# THE TECTONICS OF THE
# *ENVIRONMENTAL SKIN*

This website is dedicated to investigating inventive Double-Skin cladding systems experimenting with environmentally “responsible” design.  It has been divided into two sections: Double-Skin Façades and Innovative Envelope Design.  We have made this distinction between the buildings examined so as to have a more comprehensive look at the different façade constructions being explored by architects and engineers in search of more environmentally “conscious” building solutions.

Buildings examined in both sections explore the notion of exterior walls that respond dynamically to varying ambient conditions, integrating effective, uncomplicated sun-shading and thermal insulation. Historically, architects such as Le Corbusier, with his mur-neutralisant, and Alvar Aalto, in the Paimo Sanitorium, have experimented with this kind of building envelope.  Only more recently has it become synonymous with explorations in transparent and glass architecture which has consequently evolved into the contemporary idea of the Double-Skin Façade.  Buildings in the Innovative Envelope Design section were included in the research so as to push the notion of the dynamic building envelope to include noteworthy buildings that are both environmentally responsible and responsive, but break from the modern transparent Double-Skin typology.

This research has allowed us to explore and classify the different cladding systems, and begin to ascertain whether or not these building envelopes represent a valid approach to energy efficient and environmentally “sustainable” design. Through this website we hope to both create a forum for further research and examination of the Double-Skin Façade, and foster a discussion of their benefits, short-comings, and legitimacy as an environmentally “sustainable” building technology.

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*Examples of Double-Skin Façades (from top to bottom) The Helicon Building, Finsbury Pavement, London, UK, The Debis Tower, Potsdammer Platz, Berlin Germany, and The Hooker Building, Niagara Falls, New York, USA*

## DOUBLE-SKIN FAÇADES

*Synonyms: Double-Leaf Façade, Double-Skin Façade, Double Façade, Double Envelope, Dual-Layered Glass Façade, Wall-Filter Façade, Ventilated Façade*

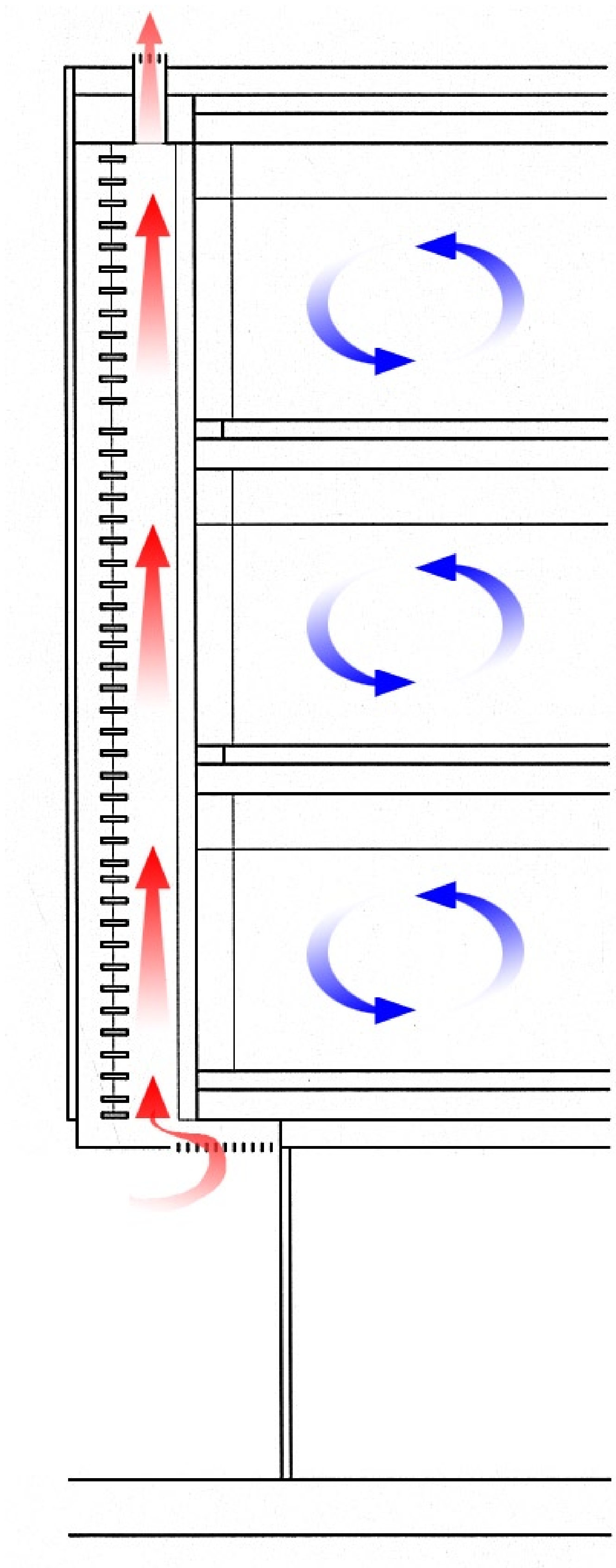
The Double-Skin Façade is essentially a pair of glass "skins" separated by an air corridor. The main layer of glass is usually insulating. The air space between the layers of glass acts as insulation against temperature extremes, winds, and sound *(Lang and Herzog, 1999)*. Sun-shading devices are often located between the two skins. All elements can be arranged differently into all numbers of permutations and combinations of solid and diaphanous membranes *(Diprose and Robertson, 1999)*. There are four basic Double-Skin typologies: the **Buffer Façade, Extract-Air Façade, Twin-Face Façade** and **Hybrid Façade**.

## THE BASIC DOUBLE-SKIN TYPOLOGIES

### THE BUFFER FAÇADE

The Buffer Façade consists of two layers of glazing mounted approximately 250 to 750mm (10" to 30") apart, with the air space between the two layers sealed. This is the oldest typology; it has been in use for nearly 100 years *(Lang and Herzog, 1999)*. The Buffer Façade was developed before insulating glazing was invented to increase sound and heat insulation without reducing the amount of daylight entering the building. A contemporary example is the **Occidental Chemical Centre (or Hooker Building)** in Niagra Falls, New York.

*The Buffer Facade with Undivided Air Space*



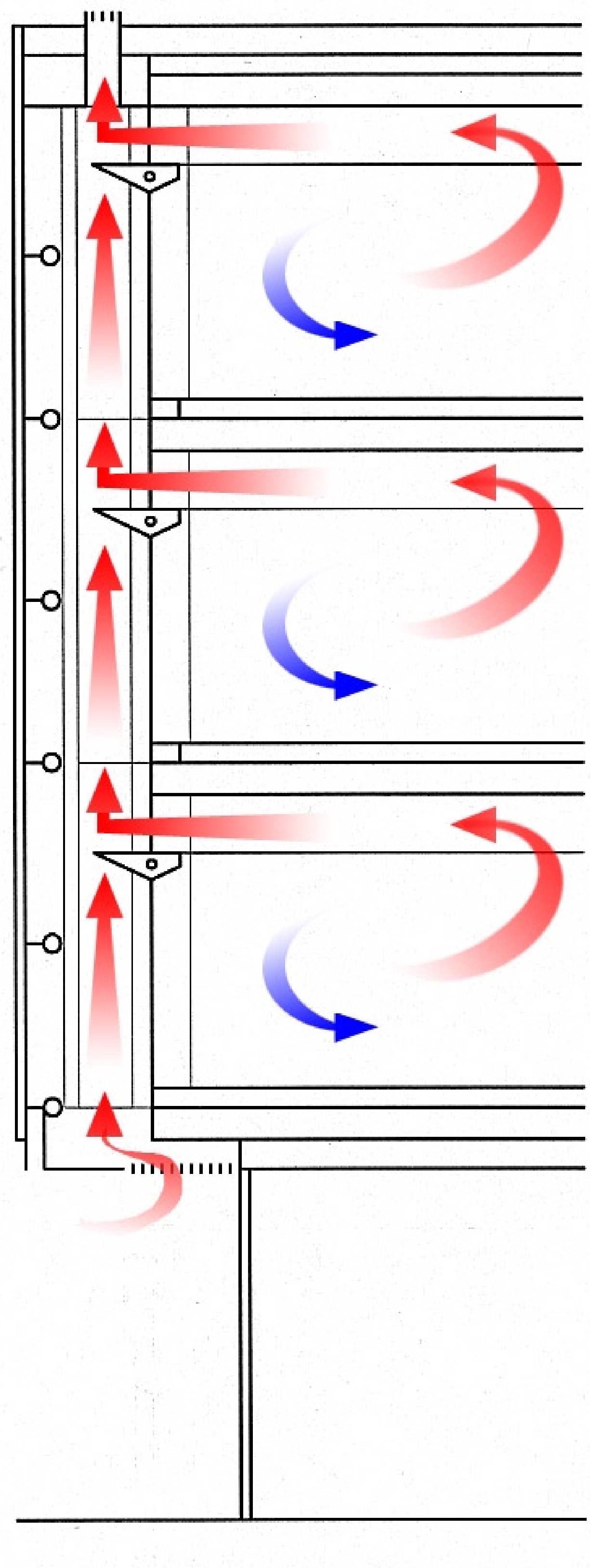
## THE EXTRACT-AIR FAÇADE

The Extract-Air Façade consists of a main double-glazed skin of insulating glass with a second single-glazed skin placed inside. The air space between the two layers of glazing becomes part of the HVAC system. The heated "used" air between the glazing layers is extracted through the cavity with the use of fans and thereby tempers the inner layer of glazing while the outer layer of insulating glass minimises heat-transmission loss. This system is used where natural ventilation is not possible (for example in locations with high noise, wind or fumes). Shading devices are mounted within the cavity. An example of an Extract-Air Façade is the **Helicon Building**, London.

## THE TWIN-FACE FAÇADE

The Twin-Face Façade is comprised of a conventional curtain or massive wall system with an outer skin of single glazing *(Lang and Herzog, 1999)*. The single-glazed outer skin is used primarily for protection of the air cavity contents (shading devices) from weather. With this system, the internal skin offers the insulating properties to minimise heat loss. This typology differs from the Extract-Air Façade in that it permits openings in the skin, allowing for natural ventilation. Windows on the interior façade can be opened, while ventilation openings in the outer skin moderate temperature extremes within the façade. The use of windows can allow for night time cooling of the interior thereby lessening cooling loads of the building's HVAC system. For sound control, the openings in the outer skin can be staggered or placed remotely from the windows on the interior façade. Some examples of Twin-Face Façades are the **Telus/Farrel Building**, Vancouver, the **Debis Building**, Berlin, and **Das Dusseldorfer Stadttor**, Dusseldorf.

*The Extract-Air Facade with Divided Air Space*



### THE HYBRID FAÇADE

The Hybrid Façade is a system that combines one or more of the basic characteristics of the aforementioned typologies to create a new hybrid system. Examples of buildings with a Hybrid Façade are the **RWE Building**, Germany, **ING Headquarters**, Amsterdam and the **Tjibaou Cultural Centre**, New Caledonia.

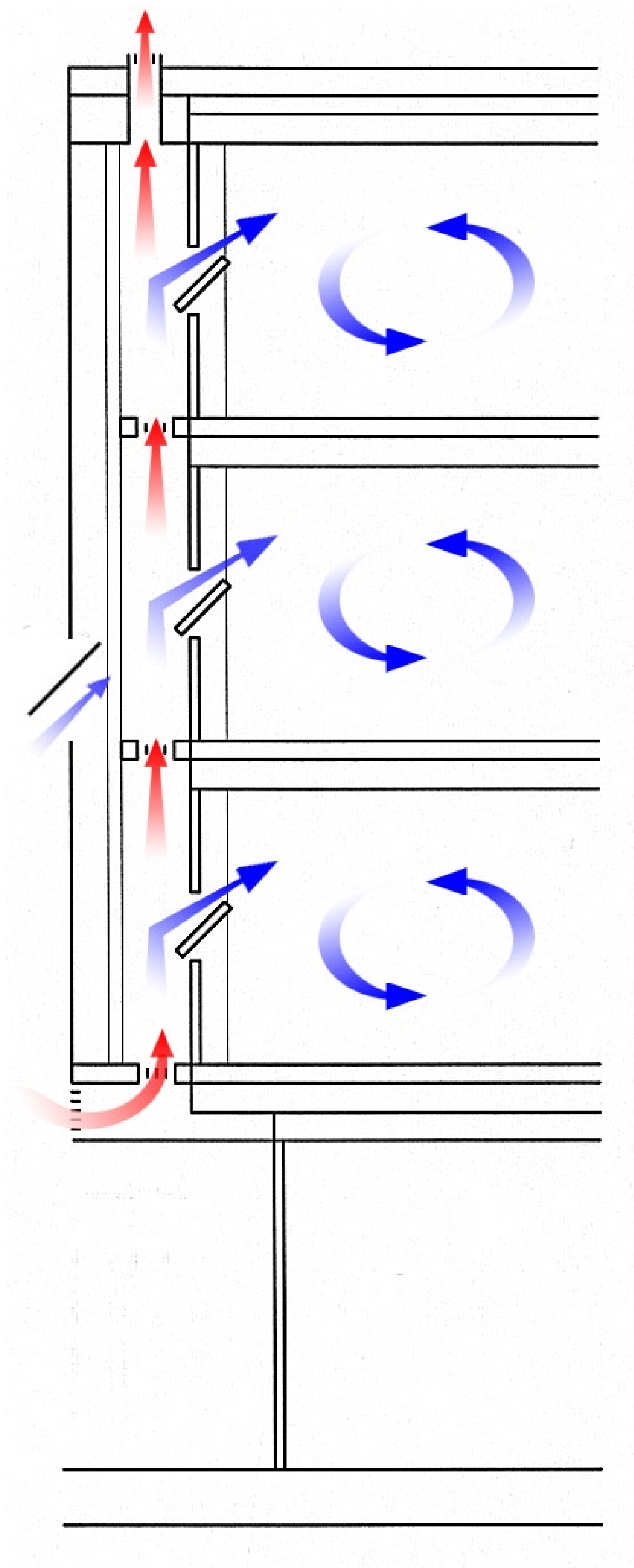
## THE AIR SPACE

Appropriate design of the air space is crucial to the Double Façade. Variations allow for improved airflow, sound control and other benefits. The air cavity can be continuous vertically (undivided) across the entire façade to draw air upward using natural physics principles (hot air rises), divided by floor (best for fire protection, heat and sound transmission), or be divided vertically into bays to optimise the stack effect.

### THE UNDIVIDED AIR SPACE

The undivided façade benefits from the stack effect. On warm days hot air collects at the top of the air space. Openings at the top of the cavity siphon out warm air and cooler replacement air is drawn in from the outside *(Lang and Herzog, 1999)*. However, without openings at the top of the cavity, offices on the top floors can suffer from overheating due to the accumulation of hot air in the cavity adjacent to their space. The undivided air space can be transformed into atria, allowing people to occupy this "environmentally variable interstitial space" *(Diprose and Robertson, 1999)*. The atria/air cavity can be used programmatically for spaces with low occupancy (meeting rooms or cafeterias). Plants are used in these spaces to filter and moisten the air as well as act as shading devices. Examples of buildings with undivided air

*The Twin-Face Facade with Divided Air Space*



spaces are the **Occidental Chemical Building**, Niagara Falls, **ING Headquarters**, Amsterdam, and the **Telus/Farrel Building,** Vancouver.

**THE DIVIDED AIR SPACE**
The divided air space can reduce over-heating on upper floors as well as noise, fire and smoke transmission. Floor-by-floor divisions add construction simplicity of a repeating unit and in turn can produce economic savings. Corridor façades (commonly used in twin-face façades) have fresh air and exhaust intakes on every floor allowing for maximum natural ventilation. Shaft facades (divided into vertical bays across the wall), draw air across the façade through openings allowing better natural ventilation. However, the shaft façade becomes problematic for fire-protection, sound transmission and the mixing of fresh and foul air *(Lang and Herzog, 1999)*. Buildings with divided air spaces are the **RWE Building**, Germany, and **Das Dusseldorfer Stadttor**, Dusseldorf.

## ENVIRONMENTAL CONSIDERATIONS

Controversy arises when trying to evaluate Double Skin Façades as an efficient and environmentally “sustainable” building approach. When assessing these buildings, the particular financial, ecological and social framework of each building must be taken into account when trying to draw conclusions. However, one crucial problem still remains: what benchmark should be used in order to compare the Double Skin Façade?

Part of the challenges that arose from this research stemmed from the [un]availability of relevant, reliable statistics due to the lack of published test data, copyrighted designs, and the absence of an agreed base case from which to compare results. Despite these restraints, we felt it necessary to assemble a comparative chart based on more “subjective” data to help evaluate the case studies. Below are listed the relative criteria used to evaluate the case study buildings.

a) Effectiveness in controlling solar gain:
*Does the system incorporate shading devices?*
*Are the devices layered? Are there blinds plus a layer of louvers?*
*Are there multiple choices of control?*
*How are they controlled? Individual or computer controls?*
*Do the devices negate day lighting when in use?*

b) Overall insulating value of the system:
*What is the U or R value of the building compared to the “base case” aluminum curtain wall system?*

c) Access to fresh air:
*Is the cavity ventilated to provide access to fresh air?*
*Is there occupant control over natural ventilation?*

d) Day lighting:
*Is this a motivational strategy for employees? How well does it work?*

e) Perceived maintenance problems:
*What is the dimension of the wall cavity?*
*How is it cleaned? How often?*

f) Embodied energy:
*How much material was required, what kind, where did it come from, and how many layers are there?*
*What is the overall dimension of system as compared to base case aluminum curtain wall?*

g) Adaptability for façades facing the cardinal directions

h) Commercial concerns:
*What is the overall dimension of the system as it relates to non-leasable floor area?*
*Costs: if known*

i) Aesthetics:
*For example, is the driving force of the building to create fully transparent glass architecture?*

j) Climatic Considerations:
*How do double skin buildings perform based on the four primary climate types (cold, temperate, hot-arid, hot-humid) ?*

## FURTHER CONSIDERATIONS

### HARD ECONOMY: UPFRONT INVESTMENT

In Europe these façades are twice as expensive as regular cladding systems. In the U.S. they can be four or five times the cost *(Lang and Herzog, 1999)*. Cost increases in North America are due to engineering costs (mechanical and structural), the amount of special glass required and the unfamiliarity of tradespeople with these systems consequently leading to higher installation costs. In Europe energy (utility) costs are much higher and therefore offset the original investment with a faster return. These systems often require less mechanical (HVAC) systems and this also can compensate for the cost of the second façade.

Further serious consideration must be given to maintenance and operating costs of these systems. Statistically, operating costs - largely based on heating and cooling - far exceed the monetary and environmental capital cost of buildings *(Cole, 2001)*. However, if it can be proved that Double Skin Façades can significantly reduce the overall long term operating, energy and maintenance costs, then the initial capital costs could be justified.

**SOCIAL COSTS**

The goal of these systems is not only to be environmentally “responsible” but also to greatly improve working conditions for the occupants of these buildings through access to day lighting, natural ventilation and greater control over the workplace atmosphere. Social costs such as employee satisfaction and productivity become factors in calculating cost because content, healthy employees produce and accomplish more. Depending on labour costs, the investment might be worthwhile *(Lang and Herzog, 1999)*.

This social ideal is exemplified in the German concept of “Grünkultur” (green culture). This concept is so fundamental to their architectural expression that it has become synonymous with their cultural environmental consciousness and consequently translated into legislation for quality of life. For example, German law mandates that every workstation in new commercial buildings be in direct sunlight *(Slessor, 1997)*.

However, North America seems to lag behind Europe in mandating the same standards for quality of workspace. Perhaps this is another reason why there are very few double façades in North America.

**OTHER COST CONSIDERATIONS**

When entering the discussion regarding environmental “costing” there are many different factors that require consideration. The extra materials used in constructing the façade (essentially the addition of a whole second building envelope) can be seen as being too excessive to balance their energy cost savings.

Operational costs associated with these systems are lower, however there are much higher maintenance costs. The air cavity must be cleaned because of the air movement within the space circulates dust particles more quickly.

Life cycle costing must also be taken into account. Many buildings with double skin façades incorporate high-tech mechanics which tend to have a higher failure rate and repair cost. These same mechanics also necessitate higher replacement costs (for example wiring must be replaced after a certain number of years; the more wiring, the higher the costs).

Retrofitting and recyclability are also important factors. The majority of these buildings are corporate in nature. If a company expands they may be required to add additional office space. Are these buildings suitable for expansion?

The location of these buildings is also important in relation to the proximity of their occupants’ homes. If these buildings are located too remotely, they may not balance the transportation energy costs of their users.

## LOOKING TO THE FUTURE

In the end, there are many different factors that must be weighed when considering the Double Skin Façade. Without access to proprietary information, actual dollar figures for capital and maintenance costs of these systems and actual performance data, it is difficult to establish definitively whether or not these cladding systems are truly environmentally "sustainable." However, when the discussion shifts from quantifiable data to those of quality of work space such as day lighting, solar control, access to and control of natural ventilation and resultant employee satisfaction and productivity, it becomes possible to have a more coherent understanding and appreciation of this controversial system, and opens the door to a larger discussion based on both the quantitative and the qualitative in assessing Double Skin Façades.


*(From left to right) The RWE Building, Berlin, Germany, Das Dusseldorfer Stadttor, Dusseldorf, Germany, and The Tjibaou Cultural Centre, New Caledonia*

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