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EVOLVING ARCHITECTURE





EVOLVING ARCHITECTURE

In November 2016 The Daylight Award of the VELUX Foundations was given to Steven Holl and Marilyne Andersen – for daylight in architecture and daylight research respectively.

The relationships between structure, material and light are at the core of Holl's approach to architecture. The jury noted that he is known for his poetic idiom, manipulation of lighting, respect for materials and adapting his buildings to their local surroundings.

According to the jury, the award for daylight research went to Andersen because she is an outstanding scholar and teacher, as well as a diligent researcher who has demonstrated a talent for initiating and directing daylight research that affects research and architecture environments. Holl and Andersen are both known to spend a lot of time at universities, conveying their knowledge and skills to the coming generation of architects and researchers.

But how do the results of Marilyne Andersen's research find their way into building design? And how can Steven Holl's ingenious spatial concepts be shared in the future built reality?

The accumulated knowledge about the benefit of daylight for human beings and our best practises in this area needs to be shared and spread by bridging science and practice, and by sharing beyond professional disciplines if we are to change architecture and develop healthier buildings for people.

We need to learn from building users' experience and we need an exponential learning curve to encompass new experience as well as new generations of designers and users. This will only be possible if we have access to users' feedback – and if we are capable of processing it professionally. Tools are at hand – but we need to make better use of them. This issue of Daylight/Architecture features these topics, from the design process to the generation of knowledge in architecture.

In the first chapter, Vellachi Ganesan describes the task facing architects and engineers: the creation of buildings and spaces that protect us like a second or third skin at

the same time as providing us with daylight and fresh air, while readily adapting themselves to all our activities and simultaneously enriching our sensory experience.

In the second chapter, Marilyne Andersen and Steven Holl share their thoughts on architectural design processes, the role of daylight in architecture, their experiences as teachers and their goals and hopes for the future.

Chapter three presents five 'bridge builders' suggested by Andersen and Holl who reflect on question like – what decides the success or failure of interdisciplinary planning processes? And what role do our human needs play in building design?

The answers make it clear that the benefits of daylight for health, well-being and productivity are becoming more and more important in discussions with clients. Public health is a valuable commodity and more productive, motivated employees make for a fast return on any investment by their employers. Buildings in which people spend up to 90% of their time today can make an important contribution to both these ends.

At the same time, existing knowledge of the benefits of daylight needs to be constantly refreshed. Architects must always be ready to go and learn how their work is used, requiring a willingness to revisit buildings after their handover to the users. Rarely have monitoring processes and the post-occupancy evaluation of buildings been more important than they are today. For this reason, the last article – chapter four – in this issue describes how the well-being of building users can be measured in order to create a knowledge base for the design of better buildings in the future.

We hope that this issue of Daylight/Architecture contributes to the discussion about how we can design healthier buildings and how the designs can be implemented in practice.

Enjoy the read!
The VELUX Group

D/A

VELUX Editorial	1
Contents	2
People	4
Process	12
Works	64
Feedback	76

12

UNDERSTANDING THE HUMAN RESPONSE TO DAYLIGHT

Marilyne Andersen has made it her mission in life to understand the effect of daylight on people. She wants to use this knowledge to develop new methods and simulation tools for building design. In Daylight/Architecture, the winner of The Daylight Award for Daylight Research reports on her research agenda, her work as dean at the EPFL in Lausanne and her experience relating to interdisciplinary cooperation.

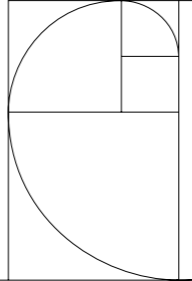


PHOTO BY: RASMUS NORLANDER

4

COMFORTABLE IN MY OWN SKIN

Great architecture addresses both our senses and our intellect. It tells us something about how it was made and conveys an attitude to human existence. In her article, Vellachi Ganesan describes how such architecture is produced. Her credo is: only someone who feels comfortable in his or her own skin can design spaces where others truly feel at home.



YING ZHENG

26

DESIGNED FOR ALL SENSES

Steven Holl obtains his inspiration from philosophy, music and literature. From these abstract sources, he derives an architecture that touches people very concretely and emotionally. Jakob Schoof spoke to the winner of The Daylight Award for Daylight in Architecture about his method of working, his teaching experiences and the meaning of daylight in his buildings.

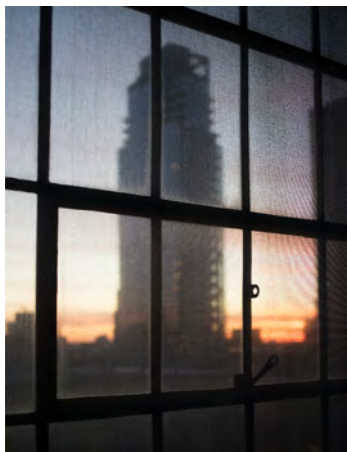


PHOTO BY: GREGORY HALPERN

50

ARCHITECTURE AS TEAMWORK

The time when small architectural practices were able to design even large buildings on their own is past. Today, the ever-increasing technical requirements for buildings make the cooperation of many different disciplines indispensable in the planning process. In Daylight/Architecture, five of these 'bridge builders' between science and the art of architecture report on their work.



PHOTO BY: TRANSOLAR



PHOTO BY: NINA VÄTÄNEN

66

WORKS BY STEVEN HOLL

The construction and subsequent operation of a building is a 'reality check' of the architect's ideas and the engineers' calculations. It is here that the daylight and indoor climate inside the spaces can be seen and felt for the first time. This visual essay shows key examples of Steven Holl's work in photographs.

76

MAKING SENSE OF SENSIBILITY

How does new knowledge in architecture arise? One way of acquiring it is to ask the real experts of everyday life – in other words, the people who actually live and work in buildings. In the last few decades, scientists have developed numerous methods of measuring their well-being and explaining their behaviour. Jakob Schoof outlines them in his article.



PHOTO BY: IVAN BRODEY

Comfortable in my own skin
By Vellachi Ganesan



Architecture is often compared to a second or third skin that protects us and at the same time, provides an important interface between the internal and the external world. Not all buildings live up to this claim to the same degree. For architecture to be both functional and sensual, and to accommodate life in all its fullness while providing opportunity for contemplation, designers must engage their own personality, their memories and convictions in the design process.

OUR SKIN, AS WITH ALL human biology, is a magnificently designed organ. It protects the interior of our body, keeping it cool, while at the same time allowing us to experience the outer world in its fullness. It is a primary organ through which we sense and interact with daylight, and it is the place where vitamin D is synthesised, an indispensable part of our nutrition that keeps us healthy and fit. Skin is constantly changing and evolving with our natural environment. It grows old with us, serving us at each stage, and serving as an account to our lives. Though we are never quite aware of our skin, it defines our very perception and is the lens through which we experience the world. Beyond just the physical touch, our skin can give us a sense of feeling alive, the vibrancy and frequency that makes us feel connected to the universe.

In so many ways, architecture is an extension of our skin, it *is* another skin. It protects us from the outer environment, and at the same time gives us a window to perceive the world through. The way in which we design architecture has the potential to keep us

healthy, to connect us with our environment, to age with us and, most importantly, to make us feel alive.

I remember summer holidays when I was a kid, and my family would travel back to our ancestral home in Chettinad in Southern India. What I remember most vividly about the house is the courtyard, the central space around which the rest of the house was built. There was an energy about it – the concrete floor had cracks in it from the years of weathering, light flooding through the house that was otherwise mostly shaded, you could access the daylight without necessarily being *in* the daylight. It was around this courtyard that the family gathered, carrying out daily tasks amid the continuous conversations, where the children played, where the clothes were hung, rainwater collected and chillies left out to dry. Even now, as I go back to this home built generations ago by my great grandfather, it feels familiar, like a part of me, and never fails to energise me.

Vernacular architecture, like the house my great grandfather built, has a way of feeling like skin, a perfect fit that has evolved over years to make us feel comfortable and at home. Built by those who would eventually inhabit the space, such houses were created in a most unassuming way. The architecture was not motivated by any intellectual notions, but rather grounded in the way of life.

Heidegger speaks of the Black forest farmhouse in a similar manner and contemplates that the human quality of the house comes from the building process, which itself was ‘dwelling’. He speaks of fourfold ele-



VELADH GANESAN



GREGORY HALPERN

ments that make up the essence of dwelling as earth, sky, mortals and divinities. Being connected to the fourfold, to the earth that grounds us and the sky that defines our limits, to the natural environment around us, to our own perception of ourselves and of our place in the universe, we are connected existentially to ourselves. It is only from this state of being connected, that we can design most authentically and meaningfully.

Contemporary architecture on the other hand, much more diverse and colourful in its pursuits, sometimes engages and nurtures us at this same level, and sometimes not. I believe that the spaces that do engage us, that do touch us, that offer experiences not only of space but also of ourselves, are designed in insightful ways that understand the essence of *being*. It is no surprise that daylight is often a key element of such dwellings, as we human beings have a primal and inextricable relationship with light as a reflection of ourselves.

From my inquiry into the design process of these master architects, as well as from my practice as a designer and artist, and from my observations of my students, I find that the design process of creating such human-centric work, is a dance between knowledge and intuition. Constantly moving between rational thinking processes, and listening to our instinctive voice within, enables us to delicately fuse the measurable and the immeasurable, both of which are essential parts of the human being. By accessing ourselves in a primal human way, we can communicate this quality to those who inhabit the spaces we design.

“Let us think for a while of a farmhouse in the Black Forest, which was built some two hundred years ago by the dwelling of peasants. Here the self-sufficiency of the power to let earth and heaven, divinities and mortals enter in simple oneness into things, ordered the house. It placed the farm on the wind-sheltered mountain slope looking south, among the meadows close to the spring. It gave it the wide overhanging shingle roof whose proper slope bears up under the burden of snow, and which, reaching deep down, shields the chambers against the storms of long winter nights. It did not forget the altar corner behind the community table. A craft which, itself sprung from dwelling, still uses its tools and frames as things, built the farmhouse. Only if we are capable of dwelling, only then can we build.”

Martin Heidegger, Building, Thinking, Dwelling

“Architecture strengthens the existential experience, one’s sense of being in the world, and this is essentially a strengthened experience of self.”

Juhani Pallasmaa, Eyes of the Skin

To allow for intuition to be part of the design process requires us as designers and architects, to engage our own personality, our own memories, our own convictions in our design. There is a certain level of vulnerability that we must be willing to accept for the design process to be genuine. To be honest in our design is to lay a part of our most intimate selves bare to the public eye.

In our present-day world, time moves very quickly. Technology, economics and politics have accelerated the pace in which we are expected to move. In this time scale, the connection with being, the essence of being human, is somewhat lost amid the countless distractions that constantly surround us. It is in this time that architecture that brings us back to this essence is fundamentally necessary. And for us designers and architects to design such work, we first need to be comfortable in our own skin and use it as a great inspiration in our work.

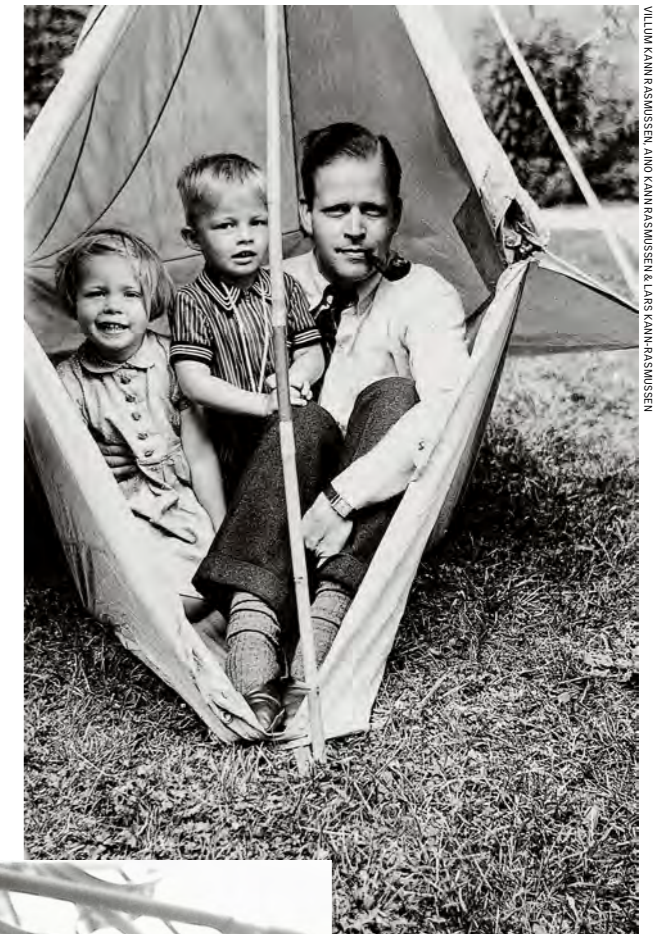
Vellachi Ganesan is a lighting designer, light artist and design educator. Born in Singapore, she studied architecture (BA) in Singapore and Paris, as well as architectural lighting design (MSc) in Stockholm. Among other things, she has worked as a lighting designer for Arup, the Design Abode, and the Icehotel in Sweden. She works collaboratively across disciplines with architects, designers and artists to create work that is meaningful to the human being. Vellachi's work has received notable recognition, including the Special Commendation Award (Special Projects) at the Lighting Design Awards. Currently she lives in Salt Lake City (USA), where she is an associate instructor at the faculty of architecture of the University of Utah.

“Kahn saw human being as a unique meeting of the measurable and the immeasurable. This meeting can be seen in the play between knowledge, which is measurable, and intuition, which is immeasurable.”

John Lobell, Between Silence and Light-Spirit in the Architecture of Louis I. Kahn

“Memories like these contain the deepest architectural experience that I know. They are the reservoirs of the architectural atmospheres and images that I explore in my work as an architect.”

Peter Zumthor, Thinking Architecture



PROCESS

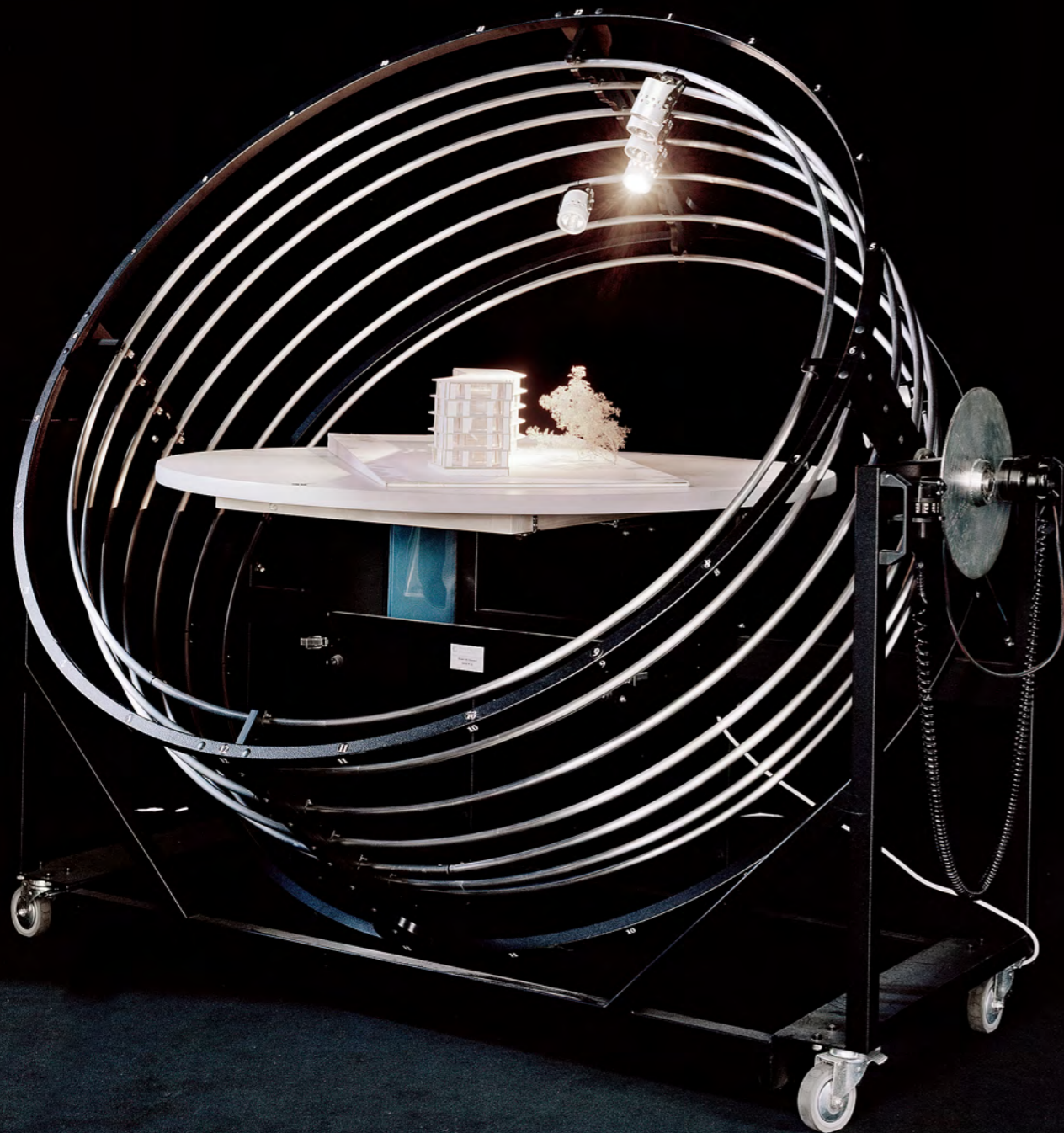
Among all the arts, architecture is the one that has always been most influenced by engineering and science. When buildings are being designed, mind and body, sense and sensibility, must come together. To this end, the designer needs not only strong conceptual ideas but also – and to an increasing extent – the specialist knowledge of many different disciplines. “The science of construction, of materials and stresses, of energy balance doesn’t sit separately from an artistic idea or the inspired feeling provoked by light and space,” says Steven Holl, winner of The Daylight Award 2016.

But how to reconcile the measurable, technical aspects of architecture with its artistic and emotional side? What sources of inspiration do architects draw on in their work? And which special disciplines have to contribute their expert knowledge so that spatial concepts can become built reality?





UNDER-
STANDING
THE
HUMAN
RESPONSE
TO
DAYLIGHT
MARILYNE
ANDERSEN



Marilyne Andersen is currently rated one of the world's leading daylighting experts. Together with her research team at the EPFL in Lausanne, the physicist has devoted much of her work to studying how natural light affects humans and how this intensely dynamic interaction can be better incorporated into the designs of buildings. In November 2016, Marilyne Andersen received The Daylight Award for Daylight Research for her work in this field.

By Jakob Schoof
Photography by Rasmus Norlander

DAYLIGHTING DESIGN is an art of mediation: between the specific daylight conditions on a given site and the comfort requirements of the building users, between qualitative design goals and measurable physical quantities, and between the different levels on which daylight influences human beings. Natural light has both visual and non-visual effects, it can cause glare and influence thermal comfort, it regulates our sleep/wake cycles and it has a significant influence on our appreciation of the quality and attractiveness of a space.

Reconciling these different aspects can be a lifelong task. Marilyne Andersen has devoted herself to this mission. Born in Switzerland, with a significant portion of her academic career spent in the United States, she is considered one of the leading daylighting experts of her generation. She is currently Dean of the School of Architecture, Civil and Environmental Engineering (Faculté Environnement Naturel, Architectural et Construit/ENAC) at the EPFL in Lausanne. Interdisciplinary thinking is a fundamental ethos at this particular school: natural scientists and social scientists, environmental and civil engineers, architects and urban planners train the students in all matters affecting built and natural environments. Many topics are taught in interdisciplinary courses.

As a researcher, Marilyne Andersen has always aimed to facilitate the close exchange between different disciplines. When she first began her studies, she wavered for a long time between her two favourite subjects: physics and architecture. "I liked to draw and I even thought I would create comic books to educate about science. The job of an architect didn't really appeal to me, however, so I decided to do physics instead. But at the end of my physics degree everything was equations and nothing was physical, and I wanted to go back to architecture.

So I went to the Solar Energy and Building Physics Laboratory (LESO-PB) at the EPFL, which offered semester projects in building physics, and the most architectural one they offered was on daylighting. This is what first got me into this subject." Marilyne Andersen has remained true to her specialist area, conducting research into topics linked to daylighting in both her master's thesis and her PhD. This was followed by a professorship at the Massachusetts Institute of Technology (MIT), before she returned to the EPFL in 2010. "The field of daylighting is extremely diverse. It deals with perceptual aspects, aesthetics and health, and has links with psychophysics, neuroscience and computer science. I find this interdisciplinarity very appealing."

In recent decades, interdisciplinarity has increased as the focus of research has shifted. "Research on daylight in architecture started in the '70s and was very much driven by energy issues at the time. People were mainly concerned with how to replace electric light with daylight in order to save energy. In the meantime, the subject has evolved to include many other aspects of daylight – from physical and mental well-being to connections to the outside, to temporal aspects, and to the weather-dependency of daylight. These aspects are less measurable and thus less comfortable to work with. But I find them more interesting than questions about energy, which, to me, tends to reduce the benefits of daylight to an intake of heat and illumination, whereas, in reality, it is much more than that."

Since a new photoreceptor in the eye was discovered in 2002, the health aspects of daylight in particular have gained increasing attention. "This is where daylight can have most impact. Good daylighting might save a few percent in terms of energy costs, but what proportion of the overall building cost does this represent? Almost nothing. In terms of well-

being, productivity and health, however, daylight can make a huge difference.”

Learning to respect others

When Marilyne Andersen was elected Dean of the ENAC in 2013, she was not just the first physicist to hold this post in a school regrouping architecture, civil and environmental engineering, she was also the first woman and by far the youngest dean in the history of the EPFL. As head of a faculty of about 800, with more than 60 professors and research laboratories focusing on subjects that range from architectural theory to environmental toxicology, Marilyne Andersen has her own view on how interdisciplinary cooperation functions. “A lot of people are involved in designing a building. This can be compared to a long chain where everybody holds hands, receiving information from the previous person and passing it on to the next one. If the whole chain is organised in a linear manner, progress is very hard. One person who lets go of one hand by stepping forward is sufficient to break the chain and make the project grind to a halt. Furthermore, it can be difficult to move all the disciplines into the same direction at the same time. In my opinion, the chain should be organised more like a circle, where each person talks to another. The architect still remains the ‘master of ceremony’ but he is probably not the only decision-maker. If he establishes a dialogue with the other stakeholders early in the design process, then the design might also be influenced by the structural engineer or the energy consultant. This kind of collaboration will make the proposal more viable and the chain will be easier to deal with afterwards.”

The people involved in the process do not necessarily have to be all-rounders. For Marilyne Andersen a deep knowledge of one’s own discipline is of primary importance. This should be combined with the ability to listen to other disciplines,

while not necessarily speaking their (specialist) language. Respect for the skills and capabilities of the other planning partners and a willingness to regard partners as equals is indispensable. “What is important is that people stay strong in their own discipline, because if everyone becomes a generalist, you don’t get anything good. On the other hand, people have to be comfortable with dealing with others who don’t speak their language. Learning this is very important and has to happen already at university. We teach our students to accept interdisciplinary collaboration as an interesting challenge, get familiar with it and consider it an enrichment to have someone with a different background collaborating on the same project. This mind-set enables them to achieve things that they could never have achieved alone.”

Similar prerequisites also apply to the teaching staff at ENAC. According to Marilyne Andersen, they need a sort of ‘T-shaped’ qualification: “We need disciplinary depth but teaching at ENAC also requires an open mind and curiosity towards other disciplines to build ties and develop new ideas at the interface of domains.”

Contrary to faculties at other universities, ENAC introduces interdisciplinary collaboration early on in undergraduate education. In the second year, all students – architects, environmental engineers and civil engineers – take a one-week intensive course together, co-taught by professors from different disciplines. “They are faced with a problem that they couldn’t solve alone and for which they have to combine their skills,” says Marilyne Andersen. “This is usually a quite successful venture for the students. It’s hard to organise, but it’s highly enriching. We repeat it in a different format in the third year, with one afternoon per week over a semester, where they also collaborate on a project in order to foster this exchange.”

Many paths lead to better knowledge

In her career as a researcher, Marilyne Andersen has acquired extensive expertise in dynamic daylight simulations. In her own teaching, she focuses keenly on simulations to give students a better understanding of daylight. But this year she will be expanding her repertoire to take account of other, unquantifiable properties of light. “We will use physical models to explore the qualitative aspects of light, supported by simple tools like the heliodon to understand and anticipate sun courses and shadows. We will use photography and drawings to capture a lighting atmosphere that the students then try to recreate in a physical model. Afterwards, they photograph the model and use this as the objective to attain in a computer simulation.”

The experience of actual, built space allows us to better understand the connection between numbers and actual conditions in terms of glare, illumination levels, views out and other daylight-related aspects. Rather than saying ‘I need 300 lux on the work plane’, the ambition is to imagine a specific atmosphere in a space and then try to turn it into reality.” Subsequently, the lighting scenario is validated through a quantitative, simulation-based approach.

In Marilyne Andersen’s opinion, simulations are especially suitable for anticipating the dynamic changes in the levels of daylight – something no other approach can achieve – and for making quantitative predictions. “There have been many attempts to make simulations usable at early design stages. This is difficult, however, because it requires decisions that cannot readily be made and an accuracy that is hard to achieve early on in the process. Physical models, by comparison, allow a straightforward approach to assessing the qualitative aspects of light. They are almost useless, however, when it comes to quantitative evaluations and





are very limited in how representative they can be of reality, especially regarding variability and dynamics. Simulations are thus ultimately the answer to enabling advanced daylighting studies and have capabilities far exceeding assessments of sensor plane illumination. Their potential is also huge in terms of perceptual effects if approached properly.

Research beyond disciplinary boundaries

In 2004, as an assistant professor, Marilyne Andersen founded the Daylight Lab at MIT. Six years later, she created a research group with a similar spirit but a slightly broader scope, called the Interdisciplinary Laboratory of Performance-Integrated Design (LIPID) at the EPFL. “At MIT, I had developed a keen interest in connecting with other disciplines, particularly from the field of health, such as photobiology and neuroscience. Even though I had been educated as a natural scientist, trying to understand each other was difficult but very enriching. In Lausanne, I wanted to continue to have a lab that could reach out to other disciplines. I had become very fond of daylight in its multiple aspects, particularly the human-centric ones. I was also interested in the ability to communicate building performance in a graphic and intuitive way. This can go beyond daylight as such. Nonetheless, daylighting remains the core that visual comfort, perception, and health all relate to.”

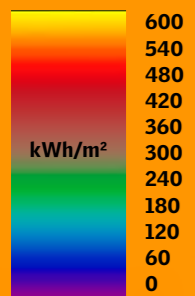
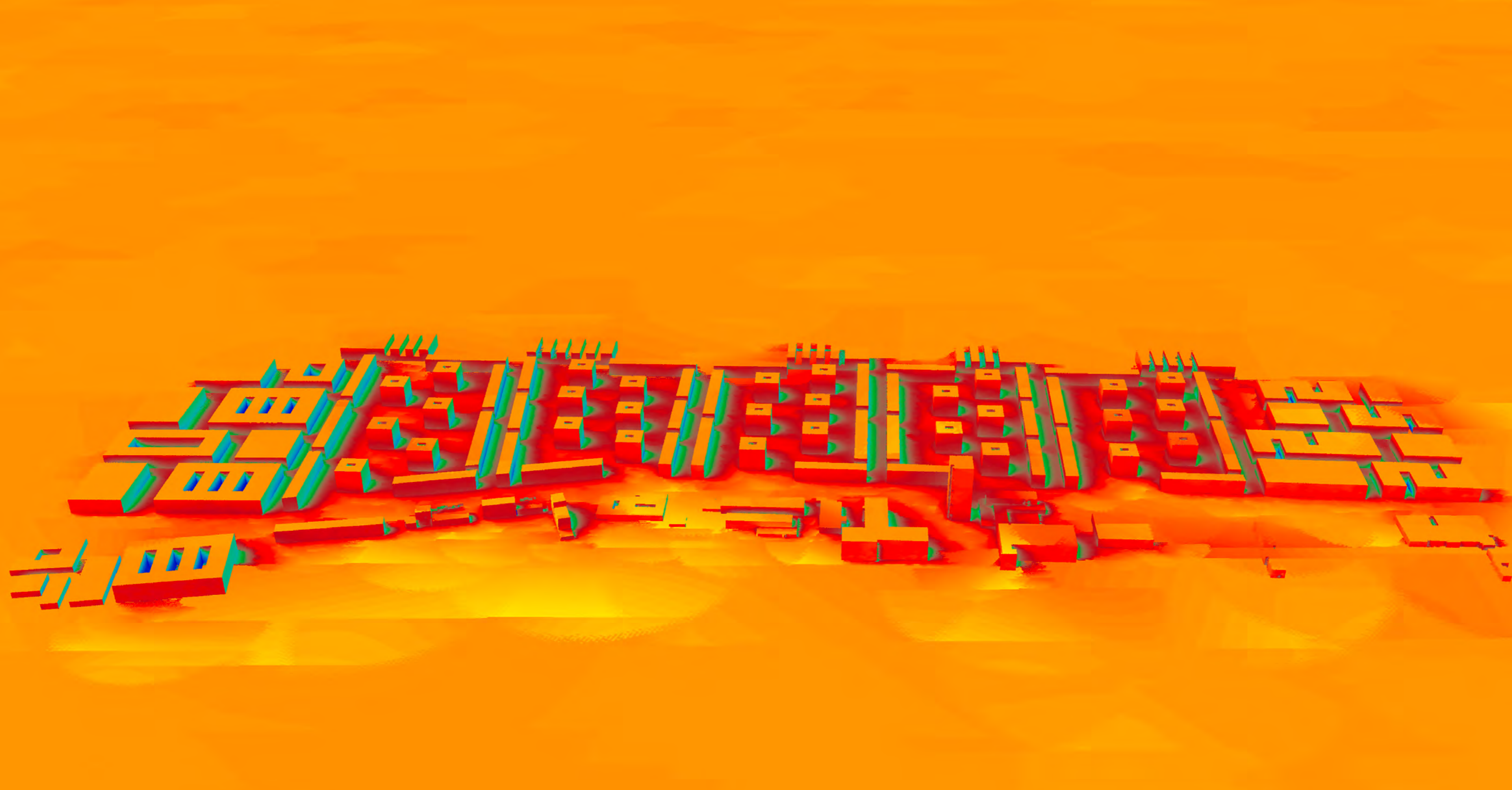
Marilyne Andersen is currently supervising nine PhD students in her laboratory. Four more PhD students have completed their dissertations in the last two years. If you look at the topics in more detail, it is striking how much they complement one another and create a central research agenda. “Most of our research is driven by questions we want to ask ourselves. We apply for funding, of course, with institutions such as the National Science Foundation or the VELUX

Stiftung, but are not doing any commissioned research at the moment. So no one is telling us what research topics to take on board. Defining a theme for a PhD student is a delicate balance, of course: on the one hand, there has to be a certain coherence in the lab and its research agenda, but on the other it is important that the PhD students take ownership of their projects and that the projects reflect their preferences and what they are best at.”

Currently the LIPID researchers are investigating the effects of daylight in four different fields – comfort, perception, health and energy – as well as the interdependencies between these fields. “We do this on the human scale but also on the neighbourhood scale,” says Marilyne Andersen. “A common denominator of our work is that we work a lot on decision support, aiming to visualise performance and provide designers with the information that enables them to understand what is happening in a building or room, and then make the right decisions.”

To this end, Marilyne Andersen and her team are currently working on further developing a daylighting simulation program called Lightsolve. The software was originally created in 2008, but researchers at LIPID have since completely reprogrammed it and added new functions. The program makes it possible to explore daylight in rooms in both its spatial and temporal dimensions. As the user moves through the virtual space, the renderings are updated in real-time. The results can be displayed both in absolute and relative values (compared with a design objective which was specified a priori).

One new element of the updated version of Lightsolve is the number of dimensions of daylight that the program can now simulate. The software does not just determine absolute light levels in a room, potential glare effects or overheating risks, but can also show representations of visual interest – especially driven



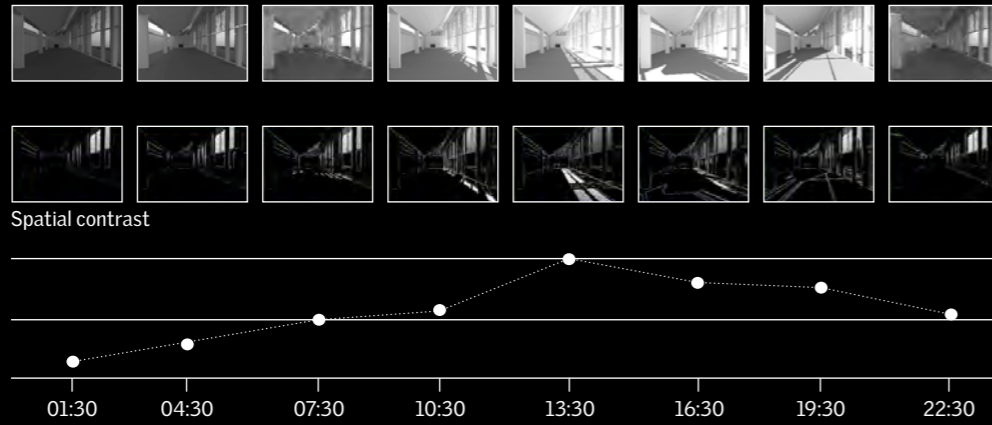
Irradiation maps in a dense neighbourhood design. The researchers at LIPID use computer simulation tools to assess the solar potential of urban design projects at an early stage in the process. This allows them to make predictions

about the energy demand for heating, cooling and lighting in the buildings, as well as about their capacity for harnessing solar energy with photovoltaics and solar thermal installations. (Image: E. Nault, LIPID Lab, EPFL)

Contrast and visual interest analysis over space and time. Using contrast and temporal variation as a proxy for visual interest in a space, PhD student Siobhan Rockcastle at the LIPID lab

is developing methods to predict how attractive an average viewer will find a given architectural space. To this end, she evaluated a number of spaces in architectural 'landmark' build-

ings using computer simulation tools. (Image: S. Rockcastle, LIPID Lab, EPFL)

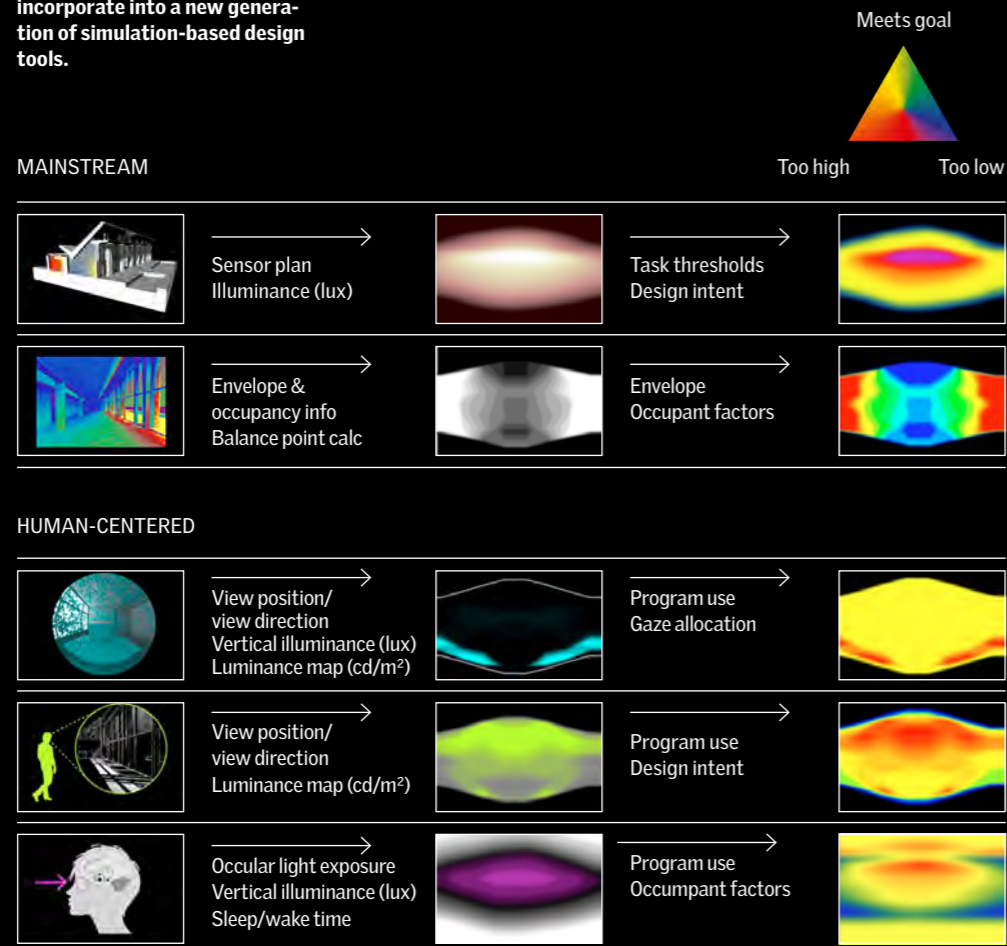


Exciting ↑
↓ Calming

Five perspectives in connection to decision support regarding daylighting performance. The graphic provides an overview of the five key dimensions of daylight and its effect on human

beings that Marilyne Andersen and her PhD students are currently studying and seeking to incorporate into a new generation of simulation-based design tools. (Image: M. Andersen, LIPID Lab, EPFL)

(Image: M. Andersen, LIPID Lab, EPFL)

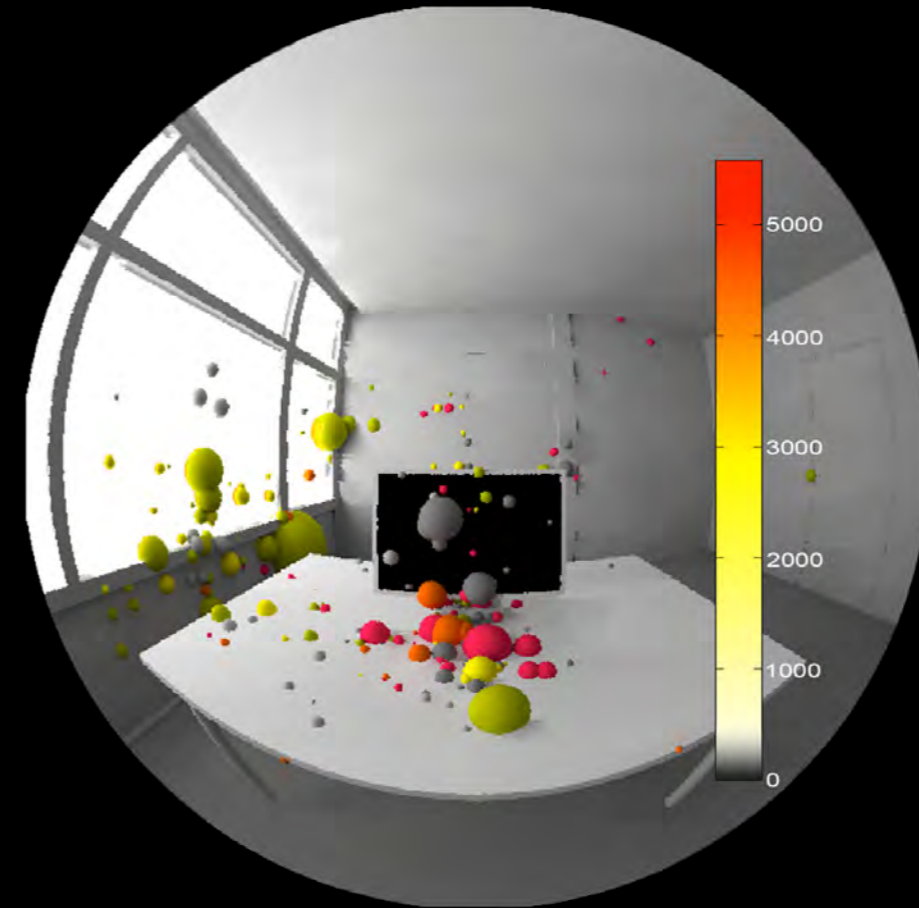


View directions depending on indoor brightness and visual discomfort conditions. Traditional methods to assess glare in office spaces do not take into account where people actually look. To

overcome this limitation, Marilyne Andersen's PhD student Mandana Sarey Khanie conducted a series of experiments under simulated office conditions and recorded the participants' gaze

using mobile eye tracking. At the same time, the luminance distribution in the room was recorded using high dynamic range imaging. Both methods were then integrated in order to derive

'gaze-centred' luminance measurements in the field of view. (Image: M. Sarey Khanie, LIPID Lab, EPFL)





by sunlight spots and high contrast areas – and of health potential. This is achieved through a novel model that embeds findings from photobiology into a lighting simulation workflow.

Deriving evidence from built reality

Anyone attempting to tackle these questions will inevitably have to deal with numerous unknowns. “The arousal effect of daylight as well as its potential benefits to health depends on a large number of variables, such as the illumination level at the eye, the time of day, the spectral composition, and even the ‘history’, i.e. what kind of light in what amounts the person has been exposed to in the previous hours and days. These factors can vary from one individual to another, due to inter-personal differences (e.g. the sleep-wake cycle) but also to behaviour, interactions with one’s environment and preferences. The probability of glare, on the other hand, depends not just on the overall brightness and contrast in a room but also on where a person is looking and thus where he or she is drawn to look. In a test room experiment, we have therefore tried to find out where people typically look in an office space, performing a range of office tasks in various lighting conditions. Not surprisingly, they tend to look away from their computer screen for non-screen-intensive tasks (e.g. thinking) and be attracted to bright areas like the window, except when the latter generates extreme brightness conditions.”

When assessing daylight pattern preferences, LIPID researchers use mainly two parameters: the contrast between light and shadow and temporal variation, both also taken from a compositional perspective. “We are currently validating this using virtual reality headsets where we display different lighting situations in a space and ask a number of test persons to judge how attractive or exciting they find this space.”

Marilyne Andersen considers such tests with real persons to be an important means of closing the knowledge gaps in the models on which the simulations are based. “We can never go further in our simulation tools than the underlying scientific evidence allows us to. Moreover, we are also investigating the linkages between different aspects of daylight. Currently, one of my PhD students is conducting another test room experiment to find out how thermal and visual comfort are correlated: Do you feel warmer at the same temperature when it is brighter, or when the light is bluer or more orange? Do you feel more disturbed by glare when it is hot, even though the brightness and contrast in a room haven’t changed?”

Marilyne Andersen also believes that surveys of users of real buildings are essential. For her, it is not just about developing simulation programs. “There is definitely a need to assess the acceptance of the indoor environment in buildings. If people are unhappy with the conditions, they tend to override the controls or resort to makeshift solutions, which usually has detrimental effects on the energy performance of the building. Furthermore, we need a more transparent communication of the lessons learned in post-occupancy evaluation. Unfortunately the results are typically not made public if there is a failure. Moreover, few clients actually commission a post-occupancy evaluation due to the associated cost – and the cost of refurbishment if a building proves to be unsuccessful. Because once you know about a failure, you have to do something about it.”

“On the other hand, current approaches to post-occupancy evaluation of buildings also have their limitations,” says Marilyne Andersen: “People may not be willing to answer a questionnaire or perform tasks that they have been assigned purely for research purposes. Then there are the measuring instruments that you

need for a post-occupancy evaluation, which always create a somewhat artificial setting. In an ideal but hypothetical world, we would therefore have non-intrusive EEGs that can sense the level of well-being and satisfaction of a person, and enough understanding that we can measure performance at work without having to assign people specific tasks. In the end, the goal of our efforts must be to anticipate people's reactions to their environment so that we can create the best possible environments right from the start."

The greatest challenge: connecting research to mainstream building design

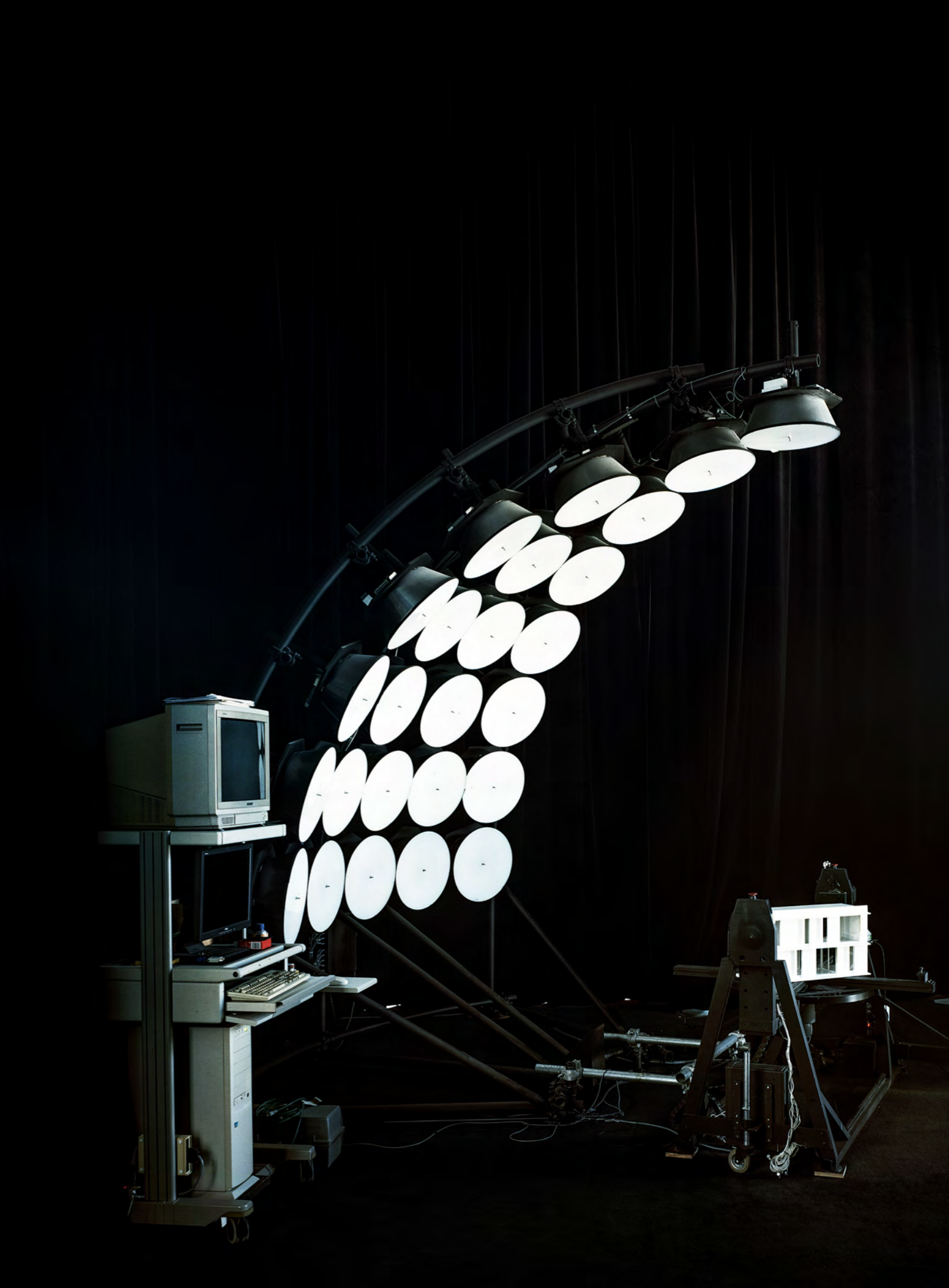
Together with her research team, Marilyne Andersen has situated herself on the narrow but important bridge that links fundamental daylight research to the everyday realm of building design. Simulation tools such as the one currently being developed at LIPID may be an important means to strengthen this bridge. Yet Marilyne Andersen is cautious about directly handing over Lightsolve to architects and lighting designers: "The questions that we still need to answer both on the perceptual and the health aspects of daylighting are getting increasingly complicated. At this stage, it would therefore be premature to provide Lightsolve as a tool to designers. They might get an answer or a set of numerical values from it but how would they know what this answer means? With only the answer, but without the ability to interpret it, you might take a decision that is wrong. For this reason, there has to be an effort to educate the public first so that the underlying concepts are better understood."

At the moment, Marilyne Andersen has noted that research and practice seem unable to reduce the gap that separates them: science is regularly producing new evidence that, however, is being taken up rather slowly and sporadically in building design. To a large extent this is due to the segmentation of design disciplines that still prevails, and to the need for new standards that ultimately impose

more ambitious objectives to be fulfilled. Nonetheless, she is hopeful about the future: "One of my greatest endeavours is that what we are working on right now will become a part of mainstream building design in the next 10 to 15 years. If we succeed in this, it will no longer be an exception for clients and architects to think about daylight and its relations to health, productivity and connection to the outside, but a matter of course. I hope that in a few years' time we will be in a situation where all of these issues will have become a no-brainer."

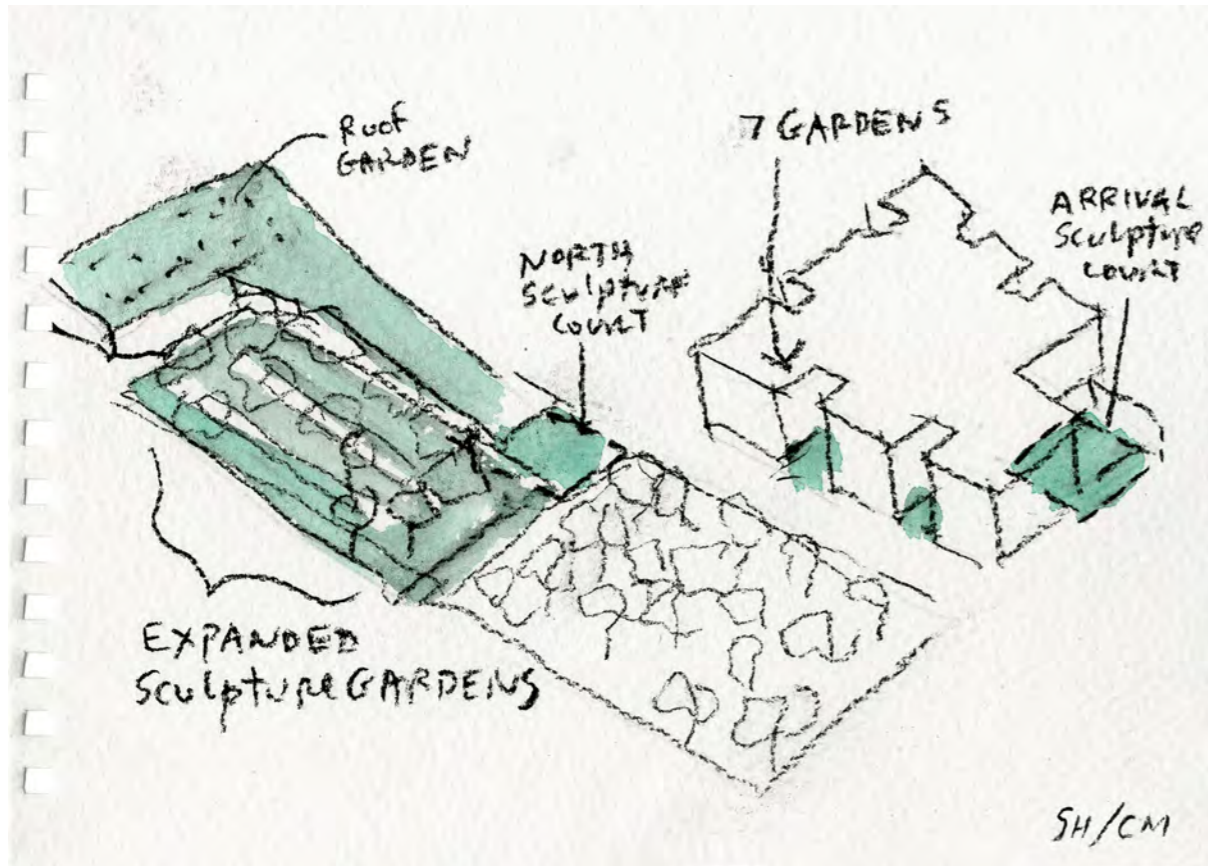
Marilyne Andersen is a professor of Sustainable Construction Technologies at the École Polytechnique Fédérale de Lausanne (EPFL), where she also serves as Dean of the School of Architecture, Civil and Environmental Engineering (ENAC). Furthermore, she is head of the Interdisciplinary Laboratory of Performance-Integrated Design (LIPID) that she launched in the autumn of 2010. Before joining EPFL, she was a professor at the School of Architecture and Planning of the Massachusetts Institute of Technology (MIT) in Cambridge, USA, and headed the MIT Daylighting Lab that she founded in 2004. Marilyne Andersen holds a Master of Science in Physics and specialised in daylighting through her PhD in Building Physics at EPFL and at the Lawrence Berkeley National Lab. In 2016, she was awarded The Daylight Award for Daylight Research by the VILLUM and VELUX Foundations.







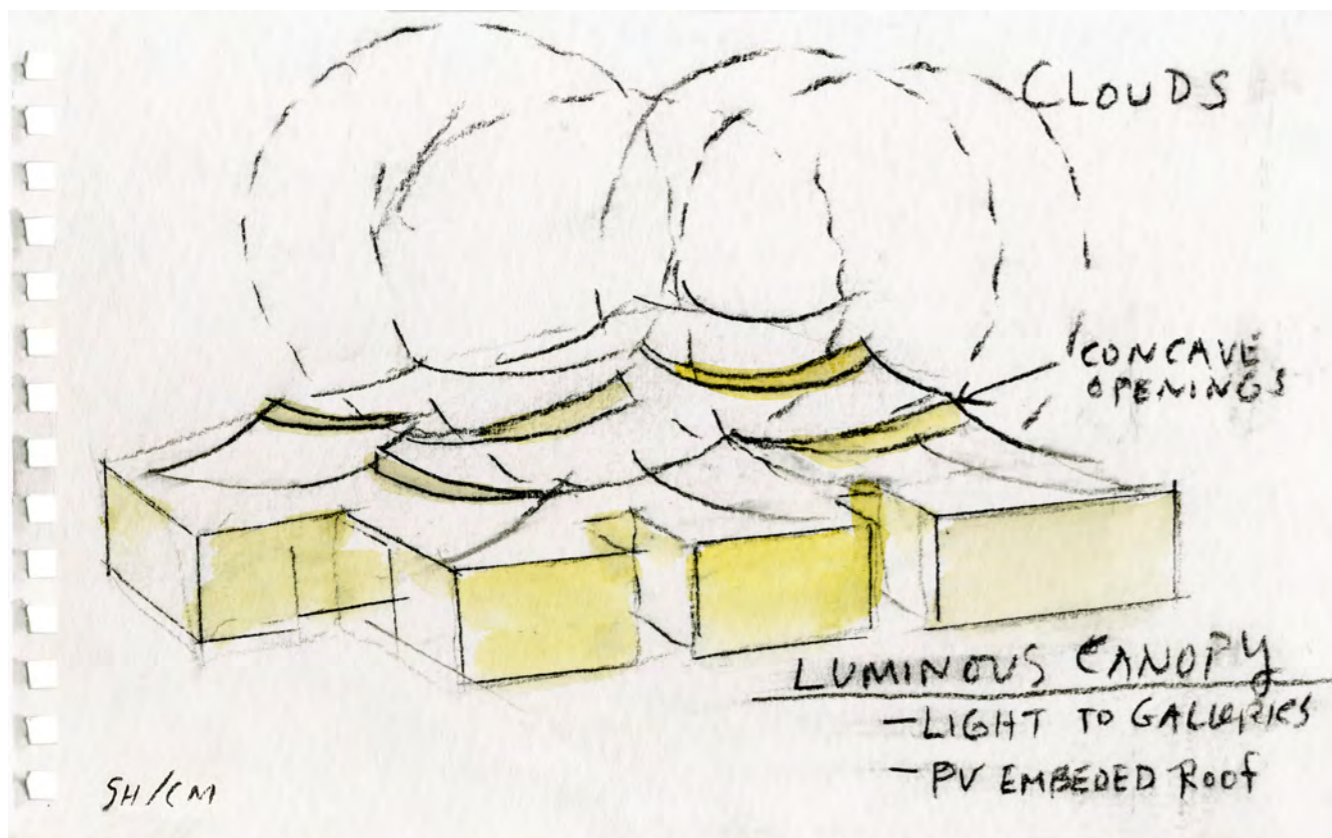
DESIGNED
FOR ALL
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THE
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COURTESY STEVEN HOLL

Expansion of the Museum of Fine Arts, Houston (in progress).

The new, 16,000-m² museum building is conceived as a porous block punctuated by seven courtyards onto which the ground floor opens up at all elevations. The concave curved roof follows the shapes of (imaginary) clouds above the building. In between the individual roof segments, daylight filters into the gallery spaces, as described by the architects: "Rather than mechanical and repetitive, the light is organic and flowing, like the movement of the galleries."



In November 2016, Steven Holl received The Daylight Award for Daylight in Architecture. Holl's ability to orchestrate rooms with light is unparalleled; the emotional intensity of his rooms and buildings is impressive. Their special quality arises from his method of working; he deliberately keeps his office small, prefers to draft his initial designs using a watercolour pad and gets his inspirations from music, philosophy and literature.

By Jakob Schoof
Photography by Gregory Halpern
Watercolours by Steven Holl

"We desire an architecture that is integral rather than empirical, that has depth rather than breadth. We desire an architecture that will inspire the soul."

OF ALL THE TEXTS Steven Holl has written over a career spanning more than 40 years, none captures his attitude to design as concisely and precisely as this sentence from his book 'Parallax' (2000). The quality of Holl's architecture cannot be expressed in terms of numbers but is immediately accessible to the senses. Rather than impressing the viewer with an eye-catching design, his buildings stimulate those who wander through them with their atmospheric density and complexity. He uses one medium in particular to inspire the soul: daylight. He has reflected on this many times in his writings. "Space is oblivion without light. A building speaks through the silence of perception orchestrated by light," wrote Holl in 2006 at the start of his book 'Luminosity/Porosity'.

Space is oblivion without light; this sentence is, in many ways, the complementary counterpart of Louis Kahn's famous verdict, "the sun never knew how great it was until it hit the side of a building." Daylight and architecture need one another; only in their interaction can they be truly experienced by humans. The spiritual kinship that reverberates in both quotations is not a coincidence. Steven Holl refers to Louis Kahn as one of the architects who had an early influence on his own work with daylight. At the start of his career in 1974, Holl almost landed a job in Kahn's office (he had already completed a job interview), but the premature death of the great American architect intervened.

Alongside the work of Louis Kahn and Alvar Aalto, two very contrasting places and the quality of their daylight captivated Steven Holl at an early age – Puget Sound near Seattle, where he spent his

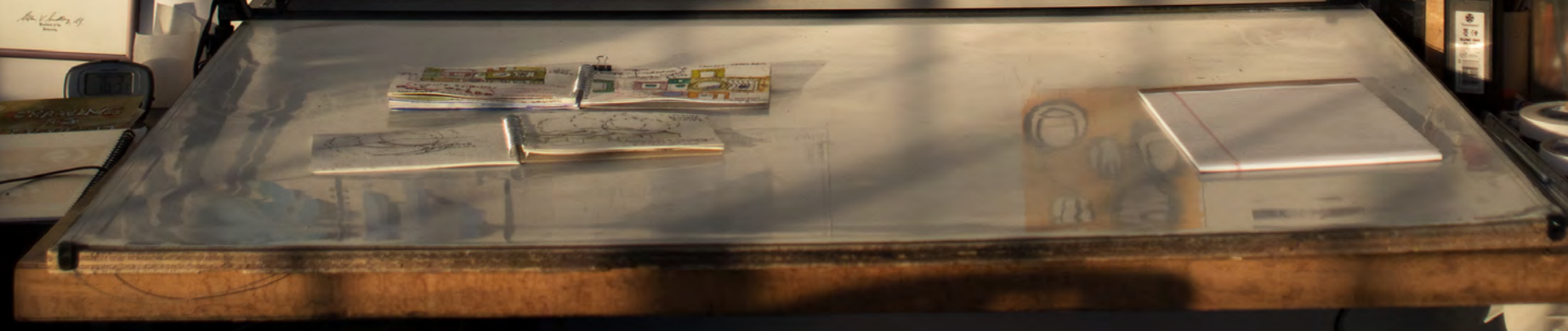
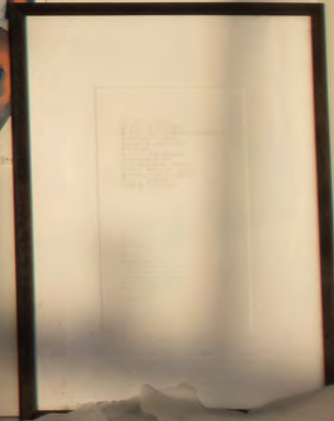
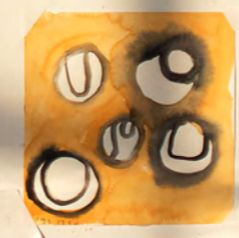
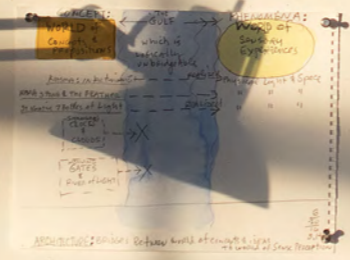
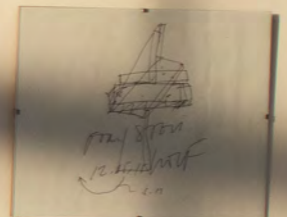
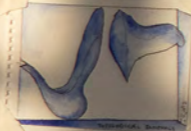
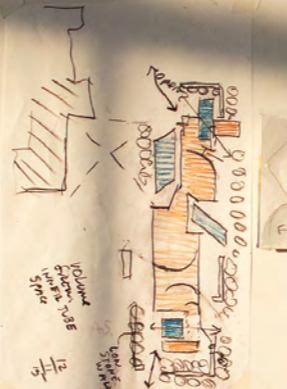
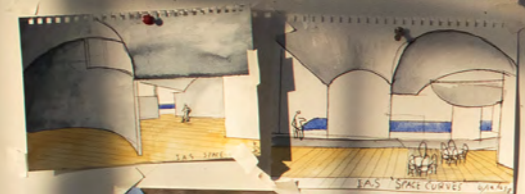
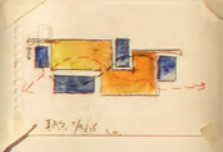
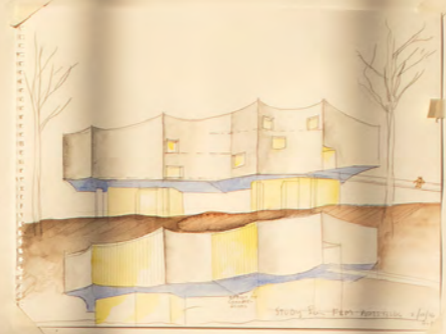
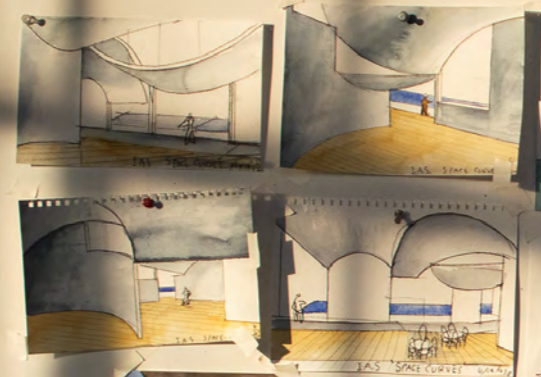
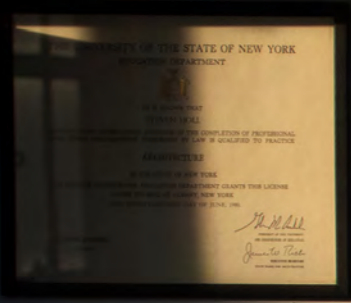
childhood, and the Pantheon in Rome. "The light of the Pacific North West is one of my earliest childhood memories. It is quite similar to the light in Scandinavia. The sun is very low in winter, casting long horizontal shadows, and it is very precious because many days are cloudy. In summer, on the other hand, there is twilight until 10 p.m. and there is this impressive chiaroscuro of the sky. This spectacle of the sunlight reflected off the water and the changing angles of the sun is very emotionally embedded in me."

At the age of 19, Steven Holl moved to Rome and lived for several months in a street behind the Pantheon. "The quality of light in this oculus and in this spherical space was mesmerising. Even in the context of Rome, with all its powerful architecture, the atmosphere of this place that forever changes with daylight is special. Whenever I am in Rome, I still go back to it and I love it."

To Steven Holl, daylight is not merely a means of shaping the atmosphere of his buildings and enriching the sensual perception of their users – "we tend to underestimate the psychological power and the health aspects of light, particularly in our society, which is often driven more towards commercial ends. As architects, it is our task to bring these aspects to the table, and to remind our clients and all the experts involved in building design today of the psychological and biological importance of light."

In all his designs, Steven Holl takes up the challenge of bringing daylight into places where it is not usually found. "In my buildings, I take great care that all rooms receive natural light. Whether it is a bedroom in a hospital, a meeting room in an office or a museum gallery, daylight is important for all these spaces. Even inside a building, you need to be able to feel the passing of the day and to see the sun setting."

In New York, the city where Steven



Pages 40–41:
Chapel of St. Ignatius, Seattle University (1997).

The central motif that inspired Steven Holl in the design of this chapel was seven 'bottles' of light sitting inside a stone box. "The metaphor of light is shaped in different volumes emerging from the roof whose irregularities aim at different qualities of light:

east facing, south facing, west and north facing, all gathered together for one united ceremony." Each of the light volumes corresponds to a part of the programme of Jesuit Catholic worship, from the procession (south) to the outreach to the community (north, towards the city). The main worship space receives light from the west and east.

Holl lives and works today, this cannot always be taken for granted. "New York has a dearth of daylight. It is a problem, because these high-rise towers are too tall and too close together." One notable exception is the building where Steven Holl's office is located. The firm operates from the eleventh floor of a twelve-storey 19th century industrial building (complete with factory chimney) right next to Hudson Yards, Manhattan's biggest urban redevelopment project. "We bought this floor because it has daylight on all four sides. Just look at these light effects," says Holl, pointing at the wall next to the old steel-framed window in the meeting room. "Just look at this superimposition of light coming in from different directions, this layering and then the texture of the glass. Some of the glass panes are very old, so they distort and refract the light in different ways. I remember someone once asked me what my favourite material was, and I said light. When you sit in this space and see the light coming in, you understand why."

Intensity beats size – Steven Holl's work philosophy

While the building on West 31st Street was an imposing edifice in the century before last, today it appears almost crushed by the towering office blocks next door. At the same time, the stark contrast between its coarse brick walls and the reflecting curtain-wall facades perfectly symbolises Steven Holl's own attitude as an architect. "Architecture is an art. For me, it's not a corporate activity. I don't like corporate architecture."¹ For this reason, Holl sees no reason to increase the size of his office – on the contrary. "I have set the limit at 44 people in the office. We had 64 five years ago but that was too many. I realised that I was spending too much time with management issues and arguing with people. And do you know what? Even with a staff of 44, we have done the

largest skyscraper you can do in China. On the other hand, the limited office size allows us to focus on details and materials, and make sure they turn out exactly the way we want them to be."

Occasionally, Steven Holl even has to reject commissions in order to keep his office small. "Not on a regular basis, but it does happen occasionally. I am interested in inspired spaces, in social spaces, and in urban spaces in the city. So when someone asks me to do a monofunctional office tower in a suburban location, I will turn it down. I love architecture too much to be doing it for money. And not every commission that approaches you will necessarily have a chance to become architecture."

In order to turn his designs into reality, Steven Holl relies on a hand-picked team of staff members. "The people here are geniuses. I am very fortunate – because every year I teach a master class at Columbia University that has twelve students. Then each year, I take the most brilliant student and bring him or her to work in this office. At least ten of the 44 people I currently work with are former students."

Ingenuity is also a trait that Steven Holl expects from the consultants he collaborates with. "They need to be fearless, inventive geniuses if you want to push the envelope each time you're doing a project. With all respect for the pragmatists – there must also be other ways to approach a creative process. You cannot find out anything about things that you don't know if you just think in a pragmatic, objective way."

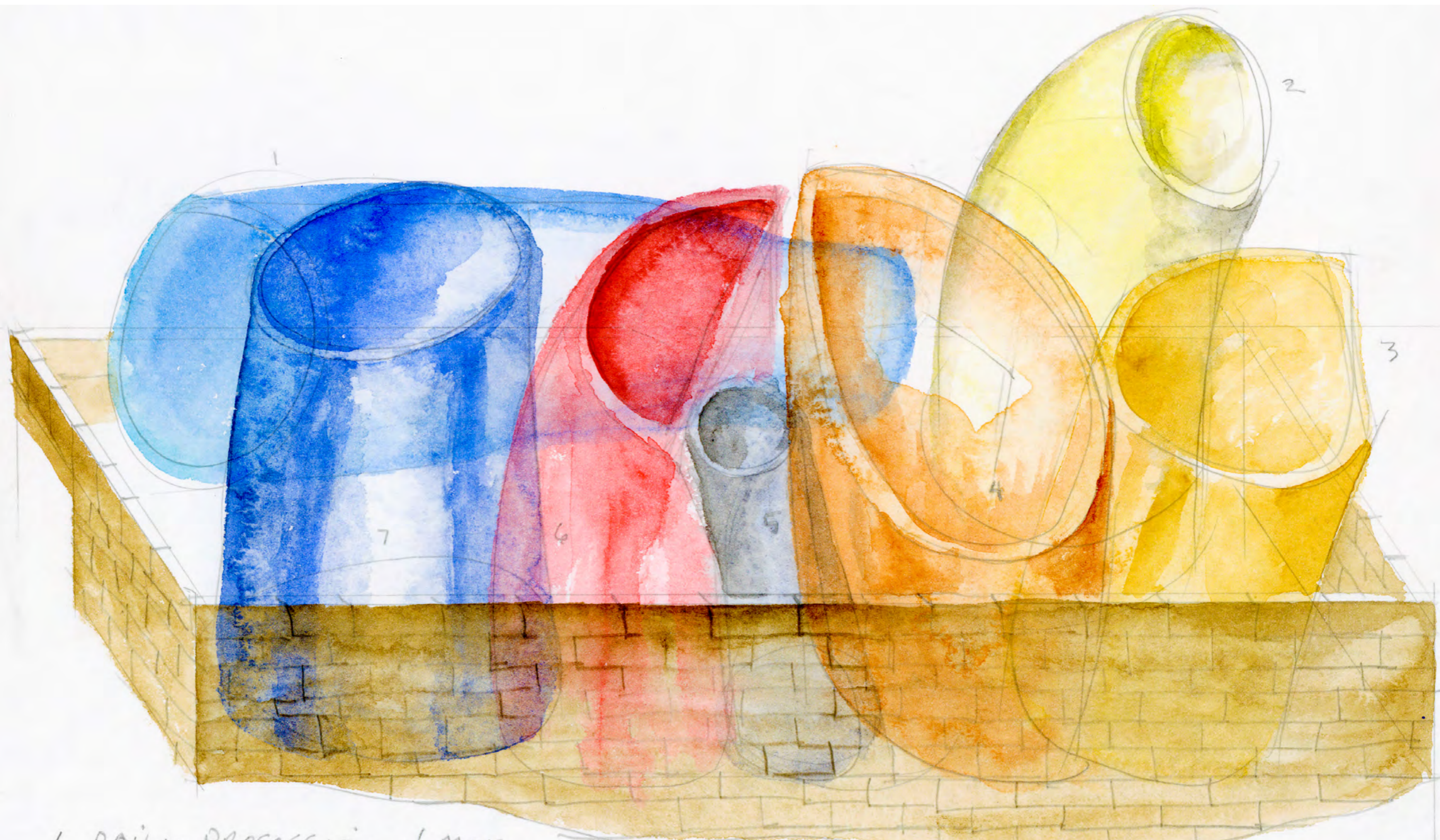
One of these 'fearless geniuses' is Matthias Schuler from Transsolar, with whom Steven Holl has been collaborating on all of his projects for the last decade. "We benefit a lot from Matthias and his obsession with the best environmental possibilities in a building – from geothermal and solar energy to the construction

and choice of materials. Whenever possible, I try to bring him in as early as possible in the design process." Currently the two designers are working on a library in Malawi. "I approached Matthias even before we knew the site and asked him, 'What would you do if you had an ideal site with no restrictions and were asked to design a 60,000 square foot library, where would you begin?' So he came up with this sketch of a curvilinear roof structure that maximises reflected light on the inside and maximises the capture of solar energy on the outside. Basically, the whole design of the library is based on energy and light, and that's all."

Bringing hand and mind together – how Steven Holl creates his designs

Usually, it is Steven Holl himself who supplies the concept sketches for his buildings. By now, he has tens of thousands of them, all carefully catalogued and stored in boxes. All of them were created using a pencil and watercolours in spiral-bound notebooks with a uniform size of 5 × 7 inches. The small paintings are simultaneously conceptual and spatial. Although they are sometimes playfully vague, they capture the idea that will drive the design of an entire project. "I think that you must, in a way, bring the mind and the hand together to begin a project. This seed that starts the project is something you're emotionally feeling as well as intellectually feeling. The concept sketch, via watercolour, is a perfect way to begin."² Often Steven Holl will sketch 20 or 30 different concept ideas in this manner before he settles on one of them. "I am uneasy until I define the concept. But once the decision is taken, I stick to it and the entire team works to reinforce it."³ Alongside the initial concept of each project, many construction details also have their seeds on Steven Holl's watercolour pad. "I also need to draw along the way so that it can steer the process. After all, I have a whole





- 1 DAILY PROCESSION of MASS
- 2 Blessed SACRAMENT
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COURTESY STEVEN HOLL

Page 43:
Herning Museum of Contemporary Art (2009)
Steven Holl's design for this museum pays tribute to the town of Herning's long relationship to the textile industry. Seen from above, the layout of the one-storey building resembles a collection of shirt sleeves strewn out over a meadow. Even the white concrete walls have

a genuine 'textile' appeal, which was created by inserting fabric tarps inside the concrete formwork. Around the museum, a new 4,000-m² landscape of grass mounds and pools conceals all the parking and service areas.

team of people working with me that has to move in the same direction.”

In addition to his watercolour sketches, the second important constant in Steven Holl's work is his use of the golden ratio as a proportioning system. For 40 years, all of his designs have been based on the Fibonacci series and an aspect ratio of 1:1.618. “This proportion is in our blood and in our bones, where it determines the lengths of the individual joints of our fingers, for example. You will find it in a nautilus shell, a pine cone, and even in the spiral of the solar wind. For me it is a fine-tuning device. I don't start with it ever, but introduce it during the design process to bring the individual elements and openings of a building in balance. Proportions in architecture are very important. Unfortunately, they are often neglected in our era of computer drawings that are inherently scaleless.”

Music-made concrete – Steven Holl's approach to teaching

Once the basic design decisions have been taken, Steven Holl Architects make use of the same full array of modern computer software utilised by other architectural offices. But the shelves in the open-plan office on the west side of Manhattan are also filled with many design models. “Models are an excellent way to experiment with materials, their translucency or transparency, and the reflections and refractions they produce. The models that we build are full of different properties of light. This is something you can never achieve in computer renderings.”

In Steven Holl's view, models are also a good way of increasing students' awareness of light, materials and the haptic quality of architecture. “I don't even tell my students not to use computers. They intuitively understand it.” Together with his wife and former student, Dimitra Tsachrelia, and the composer Raphael Mostel, Steven Holl currently teaches a

series of studios called ‘Architectonics of Music’. Here the students undertake experiments translating music scores into space, material and form. “This year we are working with music by Iannis Xenakis, who used to work for Le Corbusier. There is a lot of scientific, mathematical depth in the way he composed and we try to conceive architectural spaces that have their point of origin in these complex musical structures.”

The parallels between architecture, music and other art forms have always interested Steven Holl. “One of the great excitements now in architecture is that we are free. I think a building can be based on references to music, dance, painting, sculpture or a poem.”⁴ In this context, he assigns a special role to music: “Music, like architecture, is an immersive experience – it surrounds you. One can turn away from a painting or a work of sculpture, while music and architecture engulf the body in space.” Just as a composer works with sound, the architect orchestrates his buildings with light. “To me, light is to space what sound is to music. The experience of architecture, the overlapping perspectives – it is the equivalent of spatial acoustics to light.”

Steven Holl does not restrict himself to such abstract comparisons. A few years ago, he created a private home with art gallery for a Korean client, the design of which was based on a piece of music by composer Istvan Anhalt.⁵ “The piece had never been played before. I thought it was really interesting that you could somehow physically build a conceptual work that hadn't actually been physically performed. It would be played in space and light.”⁶

Experienced space – what makes architecture last

The dualism of ideas and phenomena, already a central theme in Plato's philosophy, also preoccupies Steven Holl. But he





does not give precedence to either side or opt for one above the other. On the one hand he says, “The real test of architecture is the phenomena of the body moving through spaces, which can be sensed and felt regardless of understanding the architect’s concept and philosophy.”⁷ On the other hand, he stresses the importance of a strong idea that must form the basis of every design. “I definitely believe in ideas driving a design, and that makes me different from the people who pretend to be phenomenologists.”⁸ Steven Holl draws on the writings of Maurice Merleau-Ponty, Henri Bergson, Peter Sloterdijk and other philosophers for many of his ideas. “Translating those thoughts into architecture is not easy and requires a lot of work. But there is a rich potential in philosophically anchoring our discipline. We may understand essences in philosophical readings, but architecture can put these essences into our existence. This is not academic conceit because the real test of architecture is, and will always remain, when a little child walks through a building and understands it.”

Steven Holl is convinced that to truly judge buildings, you have to experience them yourself, have to wander through them and perceive them with all your senses. “The phenomenological properties of a space, its light and acoustics, the overlapping perspectives and the details – they form the true experience of architecture. This is not something you can reproduce in a magazine.”

At the same time, it is these sensual and haptic qualities that allow buildings to last. “If you visit Le Corbusier’s buildings, for example, it is fantastic how they hold up over time. There’s a crudeness to the detailing, and of course there’s the *béton brut*, but they still look terrific. I think the problem in our time is that along with the increasing size of architectural offices, there is no checking back. Rather

than just being interested in nice images, in the flash of publicity once a building is completed, architects really ought to return to their buildings a few years afterwards to see what happened.”

It is important for Steven Holl to follow the fortunes of his buildings over the long term. “I always used to say that my buildings are my children. Now I have a one-and-a-half year old daughter, so I tend not to make that comparison any more. But I still go back to my buildings regularly. It must be 12 or 13 times now that I revisited the Chapel of St. Ignatius in Seattle,⁹ and I have recently been back to the Kiasma Museum in Helsinki, which we completed nearly 20 years ago.¹⁰ They have done some renovation work to it and it is still working great; it is a socially active place and a place full of natural light. I think that is the legacy that I would like to leave behind – buildings that will remain for many years to come and, despite all the wear and tear, stand the test of time. In a way, this is the most wonderful thing you can do as an architect.”

Steven Holl was born in 1947 in Bremerton, Washington. He graduated from the University of Washington and pursued architecture studies in Rome in 1970. In 1976, he attended the Architectural Association in London and established Steven Holl Architects in New York City. Since 1981, Steven Holl has taught at Columbia University in New York, where he currently serves as a tenured professor at the Graduate School of Architecture and Planning (GSAPP). Among other prizes, Steven Holl has been awarded the 2014 Praemium Imperiale, the 2012 AIA Gold Medal, and The Daylight Award 2016 for Daylight in Architecture by the VELUX Foundations. Alongside his architectural work, Steven Holl has published numerous books throughout his career, such as *Anchoring* (1989), *Intertwining* (1996), *Parallax* (2000), *Luminosity/Porosity* (2006), *Architecture Spoken* (2007), *Urbanisms: Working with Doubt* (2009), *Color Light Time* (2012), and *Urban Hopes* (2013).

Notes

1. Q&A: Steven Holl – Point of View. Interview by Martin C. Pedersen, Metropolis Magazine, 20 March 2013. www.metropolismag.com/Point-of-View/March-2013/Q-A-Steven-Holl/
2. Steven Holl in GA Document 110. Quoted in Robert McCarter: Steven Holl. Phaidon Press 2015, p. 329
3. Concepts and Melodies. Steven Holl in a conversation with Sol Madrilejos, Juan Carlos Sancho and Antón García Abril. El Croquis 172/2014, p. 9 ff.
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5. www.stevenholl.com/projects/daeyang-gallery-and-house
6. Steven Holl on Designing Houses. Interview with Josephine Minutillo, Architectural Digest, 31 December 2011. www.architecturaldigest.com/story/architect-steven-holl-interview-article
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9. www.stevenholl.com/projects/st-ignatius-chapel
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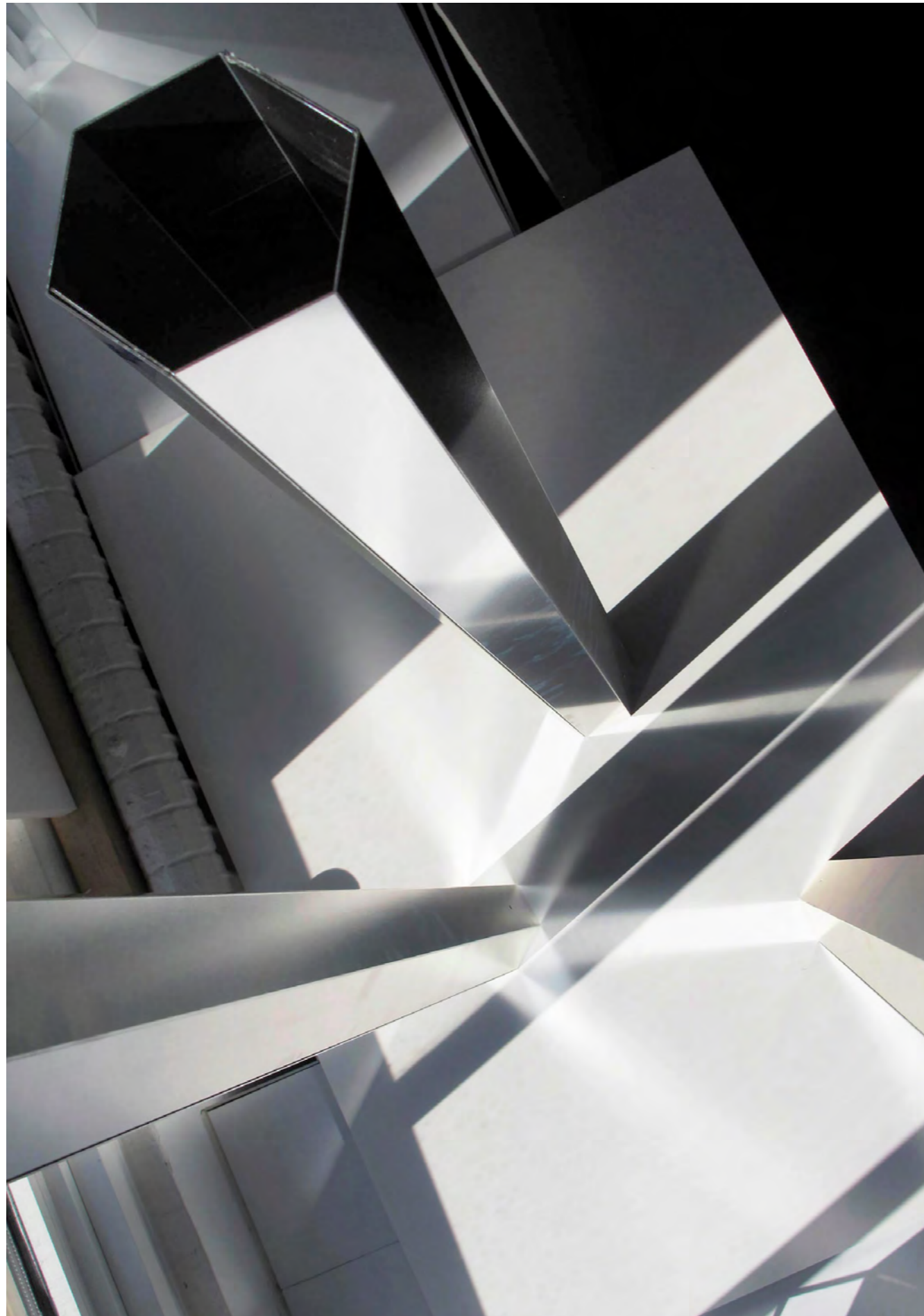


PHOTO BY: © METROPOLITAN TRANSPORTATION AUTHORITY/PATRICK CASMIN

ARCHI- TECTURE AS TEAM- WORK

Architecture is created at the intersection of science and art. The closer the links between these two domains, the more likely it is that buildings will achieve a maximum for their users with just a minimum of resources. Yet who are the 'builders of bridges' between science and the art of building, and how do they approach their task? On the recommendation of Marilynne Andersen and Steven Holl, five experts from different disciplines talk about their experiences.

By Jakob Schoof



Pages 51, 53
Sky-Reflector Net at Fulton Center, New York City (James Carpenter Design Associates in collaboration with Carpenter Norris Consulting, Schlaich Bergemann und Partner, Grimshaw and Arup).

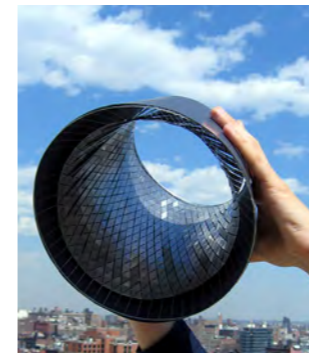
Installed inside the dome of Lower Manhattan's largest transport interchange, this artwork reflects

the image of the sky down into the underground core of the building. At the same time, the reflecting panels (which are suspended from a cable-net structure) conceal the structural framing and mechanical equipment within the dome.

Page 52
Suspended Light Pillars, Salt Lake City (James Carpenter Design Associates in collaboration with Carpenter Norris Consulting and Thomas Phifer and Partners).

Mock-up for a sculpture in the new Salt Lake City Courthouse. Consisting of aluminium and stainless steel rods, the artwork

is conceived as a suspended grid of vertically suspended hexagonal 'pillars' that mimic a cloud composed of ice crystals. Such ice clouds are common phenomena in the Salt Lake City area and occur when cold air and water in the upper atmosphere combine to create suspended ice crystals that often take on a polygonal form.



IN RECENT DECADES, architecture has developed a new guiding principle. The idea of buildings as monuments has been replaced by the concept of architecture as an adaptive organism that makes use of locally available natural resources in order to provide building users with light, air, comfortable indoor temperatures and sensory experiences.

Marilyne Andersen and Steven Holl, the two recipients of The Daylight Award 2016, have both followed this principle, each in their own special way, as a leading researcher and as a leading architect respectively. A close collaboration between specialist planners from different disciplines is necessary for research results to make their way into architecture and for Steven Holl's spatial creations to take shape. Yet how to ensure that such collaboration turns out successful? What priorities need to be set? And what is the role of the architect in the design process? For this article, Marilyne Andersen and Steven Holl have nominated five 'builders of bridges' between science and architecture who report on their approach to interdisciplinary design processes.

The art of collaboration

In many respects Marie-Claude Dubois embodies the specialisation that has occurred in the planning professions in recent decades. After training as an architect, in the early 1990s she began to concentrate entirely on daylighting design and energy-efficient construction. She teaches these subjects at Lund University and works part-time as a consultant for the Swedish architectural firm White Arkitekter¹. She says, "today the requirements on building performance are very high, and the design teams have to prove that they will meet these targets before construction starts. To be able to do so, however, you need a lot of understanding and knowledge. You cannot achieve this without experts – and I would say that it

takes about 20 years to really gather sufficient experience in a field."

Together with James Carpenter, Davidson Norris manages Carpenter Norris Consulting², a consultancy for daylighting design based in New York. He describes the challenges they face. "In our work, it is not sufficient to merely analyse the daylight conditions in a given location and provide sufficient quantities of daylight indoors. We also have to create something that captures people's attention. This is what contemporary building design is all about – science, art, and the back and forth that occurs between these two."

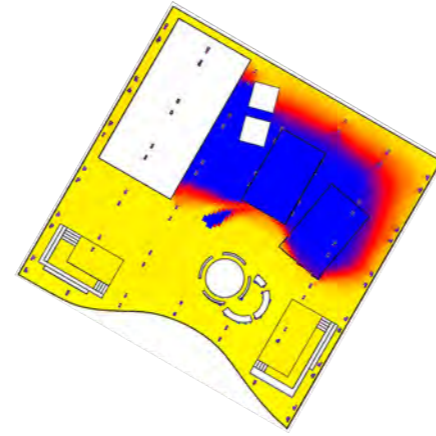
Sheila Kennedy, one of the founders of the interdisciplinary design practice KVA Matx³, proposes an even more comprehensive view of building design. "Rather than just designing 'sustainable' buildings, architects have to imagine a viable future for mankind in the face of climate change. This task can't be focussed only on numbers and metrics – it is all about developing ideas that shift our culture. But we cannot develop these ideas using the knowledge of our own discipline alone. We need to work with experts from other fields that have an impact on architecture, such as climate design, physics, engineering and even biology."

At Transsolar⁴, one of the world's leading engineering offices for climate design, interdisciplinarity is already innate in its personnel structure. The company employs mechanical engineers, physicists, process technicians and architects. "Above all, our collaboration is based on two concepts we all hold in common," says Nadir Abdessemed, "an understanding of buildings as dynamic systems that change over time, and a great openness to the architecture." Matthias Schuler, the founder of Transsolar, believes that the ability to listen to architects is one of the most important criteria for success. "Architects predominantly think in images. We have to take each image seri-

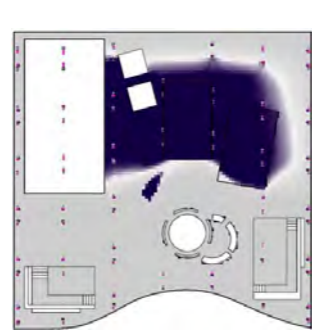
Malawi Central Library in Lilongwe (Transsolar in collaboration with Steven Holl Architects).

The 6,600-m² library receives natural light through clerestory rooflights and a glass facade shaded by screens made of locally crafted bamboo. In their daylight simulations, the climate designers evaluated the useful daylight illuminance (UDI) inside

the spaces. UDI is a measure of what percentage of the daylight hours per year the illuminance on the work plane is inside a range considered 'useful' (here, between 300 and 3'000 lux). The second diagram shows the amount of time during which the illuminance is too low (<300 lux), whereas the third one indicates the occurrence of excessive brightness (>3000 lux).



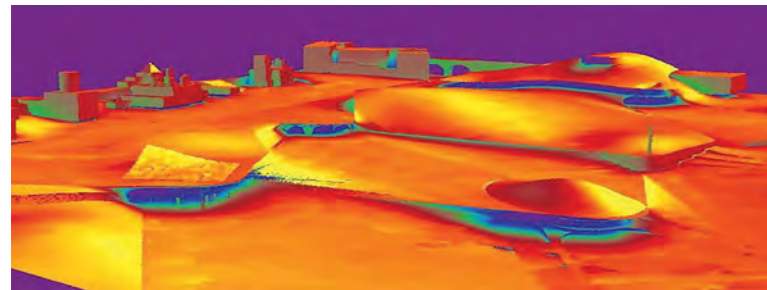
Average UDI 300,3000: 52%



Average UDI <300: 31,7%

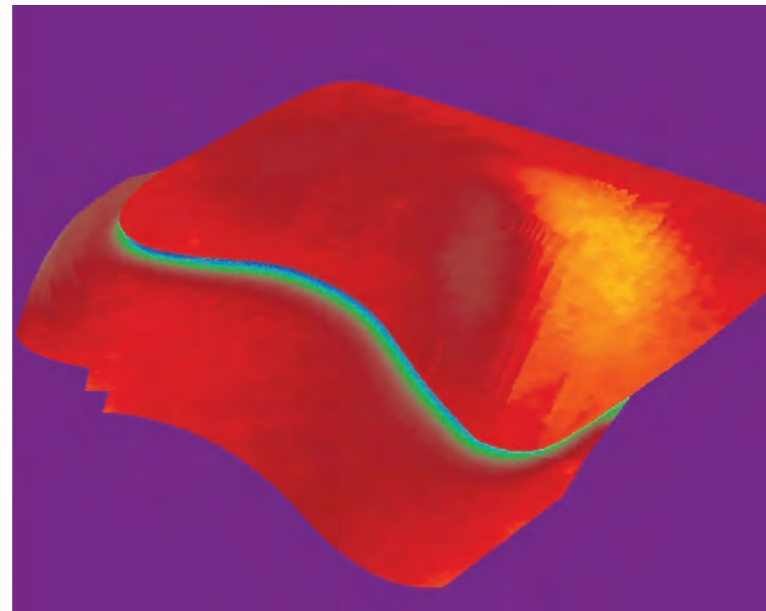


Average UDI >3000: 16,3%



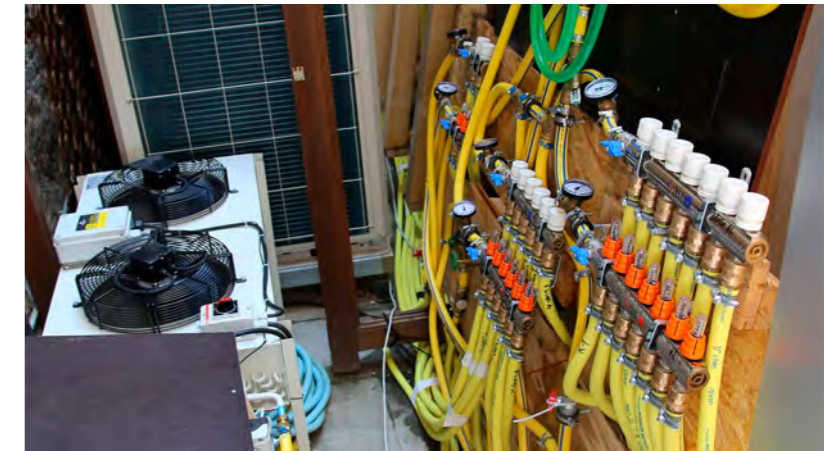
Zaryadye Park in Moscow (Transsolar in collaboration with Diller Scofidio + Renfro, Hargreaves Associates and Buro Happold).

Scheduled to open in 2017, this new park surprises its visitors with a series of 'augmented climatic moments'. There are sites that feel cooler than the surrounding areas in summer, and places that can be perceived as relatively warm in winter. These effects are achieved through a careful assessment of solar exposure, wind shelter, the thermal storage capacity of materials and exposure to the night sky. Furthermore, some areas are equipped with mild space conditioning that is powered by renewable energies.



Augmented Atmospheres (Transsolar in collaboration with Diller Scofidio + Renfro).

This installation, which was created for a collateral event during the 14th Architecture Biennale in Venice, provided visitors with a 'foretaste' of the new Zaryadye Park in Moscow.



IBA Soft House in Hamburg (KVA Matx).

Designed as part of the 2013 International Building Exhibition in Hamburg, this terrace of three-storey houses launches a model for low-carbon living that relies on a massive timber construction

and flexible solar panels that generate renewable energy. Inside the houses, movable curtains with integrated LED lighting allow for a flexible adaptation of the spaces to different uses, and create a daylight atmosphere characterised by reflectivity and translucency.

ously and try to understand it – even if it is a transparent glasshouse in a climate where the temperature drops to -27°C in winter. It is only then that we can start to think about technical solutions and the physical phenomena that will allow us to materialise the image.” Other planning offices sometimes describe Transsolar as “the architect whisperer.”⁵ “I take that as a compliment,” says Schuler, “because before you can whisper a horse, you have to understand it.” It is their holistic approach that chiefly sets Transsolar apart from more conventional engineering offices. “We do not try to solve every problem by throwing the maximum number of technical installations at it. You can often reduce the scale of the building technology quite considerably by regarding the building’s shell and its technology as a single entity.”

Sheila Kennedy believes that a basic understanding of the language of other specialist disciplines is essential for interdisciplinarity to succeed. “It would be interesting to know whether people who find it easy to learn foreign languages have an advantage. Understanding vocabulary and language is essential for collaboration,” she says. Davidson Norris adds, “Some degree of knowledge about the other disciplines – whether it is mechanical design or electric lighting design – is definitely beneficial for a successful collaboration.” Norris also stresses the responsibility of clients: “The most frustrating are clients who say ‘OK, well do what you want’. On the contrary: we like constraints, and we like challenges. If you operate a daylighting design office in New York City, which is essentially a city of shadows, you learn how to develop design solutions within constraints.”

According to Marie-Claude Dubois, clear common goals are particularly important for successful design processes. “Very often it is the architects who are unaware of what might be possible if you

set ambitious goals at the beginning of the design process.” She cites daylighting as an example, where many design teams are content with a daylight factor of 1–2% although, from a health and perceptual perspective, a factor of 5% would be preferable. Glare protection is another area where, in her view, better results could be achieved. “Many architects do not know that solar blinds can also be optimised for glare protection and visual comfort. Quite often they are merely conceived as a means to keep solar heat out.”

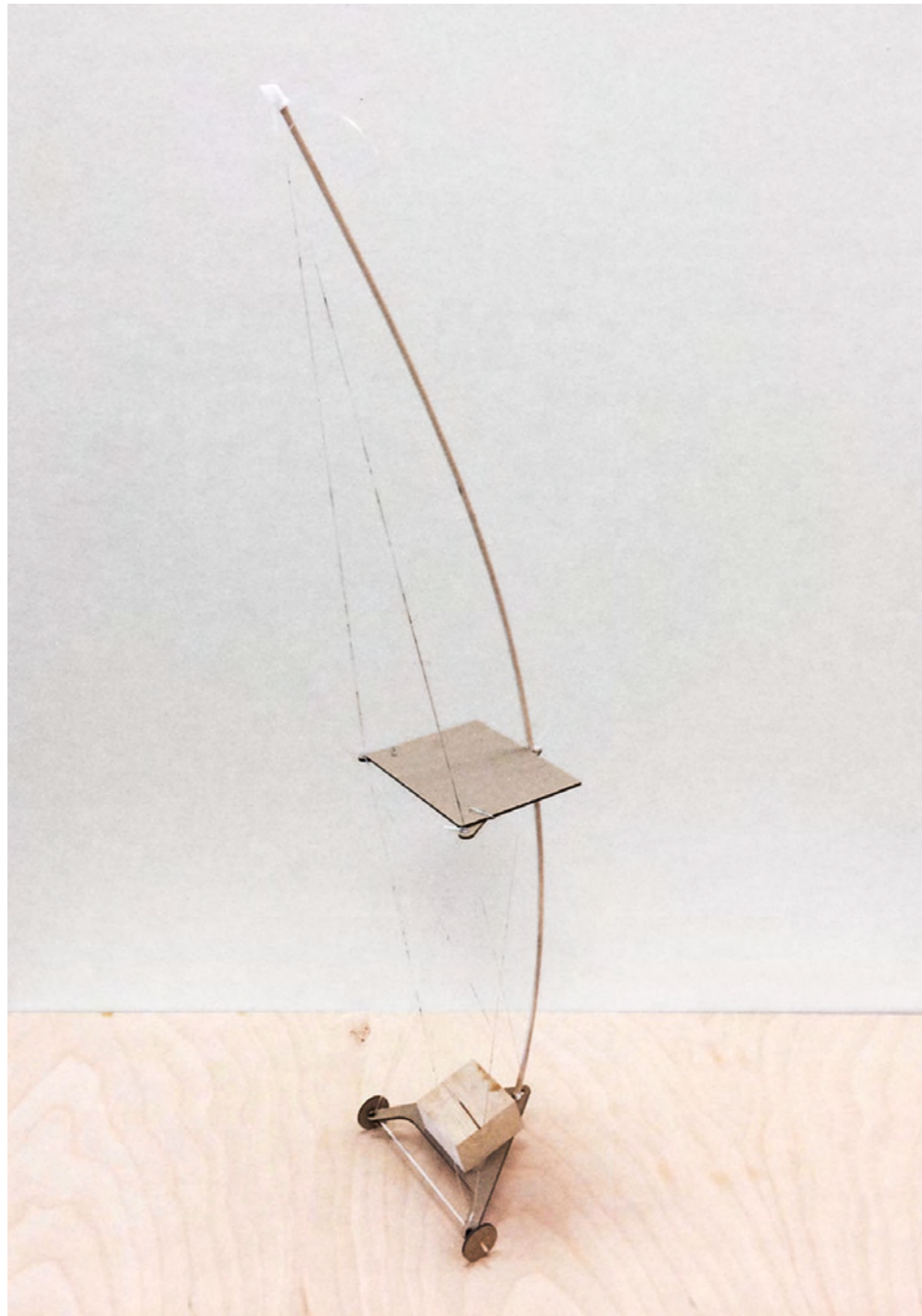
In Dubois’ view, architects have to coordinate the design teams while at the same time monitoring adherence to goals. Sheila Kennedy elaborates further on this. “The architect needs to provide an integral vision to the project, which needs to be specific yet, at the same time, flexible enough to undergo changes if needed without losing its essence. Then, during the collaboration process, the architect needs to be a curator of ideas.”

What is more, Matthias Schuler adds, all the ideas do not have to come from the architects themselves. “We engineers should occasionally also drop our reticence and suggest issues and subjects to the architects that could lead them to developing new images.” Schuler cites his collaboration with Steven Holl as one example of this. “We had only been working together for a few months when the film ‘An Inconvenient Truth’ by Al Gore was released. I told Steven that he should watch the film. Afterwards he said to me, ‘I don’t know how many buildings I will still build in my lifetime, but I would like to take what this film has shown as defining the substance of my work.’ Ever since, we have worked on all his projects together. Aspects such as solar thermal energy, geothermal energy, wind and daylight have become an integral part of his concepts and also appear more and more frequently in Steven’s watercolour sketches.” Schuler’s colleague Nadir Abdessemed



Model of a solar-powered street light (KVA Matx).

So far, the Selco company from India has supplied thousands of rural communities with solar-powered, off-grid LED streetlights. Most of these have been mounted on steel or concrete poles. To further improve the eco-balance of its products, Selco approached KVA Matx to explore alternative constructions using locally available bio-materials such as bamboo.



mentions two more criteria that are essential for good teamwork. “It really helps us if the architects view their building as a dynamic system and are not just interested in it as a static image for publication in journals. Continuity is also important. Particularly when you are dealing with large-scale projects, the planning and realisation can take many years. If the architect is prepared ‘to stay the course’ from start to finish the quality will benefit.”

This striving for quality can be quite demanding for everyone involved, as Matthias Schuler comments. “I have frequently had the experience that architects continue to make fundamental changes to their design even during the construction phase. For the engineers, that entails additional work because they have to redesign and recalculate many things. But it is fascinating to watch how many architects continue to fine-tune their designs right until the end.”

Sheila Kennedy criticises the fact that collaboration is being hampered by laws and fee structures, which rigidly subdivide the services provided by architects and engineers into individual work packages and phases. Up to now, at least in the USA, professional associations have shown little inclination to change this. Sheila Kennedy hopes that the digitisation of design processes could result in better interconnectedness between collaborators and disciplines. “If we look at the software being used in building design, we can already observe a much more collaborative approach relying on 3D models that are shared between the different disciplines, and can be worked on by multiple people synchronously.”

Architecture for human beings

Marie-Claude Dubois states that there should be clear priorities when planning buildings – people should come first, and the building should follow. “We tend to

forget that we design buildings for human beings rather than to save energy. I see too many so-called passive houses with poor daylight, where people are not optimally supported by the building. This is not a good idea. We should first support people and only then try to achieve this with the least energy use possible. Sometimes we may have to sacrifice a bit of energy to create better luminous conditions.”

The impact of daylight on human circadian rhythms in particular is becoming increasingly important in design, Davidson Norris believes. “Science tells us that for our sleep-wake cycle, obtaining the right dosage of short-wave light at eye level is crucial. In terms of daylighting design, this is far more than just a technical question. We also need to focus on where people look, and try to attract their attention to the source of the light.” In order to achieve this, Carpenter Norris employ metal reflectors, diffused glass panes, dichroic glass and similar materials to create what Norris calls ‘daylight events’ on otherwise blank walls or inside facade cavities.

Transsolar has been pursuing a planning philosophy for many years that focuses on people. Nadir Abdessemed says, “instead of first designing a building and then analysing its impact on users, we start from the question of what the people working within a certain programmatic context actually need. Concentrating on people’s truly essential needs is difficult – but once you have achieved that, it opens the door to entirely new creative opportunities.”

To give one example of this, working on behalf of a major European airport Transsolar investigated whether it would also be possible to build an airport terminal that functions entirely without air-conditioning. And in Moscow, the office is collaborating with American architects Diller Scofidio + Renfro to implement their designs for Zariyadye

Park, which will be opening in the autumn of 2017 near the Moscow Kremlin to commemorate the 100th anniversary of the Revolution. “Our basic approach always remains the same, irrespective of whether we are designing a building or an outdoor space. And most of the planning tools we use also remain the same,” Matthias Schuler explains. “The only major difference is that the principles of thermal comfort differ somewhat when you are outside.”

According to Davidson Norris, health and well-being are increasingly becoming important arguments for those who commission buildings. “There is a need to justify daylight beyond the ‘energy box’ in which it has been contained for decades. Advanced daylighting controls are costly, and the tangible but modest energy cost savings that they yield are usually not a decisive factor from a client’s point of view.” Fortunately, says Norris, some clients are paying increasing attention to the biological benefits of daylight. “The firms in Silicon Valley in particular get the idea. On the one hand, they are competing for people who are aware of this issue, know the science behind it and are conscious of their own health and well-being. On the other, these firms are also interested in advanced design solutions to solve daylighting issues.”

Matthias Schuler has made similar observations. “In Europe, companies may want to build sustainable buildings to bolster their own reputation. In the USA, it helps more if we base our arguments on the improved productivity and lower sickness absence rates. It is difficult to put a price on it but potentially we could be looking at millions of dollars.” Schuler cites the Canadian energy supplier Manitoba Hydro as an example. Together with KPMB Architects, Transsolar planned and built a new administration building for Manitoba Hydro. Since moving into the new building, every employee

Daylight and glare assessment for La Maison Simons in Sainte Foy (Marie-Claude Dubois and Francois Cantin).

For the extension of an existing shopping mall, Marie-Claude Dubois and her student Francois Cantin assessed whether the large, south-east-facing glass facade that the architects had designed would cause glare

among visitors and affect the visibility of the merchandise. In another part of the same mall, the two daylighting experts proposed to introduce skylights in order to use daylight as the main source of light. Unfortunately, the concept was eventually scrapped and the mall was provided with mainly electric lighting.

on average takes 1.5 days less sick leave per year than before. This has saved the company 2.5 million dollars annually.

From research to practice

Sheila Kennedy advises a more detailed – and at the same time critical – consideration of human needs. “We have to differentiate between needs and wants. Much of what is being designed today is aimed at satisfying short-term wants. On the other hand, there are a lot of needs that we do not even recognise, such as the very real need to change our behaviour and our fundamental ways of thinking. We still conceive of the human realm as something separate from nature when in fact, in the era of the Anthropocene, they are both parts of the same system.” She also criticises the current tendency to quantify all aspects of building design with numerical performance indicators. “Building design leans ever more heavily towards quantifiable aspects, and many clients think that metrics are the way forward. But how do you quantify our responsibility to the planet? It is very difficult to assign natural resources like air and water a measurable value in an economy.”

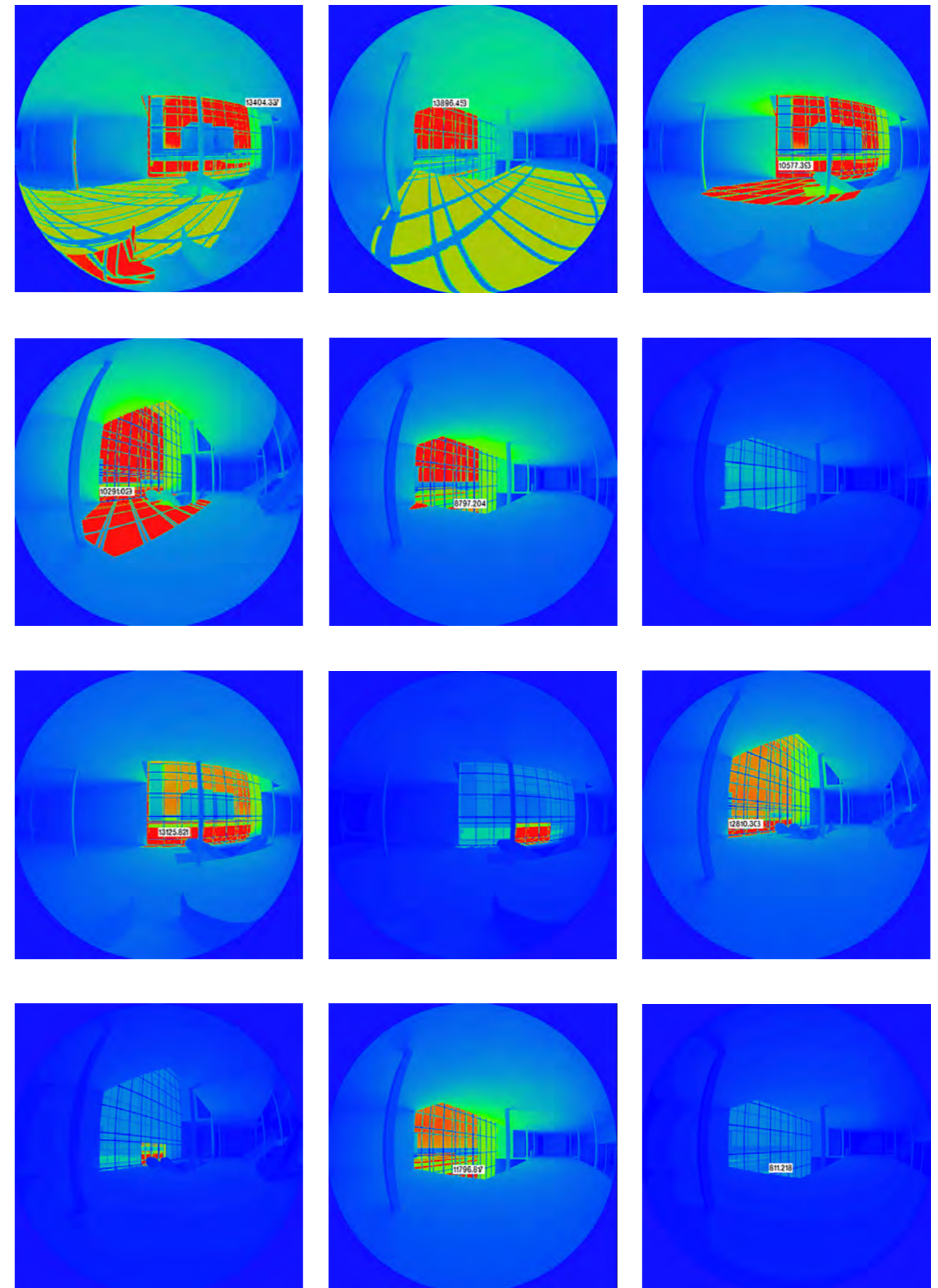
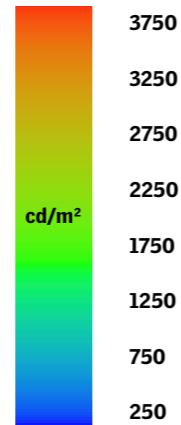
Kennedy believes that the current mainstream practice of building design is overly focused on operational energy use, whereas the embodied energy, the recyclability and the local provenience of building materials are hardly taken into account.

Partly in an endeavour to change this, Sheila Kennedy’s architectural practice, Kennedy & Violich (KVA), founded their own materials research laboratory, Matx, in 2000. Here the architects build prototypes and mock-ups for their own projects, but also conduct contract research for clients from the industry. The projects that Matx has worked on range from a thermally responsive linen textile for a French manufacturer to lamp cases

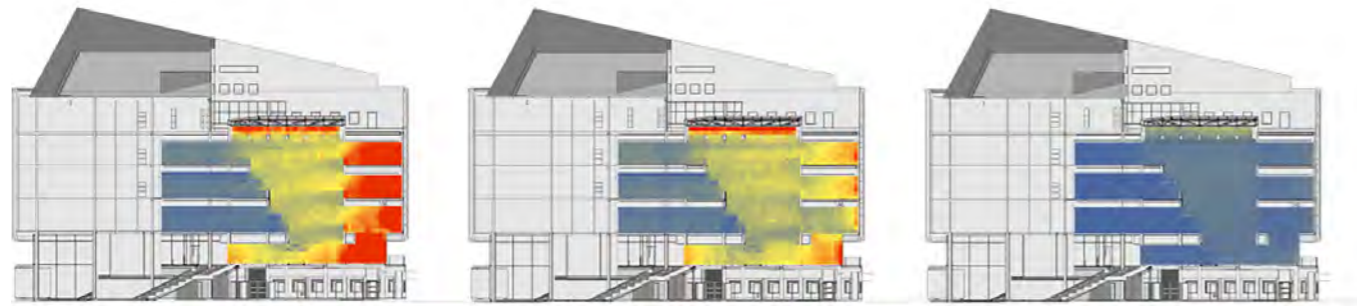
and solar powered streetlights made out of Areca palm leaves grown in Western India, which the architects developed together with a local NGO. According to Sheila Kennedy, working with materials in this hands-on manner also helps to develop a sense of material resistance, which is often lacking in computer-driven design processes. She estimates that more than a quarter of the workload of Matx is funded by industry or through research grants. “But even in the case of self-instated research projects that emerge from our work in architecture, we aim to bring material research ideas to market and to industrial production.”

White Arkitekter, one of Marie-Claude Dubois’ two employers, have also set up their own facility called the White Research Lab (WRL), with a focus on research directly applied to ongoing architectural projects. However WRL also conducts commissioned research projects for manufacturers of building products and other companies. Dubois reckons that she has been able to infuse significant new knowledge into her firm through her work. “I wish I had more research colleagues doing what I am doing. However, most people do not want to have to bother with two jobs. It is very demanding and not a good financial deal.”

When asked what could be done to bring the two worlds of academia and architectural practice closer together, Dubois responds, “to ask every researcher to spend one day per week in an architectural office, as I have done for the past three years, would be a good start. They would see that many of their research endeavours are pointless given the speed demanded in the private sector. On the other hand, the role of research is to provide answers for society 20 years ahead of time, so many seemingly useless things that we do in research today might actually be relevant 20 years from now.”



SECTION A



Equinox: September 21.
CIE clear sky 09:00

Equinox: September 21.
CIE clear sky 12:00

Winter solstice: December 21.
CIE overcast sky 12:00

Learning processes and knowledge transfer

New knowledge in architecture does not just originate in research laboratories, however. Many insights can be obtained from existing buildings if designers are prepared to revisit them after they have been handed over to their users. “When we design a building, we do not simply walk away from it once it is completed,” says Sheila Kennedy. “Especially in our research and university buildings, we have a lot of repeat clients. Through continuous dialogue with them, we keep close tabs on what works and what doesn’t.”

For Carpenter Norris Consulting, “the feedback loop is mostly about how a building responds to light, and how the people inside it respond to light,” says Davidson Norris. “By the end of the design process, we have usually developed a very clear understanding of the light effect we want to achieve. Once the building is completed, we usually go on site and ask: ‘Is it delivering what we expected and imagined? Are people identifying with it, and responding to it in a way that we can observe?’”

Norris admits that beyond this rather ad-hoc approach, a more systematic post-occupancy evaluation would be desirable. Unfortunately very few clients are willing to pay for it. “Initially, they often tend to be receptive to the idea but by the time the project is under construction and the money is beginning to disappear, it becomes less of an objective.”

Nadir Abdessemed from Transsolar mentions a further obstacle. “Often there is a conflict of interests behind it: no one wants to be the spoilsport who calls people’s attention to malfunctions. So we sometimes drop by buildings at our own expense, talk to the people and check whether everything is working as planned. That strengthens customer loyalty and we also learn a lot from it.”

Learning effects are also at the heart of another initiative that Transsolar has

launched in the year of the company’s 20th anniversary. “Rationally speaking, our office and other offices for climate design do not even influence one percent of what is being built annually across the globe,” says Matthias Schuler. “Our approach is virtually unknown, particularly in the ‘majority world’. This is the term used to describe that part of the world that is often wrongly referred to as the ‘Third World’, despite the fact that the majority of people in the world live there.”

These considerations led the company to set up the Transsolar Academy in 2012, an in-house training facility that welcomes six scholarship holders every year. “Usually, half of them are architects and half are engineers, and the majority of them come from Africa, Latin America, India and Southeast Asia. They spend one year with us and during that time they learn in three different ways: we teach them the basics in the seminars; they work on a research project they chose themselves; and thirdly, after a period of familiarisation, they are included in our project teams. This enables them to experience the typical office routines for themselves, along with all the planning amendments and changes to customer demands, the discussions with architects and the presentations to developers.”

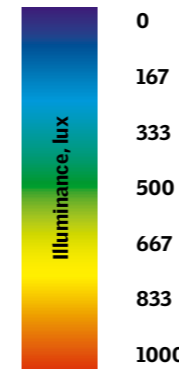
In the long term, Nadir Abdessemed says that hopefully, after returning home, the scholarship holders will be able to get things moving in the direction of more sustainable building practices in their home countries too. “The effect may only become perceptible in 10 or 20 years. But it allows us to establish contacts in countries where Transsolar has not previously worked.” Matthias Schuler adds, “we also benefit a lot from the cultural exchanges with our scholarship students. And our employees also learn something new – either because they participate in the training sessions of the academy or through their mentoring of the students.

Because if you want to teach something to someone, it forces you to structure the work and pass on the knowledge systematically.”

Technology transfer to the ‘majority world’ is the focus of a project that KVA Matx initiated in 2005. ‘Portable Light’ is a kit that consists of flexible thin-film solar cells and LED lights. The solar cells can be integrated into any locally available textile, bags or clothing; the aim is to provide light generated from renewable energy to people living in off-grid areas. “In contrast to traditional product design, which seeks to create highly specific objects, we developed Portable Light as an adaptable kit of parts,” says Sheila Kennedy. “We provide this kit to local NGOs who distribute it among isolated and vulnerable communities. It is the local people who decide what to make out of these parts.” In the meantime, Portable Lights are being used in seven countries worldwide, from Kenya to Brazil and Mexico. As in many of their research projects, the architects did not wait for anyone to request this kind of solution but developed Portable Light on their own initiative. “A lot of the times, the idea comes first in our work. It emerges as a question whether something could be done. And trying to answer this question, even if you do not have a precise idea of who will benefit from it, is definitely better than not acting at all.”

Notes

1. www.white.se
2. www.carpenternorris.com
3. www.kvarch.net
4. www.transsolar.com
5. A title that refers to Robert Redford’s movie “The Horse Whisperer” of 1998



0
167
333
500
667
833
1000

Studenthus Valla in Linköping (White Arkitekter).

Conceived as a central meeting place for the out-of-town campus of Linköping University, this new build was designed around the principles of sustainability and social interaction. Parts of the former student centre were re-used in the construction. The centrepiece of the building is a

two-storey entrance hall that diagonally connects with a top-lit atrium further above. Daylighting simulations were carried out to assess whether sufficient daylight would penetrate deep into the interior spaces.

Davidson Norris received a BA in French literature and history from Williams College, Williamstown and an MArch from the Yale School of Architecture in New Haven (USA). In 1984, he founded his own architectural office in New York and, in 1994, established Carpenter Norris Consulting, a firm dedicated to daylighting design and simulation, with James Carpenter. Davidson Norris has been involved in architectural education since 1992, and has been an Adjunct Professor at Columbia University, School of Architecture, in New York since 1998. He has collaborated with Marilyne Andersen on a number of projects in the last 15 years, particularly during her time as professor at MIT in Cambridge (USA).

Sheila Kennedy holds a bachelor’s degree in history, philosophy and literature, and received her architectural education at the École Nationale Supérieure des Beaux Arts in Paris as well as the Graduate School of Design at Harvard University. In 1990, she founded the Boston-based architectural practice Kennedy & Violich Architecture (KVA) together with Juan Frano Violich. In 2000, the practice created its own in-house materials research facility Matx and, in 2005, established the Portable Light project to deliver low-cost, reliable, PV-powered electric light to communities in developing nations. Currently, Sheila Kennedy teaches as Professor of the Practice of Architecture at MIT in Cambridge (USA), where she has also been a colleague of Marilyne Andersen for a number of years.

Marie-Claude Dubois is an architect who has worked with energy and daylighting in buildings since 1996, when she began her PhD at Lund University in Sweden. After completing her dissertation in 2001, she worked as a senior researcher at the Danish Building Research Institute (2001-2003) and as an associate professor at the Université Laval in Québec/Canada (2003-2010). Today Marie-Claude Dubois shares her time between White Arkitekter in Malmö, where she works as an environmental specialist, and Lund University, where she is associate professor at the Division of Energy and Building Design.

Matthias Schuler studied mechanical engineering at the University of Stuttgart. In 1992, he set up the company Transsolar Energietechnik in Stuttgart as a shareholder and its technical manager. This was followed in 2001 by the establishment of the company Transplan Technik-Bauplanung GmbH. In 2006, Transsolar opened a branch office (Transsolar Inc.) in New York. Over the past 25 years, Transsolar has carried out projects together with Steven Holl, Zaha Hadid, Shigeru Ban, Renzo Piano and Jean Nouvel. Matthias Schuler has been teaching since 1999. Between 2000 and 2014, he was initially a guest professor and subsequently an adjunct professor at the Graduate School of Design of Harvard University in Cambridge (USA).

Nadir Abdessemed studied mechanical engineering at the Technical University of Darmstadt and the University of California in Berkeley (USA). In 2007, he completed his doctorate at the Department of Aeronautical Engineering of Imperial College in London. Nadir Abdessemed has been working at Transsolar since 2009; from 2013 he was project leader in the New York office, returning to Stuttgart again in 2016. In addition, he has been a lecturer in landscape architecture at the Harvard Graduate School of Design since 2016.

3

WORKS

The design process of any building culminates in the act of construction and subsequent operation. It is here that ideas become physical, materials take shape, and good intentions must stand their reality test. From the chaos of the construction site arises beauty, and lasting impressions are created among those who use and inhabit the building. The daylight and indoor climate inside the spaces, which until then only existed in the architect's mind and the engineers' calculations, can now be seen and felt for the first time.

The following photographs of key works by Steven Holl remind us of a stance that the architect expressed in an interview in 2002: "The real test of architecture is the phenomena of the body moving through spaces, which can be sensed and felt regardless of understanding the architect's concept and philosophy."



COURTESY STEIN HOLL

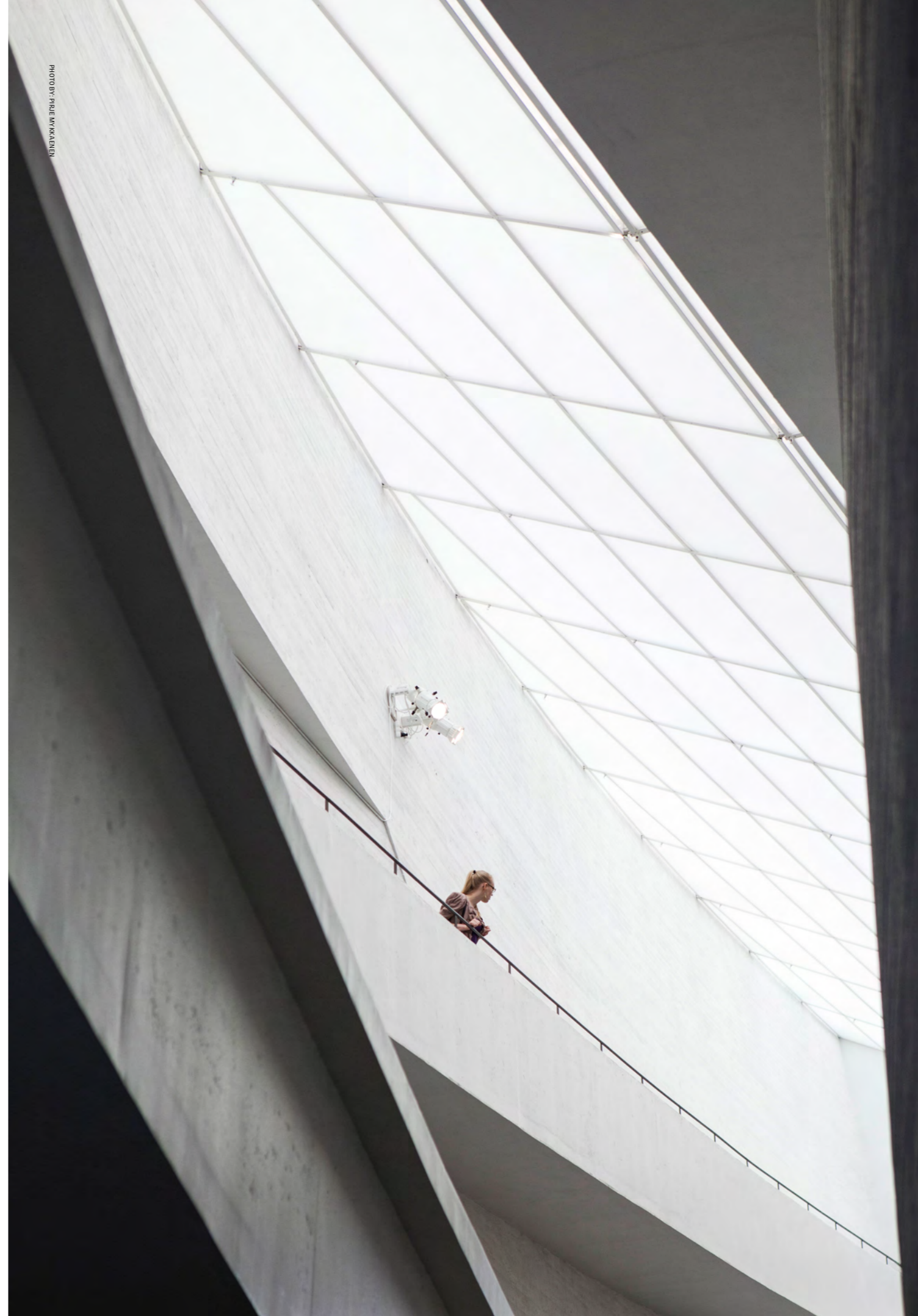


PHOTO BY PIIE MYKKÄENEN





PHOTO BY ANDY RYAN (PAGES 68-70) PAUL WARCHOL (THIS PAGE)

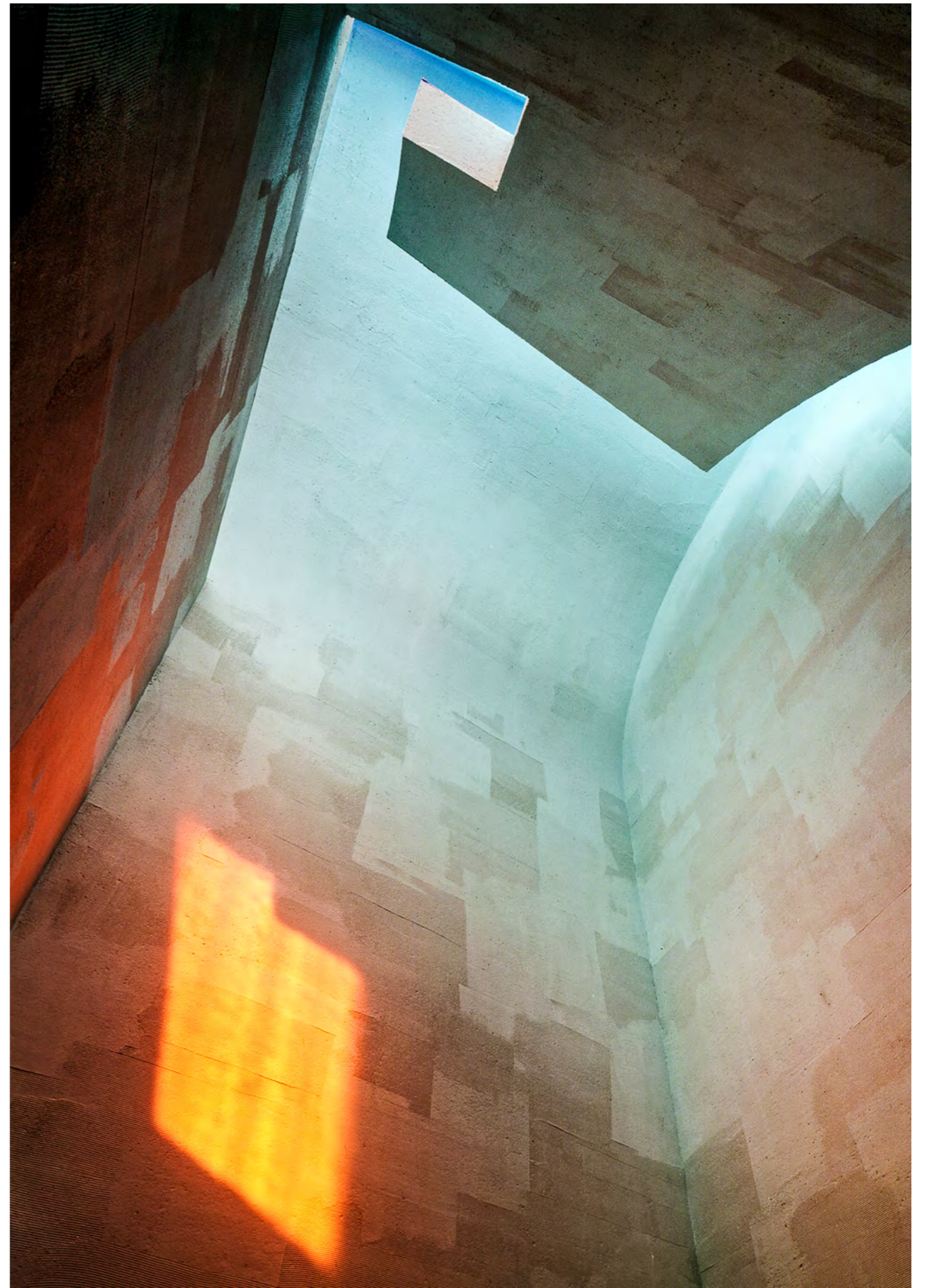






PHOTO BY PAUL WARCHOL

NELSON-ATKINS MUSEUM OF ART,
KANSAS CITY (2007).

Pages 68–70:

'The stone and the feather' was the motto of this museum extension, which ranks among Steven Holl's finest buildings. The 'stone' denotes the neoclassical, heavy 1933 limestone main building of the museum while the 'feather' consists of five luminous, partly underground pavilions clad in translucent glass that Steven Holl added along the perimeter of the museum grounds. These are linked by a continuous sequence of galleries and ramps that receive diffuse natural daylight through clerestory rooflights overhead.

KIASMA MUSEUM OF CONTEMPORARY ART,
HELSINKI (1998).

Pages 66–67, 72–73:

Steven Holl's first major international commission, this museum building reacts to its unique setting at the intersection of city and nature, between the train station, the Finnish parliament building and Töölö Lake. The building concept is based on the 'intertwining' (a notion that Holl also discussed in one of his earliest books) of two large volumes that flank a central, daylight atrium with access ramp. According to the architects, "the general character of the rooms, which are almost rectangular with one wall curved, allows for a silent yet dramatic backdrop for the exhibition of contemporary art. These rooms are meant to be silent, but not static; they are differentiated through their irregularity."

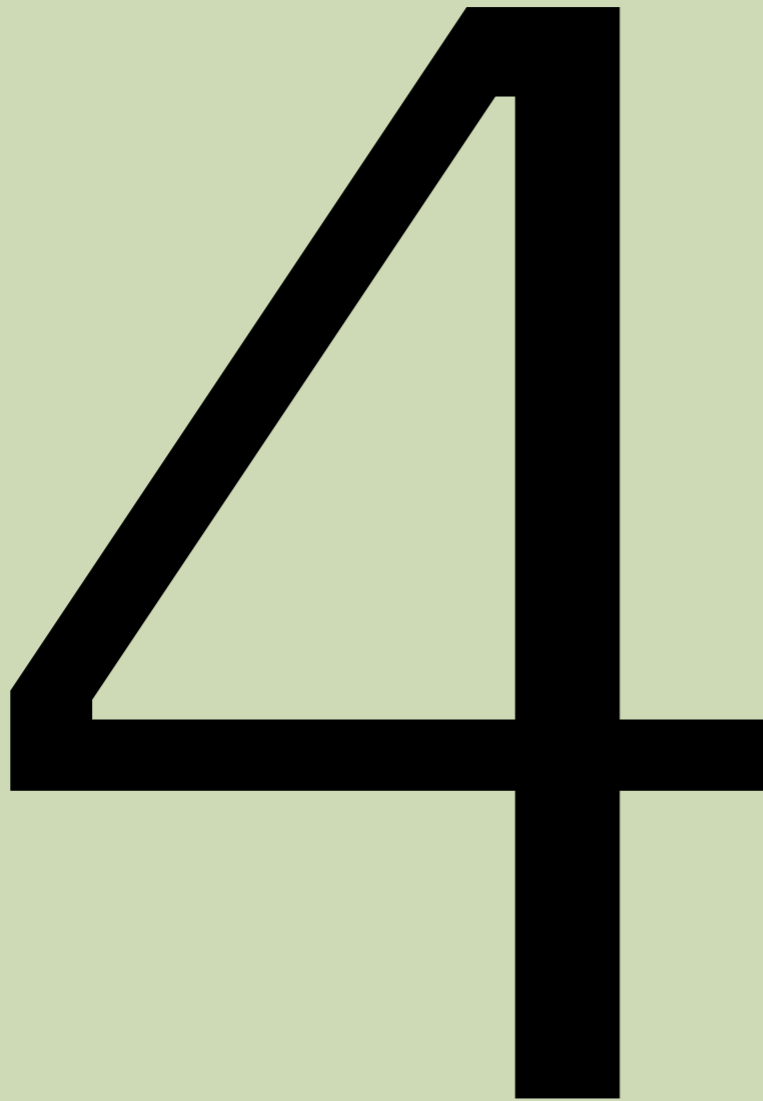
CHAPEL OF ST. IGNATIUS, SEATTLE
UNIVERSITY (1997).

Pages 70–71:

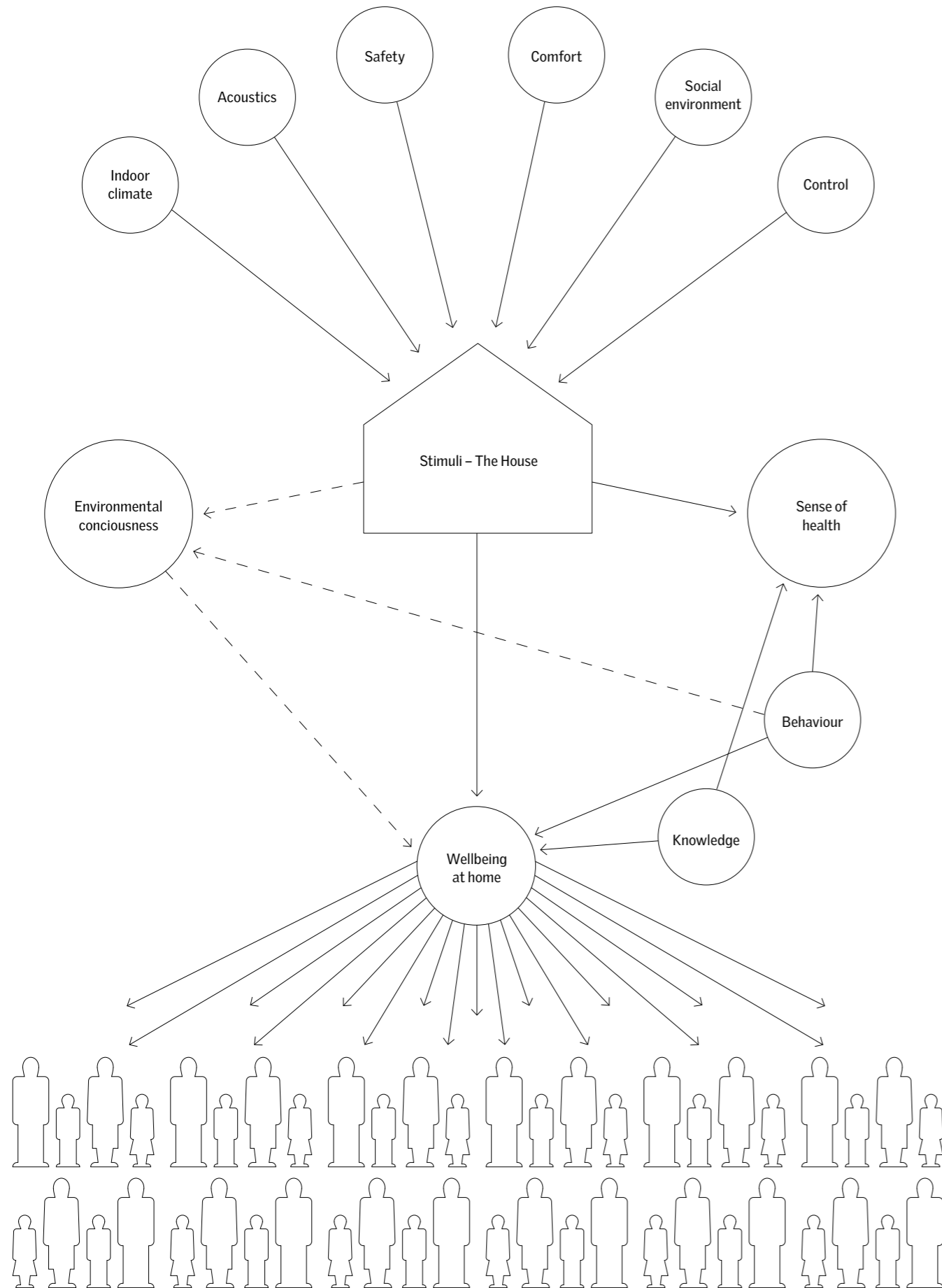
The curving roof forms of the chapel provide the sanctuary with six different qualities of light, each calibrated to illuminate a separate aspect of the religious ritual. On one hand, daylight directly enters through small coloured glass lenses (a modern interpretation of Gothic stained windows). On the other, it is introduced indirectly through larger openings with clear glass. This mix of different forms of light gently grazes the surfaces of ceilings and walls, which were given their characteristic checkerboard structure with the help of the mason's toothed trowel.

FEEDBACK

In the end, the success or failure of buildings is decided on by the users who occupy them. Hardly any architect or client would maintain that he or she was indifferent to the fate of buildings after their completion. But systematic surveys of users are only carried out in the rarest of cases. The users' personal attitudes and their wealth of experience affect how they feel in a space and how they judge it. Nonetheless, the well-being of people in buildings can be explained scientifically and expressed in objective, quantitative terms. In the past decades, scientists have developed methods to do so. Wouldn't it be possible to make more of these methods and models? What if the knowledge about what contributes to user well-being was used to design buildings for better well-being in the first place?



Methodological approach to home wellbeing.
See also page 81.



MAKING SENSE OF SENSI- BILITY

There is a lot that can be learnt from existing buildings in order to generate new knowledge for future architecture. Architects and engineers employ many different strategies to assess the successes and failures of their designs. Yet who could be more competent to judge than the true experts on everyday life – the people who actually live and work in the buildings? In the last 40 years, a whole range of methods has been developed to quantify residents' well-being and their level of satisfaction with their living conditions.

By Jakob Schoof
Photography by Ivan Brodey

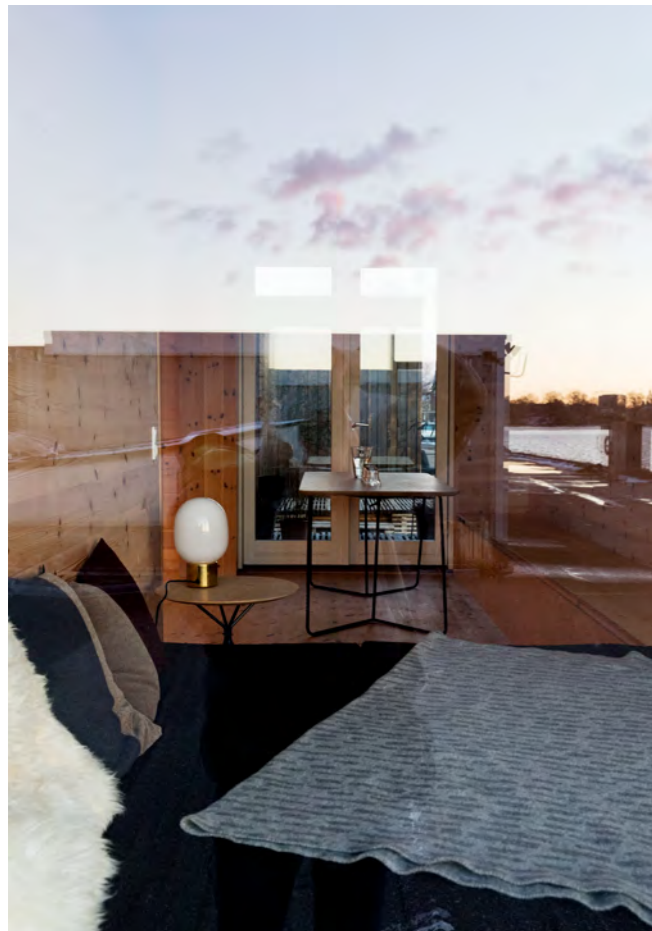


Figure 1
Page 78

Theoretical model of the Healthy Homes Barometer by the VELUX Group.

Housing well-being is influenced by a number of factors: the house itself, how healthy we feel, our home satisfaction, how we behave and the level of knowledge we have. To measure well-being at home, the model identifies eight factors.

Source: Bernd Wegener, Moritz Fedkenheuer

Tegnestuen Vandkunsten: CPH Shelter/CPH Village, Copenhagen

Discarded containers from one of the world's largest shipping companies serve as construction material for the housing concept CPH Shelter, with which the Vandkunsten architectural office wants to respond to the shortage of student housing in many large cities. Working with the start-up company CPH Containers, the architects aim to create temporary 'student villages' in the coming years for several hundred occupants on abandoned sites in Europe's large cities. This is being started with the CPH Village for 250 students due to be erected on the island of Refshaleøen in Copenhagen's harbour in 2017. The container housing units are 20 or 40 m² in size and already set to comply with the Danish energy standard for 2020.

CAN BUILDING DESIGN learn from its own successes and mistakes? How do you measure the success of a design if not by looking at the well-being and health of the users? And how can you find out whether the indoor climate really does enhance people's well-being?

The idea that the systematic evaluation of existing buildings could generate knowledge that will be useful when designing new ones is not new. A method, first deployed in the USA and Great Britain, was developed in the 1960s and 1970s that consisted of scrutinising existing buildings and asking the users about their experiences with the building. It is known by the collective English term 'post-occupancy evaluation' (POE).¹ The first user surveys were carried out towards the end of the sixties in student halls of residence in America. In the seventies, the method was expanded to include hospitals, office buildings, schools, social housing, and military facilities. Since the 1990s, post-occupancy evaluation has become a more common procedure, particularly for offices and administrative buildings. There are two main reasons for this: on the one hand, it was recognised that the buildings often consumed far more energy than previously calculated; on the other, the numbers of complaints about the poor indoor climate and malfunctioning technical equipment began to escalate. Investigations in the USA and in Germany have shown that the average user satisfaction in energy-efficient or LEED certified office buildings is no higher than that reported for most office buildings.² Experts put the blame for the performance gap between theory and practice primarily on the buildings' increasingly complex technical equipment and the inadequate induction given to subsequent facilities managers and users during the handover.

Meanwhile, in some countries the legislators began to react. In the UK, for

example, all new-build public buildings since 2016 are subjected to a three-year monitoring process that includes an annual user survey.³ But the situation for residential buildings is quite different – and not just in the UK. There are only a few systematic studies of people's well-being at home. According to Fionn Stevenson, professor at the School of Architecture of the University of Sheffield, the rarity of post-occupancy evaluation in this sector is linked to residents' expectations of privacy: "Simply gaining access to people's homes, which are private by their nature, can present a real barrier." One aspect that may play a role in this could be the fact that the clients of office buildings have a vested interest in a healthy and productive workforce, while the owners of residential buildings do not benefit directly from the improved well-being of their tenants. Nevertheless, there are a few hopeful developments, which will be discussed below.

Measurements and surveys: the methods of post-occupancy evaluation

In principle, post-occupancy evaluations can be carried out at any time during the lifecycle of a building to provide key insights: hindsight is useful as it allows the planning process and its success to be analysed; current insights can be used to adapt the building to the needs of users, while foresight can be used to learn about planning similar buildings in the future.

According to Fionn Stevenson, a POE offers numerous benefits: it reduces lifecycle costs and the environmental impact of buildings, decreases the developer's liability risks, minimises the expenditure required for maintenance, increases user satisfaction, and generates valuable knowledge that can be incorporated into making future designs better. A post-occupancy evaluation usually includes the following steps:

“People are the best measuring instruments. They are just harder to calibrate.”

Gary Raw

- a tour of the building together with the users and/or the facility manager
- technical measurements (e.g. room temperature, heating energy consumption, light/level of illumination, amount of CO₂ in rooms, air humidity, ...)
- user surveys using printed or digital questionnaires, or - more rarely - structured interviews

Technical measurements can, in themselves, provide interesting information about user behaviour in residential buildings. It is well known, for example that heating energy consumption in buildings that are otherwise identical in terms of construction can vary by a factor of three or even more, depending on user behaviour. In nine recently renovated apartment buildings in Karlsruhe, researchers from RWTH Aachen attempted to uncover the possible causes for this.⁴ To do so, they measured room temperatures based on thermostat settings but also determined ventilation behaviour using window contacts. They found that almost all combinations of temperatures considered agreeable by tenants and fresh air requirements were present. Some tenants preferred room temperatures of 24°C but kept their windows open 24 hours a day even in winter, while other tenants were content with an ambient temperature of 19°C and almost never aired their rooms.

But in order to get to the bottom of the motives for such behaviour and find out whether residents actually feel comfortable in the indoor climate they have chosen for themselves, one has to talk to them. Only a combination of measured physical data and qualitative statements by residents will reveal what the British building evaluation specialist Bill Bordass calls “the story behind the data”. Together with Fionn Stevenson and Adrian Leaman, he wrote in an article published in 2010: “In our experience, nothing

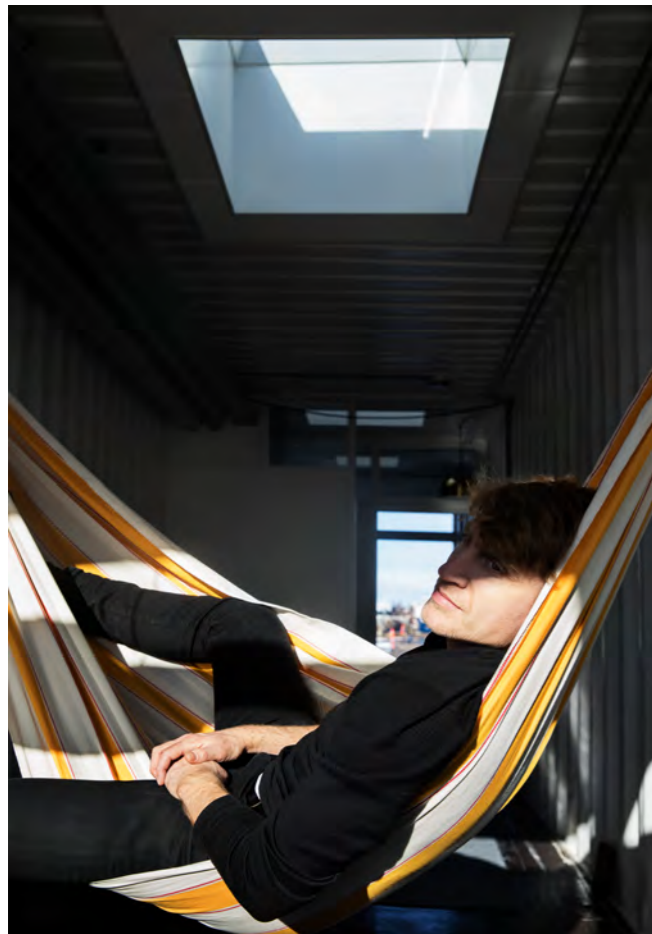
better case studies of named buildings backed by thorough data collection, benchmarked against a national sample finishing with a list of lessons learned, preferably including reflections on the results by the parties directly involved, and especially the design team.”⁵

What do we want to know?

Questionnaires and their contents

Numerous questionnaires - some of them standardised - have been developed in the last 30 years as a means of surveying the users of buildings (Fig. 5). The questionnaires most commonly used internationally are the British Building Use Studies (BUS) Questionnaire⁶ and the CBE Occupant Indoor Environmental Quality Survey developed at University of California, Berkeley⁷. Both were originally developed for office buildings, schools, and other non-residential buildings; since 2010, the BUS questionnaire has also become available in a version for residential buildings. The questionnaire has also been deployed when carrying out user surveys for the certification systems NABERS (Australia) and BEES (New Zealand). The international engineering consultancy Arup now curates the commercial version of the BUS questionnaire. Adrian Leaman of BUS estimates that around 60% of all surveys that use the BUS option are carried out by planning offices and 40% by university institutes. When the questionnaire was developed, he says, care was taken to keep it as short as possible and to focus on aspects that designers and managers can actually influence. Leaman believes it is important that the questionnaire is both practical and viable because, when they survey users, planners and academics are often pursuing very different and, in many cases, incompatible goals: “POE in the university sector has another agenda. It is often far too statistical and/or modelling orientated. And the work does not





speaking clearly to a designer audience. It is an academic echo chamber, not assisted by the conventions of academic publishing, especially writing styles.”

Adrian Leaman believes it is important that survey results are published; it is the only way to achieve broad improvements in the planning quality and user-friendliness of buildings. Unfortunately, according to Leaman, many planners and building contractors do not pay much heed to this recommendation – in particular when it is a question of making less flattering individual results public. In the UK, the Usable Buildings Trust charity was established in 2002 to pursue a wider dissemination of results, in a readable and understandable form, but with limited success.⁸

Furthermore, many user surveys of residential buildings continue to use questionnaires that have been customised to the respective research project or building. According to Adrian Leaman, this often means that results are not comparable, and cannot be successfully benchmarked against a common data set. Surveys almost always include questions about the user’s satisfaction with the size of the apartment, ease of use of the heating system and (where present) ventilation system, along with room climate parameters such as daylight, temperature and air quality. Additional questions can cover almost anything in or on the building – the view, privacy, the furnishings, cleanliness, the materials used, the atmosphere in the room, or technical installations. Occasionally, questionnaires may also delve into very fundamental issues. They can even include questions on the user’s satisfaction with the dwelling’s water and electricity supply – if such supplies cannot be taken for granted in that country.

At the other end of the development spectrum are highly efficient buildings and energy-plus houses of the type currently being built in many European

countries. More than 30 residential buildings that comply with energy-plus standards have been constructed in Germany in the last four years as part of the research programme “Efficient House Plus”. Researchers working at the Berlin Institute for Social Research surveyed the residents for the purposes of sociological monitoring.⁹ They focused particularly on how residents coped with the domestic technology installed in the buildings, but they also looked at users’ energy consumption behaviour. Residents’ attitudes towards the installed technology tended to vary quite considerably, ranging “from delight to scepticism”. However, the majority of people surveyed reported that the operation of the heating and ventilation systems was not yet intuitive for everyone. Many residents were also sceptical about the automatic regulation of the technological installations and expressed their preference for installing only as much technology in their homes as necessary. The respondents also made ambivalent statements about their energy consumption behaviour; most of them said that, since moving into an energy-plus house, they had become far more aware of their own energy consumption. The various displays in the houses, which constantly show energy consumption in real-time, certainly contributed to this increased awareness. But only a minority of the residents stated that they had actually changed their everyday habits since living in the new house.

Quantitative determination of well-being: The Housing Well-being Inventory

Bernd Wegener, professor of social sciences at Humboldt University in Berlin, and his colleague Moritz Fedkenheuer have developed a new approach to obtaining a quantitative understanding of housing well-being. The Housing Well-being Inventory (HWI) is based on the fundamental premise that well-being encompasses more than just the usual comfort

“The elephant isn’t *in* the room.
It is the room.”

Bill Bordass

**DataAE +Harquitectes:
Students' hall of residence in
Sant Cugat del Vallès**

Surrounded by overgrown meadowland, the architectural college of Sant Cugat del Vallès near Barcelona has stood alone at the edge of the town ever since its foundation. Now, 57 modular student flats have been built there. Two long, two-storey blocks made of prefabricated concrete modules flank a central, open courtyard. The individual apartments are private areas to which students can retreat, whereas the communal life of the students takes place in the green courtyard. According to the calculations of the architects, the energy requirement of the flats is around 70% less than the maximum allowed by Spanish law.

parameters such as temperature, daylight supply and air quality. But what does this ‘more’ consist of? To find out, Wegener and Fedkenheuer initially carried out numerous interviews with students but also with test families such as residents of the VELUX LichtAktiv Haus in Hamburg. Based on the responses, they consolidated ten dimensions of housing well-being that were summarised into three groups (Fig. 4). The two social scientists used a questionnaire with 29 statements (items) to determine how pronounced the dimensions of well-being were in certain buildings and for their residents. When responding to the questionnaire, residents had to specify how much they agreed with each individual statement. Statements ranged from “I feel at home in my apartment” to “My apartment needs to be renovated” to “It’s too light where I sleep”. Two to three items were assigned to every dimension of housing well-being to improve the reliability of the results.

With the HWI, Wegener and Fedkenheuer also aimed to find out how people’s well-being at home affects their energy consumption behaviour. To identify this, they added additional modules to their questionnaire. The modules contained questions about environmental awareness, the preferred style of living, the residents’ attitudes to housing technology and to their own health.

International comparison of housing satisfaction: the VELUX Healthy Homes Barometer

The Housing Well-being Inventory method can be also used to determine the housing satisfaction of entire populations and communities. This is precisely what Wegener and Fedkenheuer did with the Healthy Homes Barometer in 2015 and 2016, working together with the VELUX Group and the market research institutes Operate A/S and Wilke.¹⁰ For the second edition of the Barometer, pub-

lished in 2016, a selected representative sample of 14,000 people from 14 European countries were given a catalogue of 20 questions. This catalogue of questions is a reduced selection of the 29 items of the Housing Well-being Inventory. During their survey, researchers also found that 77% of Europeans do not have optimal sleeping conditions at home and that 82% live in rooms that are occasionally too cold in winter. Complaints of overheating are even more common – 87% of Europeans stated that their home was sometimes too warm in summer.

The study confirmed the association between ventilation, daylight and respondents’ subjective feeling about their health; people who reported that they regularly aired their rooms and had enough daylight at home assessed their own health as significantly better compared to people who lacked fresh air and natural light in their home.

The size of their home, the condition it was in (i.e., whether it required renovation or not) and relations with the neighbours had the biggest impact on housing satisfaction. According to Moritz Fedkenheuer, this is a clear indication that post-occupancy evaluations in residential buildings should not just be limited to questions about classic comfort parameters – socio-demographic factors and the building’s location also play a role. Owners of apartments are, on average, more satisfied with the apartment than tenants; people living in the country tend to be more satisfied than city dwellers; and younger people are more likely to be content than elderly persons. Moreover, it was found that the newer the house or apartment, the more likely its residents were to feel comfortable. On average, North Europeans were the most likely to be satisfied with their living conditions, followed by people living in Western, Eastern and Southern Europe. For those living in the Mediterranean area, housing satisfaction depended very



Figure 2

Design strategies aligned with user needs and expectations according to Bill Bordass and Adrian Leaman. Whereas essential functions that do not require user interaction should operate silently in the background (upper left quadrant), all systems requiring interaction with the users should be either easy to understand (upper right quadrant) or provide the necessary flexibility for unpredictable changes and individual needs (lower right quadrant).

Source: Adapted from A. Leaman, 'User needs and expectations', in Buildings, Culture and Environment: Informing Local and Global Practices, Oxford: Blackwell Pub. (2003)

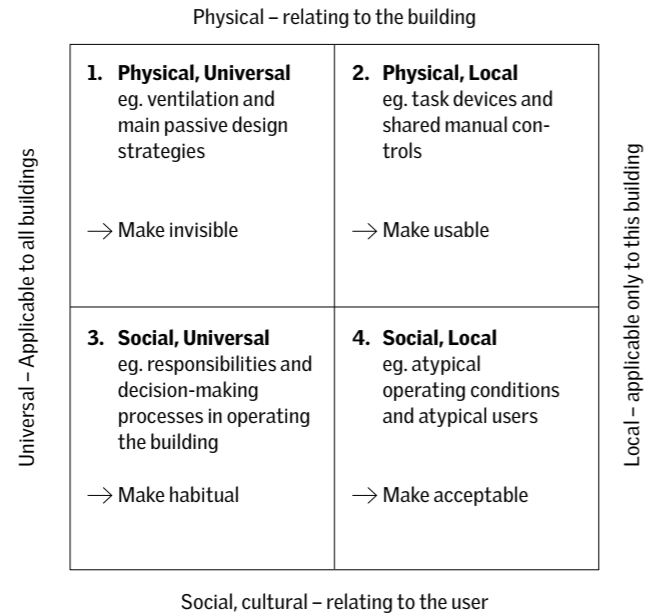


Figure 3

Conceptual model for the evaluation of building performance by Marans and Spreckelmeyer. Our environmental satisfaction and our behaviour inside a building are not just influenced by the objective environmental attributes of the building, but also by how we 'frame' our experience of the building, i.e.: what buildings have we experienced in the past, and what standards are commonly applied to buildings in the culture that we live in?

Source: R. W. Marans & K. F. Spreckelmeyer, Evaluating Built Environments, Chicago: The University of Michigan (1981).

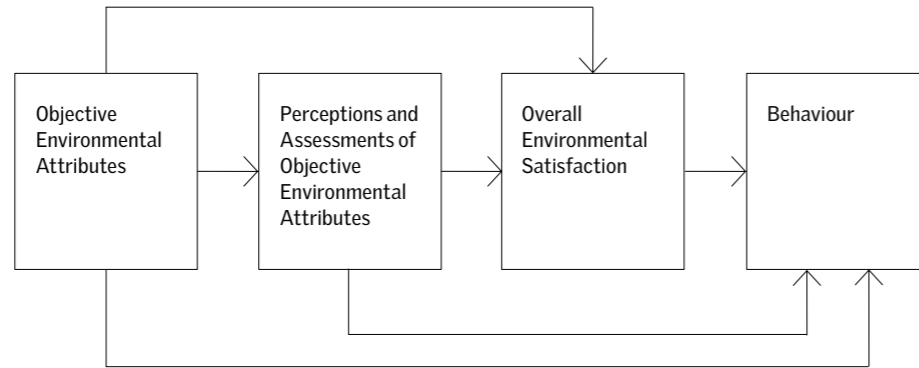


Figure 4

First-order and second-order well-being factors according to the Housing Well-being Inventory (HWI). The size of the home is not correlated to any of the other factors and hence forms its own second-order category. However, its influence on overall housing well-being has been shown to be less significant than that of both the affective and functional well-being.

Source: Bernd Wegener

- | | | |
|---|---|--|
| <p>1.
Affective well-being</p> <ul style="list-style-type: none"> Emotional attachment Indoor climate Neighbourhood Daylight Quality of sleep | <p>2.
Functional well-being</p> <ul style="list-style-type: none"> State of renovation Energy consumption Humidity Heating control | <p>3.
Space for well-being</p> <ul style="list-style-type: none"> Size |
|---|---|--|





Technical University of Darmstadt, Department of Design and Building Technology: students' hall of residence 'Cubity' in Frankfurt

Cubity is a real-life laboratory for new forms of communal student living. There are only eight square metres of available space for each occupant, whereas the communal areas are all the more spacious. The build envelope is formed by a translucent polycarbonate facade in which windows can be opened

only at the corners of the building. A modular rooflight supports the natural ventilation. Only the prefabricated living cubes in the building are actively heated and cooled. The large communal area can only be slightly tempered with the help of an underfloor heating system, which allows the temperatures to fluctuate between around 18 and 28 °C depending on the season and the amount of sunshine that enters.

much on the size and state of renovation of their home, while in Eastern Europe the indoor room climate had a big impact on housing satisfaction.

The survey also provided interesting answers to the question of why people did not air their rooms more often or heat their homes more in winter. Technical shortcomings, such as too little insulation or an inadequate heating system, were some of the reasons cited. The wish – or the necessity – to save on energy costs at home is quite common. But lack of knowledge is also a possible explanation; many people overestimate the heat loss caused by a short period of intensive ventilation. And many more people ventilate their homes after getting up in the morning than before going to bed. And yet a sufficient supply of fresh air in the evening is essential for healthy sleep.

Often it is not abstract knowledge but actual experience that changes people's attitudes towards housing. This was also demonstrated by the evaluation of the LichtAktiv Haus and the VELUX Model Homes 2020 buildings. People often only perceive the difference between a dark home and a light home when they experience it in everyday life. Or to put it differently – we simply do not know what we are missing until we see an abundance of daylight in our new home with our own eyes.

New ways of living and what the residents think about them

For the upcoming years, Bernd Wegener and Moritz Fedkenheuer have planned another research project in which they want to go back to the roots, as it were, of post-occupancy evaluations. Student halls of residence were the first buildings whose residents were systematically asked about their housing satisfaction. In many respects, halls of residence are the laboratories of the future for living in expanding urban centres; they are places where people who cannot afford large

apartments live together in confined spaces, and they are where new ways of communal living that go beyond traditional nuclear families can be tried out.

In the coming years, the two social scientists want to carry out sociological investigations in three student halls of residence. The first is a fairly traditional hall of residence with many small individual apartments; the second is a so-called Vario living concept where residents can vary the size of communal and private spaces using movable wall elements; and the third is the experimental 'Cubity' hall of residence. In Cubity, each resident only has eight square meters of private space. In return, the students will be provided with a generous communal area.

The Vario hall of residence, based on a design by the architecture firm Drexler Guinand Jauslin, will be built in Heidelberg as part of the International Building Exhibition (IBA). Cubity has already been built. It was designed by students of TU Darmstadt under the direction of Anett-Maud Joppien and Manfred Hegger, and was completed in Frankfurt at the end of 2016. Here again, the evaluation will be based on the criteria of the Housing Well-being Inventory, although the Inventory was expanded by several aspects specific to living in halls of residence. Compared to typical single-family apartments and houses, social interaction, privacy, customisability and productivity (how easy is it to study undisturbed in the rooms) tend to play a significantly greater role in the case of Cubity & Co.

In addition to questionnaires and individual and group interviews, Moritz Fedkenheuer also uses methods of participant observation to study how students live together. To do this, he spends several days living in the halls of residence himself; while staying there he records his own subjective impressions. He additionally logs as many activities in the halls as possible: Where do students meet each

other? What is the communal area used for and how intensively is it used? The interviews with the residents also aim primarily to obtain a better understanding of how the different rooms are used. The students are asked to tell where they stay, how often they linger there and for what purpose. But they are also asked to give free rein to their creativity by designing – based on their own personal experiences with the house – an alternative Cubity that would meet their needs even better.

What to do with the knowledge acquired? A concept for new feedback systems

But what can the knowledge obtained about the conditions under which people feel comfortable at home be used for? In the short term, it can be used to carry out small modifications in the investigated buildings or to improve the usability of the technical installations. In the long term, the knowledge can be used to design even better residential buildings tailored to the needs of their residents. But the knowledge obtained could also be used to motivate residents to behave in a more energy-conscious way. Nowadays, many energy-efficient new buildings use display screens to inform residents about their energy consumption in real-time. The hope is that this feedback will encourage people to be aware and use energy more responsibly. But experience has shown that the result of these displayscreens is often only a one-off effect; energy consumption tends to drop by a few percentage points in the first few weeks after moving in and then remains constant at the new level – or may even increase again as residents revert back to their old habits. “To achieve sustained changes in behaviour, the feedback needs to be much more personalised and should include concrete tips on changing behaviour,” says Bernd Wegener. And feedback systems also need to spot what the right motivation could be. Instead of attempting to entice residents by energy savings of

a few pennies, it might be better to tempt them by the prospect of better well-being, Wegener thinks. The system’s energy-saving tips should be adapted to take account of the building’s efficiency standard and the residents’ attitudes. How pronounced is their overall energy awareness? How much time do they spend at home each day? In a research project funded by the EU, Bernd Wegener and Moritz Fedkenheuer have developed a concept for such an interactive feedback system. There can be no doubt that a lot of development efforts will still be needed to implement their concept. But if this is what could close the feedback loop between buildings and users, then ultimately both sides could benefit – the residents and the environment.

Outlook: rarely has building evaluation been as important as it is today

How does new knowledge arise? In science, this is an everyday occurrence. Hypotheses are proposed, tested and, depending on the results, accepted or rejected. Architects would also do well to regularly examine their built hypotheses if they want to adequately meet future challenges. The evaluation of existing buildings makes an important contribution to this. It is the missing link that can complete the learning curve in architecture and ensure that future generations of buildings perform better in practice than those of today. To do so, it is clear that buildings need to contribute to their users’ well-being.

Although experts – including those who were interviewed for this issue of Daylight/Architecture, such as Marilyne Andersen, Davidson Norris and Matthias Schuler – repeatedly stress the importance of post-occupancy evaluation, the method still leads a niche existence in Europe. At the moment, however, it is receiving valuable impetus from two directions – the social sciences and information technology. For residential

buildings in particular, there are now promising new approaches to the quantification of occupants’ well-being. In future, intelligent control systems could be able to learn the individual preferences of their users and adapt the interior climate accordingly. But even if this happens someday, it will not be the end of development. Even then, existing buildings will supply architects and planners with valuable information so that they can expand their wealth of experience and generate knowledge for future designs.

Notes

1. The Usable Buildings Trust from the UK uses a narrower definition of POE, applying this term only to building evaluations carried out as part of the overall design and building process. For surveys done purely for research purposes, the more generic term ‘building evaluation’ is used.
2. S. Altomonte, S. Schiavon (2013): Occupant satisfaction in LEED and non-LEED certified buildings. *Building and Environment*, Vol. 68, pp. 66–76 A. Wagner et al. (2015): Nutzerzufriedenheit in Bürogebäuden. Fraunhofer IRB Verlag, Freiburg
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8. www.usablebuildings.co.uk
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10. www.velux.com/article/2016/europeans-on-healthy-living-the-healthy-homes-barometer-2016

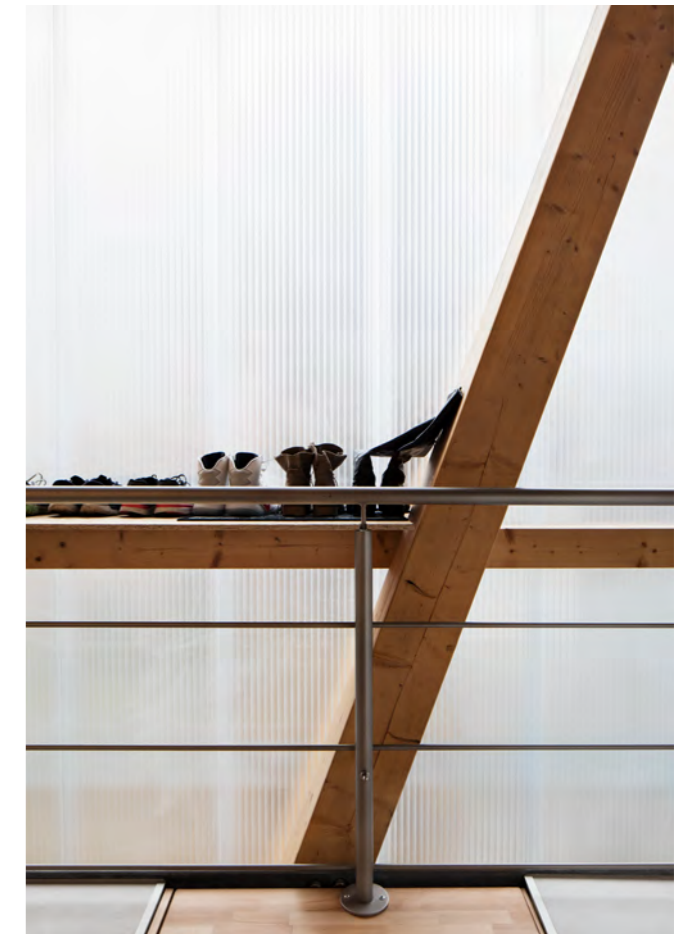


Figure 5

Questionnaires used for post-occupancy evaluation in residential buildings, with the respective criteria and aspects covered.

Name	Building Use Studies	Design Quality Indicator	CBE Occupant Indoor Environmental Quality Survey	Effizienzhaus Plus questionnaire	Housing Well-Being Inventory
Developed by	Building Use Studies Ltd. (UK)	Construction Industry Council (UK)	Center for the Built Environment, University of Berkeley (USA)	Berliner Institut für Sozialforschung (DE)	Bernd Wegener, Moritz Fedkenheuer (DE)
Year	1985 (original version) 2010 (residential version)	2002	2004	2013	2013
Applicable to residential buildings	Yes	Partly	Partly (with adaptations)	Yes	Yes
Criteria/aspects covered	<ul style="list-style-type: none"> - Location - Space - Layout - Storage - Appearance needs - Temperature in winter - Air quality in winter - Temperature in summer - Air quality in summer - Noise - Lighting - Health (perceived) - Personal control - Design (overall) - Changes in lifestyle - Utilities costs 	<ul style="list-style-type: none"> - Use - Access - Space - Character & innovation - Form & materials - Internal environment - Urban & social integration - Performance - Engineering systems - Construction 	<ul style="list-style-type: none"> - General satisfaction-building - General satisfaction-workspace - Ease of interaction - Building cleanliness - Comfort of furnishing - Amount of light - Building maintenance - Colours and textures - Workspace cleanliness - Amount of space - Furniture adjustability - Visual comfort - Air quality - Visual privacy - Noise - Temperature - Sound privacy 	<ul style="list-style-type: none"> - Size - Appropriateness of the floor plan - Brightness - Neighbourhood - Indoor climate - Functionality of the heating system/heating controls - Functionality of the ventilation system/ventilation controls - Health/Allergic reactions - Energy balance - Ease of Interaction - Ease of maintenance - Consumption behaviour (related to energy and other resources) 	<ul style="list-style-type: none"> - Emotional attachment - Size - Modernity - Daylight - Neighbourhood - Heating control - Energy consumption - Humidity - Quality of sleep - Indoor climate



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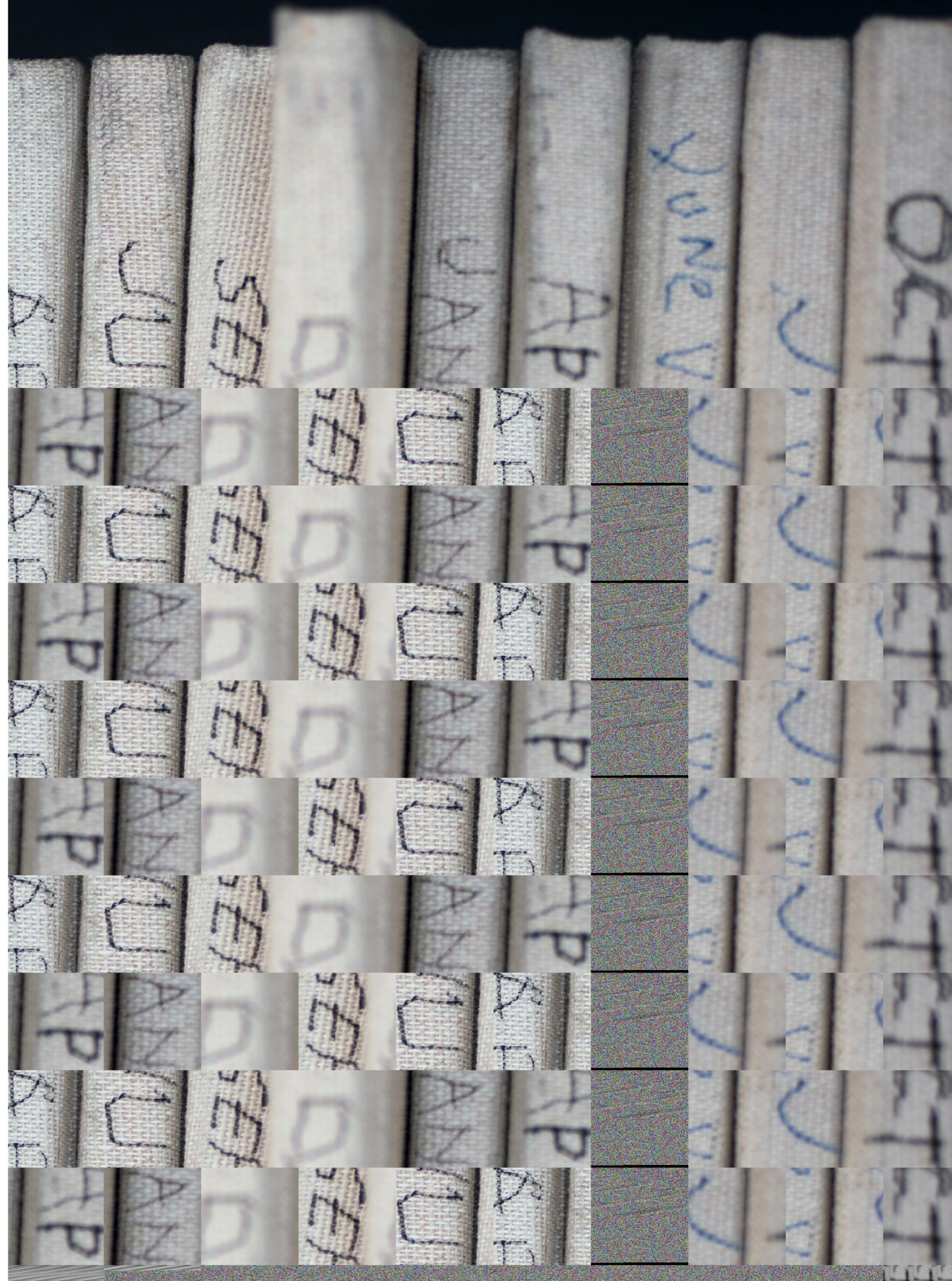
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