering on EU and national level could define specific standards for DSF and be the link between the designers and the construction industry. The board could ensure that, all those associations involved in façade, work more closely together and enhance to develop, evaluate and disseminate information on regulations and standards on DSF.
The documentation of DSF best practice examples including real data of their energy and environmental performance along with operational and investment costs is important to increase reliability of the product and awareness among the target group The main competitor to the DSF is the conventional glazed systems due to their reduced investment and construction costs. It should be noted that the driving force for the application of DSF should not be the cost but the advantages of the technology and the system selected. However, because of the high initial construction cost of the DSF and integrated shading systems, the DSF buildings could be assessed as cost-effective through the life-cycle cost

method, assessing the total building cost over time. Finally, public support and support from the government is always important in developing the DSF market; funding also is an essential motive for the promotion of DSF systems on research and construction level.

12 References

BESTFACADE project EIE/04/135/S07.38652, WP1 Report: ‘State of the Art’

BESTFACADE project EIE/04/135/S07.38652 WP2, WP2 questionnaire for the analysis of the non-technological barriers

EN Standards : EN 13830 : 2003 " Curtain Walling - Product Standard "

RESHYVENT project, Contract No: ENK6-CT2001-00533, WP2 Report: ‘Market survey for demand controlled hybrid ventilation in residential buildings’. RESHYVENT report No: RESH-WP2-D2.1 2005-02-25

13 Appendix - Answers to the WP2 questionnaire.

Legislation	Austria	Belgium	France	Germany	Greece	Portugal	Sweden
Any legislation on DSF	YES & NO legislation All DSF projects have to observe existing standards- but no regulations deal exclusively with DSF	YES & NO legislation YES: All legislations applicable to traditional facades are also to DSF, NO; There is no specific text related to this kind of façade	NO legislation	YES & NO legislation For DSF facades the same legislations apply as for other types of facades. There is however no special legislation for facades, but legislations for buildings. In these legislations there are partly special (sometimes reduced) requirements for glass facades.	NO legislation	NO legislation The general Portuguese building construction regulation is written so that all technologies are legislated. There is an article that states that every technology has to be certified. This certification is usually made by Portuguese Building Reseach Laboratories (LNEC). The fact remains that no specific legislation for DSF buildings exists, and no certification by LNEC exists. NO THREAT because there is poor control in the building industry. If the general legislation would apply threat could arise.	YES&NO legislation YES; All legislations applicable To traditional facades are also to DSF NO: There is no specific text related to This kind of facade

						It can be said that it is the specific legislation of fire protection that causes trouble	
Existence of legislation on fire protection	YES - each province (9 in Austria) regulates fire protection by own federal state legislation. A harmonized regulation (valid all over Austria) is under examination	YES legislation The fire safety aspects are always integrated in case of construction of buildings. Special rules are applicable to the façade. At the beginning of a national project on DSF in year 2000, no specific rules were available to treat the case of the DSF. This did pose problem since each project had to be evaluated by the local responsible fireman. Accepted solution somewhere could be rejected elsewhere. During	YES legislation	YES legislation- THREAT because fire men face more difficulties at DSFs, second escape route via façade is not possible. The fire transfer from one room to the other must be reduced.	YES legislation - may be a THREAT because fire protection legislation may put restrictions in the design of the façade	YES legislation This legislation makes no reference to DSF particulars. It poses problems to DSF buildings, and architects have experienced difficulties in the past because of licensing can be denied by fire brigades… some times different fire brigades have different opinions, so a clarification of this subject would certainly help the licensing of DSF buildings.	YES legislation, but no specific legislation For DSF. The building code states that the risk Of fire spread between fire cells shall be limited. The requirements on DSF can therefore vary From DSF to DSF

		this national project, specific rules have been proposed to handle the case of DSF. A working group including authorities has been constituted. These rules should be approved and applicable at the national level in the coming months.						
Existence of legislation on sound protection	YES - Each province (9 in Austria) regulates sound protection by own federal state legislation. A harmonized regulation (valid all over Austria) is under examination legislation - under circumstances can be an OPPORTUNITY to DSFs as they allow	YES legislation Rules are available within standards (and not within legislation) for the airborne acoustical insulation of facades. These rules are applicable to all kind of facades and not only to DSF. THREAT propagation of sound between adjacent spaces	YES legislation	YES legislation- OPPORTUNITY: noise from the outside is mostly reduced by DSF. This advantage is often used by architects to introduce DSF. THREAT: the telephony effect via DSF needs special care.	NO legislation , thus NO THREAT	YES legislation Usually DSF buildings perform better than single skin buildings, so no specific threat has been identified. There can be some complaints regarding the propagation of sound between adjacent spaces through the DSF cavity.	YES legislation. The building code states a certain level of sound reduction of the façade, related traffic	

	to realize a building on location with high noise levels	through the DSF cavity. More info about this topic on www.normes.be					
Existence of legislation on energy issues - savings	YES legislation - Promotion money for residential use is mostly linked to calculated energy performance values (kWh/m²a). The software which has to be used is simple and not able to calculate DSF facades. – regarding to this is there is no preference	YES legislation Thermal regulations are applicable in the three regions of Belgium. These regulations are under revision to fulfill the requirements of the EPBD. In short, the buildings have to fulfill to maximal U value and to a maximal average U value (via the so-called K-level). Since the 1st of January 2006,	YES legislation	YES legislation - Energieeinsparverordnung: a legislation that defines a maximum primary energy demand of buildings depending on the A/V ratio. For buildings with large glazed facades (therefore also the DSF) it includes another requirement on the maximum thermal transmittance through the building envelope. This will	NO legislation	YES legislation Until now, Energy legislation has never proved to be a threat to DSF buildings. This could mean that no particular problems arise in the specification of materials and DSF technology, or could simply result from the fact that in most cases the Energy regulation isn't subject to a stiff control.If it is proved that DSF buildings	YES legislation – The energy requirements of the building code are being revised to fulfill the EPBD. The current building code has heat recovery on ventilation (unless renewable district heating) and U-Value requirements. The last requirement is often difficult for a glazed building to meet. There is always the possibility to establish a reference building and carry out

		requirements about the energy performance at the building level have been entered into force in the Flemish region; the two other regions will follow this last step in the coming months. The legislation could be a opportunity if the described DSF is performing well (due to the presence of two glazed skins) but could be a threat if badly designed (due to overheating in summer for example). More info about this topic on www.normes.be		be replaced by a new legislation soon that includes a new calculation standard (DIN V 18599) THREAT: not every glazed façade can meet the requirement of the maximum thermal transmittance OPPORTUNITY: second layer is regarded a buffer zone, therefore reduced u-value of façade.		posses a poor performance due to DSF technology, namely, overheating problems, then, for cooled DSF buildings the Energy legislation will be a obvious threat to DSF buildings… but this is the way things should be!	energy simulations for the reference and the actual building. The revised requirements will also have the alternative with a required energy use of the building, which might facilitate for glazed buildings
Existence of legislation on environmental issues (lighting, glare,	YES legislation The use of efficient lighting is often suggested but not regulated by Law.	YES & NO legislation The energy impact of the lighting in office building will be	YES legislation	YES & NO legislation lighting: yes. miminum requirements for	NO legislation- Guidelines based on Guide:Ergonomic Problems of Employers,	YES legislation NO THREAT - This is a general regulation, not specific to DSF buildings and until	YES & NO legislation. The energy impact of the lighting in office building will be included in the new

indoor comfort, air quality)	Occupational medicine has a look at each workplace and gives comments to glaring conditions at workplace. Discussion on overheating temperatures in working places and the influence on lease prices of office buildings is disputed-but no general regulation exists until now. The indoor air quality is only touched by the regulations dealing with ventilation and the Employee Protection Law which deals with smoking regulations. In industrially used buildings (for example paint	included in the new regulation about energy performance of building.The RGPT ("Règlement général pour la protection du travail") specifies values about the lighting (lux) level to reach into offices and deals with the availability of natural light. European standards are also specifying lux-level in office buildings. No quantitative specifications about glare are existing.The RGPT specifies rules about acceptable indoor air temperature in function of the activity realised (and not in function of the type of room).		daylight factor (THREAT) glare, indoor comfort, air quality: no specific for DSFif there is a AC system included, the maximum indoor temperature has to be 26°C (THREAT) to avoid overheating there is a maximum solar transmittance factor defined that has to be met by all facades (OPPORTUNITY because STF is usually lower in spite of usually higher temperatures behind DSF) glare: offices have to have a glare protection (OPPORTUNITY)	ELKEPA, 1987 for Lighting - THREAT	now hasn't produced any relevant threat to DSF building	regulation about energy performance of building. The National Swedish Board of Occupational Safety and Health Standards state that for working environments there should be satisfactory daylight and possibility to view outside. There should also be adequate lighting and glare should be avoided. The indoor climate must be suitable and adapted to the character of the activity. The CO_2 content of the air should be below 1000 ppm, assuming that other pollutants are at an acceptable level.

	shops) there are special regulations for air quality.	No requirements about the air quality except rules concerning smoking areas in office buildings. Rules are well existing concerning the ventilation (see next question).					
Existence of legislation on ventilation requirements	YES legislation For some utilizations mechanical ventilation is mandatory (labs, commercial kitchens) but it is never forbidden.If a mechanical ventilation is implemented you have to prove that the asked hygienic rate of air change is possible. If window ventilation is implementd the planner has to	YES legislation The RGPT specifies minimal airflow to realise a.o. within office buildings. The new regulation entered into force in 2006 in the Flemish region defines an extended set of rules applicable to office buildings. These rules could also become valid in the future into the two other regions. There are no rules defining the type of	YES legislation	YES & NO legislation Only for assembly rooms (30 m^3/ph) In case for mech vent 30m^3/ph and $0.5h^{-1}$	YES legislation T.O.T.E.E 24/23, 2425/86, dated 1987 NO THREAT	YES legislation - NO THREAT There is legislation on ventilation. None to openable windows. The legislation on ventilation is a general one, not specific to DSF buildings and, until now, hasn't produced any relevant threat to DSF building	YES legislation NO THREAT but NO OPPORTUNITY. A minimum outdoor air ventilation rate is specifed in the building code 0.35 l/(sm2)

	account for the asked minimum openable window area. Hygienic flow rates and openable window area are specific to the utilisation and given by the national standards.	ventilation to realise (natural or mechanical) nor the size of the openable windows.					
Current legislation on percentage of glazing	YES legislation National standards dictate the minimal account of glazing for living spaces to guarantee enough sunlight. No regulation according to the maximum.	NO legislation The authors don't know the existence of requirements about the maximum percentage of glazing. Indirect requirements are set by imposing a maximal average U-value to the building.Indirect minimum requirements are existing by imposing daylight availability into the office.	YES legislation	YES legislation Minimum requirement of window size dependent on room floor area (dwellings, Landesbauordnungen) Offices: dependent on room width (DIN 5034)rather an OPPORTUNITY, there is no maximum size, but recommendations THREAT: the Energiesparverordn	NO legislation	YES legislation - NO THREAT This is a general regulation, not specific to DSF buildings and until now hasn't produced any relevant threat to DSF building	NO legislation

				ung requires a calculation that proves that there are no overheating problems in case of not air-conditioned buildings. Large glazed areas without good shading devices have problems to meet the requirements.			
Current legislation on thermal insulation - achieved U-Values	YES legislation There are 9 federal states each administrating its building codes. Each federal state government legislates a set of U-values that you are not allowed to exceed. The harmonisation of these standards between the provinces is under examination.	YES legislation (see question about energy issues)	YES legislation	YES legislation Specific requirements for non-residentials with high window area ratio, maximum thermal losses (Energieeinsparverordnung) Calculation of U-Value of facades according to ISO standard OPPORTUNITY: the U-value is mostly lower for DSF than for other glazed	YES legislation Thermal Regulation 1981, THREAT only if the DSF construction does not meet with the thermal regulation	YES legislation The current energy legislation is not very severe regarding U values. No specific mention to DSF constructions is made. Until now the current legislation hasn't produced any relevant threat to DSF building	YES legislation THREAT as it makes it difficult to get a building permit, because it is difficult to meet the requirements of the building code (see also question concerning energy issues)

				façade types			
Requirements for integration of renewable energy - PV cells	No obligation but government aid and tax relieves depending on federal states. In case of installation, technical requirements are to be met.	NO requirements This kind of technology is taken into account into the new energy performance regulation entered into force in 2006 in the Flemish region. The regulation are specifying that in case of construction of large buildings (>1000m²), feasibility study have to be made to	YES requirement s	YES & NO requirements OPPORTUNITY: Energieeinspeisung sgesetz (not on DSF, but on DSF in combination with PV-Systems and other renewable energies) fixes high prices for the PV-electricity if fed into the grid	NO requirements	NO requirements	NO requirements

		assess the interest of such technologies.					
Requirements on thermal and energy modelling of buildings	YES requirements Heat demand calculations are requested by all provinces (according to a simplified EN 832 approach) for residential buildings for the subsidy schemes. Only some provinces have this request in the building code. No special requirements for DSF	YES requirements EPBD requires to calculate the energy demand of buildings no satisfactory answers on the way to handle DSF. There is a lack of rules for these facades.	YES requirements	YES requirements new DIN V 18599 conservative approach for DSF (THREAT for good DSF that might provide better results than calculated with the DIN)	NO requirements - will be with the EPBD implementation from January 2006 - THREAT	NO requirements Probably this will change in the near future, and then, threats will depend on the actual performance of DSFaçades.	YES requirements, but only for the use of a very simple energy tool - THREAT (difficult to make calculations for a DSF)
Requirements on thermal and	NO requirements to simulate the	See above	NO requirement	YES & NO requirements	NO requirements - will be with the	NO requirements - Probably this will	NO requirements

energy modelling of DSF performance	performance of DSF since there is no specific legislation for DSF		s	For simulation tools: NO requirements. There is a new CEN norm that demands a proof that the used simulation tool is accurate enough for the simulation performed For calculation with the new German standard DIN V 18599: conservative approach, ventilation rate of 10 h-1 (in relation to the cavity), frame size of outside skin defined. Thermal transmittance, solar irradiation into the room behind is calculated similar to the wintergarden principle of EN 832.	EPBD implementation from January 2006 - THREAT	change in the near future, and then, threats will depend on the actual performance of DSFaçades.	

Safety regulations influencing DSF	Possible OPPORTUNITY:- The cavity can be used as a fire escape route. - Night ventilatoin is possible without safety risk	NO regulations In terms of stability, safety of the occupant or of the pedestrians, the same criteria as those applicable to traditional single façade are applicable to VDSF.About the safety in case of fire, see specific question on this topic.	NO regulation	YES & NO regulations no special requirements, safety regulations as for standard facades but see fire regulations	NO regulation	YES regulations NO THREAT besides the fire protection ones	YES regulations. According to the building code the risk of personal injury from glazed areas shall be limited.
Other legislation with an impact on DSF	Regulations on air traffic in some cases demand the implementation of radar damping systems on DSFs						

Knowledge	Target Group	Austria	Belgium	France	Germany	Greece	Portugal	Sweden
		HIGH/LOW	HIGH/LOW	HIGH/LOW	HIGH/LOW	HIGH/LOW	HIGH/LOW	HIGH/LOW
Level of knowledge on the typology and performance of DSF	Scientific - educational institutions	HIGH -Only in a small range of institutions (mainly scientific) in aspects of builidng physics and resistance. LOW - Nearly no information on construction, costs and performance of DSFs is provided at educational institutions. .	HIGH-BBRI has set up a specific document about the typology of DSF. Performances (thermal, acoustics, etc) of DSF have been determined. PhD's in Belgian universities have been performed. The main difficulty lies in determining the thermal performances at the building level (and not only at the façade level)	LOW	IBP: HIGH - literature studies, simulation, measurements at VERU	LOW-But some educational institutions participate in research programmes, i.e. NKUA participates in the BEST FAÇADE programme that offers knowledge on DSF issues and awareness on the level of knolwledge on DSF in other countries		LOW, except for e.g. Energy and Building Design Lund University

Building Industry - Construction	HIGH -Big construction companies which work internationally have their own systems of proved construction typology. Big facility management firms do know the DSF performance quite well	HIGH in the façade industry		Façade Industry: HIGH	LOW, a few costruction companies that have already participated in the design of DSF, i.e. ALUMIL company, are aware of the typology and performance of DSF	LOW - Regarding constructors most of the DSF technology is imported and installed by foreign companies. Therefore a low level of knowledge exists among Portuguese constructors.	LOW, among clients and engineers (apart from some major property owners/developers and engineers with some knowledge on typology and performance). The knowledge on the energy performance is rather low
Architects	LOW There is just minimal kowledge about DSF facades in the bulk of architects.	The majority of architects are not really aware about the real performances of DSF, apart from some specialised architects.		HIGH -Some architects are specialised in DSF buildings, some consultant offices as well LOW - Conventional architects don't know too much about DSF, further education at engineers is not too common	Extremely LOW, limited architectural practices that have participated in the design of DSF(maybe 1 or 2). However the majority of architects are not aware of DSF	HIGH -Between architects, there is knowledge about typology. There are several DSF buildings in Portugal, more than 10 only in Lisbon, and some architects have designed more than one. LOW	LOW apart from some major architects with some knowledge on typology. The knowledge on the energy performance is rather low

						knowledge in thermal and energy performance of DSF! Architects don't actually know in design stages how the DSF building will perform.	
Other (optional)				Building owners: LOW -Building owners don't know too much about DSF. Architects sell them this feature with arguments that it solves all the problems of the building. Investors:LOW - Investors don't know too much about DSF. Architects sell them this feature with arguments that it solves all the problems of the			

					building. However they know that DSF causes higher investment costs. Therefore it is mostly used for high-representative buildings.			
Level of knowledge on the design, construction and technology of DSF	Scientific - educational institutions	Relatively HIGH	HIGH BBRI not specialised in the design but followed some work on the construction work of buildings equiped with VDSF		IBP:HIGH -case studies: Library Ulm, Fraunhofer central building	LOW-But Educational institutions participate in research programmes, i.e. NKUA participates in the BEST FAÇADE programme but at research level, not at design & construction level		LOW
	Building Industry - Construction	HIGH -Only in a small range of companies in terms of construction knowledge and costs	Specialised façade constructions have a high knowledge on the design , construction and		Facade Industry: HIGH They have to know about this. It is their business. However reality proves that often the wrong type	LOW in the total of companies- High in a few of companies that have participated in the construction of	LOW- For the Portuguese building industry	LOW among clients and engineers (apart from some major property Owners/developers and engineers)

		technology of DSF.		of DSF is applied for buildings. The result is bad comfort and/or high energy consumptions. There is a big interest to improve the reputation of the DSF.	DSF , ie. ALUMIL		
Architects	LOW There is just minimal knowledge about DSF in the group of architects	Low in general, apart from some major architects.	LOW - Design of buildings without calculation methods	HIGH Some architects and consultants are specialised in DSF buildings	LOW	HIGH-For architects who have designed DSF buildings	LOW , apart from some major architects with some knowledge
Other (optional)				Building owners: LOW -Building owners don’t know too much about DSF. Design, construction and technology is not of much interest to them Investors: LOW - Most investors have to depend on the architect/engineers in the			

					design/construction and technology of DSF.				
Dissemination of knowledge on DSF (through University, Internet, Seminars, Other Methods)		As far as we know explicit DSF knowledge is not included in any education system. In lack of other sources in the moment maybe internet is the best source to get information. But the quantity of high quality information is rather small	Dissemination through: University, Internet, Seminars	Disseminati on through: University, Internet and Seminars	Dissemination through: University, Internet, Seminars and Other Methods)	Through Internet and Seminars and indirectly through educational institutions that may participate in research programmes on DSF	Dissemination only through University -(No dissemination through Internet, Seminars)	Website of University of Lund, Energy and Building Design
Level of knowledge on the advantages and disadvantages of the DSF compared to a conventional façade	Scientific - educational institutions	LOW- The best source until now in this case comes out of self done projects- or projects we are close to. Reliable comparative studies are missing	HIGH –BBRI and some universities have written documents dealing with these topics. The main uncertainty is related to the thermal	LOW	IBP:HIGH	LOW, educational institutions partticipate in research programmes in order to assess advantages and disadvantages on DSF compared to conventional construction	Universities an research centers are starting to work on these subjects (MSc, PhD thesis undergoing).	LOW, apart from University of Lund (Energy and Building Design)

		the level of the building, of a DSF compared to these of a traditional glazed façade.					
Building Industry - Construction	The facade industry mostly knows	The facade industry : In principle yes		Facade Industry: HIGH-They have to know about this. It is their business. However reality proves that often the wrong type of DSF is applied for buildings. The result is bad comfort and/or high energy consumptions.	LOW but companies that participate in the design of DSF can investigate the advantages and disadvantages through their built examples		LOW apart from some engineering firms
Architects	Low - Architects often do only see the design advantages	Low in general, apart from some major architects		HIGH -Specialised architects and consultants have done further education courses concerning DSF and take part in information seminars	LOW, even those who have participated in the design of DSF examples	LOW-There is a lack of knowledge on these subjects by architects and these are the ones with the most knowledge in the building	LOW even among those who have participated In the design of DSF examples

				LOW-Most architects and consultants don't know too much about DSF		industry	
Other (optional)				Building owners: LOW - Building owners don't know too much about DSF. Investors: LOW			
Availability of DSF built examples in your country	Several examples exist. The availability to take a photo is high, the availability of reliable data is low.	YES built examples, mostly mechanically ventilated DSF. DSF buildings are more and more often build in Belgium since the 90's. It has to be noted that the concepts applied in Belgium are rather different from those applied e.g. in Germany. The applied façade	YES built examples	YES built examples, but their energy consumption in most cases is not published	A few office buildings in Athens and Thessaloniki already built. 2 other now in construction (exhibition centre, hotel) in Athens and Thessaloniki	YES built examples	YES built examples- maybe ten buildings, of which most have been in operation only a couple of years

		concepts in Belgium are mostly based mechanically ventilated.					

Sociological-Behavioral aspects	**Target Group**	**Austria**	**Belgium**	**France**	**Germany**	**Greece**	**Portugal**	**Sweden**
Local climatic conditions		APPROPIATE for DSF. The conditions given by the climate in Austria can usually be controlled by DSF related technical equipment. If this justifies enormous additional investment is not decided yet.	Several concepts of façade are existing. Each of them is more appropriate to a specific type of climate. Naturally ventilated DSF are in general not very appropriate in warm climate while mechanical ones could be adapted.	APPROPIATE for DSF	APPROPIATE for DSF Depending on the building use and the type of DSF (naturally ventilated, with or without air-conditioning…)	If not well designed and shaded, maybe a problem of overheating in the summer because of extreme high temperatures	APPROPIATE for DSF This is the answer from architects that design DSF buildings. They state, however, that this is in the case the design is actually inforced… some times, usually due to costs, the actual façade differs from	APPROPIATE for DSF, according to some architects

						the designed one, for instance the building owner decides not to include shading devices	
Local architecture-aesthetics for full transparency	YES a problem. Transparency to look outside is usually not a problem. Transparency to look inside is a disputed item and causes opposition in the group of users. Depends on clentele, many architects like full transparency, many users don't.	Tendency to adopt more and more transparent buildings in Belgium. It is often one of the elements to consider when adopting a DSF	NOT a problem	NOT a problem DSF became an architectural trend in high-level high-rise buildings in the last 15 years. Some provisos on the use of these buildings exist.	NOT a problem	NOT a problem	NOT a problem
Is the area covered by the DSF cavity calculated in thetotal net floor area of the building? Reduction of rentable Office space	YES a problem. Ecological impact, need for energy and cost to be compared to the usefulness of a building, in this			YES a problem net floor area does never include the interspace…but the reduction of the net floor area by the double skin façade	YES a problem Possible reduction of office space	NOT a problem	YES, it is often a problem. It is not clearly specified in the Swedish standard for calculations of

	comparison space for cavity cannot been seen equal as floor space.			is a problem because of smaller rented floor area (net floor area). The maximum size of the building is defined by taking the length of the outside facade			building areas
Is in your country DSF appropiate for all types of buildings? If not please state what buildings are not appropiate	In single family houses the concept of double glazed spaces is often used in the 'wintergarten' concept, which is popular inAustria. In multi storey residential buildings it is not common to use DSF. DSF can be used for all types of buildings in Austria, but due to the costs the main field of application is office buildings	The diversity of DSF is so high that in principle such façades seem to be applicable to all kind of buildings excepted for residential buildings where the kind of technology is not considered (due to higher costs).	NOT a problem	NOT a problem Generally yes, but used mostly in high-level office buildings because of high investment costs.	Mostly in offices and public buildings (because of high cost). Not in residential buildings	Not a problem. Until now DSF buildings are mainly office buildings and shopping malls.	Not a problem. Until now DSF buildings are mainly new office buildings
Is occupant control for	The discussion	YES a problem	NOT a	YES a problem	Important	YES a problem	YES a problem,

ventilation important under specific climatic conditions? Is this a problem for the operation of DSF?	about openable windows is a very emotional one in Austria. We have seen in many discussions that the pure possibility to open the window, to contact outside, is a value most people do not want to miss. Complete control by occupants is not necessary but the possibility to influence the indoor climate at the own working place in a small range is needed for high using acceptance. Conclusion: if a facade (ventilation system) does not allow at least a small range of user control it will not be accepted and if the	It has been often observed that the occupant needs to have a certain control on his environment (e.g. control of the solar shading, of the temperature levels or opening of the windows). Adapted concepts of DSF could take advantage of this. Otherwise, that could be a problem for the use of DSF	problem	Most people prefer an indoor comfort that they can influence themselves (e.g. by opening the windows at their choice). This is most of the times not possible with DSF and the linked technical systems like air-conditioning/mechanical	occupant control. The use of openable windows is desirable , YES a problem if DSF design does not permit flexibility	Occupant control is a problem for occupants; but no problem for office managers who some times impose their rules…	most people prefer being able to influence the indoor comfort (e.g. by opening the windows at their choice). In office buildings the users can most of the time not control the mechanical ventilation, but can usually at least open some windows. This is most of the times not possible to the same extent in existing office buildings with DSF.

		technical concept is not able to handle this it is the wrong concept						
Reputation of DSF	Scientific - educational institutions	The reputation in the group of experts in the field of building physics and energy is rather sceptic but never the less interested	BBRI: GOOD reputation The authors assumes that in general the DSF have a rather good reputation since more and more buildings are build with this kind of facades. Examples of bad working building equipped with DSF also exist. But for many actors, the reputation of DSF is a confused subject due to the lack of knowledge about the energy performances of buildings equipped with DSF		Summary: GOOD - for architects DSF the solution to everything in high-rise buildings BAD - Most articles on energy consumptions of buildings including DSF show that the consumptions are much higher than in conventional buildings	NO reputation currently- Investigation on DSF reputation through research work	GOOD - Considering the amount of DSF buildings in Lisbon, DSF buildings must have a good reputation, mainly due to aesthetics	BAD i.e. scepticism concerning energy efficiency and quality of indoor climate. The level on knowledge is not yet so high, but will be.

	Building Industry - Construction	Mixed - some consider DSFs to be a good selling argument - others do see more problems than advantages			Façade Industry:GOOD	GOOD in a few companies that try to promote DSF and improve their performance		BAD – high investment cost
	Architects	In the group of architects the reputation regarding aesthetics is good because it gives new possibility to design the building envelope.			GOOD architectural papers often praise the designs of DSF buildings and sell the idea that this façade solves all problems BAD Engineers exchange informations on technology related symposiaEvery consultant tries to develop a more efficient system	NO reputation in the group of architects since the majority of them are not aware of DSF		GOOD, among many architects
	Other (optional)		See		Building owners:GOOD - if reading architectural papers BAD-if reading publication on real			GOOD , among investors in high Profile office building

					consumptions and partly also comfort Investors:GOOD-for high-level office buildings-BAD			

Financial aspects	**Austria**	**Belgium**	**France**	**Germany**	**Greece**	**Portugal**	**Sweden**
Cost of DSF buildings compared to traditional facades	Mostly higher but very few comparable data available	BBRI: According to us, it is not really possible to give any general rule about this. High cost / Low cost are subjective	HIGH	HIGH	HIGH	HIGH - but identical to that of common single skin buildings with identical typology (Portuguese	HIGH – Investment cost

		concepts The costs are extremely variable from one building to another one. As general rule, it can be said that DSF should cost more than traditional façade (investment cost) and that the operational costs should be reduced. It is however observed in some buildings that the cooling consumption can be higher than in traditional buildings. Maintenance costs should be also taken into account.				DSF buildings are usually multistory buildings owned by banks, Tech companies and shopping mall’s). Since DSF technology is imported, the cost depends very much on the contract	

Level of knowledge on the cost of DSF (Investment , Operational, Maintenace)	Scientific - educational institutions	LOW - Investment , LOW - Operational , LOW - Maintenance Extremely difficult to get data, reasons for economics and the fear of bad reputation seems to block dissemination		LOW - Investment LOW - Operational LOW - Maintenance	IBP :HIGH - Investment HIGH - Operational LOW - Maintenance	LOW , knowledge acquired through research programmes and study of built examples	LOW - Investment LOW - Operational LOW - Maintenance	LOW - Investment , Operational , Maintenance due to lack of data
	Building Industry - Construction	Investment - high Operational and maintainance - low			Façade Industry: HIGH Investment ,HIGH & LOW - Operational ,HIGH - Maintenance	In general LOW , HIGH for the companies that have participated in the construction of DSF		HIGH – Investment LOW –Operational and Maintenance due to lack of data as there are few buildings and as they are fairly recent
	Architects	Low			HIGH & LOW - Investment LOW - Operational LOW -	LOW		LOW – Investment, Operational, maintenance

				Maintenance			
Others (optional)				Investors: HIGH & LOW - Investment, LOW - Operational , LOW - Maintenance Building owners: LOW - Investment , HIGH & LOW - Operational ,HIGH & LOW - Maintenance			
Funding/grants on DSF	Not available	Not available	Not available	Not available	Not available	Not available Low level of incentives for energy efficient buildings.	Not available

Institutional aspects	Austria	Belgium	France	Germany	Greece	Portugal	Sweden
Support from the Government or Professional institutions	NO support	YES & NO support There is no direct support. There is indirect support via the financing of research projects like the national DSF project (2000-2004) coordinated by BBRI.	NO support	YES & NO support Support only for intergrated PV glass systems	NO support. There is indirect support through the financing of research programmes	NO support	NO support
Regional Support-Planning policy	NO support	NO support	NO support	NO support	NO support	NO support	NO support
Required bureaucracy-authorisation for the new technology	Yes	YES increased With the future energy performance regulation, technology not covered by the standard calculation procedure will have to be assessed by the so-called principle of equivalence. The exact way to fill in this is not know yet. It will probably require specific complementary studies in order to be able to evaluate the energy performance of this kind of technology (as VDSF).	YES - increased bureaucracy	YES increased Same as for other facades	YES - increased bureaucracy	YES increased - Due to huge bureaucracy some new technologies are used without specific authorization. Fire protection is the main cause of problem for DSF buildings in Portugal.	YES – risk for increased bureaucracy, Especially with the new building code stating the energy performance, but not any recommendation as to how take into account DSF

Additional comments	Austria	Belgium	France	Germany	Greece	Portugal	Sweden
Other comments on the non technological barriers	Sometimes the needed additional space is simply not available. If you are limited with the space and you have to downsize the floor space DSF is getting extremely expensive because you loose floor space for renting or selling.	The authors have tried to give synthetic answers to this questionnaire. A lot of complementary elements would have to be mentioned in order to be complete. The questionnaire would become > 50 pages – differentiated answers according to the typology of building.		Higher cleaning costs for DSF			
Initial comments-proposals on the barriers to overcome the non thechnological barriers (discussion during the next meeting 19-21 December)	A centralized information network database performed by professionals of all sections of the design-, construction- and maitenance process of DSFs should be established. National legislation should act on the topic and provide standardisation schemes to easly evaluate projected DSFs.				In the case of Greece, through workshops and seminars in order to introduce best practice of DSF.Publication of bad practice examples and solutions to the problems (technical & mechanical solutions)		Dissemination of best practice and advantages/ disadvantages to clients and architects