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DAYLIGHT & ARCHITECTURE MAGAZINE BY VELUX  
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NEW EYES ON EXISTING BUILDINGS







# VELUX EDITORIAL

## NEW EYES ON EXISTING BUILDINGS

"We are dwarfs standing on the shoulders of giants". This quote by Isaac Newton expresses the fact that each generation builds on the intellectual and material legacy of preceding eras. This is also the case in our cities, where the annual rate of newbuilds is less than 1%, and more than 65% of all buildings are more than 30 years old. We profit from this gigantic treasure of buildings and infrastructure while facing the challenge of having to adapt them to future sustainable requirements

This issue of D/A discusses that challenge, and deals specifically with the role daylight has to play in this endeavour. To gain a deeper insight into the topic, the VELUX Group collaborated with members from Arup's global lighting design team throughout the editorial process of this magazine. With their knowledge and their points of view, the Arup team has made an invaluable contribution to the discussion about the role of daylight in existing and refurbished buildings.

We know that better daylight provision in buildings leads to healthier indoor environments, lower energy consumption, more useable floor space and a higher real estate value. Daylight enhances general well-being and efficient working. Daylight is indispensable for a healthy wake-sleep cycle, protects against depression and boosts the immune system. Furthermore, the sun is a vital source of year-round energy in buildings.

With this in mind, this issue of D/A proposes a new approach to the discussion on climate renovation of the existing building stock. What if we prioritise daylight first when buildings and urban districts are to be renovated?

Our exploration of the daylight theme takes us through centuries, considering all scales of building and many other factors. We start by going back to the beginning of all matter and all light: the Big Bang. The Dan-

ish astrophysicist Michael Linden-Vørnle explains the origin of this form of energy that keeps us all alive – and when and how it might end.

Francesco Anselmo and John Mardaljevic then describe how and why the availability of daylight varies in different regions of the world and how people have been using daylight in their dwellings for centuries. Through which 'eyes' – i.e. windows – do these buildings look out on the world? And what do these eyes tell us about daylight and the climate in the place where the building is located?

We then focus on specific daylight perspectives for climate renovations in four buildings, with daylight being at the very centre of the projects.

Taking the challenge of bringing more daylight into our cities and indoor lives, we need to think beyond the scale of the individual building and commit ourselves to the objectives of urban daylighting design. The advantages are manifold, as the author collective headed by Henning Larsen Architects argue in their newly-published daylighting design manual. What about Daylight and in this issue of D/A. Signe Kongebro, Peter Andreas Sattrup and Charlotte Algreen have investigated what a redesign of our cities could look like in a study that presents a new approach to considering daylight in the city; not as an unalterable given but as a variable that can be shaped and designed.

In Germany, the approach to architecture and urbanism with specific focus on light, air and sun, dates back to the beginning of the past century. Since then, international building exhibitions (IBA) – which can be compared to giant 'tool boxes' for planning strategies – have taken place regularly in the country. In this issue of D/A, we take a look back at some key developments in the history of IBAs, as well as taking a glance

at the newly-opened IBA Hamburg 2013 – an urban laboratory where the inhabitants can influence and control their immediate surroundings.

The final article of D/A #19 summarises a discussion between members of Arup's global lighting design team and the D/A editorial team. Key messages of this discussion are:

- Daylight is different everywhere you go. We need buildings that allow us to experience the fundamental rhythms of nature, especially in view of the fact that we spend 90 per cent of our time indoors.
- We need freedom of choice instead of average solutions. Users of buildings should be able to fine-tune their environment themselves, depending on the conditions in which they feel comfortable, irrespective of what some experts may think is best.

A final recommendation that we find especially important is – talk about it! The more we exchange ideas about daylight, the more precisely we can articulate our expectations of daylight in buildings. And the more the advantages of daylight are communicated in public, the more likely decision-makers will be sensitised to the issue as a crucial tool of sustainable living in buildings.

With this in mind, we wish you an enjoyable read!

The VELUX Group



D/A

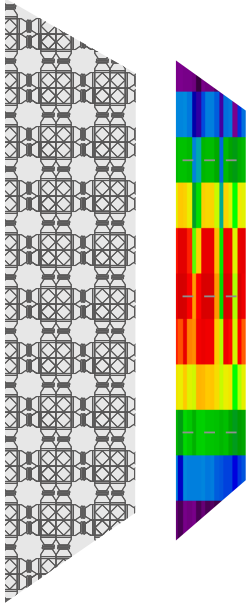
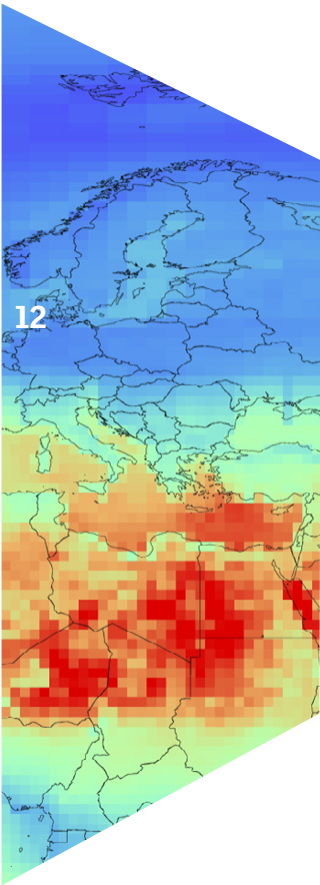
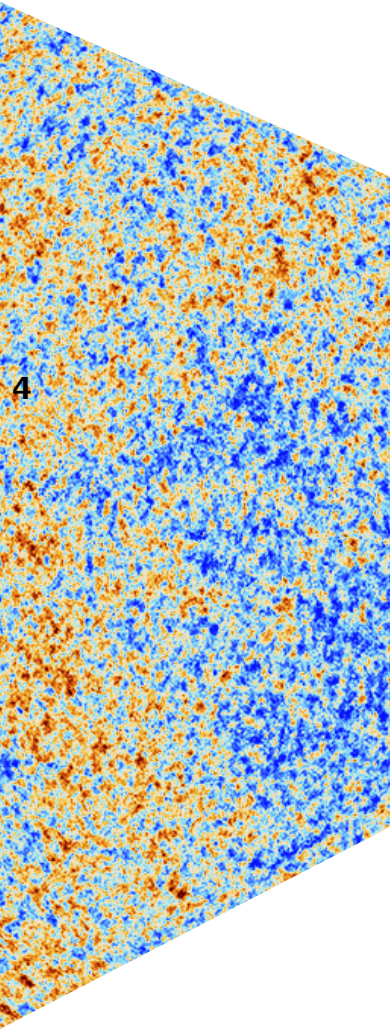
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FIRST LIGHT

European astronomers have made the oldest known form of light visible with the help of the ESA's Planck satellite. In his article, astrophysicist Michael Linden-Vørnle describes the way in which light originated, the form it appears in today and how all light may eventually end.

DAYLIGHT MAPPING –  
PLANET EARTH

Many factors influence the availability of daylight on Earth: topography and vegetation, air and water currents and, in particular, people themselves. Francesco Anselmo and John Mardaljevic write about the insights achieved with modern methods of daylight mapping.





## EYES ONTO THE WORLD: VERNACULAR WINDOWS

For centuries, anonymous builders from all over the world have been designing buildings and their openings to match the local climate and regional culture. Francesco Anselmo and John Mardaljevic explain what contemporary architects can learn from the variety of traditional windows.

## INSIGHT INSIDE

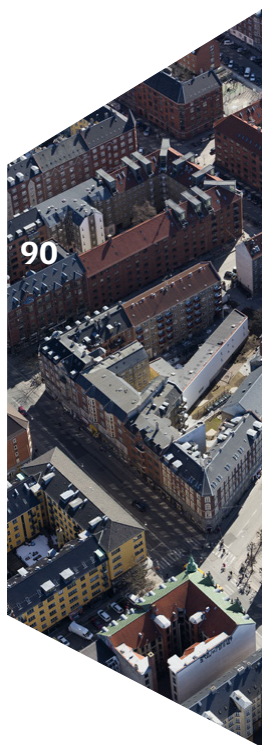
Four project examples illustrate the potential of daylight refurbishment. Ten Dutch terraced houses have been converted into Active Houses; a Danish town hall has been turned into a kindergarten and a warehouse in Paris has been reborn as office building. The Victoria and Albert Museum is rediscovering daylight too, after museum curators around the world have sought to keep it out of museum galleries for decades.

## CREATING BRIGHTER CITIES OF TOMORROW

Where can we make a start on bringing more daylight into our cities and living rooms? A Danish team of architects has now looked at this question for the first time. Their study entitled 'What about Daylight?' formulates a completely new approach to the renewal of houses and city districts, whereby the central focus is on people and their fundamental need for daylight.

## IDEAS FOR A DAYLIT FUTURE

Will we have enough daylight in our cities and buildings in the future as in the past? With what tools will we plan this? And who will decide what role daylight plays in planning decisions? In a conversation with the daylighting designers from Arup, Daylight/Architecture discussed these questions and other issues as well.





# FIRST LIGHT



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Today, we take the existence of light for granted. But what was the world like when light was created? New answers to this question have now been given by the European Planck satellite. It has made the most detailed observations so far of the afterglow from the Big Bang – the very first light that filled the Universe.

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By Michael Linden-Vørnle

OUR WORLD has changed. Not literally, but because the ambitious European satellite mission named Planck has given us new insight about our knowledge of the universe. We now have a clearer picture of what we do understand and where we still have lots of work ahead.

The immensely precise measurements from the Planck satellite that were made public on 21 March 2013 tell us that the universe is simple – but also challenging. Simply because Planck's measurements basically confirm our overall theoretical description of the universe. Challenging because Planck has discovered very small, but potentially important deviations that might require new physics to be explained.

#### THE COSMIC FOG

The Big Bang occurred almost 14 billion years ago, when the infinite universe was born in a very hot and dense state. Immediately, the universe began to expand, lowering both the temperature and the density – a process that is still continuing today. In the first few minutes after the Big Bang, the fundamental building blocks of our world were formed: protons, neutrons and electrons.

During the first many thousands of years after the Big Bang, the universe was so hot that it was a seething soup of matter and radiation, where light was continuously scattered in all directions. After 380,000 years, its temperature had dropped sufficiently to allow matter and radiation to disentangle, so that light could travel freely. The cosmic fog that had filled the universe since the Big Bang lifted and today we can see this first light as a very smooth and weak microwave radiation coming from the entire sky. It is

exactly this afterglow from the Big Bang that Planck has made the best observations of so far.

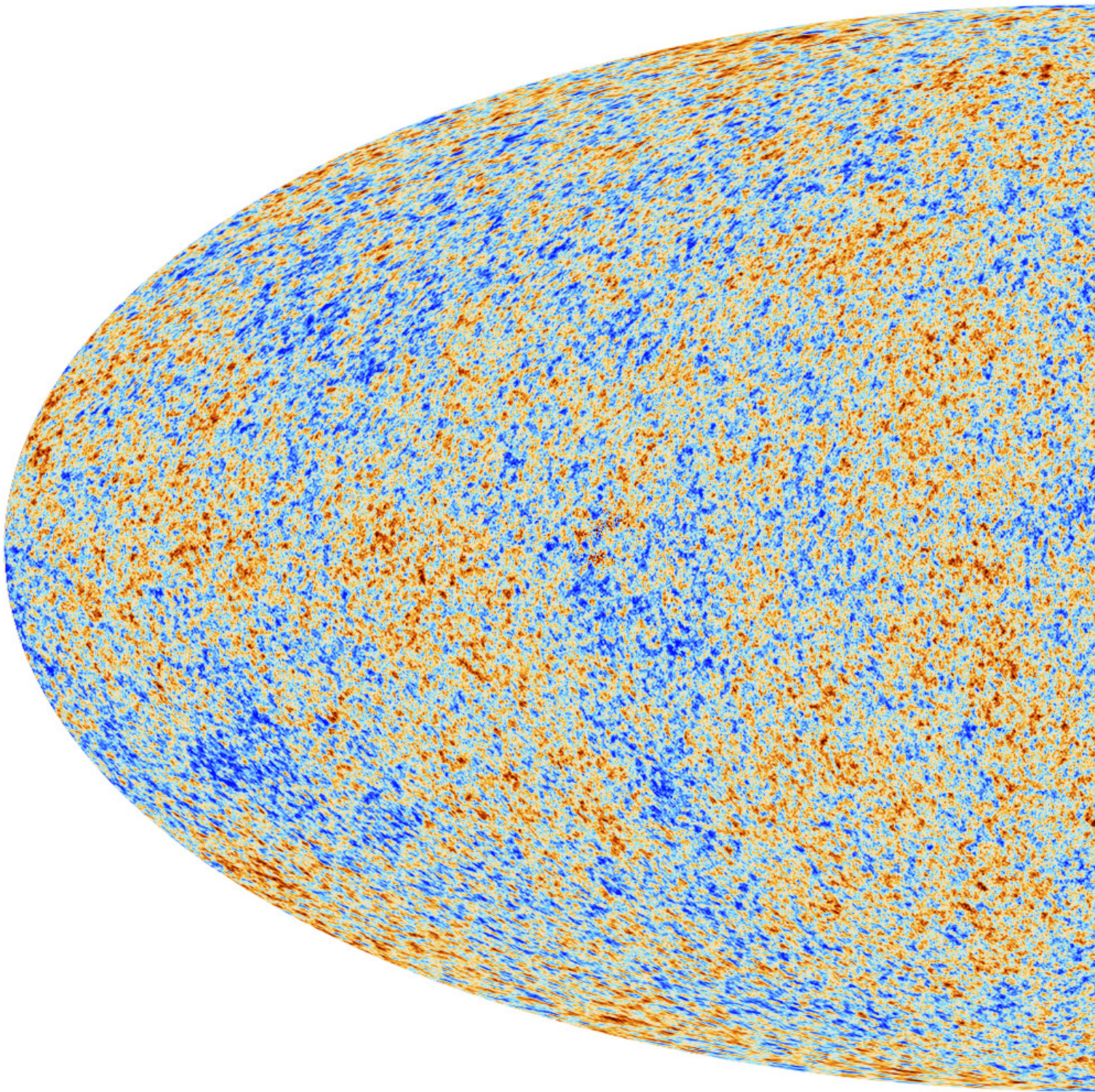
This relic radiation fills the entire universe – it is all around us – but is continuously 'diluted' as the universe expands. The expansion stretches the wavelength of the afterglow: when it was emitted 380,000 years after the Big Bang, it had a yellowish hue, similar to light from a light bulb, whereas the wavelength today corresponds to microwaves. So the first light will continue to exist, but in an ever-more diluted form and with an ever increasing wavelength.

#### FRAMEWORK LAW OF THE UNIVERSE

The afterglow from the Big Bang is called the cosmic microwave background and is, in its nature, a snapshot of the universe as it looked 380,000 years after the Big Bang. The distribution and movement of matter at this early stage of cosmic history, as well as the physical processes and conditions present from the Big Bang (and up to the point where the radiation was released) are, so to speak, 'frozen into' the microwave background.

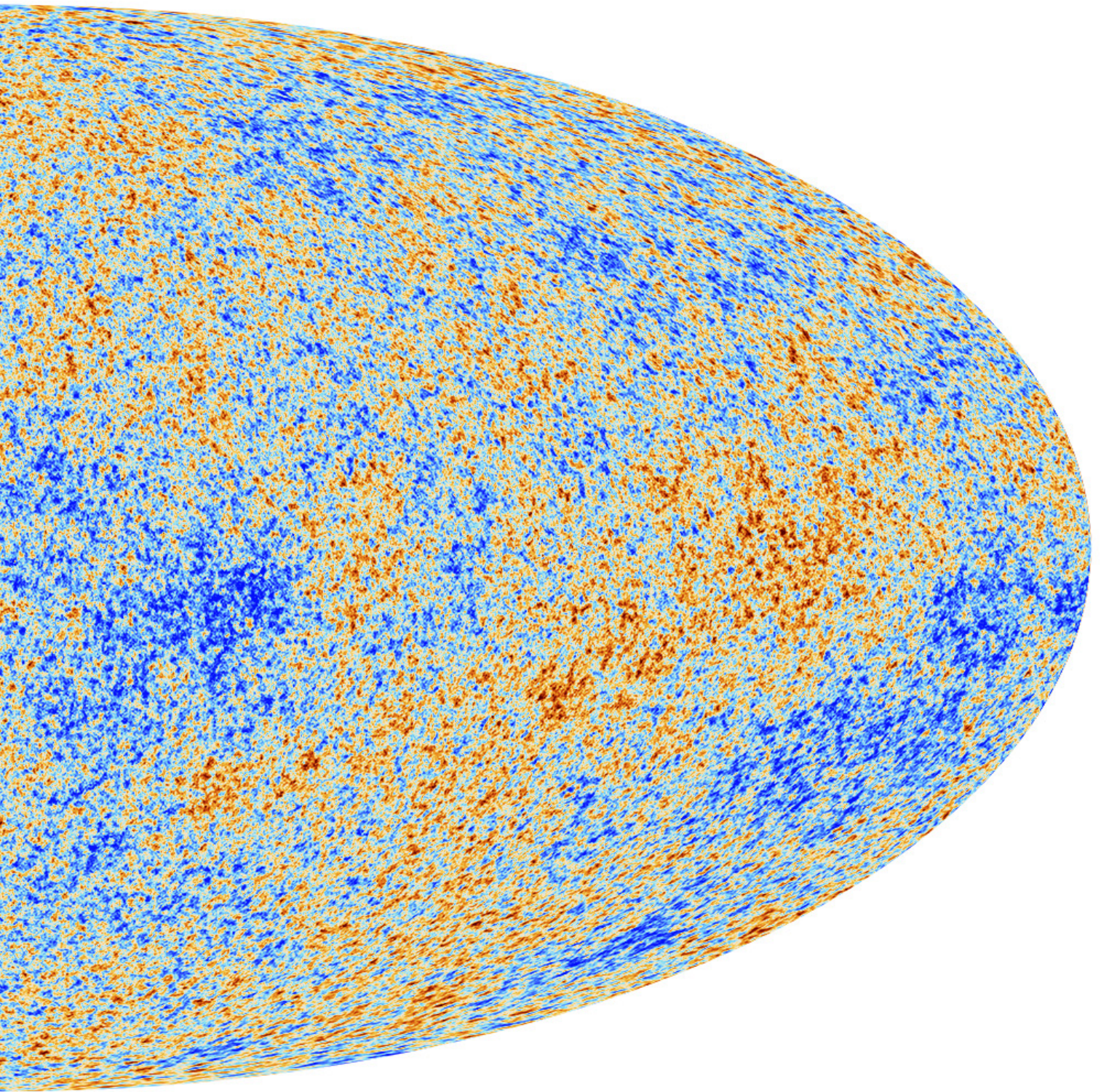
Planck's extremely detailed observations of the afterglow therefore allow us to study the physics of the very early universe, the so-called inflationary phase. It occurred a minuscule fraction of a second after the Big Bang and caused an extremely violent expansion of the universe. In very broad terms, Planck's observations of the cosmic microwave background allow us to settle the framework law of the universe that describes how our world is put together using only six numbers. And this simple theoretical model fits the observations with extremely high accuracy.







Using ESA's Planck satellite, cosmologists have compiled the most accurate image so far of the cosmic microwave background, the afterglow from the Big Bang and thus the most ancient light we can observe in the universe.





**Opposite page bottom** Planck's data largely confirms the standard model of cosmology, according to which the universe is highly homogeneous and isotropic. However, the new data also reveal large-scale deviations (shown here in different colours), which will require more research and might even require new theories to be developed.

#### **Named after Max Planck**

The Planck satellite is named after the German physicist Max Planck who was the first to describe how a body with a specific temperature emits radiation. The afterglow from the Big Bang that the Planck satellite has observed has exactly this property.

#### **The Milky Way and other galaxies**

The Planck satellite has not only looked at the afterglow from the Big Bang. The Milky Way and other galaxies form a natural foreground that has also been observed by Planck and radiation from gas and dust in them have been registered. Data from Planck, therefore, also allows us to learn more about the Milky Way and other galaxies.

#### **DANISH TELESCOPE ON BOARD**

Planck is a European project realised by the European Space Agency, ESA. The Space Agency delivered the satellite, with the launch taking place on 14 May 2009. A French and Italian consortium delivered Planck's two ultra-sensitive instruments and Denmark contributed with Planck's telescope

#### **OLDER AND WITH A DIFFERENT COMPOSITION**

To a very large extent, Planck confirms our current understanding of how the universe has evolved from a fraction of a second after the Big Bang and onwards. Though its measurements have given us a slightly higher value for the age of the universe. Based on Planck's data, the entire universe was born with the Big Bang 13.82 billion years ago, which is 75 million years more earlier the previous value.

Planck's observations have also given us new values for the overall composition of the universe. About 4.9 % of the universe consists of the normal matter that stars, planets and humans are made of. On top of that is 26.8% invisible dark matter that affects its surroundings with its gravity. The remaining 68.3% is what researchers call 'dark energy' that accelerates the expansion of the universe. Planck's measurements have shifted the balance between dark matter and dark energy – where the previous values were 22.9 % and 72.5% respectively.

#### **MORE TO COME**

The most interesting factor to emerge from Planck's results, however, is the very small deviations from the framework law. Previous experiments have indicated deviations, but with the unmatched quality

of Planck's measurements, we now have to take these deviations very seriously and work hard to find an explanation. But that is exactly what science is about: to ask questions of nature and try to make sense of the answers – even if they are completely unexpected.

Luckily there is much more to come. The data and results from Planck that were made public on 21 March are based on observations made during the first 15.5 months of scientific data acquisition. About the same volume of data is still being analysed and will make the final maps of the cosmic microwave background even better. This data will be made public in 2014 and, together with the results already presented, will form the basis for studies of the universe and the Big Bang for many years to come.

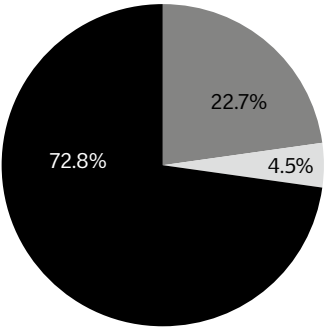
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**Michael Linden-Vørnle** is an astrophysicist and chief adviser at the National Danish Space Institute (DTU Space). He holds a PhD in astrophysics from the Niels Bohr Institute in Copenhagen, Denmark, and has been involved in the European satellite project Planck since 1995. Michael is also a very active science communicator. He frequently appears on TV programmes and interviews in Denmark, and has written numerous popular articles on space research, astronomy, space flight and related topics.

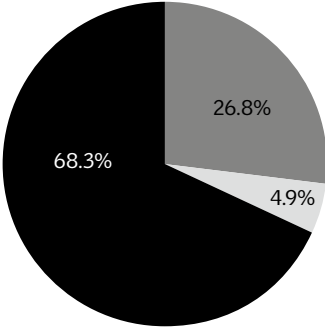
1. Senior scientist Hans Ulrik Nørgaard-Nielsen from the National Danish Space Institute (DTU Space) led the development of the Planck telescope. This work was done with the support of the Danish company Tica A/S. The Danish contribution to Planck has given Hans Ulrik Nørgaard-Nielsen and his colleagues direct access to the observations that Planck has delivered.

Launched in 2009, the Planck satellite provides scientists with a more accurate idea of what the universe actually consists of. Ordinary matter only accounts for a small fraction of the Universe. The large majority is made up of dark energy, a mysterious element that permeates the universe and is driving its currently accelerated expansion. A minor, but still significant portion of the universe consists of dark matter – invisible matter that constitutes the 'scaffold' on which galaxies and other cosmic structures formed.

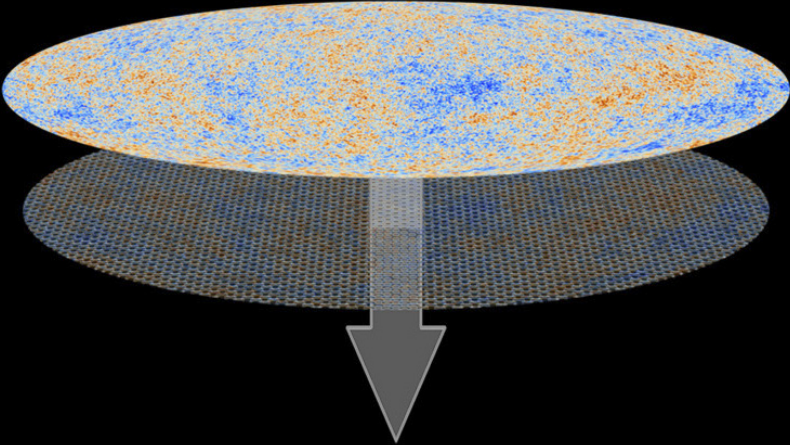
Before Planck



After Planck

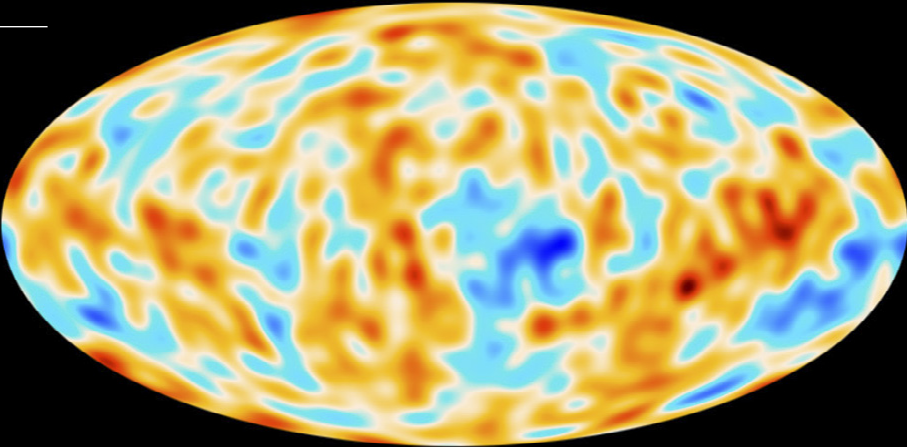


Observation



Model

Anomalies

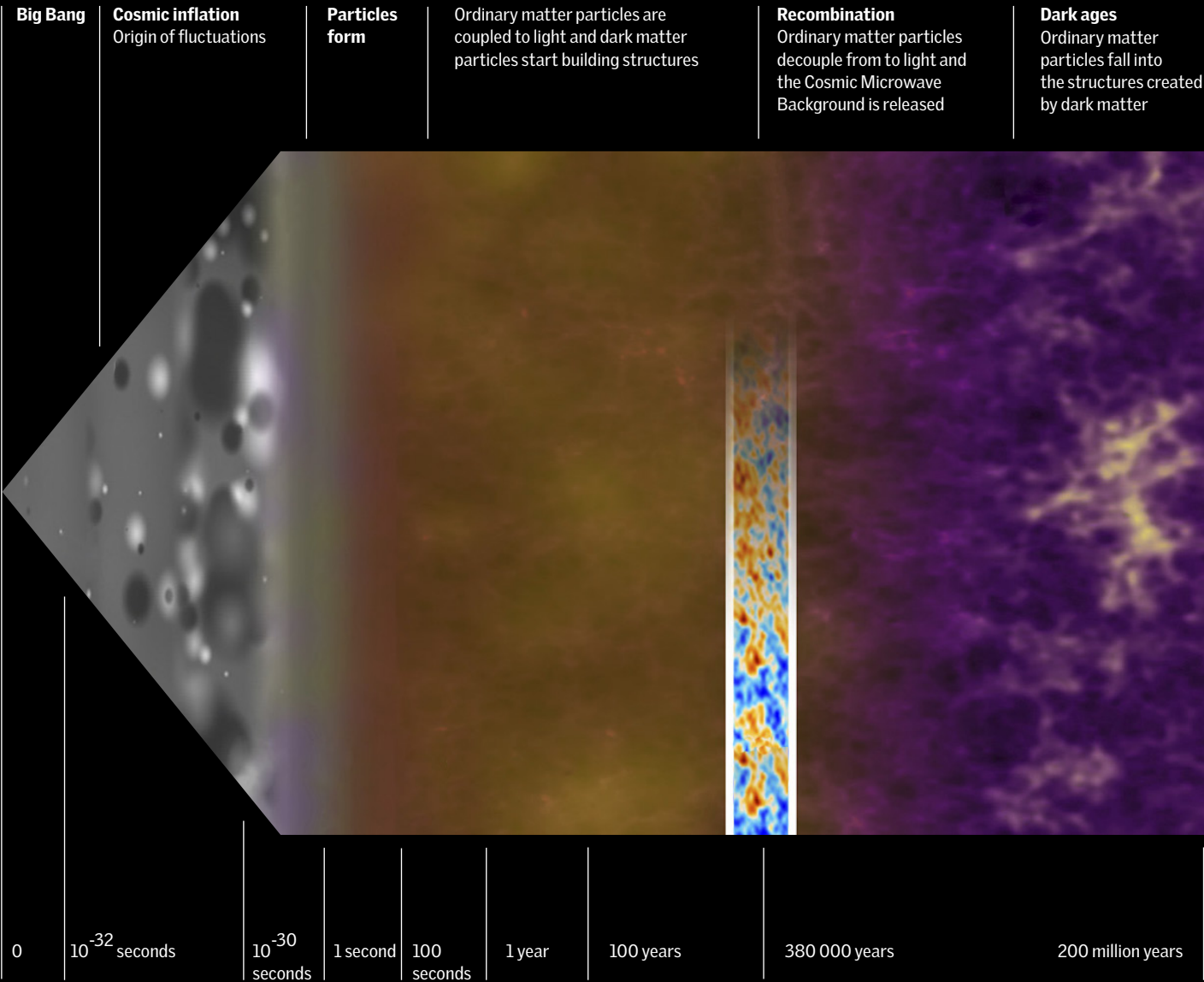


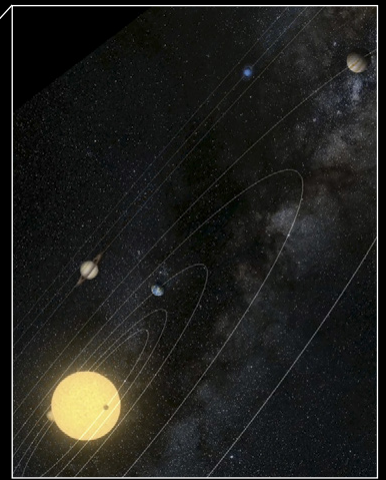
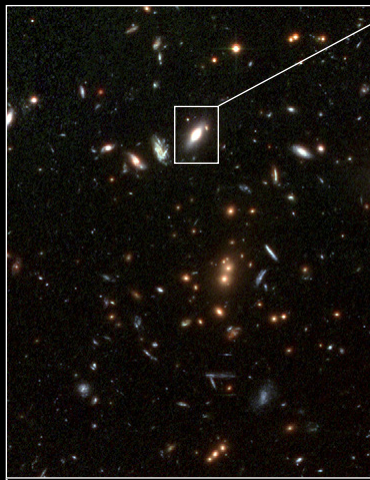


# TIMELINE OF THE UNIVERSE

The first light was set free some 380,000 years after the Big Bang, when it decoupled from ordinary matter particles. The cosmic background radiation has existed ever since, filling the entire universe. Only its wave-length has changed with the expansion of the universe.

From a yellow light (similar to that of a light bulb), the cosmic background radiation has slowly shifted to microwave radiation, which is invisible to the human eye.

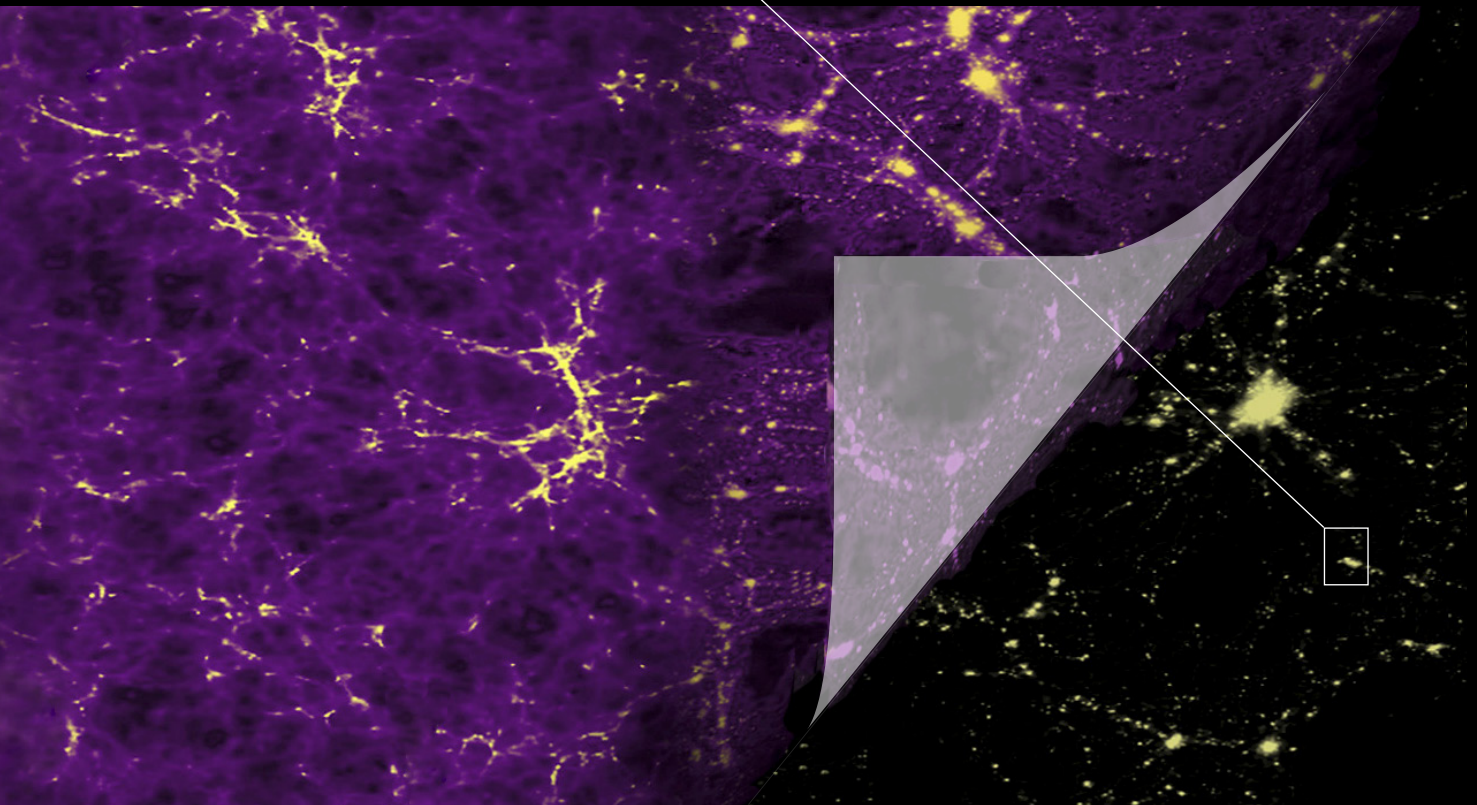




**First stars & galaxies**

**Galaxy evolution**  
Cluster of galaxies and  
superclusters form

**Today**



1 billion years

10 billion years

13.82 billion years



DAYLIGHT  
MAPPING

PLANET  
EARTH

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Our experience of the world is strongly determined by the amount and quality of daylight that we receive. Modern methods of daylight mapping can tell us fascinating stories about the availability of natural light in different parts of the world, and on the diverse factors – both natural and man-made – that influence it.

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By Francesco Anselmo and John Mardaljevic

ASTRONOMERS AND SCIENTISTS have told us for some considerable time about the angle of the Earth's axis to the sun, the direction and speed of rotation of our planet, the characteristic irregular distribution of land masses and oceans that defines our geographic knowledge.

Sixty years of space exploration and the images sent by a constantly increasing number of artificial satellites (there are more than 3,000 currently in orbit around the Earth) have strongly ingrained in our personal and collective memory the emotional view of our blue planet from space. But the experience of life on Earth is still perceived from the vantage point of space travellers confined on the thin crust of a planet orbiting at the average speed of 107,200 km/h around a yellow dwarf star, the Sun.

The rotation of the Earth around its axis defines the sequence of light and darkness on the surface, creating the concepts of day and night. The light of the day becomes what we humans call daylight.

Daylight is composed of the light of the sun (small directional source) and the light of the sky (large diffuse source). Skylight is sunlight that is scattered by the air – without an atmosphere, the daytime sky would be black, as it is on the Moon.

The surface of the Earth (with its materials, orography and vegetation, but also with the results of anthropic activities) interacts with the energy from the Sun, creating different events in the atmosphere that, in the long term, characterise the lo-

cal climate and with it also the luminous climate, that is the climate that interacts with visual perception.

The need to understand and predict weather, mainly for agricultural and socio-economic reasons, has developed climate science and created a network of weather stations that sense, log and monitor a number of environmental variables on the ground. Stationary satellites have also been deployed to gather weather patterns remotely, allowing us to extrapolate the ground readings, with good accuracy, to any location on Earth.

These data can be filtered statistically and visualised to give an insight on the global climate history and future trends.

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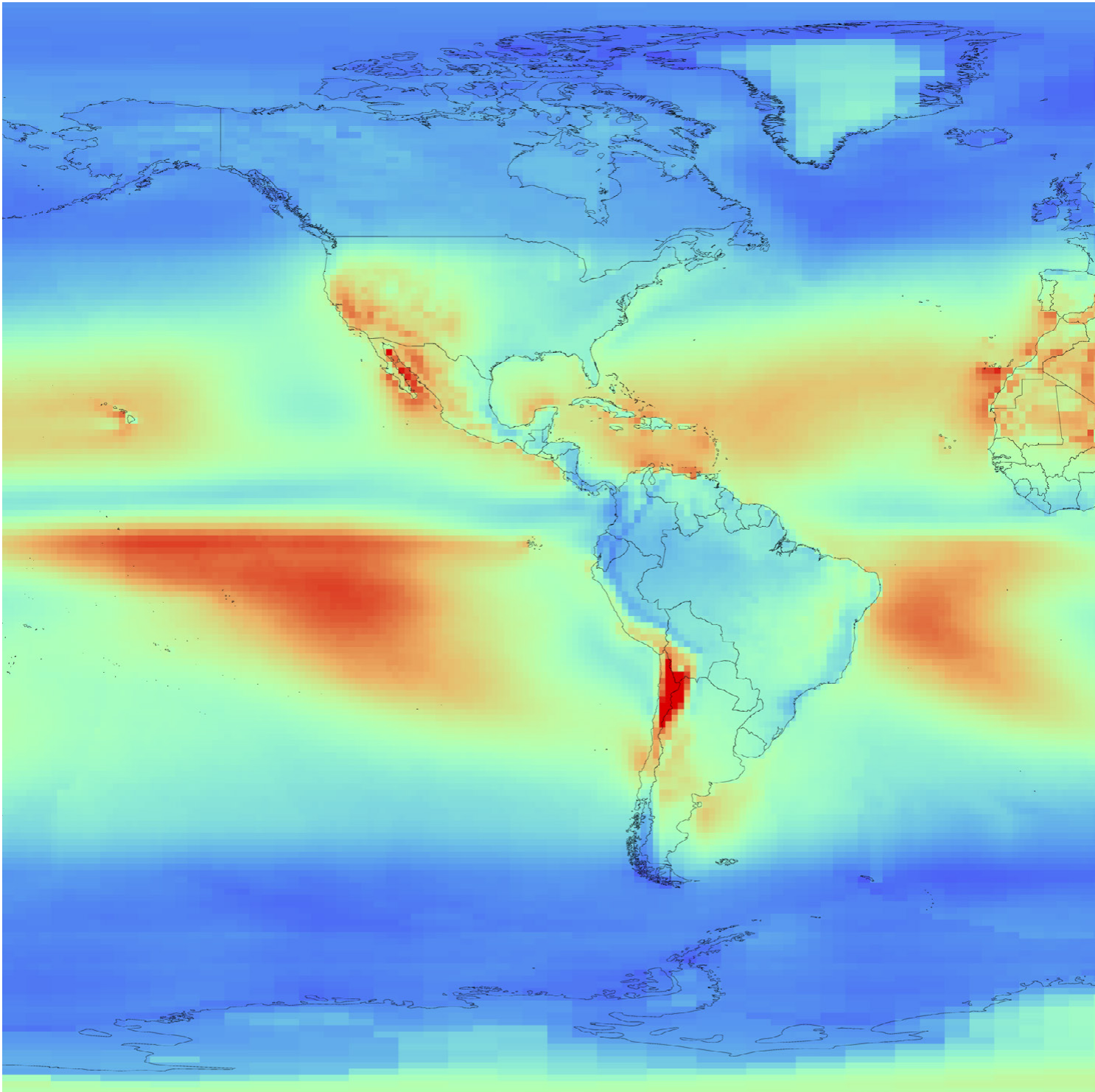
**Francesco Anselmo** is a Senior Lighting Designer at Arup in London. He holds a PhD in Environmental Physics and a degree in architectural engineering. He is an expert in numerical simulation and visualisation systems and develops computer tools for lighting design, building simulation and interaction design.

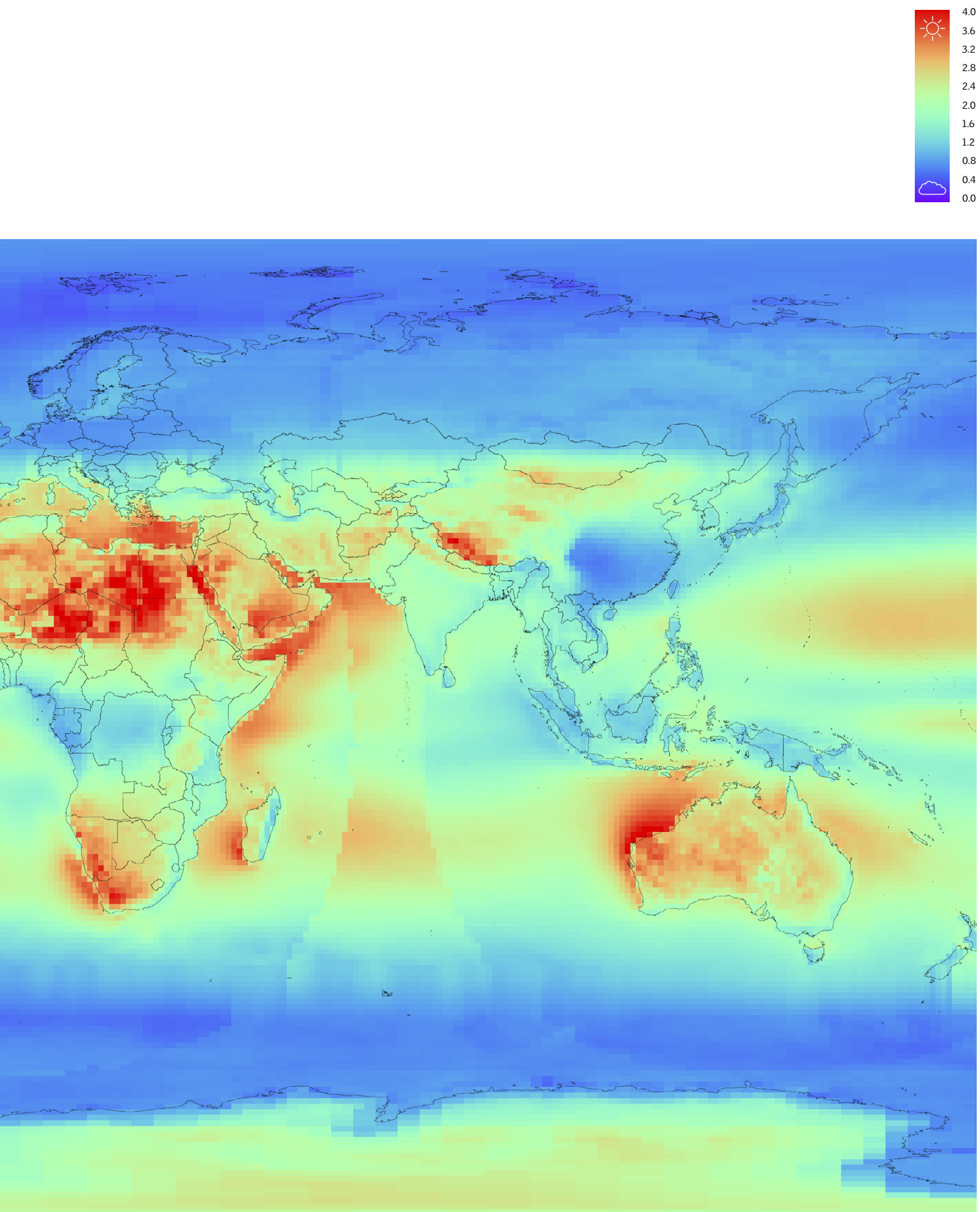
**John Mardaljevic** is Professor of Building Daylight Modelling at the School of Civil & Building Engineering of Loughborough University in the UK. Since the 1990s, he has pioneered the application of climate datasets for daylight and solar modelling on all scales, from the urban to the single building. He currently serves as the UK Principal Expert on Daylight for the European Committee for Standardisation.



## A GLOBAL OVERVIEW

Direct-to-diffuse  
irradiation ratio







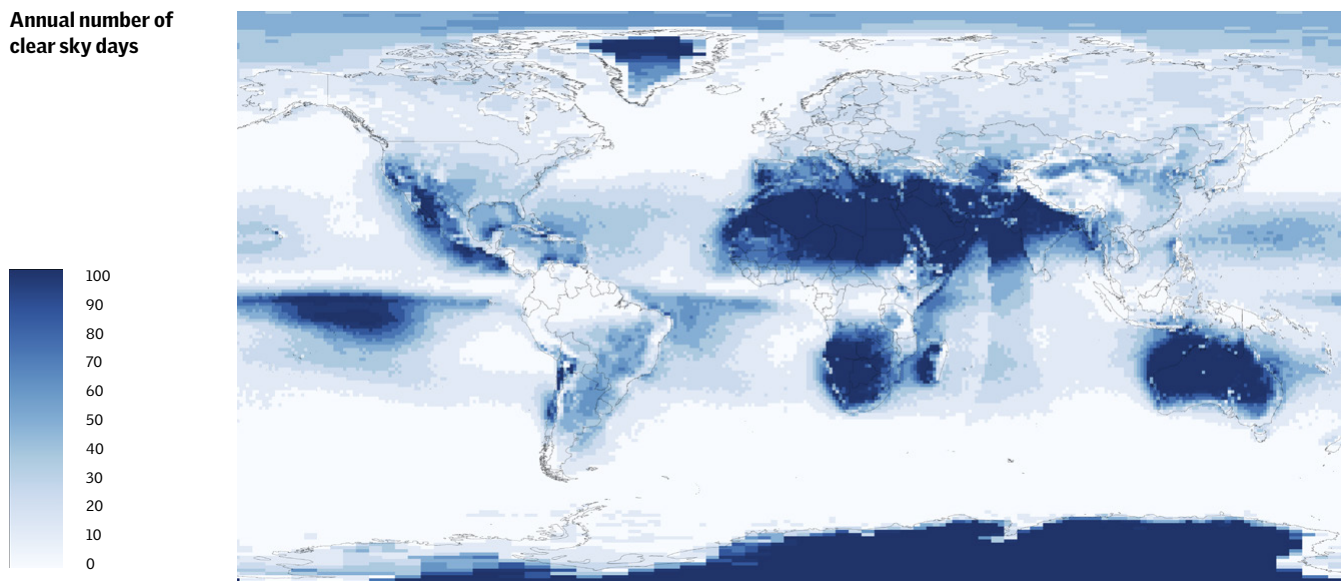
The maps presented on these pages attempt to display the luminous climate at planetary scale. They make use of the NASA SSE (Surface Meteorology and Solar Energy programme) weather dataset, which is based on monthly data collected over a period of 22 years (between 1983 and 2005 by satellite measurements) and projected onto a grid of  $1^\circ \times 1^\circ$  tiles over the world ( $1^\circ$  equates to approximately 111 km on the surface of the Earth).<sup>1</sup>

The maps show the strength of sunlight compared to the light from the sky for a typical year.

The annual number of clear sky days is represented in blue – the stronger the blue, the higher number of clear skies. The dark blue areas are the places on Earth where sunlight is prevalent.

The direct-to-diffuse irradiation ratio map provides more insight into the difference in magnitude between the irradiation from the sun compared to the one from the sky. This map only shows the ratio between the different kinds of annual cumulative radiation and therefore contains no information about seasonal variation. However, it is useful for understanding prevalent daylighting conditions and whether daylight design should address mainly shading or diffuse illumination.

**Annual number of clear sky days**



1. The SSE dataset is a spatially continuous global climatology source of insolation (i.e. sunshine) and meteorology data. It is derived from several databases, including the Goddard Earth Observing Systems (GEOS-1), the International Satellite Cloud Climatology Project (ISCCP D-1), from data of the Geostationary and Polar Satellites for Environmental Observation (GOES and POES), the European Geostationary satellite Meteosat, similar Japanese satellites. and many more.

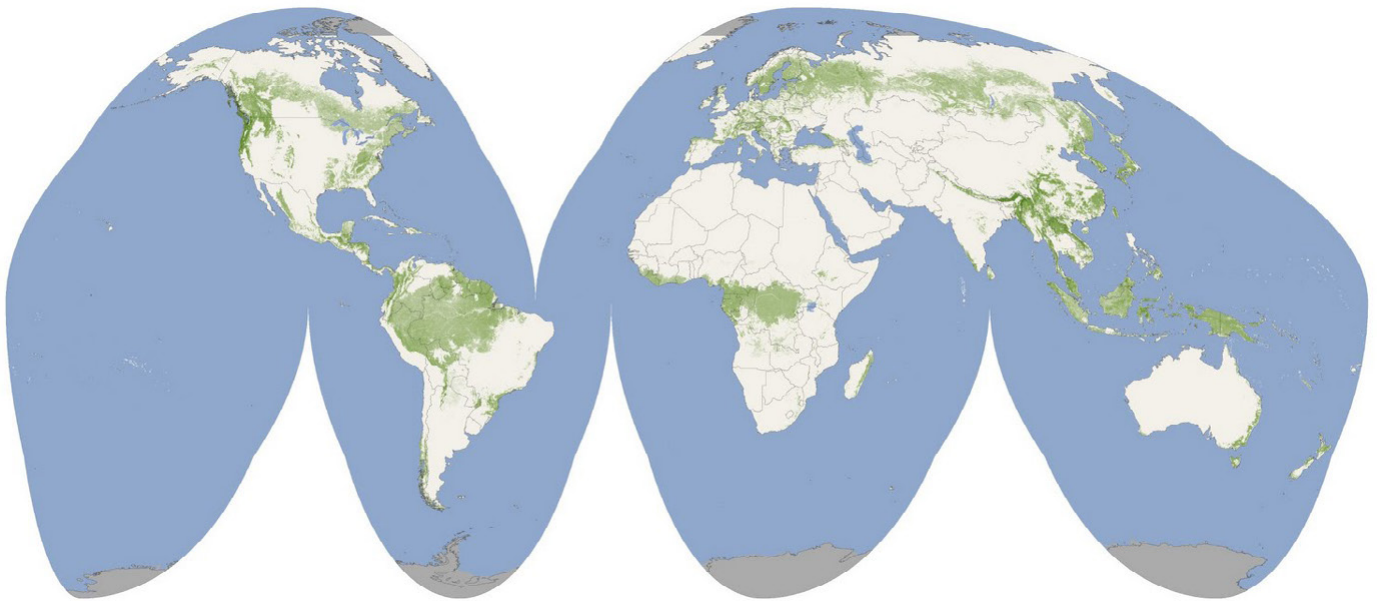
Weather and Radiation Data from NASA:  
<http://eosweb.larc.nasa.gov/sse/>  
Monthly and annual averaged values for a 22-year period (July 1983 – June 2005)

NASA Earth Observations:  
<http://neo.sci.gsfc.nasa.gov>  
<http://earthobservatory.nasa.gov/GlobalMaps/>

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It is instructive to read these maps in conjunction with the map of forest coverage. There is, in fact, a direct correlation between areas with forests and areas where there is prevalent cloudiness. This is due to evapotranspiration (ET), that is the sum of evaporation and plant transpiration from the Earth's land surface to the atmosphere. Evapotranspiration is an important part of the water cycle, the continuous movement of water on, above and below the surface of the Earth.

The balance of water on Earth remains constant over time, but individual water molecules move from river to ocean or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, runoff, and subsurface flow. In doing so, the water becomes ice or vapour, thus exchanging heat – for instance, cooling the environment when it evaporates, or warming the environment when it condenses. These heat exchanges strongly influence climate.



**Global map of forest coverage. Forests produce clouds due to water evaporation, thus exerting a considerable influence on the climate and the availability of daylight in a region.**

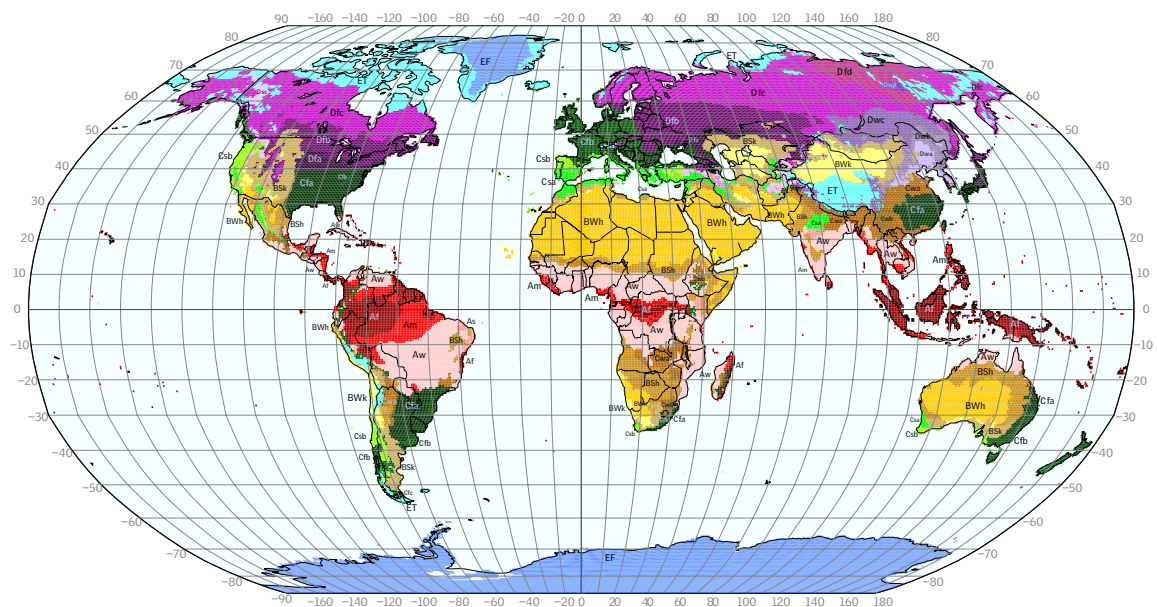


The idea of using vegetation to read the local climate is not new. It was first used by the Russian-German climatologist Wladimir Köppen in 1884 to devise a climate classification system that is still one of the most widely used.

The system is based on the concept that native vegetation is the best expression of climate. Climate zone boundaries have been selected using the vegetation distribution and combining average annual and monthly temperatures and precipitation, and the seasonality of precipitation.

### World map of Köppen Geiger Climate Classification

Updated with CRU TS 2.1 temperature and VASclim0 v1.1 precipitation data 1951 to 2000



#### Main climates

A: equatorial  
B: arid  
C: warm temperature  
D: snow  
E: polar

#### Precipitation

W: desert  
S: steppe  
f: fully humid  
s: summer dry  
w: winter dry  
m: monsoonal

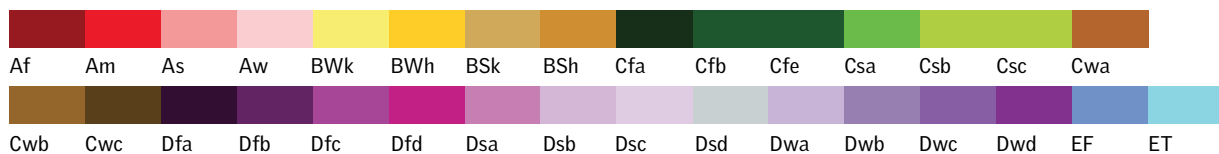
#### Temperature

h: hot arid  
k: cold arid  
a: hot summer  
b: warm summer  
c: cool summer  
d: extremely continental  
F: polar frost  
T: polar tundra

Version of April 2006  
Resolution: 0.5 deg lat/lon

<http://gpcc.dwd.de>  
<http://loepfen-geiger.vu-wien.ac.at>

Kottek, M, J Grieser, C. Beck, B. Rudolf and F. Rubel, 2006: World Map of Köppen – Geiger Climate Classification updated. Meteorol. Z., 15, 259–263.



## ZOOMING IN TO THE MAP

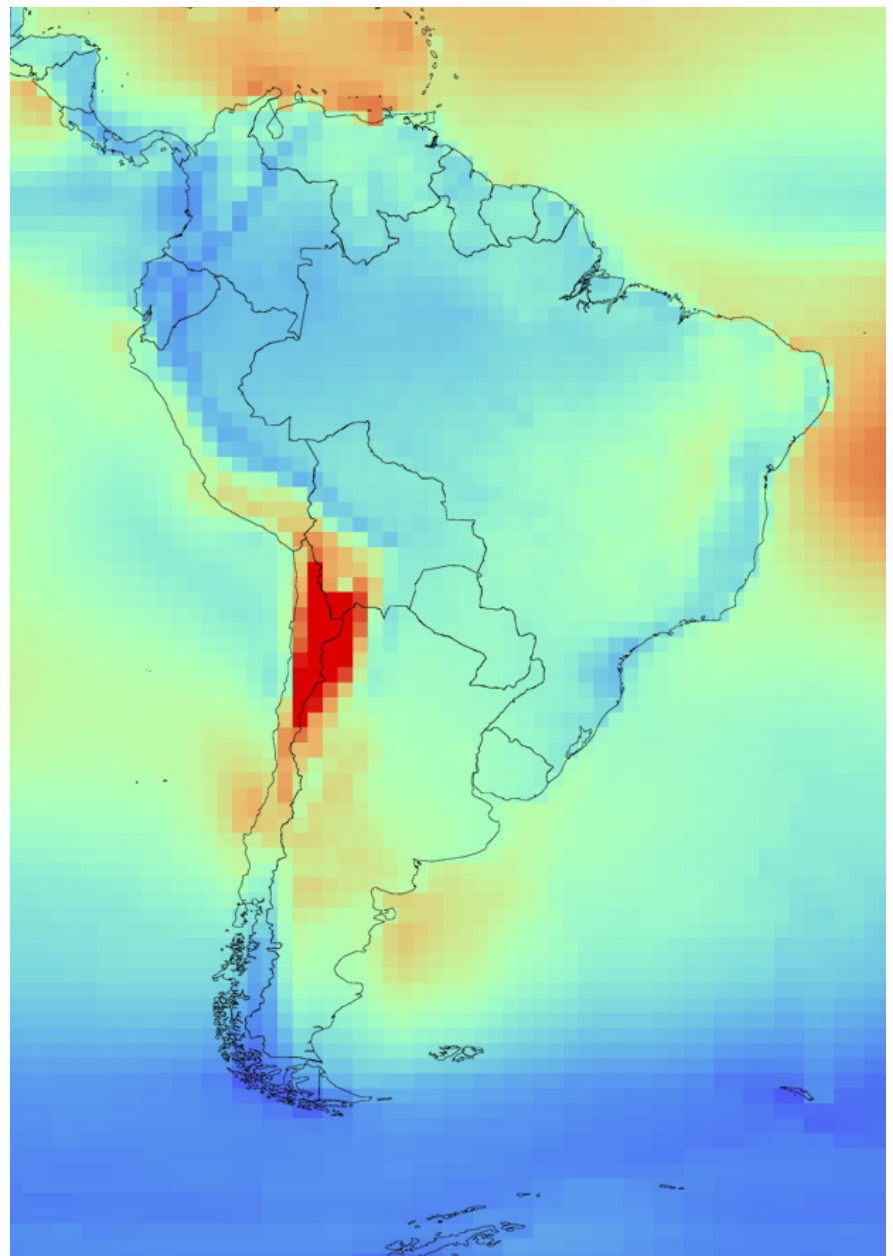
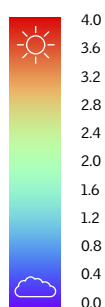
The relationship between orography and climate is remarkably evident for the Andes. In fact, the relief of the Andes allows a variety of different climatic zones to develop within relatively short distances.

This is particularly true of Chile. Its large expanse of latitude, spanning 4,300 km and 38° in latitude, and the presence of the Andes make it the nation with the most micro-climates on Earth. While the northern region is extremely dry, and includes the Atacama Desert and many places where rain has never been recorded, the central region is a fertile area

with a temperate climate. The southern region by contrast is cold and rainy, with icy fjords and glaciers at the southernmost end.

Climate has played an important role in defining the Chilean cultural identity. Apart from the desert area, the occurrence of cold and cloudy winters, similar to those experienced in northern Europe, has influenced the attitude of people towards a work ethos in society, to the point that Chileans generally distrust the idea of a tropical culture, which is seen as encouraging indolence and underdevelopment.

**Direct-to-diffuse irradiation ratio in South America. The map clearly shows how isolated the climate of Chile is from the rest of the continent, and what differences exist between the dry north and the humid, cold south.**

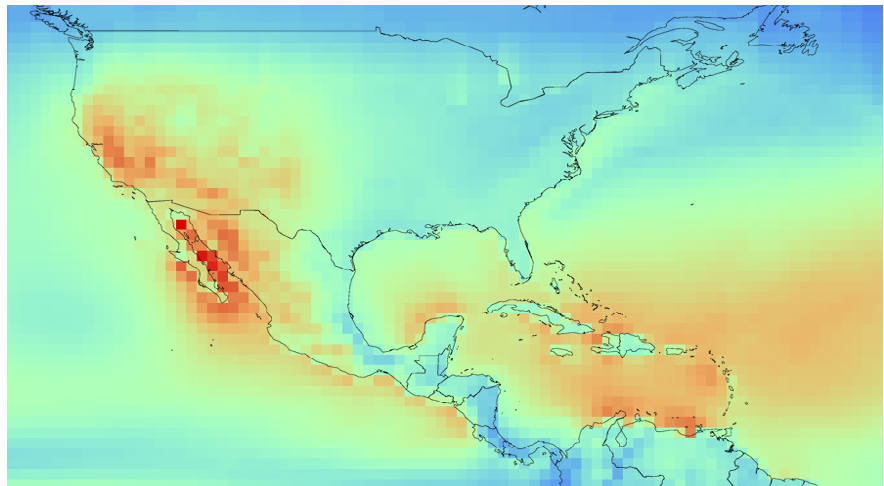




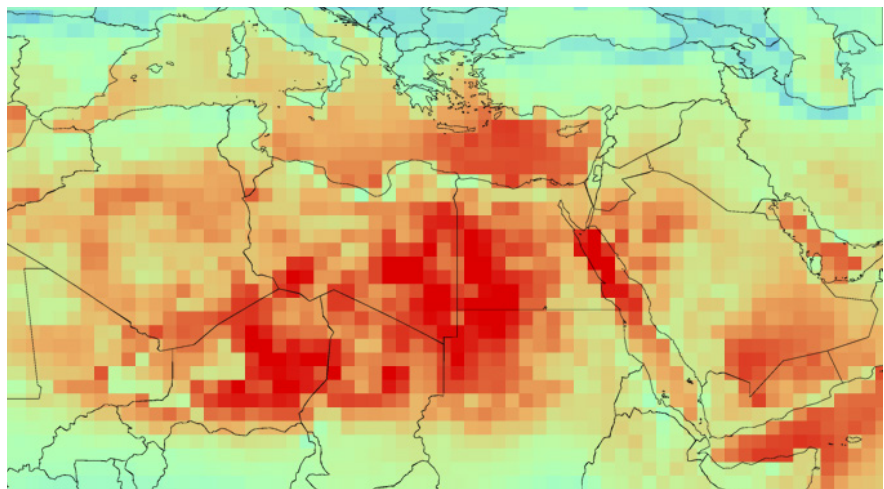
Another interesting phenomenon is the fact that, in temperate and humid climates, the land areas show a prevalence of cloudy conditions, while the sea has sunnier skies. Conversely, in desert areas it is typically the opposite. This is true for instance, of the Sahara desert, the Atacama desert, Namibia and the desert areas of North America and Australia.

However, it is also true that an extremely low level of cloudy skies is evident for Antarctica. Hence the classification of this continent as a desert – a frozen desert of snow, in fact, with little or no precipitation.

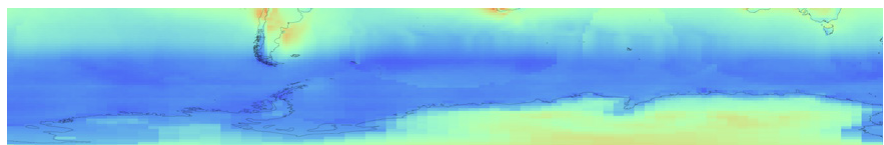
**Direct-to-diffuse irradiation ratio in North and Central America.** As in most of the Earth's humid and temperate zones, the sky is often cloudy over the land, whereas, over the sea, the weather is usually sunnier. In the desert regions of California, however, the opposite is true.



**The map of North Africa shows a similarly strong contrast between land and sea:** over the Mediterranean and the Red Sea, the sky is clear; over the coastal regions, however, precipitations can occur more frequently. In the interior of the Sahara and the Arabian Desert, on the other hand, direct irradiation is prevalent (cloudless sky).



**As in desert areas, the sky over the Antarctic continent is normally cloudless, in spite of the extremely low temperatures.**



On closer inspection, the luminous climate maps can tell interesting stories about humans, too.

For instance, why is sunlight so weak in China?

It is true that China has cloud forests on the Yunnan Plateau. Cloud forests are tropical or subtropical forests characterised by low-level cloud cover that can be persistent, frequent or seasonal and that can therefore influence the prevalent daylight conditions in these regions.

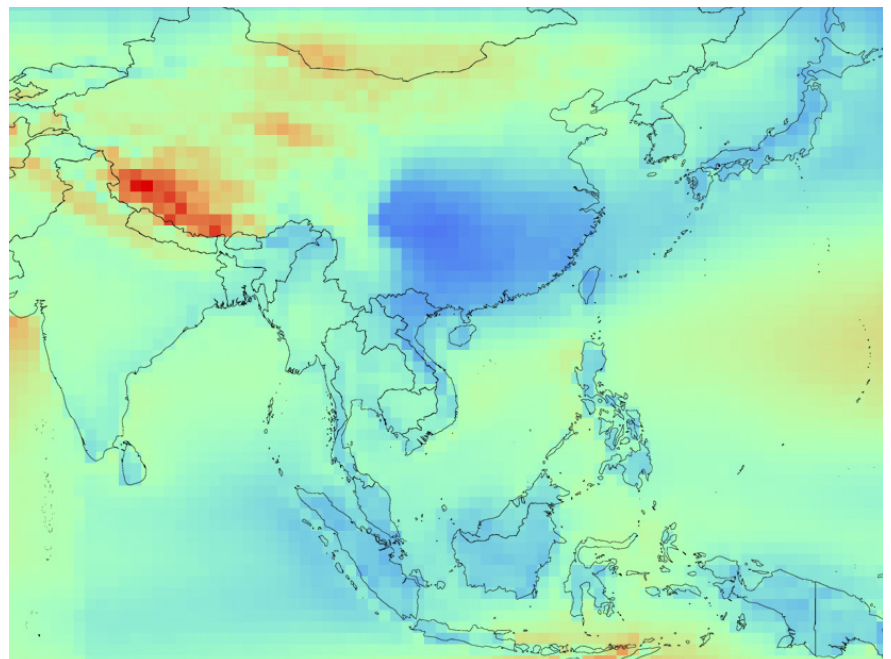
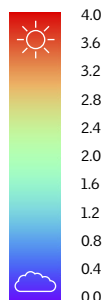
But it is also true that most of the world mining and industrial manufacturing has recently been concentrated in this area of the world because of physical resources

location and global socio-economics, combined with an energy-generation strategy largely based on coal, and the occurrence of natural seasonal phenomena such as Asian Dust. This has had a strong impact on air quality and pollution levels in recent years, to the point of forcing the Chinese government to take action in January 2013, ordering factories to reduce emissions and spraying water at industrial buildings to help contain the haze that has covered the region. Schools were ordered to suspend outdoor activities and citizens urged to “take measures to protect their health”.

This situation had already been described in a World Bank report in 2007 (Cost of Pollution in China), which stated that 16 of the 20 most-polluted cities in the world are in China, and that the cost of air and water pollution is between 3.5% and 8% of the Chinese GDP.

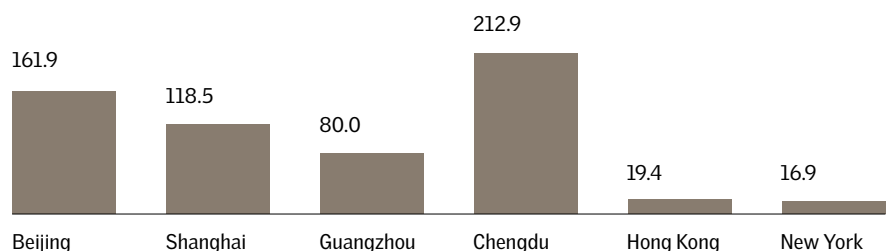
The maps clearly show that the impact of pollution is also evident from a daylighting and irradiation perspective, with a noticeable reduction in direct solar radiation and illumination to levels comparable to those found in tropical forests or in sub-polar regions.

**Direct-to-diffuse irradiation ratio in South Asia. What is striking is the large amount of direct solar irradiation over the Himalayas and the extremely low levels in large parts of China. These levels are only partially due to natural phenomena; man-made smog is also a large contributing factor.**



## PM 2.5 Charts January 2013

Amount of fine particulates (2.5 microns or less in diameter, measured mid-mornings) in different cities of the world. The bar diagram shows the monthly averages for January 2013.



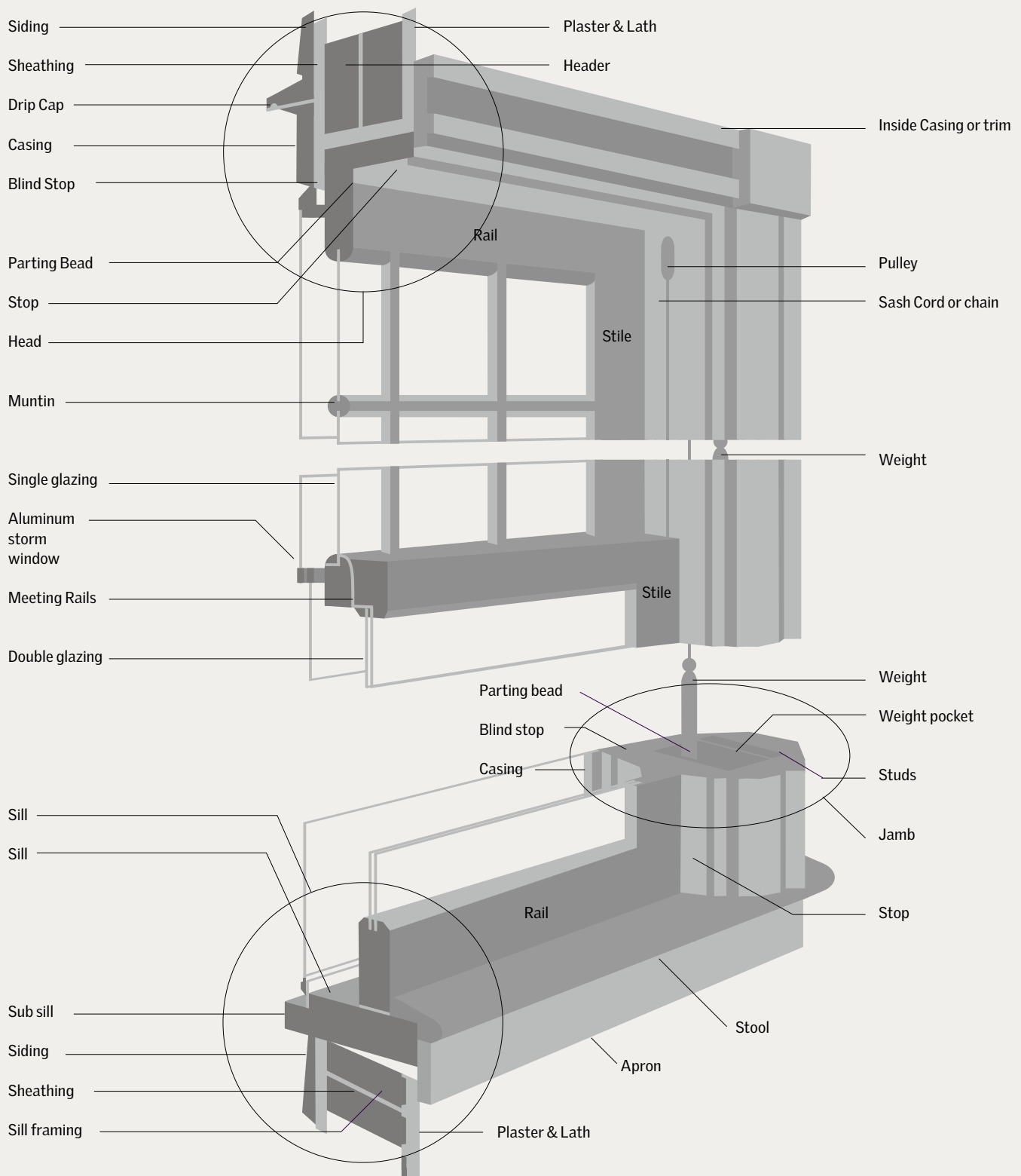


# EYES ONTO THE WORLD





**Components of a traditional British sash window. The interplay of frames and glazing, reveals and shading elements provides every window with its own specific characteristics in terms of daylight distribution.**



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# VERNACULAR WINDOWS

Throughout the centuries, anonymous builders from all parts of the world have increasingly fine-tuned their window designs to the context of climate and culture. Their creations offer a number of lessons to be learnt for contemporary buildings that aim to save energy and maximise the use of natural daylight.

By Francesco Anselmo and John Mardaljevic

OUR IMPRESSION of a building is largely defined by the detailing of the facade. Irrespective of the building size, our attention is immediately drawn to the windows. The shapes, proportions and sizes of windows, their materials and construction details, the glass types, the methods of opening, the finishes of windows all contribute to the character of our buildings, and so also our towns and cities.

From simple rectangular openings to arched or intricately ornamented screens, vernacular windows are carefully sized and located in buildings as part of a broader environmental and cultural strategy.

Vernacular window designs have been developed and transferred from generation to generation under the protective wing of tradition. One might think that tradition is immutable, but transmission is also the key to evolution. Genetic information is transferred from parent to offspring through inheritance, with the introduction of beneficial mutation that improves the fitness of the species.

The idea of tradition as such is strongly intertwined with evolution. This means that tradition can change in time, adapting to changes in context, be it social, cultural or environmental.

## ADAPTATION TO CONTEXT – THE EXAMPLE OF TREES

Take the trees for example. The ‘design goal’ that governs a tree’s distinctive shape is to ensure that the leaves get the maximum possible amount of daylight. However, the remarkable diversity in form that exists is testimony to nature’s ability to find an effective ‘design solution’ whatever the environmental context and its restrictions, ranging from water avail-

ability and method of pollination to seed dispersal, structural integrity and protection from wind.

The simplest distinction that we can make is to categorise tree shapes into either conifers or hardwoods. The steeply conical shape of conifers that grow at high latitudes is formed by branches that slope downwards to shed snow and maximise the exposure to sunlight, where the sun is typically low on the horizon.

In contrast, Mediterranean pines have developed an umbrella shape that can resist drying winds. It also maximises the area that provides shade from the stronger and higher sun, thus promoting heat dissipation.

The dome or spherical shape of hardwoods, which are more widespread in more temperate, cloudy climates, is adapted to diffuse lighting and tries to maximise the exposure to daylight coming from the entire sky.

Evolution and adaptation to the environmental context have therefore created the rich variation in tree shapes that we can see and experience today.

SHINING HOLES AND WIND-EYES – THE EVOLUTION OF VERNACULAR WINDOWS  
Like leaves on trees, windows mediate between the exterior environment and the interior space. They are filters that can either block or admit light, air, heat and other factors. Modulating these external influences can require different solutions. Windows, like trees, are therefore never optimised for only one purpose.

The etymologies of the words that we use in different languages for windows clearly express this role. Among others, the French *fenêtre*, the German *Fenster*, the Swedish *fönster*, the Dutch *venster*,

the Italian *finestra* all derive from the Latin *fenestra*, whose ancestral origin has been tracked by etymologists to the word root *fan* or *phan*, meaning ‘to shine’. The English word *window*, the Danish *vinde* and the Norwegian *vindu* derive from Old Norse *vindauga*, from *vindr* ‘wind’ + *auga* ‘eye’. This emphasises the functions of ventilation and vision. Similarly, the Spanish *ventana* has a direct connection to the word *viento*, wind.

In their simplest, archetypal form, windows are openings in the walls. The depth of the wall is an integral part of the window and how it performs. This depth, together with the ratio between the window width and height and the overall window size are key parameters governing the overall luminous and thermal performance of the window. They vary dramatically depending on the building location, typology and construction materials.

If we exclude special functional openings such as the arrow slits or loopholes used in medieval castles, windows have evolved into small apertures where it was necessary to avoid heat escaping from the inside in cold climates, or to minimise heat and solar gains entering in hot climates. Where cloudy conditions are prevalent, the balance between light and heat allowed people to build bigger windows that let more light in.

Horizontal window shapes provide a more even distribution of daylight. Vertical windows are more likely to create contrasts between brightness and darkness, but taller windows also mean deeper daylight penetration.

A mere opening in the wall might work in a climate with a relatively stable temperature. However, it would not be able to accommodate all the conflicting require-



ments of illumination, vision and privacy, ventilation as well as heat and sound insulation without the addition of an operable, possibly glazed frame that can be opened and closed.

The variations in design, materials and construction methods of such window frames are enormous. They can include transparent or translucent materials to let in light but not outside air. Furthermore, they can be complemented with interior or exterior accessories such as shading devices, shutters or curtains to reduce solar gain and increase visual comfort, privacy and security. The design of these systems is typically mediated by local culture and art, creating outstanding examples of holistic and interdisciplinary construction.

#### AN INSPIRATION FOR SUSTAINABLE DESIGN

In fact, the examination of vernacular windows offers many surprises, because the invisible, evolutionary architect who has created their designs is the local community. This 'architect' often responds to the environmental challenges and physical circumstances with inventiveness, uses simple tools and local materials, but also shapes his creations according to the culture, beliefs, customs and myths of the community itself.

In this article, we have attempted to 'read' the evolution of vernacular windows in the context of the local luminous climate for a few locations around the world. Our aim is to demonstrate how different environmental conditions influence the design and performance requirements of traditional windows.

These designs are the fruit of simple rules that have been shaped through time by the simple principle of maximising comfort using local resources as well as the geometry and orientation of windows.

We hope that the forgotten skills of our ancestors can offer new inspiration for a more sustainable design of the building envelope.

#### HOW TO READ THE DIAGRAMS ON THE FOLLOWING PAGES

The temporal luminous climate maps presented in the next pages use different colours to display the variation of exterior horizontal illuminance through one year. This metric can be easily related to daylight brightness: the more exterior illuminance, the more light outside.

These maps are like calendars or diaries that, for each hour, indicate the average solar (direct), sky (diffuse) or total (global) horizontal illuminance.

Days flow horizontally, from 1 January on the left to 31 December on the right.

Hours flow vertically, where midnight is both at the top and bottom of the plot and noon is the horizontal line at the centre.

The lighting levels indicated in the maps are those of a typical year, which has been derived using statistical techniques that select the most relevant months from a database of many years.

Looking in more detail at the maps, it is possible to read the duration of the day in different seasons by looking at the length of the coloured vertical lines. The areas in black indicate night hours.

By looking at the diffuse and direct maps, it is also possible to see which days are cloudy (high diffuse illuminance and low or zero direct illuminance) and sunny days (low diffuse illuminance and higher direct illuminance). This observation enables us to identify cloudy/rainy seasons and tell how strong the direct sunlight is compared to the diffuse skylight.

The pattern of hourly values in a climate dataset is unique and, because of the random nature of weather, it will never be repeated in precisely that way. Climate datasets are, however, representative of the prevailing conditions measured at the locale, and they exhibit much of the full range in variation that typically occurs. Furthermore, these standard datasets provide definitive yardstick quantities for the evaluation and selection of compet-

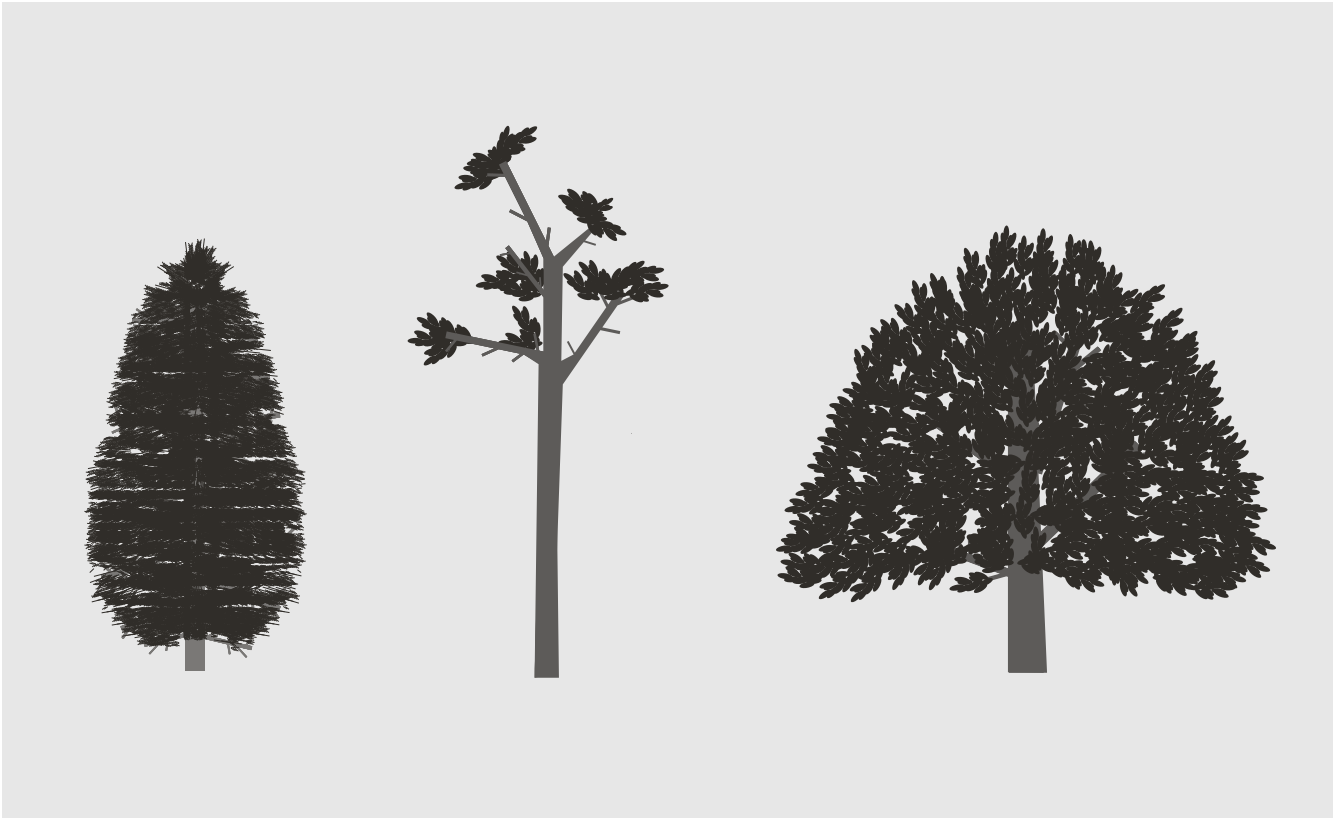
ing design options – in other words, they can help us in the process of 'evolving' towards better building design solutions.

#### ILLUMINATION THROUGH WINDOWS:

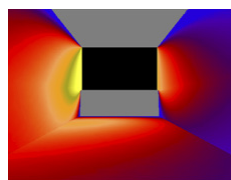
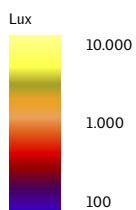
##### LIMITLESS COMPLEXITY AND RICHNESS

The remarkable complexity of natural illumination through windows is appreciated in a direct, instinctual way. It is impossible for us – unaided – to unpick all of the interactions and transformations that occur between the source of daylight (sun and skylight) and the resulting patterns of illumination inside a room. We can however get a glimpse of them from this simulated example of a very simple daylight space. The main image shows how this space might appear to the eye, i.e. a simulation of the surface brightness (the light reflected off the surfaces). The walls, floor and ceiling have typical reflectances, but no colour. To get an impression of the light moving around the space, the four inset images show the components of illuminance (in lux) for light falling onto the surfaces. The four components are light arriving: (a) directly from the sky; (b) directly from the sun; (c) indirectly from the sky; and, (d) indirectly from the sun. Indirectly means after one or more reflections and excluding the direct part. This image allows us to 'unpick' some of the transformations and get a deeper insight into the complexity of illumination for this simple space. Now, imagine how such patterns might appear for the examples of window design that follow. In each case, the combination of (momentary) climate conditions and window/building form will result in a unique, highly complex pattern of illumination. This is a large part of what gives distinctiveness and diversity to our building interiors.

Like windows, trees are examples of evolutionary adaptation to the regional context with its characteristic climate. Both their overall shape and the shape and distribution of their leaves (or needles) have evolved in response to patterns of precipitation as well as direct and diffuse solar irradiation.



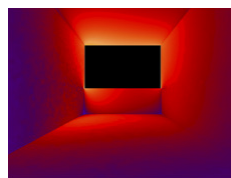
Simulation of a simple daylit space with one window. The overall appearance of surface brightness can be analytically broken down into four components, each of which has a different illuminance distribution in the room.



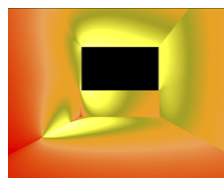
Direct sky



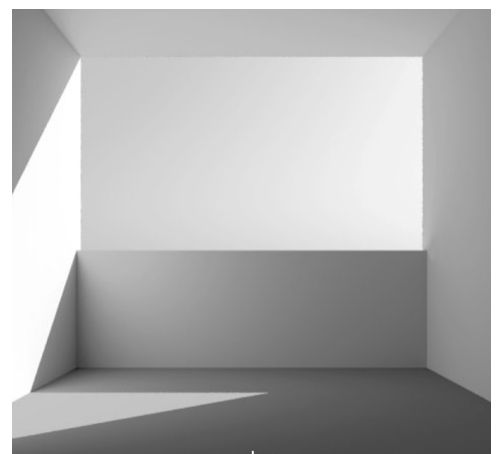
Direct sun



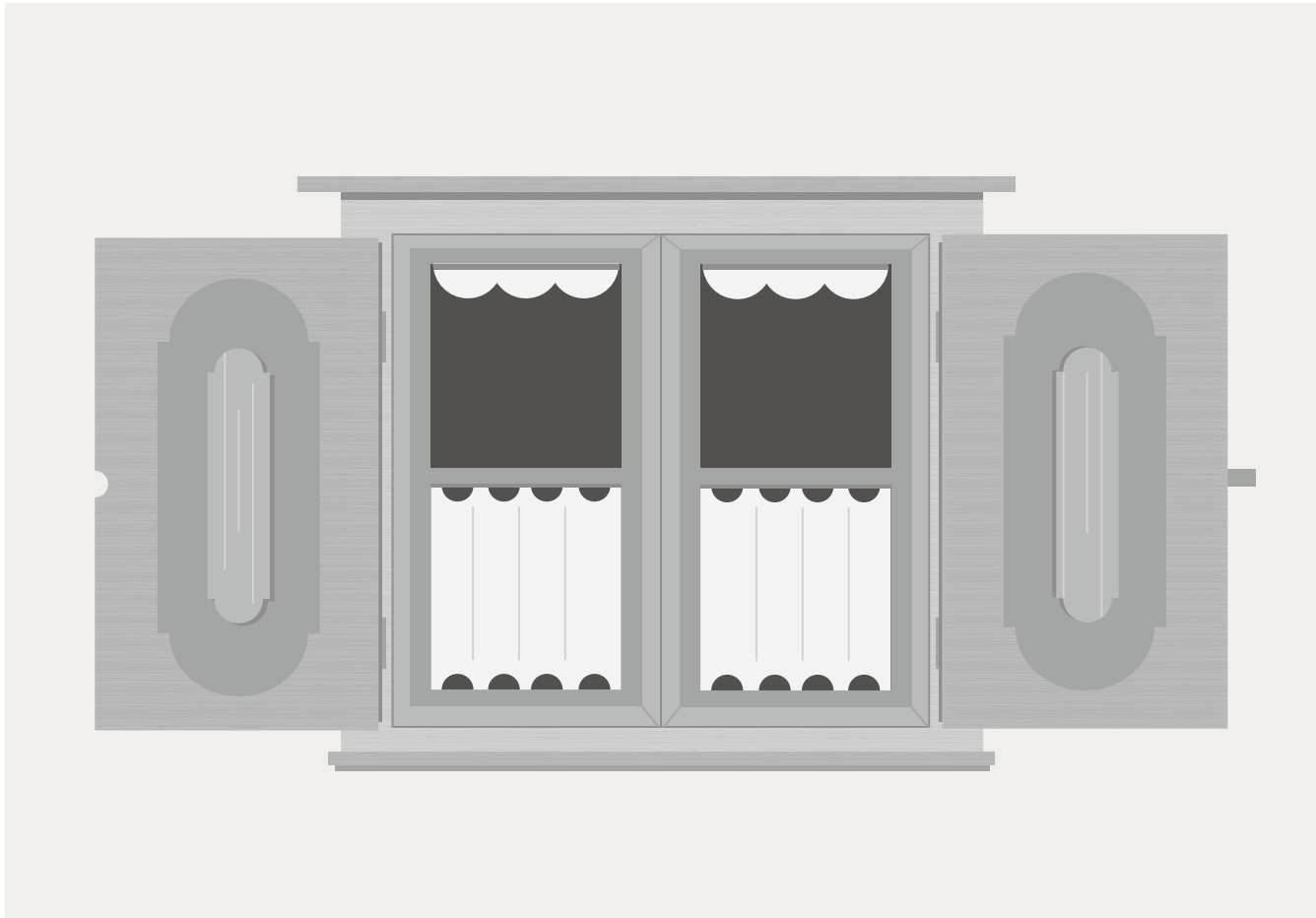
Indirect sky



Indirect sun







## STOCKHOLM

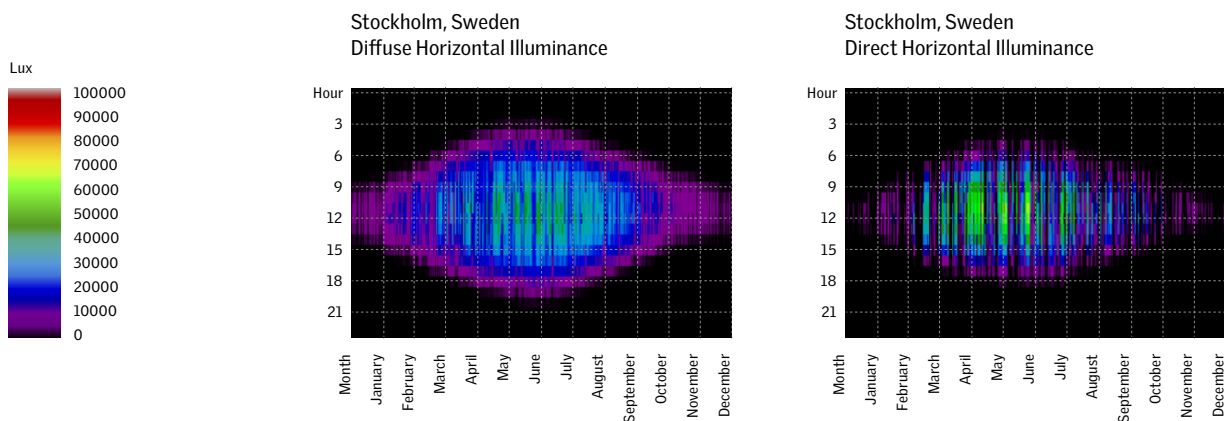
We start our journey around the world of vernacular windows from Scandinavia, located at the extreme north of Europe.

The direct and diffuse maps for Stockholm display clearly the seasonal difference in duration between day and night. This has a direct impact on the traditional window design: longer days mean that natural light can be present during sleeping hours, therefore the addition of exterior solid shutters helps to create a night environment inside the house during the summer months.

The low illuminance values (compare them with the illuminance in the Mediterranean, tropical and desert examples) require windows to let in as much light as possible. This means that privacy might be an issue if windows must maximise lighting.

A good approach to solve this issue whilst mitigating glare from the proverbial low sun of northern climates is the separation of view/privacy and light in windows. The top parts of the windows can be left clear to capture as much light as possible from the sky, but the lower parts

can be screened with curtains or other translucent layers to avoid direct view from the outside in.





## LONDON

The London maps, with their seasonal variability and irregular cloudy and rainy patterns, represent the luminous climate of most of the European locations.

Before the sixteenth century, most European windows were built from stone or timber with unglazed openings, closed with wooden shutters, oiled cloth, paper, or thin sheets of horn. Only the wealthiest houses could afford glazed windows. By the end of the 17th century, larger glass pane sizes could be produced and timber sash windows and casement windows came into use. Since then,

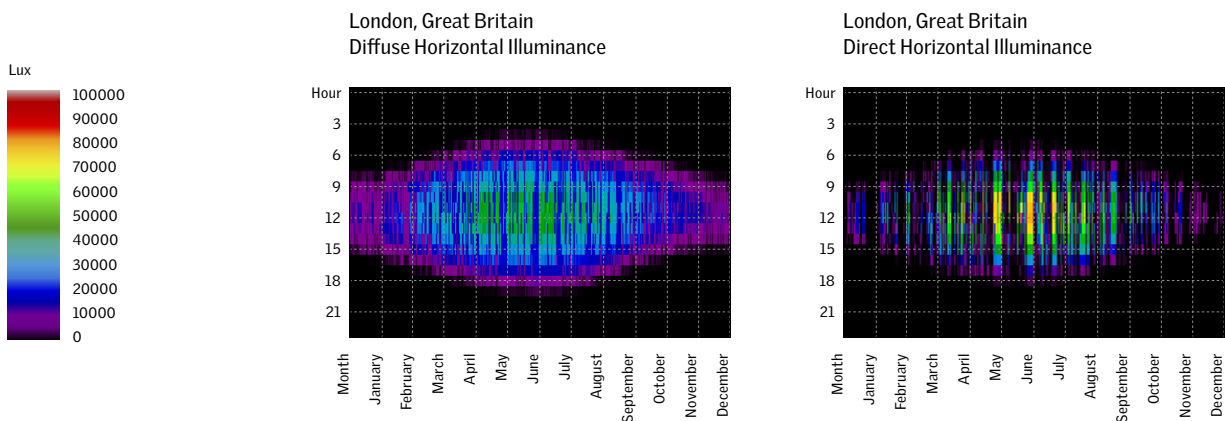
the different glass production methods resulted in a wide range of thicknesses, colours, and refractive and reflective qualities.

A relatively temperate climate allowed architects and vernacular builders to experiment with designs that maximise light. This resulted in a general trend for decreasing thicknesses of glass and increasing sizes of window openings. A large variety of glazing patterns became widespread in the early 19th century with 'lying-pane' (landscape format) sashes becoming popular.

The shape of the bay-window is

particularly connected to the need to maximise light penetration throughout the days and seasons. With their angled profile, they increase the flow of natural light into a building depending on their orientation. They also make a room appear larger and provide views to the outside which would not be available with a flat window.

The sills, reveals and most timberwork associated with European windows is traditionally painted in white colour to increase the reflection of daylight and its distribution to the inside.







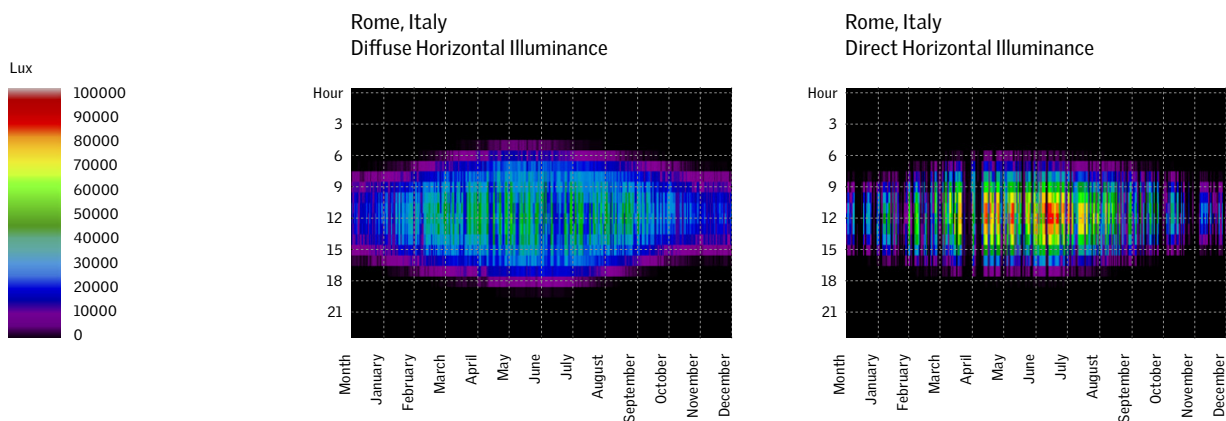
## ROME

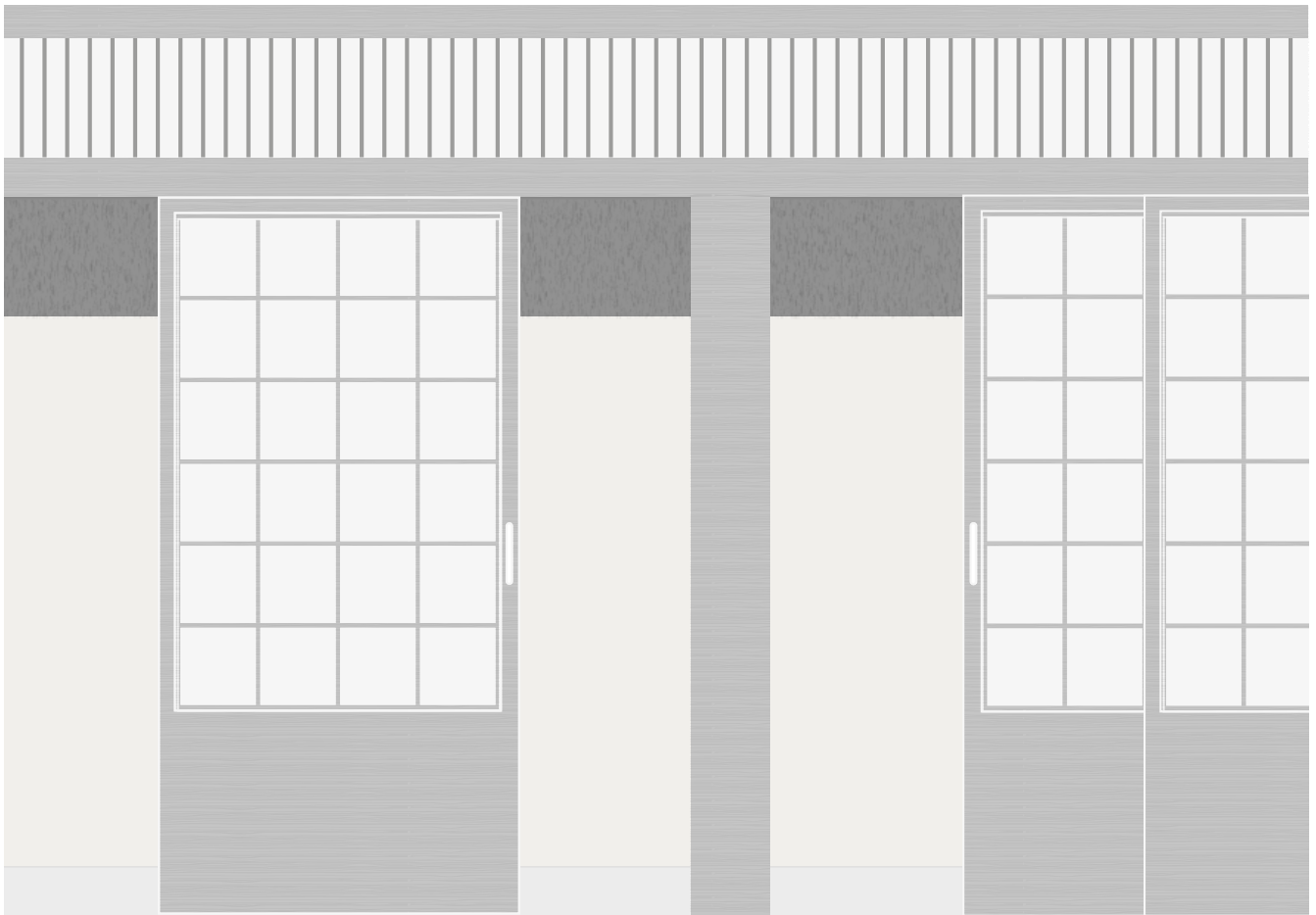
Shading devices perform a triple function: they keep out the sun's heat, block uncomfortable direct sunlight and soften harsh daylight contrasts. In the Mediterranean, the need to accommodate the conflicting requirements dictated by a climate that can have both cold, humid, dark winters and hot, dry and bright summers has influenced the development of a flexible window shading system.

Exterior, so-called Persian or Venetian blinds are the exterior shading layer of a complex system that also

includes glazing and an interior shutter system for increased privacy and security.

The high degree of adjustability of this system allows the windows to cope with high variations in illumination conditions. The positioning of the adjustable shading device on the outside of the window is important to minimise solar gains in summer.





## OSAKA

With the notable exclusion of the northern island of Hokkaido, the climate of most of Japan is similar to the Mediterranean one, with more humid and hot summers. The temporal luminous climate maps for Osaka also show a particularly strong sun, especially in summer.

However, the traditional window design in this part of the world is

distinctly different than the Mediterranean counterparts and can only be understood by looking at the natural, social and aesthetic context of Japan.

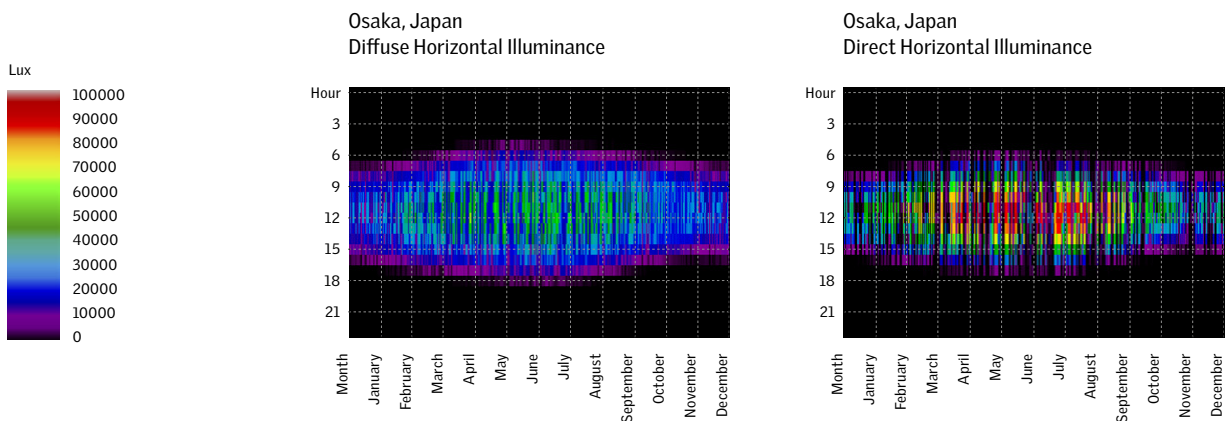
The destructive effects of earthquakes, tsunamis, volcano eruptions and typhoons, coupled with the temperate climate, have contributed to the development of houses that are lightweight enough to allow a quick escape and that can be rebuilt or refurbished more often than in other countries.

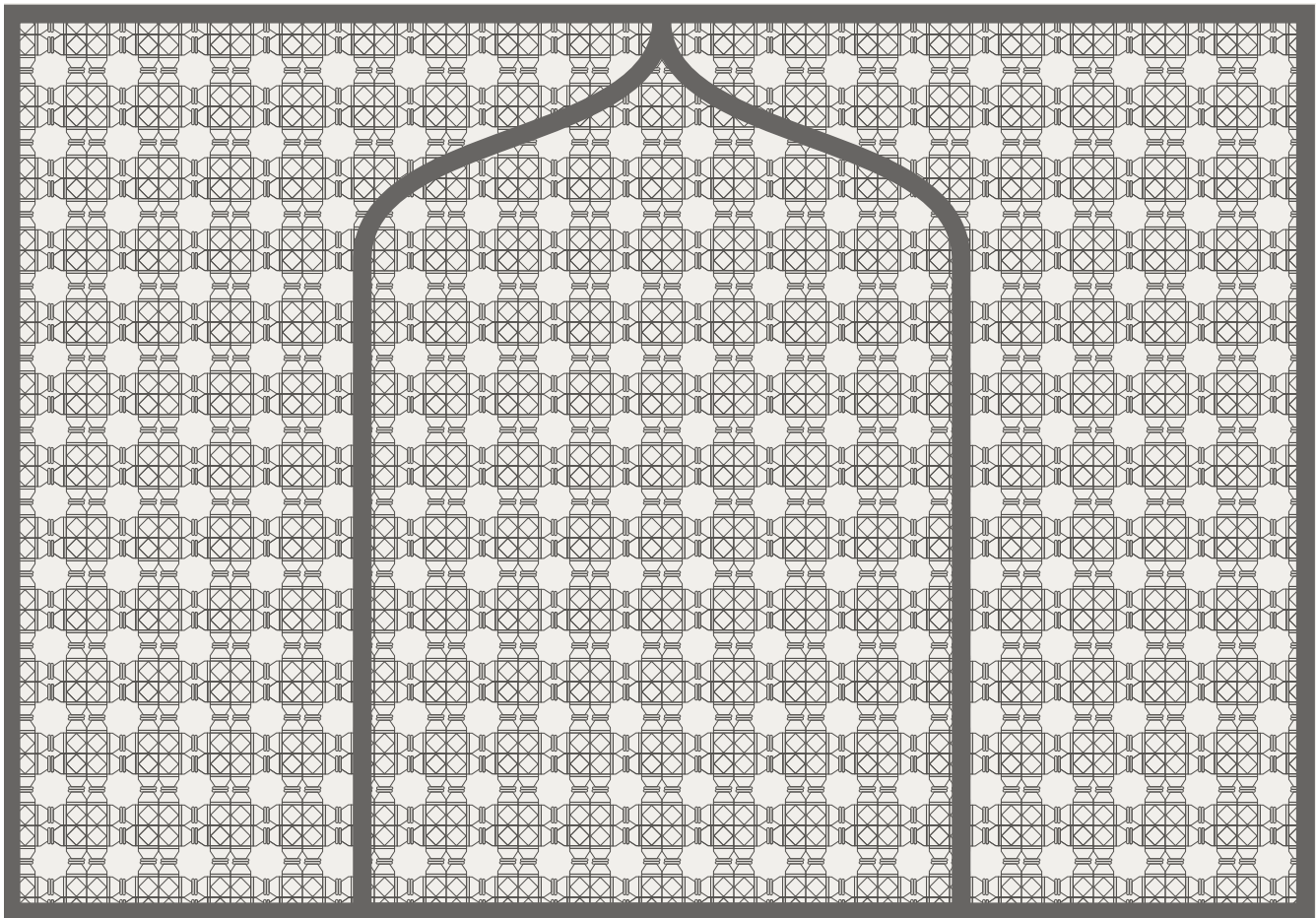
The characteristic thin walls of the traditional Japanese house include translucent 'shoji' screens that

can be used both inside as partitions and at the building perimeter to protect from the outside environment. They also act as daylight diffusers, attenuating and gently distributing the strong sunlight. Exterior 'shoji' screens are combined with heavier 'amado' wooden panels, that are set into tracks running along the exterior walls, creating a verandah, or 'engawa'. The 'amado' panels can be opened in good weather to bring in additional light and allow a view to the outside world.

The widespread use of translucent 'washi' paper for the window screens

has created a peculiar aesthetic of soft light and soft shadows, which is in strong contrast with the more dramatic use of light and shading of the western world. Europe has created a complex sequence of adjustable shading layers based on the geometry of the sun path, that can still project the harsh contrast of light and shadow to the interior of a building. Japan resolves a similar daylighting problem with a single layer of diffusing paper and a sophisticated yet uncomplicated use of material. This approach both simplifies the window components and reduces their number.





## ABU DHABI

Mashrabiya screens are the most widespread form of window in Middle-Eastern architecture. They are projecting oriel windows enclosed with wooden latticework, but more generally the term Mashrabiya identifies the latticework itself, that can be made of wood or stone. In India, Mashrabiya are indicated with the term Jali, while the projecting balcony decorated with Jali is called Jharokha. Similar latticework is also widely present in vernacular Chinese architecture.

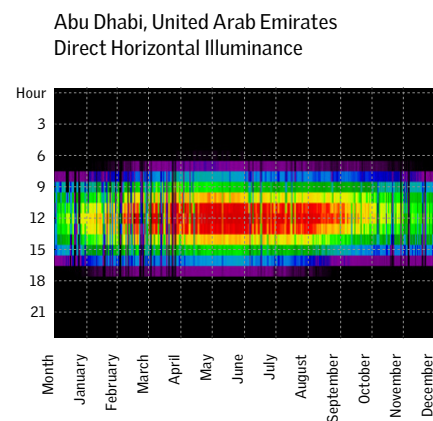
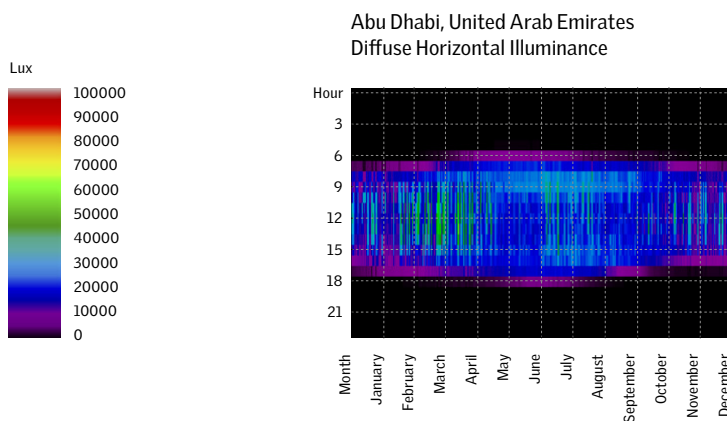
This type of window has originated in countries where the preva-

lent weather conditions are dry and sunny. The weather data plots for Abu Dhabi show this solar prevalence very clearly throughout the year. This implies a clear need for shading and ventilation.

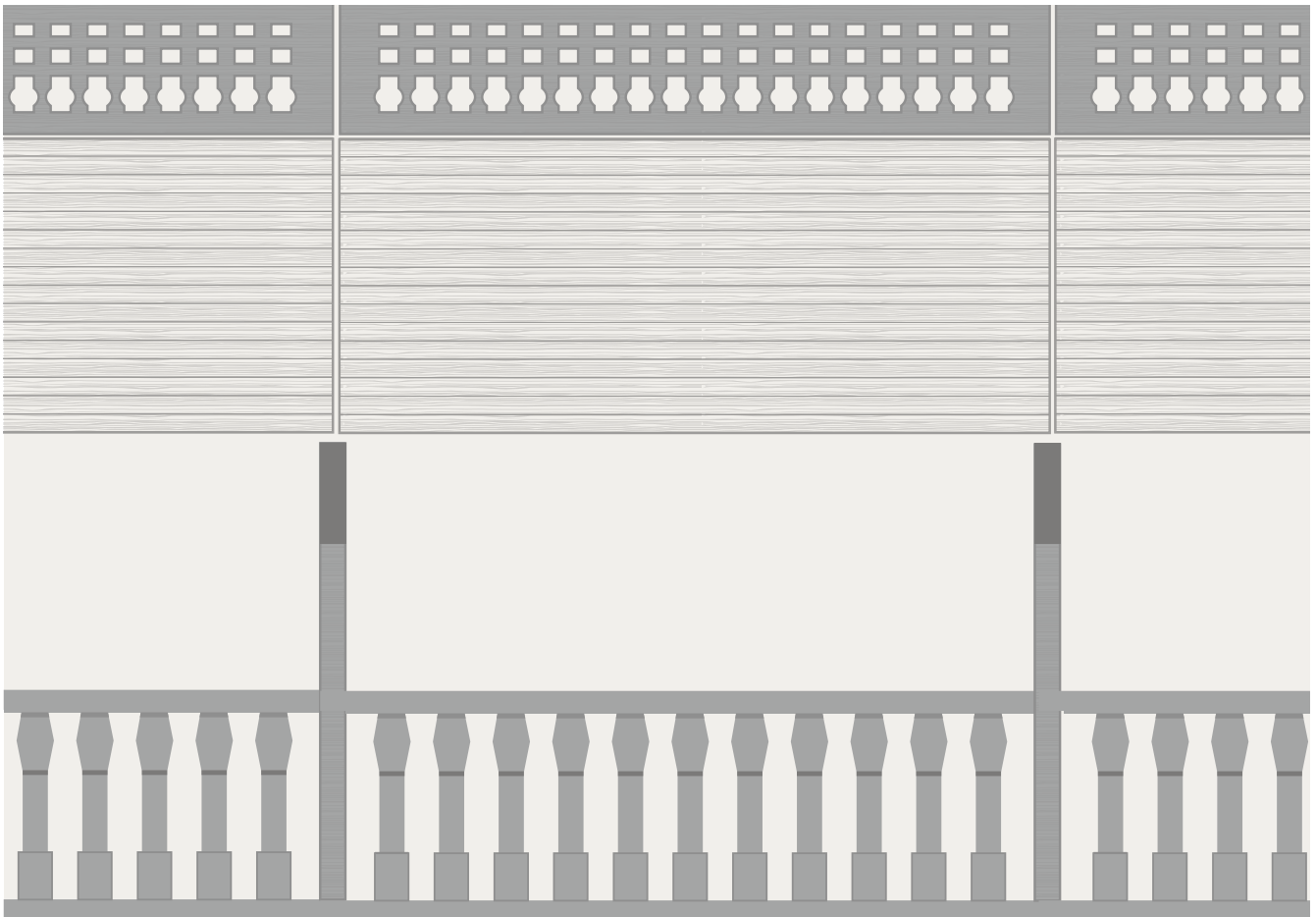
The open latticework created by the wooden frame and pegs of the Mashrabiya screens is the best solution to this problem. Leaving openings in all the windows promotes continuous air flow and cooling inside buildings, while the rounded shape of the pegs disperse the light, reducing the contrast and glare.

Another function of the Mashra-

biya is related to the Arab culture and desire of privacy. The bright appearance of the exterior screens from the outside conceals completely the view of the darker interiors, while the dweller can observe the outside world clearly without being seen and without needing to open the window.







## PORT AU PRINCE

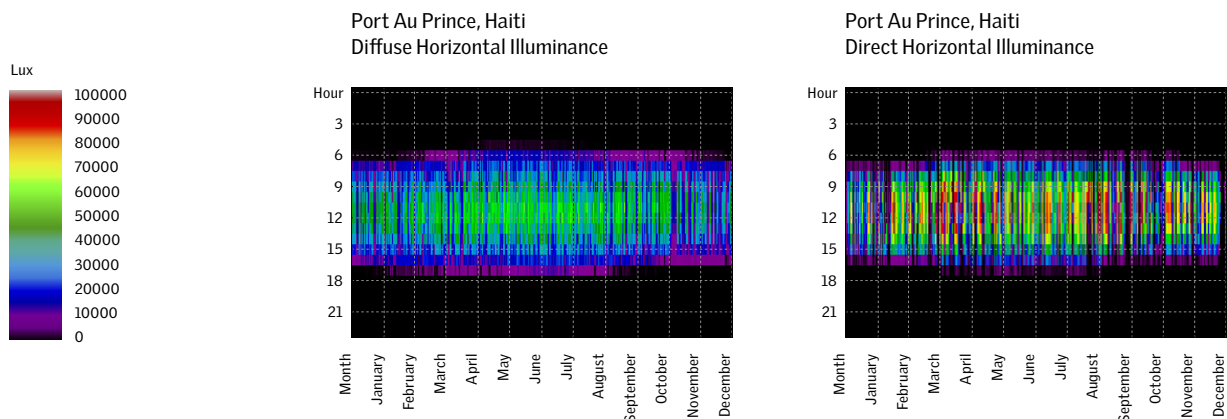
In tropical climates, in this case represented by the temporal luminous map of Port au Prince in Haiti, days have similar length throughout the year and the sun spends most of its time overhead, in the highest part of the sky.

Deep solar penetration can still be a nuisance in the morning and afternoon, therefore local builders have developed window designs with awnings, jealousies as well as adjustable shading panels and shutters with higher and lower sections, that can be hung horizontally or vertically. A façade with some depth, like a porch

or a covered balcony, creates a buffer zone that can contain shading elements to filter glare and block sun.

All these principles are embedded into the design of the Caribbean chattel house. These houses were occupied initially by the African slaves working in the British West Indies. They were designed to be movable, so that slaves living in them could build them on the margins of sugar plantations on land that they didn't own and then dismantle and move them easily at the end of the growing season. For this reason the houses were built in wood and assembled without

nails. Their windows had two types of shutters: the top ones were hung with horizontal hinges and the lower ones were hung vertically to allow maximum flexibility against the wind and solar penetration. Their colloquial name - 'jealousy shutters' - reminds of the function to keep the inside of the house not visible to the eyes of the neighbours.



# INSIGHT

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Daylight is an indispensable tool for the sustainable renewal of our cities. The following pages provide insights into this great transformation. Here, four buildings are portrayed that could hardly be more different – from a social housing estate to an art and design museum and from a kindergarten to an office building – but that have one thing in common: daylight was the prerequisite for their renewal. Daylight allowed former residual and storage spaces to be put to new uses. Using natural light, the architects created rhythm and atmosphere and, sometimes, a sense of magic in the buildings. Daylight makes the rooms in a building appear larger while energy bills become smaller.

# INSIDE

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In order to change the status quo, however, visionary thinking on a large scale is also required. On the urban level, too, daylight strategies can be developed and implemented. What role such strategies have played in 20th century urbanism and what role they might play in the future is another topic of this magazine. The articles look back to 113 years of international building exhibitions in Germany and present a study that investigates the potential of daylight refurbishment in Danish cities. This study provides one important insight: improving the daylight availability in our cities is a long-term effort and requires the collaboration of many stakeholders. But it is worth the effort, as urban daylighting design can establish the basis for better living conditions for many people.





# POORTER STRAAT MONT FOORT









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# DAYLIGHT FOR ALL

In the small town of Montfoort, the first ten of millions of Dutch terraced houses have been converted into Active Houses. Their roofs harness the sun's energy in three ways: to generate power, to supply heat, and as a source of light that significantly enhances the comfortable living conditions in these spacious but very deep houses.

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By Jakob Schoof  
Photography by Torben Eskerod

BETWEEN 1945 AND 1975, 2.5 million houses were built in the Netherlands, about 1.3 million of which were terraced houses. Many of these are now waiting their turn to be renovated, fit for the 21st century.

For the houses at 29–47 Poorterstraat in Montfoort, this future has already begun. In the last few months they have been converted into the first 'active houses'<sup>1</sup> in the country, and now achieve an A++ energy label for energy performance.

The term 'active house' indicates that the houses use only a fraction of the energy that new-build housing in the Netherlands would normally consume. Furthermore, and possibly even more important, there are high levels of daylight, fresh air, a good indoor climate, and healthy materials.

The ten active houses are part of a larger estate of terraced houses in which the same owner, the GroenWest housing association, has recently renovated a further 82 houses. The principal difference between the buildings in Poorterstraat and their neighbours is the extended top floor, literally every square centimetre of which makes use of the light of the sun.

## A PRISM FOR MORE DAYLIGHT – THE CONVERSION CONCEPT

The architects' strategy for the conversion was to open up the centre of the houses, and bring in daylight from above. Previously, the attic had served simply as a storage space; accessible only via folding stairs. Now it has been significantly en-

larged and turned into a living area, with a new permanent staircase leading up from the first floor.

The increase in space is also visible from the exterior, most noticeably at the gables of the houses. The architects have added a prismatic element covered with large expanses of glass, solar panels and zinc sheeting onto the existing asymmetrical roofs. This new rooftop extension channels daylight from both sides into the attic. So if the residents have their bedroom on this floor, they are not only woken up by the morning sun streaming in from the roof terrace in the east – they can also enjoy the evening sun that enters through the high roof windows in the west and is reflected back into the room from the white-plastered inside of the opposite roof.

The size of the lower two floors was not altered, neither was the size of the facade windows; the old, poorly insulated windows with their thin aluminium frames were merely replaced by new, triple-glazed windows with timber frames. Nonetheless, the rooms have become perceptibly brighter, as the new open staircase now allows daylight to penetrate right down to the ground floor and into the spaces that surround it. On the first floor, the timber and glass partitions that previously surrounded the staircase were replaced with a low balustrade, so that natural light now also floods the adjacent corridor.

1. See [www.activehouse.info](http://www.activehouse.info)

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"The overall change that the refurbishment has brought is tremendous. No more flaking paint, no more draughty or leaking windows. The new paint on the walls feels much sunnier now, and of course the attic is bright. I also like the views from up there – they make you feel as though you are at the same level as the birds. We will use the additional space as a study for my wife and me, because we both work quite a bit from home."

Gerard Michels lives in Poorterstraat 41 together with his wife and two small children.

On the ground floor there is an open-plan kitchen/dining/living area of around 45 square metres, stretching from the entrance side right back to the garden. In order to keep this space as open as possible, the stairs consist only of treads, so that whoever enters the building can see right through horizontally. The surfaces in the rooms further contribute to better daylight provision, as the old light-absorbing spray plaster was replaced with smooth, white walls and ceilings that reflect the light. Next to the stairs, a white wall was added in order to reflect daylight into the living room.

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"The refurbishment has brought a magnificent change to our house! Before, it was difficult to get it to a comfortable temperature due to the lack of insulation, and the windows were draughty. If we wanted to have a temperature of 20°C inside our home, we had to set the thermostats to 23°C. Still, we liked the house because it is one of the largest rental homes in Montfoort, and also has an unusually spacious back garden, which you don't find in newer rental homes any more."

Edwin Hamelink lives in Poorterstraet 33 with his wife and four children.

The natural ventilation also benefits from the permeability between ground floor and attic. Opening the roof windows on the top floor creates a chimney effect around the stairwell that channels the used air up from both the floors below, and allows it to escape through the roof into the open. This strategy ensures, above all, that there is some welcome cooling in the houses in the summer. In winter, a mechanical ventilation system with CO<sub>2</sub> sensors guarantees a comfortable and healthy circulation of air.

#### SOCIAL HOUSING MADE ATTRACTIVE – THE CHOICE OF MATERIALS

The roof structure and the facades of the houses were almost totally revamped. In this way, it was possible to attain the ambitious energy targets in the most efficient manner, because these require good insulation and good solar gain from the windows.

The choice of materials used for the facade and roof was important for another reason. The ten houses are part of the social housing stock – and in the Netherlands there is an unwritten law that these should not look any different from other

houses. The facades were fitted with a new brick facing and dark weatherboarding. From a distance, this range of materials is reminiscent of the pre-conversion situation. But the new bricks are only half as thick as the old ones, which means that the wall cavity (and thus the space for thermal insulation) became wider without the need to increase the width of the foundations. The floor was insulated from underneath too, with extra insulation being installed in a 50 cm deep, existing crawl space underneath the floor plate.

#### A COMPLETE SOLAR SOLUTION – THE ENERGY CONCEPT

Key to the energy concept is the new roof that was developed as an all-in-one 'Solar Solution' by VELUX and Danfoss. This element combines numerous functions: added space, the supply of daylight, ventilation and the generation of solar energy. The orientation of the houses dictated how much solar energy could be 'harvested' from the roofs.

On the side of the entrance, which faces west, each roof has a 21 square metre photovoltaic installation. On the eastern side, right up against the roof ridge, is a row of solar panels that provide the houses with hot water. Positioning both systems on the side of the entrance might have improved the energy balance by another few kilowatt hours. But the planners considered that exposing the attic floor to daylight from both sides was more important than unilateral maximisation of energy yields.

The architects reckon that the houses will eventually use between 80 and 90 per cent less energy than before the conversion. In addition, the buildings have been turned into all-electric houses that need no gas boilers or chimneys. Heating is supplied by a ground source heat pump and two ground source heat probes in each house. The heat pump takes its power from the photovoltaic modules on the roof. All the essential technological installations – heat pump, hot water tank and inverters for the PV system – are concentrated in a utility room in the annex on the street side.

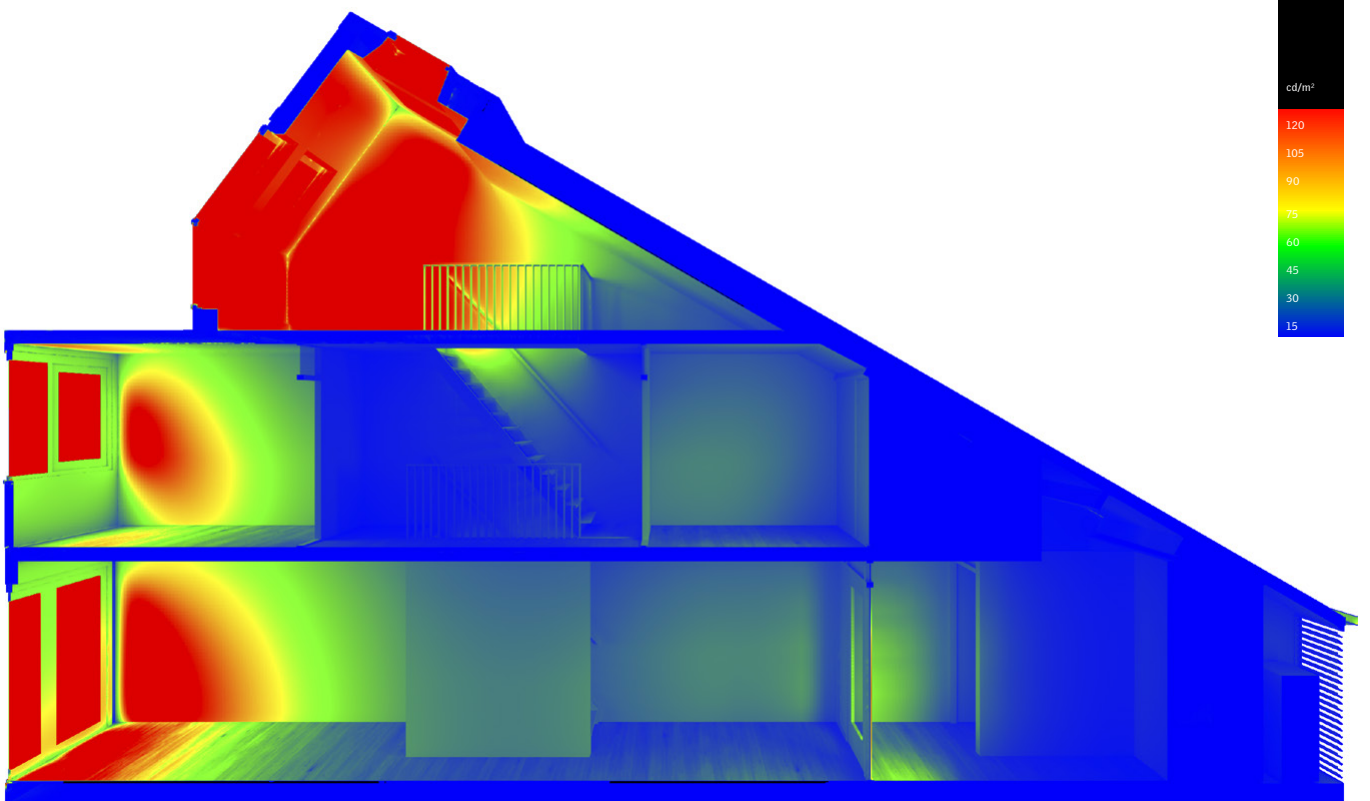
#### THE TRIPLE BENEFIT – LESS COST, MORE SPACE, A BETTER IMAGE

Replacing the old gas boilers in the houses by a stand-alone system that relies purely on renewable energies was a daring but forward-looking move in a country like the Netherlands, where gas prices are traditionally low. However the client and the architects expect that with rising prices for fossil fuels, this move will eventually pay off. According to calculations by BouwhulpGroep, the energy costs for the residents will be reduced by around 130 Euros per month as a result of the conversion. Tenants pay around 115 Euros more rent per month for their houses, which, in turn, have been enlarged by 17 square metres each.

The increased revenue from the houses will help the GroenWest housing association to pay back the costs of the conversion – about 130,000 Euros per house. Only a fraction of this sum however, was incurred by the Active House standard – the largest part went to standard maintenance and refurbishment. Another benefit of the conversion project is that, being a research and development investment, it will help the company to future-proof the thousands of other existing homes in their possession. As Peter Korzelius, former Chairman of GroenWest said before the start of the works, "We are faced with a situation in which we will have to renovate one third of our housing stock – in other words 4,000 residential units – within the next five to seven years. This is an enormous task. By running this project, we wanted to gauge what it means to really push back the boundaries of what is technically feasible: as much incidence of daylight as possible, coupled with as little energy consumption as possible."

For the tenants, the conversion will result in a net saving – and, more importantly, a distinctly improved quality of living both in their houses and in the neighbourhood. Poorterstraet used to be a socially-underprivileged part of Montfoort: it is now a flagship district where residents count themselves lucky to be able to call some of the most extraordinary social housing in the Netherlands their own.

Section through one house showing the distribution of luminance levels under overcast sky conditions in photo-realistic (above) and false colour (below) views.













Generous, except by daylight: houses in Porterstraat 29–47 before conversion

For a long time, Poorterstraat in Montfoort, a small town west of Utrecht, looked like hundreds of other estates of terraced houses in the Netherlands. Two-storey houses, built in 1976, with tiled roofs, brick facades, and weathered, light blue timber cladding, lined the street.

The row of houses already had a striking asymmetrical roof shape before the renovation: on the entrance side, a string of almost windowless extensions stretched right to the pavement, containing cloakrooms, toilets and storerooms. While on the garden side, flat roofs extended over half the depth of the building.

When asked what they liked most about their houses, residents would typically reply, "The size. Otherwise there's nothing special." The terraced houses offered more space than to-

day's new buildings, but they were badly insulated and dark. The ceilings were low, the steep pitch of the roofs did nothing to contribute to the light in the rooms, and the entire attic was only used as storage space. In addition, the extensions on the street side cast shade on the entrance facades. Most of all, the residents were not too happy about the reputation of Poorterstraat. "I am really not proud of my address," admitted one resident before the conversion. The renovation of the ten social housing units therefore also became a social concern for the GroenWest association. As former Chairman of the association, Peter Korzelius said, "It is good that this of all streets has now become a flagship project."



Before the conversion, the coarse plaster and the wall claddings that the inhabitants had added took away a lot of daylight from the rooms. They have now been replaced by white, smooth render that evenly reflects the daylight coming in through the windows.



"The Active House principles are all about designing buildings that are suited to their occupants. In our vision for the houses in Montfoort, we translated this concept into light, air and space. These three aspects were the key to our design, whether it was in rooftop extension, the column of light in the staircase or our focus on the indoor air quality.

The focus on people is also what makes our project in Montfoort stand out from other approaches to energy-efficient refurbishment, including so-called 'passive house' refurbishments. In passive houses the building plays the most important role, whereas in an active house, the user is at the centre.

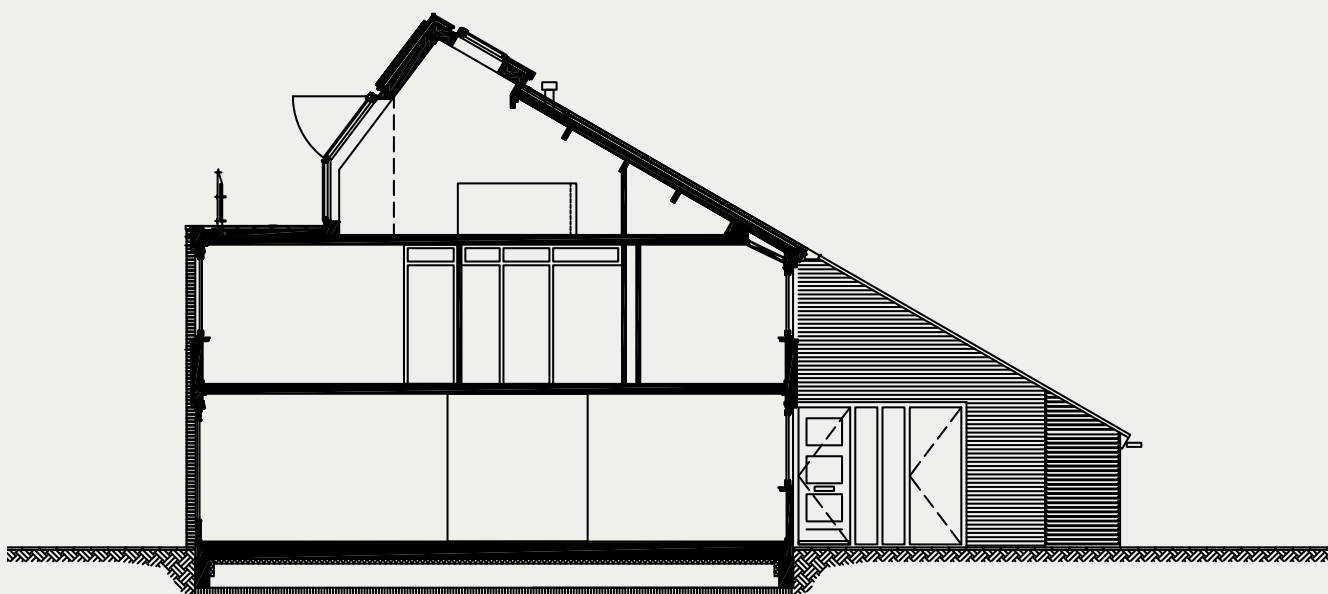
An active house therefore ought to emphasise the active role of the occupants. The Active House specifications are just a reminder of how well the project was executed, and not a goal on their own."

Yuri van Bergen and Haico van Nunen, BouwhulpGroep

#### Credits

Client:	Stichting GroenWest, Woerden, NL
Architects:	BouwhulpGroep, Eindhoven, NL
Construction:	BAM Woningbouw, Nieuwegein, NL
Project partners:	VELUX Group and Danfoss
Location:	Poorterstraat 29-47, Montfoort, NL

#### Section







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## COLLABORATION FROM DAY ONE

Interview with Karin Verdooren  
and Bernard van Dam

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"The interest that our project has aroused shows us that we are on the right track, and that other companies also feel that something has to change in housing refurbishment in our country."

Bernard van Dam

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*Mrs Verdooren, what was your ambition in being the first housing corporation in the Netherlands to carry out an Active House refurbishment?*

KV: The decisive step forward to renovate some of our social housing in as sustainable a way as possible was made when our former CEO, Peter Korzelijs, spoke to the Mayor of Montfoort on the occasion of Duurzame Dinsdag (Sustainable Tuesday) in September 2009. Sustainable Tuesday is a nationwide, annual event where a jury awards prizes to the best sustainable ideas and initiatives developed by companies in the country.

On that day, we decided we would renovate the ten houses in Poorterstraat to energy level A++. Soon afterwards, we learned that VELUX Netherlands was also looking for an ambitious refurbishment project to implement the Solar Solution concept that VELUX had developed together with Danfoss. So we got in touch with each other to discuss a possible collaboration.

*What is your usual approach to refurbishing homes, and how does the project in Poorterstraat compare to a standard renovation in terms of costs?*

KV: Usually we aim to upgrade our houses from energy level F or G to level C in the Energy Performance Certificate. As far as costs are concerned, I cannot give you the precise figures, but for the same money we would have been able to build new houses to level A, and you can imagine that a standard renovation would have been significantly cheaper. But we wanted to try out the experiment in this case because we believe that this is the way forward.

*Was there any public funding for the refurbishments?*

KV: Unfortunately not, as the situation regarding funding in the Netherlands is rather difficult at the moment. However, while we certainly would not have minded

a little extra money from the state, the fact that we did not receive any also helped us to figure out what was financially viable. After all, if we are to do similar refurbishments in the future, there will not always be funding available either.

*Mr Van Dam, what have you learned from the project that you can potentially apply to future, similar refurbishments?*

BVD: The project was unique for us because, for the first time, we considered rent and energy costs together – that is so-called living costs. We wanted to achieve a trade-off between an increase in rent (which is beneficial for us) and significant reductions in energy costs (which are beneficial for the tenants).

To really turn these refurbishments into a business case, however, we would have needed to increase the rent a little more than the law allows us to. In the Netherlands, there are legal limits to the overall rent for social housing. But these regulations consider only the rent itself and completely disregard the energy costs. We can only hope that this law may change in the future to include both.

We also learnt a lot from the planning process in this project. Usually when we start a refurbishment, we draw up the plans, then send out a tender to several contractors and ask them for their bids. In this case, though, all the parties worked together from the start and developed a good solution together. I think that more and more projects ought to be developed like this in order to be truly sustainable."

*To what degree did the particular focus on daylight in this project open up any new perspectives to you?*

KV: One of the main objectives of GroenWest is that our tenants should live comfortably. And daylight can make a significant contribution to that. Daylight makes homes feel bigger than they actually are, and I hope it will also make the

residents feel better. If people feel better in their house, they take better care of it, and you also have fewer problems in the area around the houses. Still, this is a very long-term perspective and it may take years to really see the effects.

BVD: The houses are entering a monitoring phase now in which their energy use, the indoor comfort, and the well-being of the residents will be evaluated. We are looking forward to seeing the results of all this. We also hope that it will become more and more common to deal with daylight in this novel way in the future, so that this will no longer just be something that an architect can do. That would certainly help us in applying similar strategies to other refurbishments as well.

*What has been the feedback on the project so far, both from the general public and from other housing corporations?*

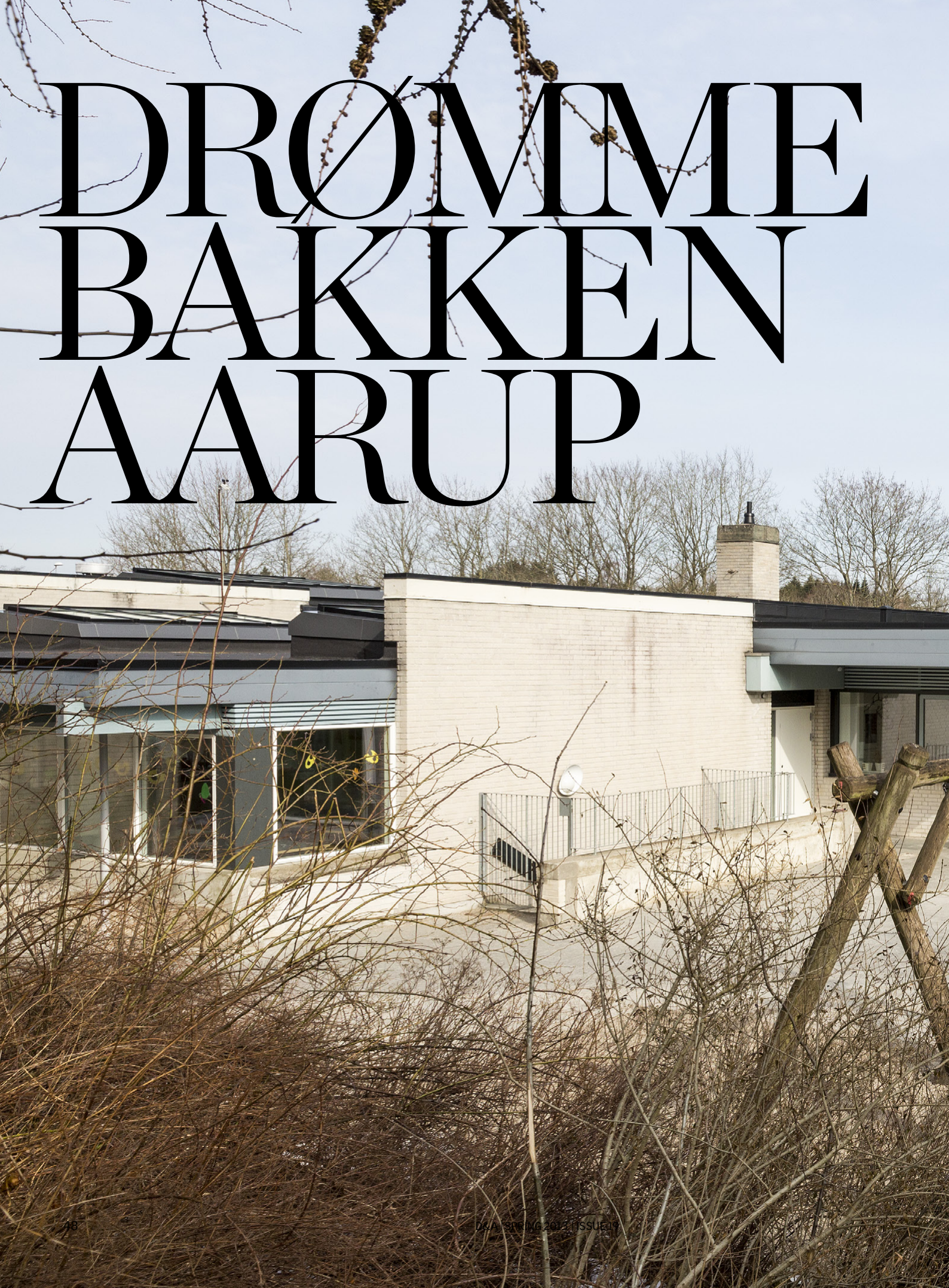
BVD: There is definitely a lot of interest in our sector. We are the first in the Netherlands to do a project like this, so everyone is looking at us as if we are experts already. But we are not experts yet. The future will tell us if what we did was right – particularly as we did it in the midst of the financial crisis. Also, the costs were extremely high. Nevertheless, the interest that our project has aroused shows us that we are on the right track, and that other companies also feel that something has to change in housing refurbishment in our country.

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**Karin Verdooren** is CEO of Stichting GroenWest, the owner of the ten refurbished houses in Poorterstraat

**Bernard van Dam** is project leader of GroenWest.





# DØMMET BAKKEN AARUP











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# DAYLIGHT FOR THE SMALL

Toys instead of files, story times instead of council meetings – new and much younger occupants have moved into the former town hall in the Danish municipality of Aarup. CASA Arkitekter adapted the 1960s building and turned it into a kindergarten, opening it up with large modular skylights to let the daylight in.

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By Jakob Schoof  
Photography by Torben Eskerod

IF AN ADMINISTRATIVE OFFICER from the municipality of Aarup were to pay a visit to his former workplace today, he would find it almost unrecognisable, the interior at any rate. The same, formerly windowless rooms where citizens used to wait for their appointments are now bathed in clear daylight. Children's clear voices ring out where typewriters once clattered. The former town hall has become a children's centre and is now known by the poetic name of Drømmebakken (hill of dreams). Eleven large modular skylights let natural light deep into the building's interior, making them appear bright even on overcast days. Peter Rebild from CASA Arkitekter, the architects in charge of the new design, says: "The apertures have a much greater impact than conventional skylights. They make the interior areas feel like light-filled atria."

Most visitors are pleasantly surprised by the amount of daylight inside when they first enter the renovated building. "From the outside, you see this flat building, like many built in the '60s, so most people expect to come into a dark building. But you don't, and many parents are positively surprised at this," explains the head of the kindergarten, Helle Pia Sørensen.

This element of surprise is compounded by the fact that externally the former town hall has not changed much. A massive projecting flat roof from the 1960s still covers the single-storey building. Only the presence of six 'entrance tun-

nels' that the architects inserted through the facades unobtrusively hint at the building's renovation.

## OPEN TO THE SKY – THE CONCEPT BEHIND THE RENOVATION

The key question the architects had to consider was how to bring light and fresh air into a building that is up to 25 metres deep. The limited budget only allowed for very selective renovation, in which clear priorities had to be set. The architects therefore focussed on improving the spatial experience and atmosphere inside the rooms and on the health and well-being of the young users.

A total of 150 children, from toddlers to preschoolers, now attend the day-care centre. Each of its six classrooms has a different theme; in addition to a creative room and a theatre room, there is a 'fairytale room' and a room where the future master builders and architects can test their skills with building bricks. Furthermore, there is a special room for preschool children and one for children who require additional special care. Entry to the building was completely changed to meet the children's needs for more privacy. The former entrance area in the centre of the building now serves as a recreation room and a dining room with an open-plan kitchen. The children enter the building through the six entrance tunnels that also serve as cloakrooms, with the inside of each tunnel completely clad either in green or in red panels. Daylight enters









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"There are sensors in various places that measure temperature and CO<sub>2</sub>. If the CO<sub>2</sub> level is too high, the system makes sure that new fresh air flows into the kindergarten. If the temperature is too high, the system reduces the underfloor heating and opens the skylights."

Ib Medegaard

each of the tunnels through two smaller skylights in the flat roof. All the other rooms have been painted matt white to ensure an even distribution of daylight. Many of the rooms were once large open-plan spaces. To improve their acoustics, the architects placed numerous large and small sail-shaped panels under the ceilings to absorb the sound. The panels additionally serve to conceal the technical installations.

The enormous roof of the former town hall was ideal for admitting daylight into the more than 1,200 square metre building. The eleven skylights consist of 49 individual modules, each of which measures 90 by 240 centimetres and is inclined at an angle of five degrees. The building's external walls, in contrast, have been left almost untouched. Even the old window frames are still serviceable; they have simply been provided with new security glazing. Apart from the entrance tunnels, the only major changes to the facades are the floor-to-ceiling glazed emergency exits in every classroom.

Although the building was originally designed for an entirely different purpose, its facade design turned out to be ideal for the kindergarten as it balances privacy with openness to the external world. In the classrooms, the windowsills are low enough for plentiful amounts of daylight to reach the inside, but prevent the children working on projects in the rooms from being distracted by visual contact with their peers playing outside. In contrast, the floor-to-ceiling glazing in the former entrance area, which now

serves as a common room, permits an undisturbed view outside.

#### *Ventilation and heating in synchrony – the technological concept*

The design of the synchronised ventilation and heating system is important to ensure a pleasant indoor climate. Instead of the air heating system which the building had previously been equipped with, all rooms now have a much more energy-efficient underfloor heating system. Ventilation flaps above the facade windows and 30 of the 49 skylight modules automatically open and close to allow air to circulate naturally. The vents and modules are controlled by a Window-Master system that is also responsible for regulating the underfloor heating. Ib Medegaard, the construction consultant for the municipality, explains the system: "There are sensors in various places that measure temperature and CO<sub>2</sub>. If the CO<sub>2</sub> level is too high, the system makes sure that new fresh air flows into the kindergarten. If the temperature is too high, the system reduces the underfloor heating and opens the skylights."

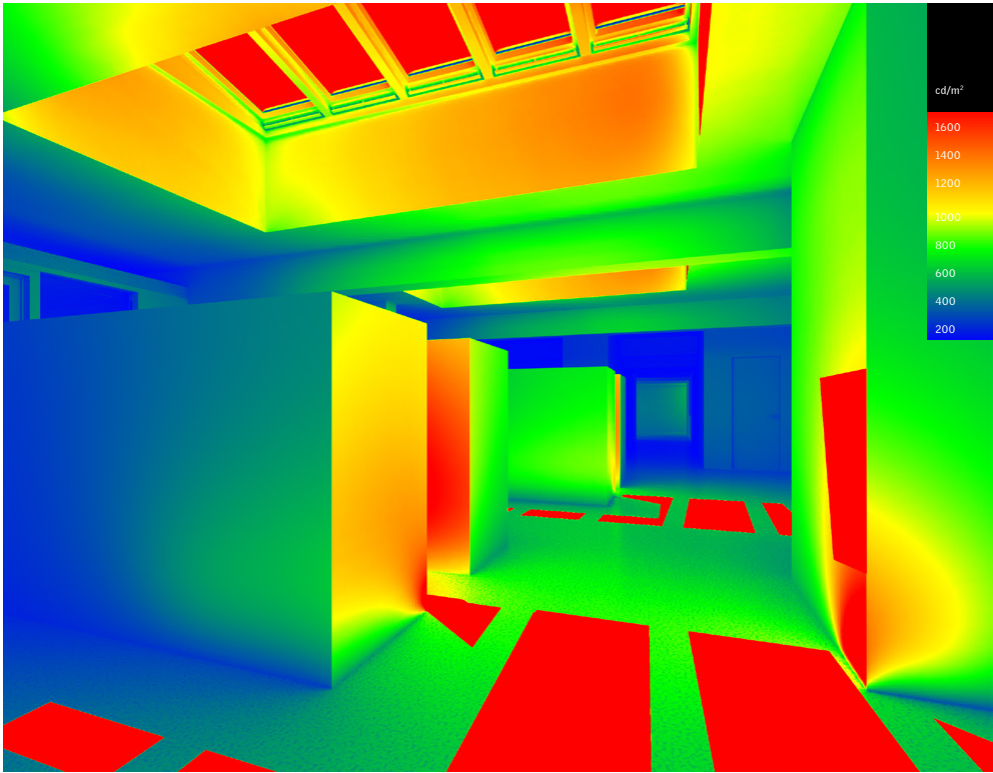
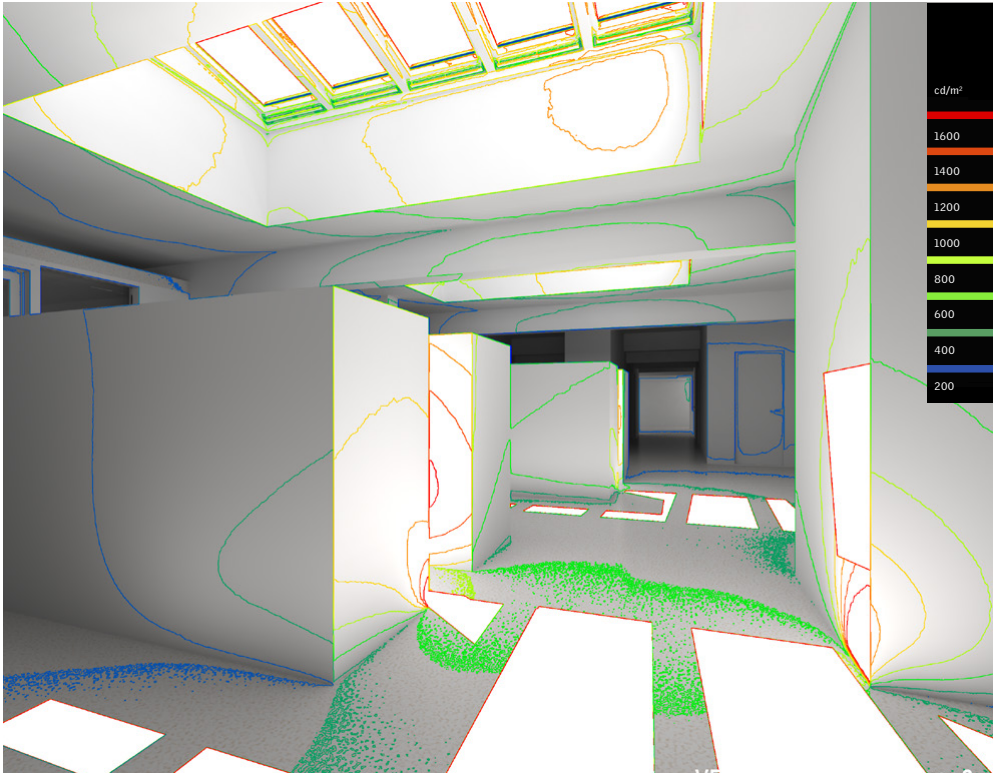
#### *Bringing nature inside – some users' impressions*

The reactions of the kindergarten teachers and of parents show that the architects made the right choices: "There's no doubt that the skylights have meant a lot to the institution. We think it's light and friendly and pleasant to be in," says the director of the kindergarten Helle Pia Sørensen.

Line Visby Hansen from the parents' association has a similar impression: "Before, it was as if there was a lid on the building. It was quite boring to look at and you couldn't see anything. But now, with the large windows and all the light coming in from the roof you can look in to something light." Line Visby Hansen feels that it is almost as though the interior and exterior areas have moved closer together because of the renovation: "It creates an organic feeling and doesn't seem like such a big change when you come in after being outside. In a way, the light helps bring nature into the building."



Luminance distribution in one of the central spaces under clear sky conditions. The rendering show the ingress of direct sunlight through the modular skylights in ISO contour (above) and false colour (below) views.



Plenty of character but not much daylight: the town hall before its renovation

Credits

Client:	Municipality of Assens, DK
Architects:	CASA Arkitekter, Næstved, DK
Engineering:	Rævdal ApS, Sønderød, DK
Location:	Indre Ringvej 2, Aarup DK

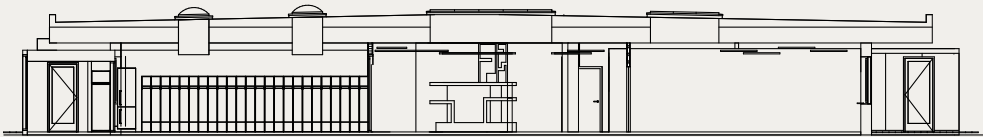
The former municipal administration building of Aarup, a small town of 5,000 inhabitants on the Danish island of Funen, was surprisingly modest and unrepresentative for a town hall. The single-storey building with a floor area of 1,260 square metres stands in the centre of the municipality yet on the edge of a greenway that extends from the town centre to the outskirts.

The tripartite building was divided into a central entrance area and two adjoining, virtually square pavilions on either side. The architects who designed the building in the sixties covered it with a projecting flat roof, almost as though they had wanted to exclude daylight from the rooms. Only a few sparse skylights allowed a modicum of daylight to penetrate inside. Structurally however, the roof construction was a static masterpiece, with concrete beams stretching from one side of the building to the other and spanning distances of up to 25 metres without any additional sup-

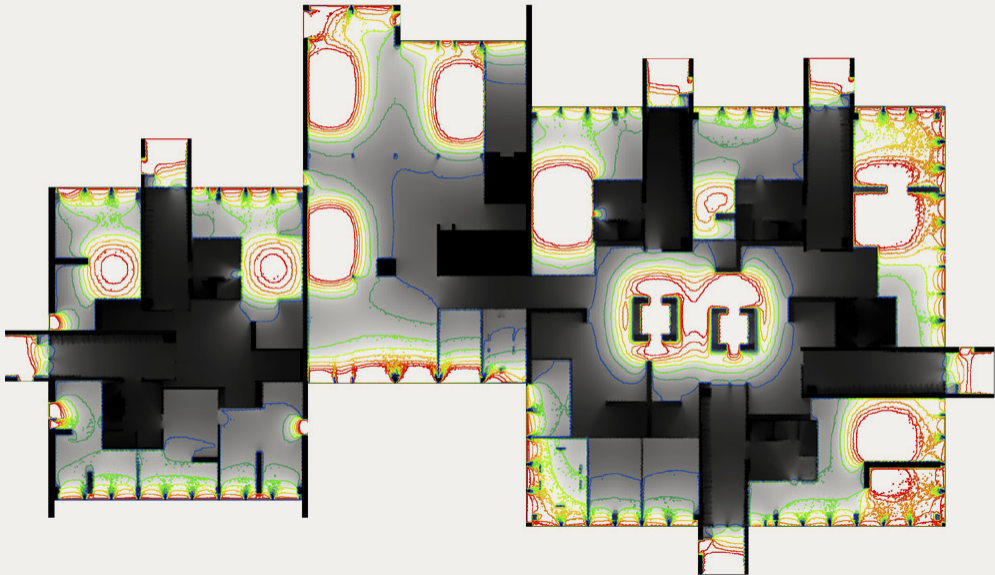
ports. Only in the entrance area was the roof construction supported by wooden trusses.

On 1 January 2011, the municipal administration packed its bags and moved south to Assens. After the Danish municipal reforms, the former town hall was no longer needed and could be remodelled to serve a new purpose. Most of the building's construction proved to be still usable, including the exterior walls, with their light-coloured brick sills, and the roof. With the exception of the middle part of the building where the leaking roof needed to be redone, the exterior of the building did not even require additional insulation.

Section through the building with "entrance tunnel"



Floor plan with daylight factor levels (ground floor). Contrary to the rendering on page 55, only diffuse daylight is taken into account here. The rendering shows that the modular skylights permit to deliver high amount of daylight in the central areas of the building where it would otherwise not be possible.











# 32 BLANCHE PARIS











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# A CORNUCOPIA FULL OF DAYLIGHT

The former warehouse and workshop building of the Galeries Lafayette in the Rue Blanche in Paris had many of the qualities that a modern office building requires. However the most important thing was missing: daylight. With a new atrium-type patio and a reflector consisting of 50,000 glass discs, the architect Franck Hammoutène succeeded in bringing this vitally important element into the offices.

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By Jakob Schoof  
Photography by Torben Eskerod

THE RUE BLANCHE in Paris' 9th arrondissement is lined with five-storey office and residential buildings, as well as a small theatre, their ground floors often being occupied by small shops and restaurants. The buildings are mostly built of stone and typically feature kerb roofs which are characteristic of traditional Parisian architecture.

A few buildings, however, stand out from their neighbours. One of them is no. 32 with its sturdy, four-storey steel-framed facade, filled in with large transparent glass panes. Suspended from the steel framework are translucent blinds made of acrylic rods that sparkle in the afternoon sunlight. Upon entering the spacious lobby, the visitor is drawn down a gently descending flight of steps towards another source of light: an elliptical patio in the heart of the building, visible all the way from the street.

Inside the spaces, there are few indications that 32 Blanche is, in fact, the conversion of an existing building. But its history goes back 100 years to the heyday of early Modernist industrial architecture. Built largely between 1910 and 1913, the huge 20,000 square metre structure originally served as workshops and warehouse for the nearby department store, Galeries Lafayette. With floor areas of some 70×70 metres each, it was well adapted to this purpose, but rather less so for later use as an office building.

## NEW WAYS TO DELIVER LIGHT:

### THE RENOVATION CONCEPT

This made it clear that the work of renovation should pursue two main objectives: bringing daylight into the depths of the building and restoring its former, structural clarity. In addition, Franck Hammoutène opened the numerous roof terraces for the users. With the conversion, office space for around 1,500 users was created. Today, it would be inconceivable for a completely new building of the same size to be given a construction permit at this location. The two adjacent residential buildings, 36 and 38 Rue Blanche, which had long ago been converted into offices by Galeries Lafayette, were also renovated, equipped with new roof windows, and subsequently returned to their original purpose as subsidised housing.

Franck Hammoutène compares his intervention in 32 Rue Blanche with a surgical operation whereby the existing steel skeleton was to be retained in its entirety. Hidden by the suspended ceilings, there are still the same lattice girders that have been there for 100 years. What's more, the round columns are made of plasterboard that encases the old steel supports and protects them against fire.

The architects decided to make a start at two places in order to bring daylight into the building again: at the facades and in the centre of the building. Thanks to large glass surfaces, the facades regained their original transparency. Next to these, narrow thermally insulated opening pan-

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"First of all, I wanted to insert something into this atrium that would accompany the light on its way and could take it even further into the utmost depths of the building. Secondly, it was to provide privacy for the office workers on both sides of the atrium. And thirdly, this object was intended to protect the interior of the fully-glazed building against excessive sunlight, similarly to what *louvres* or *brise-soleils* do."

Franck Hammoutène, architect







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"If I had to describe the project '32 Blanche' in one word, this word would be 'light'."

Carole Benzaken, artist

els in the few opaque areas of the facade serve to ventilate the office floors. The effect of opening the building in this way is remarkable; the urban density prevailing at this location in Paris becomes visible, with neighbours almost within touching distance of 32 Blanche. On each side of the building, there is a view of another interior courtyard, displaying zinc roofs, stone house facades, ivy-covered separating walls and an adjacent fire station. How much the original clients wanted to bring daylight into the basement floor of 32 Blanche 100 years ago also becomes visible. The rear facades of the building are surrounded by deep light wells, which are enclosed by retaining walls and, in some cases, go down as far as three storeys into the ground.

Today, as in the past, the outer steel load-bearing structure lends the greater part of the facades their character. The heavy double-T girders still carry the load of the building. In the facade facing the street, filigree sunshades made of acrylic rods are suspended from the cross-beams to provide privacy for the offices and protect them against the low sun in the west. However, they are much more than just a technical tool – and it is exactly their aesthetic added value that makes them symptomatic of the entire renovation project. In the afternoon sunlight, the rods produce a multi-faceted interplay of refraction and reflection inside the building as well as in the narrow, shady street at its feet.

#### A KALEIDOSCOPE OF GLASS DROPLETS: THE MANTILLA

A similar, but much more impressive, spectacle of light and matter is offered to the observer inside the oval atrium

that Franck Hammoutène arranged to be cut 30 metres deep into the former warehouse. But he did not content himself with merely creating a hollow space for daylight here: "First of all, I wanted to insert something into this atrium that would accompany the light on its way and could take it even further into the utmost depths of the building. Secondly, it was to provide privacy for the office workers on both sides of the atrium. And thirdly, this object was intended to protect the interior of the fully-glazed building against excessive sunlight, similarly to what *lou-vres* or *brise-soleils* do."

The 'object' that the architect eventually developed in collaboration with the structural engineer, Jean-Marc Weill, is a filigree meshed cable structure in which over 50,000 glass discs are hung, attached to stainless-steel wires. The round discs have diameters of 10 and 16 centimetres and an irregular light-refracting surface structure. Depending on the incidence of light and the imagination of the observer, they are reminiscent of a frozen waterfall, a cornucopia of daylight or a wafer-thin glass veil. The latter image is also what inspired Franck Hammoutène to come up with a name for it; the Spanish *mantilla* or, in Berber, the *serdal*, is a delicate lace veil with which women used to cover their hair, neck and shoulders in bygone centuries.

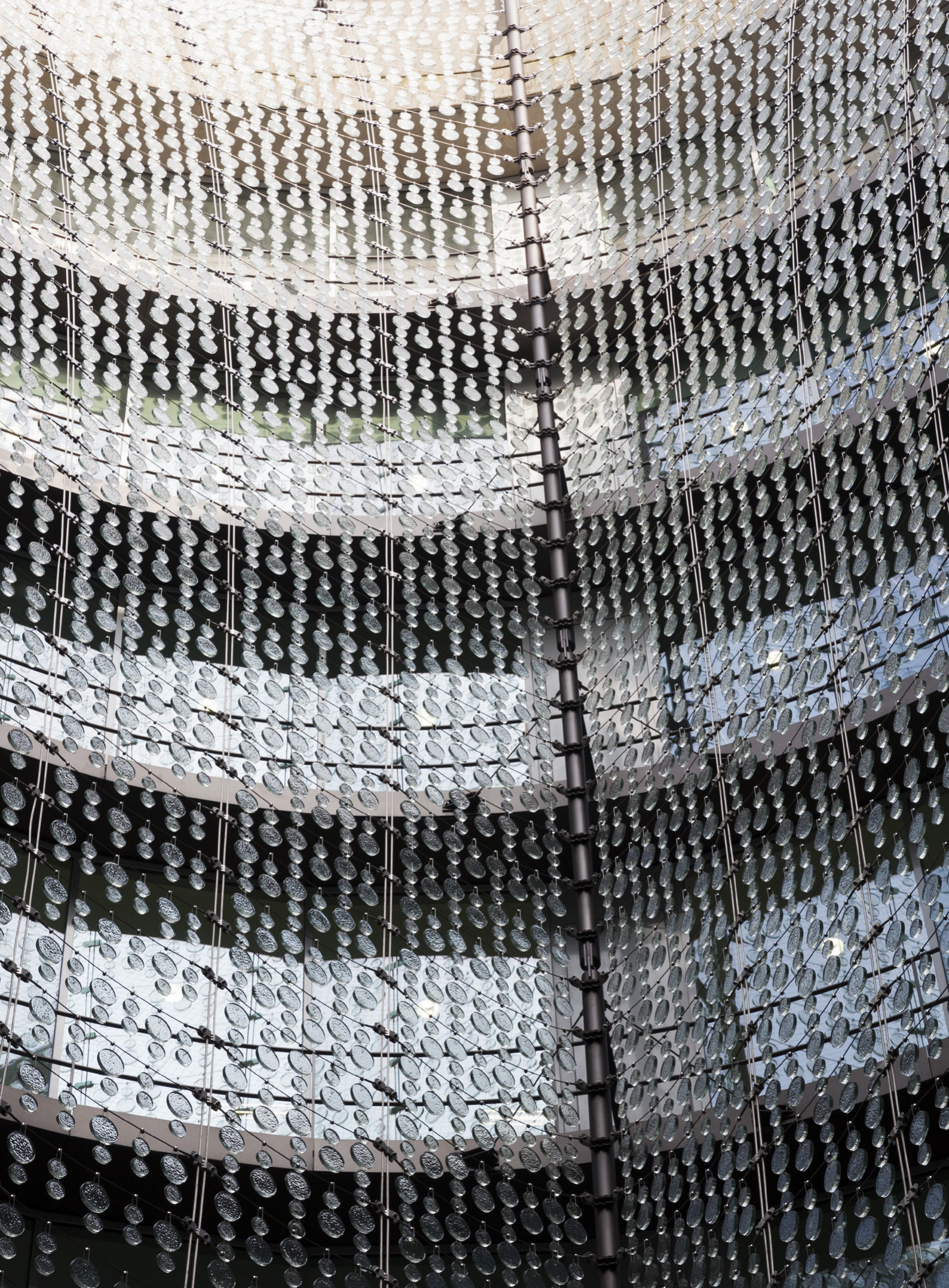
In the Mantilla of 32 Blanche, the distribution of the glass discs is oriented to the course of the sun. At the top on the north side – i.e. where direct sunlight is most often to be expected – 50% of its surface is made of glass. At the bottom on the south side, the proportion of glass decreases to below 20%.

At its upper end, the glass veil continues in a metal cone that arches over the flat roof like a gigantic conch. Whereas the Mantilla is intended to filter people's view through the building, the metal conch serves to conceal things – for example, the heavy steel fastening anchors from which the 30 vertical cables of the Mantilla are suspended, as well as the unavoidable technical installations that have to be accommodated on the roof of any office building.

At the bottom of the atrium, there is the third section of the light and glass installation: a round, stainless steel disc with a diameter of 14.6 metres slightly tilted towards the south, on the surface of which there are another almost 8,000 lens-shaped glass discs. They reflect part of those beams of light that have found their way all down to the bottom so that light thus transported enters the office levels as well.

A PROJECT WITH MANY BENEFICIARIES Economists talk of a 'win-win situation' when all parties to a transaction profit from it. This situation also seems to have occurred in the case of 32 Blanche: the investor receives an office building in the centre of Paris that will (hopefully) remain profitable for years. The city is enriched by an exemplary illustration of how the high density of buildings can be combined with high quality architecture and high quality of life. The neighbours, rather than looking at dirty-white brick walls, now face transparent glass facades and planted roof terraces. The architects were accorded recognition for the virtuosity with which they breathed new life into the old structure. And the environment is spared many tons of building waste, greenhouse-gas emissions from additional commuter traffic, and other negative effects that would have occurred if an attempt had been made to create the same office space in new buildings here and elsewhere.







Great potential,  
slumbering in the dark:  
32 Blanche before  
renovation

In 1912, and to much public acclaim among the Parisian bourgeoisie, the Galleries Lafayette opened their new, 18,000 m<sup>2</sup> department store at Boulevard Haussmann to the public. To this day, the Art Nouveau building still occupies a complete block in one of the best shopping locations in Paris, right opposite the Opéra Garnier.

Less than one kilometre to the north, but largely ignored by the public, an even larger building for the same client was erected at almost the same time. Most of this building, with its 20,000 square metres of space used as workshop, warehouse and offices, was situated in an inner courtyard that it almost filled completely. Having seven upper floors and four basement floors, the building towered over the adjacent residential buildings and still does so today after its renovation by Franck Hammoutène.

Its architecture is also distinctly different from the neighbourhood's stone buildings: a skeleton-frame structure based on a 5x5 metre grid, with steel supports and filigree steel lattice girders holding up the ceilings. Only the side of the building that faces onto the street fits in with its neighbours with a modest four-storey front. Behind this, its height tapers upwards in the direction of the block's interior.

Franck Hammoutène is full of praise for the building, the renovation of which he was entrusted with by the Carlyle Group as investor in 2007. "At this location in Paris, we have a floor space, a density, a height, a view and an urban-planning significance that, today, would be impossible to achieve with a new building in the capital. On top of this, there is a second advantage: the intelligence of the building, namely the systematic nature and



The interior courtyard of 32 Blanche before renovation. The steel skeleton of the storage and workshop building had been filled in with brickwork over the years. Only small window openings allowed daylight into the interior.



After refurbishment, the steel skeleton is clearly visible again and now lends character to the facade. Large glass windows bring daylight deep into the offices.

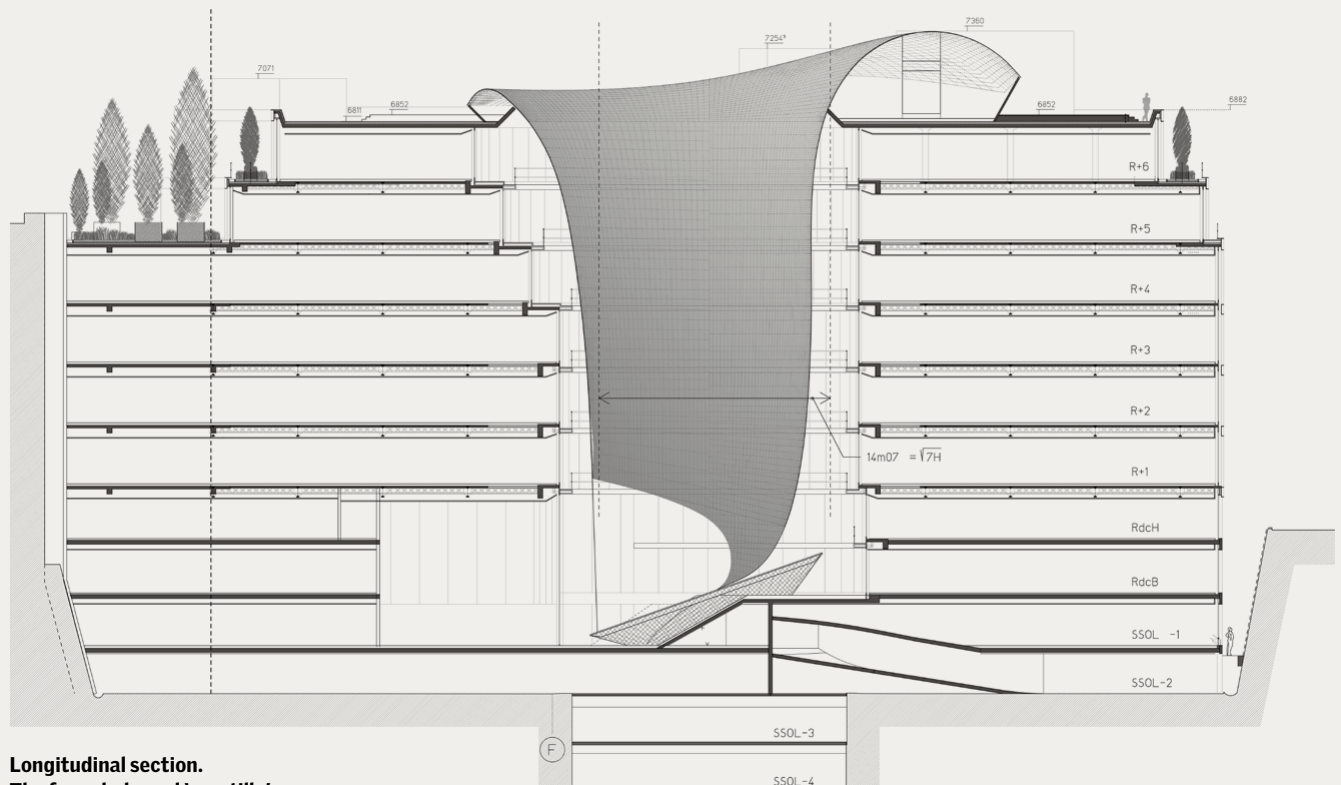


rationality of the construction. This structural simplicity also results in a high degree of adaptability.”

As far as its use as an office building was concerned, however, 32 Blanche had a serious disadvantage: the structure was so compact and had such a small facade that enough daylight for working only reached a small part of the interior spaces. The situation deteriorated even further in the 1960s when the once transparent facade facing onto the inner courtyard was walled up and fitted with small window openings. The character of the old industrial building was retained to some extent on the facade facing the street, where horizontal strip windows and closed balustrade elements alternated with each other.

#### Credits

Client:	Orosdi – The Carlyle Group, Paris, F
Architects:	Atelier Franck Hammoutène, Paris, F
Construction of the Mantilla:	Atelier Banneel, Paris, F
Location:	32–38, Rue Blanche, Paris, F



**Longitudinal section.**  
The funnel-shaped 'mantilla' continues on the roof terrace in the form of a metal shell accommodating the technical equipment rooms.

## DAYLIGHT WAS THE PREREQUISITE FOR THIS PROJECT

Interview with  
Franck Hammoutène

"Daylight was the prerequisite for the implementation of the project. [...] Our task was [...] to open the building to the light and, at the same time, create views that future users would find agreeable."

Franck Hammoutène

*Mr Hammoutène, what were the most important qualities of 32 Blanche before its renovation?*

The building had three essential strengths. Firstly, an urban strength – 32 Blanche is completely interwoven with its surroundings, which are among the most architecturally diverse in Paris and possess an almost painterly quality. Secondly, a constructional strength that derives from its homogeneity. Basically, the building is very simply constructed but in a very pragmatic and systematic way. And thirdly, a spatial quality; due to its large volume and its depth, the building offers enormous spaces that can be used.

*What considerations led you and the Carlyle Group, to retain the existing load-bearing structure almost entirely instead of erecting a new building?*

The starting point was a very simple consideration. The volume and the floor space of the existing building were much larger than would be permissible for a new building at this location today. In addition, our investigations showed that it would not have been worthwhile to tear down, replace or alter the existing load-bearing structure. On the contrary, retaining it had great advantages, not only in terms of construction time and costs but also with regard to the architectural quality. From then on, our client virtually had no choice but to agree.

*What role did daylight play in the refurbishment, and how great a challenge was it to bring more light into the interior?*

Daylight was the prerequisite for the implementation of the project. After all, the building was in the middle of a densely built block of buildings and was itself so compact (with floor spaces on each different storey of around 70×70 metres) that large parts of the interior received almost no light at all. Our task was therefore to open the building to the light and, at the

same time, create views that future users would find agreeable.

*What design strategies and tools did you use to develop the daylighting concept?*

That depends on what aspect of daylight we are dealing with. We calculate quantitative variables such as the daylight factor, for which specific minimum levels are prescribed by law. In this way, all our design decisions are checked numerically as we go along.

Achieving a good quality of light, on the other hand, is more a question of experience. In the case of 32 Blanche in particular, photorealistic visualisations were extremely helpful. They don't show the later quality of the daylight in the interior spaces exactly, but they do provide an impression of how the light is distributed and what lines of sight there will be between the different spaces. For example, there are many places where it is possible for a person standing on one side of the building to look through the patio into the opposite offices and then further through the rear facade to see the panorama of Paris. We used drawings to verify these viewing relationships in the context of the design.

*How did the idea of the Mantilla originate?*

The building could only continue to exist if we hollowed it out and placed this inner courtyard in the form of a patio or atrium inside it. Its geometry is such that it captures a maximum amount of daylight. In contrast to the building, the atrium is precisely aligned in a south-north direction, for example, and its south facade is inclined at a slightly greater angle than the north one.

However, we also needed a reflector that would guide daylight right down into the atrium. After some consideration, we realised that the most efficient and least expensive way of doing this would be to detach the geometry of the patio from the geometry of this reflector. As a result, the

reflector became a surface that we wanted to make out of as many small individual parts as possible. And we wanted to keep the number of different parts to a minimum – like the alphabet, where a very limited number of letters can be used to express any conceivable notion.

*In many European metropolises, there is currently a discussion about density and how it can be balanced with the inhabitants' quality of life. To what extent could your project contribute new viewpoints to this discussion?*

32 Blanche was a purely private construction project, but the city of Paris was very interested in it and organised public visits of the building once it was finished. The city administration evidently saw it as a reference project that, in an interesting way, illustrated how density can be reconciled with quality of life, urbanism and neighbourly coexistence.

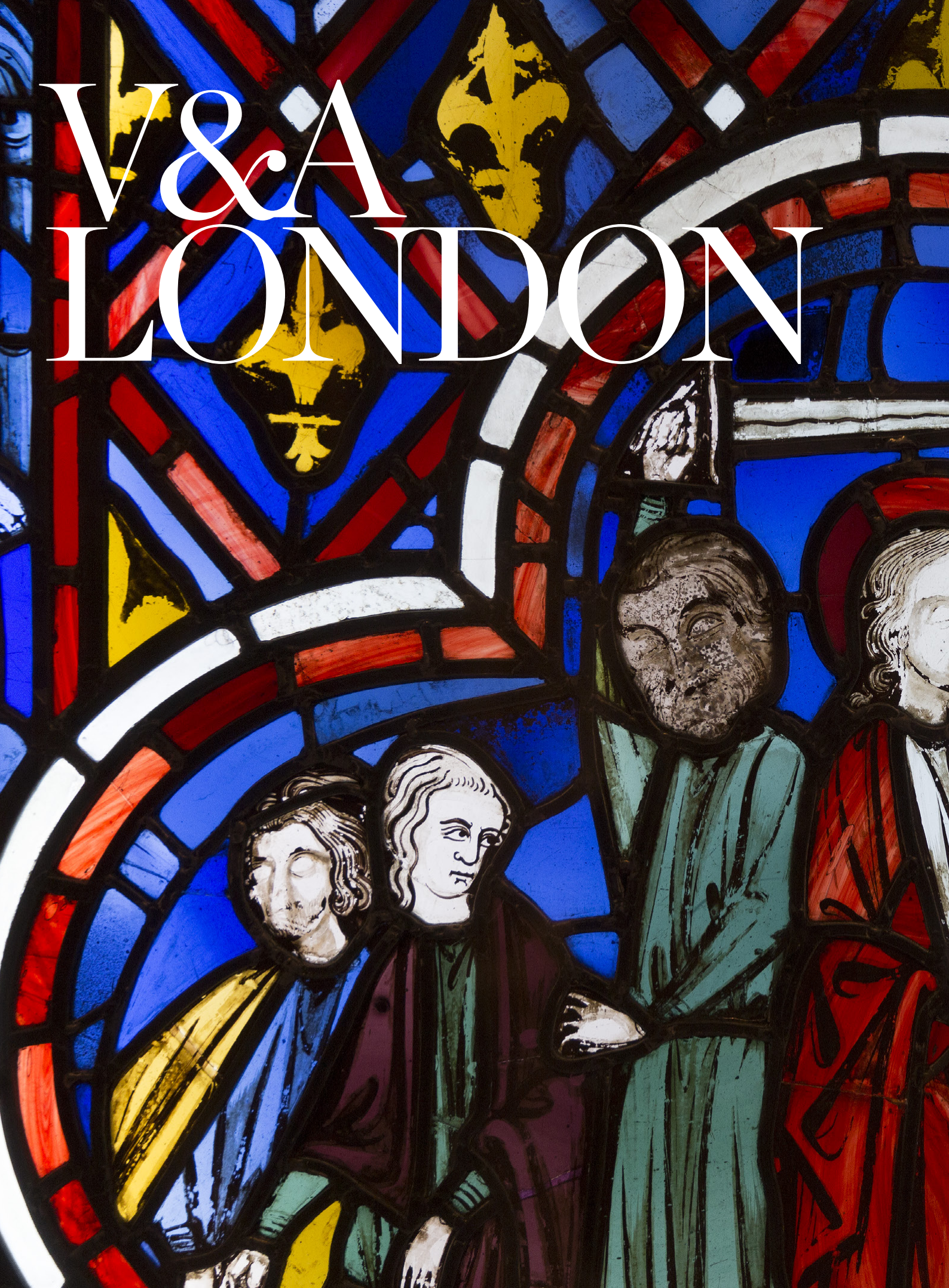
Indeed, almost all our neighbours have attested to the fact that they themselves are profiting from the renovation, even though 32 Blanche continues to be spatially very close to them. But they are relieved that the renovated building has not turned out to be an unprepossessing intruder but is an agreeable neighbour with all its openness to the street and the patio-type courtyard. The building has many qualities that tend to be atypical of a building financed by investors, but they do have something to offer everyone – the staff who work in it, the neighbours, the passers-by in the street, and, finally, the investor as well.







# V&A LONDON













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# A JOURNEY THROUGH TIME AND LIGHT

With the creation of its Medieval & Renaissance Galleries, the Victoria and Albert Museum in London highlights the important role that daylight can play in 21st century museums. By opening up spaces that had long been kept in the dark, the architects McInnes Usher McKnight Architects (MUMA) have impressively orchestrated a suite of galleries that invites visitors to a journey through 1,300 years of European art, design and culture.

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By Jakob Schoof  
Photography by Torben Eskerod

FINDING COMMON GROUND between conservation and accessibility was one of the main tasks that the Victoria and Albert Museum (V&A) and architects MUMA faced when they created the new Medieval & Renaissance Galleries. In terms of lighting, their aim was to allow as much daylight as possible to enter, but without harmful UV radiation and, wherever possible, without direct sunlight on the exhibits. Apart from its aesthetic value and benefits for energy efficiency, daylight also had an almost didactic meaning in the project: "It was particularly important to dispel the still popular notion of the medieval 'dark ages' by creating spaces that feel light," says project chief curator, Peta Motture. "This is no mean feat, given the constraints of combining materials requiring different light levels, notably sensitive objects such as textiles and drawings." The challenges were thus considerable but they have been resolved in a way that may well make the newly created galleries a model for future daylight museums throughout the world.

The Medieval & Renaissance Galleries are located in the south wing of the V&A, which was completed in 1909 to designs by Aston Webb. They comprise three series of spaces located on three different levels that were, before their recent conversion, partly used for non-exhibition purposes. Two of them are located in the lower ground and on the first floor next to the south facade of the museum; a third is adjacent at ground level (Gallery 50). In

between, there used to be an open lightwell, which had, over the years, been built into at the lower levels for behind-the-scenes use by the Museum.

## ESTABLISHING CONNECTIONS – THE SPATIAL CONCEPT

The architects identified the lack of spatial interconnection as a significant challenge of the project: how would it be possible to join together the spaces distributed over three levels and separated from each other by an open lightwell? MUMA's solution was to remove some connecting stairs and delivery ramps, excavate the lightwell down to basement level and put a glass roof over it. This strategy made the former outdoor area usable as an additional space for exhibitions, as well as for a new stair and lift providing access to all six levels of the museum.

The newly-created gallery, which curves in a U-shape around the apse of Gallery 50, now joins what used to be separate spaces. The character of the external walls has been retained, and this tranquil space is an ideal place to relax and contemplate the works of art.

## LIGHT STRUCTURES SPACE – AN ORIENTATION SYSTEM WITHOUT SIGNPOSTS

In the new sequence of spaces made up of ten galleries altogether, several ordering systems are superimposed on each other, which largely manage without any classical aids such as partition walls and signposts.

At the heart of the exhibition organisation are the objects themselves. MUMA placed particularly striking or important exhibits at the end of lines of sight and in other strategically significant places in order to guide the visitors. To divide up the spaces, including the largest ones, they almost exclusively the exhibits, together with their pedestals and the frameless glass showcases in which they are displayed.

While each room has its own narrative, there is also an overlapping chronology that structures the exhibition. It covers 300–1500 on the lower level, and 1400–1600 above, complemented by often larger-scale objects dating from 1350–1600 in Gallery 50.

In terms of atmosphere, the curatorial brief sought a change of pace and rhythm throughout the galleries. Aston Webb's architecture provided a sequence of spaces of changing scale and MUMA reinforced this rhythm with the use of light and colour. Along the south facade, light-filled, elongated spaces alternate with darker, quadratic ones on both the exhibition levels. In Gallery 50, in contrast, the lighting levels become more and more subdued from the entrance in the west to the apse in the east. This dramaturgy of light corresponds to the composition of the exhibition. The first half of Gallery 50 mainly accommodates sculptures and other light-insensitive works of art. In the second, there are religious art objects, some of which are sensitive to light to a degree.















#### CONGENIAL COLLABORATION – MUMA AND ARUP

In the architects' competition submission, daylight already played a key role. The Museum's Board of Trustees therefore commissioned two specialists to do the lighting design; DHA Design was responsible for the artificial lighting and Arup for the daylighting design. "This was an extremely exciting and, at times, challenging brief," said Steve Walker, Associate Director at Arup. "The luminous qualities of natural light cannot be replicated artificially and, in this project, it was a fundamental goal to illuminate these new galleries as far as possible with natural light – for the way it can beautifully illuminate materials and objects, its ability to create atmosphere and, of course, because it is an energy-free source of light."

At the beginning of the daylighting design stage, the Arup engineers created a detailed 3D computer model of the exhibition spaces and the surrounding buildings. This formed the basis for further calculations and modifications. Most design decisions were checked mathematically and visually with reference to this model. It was only in the final design phases that, for some of the spaces, the client had 1:1 mock-ups built in order to verify the interaction of daylight, materials and wall colours.

#### STEP-BY-STEP OPTIMISATION – GALLERIES ON THE SOUTH FACADE

In terms of daylighting, the galleries on the south facade posed the greatest challenges in that they receive direct, sometimes very strong sunlight and are only naturally lit from one side. Without shading, the rooms can be intensely illuminated during periods of strong sunshine and yet, when the sky is cloudy, they might only receive lighting levels in the order of 10 lux. "We had to bring these extreme fluctuations of brightness down to an acceptable level without completely suppressing the dynamics of the daylight," explained Francesco Anselmo, who was responsible at Arup for daylight simulations.

In their calculations, the engineers proceeded one room at a time and, in doing so, had to take two important aspects

into account: the daylight atmosphere desired by the architects, and the light sensitivity of the individual exhibits. For the most sensitive exhibition pieces, a limit of 200,000 lux hours per year was imposed, which corresponds to an illumination of 50 lux over a period of 10 hours per day.

The engineers now had to balance this requirement with the amount of daylight in each space. First they calculated the cumulative light exposure (in lux hours) in the course of a year for each window using the weather data available for London. From this, they derived the annual light exposure for every given point both horizontally and on the walls in each gallery space. This calculation was repeated

several times, with varying light transmission values for the windows, until even the most sensitive exhibits in the room would receive only the permitted amount of daylight.

The maximum permissible light transmission thus determined for each window now had to be achieved through a suitable combination of window, light diffusers, UV filters and shading elements. At the same time, the great variability of the daylight had to be taken into account, according to Francesco Anselmo, because, "we wanted to darken the spaces that the architects' concept required to be dark and we wanted to make those spaces that were supposed to be bright as light-filled

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#### Daylight calculations and simulations

##### 1. 3D Model

##### 2. Weather data analysis (luminous climate for london)

##### 3. Lighting Survey

##### 4. Galleries along the south facade

- a. Lighting exposure profiles on external windows
- b. Cumulative lighting exposures on external windows
- c. Sun views study for external windows
- d. Daylight factor analysis
- e. Lighting exposure plots with highlighted sensitive objects
- f. Optimisation of control strategy to maximise daylighting
  - I. Comparative study of 5 options:
    1. Static diffusing fabric blinds (no control)
    2. Seasonally adjusted blinds (manual control)
    3. Automatic open/close roller blinds (9/18)
    4. Automatic venetian blinds
    5. Fixed interstitial louvres ("egg-crate", 1 to 1 ratio)
  - II. Lighting profiles on the most sensitive object
  - III. Cumulative lighting exposure on the most sensitive object
- g. Selection of display case glazing to avoid veiling reflections
- h. Comparative logarithmic chart for brightness evaluation
- i. Characterisation of brightness for each gallery room (both visual and quantitative)
- j. Visual simulation of translucent stone appearance in sunny and cloudy sky conditions

##### 5. Gallery 50

- a. Sun views study for external windows
- b. Daylight factor analysis
- c. Lighting exposure plots with highlighted sensitive objects
- d. Seasonal illumination matrix
- e. Sun path diagram and selection of glazing to limit solar penetration

##### 6. Daylit Gallery

- a. Characterisation of brightness
- b. Daylight factor analysis
- c. Sun hours analysis



THE PAUL AND JILL RUDDOCK GALLERY









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"This was an extremely exciting and, at times, challenging brief. The luminous qualities of natural light cannot be replicated artificially and, in this project, it was a fundamental goal to illuminate these new galleries as far as possible with natural light – for the way it can beautifully illuminate materials and objects, its ability to create atmosphere and, of course, because it is an energy-free source of light."

Steve Walker, Associate Director, Arup

as possible – irrespective of the weather conditions outside."

Altogether, Arup simulated five types of shading devices in their computer model. It soon became apparent that only an automatically-controlled system that reacted to natural variations in daylight would deliver the best possible results. Above all, this system – commercially available venetian blinds with rotating louvres that are automatically adjusted to let in the right amount of light – is able to exclude any direct sunlight from the south, which would otherwise be responsible for most of the fluctuations in brightness.

On the room side of the shading elements, each window was equipped with a UV filter membrane and an additional light-diffusing layer. The latter consists of open-weave fabric or – where called for by the scenography of the respective spaces – a material with an appropriately atmospheric impact. In one of the galleries, for example, ceiling-high glass panels with a layer of white, translucent onyx laminated onto them cover the windows.

Nevertheless, it was not always pos-

sible to create completely satisfactory daylight conditions in the galleries in this way. In some cases, the calculations also showed that relocating individual exhibits (to areas further away from the windows) would open up the possibility of considerably increasing the overall level of daylight in the space.

#### THE ROOF AS LIGHT FILTER – GALLERY 50

Another challenge was presented to the daylight planners by Gallery 50, which received light from above. Before redevelopment, the gallery's roof, which was made of wire-reinforced cast glass, had not been fitted with any means of protection against the sun. A daylight factor of 17.5% and more frequent, direct ingress of sunlight were the consequences. The aim was to reduce these values to a level compatible with the exhibits and to minimise glare, which would be inappropriate in a museum. A further objective of the architects' concept was to clearly mark out specific zones. The west section of the gallery – the Renaissance Courtyard and Garden – was to be flooded with daylight, whereas the east part – entitled Inside the Church – was to be given a more controlled lighting atmosphere and accommodate some exhibits that required lower light levels, including a fresco and several polychromed altarpieces.

This resulted in two strategies of light control and diffusion. In the west part, wide, rigid light-directing louvres were mounted under the glass roof. They keep most of the direct light out of the space, so that even the most exposed part of the north wall receives no more than 200 hours of sunlight per year. In addition, they complement the barrel vault, the shape of which was formerly implied only by the arched steel beams of the roof. Despite the new shading elements however, this gallery still counts among the brightest spaces in the entire museum.

In the east part of the gallery, in contrast, the lower three quarters of the vault are now covered by plaster-board; only a skylight along the roof ridge lets in light. In terms of the average daylight factor, this space is less than 1/15 as bright as

the section in the west; direct light does not reach the more light-sensitive exhibits. Light-diffusing film that excludes UV radiation, and whose light transmission ratio varies from pane to pane, has been applied to all the panes of glass in the roof. Only from the open west end does direct light occasionally enter the 'church' space, with spots of light wandering over the floor from time to time, but never coming near the more sensitive artefacts.

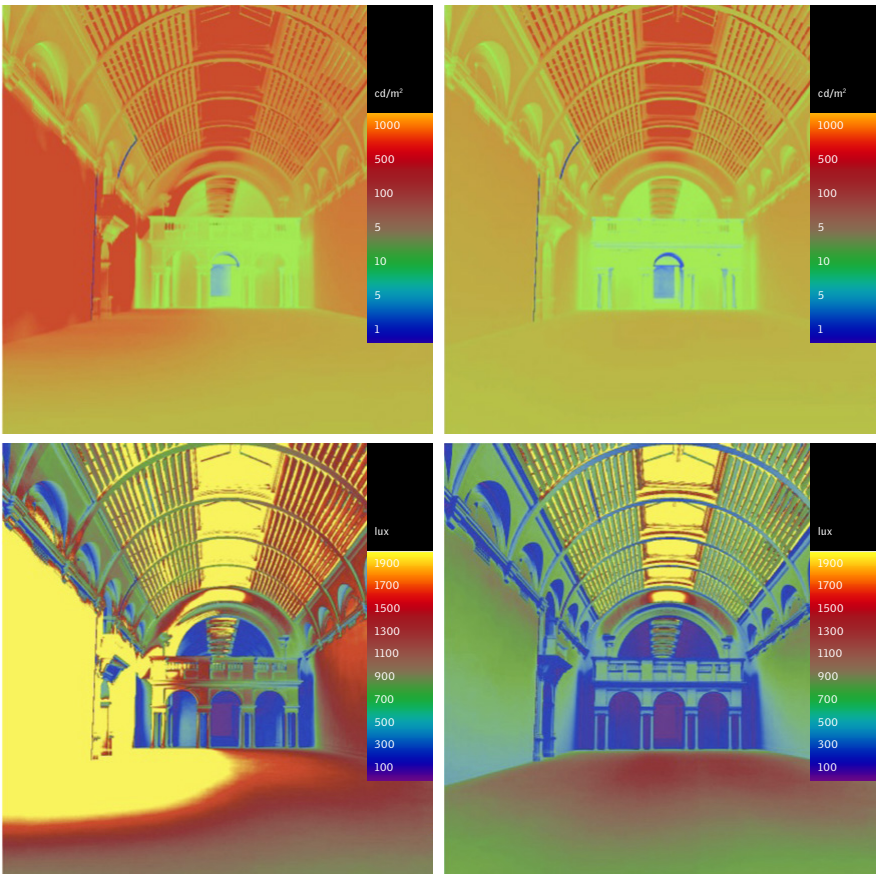
#### GUIDED VIEWS – THE DAYLIT GALLERY

In the former external lightwell, converted into a daylit gallery, the key to controlling daylight is the inclined glass roof with its approximately 50 centimetre high structural glass beams. The glazing for the roof was chosen to ensure that it transmits as much visible light as possible but no ultraviolet radiation.

The glass beams (some of which are more than nine metres long) are arranged to allow vertical views of the sky above but are opaque to oblique views towards neighbouring buildings. Still, their translucency relieves them of any appearance of heaviness. At one point in the design process, due to a need to consider cost savings, there was a discussion about whether to use aluminium beams instead. To help explain MUMA's preference for an entirely translucent structure, the Arup engineers simulated the lighting effect of each variant by means of luminance renderings. The simulation results clarified that whereas the aluminium beams cast stark shadows on the brick walls of the apse in sunlight, the contrast of brightness in the case of the glass beams is substantially more gentle – and more pleasing to the observer.

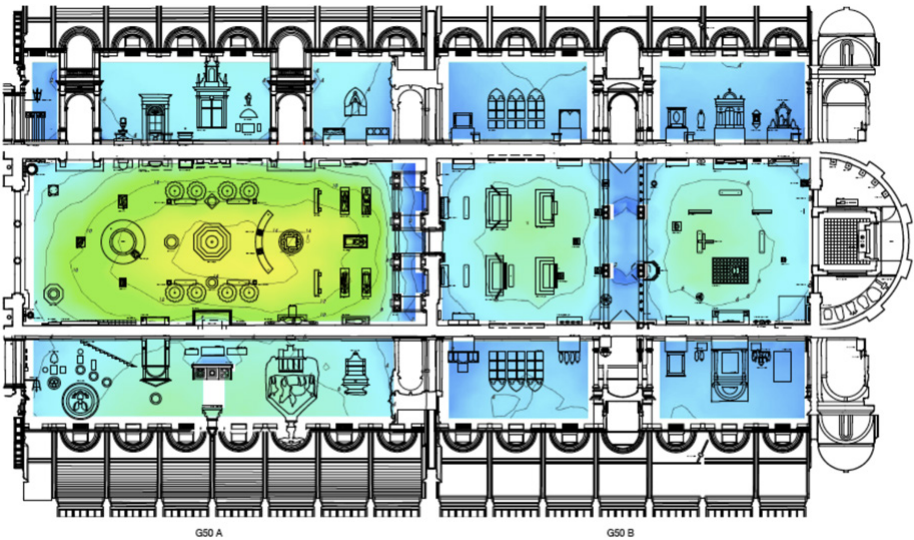


Luminance distribution (top) and illuminance on surfaces (bottom) for Gallery 50. The results of simulation for sunny sky (left) and cloudy sky (right) are shown.



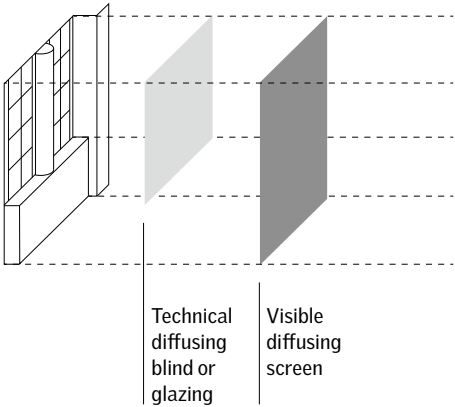
Daylight factors for Gallery 50. The differences in brightness between the west and east parts of the gallery are evident. They were reinforced yet again in a later planning phase.

DF (%)

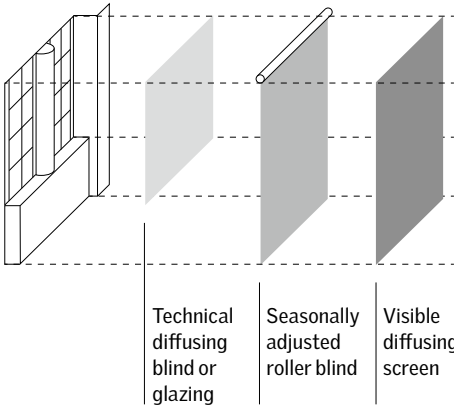


In their computer model, the engineers from Arup simulated five different methods of providing shade against the sun. A combination of adjustable blinds, UV filter membranes and fabric light-diffusion screens (centre, right) met the requirements most precisely.

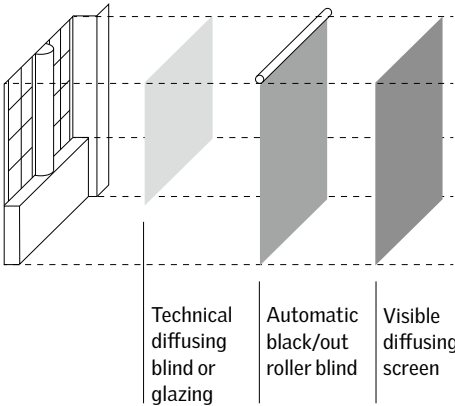
Option 1:  
Static Diffusing  
Fabric Blinds



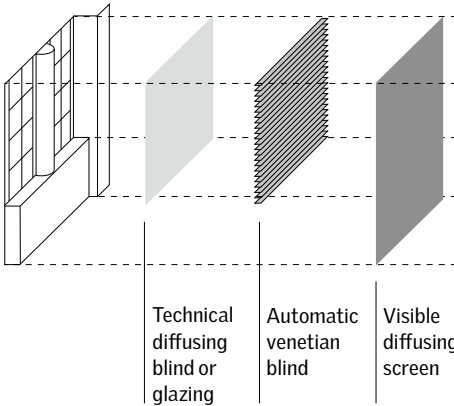
Option 2:  
Seasonally  
Adjusted Blinds,  
Manual Control



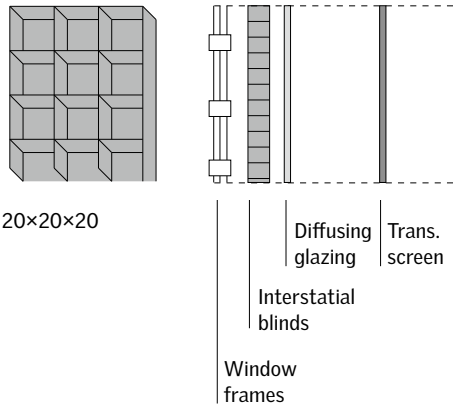
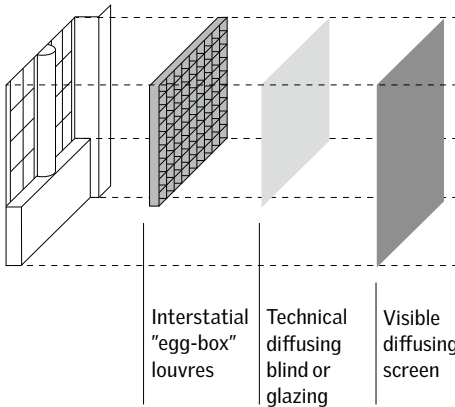
Option 3:  
Automatic  
Open/Close Roller  
Blinds (9-18)



Option 4:  
Automatic  
Venetian  
Blinds

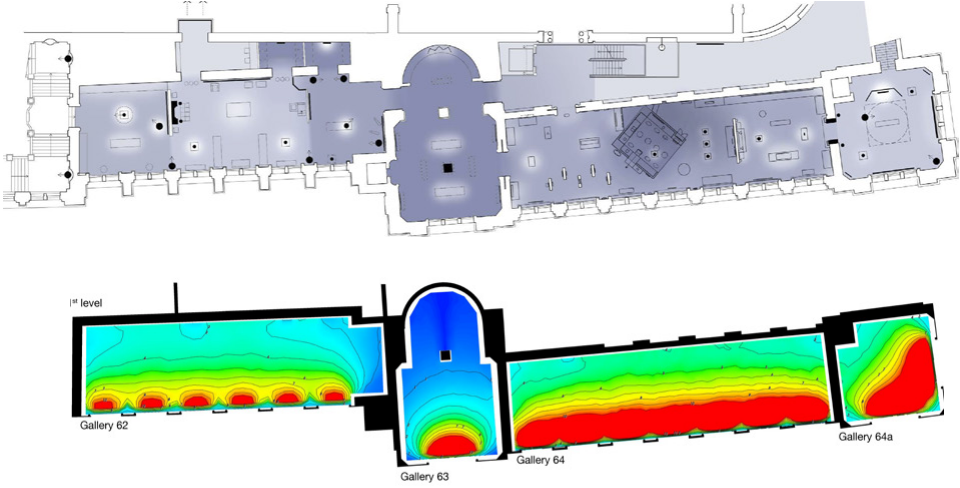


Option 5:  
Fixed  
Interstitial  
Louvers  
(1 to 1 Ratio)

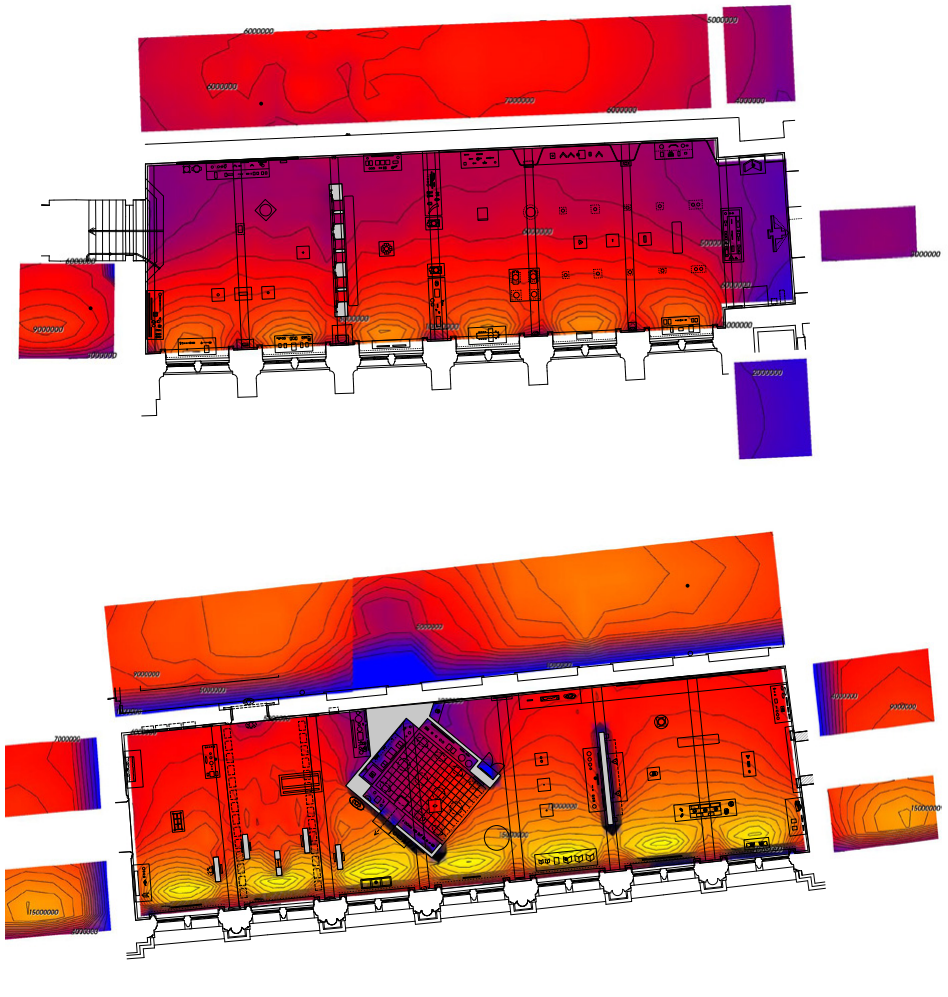




Perceived brightness (top) and daylight factors (bottom) in the rooms on the south facade. The rhythm of brighter, elongated and darker square rooms is clearly visible.



Annual cumulative light exposure in lux-hours in two galleries on the lower ground floor and on the upper ground floor. These diagrams were used as decision-making aids for placement of the exhibits.

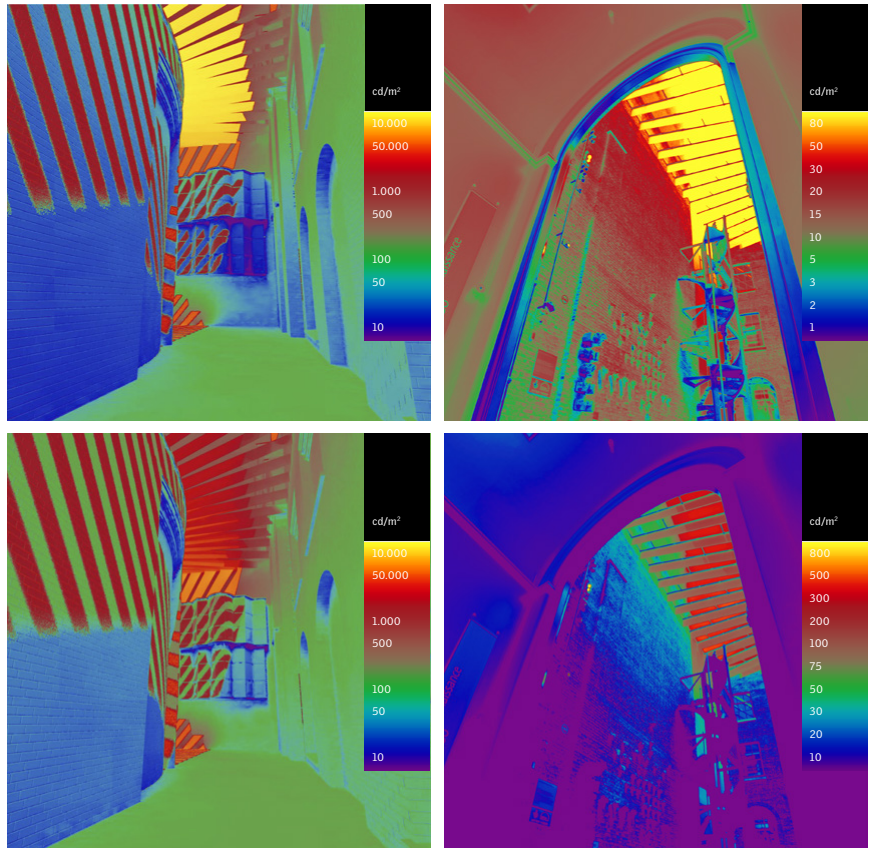








Luminance distribution in the roofed-over lightwell. Here, two designs were compared with each other. The roof beams made of frosted glass (top) that were used in the end cause considerably smaller contrasts between light and dark on the walls and exhibits than the alternative solution with aluminium beams (bottom).



Lots of light and  
lots of shadow:  
the galleries before  
the conversion

**Credits:**

Client/Developer:	The Board of the Trustees of the V&A, London, UK
Architects and Exhibition Design:	MUMA, London, UK
Daylighting Consultant and Environmental Engineer:	Arup, London, UK
Location:	Cromwell Road, London, UK

The Victoria and Albert Museum – then still known as South Kensington Museum – was founded soon after the London World Exhibition in 1851 as a publicly accessible treasure house of objects chosen to inspire designers and manufacturers. Erected between 1857 and 1909, the Museum building in the London district of South Kensington covers an area of around five hectares; with 4.5 million exhibits, it is still regarded as the world's greatest museum of art and design.

The final part of the museum, completed in 1909, is the south wing. Designed by Aston Webb, it features a 220-metre long street facade and a huge entrance rotunda, and is now home to the new Medieval & Renaissance Galleries. Their completion was a significant step in the V&A's ongoing Future Plan to renovate their premises in order to meet the needs of a modern museum and its diverse audiences.

Aston Webb's architectural design followed the tradition of the large museums of the 19th century: high, light-filled galleries in the neo-renaissance style, often with glass roofs and large windows. Although artificial light was already commonplace in the museums of his time (in 1858, the V&A even introduced the first late-night openings under gas light), it was not inexpensive; daylight in the museums was therefore considered to be essential.

Not much of this spaciousness remained, however, when the London-based firm MUMA was given the job of designing the Medieval & Renaissance Galleries in 2003.

The eastern section of the lower ground floor had been partitioned, with a mezzanine level inserted to accommodate offices, and the windows in the areas used as gallery were blacked out. Similarly, the galleries on the raised ground floor were not fully devoted to displays, although originally designed to be so.

Only Gallery 50 had retained its original size. A vast daylit hall, covered with glass roofs, it is separated into two areas by a rood-loft from the Netherlands, and terminates in a semi-circular apse in the east, which houses a Renaissance chapel. In these spaces, however, there was an excessive amount of uncontrolled daylight; without protection against the sun under the glass roof, the gallery was anything but ideal for the contemplation of art and completely unsuitable for the presentation of light-sensitive artefacts.







## EXPERIENCING THE PAST IN A NEW LIGHT

Interview with Peta Motture  
and Stuart McKnight

*Peta Motture, what were the intentions of the V&A eleven years ago when you set about redesigning your Medieval and Renaissance Galleries?*

PM: The aim was to bring together the Museum's outstanding European collections from the years 300 to 1600 and to make them accessible to the widest possible audience. At the same time, we wanted to remain true to the character of the Grade I listed building. The objects were to take pride of place, and we wanted to create a variety of pace and mood in the galleries and displays, and for visitors to be able to have a sense of discovery. This ambition is reflected in both the exhibition and the lighting design. Objects are placed so as to allow as much daylight to enter the galleries as possible, and to use the lighting to complement the narrative of the displays where appropriate. It was especially important for us that the lower level galleries, which house collections from the earlier periods, were as light as possible, as we were determined to overcome the still popular misconception revealed in our audience research of the 'dark' middle ages, which – in contrast to the Renaissance – were not associated with art.

The effect of the daylight changes the way in which visitors can relate to the objects on display. We want them to encounter the works directly so that they might resonate in their memory, and we have therefore also shown as many objects as possible on open display.

*Stuart McKnight, how would you characterise the qualities of the Aston Webb galleries as they were originally designed?*

SM: They were bright sidelit galleries with a rhythm of spatial sequence that had been designed in consideration of proportion and scale. Unfortunately the east wing was isolated for many visitors, which was a fundamental flaw in the original architecture.

Still, these galleries were very much different from what is commonly found in museum architecture today, where there can be a tendency to create generic 'black box' spaces that exclude daylight.

*What were your main conceptual intentions when you started work on the galleries?*

SM: Our competition submission already emphasised maximising the use of natural light. Furthermore, we wanted to recover spaces and use colour, tone and light levels in order to reinforce the original rhythm of Aston Webb's architecture. In terms of the exhibition design, our goal was to minimise the method of display to maximise the impact of the objects themselves.

*Peta, to what extent does your ambition of bringing more daylight into the galleries mean a return to the roots of your museum?*

PM: You could say that we have been taking a step into the future while simultaneously recollecting our roots in the past. We are continuously working to improve on how we open up the collection and make it relevant to today's audiences, while at the same time aiming to recapture the quality of the original 19th-century building. For example, in the lower level galleries (Galleries 8–10a), we removed the cladding from the previously blocked windows to let daylight in again, and opened up some behind-the-scenes spaces for display. This transformation also had the benefit of regaining the spatial proportions that had been lost, and some rooms that were designed as galleries are now being used as such for the first time. Elsewhere, in Gallery 50, MUMA improved the effects for viewing by controlling the previously unmediated daylight from the roof with louvres, and by adjusting the lighting to work with the narrative outlined by the curators.

"The effect of the daylight changes the way in which visitors can relate to the objects on display. We want them to encounter the works directly so that they might resonate in their memory, and we have therefore also shown as many objects as possible on open display."

Peta Motture

*To what extent could the opening of the galleries to the light and your return to passive methods of climate control be a model for future refurbishments at the V&A and other museums?*

PM: For several years, the V&A has been making great efforts to ensure we save energy and reduce carbon emissions, for instance in the Medieval & Renaissance Galleries, where we chose a system of more passive environmental control. But, given that this is a new approach, we will need to monitor it for the long term. We have to continually re-negotiate the need for visitor-friendliness on the one hand, and the protection of sensitive exhibits on the other. Future projects will also be as passive as possible, depending on the nature of the specific objects being displayed.

Other museums have been interested in our approach, for example in the reduction of casing, but not everyone will feel comfortable in taking the same approach, as no doubt local traditions, climate and other relevant issues will play an important role in their decisions. But they can at least see what we are doing and then weigh up the issues, taking into account their own specific needs.

**Peta Motture** was chief curator of the Medieval & Renaissance Galleries Project at the Victoria and Albert Museum in London.

**Stuart McKnight** is a founder and partner of MUMA (McInnes Usher McKnight Architects), who were responsible for the design of the new Medieval & Renaissance Galleries.



## TELLING STORIES WITH LIGHT

Interview with Steve Walker  
and Francesco Anselmo

*What made the refurbishment of the Medieval and Renaissance Galleries stand out from other projects that you have been working on in the past few years?*

sw: In this project, there were many different interrelated aspects: the unique collection, the special way of handling daylight and the indoor climate, not to mention the quality of the building itself. The intervention of MUMA is subdued and, yet at the same time, self-confident in that it allows what is most important about the exhibition – namely the variety of exhibits – to speak for itself. Moreover, architecture and environmental solutions work particularly closely together here. This is true of the daylight as well as the largely passive environmental control system for the exhibition galleries. Such a strategy enables the V&A to create a stable indoor climate and simultaneously save operating costs compared with similar galleries. FA: I found it remarkable that the architects assigned such an important role to daylight from the very beginning. Their design was comparable to a narrative whose vocabulary consists of materials, colours and light moods. The close attention of the architects to natural light is something that I have not experienced so strongly before in any other project.

*What is special about your strategy for air-conditioning the spaces?*

sw: In this case, ventilation involves no mechanical cooling at all. A sophisticated control system constantly monitors conditions both inside the galleries and outside the building and determines the rate of outside air supply, recirculation and, at certain times of the year, how much heating is necessary. Here, the key criterion is humidity, which has to be kept within tight limits for conservational reasons. But with this system, the indoor air temperature can indeed fluctuate; the spaces are relatively cool in winter and can become relatively warm in summer. This is a

somewhat different approach to what has traditionally been practised in museums, whereby both room temperature and humidity usually have to be kept constant throughout the year. With this concept, we estimated that the V&A could save 20 to 30% of the energy costs that normal air-conditioning would incur. What's more, the equipment is less complex, so the construction costs were reduced considerably since fewer changes were needed to the building's existing fabric.

*What tools did you find particularly useful for communicating the results of your daylight planning to the client?*

sw: Not everything that a technically accomplished architect would understand is suitable for communication with a client. The computer renderings turned out to be useful, as well as photographs of the existing building, material samples and, in the final phase, full-scale mock-ups.

FA: We often walked through the museum and took HDR photos<sup>1</sup> of the existing galleries, which we then compared with the results of our own simulations. In this way, we were able to show the client reference spaces with which the light mood in the new galleries would be comparable. This comparison made it possible to concretely experience our abstract simulation results.

The mock-ups were useful for a similar reason. With their help, we were able to judge how a certain material or a wall colour, for example, would look under real lighting conditions. A computer simulation is hardly a substitute for this experience.

*What opportunities do you see for applying the 'low tech' approach to lighting and ventilation practiced here in other museums?*

sw: I see a great deal of potential. It is possible that we are seeing one of those generational problems where certain attitudes and received wisdom have become so

"Currently, I see a strong trend towards introducing more daylight into museums. [...] Because if you cut down UV levels, and if you skilfully model daylight in terms of amount and direction, you can display the exhibits in the best way possible."

Francesco Anselmo

ingrained that they have coalesced to become a tradition with its own logic. Such traditions are often difficult to change but, in this project, the design team and client were successful. And the more the younger generation, which has grown up with the idea of sustainability, takes over responsibility, the more frequently it will be possible to question the current, often energy-hungry and expensive-to-run technical installations that we still have in many museums.

FA: Currently, I see a strong trend towards introducing more daylight into museums. In almost all of the museums we have recently worked on, daylight is used as an element to create an experience of space, to provide character and a sense of time. Because if you cut down UV levels, and if you skilfully model daylight in terms of amount and direction, you can display the exhibits in the best way possible.

1. High Dynamic Range, a photographic technique that makes it possible to examine the luminance distribution in existing spaces.

**Steve Walker** is an Associate Director of Arup in London. As Arup's design leader, he was responsible for daylighting design and M&E engineering in the new Medieval and Renaissance Galleries.

**Francesco Anselmo** is senior lighting designer at Arup. He was responsible for the computer-aided daylighting modelling and simulations.





# NØRRE BRO KØBEN HAVN











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# CREATING BRIGHTER CITIES OF TOMORROW

Daylight should always be considered when converting buildings. How can an approach of this kind be systematised? What new potential and synergies are created when we make daylight our starting point for the redevelopment of a building or district? A team of Danish architects has answered these questions in the recently published study 'Hvad med Dagslys?' (What about Daylight?).

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By Jakob Schoof  
Photography by Torben Eskerod

The light of the sun contributes to human well-being and is an important source of energy for a building. Even the market value of a property can be increased by a good supply of daylight. What is more, improving the daylight situation is one of the few measures that is effective at all scales of architecture – from a whole residential area to an individual room.

It seems only logical, therefore, to make daylight the starting point of any building refurbishment. Yet how to implement such an approach in practice?

The potential and possibilities of holistic 'daylight refurbishment' of cities and buildings have now been summarised in the study *Hvad med Dagslys?* (What about daylight?)<sup>1</sup>. It was compiled by a group of seven architects from the Danish firm, Henning Larsen Architects, in collaboration with Peter Andreas Sattrup (Technical University of Denmark) and Charlotte Algreen (Algreen Arkitekter). The study was funded by the Danish association, Realdania.

Using design creativity and modern simulation tools, the authors investigated what the benefits of daylight renovation are for everyday life on the streets and in public spaces, as well as for residents' comfort levels and year-end energy bills. They also suggest a practical refurbishment strategy that can be applied at three levels: for an entire residential area, for a single apartment block and for individual apartments.

These three assessment levels also represent three time frames: while re-

furbishment measures for an individual apartment can be planned and implemented within a relatively short time, strategies for an entire city district take longer to carry out because they involve more people and a large number of buildings. The most complex and long-term conversion strategies are those encompassing entire districts. But these too are important, because they provide a lasting basis for smaller-scale interventions to take place. "Furthermore," says Signe Kongebro, "an important message of our study is that the effects of interventions at all three scales – the city, the building block and the apartment – add up. In order to ensure that an intervention has maximum benefit, all three scales should therefore be considered in a holistic design strategy."

TIGHTLY-PACKED, MULTIFACETED AND POPULAR: NØRREBRO, COPENHAGEN'S FORMER WORKING-CLASS NEIGHBOURHOOD

Before we concentrate on the results of the study, it is worth taking a look at the area that 'What about Daylight?' investigates. The district between Stefansgade and Jagtvej in the Copenhagen district of Nørrebro is, in some ways, extreme, but also typical of many tightly-built residential areas in the city centres of Scandinavia. The findings of the study are therefore not only applicable to the city of Copenhagen, but to many cities across Northern Europe.

1. See [www.dagslysrenovering.dk](http://www.dagslysrenovering.dk)

**Next spread, right page:** Rendering of a potential daylight renovation in Nørrebro by Henning Larsen Architects according to the study "Hvad med dagslys"?











## Assessment level 1: Urban district

### Method:

#### Investigation of climate, daylight and energy potential by means of:

- Shadow analyses for different times of year
- Investigation of solar radiation on facades and roofs at different times of year.

#### Suggested measures:

- Complete or partial demolition of individual buildings
- Building on roofs and densification
- Greater variation in building styles and building heights
- Allowance for solar radiation in the design of new buildings
- Specific use of surface materials:
  - Light-coloured materials to improve daylight levels
  - Dark, heavy materials to store solar heat
  - Smooth materials for light reflection
  - Raw materials for light dispersion

Nørrebro is the most densely-populated urban district in Denmark and also has the least green area per person. And the population levels are still increasing, as what was once a working-class area is becoming more and more popular, in particular with students and young families. The reason for this is that relatively affordable living space is still to be had here.

In this district, the floor area ratios range from 2.0 to 4.5, depending on the property. Most of the buildings here were erected around 1900 as speculative rental development by investors. Typically they have 5½ storeys and often contain two-room apartments with a surface area of less than 60 square metres. The ground floor levels along some of the wider streets are used intensively by shops, cafes and restaurants, which also enliven the pavements in the summer with their outside tables.

The layout of streets in the district is certainly advantageous for good lighting: the grid pattern is angled at about 60 degrees to the four points of the compass. This means that daylight is distributed more evenly within the streets than it would be in a network of roads aligned

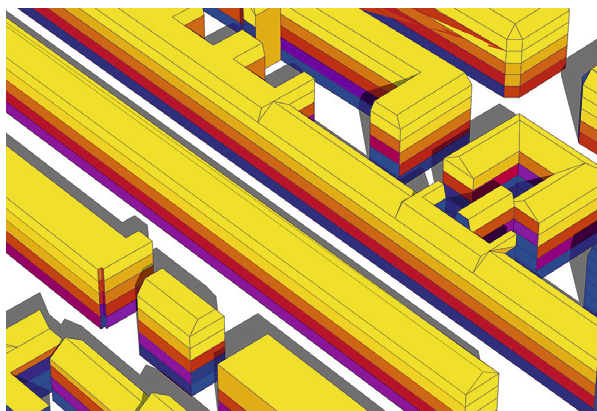
rigidly with the points of the compass. However, despite this, some streets and courtyards still get very little daylight. This is because the building height of 22–24 metres is considerably greater than the average width of the streets (18 metres) – and some of the courtyards are only 10 metres wide. So how can the sun be let into the streets and courtyards – and how can the amount of sun that shines on the facades be increased? For it is this sunshine that is essential to provide good light and improve the well-being of residents who live in the apartments.

#### MEASURES FOR THE CITY DISTRICT: BREAKING UP THE MONOTONY

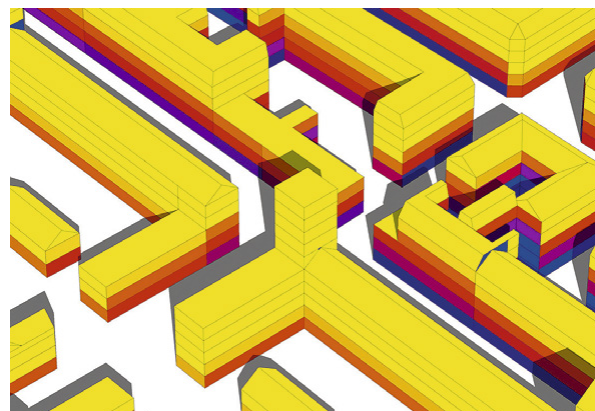
The most important finding in the study at district level is that variety is of the essence. Greater variety in the types of building, height and spacing allows for new ways of using buildings and more diversified open spaces. And it can also improve the daylight situation significantly. The study concludes: “Variety allows for something unique. It gives an unexpected ray of sunlight the opportunity to find its way into a narrow courtyard. [...] it lets you create a diverse cityscape and provides

Average solar radiation values (in Wh/m<sup>2</sup>/day) for a part of the study area in Nørrebro. The left-hand diagram shows the status quo whereas the right-hand diagram depicts the conditions after the refurbishment measures suggested by the authors are implemented.

Before



After



Wh/m<sup>2</sup>  
Average  
per day





the basis for incredibly diverse functions in the district”.

The idea that this block structure in the Nørrebro district, which, until now, has been fairly homogenous, may give way to greater diversity can, of course, only be implemented in the long term. What is important is that it must happen in a strategic rather than haphazard way. Where the buildings are particularly close together and the courtyards narrow, open spaces can be created by pulling down individual buildings or parts of buildings. In other places (especially at the corners of the blocks) buildings could be built onto and upwards, like towers. Attic conversions and rooftop extensions are also possible elsewhere in the district where the daylight situation allows. The district would thus gradually develop a real ‘skyline’ that would replace the current unbroken lines of eaves and roof ridges.

At street level too, the study suggests creating create more permeability to improve the quality of life in the district. Grass verges and even front gardens could be planted in some of the streets. New passages through the blocks could provide additional links from one street to the next. The study even claims that all this would be possible while still increasing the concentration of buildings in the area: according to calculations, a total of 3800 square metres of new living space could be created in the district. Despite this, the amount of solar radiation on the facades could be increased by 10-15% in the darkest places and by as much as 15-20% in the courtyards.

“The clue to this ‘win-win situation’,” says Peter Andreas Sattrup, “lies in the careful consideration of the sun’s changing positions throughout the day and the seasons. Furthermore, guidelines ought to be created for glazing proportions and the use of reflective facade materials in locations where daylight is sparse.

#### MEASURES FOR THE APARTMENT BUILDING: LIGHT FACADES AND SOLAR GEOMETRIES

In a single building or building block, the daylight supply can also be improved in

numerous ways. The reflectivity of building facades, in particular, has an influence here that is often underestimated: while red bricks only reflect 13% of light, the reflectivity of light grey plaster is 54%. By using lighter materials with a more matt finish in facade refurbishments, it is possible to increase the daylight yield in an average courtyard in the district by 15%.

However, caution is advised with large window areas: they let more light into the individual apartments but also reduce the proportion of daylight reflected to the outside. In other words, large expanses of glass result in a ‘privatisation’ of daylight in city areas.

Specific changes to the building volume can also improve the daylight situation in a courtyard. Staircases or other extensions, for example, often take the light away from neighbouring buildings. The same applies to balconies, which shade the apartments below them. If balconies are replaced with bay windows and extensions built in shapes that follow the course of the sun, considerably more light will enter a building.

‘Classical’ methods of creating extra, well-lit living spaces include rooftop extensions – if the existing building will support them – and converting unused attic space into living area.

But there are also methods of improving daylight in the lower storeys of a building that do not require the building to be enlarged or to change shape. Several small apartments can, for example, be joined together vertically rather than – as it often happens – horizontally. By creating maisonette apartments in this way, apartments on the lower storeys literally ‘grow’ upwards to the sun. Furthermore, double-storey rooms can be created inside them, which allow daylight to penetrate particularly deep into the building.

#### MEASURES FOR A SINGLE APARTMENT: CREATE BIGGER WINDOWS, BUT BE CAREFUL WITH BALCONIES!

Next, let us take a look at possible approaches to refurbishing an individual apartment. As meaningful refurbishment strategies are always building-specific, the study analyses a room in a typical apart-

#### Assessment level 2:

##### Single building and block of buildings

#### Method:

#### Investigation of daylight and energy balance by means of:

- Shade analysis
- Calculating solar exposure on the facades
- Calculating the daylight factor in the courtyard

#### Suggested measures:

- Selected demolition of buildings or parts of buildings
- Design of new buildings and extensions according to the principles of exposure to sunlight
- Use of bright, matt materials on facades to improve the amount of light reflected in inner courtyards
- Attic conversions and building onto the top of buildings – roof terraces
- Joining apartments together to create maisonettes
- Increasing the proportion of glass in the outer surface of a building
- Replacing windows and glazed areas
- Improving access to the outside with glass doors and areas of the facade that can be opened up
- Improving insulation
- Improving technical installations (heating, lighting, plumbing)



Assessment level 3:  Individual apartment	Refurbishment cost per room [DKK]	Energy consumption [kWh/m <sup>2</sup> ]	Daylight factor (average)
1 Original situation	–	165	1,92%
2 100 mm interior insulation + mechanical ventilation	18.000	101	1,73%
3 Additional window panes to cover existing windows	2.000	127	1,55%
4 Installation of new windows, double-glazed	16.500	126	1,66%
5 Installation of new windows with solar control glass, triple-glazed	19.500	125	1,17%
6 Enlargement of windows for glass doors (French windows), double-glazed	82.000	126	2,48%
7 Installation of a glazed wall running along entire side of room, triple-glazed	136.000	114	3,69%
8 Installation of French windows, double-glazed + 100 mm interior insulation + mechanical ventilation	88.000	73	2,29%
9 Installation of glazed wall running along entire side of room, triple glazed + 100 mm interior insulation + mechanical ventilation	138.000	77	3,60%
10 Installation of French windows, double-glazed + 100 mm interior insulation + mechanical ventilation + 750 mm deep balcony	229.000	73	1,75%
11 Installation of French windows, double-glazed + 100 mm interior insulation + mechanical ventilation + 1500 mm deep balcony	235.000	72	1,26%



G value,  
windows

Light transmission,  
windows [%]

U value, windows  
[W/m²K]

U value, outer walls  
[W/m²K]

E-ref windows  
[kWh/m²]

0,85	89%	4,2	1,2	-279
0,85	89%	4,2	0,27	-279
0,72	74%	1,8	1,2	-78
0,68	78%	1,7	1,2	-73
0,33	58%	1,2	1,2	-70
0,68	73%	1,7	1,2	-60
0,58	71%	1,2	1,2	-23
0,68	73%	1,7	0,27	-60
0,58	71%	1,2	0,27	-23
0,68	73%	1,7	0,27	-60
0,58	71%	1,2	0,27	-60



Page 98–99 contain an overview of all of the proposed strategies for renovation at assessment level 3 from the study "Hvad med Dagslys?". Besides the solid numbers of energy consumption and renovation costs, the aim is a high light transmission and G-value in windows to let more daylight and

passive solar heat pass through. This will improve the E-ref value (annual energy balance) of the window and improve the overall U-value of the construction. It is therefore essential to consider all factors when analyzing and comparing the strategies.

### Assessment level 3: Individual apartment

#### Method:

#### Investigation of daylight, energy balance and economy by means of:

- Calculating the daylight factor in the apartment
- Calculating the energy consumption for heating, cooling, hot water and electricity for lighting and ventilation
- Calculating the cost of redevelopment

#### Building structure (starting point):

- Outer wall: 480 mm brick wall, not insulated, U value: 1.2 W/m<sup>2</sup>K
- Windows: single glazing in wooden frames, U value: 4.2 W/m<sup>2</sup>K  
Light transmission: 89%  
g value (glass): 0.85  
Percentage of glazed surface in entire window: 60%
- Orientation of facade: south-west

#### Measures investigated:

- Internal insulation of the outer wall
- Installation of a mechanical ventilation system
- Installation of new or additional glazing in the existing frames
- Installation of new windows (maintaining the existing window size)
- Installation of larger windows
- Building balconies onto the facade
- A combination of the above measures

ment block, hundreds of which can be found in Copenhagen's inner city districts: built at the beginning of the 20th century, with five storeys and situated in one of the many narrow residential streets that criss-cross the area. Its ornamented facade onto the street is built of exposed, unplastered brickwork, which means it can only be insulated from the inside. The single-glazed latticed windows allow a great deal of heat escape to the outside, but also admit a lot of daylight into the rooms. Because the apartment in question is on the second floor and the windows face south-west, it gets most of its direct sunlight in the evenings and during the summer. In the winter, however, and when the sun is low in the sky, it is often shady.

The redevelopment strategies range from simple insulation and mechanical ventilation to improvement and enlargement of the windows, and even the installation of balconies.

The results clearly show the interaction between energy consumption, supply of daylight and costs for each measure. The (relatively economical) internal insulation of the outer wall reduces the energy consumption significantly, but also slightly reduces the amount of daylight entering the apartment because the thickness of the walls is increased. A similar effect is achieved by replacing the existing windows with new ones of the same size. In this case, it is primarily the triple glazing with solar control glazing that swallows up a great deal of light, but (compared to double glazing) barely lowers the energy consumption. On the other hand, increasing the window size is extremely beneficial both for the energy balance and the comfort level, even if the new windows are only double-glazed. The only limitation here is that this measure costs slightly more than simply replacing the windows. Even more expensive, but popular with residents, are balconies. These do, however, take light away from the rooms below them. The balcony in our example, which is 1.50 metres deep, results in lower levels of daylight than in the original apartment before renovation, even though the size of the windows has been increased.

#### POSSIBLE IMPLEMENTATION: WHAT NEXT?

Signe Kongebro, head of the sustainability team at Henning Larsen Architects and co-author of the study, reports that the idea has been well received, but that 'Hvad med Dagslys?' has also been met with a certain amount of scepticism from the general public. "Many architects need to get used to the idea that sustainable building is not just a question of technology or insulation and that daylight has a considerable effect on the energy balance in buildings." The authors are planning to further publicise the holistic concept of 'daylight renovation' in several conferences and a summary of the study, which is to be sent free of charge to all architects in Denmark. At the same time, Henning Larsen Architects are already testing the newly developed strategies in practice: they have been contracted by a Danish pension fund to draw up a redevelopment project for a street block in Nørrebro. This project is to double the current building density and at the same time improve the natural lighting. "We recommended to the building owners to increase the density in the area," says Signe Kongebro. "We told them it would be good for their profit and for the entire district. Now everyone is excited about how the results will turn out."



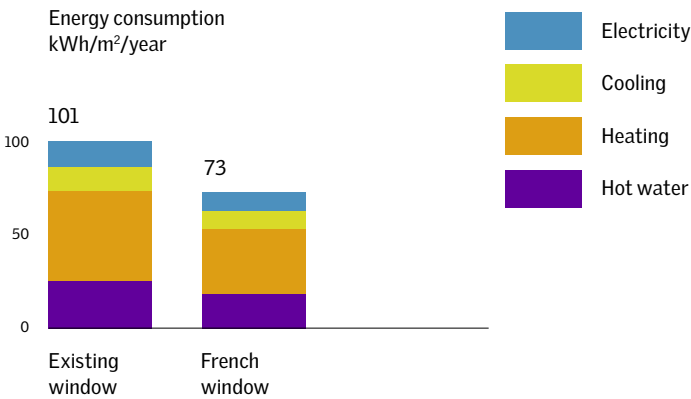
Assessment level 3:  
Individual apartment

This strategy demonstrates the effect of replacing and enlarging the windows.

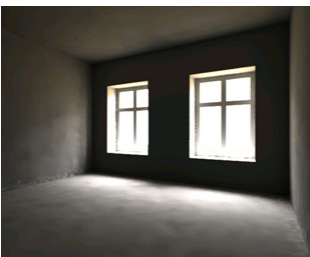
The cost is a one time investment with a high amenity value from day one, and an increased financial value of the apartment for a future selling situation.

- Energy consumption can be reduced by approximately 25% by replacing existing windows with French windows
- The construction becomes more energy efficient with the increased window area, because of the installation of windows with a better (lower) U-value
- The daylight factor increases by 30% due to the larger window area
- Very large windows, however, can cause overheating if shading is not integrated, depending on the orientation and the surroundings

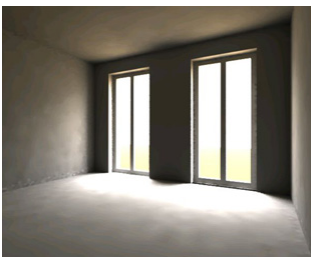
Energy



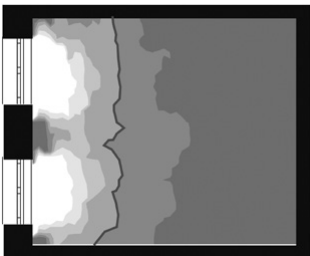
Daylight



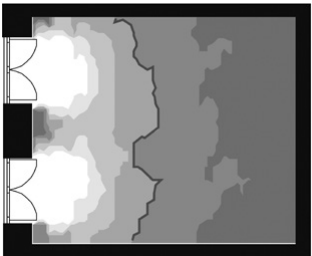
Traditional single-glazed window  
Daylight Factor 1,92%



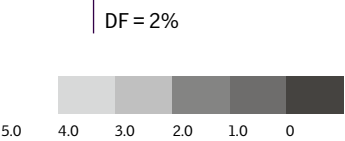
French window  
Daylight Factor 2,48%



This scenario references the existing conditions, so there are no expenses.  
  
Price for this room:  
0 dkr



The price includes materials and labor for changes to the facade and installation of French windows, including expenses for setup of a construction site.  
  
Price for this room:  
82.000 dkr



## DARE TO DO THINGS DIFFERENTLY

Interview with  
Signe Kongebro

"Here he is, his name is Daylight. Please accept him. He has a great many skills, but you need to work with him, instead of forgetting him and locking him up behind three layers of glass and a thick layer of insulation"

Signe Kongebro

*Signe Kongebro, what inspired you and your team to compile the handbook 'What about Daylight'?*

We have always worked intensively with daylight at Henning Larsen Architects – one might say that natural light is our trademark. It has become increasingly clear to us during the past few years that daylight, unlike any other tool, can generate synergies between the energy side of construction and many other factors, such as levels of comfort experienced by people using the building. Or put a different way: daylight pays off in both hard and soft dollars.

These facts have really been common knowledge in architecture for more than 2000 years. But now we are faced with the challenge of having to measure them, because there is now an extreme movement towards measurability in architecture world-wide.

Another factor is that daylight can be an incredibly attractive means of communication: everyone understands its use intuitively and without long explanations. And so daylight gave us the opportunity to talk about ecological architecture in a context other than simply energy efficiency.

*To what extent is your study a reaction to the current practice of building refurbishment in Denmark?*

Refurbishment is a big issue at the moment but has a lot of uncertainty bound up in it. People are frightened of damaging valuable buildings with redevelopment work. Also, we architects in particular are gradually becoming tired of the one-sided view that energy refurbishment is entirely a matter of thermal insulation. Sustainability is not only a technical problem – we want to make this clear to all the engineers and political decision-makers in charge of building refurbishment in Denmark at the moment.

This is why we have, in a way, 'intro-

duced a new pupil to the class' and said, "Here he is, his name is Daylight. Please accept him. He has a great many skills, but you need to work with him, instead of forgetting him and locking him up behind three layers of glass and a thick layer of insulation".

*How could your concepts fit into an overall strategy for the buildings we already have?*

We already see our study as being part of an overall strategy. It deals specifically with all those tens of thousands of buildings all over Denmark that are often overlooked: they are not listed buildings, they don't benefit from being in any particular location and are not usually completely refurbished because their owners simply cannot afford it. It is for precisely these buildings that we have found a way of saving about a quarter of the energy and at the same time creating added value for the owners and the people who live in them.

*How can your strategies be implemented in practice? Do architects need more and better tools for daylighting design, for example?*

The tools for working with daylight in architecture are really all available. The difficult part is that working with daylight calls for a holistic approach. However in my opinion it just takes courage to tackle these things positively and put them into practice. And they are, in fact, being put into practice. I am increasingly becoming aware of competition designs by other architects' offices in which daylight plays a vital role, and to me that indicates that a new agenda is rising.

*In your recommendations for the redevelopment of urban areas, you argue for greater differentiation in the way building density is handled. What is new about your concept?*

Of course, high building density can be a problem – but if it is approached in the

right way, it can even be increased while still bringing more daylight into the city. By no means do we have to give up our ideal of a densely-populated city with mixed uses if we want more daylight. This, however, assumes that density is seen as a qualitative and not a quantitative measurement and that it is considered in detail block by block, building by building.

*Wouldn't this mean adopting a completely different view of cities from what we are used to nowadays?*

It certainly would. Working this way means you end up with urban design that aims to improve the performance of a city rather than to generate building volume. It is time the planning offices stopped making detailed requirements for building boundaries, roof heights, roof pitches and distances between buildings. Instead, they should be defining qualities they want to achieve – a certain building density, open spaces that are protected from the wind, and specific amounts of sunlight per year – and leave the creative part up to us architects.

**Signe Kongebro** is an associate partner and head of the sustainability team at Henning Larsen Architects in Copenhagen. Together with a team of eight other authors, she initiated and co-authored the study 'What about Daylight?'.



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## DAYLIGHT HAS A FINANCIAL VALUE TOO

Interview with  
Peter Andreas Sattrup

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"This sensitivity for daylight can also be found in the works of many great architects like Alvar Aalto, Henning Larsen or Jørn Utzon – and it is also taught to us at university. For this reason, I think one can speak of a 'trained sensitivity' towards daylight in Nordic architecture."

Peter Andreas Sattrup

*Peter Andreas Sattrup, your study 'What about daylight?' shows the influence architects can have on our built environment when they use daylight. How would you characterise the attitude of architects to daylight?*

I think that, in Denmark and probably in the Nordic countries in general, all architects value daylight as an extremely important quality in our environment. It is also a fact that many people experience a lack of daylight due to our indoor lifestyle here in northern Europe, especially in the winter. This has important health and psychological effects on people living here.

This sensitivity for daylight can also be found in the works of many great architects like Alvar Aalto, Henning Larsen or Jørn Utzon – and it is also taught to us at university. For this reason, I think one can speak of a 'trained sensitivity' towards daylight in Nordic architecture.

In contrast, the analytical and quantitative aspects of daylighting design are still somewhat underdeveloped in our design culture. Now, however, new digital simulation tools give us the opportunity to bring together the measurable and non-quantifiable aspects of daylight.

I do not think there is a contradiction between the aesthetics and the physics of light. Rather, the new digital simulation tools may help us refine our sensitivity and feelings for daylight and achieve a much more precise kind of design, which can at the same time be efficient, poetic and delightful. There is huge potential here, particularly for future generations of architects.

*You mentioned new digital simulation tools for daylighting. To what extent are they already being used, and what would be the ideal way to use them?*

Simple simulation tools are becoming increasingly widespread in the architecture and engineering departments of

universities. But we also need to take this knowledge and technology from research and put it into practice in architecture and planning. Until now, people have only used simulations to verify simple design parameters like the daylight factor, for which there are minimum levels required by law. However, these tools could be used for much further-reaching analysis, which also integrates the aspects of energy use and comfort. We now understand the complexities of this field with much greater detail than before, and we can use them to develop innovative design solutions that are both energy efficient and provide good daylight conditions. This is also what we seek to demonstrate in 'What about daylight?'

*How important are new measurement methods that go beyond a static understanding of the daylight factor?*

I believe assessment methods like daylight autonomy or useful daylight illuminance are very promising and should be integrated in new standards for daylighting assessment. Because they are based on real climate data, account for the temporal changes in daylight and take direct sunlight into account. By doing so, they give us a much deeper understanding of daylight and all its many facets – including heat energy. We do, however, need a great effort on the part of architects and schools of architecture if we are to improve our design practice in this way.

*In your study, what value have you found daylight to have, apart from energy efficiency and comfort levels?*

Our study involved questioning numerous experts from very different fields – health and real estate experts, and representatives of welfare organisations. Across the board, they were all of the opinion that daylight has huge potential in their special areas. One real estate developer told us that there is a strong

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"It is important to understand how the different assessment levels, from the city to individual buildings, interact with each other. This is the only way we can achieve greater quality in our city environments – and after all, that is what should really be the goal of energy refurbishment."

Peter Andreas Sattrup

correlation in his projects between the value of an apartment and the natural lighting in that apartment. With every storey that takes you closer to the sky, the sale price of an average 80 square metre apartment increases by about 20,000 Euros. Of course these price differences are also due to issues such as privacy and views, but daylight definitely plays a role here. We were rather fascinated by this insight. Architects often have to fight to prove that design decisions also have a financial value. Now, if we can demonstrate that we improve daylight and solar access in an urban area, it will be easier to argue that we create not just a good place to live but a place with a high financial value too.

*How has your study been received by the general public so far?*

We have observed that local administrations are becoming more interested in the subject and that daylight is allocated a much more important role than it used to be, for example in the granting of planning permission. And we have noticed that some of the more innovative property owners and developers are keen to use this knowledge too, as it improves their businesses.

On the other hand, the term 'daylight refurbishment' that we coined in our publications has now become an established term among architects and engineers in Denmark, and has become a separate field of activity that they can apply themselves to. This is a great achievement for us, because the holistic approach of 'daylight refurbishment' covers a much wider spectrum than pure energy refurbishment. It shifts the focus from purely saving the costs of energy to an improvement in the quality of life. I think that is what we should aspire to.

*What do you think we need to do to improve the supply of daylight to our cities?*

Our ideas for refurbishing city districts are designed for the long-term and may seem radical at first sight. After all, it is certainly a controversial idea simply to tear some buildings down, and build on top of others, in order to improve the availability of daylight in public spaces. If, however, measures of this kind are embedded in a long-term strategy they definitely make sense. They have the potential to make the urban environment and its daylight more complex, dynamic and lively. If, then, we were to begin using bright, matt surfaces to reflect daylight into narrow back courtyards and canyon-like streets, this would be the start of a completely new kind of urban daylighting design. It would not even be necessary to decrease the urban density in this case. We have shown in our study that it is possible to achieve both greater density and, at the same, more daylight. It is, however, important to understand how the different assessment levels, from the city to individual buildings, interact with each other. This is the only way we can achieve greater quality in our city environments – and after all, that is what should really be the goal of energy refurbishment.

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# DAYLIGHT AS A DRIVING FORCE FOR URBAN TRANSFORMATION

There are many ideas for how our cities could be re-designed to make greater use of daylight. But what does the reality actually look like? How much still remains of the classical modernist notions of 'light, air and sun'? The following article provides an overview of the role played by daylight and health in 20th-century urban planning.

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By Jakob Schoof  
Photography by Torben Eskerod









LIGHT, AIR AND SUN – it was no more than 80 years ago that this battle cry of classical modernism sounded like a promise of better health and higher quality of life. Sunlight was considered an important cure for diseases and a means to keep dwellings warm, dry and hygienic.

Today, modern sanitary installations, antibiotics and disinfectants have contributed to ensuring that epidemics such as typhus and tuberculosis (which sunlight was once supposed to cure) have largely disappeared from Europe. However, recent scientific research shows how much people really need light. We require 1,000 lux to readjust our ‘inner clock’ to the 24-hour cycle every day and we even need 2,500 lux or more before light can unfold its well-known anti-depressive effect. However, long-term studies show that most people only spend from 10 to 20% of their time in surroundings with such an intense level of lighting.<sup>1</sup>

A process of rethinking is essential for the future – but in order to start it, we need to be aware of how the relationship between our cities and the sun evolved in the 20th century. Our historical digression starts with a current event that aims to pioneer new approaches to urban planning: the Internationale Bauausstellung (IBA = international building expo) in Hamburg in 2013. This expo is the last in a series of building exhibitions in Germany that goes back to 1901 and represents an exemplary cross-section of urban planning and architecture in the 20th century.

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2013:

## The city and climate change

The venue of this year’s IBA is the Hamburg city of Wilhelmsburg – Europe’s biggest river island, located right in the geographical centre of the seaport city and yet, socially speaking, still more of a marginal problem district. In some residential areas, migrants make up over 50% of the inhabitants and the unemployment rate far exceeds the average for Hamburg as a whole. In this context, an IBA has to

be more than just a building exhibition – it must also deal with the coexistence of different cultures, with education and employment. The event has brought a number of improvements to the city district: educational facilities, training workshops for young people and several new social meeting points. The Weltquartier (World Quarter), a working-class housing estate from the 1930s with 1,700 inhabitants from 30 different nations, has been renovated in line with the current social situation. Above all, however, Wilhelmsburg has been given a ‘new middle’, with a hotel and medical centre, a sports hall and swimming baths, a municipal administration building and 17 new apartment buildings.

## TECHNICAL SOLUTIONS RATHER THAN NEW PLANNING PARADIGMS

The City and Climate Change is one of the three main themes of this international building expo. One might thus assume that the sun and its energy take centre stage in the redevelopment of Wilhelmsburg. And indeed, many of the new buildings at IBA use one or another form of solar energy to improve their energy balance. This includes experimental technologies such as novel types of solar cells or facade-integrated algae bioreactors. A World War II bunker has been converted into a power station for the district and supplies some 3,000 households with heat and electricity from the sun.

Yet in terms of the use of space in the city, ‘building with the sun’ does not appear to be a guiding principle for IBA Hamburg. Only a few isolated projects explicitly strive to improve the supply of daylight. And the ‘solar urban planning’ of previous decades has long been on the retreat in Germany – as elsewhere in Europe. Instead, the aim now is to build dense city districts for a variety of mixed uses, whereby the buildings are to be compact and well insulated with low energy consumption. This approach may be justified – but is it sufficient in itself? Might there be more to urban planning than density, compactness and mixed-use? Can health and human well-being once more become leading paradigms for the planning of urban spaces?

Even if it may not be possible – or even adequate – to directly copy the urban planning models of previous decades, the history of German building exhibitions may hold some clues to answering these questions. Let us therefore take a look at how it all began, the first German building exhibition in Darmstadt in 1901.

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1901:

## Life reformers on the way into a shining new century

The new century started with an exodus from the city – albeit to somewhere only a few hundred metres away. In 1899, Grand Duke Ernst Ludwig von Hessen-Darmstadt founded the ‘Darmstadt artists’ colony’, which was to be located on the Mathildenhöhe, a tree-covered hill on the eastern outskirts of the city. For a first show of the colony’s work, he planned a large art and architecture exhibition that





was to take place in 1901 under the leadership of the Austrian architect Joseph Maria Olbrich.

#### THE NEW NAKEDNESS: LIFE REFORM AND ARTISTIC RENEWAL

Olbrich himself once referred to the artists' colony as a "milestone on the way to a renewal of the way people live". The colony was influenced by a broadly-conceived reform movement among the progressively-minded German bourgeoisie. This 'life reform movement' propagated natural healing methods and vegetarianism, clothing reform and naturism, the protection of nature and the establishment of communities far away from the city. As early as 1853, Arnold Rikli had set up the first 'sun healing institute' in Switzerland; in 1906, the naturism movement in Germany already operated 105 so-called Luftbäder (air spas).

The sun increasingly gained admission to the homes of the bourgeoisie as well. In the 19th century, bourgeois residences were regarded as the antithesis of the anonymous, public world and were shielded correspondingly. Curtains and shutters protected the sumptuous interior furnishings against the unwanted effects of sunlight, which was regarded as harmful.

Around 1900, the protective barriers gradually began to be disappear; home furnishings became brighter, progressive designers rebelled against the profusion of curtains and heavy drapery. Furniture and everyday objects were divested of their excessive ornamentation. The name of the new art style that replaced it – Jugendstil or, in French, Art Nouveau – reflected the concept of newness while incorporating nature in the images it used.

#### EXODUS FROM THE CITY:

##### THE GARDEN CITY MOVEMENT

Ernst Ludwig's small exodus from the city was also inspired by the social and health reforms introduced in Great Britain in the course of the 19th century. In 1898, the year when the Darmstadt artists' colony was founded, Ebenezer Howard published his vision of the garden city as an alternative to the dirt and misery of the large industrial cities of the late 19th century.

However, neither Howard's (circular) prototype of the garden city nor the Darmstadt artists' colony were 'solar-optimised' in today's sense. Their network of streets was primarily based on artistic considerations or the topography but not on the course followed by the sun during the day. Good lighting was to be achieved solely by restricting the building density and imposing limitations on height.

1927:

#### Sunlight therapy for German cities

Germany in the 1920s – the First World War had been lost, the political situation was unstable and there was still widespread social deprivation and hardship. In 1927, there was a shortage of 600,000 homes, mainly for poorer city dwellers. The trauma of the unhealthy, over-occupied blocks of flats that prevailed in large German cities was still ever present. The Berlin illustrator Heinrich Zille (1858–1929) once wrote about this, saying that "an apartment can kill people just as much as an axe can".

The representatives of the 'New Building' movement wanted to remedy this crisis with a radically new architecture for all layers of the population and not just for the privileged few as did the reform movements of the preceding decades.

The first opportunity to implement their ideas on a large scale presented itself in Stuttgart. The progressively-minded mayor of the city had released funds for a model village to 'showcase' the new

pioneering approach to building. Only architects who "worked in the spirit of a progressive artistic form adapted to current conditions" were to be allowed to participate.<sup>2</sup>

#### THE WEISSENHOF SETTLEMENT – A BUILT REPRESENTATION OF HEALTH REFORM?

The buildings that Le Corbusier, Mies van der Rohe, Walter Gropius and their colleagues erected at the Weissenhof location have been widely publicised and require no further description. What is more interesting is the question as to what hygienic considerations their architecture was based on. For decades, the German building laws – in line with the opinion of leading hygiene experts at the time – had assumed that the volume of air in a room determined the quality of the air in it. This explains the high (still popular) ceilings in many late 19th century buildings.

It was only gradually that these attitudes changed. Scientists realised that it was not the volume of air but the replacement of air that was responsible for good quality air in rooms. And people learned to appreciate the direct positive effect of sunlight on human health.

Correspondingly, the introduction of the Modernist ideas led to a lowering of ceiling heights and a reduction in room volume. The permeability of the facades to light and air became more important – as did the limitation on room depth – in order to boost natural lighting and cross-ventilation. In many respects, the Five Points Towards a New Architecture that Le Corbusier published in the run-up to the Weissenhof exhibition are a testimony to this new attitude. In his essay, Le Corbusier advocates, among other things, that buildings be placed on supports (pilotis): "As a result, the rooms are moved away from the dampness in the ground; they have light and air [...]". He also calls for the creation of roof terraces and gardens as well as the use of horizontal, elongated windows, the reason being that "the rooms are then lit uniformly from wall to wall. Experiments have shown that the intensity of light in a room that is lit in this way is eight times stronger than in a room that has high windows with the same surface area".













#### A 'SCIENTIFIC' APPROACH TO URBAN PLANNING

In the following years, terraced houses with a strict east/west or (more rarely) north/south orientation constituted the Modernists' favourite approach to residential building in Germany. The orientation and height of buildings, the distance between them as well as their layouts were intended to ensure that each home received some direct sunlight even in winter. To prove that their designs were 'scientifically' correct, architects soon took to producing diagrams that illustrated the exposure to sunlight and the light and shade arrangements.<sup>3</sup>

In reality, however, the new planning principles could only be applied to areas where new buildings were to be erected; they were largely incompatible with existing city districts.

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1957:

#### IndividualistsW in the green

At the beginning of the 1950s, the ruins in Berlin resulting from the world war had been cleaned away and a start was made (and had to be made) on reconstruction and restoration. In 1953, the city senate decided to present the 'Interbau' building exhibition in the Hansa district, next to the Tiergarten in the centre of Berlin. 90% of this area had been destroyed in the war. Of the 54 architects who were invited, a third came from abroad, including Alvar Aalto, Arne Jacobsen, Le Corbusier, Oscar Niemeyer and Pierre Vago. Compared to the pre-war Hansaviertel, the density of the built-up area in the new district had halved, as well as the number of inhabitants. Solitary buildings in the park became the new guiding principle of urban planning. The building topologies ranged from single-storey atrium houses to 17-storey high-rise towers. But although the arrangement of the buildings no longer followed the grid of streets, there was nevertheless an ordering principle that was adhered to in the Hansa district; all the building had been strictly aligned to the four points of the compass.



#### URBAN PLANNING AS AN URBAN LOOSENING-UP PROGRAMME

In this respect, the Hansaviertel was typical of post-war urban planning. It kept to the ideal of the loosely built, greenery-filled city but without the rigidity of earlier terraced-house developments. There was less dogmatic application of 'scientific' principles of sunlight utilisation; the new districts were to receive daylight mainly through the use of large open spaces and higher buildings. However, the rise in height was often accompanied by an increase in building depth, a situation that imposed new challenges on the architects. They reacted by adding oriels, loggias or atria to the buildings or by staggering them in such a way that light could enter all the apartments from several sides.

#### FUNCTIONALISM BECOMES RIGID

All in all, however, the rigid application of 'solar' principles in urban planning seems to have gone along with a reduction in architects' knowledge of lighting and the use of sunlight. This went hand in hand with a change in mentality among the public, whereby the 1950s and 1960s were an era of (almost) uninterrupted confidence in technology. Modernism, with its brightly lit rooms and transpar-

ent facades, was commensurate with this zeitgeist. At the same time, however, it became a 'style' that could one day grow out of fashion. The medical necessity of daylight was no longer seen. On the contrary, anyone trusting in the healing powers of nature (including sunlight) was regarded as hopelessly out-of-date. After all, there were antibiotics, high-tech healthcare and all the other technical accomplishments of post-war civilisation.

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1987:

#### Preservation and solar pioneers

Local politics in Berlin at the beginning of the 1980s still adhered to the principles of post-war urban planning – with the active support of the local building industry. The prevalent practice was to tear down the remains of the pre-war blocks of flats in large areas and to replace them with new buildings. In the light of a growing protest movement among the public, the IBA expo in 1987 countered this practice of demolition with two new models: 'careful urban renewal' in districts containing old pre-war buildings and 'critical reconstruction' in the case of new buildings. Instead of 'green' and 'spread-out', the new 'magic words' of urban planning were now 'density' and 'mixed use'. The 'grand narratives' of urban planning (according to the German urban planner Thomas Sieverts<sup>4</sup>) had come to an end for the time being. They were replaced by the plugging of gaps in the existing context, whereby scrupulous attention was paid to ensuring that new constructions related to the locality and its history.

#### A FOCUS ON REFURBISHMENT AND FIRST ECOLOGICAL EXPERIMENTS

"The IBA expo's important contribution to urban planning was the abandonment of modernist urban planning with its 'light, air and sun'", wrote two planners who were involved in the 1987 IBA expo and looked back 20 years later.<sup>5</sup> The housing shortage had been eliminated, health and hygiene problems seem to have been resolved but now issues relating to the en-





ergy supply and environmental protection were becoming more urgent. Once again, the sun became the focus of many efforts – albeit not so much on the urban-planning level as in the design of individual buildings. The first pioneer ‘solar’ buildings had been erected in the 1970s in North America and Europe – mostly as solitary structures situated far away from the cities. The new challenge now was to implement the new design principles in the context of dense inner cities as well.

It was not that such efforts dominated the IBA 1987 – but they did exist, especially considering that some of the people involved in the building exhibition were closely associated with the ecology movement in Berlin. In the context of the exhibition, several pioneering buildings in the form of ecological apartment complexes were created – with winter gardens and solar hot-water collectors, planted roofs and rainwater utilisation systems.

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1999:

## Change without growth?

In 1972, Dennis Meadows and his co-authors from the Club of Rome had published their book *Limits to Growth*. A quarter of a century later, the problem of how to deal with shrinking cities also became a theme of an international building exhibition. The Ruhr district, once Germany’s number one production location, had already lost a million people since the 1960s. An often painful structural change from an industrial to a services region had started long before this. The Emscher Park building exhibition was intended to provide a new economic and, above all, ecological stimulus.

The name ‘park’ for the region was itself a provocation; the President of the Federation of German Architects at the time, Andreas Gottlieb Hempel, wrote

in 1996: “the Ruhr district, especially the Emscher area, [...] was long regarded as a synonym for silicosis, smoke-filled skies, soot-coloured miners’ faces, coal heaps, steelworks and ruined nature.”<sup>6</sup>

**A GREAT PAST AND GREAT CHALLENGES**  
For the first time, one of the main themes of the IBA expo focused on the conservation of greenfield sites and the conversion of former industrial brownfield land into parks. A second theme was the preservation and new use of existing industrial monuments. Converted mining installations and majestic factory halls are among the most impressive legacies of this building exhibition.

In addition, solar energy was used to a larger extent than ever before. The Mont Cenis academy in Herne, by Jourda & Perraudin and HHS Architects, became one of the main symbols for the ecological redevelopment of the coal-mining district. The new 1.3 hectare building embodies – in miniature as it were – an urban-planning vision of Buckminster Fuller and Frei Otto: the city under glass, here reduced to a community centre plus an academy of further education with adjoining hotel and apartments.

## THE BRIEF HEYDAY OF SOLAR URBAN PLANNING

At the same time as the Emscher Park building exhibition, globally renowned architects made solar building into one of their primary concerns. In Berlin in 1996, thirty of them, from Renzo Piano to Thomas Herzog and from Frei Otto to Ralph Erskine, signed the European Charter for Solar Energy in Architecture and Urban Planning. Although it placed its main emphasis on energy efficiency and the use of renewable energy, it also specified air and light as a requirement for well-being.

In the years that followed, solar urban planning in central Europe enjoyed a small renaissance. One of the most ambitious projects was the ‘solar city’ in Linz, a new city district for 3,000 inhabitants, built according to a master plan drawn up by Foster + Partners, Richard Rogers and Thomas Herzog. They intentionally avoided the monotony of strictly south-oriented terraced houses of preceding solar estates. Instead, they imposed a radial structure on the quarter, with buildings whose positions in relation to the sun differed considerably from each other but with public spaces that could be used to better effect. This moved solar building a step further towards the goal of becoming compatible with existing urban structures. However, things did not go much

further in this direction – the Solar City was both the high point and the endpoint of solar urban design in the last decade.

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## The future: Density and quality of life

There may indeed be a need for new, visionary guiding principles for urban planning in Germany. The country is experiencing a lack of new housing, especially in the large cities. A study conducted by the Pestel Institute recently showed that there might be a shortage of 50,000 apartments in Hamburg alone by 2017.

In this situation, density in built-up urban areas is likely to rise. This can be beneficial in many respects: more density often means less car traffic, better utilisation of district heating and other supply networks, and more social contact among the inhabitants. To ensure quality of life in our future cities, however, a qualitative approach to density ought to be taken rather than a purely quantitative one. And the human need for daylight must not be allowed to fall victim to the increasing densification.

Future building exhibitions will show whether lessons have been learnt. The next occasion will be in 2020, when two more international building exhibitions will be taking place in growth regions – one in Berlin and one in the tri-state area around Basel.

1. Silvia Hubalek: Office Workers’ daily exposure to light and its influence on sleep quality and mood. Presentation during the VELUX Daylight Symposium in Lausanne in 2011, p. 13, 18–19)
2. Peter Bruckmann, quoted in: Manfred Ulmer, Jörg Kurz: Die Weissenhofsiedlung. 2006, p. 21
3. Michelle Corrodi and Klaus Spechtenhauser in: Licht Einfall. Tageslicht im Wohnbau. 2008, p. 59
4. Thomas Sieverts in Metropole: Reflexionen. IBA Hamburg – Entwürfe für die Zukunft der Metropole. 2008, p. 178 ff.
5. Cornelius van Geisten, Erhart Pfothenhauer in Metropole: Reflexionen. IBA Hamburg – Entwürfe für die Zukunft der Metropole. 2008, p. 228
6. Andreas Gottlieb Hempel in: Wandel ohne Wachstum? Catalogue for the German contribution to the Vth architecture biennial in Venice, 1996, p. 77









# IDEAS FOR A DAY IN THE FUTURE





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Daylight is indispensable for the sustainable renewal of our cities. But how do we convince politicians, investors and citizens of its advantages? What means of communication do we need to convey our experience of daylight to others? And how is daylighting design likely to change in the future?

These themes and questions have been discussed in a conversation between Francesco Anselmo, Arfon Davies and Florence Lam from the engineering firm, Arup and the editorial team of Daylight/Architecture from the VELUX Group.

*In times of progressive urbanisation, how can we ensure that daylight is prioritised in the development of our cities?*

We can learn from the way in which traditional cities adapted to local climate. The shape and density of traditional cities and settlements everywhere depend on the availability of daylight and the angle of incidence of the sun. Earlier, of course, people had to build in this way due to the almost total absence of artificial light. But the question as to how we can make the best possible use of natural resources is more relevant today than it has ever been before.

In a city like Hong Kong, for example, where the densely built-up urban fabric lets in much less daylight than in the cities of the west, natural light was translated into a commercial value at a very early stage; buildings and apartments that receive a lot of daylight are easier to sell and offices with a high incidence of daylight have a higher market value. This is also why Hong Kong has very detailed planning guidelines, which stipulate the distance between buildings, for example.

In London, planning is going in a similar direction. Here, the 'right to light' principle applies; it prevents new buildings from taking daylight away from already existing neighbours. Previously, however, it was possible to pay a neighbour a certain amount of compensation in order to circumvent this right. This did not exactly devalue daylight but did make it a commodity and a matter for negotiation. Fortunately, this practice is changing at the present time. New guidelines and regulations are now being formulated that allow the issue of daylight to be handled in a differentiated manner.

The increasing degree of urbanisation both necessitates and, at the same time, is a prerequisite for such new regulations and planning tools. After all, an individual client or architect can only achieve very little in this area. Politicians, as well as

urban society as a whole, need to engage themselves with this issue.

In all the world's large cities, we need to create the awareness of how important daylight is in the present process of urbanisation. This is all the more important in view of the conflicting requirements in the case of many buildings. If the aim is to improve the supply of daylight, this often reduces the volume of a building or increases its distance from others. The lettable floor space in buildings – the aspect that property developers are most interested in – becomes smaller as a result. However, there are strategies for optimising daylight and floor space simultaneously.

It is up to all designers of buildings to sensitise clients and investors to the importance of these strategies. Much of the work of Arup's lighting designers, for example, consists of conveying the benefit of daylight to others. In this context, it is useful sometimes to consider things from other people's point of view. Architects tend to understand the value of daylight for human well-being immediately. Property developers would perhaps listen to this argument but, in order to influence their decisions, we have to offer them some tangible added value. If, for example, it can be shown that they can have more floor space in buildings through an interactive process of design and optimisation and yet still meet all the requirements in respect of urban planning and daylight, the whole thing becomes interesting for them.

The term 'value' is of interest because it is often used in the communication between designers and clients. Usually, people spontaneously take it to mean monetary value. But, in reality, values are primarily to do with people.

Indeed, we would systematically misunderstand many of the non-monetary values – whether this is health or happiness – if we tried to count them in figures.



In this context, it is worth remembering the prophecy made by the Cree Indians: "Only after the last tree has been cut down; only after the last river has been poisoned; only after the last fish has been caught; then will you find that money cannot be eaten".

*How do we introduce greenery to our cities? How do we use solar energy? Where and how do we create shade in urban areas and what would life be like under treetops created by people?*

At the heart of sustainable urban development, there is a simple question: what do we actually need to survive? This includes forests; the way in which we are developing our cities and cutting down forests today has a considerable impact on our ecosystem. With every hectare of forest that is lost, evaporation decreases, there are fewer clouds, the atmosphere becomes warmer and the CO<sub>2</sub> level rises. Would it not be possible for us to transform our cities into man-made forests, with surfaces that, like trees, filter light, use the energy of the sun and improve the microclimate? This would elevate the importance of daylight in the city and immensely improve the quality of urban life as a whole.

In many cities, consideration is already being given to how sunlight could be used in this way. Large surfaces of buildings could be clad in photovoltaic panels or have vegetation planted on them. If such methods were to be adopted, the availability of daylight in the city would acquire a completely new significance. Our cities would not become real forests but possibly metaphorical ones, designed by people according to the principles of biomimicry.

A lot of things that used to take place organically now have to be planned carefully. Today, the control of land is in the hands of politicians, planners, investors and lobbyists. They decide what is built and have the opportunity to shape our fu-

ture with good ideas. But they also bear the responsibility for doing this in a way that really does justice to human needs.

*What are our basic needs? What kind of comfort do we strive for – and what consequences does this have for daylighting design?*

At the end of the day, these questions are central to any building design process. It seems that we are no longer planning buildings for individuals but for standardised average persons. Quite often, today's buildings tend to have an indoor temperature that is constant over the whole year but it tends to be too high, thus fostering illness. Perhaps, we should allow ourselves a little less 'comfort' in this static sense and expose ourselves more to the fluctuations of the natural climate and sunlight. We should much more often let people choose the kind of climate they would like to live in – both indoors and outdoors.

In daylighting design, for example, we often consider glare as something negative. However, it could be seen positively as well; people stand up when they are dazzled by light and move to a different position in relation to the sun. In this way, glare could be made into an activating factor that changes personal behaviour.

So we are facing two tasks at the same time: to change our cities with the help of daylight and, at the same time, to individualise them. We may, therefore, need to abandon the 'international style' of recent decades. It has made cities the world over look exactly the same, without any relation to the climate, the sun or even the local culture. But where can we make a start in changing things? Would it be possible to develop a differentiated vocabulary for openings used for daylight and ventilation in buildings so that the existing 'one size fits all' buildings can be re-designed and reshaped?

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"The great challenge for us designers is to make our clients understand that money is not everything and that, sometimes, it is worth investing more to generate benefits for human beings. This is not easy, of course, but I see this as a great task that we share for the future: giving people in buildings priority over money."

Arfon Davies



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"We should strive for a variety of spatial situations in which users can make their own choices. Here there are close parallels to urban planning, which is currently turning away from the monofunctional urban districts of the past and trying to generate a small-scale, more vital mix of living and working. Now is the time to promote such ideas; people all over the world are learning to re-assess the value of variety and local identity."

Florence Lam

*What tools are available to architects and engineers for daylighting design today? And how could these tools be improved?*

Talking about tools, we shouldn't forget the past. Many young designers are very enthusiastic about computers and computer-aided simulations. However, we should also value the physical, manual tools previously used for working.

It has been very important for Arup to nurture this 'craft' of daylighting design – and with it, the intuition regarding daylight that can only be acquired through attentive observation, absorbing sensory experience and engaging in experimentation.

The best tools we have are our senses. But people today often look at buildings and rooms through cameras – and through the pictures they make – rather than with their own eyes. At the same time, all outstanding architecture involves spatial and sensory experience, which can only be had in situ and with sufficient time being allowed. It is essential to re-acquaint architects with this insight.

This also applies to the schools of architecture, where we are experiencing a wave of parametric design at the moment. This design practice focuses closely on form and geometry, but are the new computer-aided tools also well suited for the selection of materials? The question as to how materials interact with light and how they are perceived, for example, can only be answered by means of observation.

Thirty or forty years ago, architecture students were encouraged to develop an instinct for daylight and its qualities in different parts of the world. This part of their education has become somewhat neglected today. Nevertheless, it is still useful to improve one's powers of observation, boost the imagination and acquire an inner receptiveness. Facts and figures are great when it comes to precision and, of course, we have to corroborate our concepts. At the beginning of every design, however, imagination should come first.

Essentially, every tool is appropriate in the design process – but the timing is what counts. Furthermore, what matters is taking time to become closely familiar

with the tools and sometimes calling them into question.

The Arup lighting team uses design tools according to this principle. At the start of a design process, there are open questions arising from the design – for example, when the architect has designed a particular shape of building that Arup wants to optimise in respect of daylighting. In such cases, the team often develops special tools, because standard software does not offer any solutions. This is what can make a project fascinating – it is necessary to be creative and develop your own spirit of research.

The Arup lighting team starts many projects in a very conceptual manner, with a sketch or an inspiring image. Then the work is continued with a physical model relatively soon after. In many of their projects, especially museums, the lighting designers insist on seeing spaces in a model or even on a scale of 1:1 before they are actually built. To Arup this is the only way they and their clients can really experience the effect of light. With numbers alone, this would be impossible.

*What potential do digital simulation tools offer?*

Computer simulations can be useful, particularly in very early design stages. The level of daylight in a room often has to satisfy certain minimum requirements, for example. With computer simulations, it is possible to judge at a very early stage whether you are on the right track. The VELUX Group has developed such an intuitive program, the VELUX Daylight Visualizer. The program is intended to enable architects to maintain control over the daylight and the indoor climate instead of delegating these matters to specialists.

Computer programs can also play another important role: if we want to express daylight's variability over time and in a space, enormous amounts of data are created. The challenge will be to process this data digitally so that people who are less used to working with computer models also understand it.

Furthermore, computer simulations are useful for developing and doing the calculations for a large number of design



variants. The problem here is that it is easy to make big mistakes, which would not be possible with the physical model. Quality control is therefore essential wherever simulation tools are used.

To the Arup lighting team, one of the most valuable tools is a collection of interior photos of their previous projects, which they use as references for future designs. This includes not only conventional photographs but also HDR (High Dynamic Range) ones, showing the luminance distribution in a space. With the help of such pictures and the spaces they show, it is possible to give clients an impression of what daylight quality they can expect to encounter inside their own – yet unfinished – buildings.

The Arup engineers also gather their own climate data at locations where they are planning buildings. Although weather and climate data exist for many places all over the world, they are not always precise or available to everyone. Arup's measuring instruments are comparable with Mars Rovers, which are set out in very different places and that supply the designers with data for a year or longer. The data is rather simple – the ratio of direct to diffuse sunlight, for example – but it is reliable.

*How do we make our data and tools generally accessible so that everyone is able to participate in the knowledge of daylight?* We have to reach many more people than today if we want to make our cities more sustainable and people-friendly. We must sensitise not only individual architects, but also investors and housing construction companies to the issues involved – as soon as possible.

When you want to repaint your bedroom at home, for example, you usually consult one of these RAL colour charts with hundreds of different swatches. It would be interesting to develop a similar chart or a picture book with hundreds of light moods from which people could make their choice. This should be a simple tool, a collection of best-practice examples. In fact, many different books would be needed – a different one for every climate and every location.

In the context of the latest International VELUX Award for Students of Architecture, the VELUX Group asked each of the participants invited to the award event to bring along his/her own 'magic daylight moment' – in the form of a photo, a poem or whatever. The task was then to talk about one's own special 'magic moment' to the other participants and try to jointly develop something like a collective daylight moment – a situation in which daylight brings people closer together. Would it be possible to develop a tool with the help of which people could communicate their own daylight moment easily and fairly precisely? It could act as a catalyst for the transformation of our cities.

*We take daylight for granted in our everyday lives. But will our children still be able to do this? Will they have enough daylight?* The British neuroscientist Russell Foster advises us to take a 'photon shower' every morning to adapt our biological clock to the rhythm of nature. Today, the need for this is often forgotten. In former times, people used to work mainly during daylight hours, sleeping longer in winter than in summer. Perhaps, this would be a more natural way of life that would be better for us. In any case, we risk a feeling of permanent jet lag unless we adapt our rhythm of life to the rhythm of the sun and recognise its signals.

The situation also has a crucial social component. We allow people to follow a rhythm of life that is unhealthy for them. At the same time, we often force them to do so. In the world of work in particular, many processes have speeded up to such an extent that people are frequently compelled to work in the evening or at night – rather than during daylight hours. So maybe we do not only need a new culture of building but also a new culture of time.

If we learned to be aware of daylight in all its nuances, this would certainly be a first step in the right direction.

*What role can future standards and guidelines play in order to supply people with daylight more effectively?*

The fundamental problem is that the time

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"We have sufficient daylight and will probably still have enough in future but not necessarily of sufficient quality or at the right time in the right place. Even now, we spend most of our lives in buildings where the level of daylight is not necessarily conducive to health. Perhaps, we will assign greater value to daylight in future for just this reason – because we will have less of it in our everyday life."

Francesco Anselmo



variable is missing from current building standards. We have made progress in moving beyond previous, static methods of measurement such as the daylight factor, which only considers diffuse daylight. But there is still a lot to be done before we have understood the fluctuating nature of daylight sufficiently to incorporate it in standards and design criteria. This concerns not only the climate-dependent variability of light but also the individually different needs of human beings.

A good tool or a set of rules is one that answers the crucial questions. And, in the case of daylight, these are: can I work under certain lighting conditions and do I feel comfortable in doing so? Future standardisation will have to address these questions. So far, standards often tend to be a result of lobbying and the intention to sell some product or other; they are less frequently aimed at improving living conditions.

*How will the practice of daylighting design change on the whole?*

We have a great opportunity to revive the forgotten art of daylighting design in architecture. Let's hope that the profession of the daylighting designer will become established in architecture – as a specialist right at the beginning of the value chain, whose advice clients request at the very start of a project. At the moment, the problem is that many specialist planners are consulted much too late, i.e. when they can no longer exert an influence to generate added value for the building.

Furthermore, daylighting should be made into a mainstream issue. We must ensure that daylighting design does not become a hermetically-sealed discipline that is excessively fixated on figures. If we want to make daylighting into an everyday issue, we must speak a language that people understand and with which they can intuitively gain access to the topic!

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