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LIGHT TO LIFE

We spend most of our lives in buildings

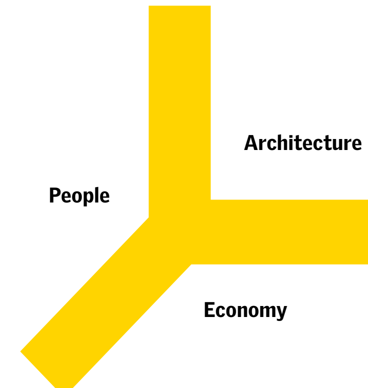
People globally spend about 70% of their time in buildings. In developed countries, this figure is close to 90%.

Indoor pollution linked to lower respiratory infections is estimated to cause about 11% of all human deaths globally each year.*

* Sustainia Sector Guide: Buildings. www.sustainia.me/sustainia-award/buildings_sector_guide.pdf

VELUX EDITORIAL

LIGHT TO LIFE



UNESCO has declared 2015 the Year of Light. That highlights the importance of light in human societies as a carrier of information and energy, a source and signal of prosperity, and, above all, a tool to improve human quality of life.

We know that the right doses of daylight and darkness at the right times of day and night are essential for human health, which is a cornerstone for human quality of life. In a time when we spend up to 90% of our time indoors, and when 80 million Europeans live in homes that suffer from damp, hardly anyone could question that architecture has an impact on the health and well-being of people living or working inside buildings.

However, there seems to be a gap between knowledge and behaviour. Europeans consider that their homes are of huge importance to their health and well-being; but, in general, they are reluctant to behave according to their beliefs and let in fresh air and daylight. This is an important conclusion in the Healthy Homes Barometer 2015 by the VELUX Group – also presented in this magazine. We want the study to inspire and enable building owners, planners and policy makers to take qualified decisions in the quest to improve peoples' lives.

But how do we put this knowledge into practice when upgrading the existing building stock? How do we set the right priorities in the design and construction of future buildings? And what synergies can be formed between good daylighting and other essential indoor environmental qualities in buildings?

Any attempt to solve this puzzle will have to take into account three aspects:

- people's needs, in particular health and well-being,
- the qualities of the existing building stock and possibilities to transform it
- the economic and political framework.

In this issue of D/A, we focus on People, Architecture, and the Economy, and the role that daylight and fresh air play. This is elaborated and discussed by different experts, highlighted by selected statistics, and illustrated by case studies from exemplary buildings.

Articles by Koen Steemers, Bernd Wegener and Moritz Fedkenheuer point out that design strategies for well-being cannot be based solely on quantitative parameters such as temperature or indoor air humidity, and that well-being is more than figures and measurements. Koen Steemers presents five ways to well-being and outlines rules of thumb for designers to nudge building users into healthier ways of living. Bernd Wegener and Moritz Fedkenheuer developed the Housing Well-Being Inventory, which evaluates the subjective aspects by asking people living in the buildings. The two authors state that if we want to enhance well-being in buildings with daylight and fresh air, universal strategies are needed. Vivian Loftness shares this point of view. Her article describes studies proving how daylight and fresh air can improve the learning speed among students by up to one quarter, and increase the productivity of a workforce by up to one-fifth. When people are asked directly, it becomes evident that there is a gap between the level of peoples' awareness of the benefits of daylight and fresh air and the level of implementation of the knowledge. To fill the gap – and tap into the potential – we need to rely on one of the most important benefits of architecture; once people live in buildings with plenty of daylight and fresh air, they experience the difference that this makes to their health and well-being.

However, for such buildings to become reality in great numbers, we need to spark the transition in the building industry and we need building owners who are willing and able to pay for the buildings designed or renovated with daylight and fresh air in mind.

Enjoy the read!
The VELUX Group

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D/A

"So far, standards and guidelines in the building sector mainly aim to prevent buildings from harming human health. Yet architecture can – and should – do much more than this," argues Koen Steemers from the University of Cambridge in his article. Building design should aim to actively 'nudge' building users into health-supporting behaviours. Researchers have identified five such 'Ways to Well-Being' in the past. What recommendations for building design can be derived from these?

Over the decades, researchers have established well-defined ranges of comfort with respect to temperature and light, and air quality and acoustics to help practitioners design comfortable buildings. Yet well-being in a holistic sense cannot be prescribed in this way, as it depends on numerous individual factors. In their article, Bernd Wegener and Moritz Fedkenheuer present a different approach: the Housing Well-being Inventory, a tool to evaluate and quantify well-being at home, based on the residents' perceptions and reactions.

With the Model Home 2020 experiment and the Healthy Homes Barometer, the VELUX Group has initiated two ground-breaking research projects to identify the key parameters that influence health and well-being at home. In his article, Moritz Fedkenheuer discusses some of the key results. Notably, people are well aware of the benefits of daylight and fresh air, but tend to underestimate their influence on well-being in practice.

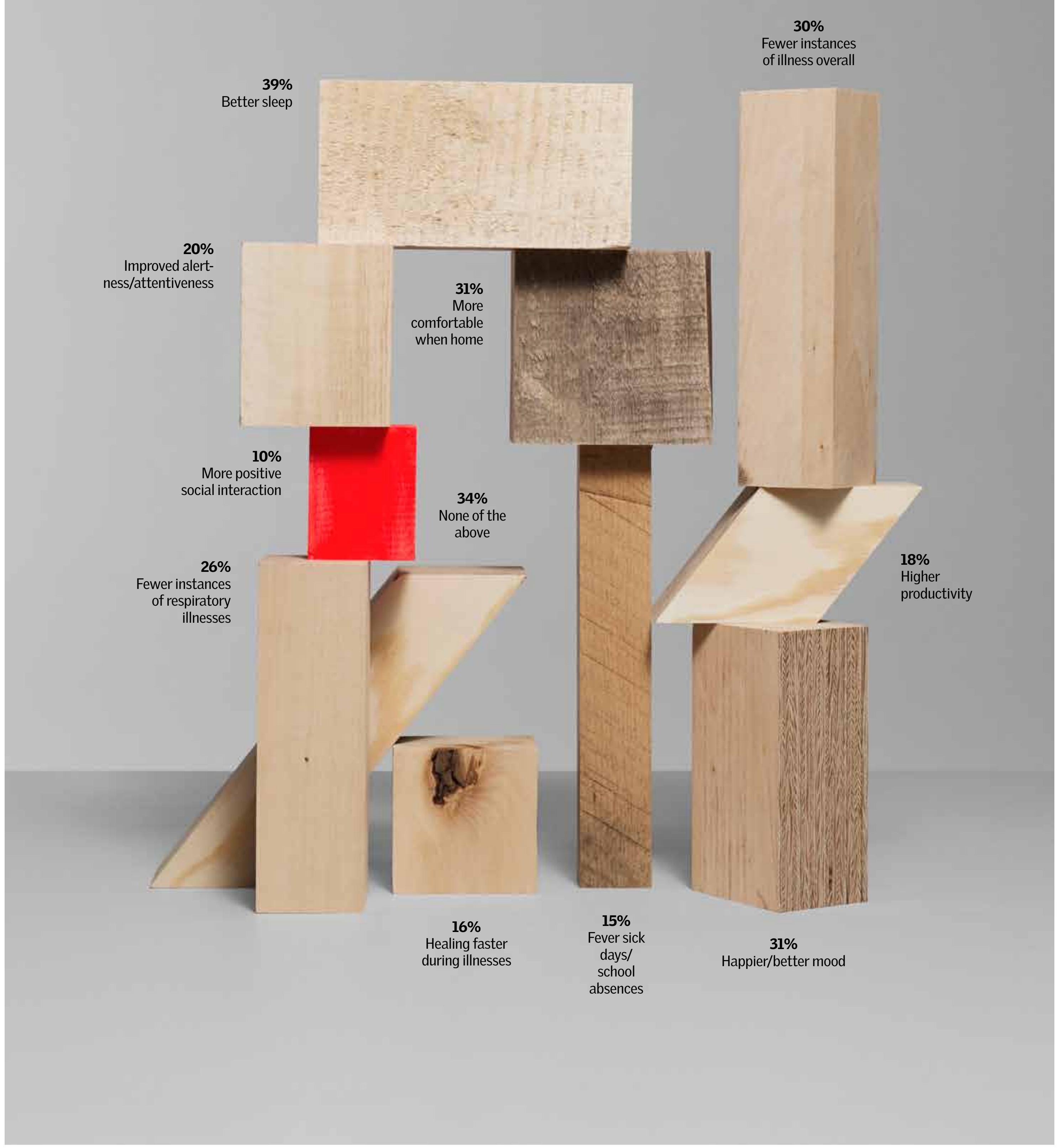
A new paradigm is gaining ground in the building sector: homes and office buildings, schools and hospitals that literally 'surf' through the seasons of the year, using windows to harness nature's renewables for heating, cooling, lighting and ventilation. As Vivian Loftness explains in her article, the true benefits of these buildings (which usually far outweigh their slightly higher construction costs) can often only be quantified in a triple bottom-line calculation that takes into account economic, environmental and social benefits.

The economics of well-being
It is not only the occupants who benefit from healthy buildings – so do building owners and society in general. The following graphics illustrate why people's health and well-being should be a core issue in the design of any building, and what still needs to be done in order to create a healthier building stock in Europe and anywhere in the world.

Photography by **Ola Bergengren**
Set design by **Iwa Herdensjö**

Homeowners clearly perceive the benefits of healthy buildings
Two-thirds of all U.S. homeowners say that their home influences their state of health and well-being. The quality of sleep, better mood, and fewer overall illnesses are among the most frequently stated effects.*

* The American Institute of Architects/McGraw Hill Construction: The Drive Toward Healthier Buildings. Smart Market Report, 2014. www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab104164.pdf.
All values apply to the United States.



Thekla Ehling is a German photographer based in Cologne. She studied photography in Dortmund, Germany, and Limerick, Ireland, and has worked for numerous magazines in Germany and abroad, including Der Spiegel, Die Zeit, GEO, de Volkskrant, Brand Eins and NEON. In one of her previous assignments for the VELUX Group, she documented the works of SANAA, Will Bruder Architects, Jarmund/Vigsnaes, and Lacaton & Vassal in Daylight/Architecture 15.

ARCHITECTURE FOR WELL-BEING AND HEALTH

By Koen Steemers

To truly enhance human well-being, building design needs to move beyond optimising single parameters such as temperature and humidity, to more holistic approaches that take their cues in health-supporting human behaviours. Based on the Five Ways to Well-Being that have recently been established by scientists, this article outlines some essential rules of thumb that designers can follow in order to nudge building users into a healthier way of living.

'BUITEN DE VESTE' SCHOOL IN STEENBERGEN, THE NETHERLANDS

> "Whether people are healthy or not, is determined by their circumstances and environment. To a large extent, factors such as where we live, the state of our environment, genetics, our income and education level, and our relationships with friends and family all have considerable impacts on health ..."
>
> World Health Organization: The determinants of health, http://www.who.int/hia/evidence/doh/en/

THE DESIGN OF OUR built environment affects our health and well-being, and can have long-term implications for quality of life. The publication of *Nudge: Improving health, wealth and happiness* by Richard Thaler and Cass Sunstein in 2008 was influential in revealing that behaviour can be strongly influenced by context[1]. People can be nudged into making better decisions in largely automatic, non-coercive and simple ways, through changing what Thaler and Sunstein refer to as "choice architecture". Can architecture create choice architecture? The role that architecture can play seems evident: "Design-led interventions can make better choices easier or constrain behaviours by making certain actions more difficult"[2].

The purpose of this article is to outline the definition(s) of health and well-being, and to determine the potential implications and opportunities for housing design. The emphasis will be on the presence of well-being rather than the absence of ill health. There can be no doubt that negative physical health-related considerations associated with, for example, poor indoor environmental quality should be avoided. However, this essay will focus instead on supporting positive mental well-being, which, in turn, has implications for physiological health. There is an established body of expertise related to the study of physical health with increasing quantitative evidence, but research into well-being in the built environment is a relatively recent and largely qualitative area of investigation that is nevertheless beginning to reveal consistent and widely accepted findings. These findings are interpreted here in terms of architectural design.

When we discuss well-being in buildings, it is more important to incorporate a wide range of both quantitative and qualitative health considerations rather than to focus on single, narrowly defined criteria. Such 'silo thinking' tends not to aid good design (perfectionism can be crippling) and often different criteria are in tension. An alternative approach is to determine 'good enough' strategies which increase diversity and adaptability, and that are user-centred. This is not to deny the potentially chronic health impacts of poor indoor environmental quality on certain sectors of the population (i.e. large impact for a small population), but rather to balance and complement this with strategies to improve well-being for the wider population (i.e. modest improvement for a large population).

The structure of this article is divided into three sections. The first section reviews the spatially relevant definitions of well-being and their relationships to health. The second section draws on research to define the implications and opportunities for architecture. Finally, the last section provides rules of thumb and architectural propositions that exemplify the findings.

DEFINING HEALTH AND WELL-BEING

The World Health Organisation now defines health not as the absence of ill-health but as "a state of complete physical, mental and social well-being"[3]. The definition of health has been changing and now includes an awareness of the interrelationships between social and psychological, as well as medical, factors. The way in which an individual functions in society is seen as part of the definition of health, alongside biological and physiological symptoms. Health is no longer simply a question of access to medical treatment but it is determined by a range of factors related to the quality of our built environment[4].

This wider definition of health comes at a time of increasing pressures on health services as a result of an ageing population, increasing obesity, rising mental health problems and higher expectations[5]. Thus, the narrow focus on individual symptoms and medical treatment is no longer sufficient or sustainable, and a more holistic appreciation of the spectrum of health-related considerations, including the prevention of ill-health, is timely. This approach sees "health and well-being as interdependent; it holds 'prevention' as important as 'cure', and looks for long-term solutions rather than more immediately attainable treatments"[6]. Staying healthy in your home and in your community is the way to limit the increasing pressure on health services, and thus designing the home, neighbourhood and work environment to improve health and well-being is an opportunity that presents itself.

In the field of sustainable development, reference is often made to the 'triple bottom line' of physical, economic and social. The health and well-being triple bottom line could be summarised as health, comfort and happiness. In order to draw more direct

The notion of well-being consists of two key elements: feeling good and functioning well.

parallels with the built environment, we can refer to Vitruvius and his tripartite model of the three elements required for a well-designed building[7]:

I "firmitas" or firmness (health)
II "utilitas" or commodity (comfort)
III "venustas" or delight (happiness)

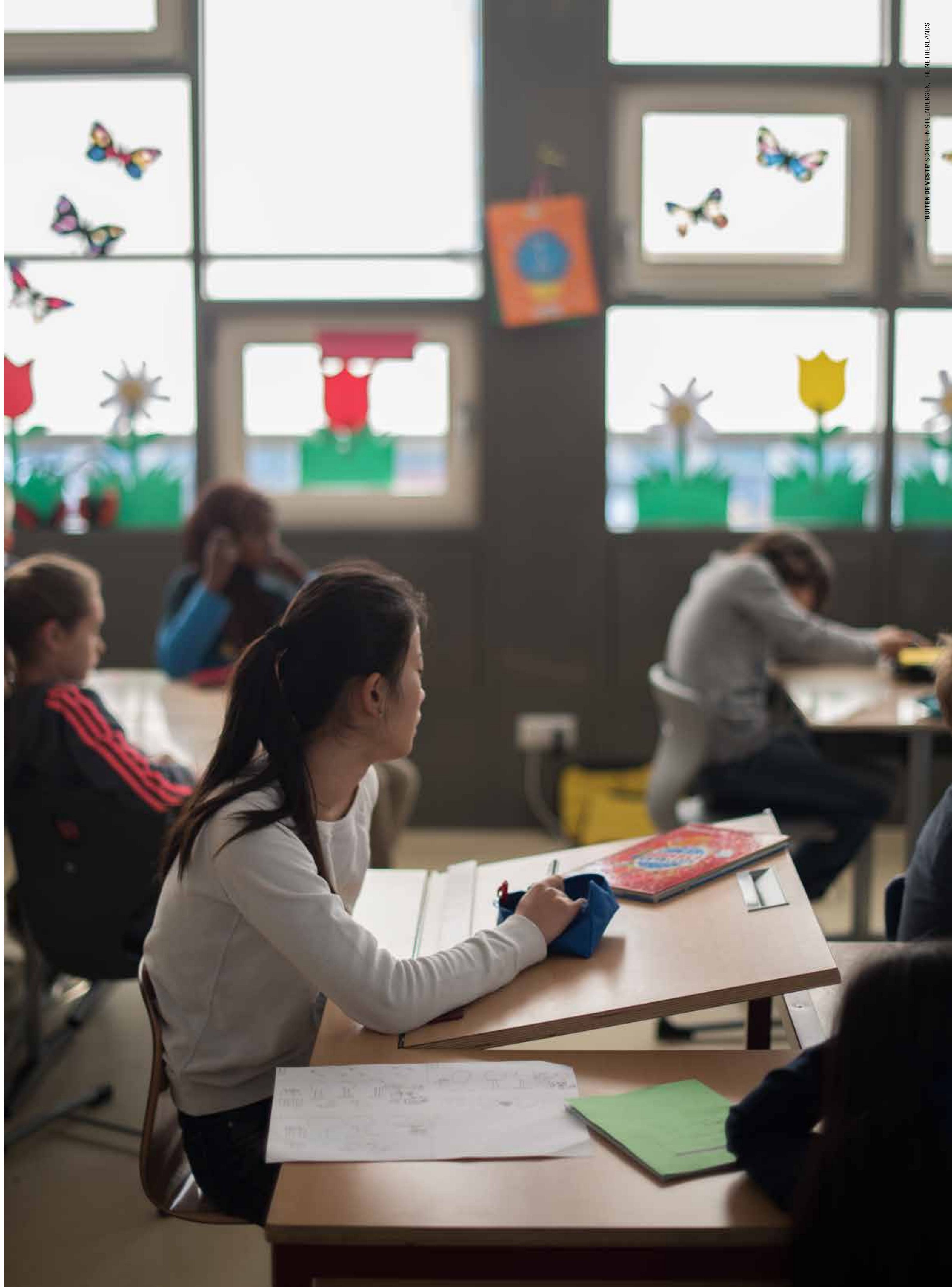
Health is referred to in this context in more conventional terms – as the absence of disease – and typically measurable in terms of symptoms such as body temperature or blood chemistry. Comfort is widely understood to be a "condition of mind which expresses satisfaction" with the environment[8] – whether thermal, visual, acoustic, etc. – and thus incorporates both qualitative psychological considerations (e.g. expectation, control) and quantitative physical parameters (e.g. temperature, air movement). Happiness colloquially refers to emotions experienced, potentially ranging from contentment to joy. Happiness is therefore primarily a subjective and qualitative consideration. Despite this, research over the last decade has begun to define well-being, which will be addressed in more detail in this paper.

One key challenge is the quantification of health and well-being, and thus the assessment of the overall health performance of design. At one end of the spectrum, physical ill health is typically identifiable and measureable in terms of the symptoms and causes. For example, air quality (e.g. VOCs, PM or CO_2) and its impact, particularly on vulnerable occupants (e.g. those with lung conditions, the young and the old), can be quantified, and even treatments of both the occupants and the buildings can be prescribed (e.g. improved ventilation, the removal of offending materials, design interventions to prevent mould growth, etc.). Although subjective assessment of air quality, particularly related to odour, can offer useful insights, often health-threatening indicators can only be measured. Specific criteria and design strategies to tackle chronic physiological health problems can be defined, and there is a wealth of expertise to support this[9].

At the other end of the health and well-being spectrum is mental well-being or happiness. As we move from the deterministic-medical to the subjective-psychological end, the common perception is that the emphasis changes from quantitative to qualitative. However, it is now evident that even within the sphere of the subjective parameters there are emerging methodologies and indicators that can be defined. For example, in the field of thermal comfort there has seen a development from narrow and precise physiological comfort theory, based on the seminal work of Fanger[10], to a more holistic understanding that has led to the adoption of adaptive comfort theory[11]. Similarly, health research has extended from the treatment of symptoms to incorporate a wider and more holistic appreciation of well-being of the population. It is the topic of well-being that is the primary focus of this essay.

The notion of well-being consists of two key elements: feeling good and functioning well. Feelings of happiness, curiosity and engagement are characteristic of someone with a positive sense of themselves. Having positive relationships, control over your own life and a sense of purpose are all attributes of functioning well. International evidence has recently been gathered to measure well-being, demonstrating that this field has now emerged as a rigorous discipline[12].

Recent research has demonstrated connections of key physical design characteristics with the Five Ways to Well-Being (Connect, Keep Active, Take Notice, Keep Learning and Give), which have been associated with positive mental health.[13] Based on these findings, the following paragraphs reveal how the provision of local urban and domestic resources can impinge on the five healthy behaviours. This supports current theory and research, which shows that a sufficient quantity and quality of diverse environmental, social and physical resources can influence human cognition, which, in turn, can increase the healthy behaviours of the wider population.



'BUITEN DE VESTE' SCHOOL IN STEENBERGEN, THE NETHERLANDS

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DESIGN AND WELL-BEING

The relationship between architecture and health has historically received little attention, beyond the design requirements of healthy buildings. Recent work has changed this and has established a more holistic awareness of the role of architecture in health. An example of this in the UK includes the publication of reports by the Royal Institute of British Architects[14] and the Commission for Architecture and the Built Environment[15]. This is supported by an increasing wealth of medical research related to physical health[16] and mental health[17]. The emphasis has been on ill health as a result of the effects of environmental characteristics such as overcrowding, noise, air quality and light. These effects are typically described as direct (i.e. consequences on physical and mental health) as well as indirect (e.g. through social mechanisms)[18]. However, rather than focusing on ill health, the definition and study of well-being has been emphasising the behaviours that support a 'flourishing' population. It is the built-environment characteristics that support such positive behaviour, which is a key point of discussion here.

The science of well-being is a relatively recent area of enquiry. However, the UK Government's 'Foresight' project, related to well-being[19], provides the critical mass of evidence that led to the definition of the Five Ways to Well-Being mentioned above[20]. These represent the key behaviours that have been shown to relate to improved well-being. Each behaviour is associated with subjective well-being as reported in research papers, notably in medical journals, that draw on large-scale and meta-analysis of exacting studies. Thus there is no shortage of evidence to support the assertion that such behaviours, the Five Ways, result in improved well-being.

I Connect: the quantity and quality of social connections (e.g. talking and listening to family or strangers) correlates with reported well-being as well as physical health[21].

II Keep Active: there is ample evidence from global and meta-studies to demonstrate that physical activity reduces symptoms of mental and physical ill-health[22].

III Take Notice: being mindful – paying attention to the present and being aware of thoughts and feelings – is a behaviour that reduces symptoms of stress, anxiety and depression[23].

IV Keep Learning: aspirations are shaped in early life, and those who have higher aspirations tend to have better outcomes. Such aspirations are modified by the environment[24]. The evidence shows that, also later in life, those participating in music, arts and evening classes, for example, attain higher subjective well-being[25].

V Give: evidence has emerged that pro-social rather than self-centred behaviour has a positive impact on happiness. Such consequences of altruistic behaviour are related both to spending on others as opposed to oneself[26] and through volunteering and offering help[27].

The critical next question is to discuss how the Five Ways to Well-Being relate to and are influenced by the built environment.

CONNECT

The provision of local 'everyday public spaces' creates opportunities for people to connect, and is a significant resource of well-being for individuals and the wider community[28]. Although not all users have the same requirements and expectations of a social space, key qualities include: location – accessible and proximity to other communal resources (school, market) to support casual encounters; places to stop and sit, on a park bench or at a café table, so that encounters can be more than fleeting; adaptability – spaces without specific or prescribed functions that enable spontaneous, impromptu activities; homeliness – a sense of safety and familiarity; pleasantness – clean and peaceful, or bustling and lively; specialness – unique qualities, aesthetics, or subjective memories. When a space is pedestrian-oriented as opposed to car-oriented, this is correlated with a sense of community, due to the perception of the pedestrian environment being particularly strongly related to opportunities for social interaction[29]. And finally, natural, green or landscape qualities have been widely and for a long time associated with a range of health benefits[30]. In summary, "public spaces that brought people together and where friendships and

Rather than focusing on ill health, the definition and study of well-being has been emphasising the behaviours that support a 'flourishing' population. It is the built-environment characteristics that support such positive behaviour, which is a key point of discussion here.

support networks were made and maintained were key to a general sense of well-being"[31].

KEEP ACTIVE

Physical activity (walking, cycling, sports, etc.) is widely associated with reducing causes of chronic conditions and the burden of disease, disability and premature death. Design characteristics associated with increasing activity include access to physical activity facilities (e.g. sports centres and equipment), convenient and proximate access to destinations (work, shops, school, public transport), high residential density (which is associated with greater proximity to facilities and destinations), land use (e.g. mixed use) and walkability (convenient and safe pavements, traffic calming features)[32]. Although there are some potential additional benefits to physical activity in an outdoor and preferably natural environment, exercise indoors can be equally effective[33]. Design strategies to promote indoor physical activity include: the provision of (shared) exercise space, encouraging stair use through the distribution (separation) of functions over different floor levels, and creating attractive experiences along circulation routes (views, art, daylight, greenery).

TAKE NOTICE

Being mindful and taking notice of a design intervention in a population is a behaviour for which there is only recent evidence. However, in a randomised control test, the provision of art, planting and landscaping, wildlife features (e.g. insect boxes), and seating are examples of the kind of interventions that resulted in significantly increased observations of people stopping to take notice[34]. The same study also showed that diverse types of open space (combining green as well as hard landscaping) and a higher relative proportion of public to private space is also associated with increased reported mindfulness.

KEEP LEARNING

There is evidence from educational research that the physical environment of the home and classroom are mediating variables that influence intellectual development. Domestic parameters include a home that is clean and uncluttered, appears safe for play and is not dark or monotonous[35]. The distance and orientation of seating in relation to others will influence the level of interaction and dialogue. For example, in a circle of seats, people facing each other will converse more than people adjacent to each other. Unobstructed eye contact is an important variable particularly in an educational context, making a semicircle classroom seating arrangement most effective[36]. At a more prosaic level, in order to support learning, interior environments need to be physically and thermally comfortable, safe, well lit, quiet and have clean air. However, there is evidence that learning will improve when comparing a poor environment (a run-down and poorly maintained space) with an adequate one (one that is 'good enough'), but that further and more extravagant facilities (specialised spaces or digital equipment) does not show further improvements in learning[37]. As previously mentioned, the opportunity to engage in art, music and evening classes increases well-being and thus such activities should be accommodated in the design of homes (light, cleanable spaces for art, soundproof spaces for music) and neighbourhoods (local communal spaces for classes).

GIVE

The presence of environmental stressors reduces helping behaviour, but little further explicit evidence is available beyond that which has been discussed above, which relates the physical environment with neighbourhood social capital[38]. There is evidence that people are less altruistic in urban than in rural environments, which, if nothing else, confirms that the integration of green space and contact with nature can be valuable[39]. Although it is difficult to observe atruism and its explicit relationship to design parameters, it can be shown that self-reported altruistic behaviour is more prevalent in neighbourhoods that incorporate the positive environmental and physical characteristics of space design (diversity, proximity, accessibility and quality) that have already been mentioned[40].

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TOUR BOIS-LE-PRÊTRE IN PARIS, FRANCE

Design should be responsive to user needs, behaviours and requirements, offering users a freedom of choice and control over their environment.

RULES OF THUMB FOR DESIGN

It is evident from the available research that there are no singular or universal design solutions to ensure that every health parameter is optimised, and that the inhabitants and wider population will flourish. As a minimum, designers should ensure that direct physical health parameters (e.g. air quality) achieve a level that is considered 'good enough' to avoid ill health, whilst not impinging on the opportunity for design to integrate wider wisdom and to nudge occupants into positive health behaviours.

The fact that there are numerous strategies related to different settings and users suggests that it is important to design adaptable environments. This is particularly relevant in the context of demographic change and climate change, but also changes in work, life styles and the availability of new technology. Design should thus be responsive to user needs, behaviours and requirements, offering users a freedom of choice and control over their environment.

A number of rules of thumb emerge and are grouped below into key themes:

NEIGHBOURHOOD AND NATURE

There is a large amount of research related to the design of neighbourhoods that supports health and well-being. Some of the design characteristics that emerge consistently are:

A High density mixed-use development to encourage walking and cycling (Keep Active) to access local services (Connect) – including access to public transport, health, social services, etc. – and reduce the reliance on the car.

B The availability of diverse public open space (in higher proportion than private gardens), including a variety of high quality and accessible green space (for play, exercise, contemplation, allotments, socialising, etc.) and hard landscape (ideally traffic free or reduced – for play, outdoor eating, etc.). This supports all Five Ways to Well-Being.

C Providing facilities and interest (Take Notice) in public open space – such as a biodiverse environment(encouraging a richness of flora and fauna), seating and WIFI – adds to the potential for social interaction (Connect and Give) and extends the use of the space.

D The threshold between the home and a neighbourhood, particularly in high-density scenarios, can be mediated with vegetation, both to give close contact with nature but also to provide a degree of separation and privacy.

E Views of the neighbourhood and nature from the home are associated with psychological benefits and encourage social interaction (Connect) and supervision (Take Notice), so low window sills and openable windows are valuable aspects).

MOVING AND ACCESS

As we lead increasingly sedentary lifestyles, encouraging a modest level of activity becomes important in order to improve cardiac health, counteract obesity and maintain general fitness (Keep Active). The recommended level of activity is at least 30 minutes of moderate exercise (>3 METS, cycling or brisk walking) on five or more days per week, or 20 minutes of vigorous physical activity (>6 METS, jogging or gym exercises) three or more days per week[41]. Although gyms have become increasingly popular for some (and can also support Connect), achieving improvement in fitness for all is the main goal. Moving up and down stairs is a simple and effective solution, which counters the tendency for choosing a bungalow house for retirement (resulting in reduced exercise at a time of life when it is important to stay active, and ending up with what is colloquially referred to as 'bungalow knees'). Three-storey homes are likely to increase personal energy expenditure and can contribute to increased housing density, which in turn leads to other sustainable design opportunities. Research on human energy expenditure in buildings has revealed that typical office workers are less physically active away from work, with an overall activity level marginally below the recommended levels. Thus even modest increases in domestic and neighbourhood activity levels through design can be health-enhancing. Climbing one floor by stairs accounts for 3.3% of extra daily energy expenditure, and getting up 20 times from a seated position equates to about 10% of a healthy daily total of

TOUR BOIS-LE-PRÊTRE IN PARIS, FRANCE

Notes

41. US DHHS. (2000). *Healthy people 2010: Understanding and improving health (2nd ed.).* US Department of Health and Human Services. Washington D.C.: US Government Printing Office.
42. Baker, N., Rassia, S., & Steemers, K. (2011). Desiging for occupant movement in the workplace to improve health. *5th International Symposium on Sustainable Healthy Buildings* (pp. 25–33). Seoul: Centre for Sustainable Healthy Buildings, Kyung Hee University.
43. Lifetime Homes. (2011). *Lifetime Homes Design Guide.* Watford: BRE Press.

metabolic activity[42]. Some stealthy design strategies to Keep Active are suggested:

A Make circulation an enjoyable experience and provide rewards for the movement (avoid boring corridors, aim for good natural light, views, opportunities for spatial variation and encounter (Connect), use art, etc.). This also supports Take Notice.

B Separate key spaces with stairs, which provide the most intense personal energy expenditure, to encourage movement (put the living space on a different level from the kitchen/dining area, don't have toilets on every floor level).

Conversely, for those who are physically disabled or are wheelchair users, it is clear that all housing design must accommodate this. There are numerous guidance documents related to this[43], but some key considerations include:

A Accessible dimensions for circulation areas (which can contribute to a more generous experience for all).

B Level access thresholds throughout (valuable for families with prams).

C Window sill heights to enable views out when seated (views out, especially of natural scenes, are conducive to well-being).

D Electrical sockets not too low, and worktops, handles, thermostats and light switches not too high (allowing all users control over their home environment).

E The potential for a lift to be installed and/or the adaptation of the home for single-floor living (bedroom and bathroom on the ground floor – also useful for temporary ill health and privacy if designed well).

Such design considerations should also incorporate strategies to ensure that partners and carers of wheelchair users are encouraged to remain active.

EATING

Poor nutritional eating habits can lead to obesity and related health problems. The preparation and cooking of (fresh) food can become a more social activity if the kitchen is designed to enable interaction with other members of the household or community.

At a community level, the provision of neighbourhood allotments to grow fresh food is recognised as enhancing health and well-being due to fresh produce, physical exercise and social interaction. Furthermore, the reduced reliance on the car for shopping and the avoidance of packaging and food miles, reduce the energy and other resources required, thus improving environmental sustainability.

With respect to the design of the home, the strategy is to create a sense of theatre related to cooking, and enabling audience participation through the design of accessible worktops and adjacent seating. To support communal eating, and the social interactions that result, the dining area/table should be in close proximity to the kitchen. Conversely, the lounge/TV area should be less accessible from the kitchen (potentially upstairs to encourage physical exercise), limiting the temptation for TV dinners but also providing potential separation in terms of noise, odours and pollutants.

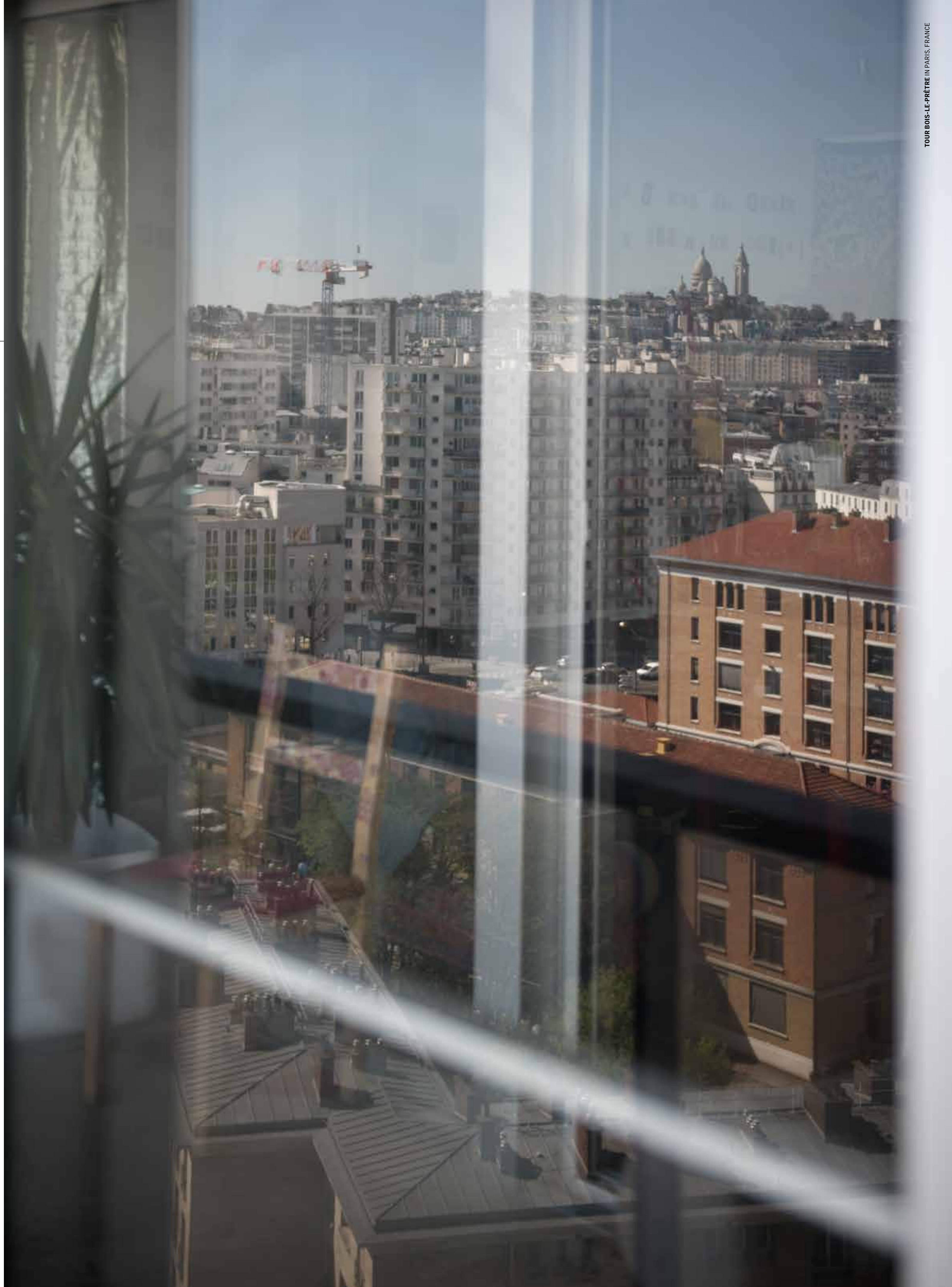
INDOOR ENVIRONMENTAL QUALITY

Light: natural light has a range of advantages over electric light, including its variability and efficiency, and creating an awareness and link to the outside conditions. Apart from being a free source of light within a home, and thus part of an energy efficient strategy, it will animate spaces and can create drama and diversity. Furthermore, the benefits to physical health are now well understood and can counteract seasonally affective disorder (SAD). However, overillumination can be detrimental to comfort and disrupt sleep. A number of rules of thumb emerge:

A Orient rooms used in the morning (bedrooms and kitchen) to the morning light to provide a dose of light to stimulate the circadian rhythm (SAD light-box therapy typically prescribes 10,000 lux for 30 minutes in the morning).

B Main habitable rooms should receive 'good' daylight (above 3% average daylight factor), and a key family room should have access to direct sunlight for at least 2 hours per day.

C Windows with high head heights provide more access to daylight by an increased sky view (which is particularly important in dense



TOUR BOIS-LE-PRÊTRE IN PARIS, FRANCE

"Design-led interventions can make better choices easier."[48]

neighbourhoods) and better daylight distribution in the room.

D Bedrooms in particular should have effective blackout options to support good sleep patterns, for example in the form of thermal shutters (for cold periods) and/or with adjustable louvres (for secure night time ventilation in warm conditions).

E Personal control over the amount of daylight provides welcome opportunities for the inhabitant to adjust conditions to suit their patterns of use, and results in a greater sense of satisfaction with their environment. Windows should offer a range of conditions (e.g. light that is from above, the side, direct, diffuse, adjustable by shutters, louvres and blinds).

Temperature: as with light, the thermal design strategy should create both comfortable and stimulating conditions that can exploit the climatic conditions to improve energy efficiency. The body senses the thermal environment not just in terms of the air temperature, but also radiant conditions (e.g. sunlight), air movement (e.g. natural ventilation) and the conduction of heat via surface materials (wood feels warm, stone feels cool). Each of these thermal characteristics is a function of, and an opportunity for, design:

A Exploit solar radiation to create sunny places to be on cool days, such as window seats (with warm surfaces) and sun spaces. Use heavyweight materials to absorb and retain the warmth.

B Allow the user to adapt so that on hot days there are opportunities to find cool, shady places to sit on more conductive surfaces in a breeze.

C Adaptive comfort theory reveals that thermal conditions can fluctuate and vary, rather than be constant or 'optimised'. Occupant control and the adaptability of the design, to suit the users' needs and preferences as they vary over time, are key factors to success.

D To cool a building down during hot spells, design openings that allow the creation of night time ventilation that is secure (e.g. through louvered sections) and exploits stack and cross ventilation principles (e.g. use the height of a staircase to enable warm air to rise and escape at the top).

Sound: as with other aspects of environmental design, acoustic conditions can be used to create opportunities to support user needs and preferences. Although noise can cause stress, acoustic contact with the neighbourhood and nature can be valuable. Similarly, within the home there are places and moments when acoustic privacy is welcome, although complete acoustic separation is rarely required.

A To encourage Keep Learning behaviours, it is important to provide quiet, calm spaces for reading and studying.

B To support activities such as music and indoor exercise without disturbing others, acoustic separation to some spaces is valuable.

C Design openable windows so that people have the opportunity to connect and talk with passing neighbours.

D In order to exploit natural ventilation in an urban environment, particularly at night, and when quiet conditions for learning or sleeping are sought, the design should incorporate noise-attenuated air paths.

E Separate noise-creating sources – such as washing machines and dishwashers – from living and study spaces to support social and learning activities.

F Consider the acoustics as one progresses through the house: a gravel path will alert the occupant to visitors arriving; an echoey hallway and stairwell can signal when people are gathering; a carpeted corridor dampens the noise to the study; and soft furnishings and bedding creates a tranquil environment for sleep.

Design quality: there are a number of other design characteristics that impact on the Five Ways behaviours; these are briefly outlined below:

A The colour of our environment, such as interior walls, can impact on our learning behaviour and, in certain spaces, can be used to support learning. Research has concluded that "red enhances performance on a detail-oriented task [such as doing homework], whereas blue enhances performance on a creative task [like art of social debate]"[44].

B Ceiling heights can play a role in our social perspective and ability to focus. Recent findings show that when people are in a low-ceilinged space, they are better at focussed tasks, such as studying or reading. More generous spaces prime us to feel free, which tends to lead people to engage in more abstract styles of thinking; they are better able to take a wider perspective and see what aspects are in common, particularly appropriate for social gathering spaces[45].

C The form of space influences our sense of comfort and beauty. Curved forms are perceived as pleasant and in recent experiments, "participants were more likely to judge spaces as beautiful if they were curvilinear than if they were rectilinear". The researchers went on to conclude that this "well-established effect of contour on aesthetic preference can be extended to architecture"[46].

D Thus blue, tall and curvilinear spaces, with views of the blue sky, are more likely to be pleasant, sociable and creative environments. Conversely, red, low-ceilinged, rectilinear environments are more likely to encourage focus, concentration and study.

Conclusion

Designing for well-being and health includes a plethora of opportunities and a range of criteria. The strategy is that designs are good enough to meet the quantitative health measures but are also adaptable to and integrated with a broader set of principles to support well-being. There is a potential risk that. in an attempt to design the technically 'perfect' environment, we risk reducing the importance of the stimuli that encourage occupants to be active, aware and engaged. Designs should 'nudge' users in to positive behaviours, not by making them comfortable and controlling their environment excessively closely, but by providing a range of suitable stimuli for behaviour change. An extreme example of this is the design for the Bioscleave House by Gins and Arakawa, intended to "strengthen life by challenging it … to stimulate physiological and psychological renewal by creating living environments that would be intentionally uncomfortable"[47]. It achieves this by, amongst other things, changing floor-to-ceiling heights, distinct use of colour, uneven and sloping floor surfaces, and uncomfortable door sizes. This intentionally disorientating approach demonstrates an extreme approach, but a moderate and pragmatic orchestration of architecture to promote well-being is clearly viable.

One of the opportunities of architecture is that, through the design of form, space and materiality, it can order our relationships with each other and our environment by creating interactive settings for life. It can do this in such a way as to provide opportunities to improve our sense of well-being, enrich our lives, make our lives healthier and more pleasurable. For example, the shaft of sunlight in a recessed window seat that creates a moment of warmth and calm, combined with a glimpse of nature, soft and acoustically absorbent seat materials, and the tactile delight of the smooth grip to adjust a wooden shutter. Our well-being is intimately linked with such moments of delight. To an extent, such stimuli happen all the time, often without being recognised or designed, but when they are orchestrated throughout a building the effect is cumulative. A poor building has few such moments and leaves our lives impoverished, whereas a successful piece of architecture is one where there is an accumulation of many moments of delight that support the five ways of well-being.

Notes

44. Mehta, R., & Zhu, R. (2009). Blue or red? Exploring the effect of color on cognitive task performances. *Science*, 1226–1229.
45. Meyers-Levy, J., & Zhu, R. (2007). The influence of ceiling height: The effect of priming on the type of processing that people use. *Journal of Consumer Research*, 174–186.
46. Vartaniana, O., Navarrete, G., Chatterjee, A., Fich, L., Leder, H., Modrono, C., et al. (2013). Impact of contour on aesthetic judgments and approach-avoidance decisions in architecture. *PNAS (Proceedings of the National Academy of Sciences, USA)*, 10446–10453.
47. Unwin, S. (2015). *Twenty-five buildings every architect should understand.* Abingdon: Routledge.
48. King, D., Thompson, P., & Darzi, A. (2014). Enhancing health and well-being though 'behavioural design'. *Journal of the Royal Society of Medicine*, 336–337.

Koen Steemers is Professor of Sustainable Design and has been Head of the Department of Architecture at the University of Cambridge. His current work deals with the architectural and urban implications of environmental issues ranging from energy use to human comfort. Alongside his academic work, Koen Steemers is a director of CH&W Design and of Cambridge Architectural Research Limited.

TOUR BOIS-LE-PRÊTRE IN PARIS, FRANCE

HOUSING WELL-BEING

An introduction

Over the decades, architects, scientists and engineers have developed ever more refined criteria on how to achieve optimum conditions for well-being in buildings. Hardly anyone, however, has so far asked those that matter the most: the occupants themselves.

In the following articles, the sociologists Bernd Wegener and Moritz Fedkenheuer describe an approach to evaluating housing well-being that starts with people's attitudes and experience rather than with predetermined quantitative parameters. Furthermore, the authors present the most important outcomes of two recent research projects initiated by the VELUX Group. In a nutshell, these can be summed up as follows: daylight and fresh air are key 'ingredients' of well-being at home. But while users are generally aware of this, they often underestimate the effect that these resources have on their health.

By Moritz Fedkenheuer & Bernd Wegener

THE HOUSING WELL-BEING INVENTORY: UNDERSTANDING HOW PEOPLE INTERACT WITH THEIR HOMES

To create optimum conditions for people's well-being in buildings, designers have so far mainly relied on a limited set of quantitative parameters such as temperature or indoor air humidity. Yet a broader approach is needed, which is based on an evaluation of residents' individual attitudes to the buildings they inhabit. The Housing Well-Being Inventory is such a concept, which could allow for a better understanding of the interaction between buildings and their residents.

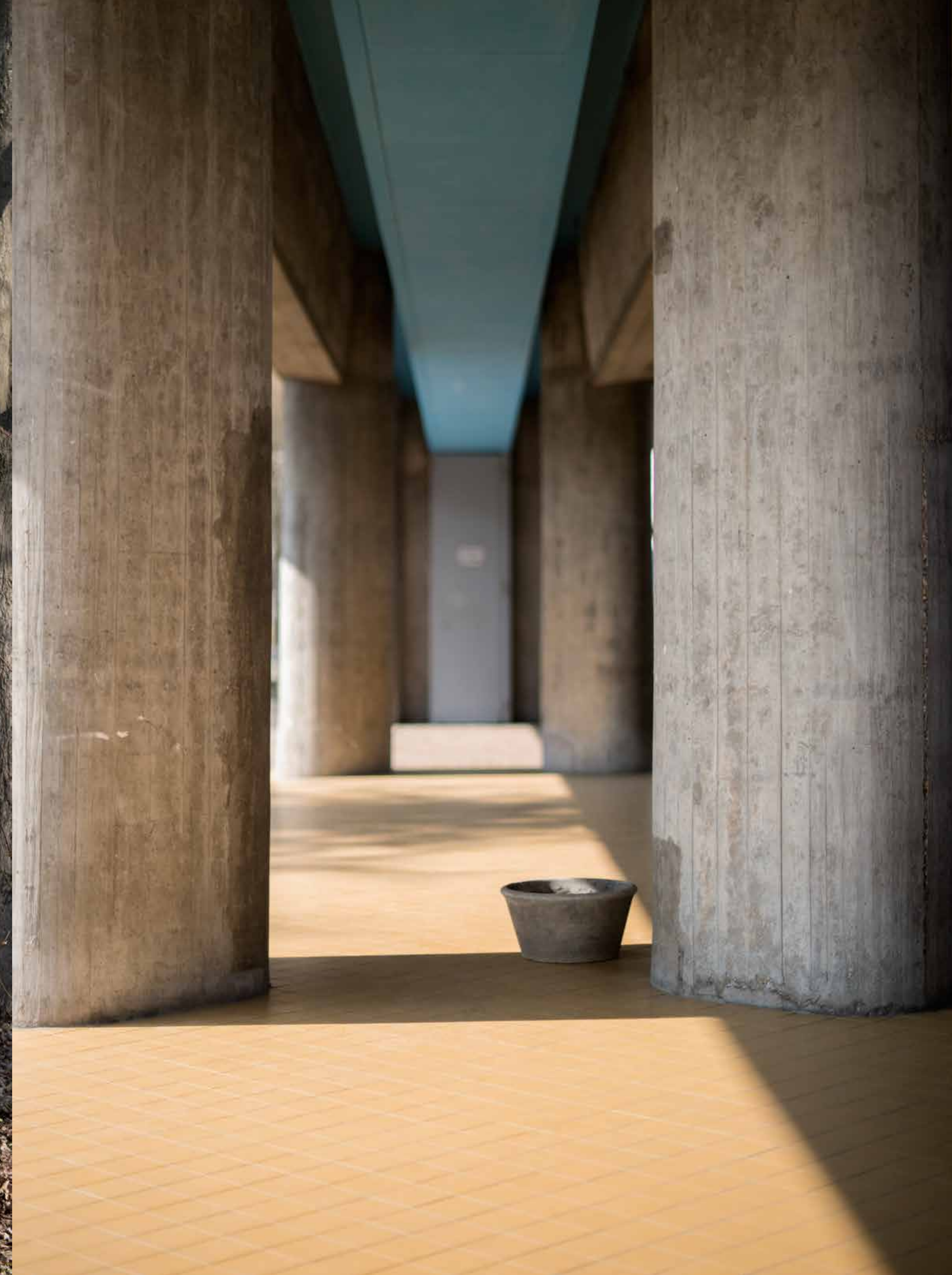
By Moritz Fedkenheuer and Bernd Wegener

In order to avoid dangerous climate change, we have to reduce long-term energy consumption and greenhouse gas emissions in all sectors of our society. As space and water heating in residential buildings account for more than a quarter of our energy consumption, the residential sector plays a key role. Furthermore, residential buildings are among the most inert elements of the energy system. Typically, it takes decades between construction and the first major refurbishment. What we build today strongly determines the energy consumption of the future. Therefore we need to convince today's homeowners and -builders of the value of energy-efficient refurbishment and help them rethink their behaviour to live in a more energy-efficient manner.

With this in mind, it is very unfortunate that, for the last few years, the public discourse about low-energy buildings has mainly focused on their environmental benefits, and mostly left out the occupants, their needs and concerns. Many people are sceptical about technical innovations such as modern insulation, mechanical ventilation or home automation, and hesitate to integrate them in their homes. Their concerns are based on health, functional and aesthetical reasons. There is a lack of communication and a lack of information on that topic. What are the consequences of these energy modernisations for the residents? How do houses, in particular highly engineered energy-efficient houses, perform socially and psychologically? What level of subjective well-being do these houses convey? How can we integrate new technical possibilities in a way that improves the liveability and the satisfaction of the occupants? We are convinced that the residential buildings of the future shouldn't only serve the environment but also bring a benefit to the people. With the Housing Well-Being Inventory (HWBI), our approach to a better understanding of the interaction between buildings and their residents, we hope to find answers to these questions.

HOUSING WELL-BEING SEEN IN A WIDER PERSPECTIVE

Like engineers, our task as social scientists in this field of research is to evaluate buildings. But while well-established procedures exist to measure physical parameters such as energy savings, indoor climate conditions and life-cycle costs, there are no instruments we can rely on when it comes to analysing the user's perspective or the housing well-being. While there are defined ‹ranges of comfort› with respect to temperature and light, air quality and acoustics that practitioners take for granted, there has been little empirical research on what residents actually experience and how they evaluate their housing environment in reality. The study of these aspects is only in its initial stages, both in terms of the availability of data and the development of theory. Therefore our first goal was to uncover the underlying structure of housing well-being in energy-efficient homes and develop a multi-faceted measurement instrument that respects the complexity of this topic. The Housing Well-Being Inventory, which we have been working on for the last three years, can serve as a standard for the measurement of the subjective quality of housing. Instead of only quantifying comfort in



PAVILLON SUISSE IN PARIS, FRANCE

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It is unfortunate that, for the last few years, the public discourse about low-energy buildings has mainly focused on their environmental benefits, and mostly left out the occupants, their needs and concerns.

a building (traditionally defined by a narrow set of parameters such as temperature or CO_2 levels), our approach is a more holistic one that includes further aspects, such as technical controllability, health or social interaction.

Our work is built on existing approaches, such as post-occupancy evaluation (POE), and tries to enhance them to a wider perspective. Although some of these approaches have already existed for around two decades, they still focus mainly on traditional comfort parameters and fail to take the entire scope of the research subject into account. From their point of view, it is usually taken for granted that particular physical building parameters have positive effects on residents' well-being. We do not doubt that there are ranges of comfort that should be achieved in a residential building, but we want to study the human-home-interaction from a more holistic perspective, respecting the subjectivity of housing. In this, we are navigating uncharted waters. Empirical research on what residents actually experience and how they evaluate their housing environment in reality is rare. This is particularly true with regard to low-energy buildings and new technologies, as well as the effects these have on the well-being of the residents and their interaction with their homes.

THE DEVELOPMENT OF THE HOUSING WELL-BEING INVENTORY

In order to obtain a conceptual understanding of the study object, it seemed reasonable to have a multi-component view of housing well-being as a multi-dimensional construct, and to conceive it in terms of traditional sociological attitude models. In this way, housing well-being is understood as an individual mental evaluation of objects, which is reflected in different dimensions. Furthermore, as an attitudinal phenomenon, housing well-being cannot be prescribed but has to be explored by asking people about how they experience their environment and how they act within it. Since the development of theory and the data pool available for understanding the human-home interaction are still in their early stages, and in order to increase the contribution towards theoretical considerations, the study area was carefully explored and an initial empirical study was conducted in the framework of the VELUX Model Home 2020 project.[1] We then used the results of our two-year exploration efforts to design a multi-dimensional device for measuring housing well-being: the HWBI. The purpose of this instrument is to have a yardstick for assessing the quality of a house and its components as it is seen through the eyes of the users.

On our way to achieving this goal, we had to deal with several methodological problems that cropped up when measuring housing well-being. First of all came the compilation of the relevant dimensions (*selection problem*). To this end, we used several qualitative methods, such as personal interviews and detailed group discussions, to find out about the different aspects of housing. In the context of the VELUX Model Home 2020 project, we analysed data from six different families in six different houses and from five different cultural backgrounds. This heterogeneity offered us a wide and eclectic view on the study object. We compared the families' statements, experiences and descriptions, and extracted several dimensions of housing well-being that seemed to be influential and relevant. The selection of dimensions is therefore user-based and derived from empirical research rather than from a normative decision a priori.

Extracting the dimensions of housing well-being was the first step, making them measurable had to be the second. Because housing well-being is a theoretical concept, as are its dimensions, we had to develop a measurement method to make these unobservable, latent constructs visible (*measuring problem*). Therefore we designed a questionnaire that not only asks for overall evaluations but also includes several indicators that measure people's reactions to the building for each dimension.

We also took care that the questionnaire covered affective (sympathetic nervous responses; statements of affect), cognitive (perceptual responses; statements of beliefs) and conative (overt actions; statements concerning behaviour) elements, as is common in attitudinal studies.

As indicators, we use several items (statements) relating to the residents' perception of and their interaction with the building. They cover a wide range of issues from "I feel at home in my apartment" to "My apartment is in need of renovation" and "Where I sleep, there is too much light." In the course of the evaluation, the residents rated each statement in the questionnaire on a five-point scale ranging from

PAVILLON SUISSE IN PARIS,

PAVILLON SUISSE IN PARIS, FRANCE

So far, we have identified ten core dimensions of housing well-being: emotional attachment, size, modernity, brightness, neighbourhood, heating control, energy consumption, humidity, sleeping comfort and ventilation.

"I fully agree" to "I fully disagree". By using multiple indicators (at least three items for each dimension) we reduce potential measurement errors and make our results more valid. The set of indicators, which we had developed based on our experiences from the Model Home 2020 project, was subsequently tested in a first pilot study with about 50 participants. This standardised survey helped us to reduce the number of relevant dimensions and indicators in a next step, using factor analysis. This procedure is the standard routine for constructing psychological tests and survey questionnaires.

THE TEN DIMENSIONS OF HOUSING WELL-BEING

So far, we have identified ten core dimensions of housing well-being: emotional attachment, size, modernity, brightness, neighbourhood, heating control, energy consumption, humidity, sleeping comfort and ventilation. These dimensions can be measured with a questionnaire that consists of 29 items and that forms the core module of the HWBI. Furthermore several periphery modules were added to the measuring instrument in order to assess the appendant features of well-being. In all, there are seven modules: (1) Housing satisfaction (core module), (2) Environmental awareness and behaviour, (3) Taste/home-living styles, (4) Engineering preferences/handling of technology, (5) Architectural properties of the house, (6) Health and (7) Sociodemographics of occupants. Measurement devices for the latter six modules were readily available and only had to be adapted to suit the study subject.

OUTLOOK AND FURTHER STEPS

Over the next few months, we will conduct two more validation studies of the HWBI core and periphery modules. Financed by VELUX Germany and by our own resources, we will test the instrument on a wider sample of about 300 respondents by conducting a telephone survey representative for the German population of 18 years and above. We will also apply the core module to the occupants of the buildings that have been erected in the context of the EffizienzhausPlus network initiated by the German Federal Ministry of Transport and Digital Infrastructure (BMVBS). This study will comprise roughly 150 respondents and will be carried out in collaboration with the Berliner Institut für Sozialforschung.

After finalising the HWBI, the next step will be to go out in the field and start collecting data. This is needed not only to test our instruments but also to find out about the underlying structure and weighting between the dimensions of housing well-being (*aggregation problem*). We want to learn more about how the dimensions affect each other and how they determine the overall evaluation by the residents. This can be achieved by using complex statistical methods such as factor and regression analysis. In the end, the general idea is to have an index for the subjective quality of houses based on weighted HWBI dimensions.

Depending on the approval of a research proposal to the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) that has been submitted by the non-profit association AktivPlus e. V., we will implement the complete inventory to the residents of selected energy-efficient houses in Germany. In addition, the research project will comprise a large-scale telephone survey of the general German population (N = 1500) so that it will be possible to compare the results of energy-efficient and standard homes. Furthermore, with this general enquiry, we are able to make statements on the condition and configuration of the German housing situation from the users' perspective: How does housing satisfaction differ among social groups and building types? What are people's current needs and requests in terms of housing? How do modernisation measures affect the residents' perceived mental and physical health?

With this data in hand, we will be able to concretise the benefits of technical and sustainable improvements from the users' perspective and to identify ways to turn homes into better places for living. We can also take a deeper look into certain social groups and learn more about how the dimensions of housing well-being and the human-home-interaction might differ between them. We hope to find out what people really value – in general but also in particular, depending on the social conditions they live in. By understanding housing well-being in a holistic way, we will be better able to build sustainable houses that not only benefit the climate but also the people, and therefore will be more likely to win the support of the general public.

SOCIAL HOUSING IN CHÂTEAUDUN, FRANCE

SOCIAL HOUSING IN CHÂTEAUDUN, FRANCE

DAYLIGHT AND VENTILATION MAKE BETTER PLACES FOR LIVING

With the Model Home 2020 experiment and the Healthy Homes Barometer, the VELUX Group has initiated ground-breaking research on people's well-being at home. Both studies revealed that people are aware that daylight and fresh air affect human health and well-being. However, they tend to underestimate both the size of this effect and the amount of daylight and fresh air needed for healthy living. To change this situation, the public debate on health in buildings needs to be intensified and supported by a sound scientific knowledge base.

By Moritz Fedkenheuer

WITH OUR RESEARCH on the human-home-interaction, we aim not only to identify the dimensions and determinants of housing well-being but also to provide concepts to make homes healthier and more comfortable. This interest results from the huge impact our homes have on our health and well-being, which has been proven in several studies. As we spend most of our lives indoors, we should be very aware of what we build and what effect it has on the human body. So we integrated aspects such as mood, physical and mental health, and productivity into our concept of housing well-being – and study their connection to modern housing concepts. In doing so, we hope to find an answer to the question of what makes a home a better place for living.

In this context, the VELUX Model Home 2020 project offered us an excellent opportunity to study the relation between homes and health from the perspective of the users. While there is medical evidence that the way we live in our homes has an essential effect on our mood and body, almost nothing is known about the users' perspective on this topic, the importance they attach to it and their resulting behaviour. This is unfortunate as health is not something objective but highly subjective, and depends on individual perception. It seems reasonable to involve the residents in this discussion and ask them how they live and how they feel about it.

The research on housing well-being in the Model Homes 2020 revealed that all the five houses involved in the project exerted a positive influence on their occupants in terms of mental and physical health as well as on productivity. The experiment showed that well designed modern homes are able to alleviate, or even resolve, health problems such as asthma or allergies, that they improve the self-reported mood and productivity and also stimulate a healthier lifestyle. Health improvements, an extra in energy level and a better mood in general were reported and have to be seen as essential advantages of the Model Homes 2020. The recreational value of the buildings can, therefore, be considered as very high.

MODEL HOME 2020: DAYLIGHT AND FRESH AIR ARE ESSENTIAL TO HOUSING WELL-BEING

When we looked for reasons for this positive feedback, we came to the conclusion that daylight and fresh air were mainly responsible for the satisfaction of the occupants. It was remarkable not only how positive the families rated their homes in terms of daylight and fresh air but also how big they considered the positive effect of these aspects on their mental and physical health. These results confirm the medical view on indoor climate from a user›s perspective and illustrate the receptivity and sensitivity of humans to these dimensions of housing.

Furthermore, it was really enlightening to realise that the participants in the experiment were not aware of the immense benefit that comes with daylight and fresh air until they experienced it in the context of this experiment. They might have had an idea that these aspects are connected to body

RENÉ GUEST SCHOOL CENTRE IN LA GARENNE-COLOMBES, FRANCE

"The sun must penetrate every dwelling several hours a day even during the season when sunlight is most scarce. Society will no longer tolerate a situation where entire families are cut off from the sun and thus doomed to declining health."

Le Corbusier in: The Athens Charter, 1942

functions but this knowledge was abstract and not linked to their personal sensations and health level. Likewise, most of the residents never expected this level of comfort being possible inside a residential building. It seemed as if the abundance of daylight and fresh air had uncovered a latent need in their bodies. The French family said that daylight had become "a new standard of living". The German test family reported that it took a while to get used to the extra amount of fresh air brought into the home by the automated window ventilation, but pretty soon they said they would "never want to miss that again". In the two British Model Homes, too, the experience of living in a bright home "changed the perception of what is light and what is dark".

This led us to the conclusion that while architects and engineers are mostly very aware of the benefits of bright rooms and good indoor air quality, many occupants seem to be much less concerned about them. This is understandable, as most people do not have the chance to compare the effect of different amounts of light or fresh air on their mood, their health and their energy level. As a consequence, homeowners planning to renovate their houses often assign less importance to these aspects than would be needed, and often do not know what ‹is possible› in terms of indoor climate, nor from what kind of refurbishment measures they would profit the most. More information is therefore needed.

THE HEALTHY HOMES BAROMETER: A PAN-EUROPEAN SURVEY ON HOUSING WELL-BEING

The findings presented so far are directly linked to the particular design of the Model Homes 2020. Although it was impressive how similar the experiences of all six families were, the results cannot be generalised due to the special context of the study, such as:

- there were only six families to study, which is not representative of the general population. Although they came from different cultural backgrounds, they were pretty similar in terms of social indicators such as age, level of education, physical health, and family status. To obtain reliable data, a larger and more diverse sample is therefore needed.

- although the experiment was impressive in its extent and duration, an evaluation of a one- or two-year episode is not sufficient to display long-term trends or the effects of habituation. Moving into a new house is always quite an exciting event, and during the relatively short monitoring period only the German family really settled in completely – they stayed in their home for over two years. This fact definitely biased the results.

- we can assume that the special situation of being involved in a scientific experiment had an influence not only on how the families perceived their new home but especially on what they reported about it. When scientists and a sponsor are observing you, effects, albeit unconscious, can be expected.

Nonetheless, the similarity in the perceptions and reactions of the residents suggests that the findings from the Model Home 2020 project can serve as hypotheses that could be tested in a larger, more representative survey. In the meantime, the VELUX Group has initiated such a survey with the European Healthy Homes Barometer (HHB), a new research programme on health, housing and liveability[2]. In the first edition of the Healthy Homes Barometer, twelve countries with a total of 12,000 respondents are involved in the sample, representing a variety of sizes and geographic locations in Europe. Looking into the results of this year's Healthy Homes Barometer and comparing them with the outcomes of the Model Home 2020 experiment, it is remarkable how much the two studies complete one another.

PEOPLE ARE TOO OPTIMISTIC ABOUT THE INDOOR CLIMATE AT HOME

In the Model Homes we observed that the families were surprised by the positive effect of daylight and fresh air had on their mood, physical health and productivity. This led us to the hypotheses that people tend to underestimate the amount of daylight and particularly fresh air that is needed to keep the indoor climate healthy. With the Healthy Homes Barometer and its representative data pool, we can verify this assumption. Although people are aware of the positive effect and the need for daylight, and fresh air in particular, they do not take adequate measures to supply their homes with these resources.

DIMENSIONS AND INDICATORS OF HOUSING WELL-BEING

STIMULI
(Building)

Time of year
Technical innovations
Public discourse
System modification
Development of prices
Life events
Other (e.g. electric car)

ATTITUDE
"Housing well-being"

Ecological awareness
Engineering styles
Health perception

AFFECT
feeling

- Perception (senses):
  – Thermal
  – Hygienic
  – Acoustical
  – Visual
- Associations
- Feeling of protection
- Feelings of stress and recreation
- Identification

COGNITION
opinions

- Rating:
  – Sensory impression
  – Aesthetics
  – Functionality
  – Architecture
- Evaluation of ecological quality
- Cost appraisal
- Living preferences

BEHAVIOUR
conative

- System-regulation (technique):
  – Monitor
  – Ventilation
  – Shading
- Energy consumption behaviour
- Space utilisation
- Interaction
  – Family
  – Neighbourhood
  – Friends

RENÉ GUEST SCHOOL CENTRE IN LA GARENNE-COLOMBES, FRANCE

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As the Healthy Homes Barometer shows, people are generally far too optimistic about the actual indoor climate conditions in their homes. They express above average satisfaction with the air quality in their current home, while there is still improvement to be made. This tallies with the experience from the Model Homes 2020. It seems that people are used to the (low) standard in their homes and do not question the conditions in which they have been living for years. Residents are satisfied with their indoor climate beyond reason, or more specifically, due to habituation and acclimatisation. Among other things, this would also explain the variations in how much daylight at home is appreciated in the different countries displayed in the Healthy Homes Barometer. While access to daylight is equally beneficial to all human beings, no matter where they live, people from northern countries – who are accustomed to living with less daylight – also tend to downplay its importance.

While the Healthy Homes Barometer clearly indicates that a comfortable home environment is very important to Europeans – even more so than energy costs, size or attractiveness – one must bear in mind that comfort is quite a vague subjective phrase, which leaves a lot to interpretation. The standardised methodological design of the Healthy Homes Barometer does not clarify what comfort really means to people and what they consider important to achieve it. People might connect daylight and fresh air to something abstract like comfort, but they do not make a strong link to precise health issues such as illness, fatigue, asthma and allergies.

MORE INFORMATION AND SMART TECHNOLOGY ARE NEEDED

The combined results of the Model Home 2020 experiment and the Healthy Homes Barometer suggest that people are aware of the effect that their homes have on their health, but that this knowledge is abstract and unspecific. Many might know that daylight and fresh air positively influence their health but they have no clue *how much* air or daylight they actually need. And even if they do know, the attempt to achieve this amount is likely to overstrain them.

So, according to all that we know so far, people want healthy and energy-efficient building solutions but they often lack the knowledge that will prompt them to take action. To improve the situation, we need to develop smart technical solutions and to inform and educate the public. The research on housing well-being provides insight into the deficits and knowledge gaps in this field, and into how the different aspects of housing and health connect to each other. While the Model Home 2020 experiment was very helpful to get a better understanding of the study subject and to generate hypotheses, studies like the Healthy Homes Barometer are needed to test these hypotheses, find out about the knowledge and preferences of the general population, and to identify trends and changes. With this information in hand, we should intensify the societal debate about the importance of healthy homes and how to live a healthy life indoors.

Notes

1. The Model Home 2020 project was started by the VELUX Group in 2008. In the context of this experiment, five single- and double-family houses were built in five European countries. After their completion, the houses were inhabited by test families for up to two years and evaluated both in technical terms and in terms of the users' well-being. More information on the houses can be found online at; http://www.velux.com/sustainable_living/demonstration_buildings
2. The Healthy Homes Barometer was compiled for the first time in the winter of 2014/15 with a total of 12,000 respondents from twelve European countries. Among other things, they were asked about the importance they assign to daylight, fresh air and other health factors at home, about their preferences when looking for a new home, and about how they rate daylight, air quality, and general comfort in their homes. The VELUX Group is planning to conduct this survey every year. www.velux.com/healthyhomes

RENÉ GUEST SCHOOL CENTRE IN LA GARENNE-COLOMBES, FRANCE

THE HEALTHY HOMES BAROMETER 2015: TAKING A CLOSER LOOK AT HEALTHY LIVING

So far, little has been known of what people consider important for their well-being at home. With the Healthy Homes Barometer, the VELUX Group now aims to change this situation. The results of this first annual pan-European enquiry of its kind have just been released this spring, and can be found on the following pages.

THE SET-UP

12
participating countries:

Austria, Belgium, Czech Republic, Denmark, France, Germany, Hungary, Italy, The Netherlands, Norway, Poland and the UK

12,000
respondents in total

9
indicators

Scale of evaluation:

From **1** → To **7**

1: not important at all

7: very important

365
To be repeated annually

THE INDICATORS

1. What does healthy living mean to Europeans?
2. How concerned are Europeans about an unhealthy home?
3. Who is responsible for ensuring healthy buildings?
4. How important is daylight at home to Europeans?
5. How important is indoor air quality to Europeans?
6. How do Europeans experience the quality of their sleep?
7. Do Europeans link indoor climate to health?
8. How important are home energy costs to Europeans?
9. How important is the environmental impact of the home to Europeans?

THE FACTS

35%
of Europeans rank both indoor air quality and the amount of daylight of the highest importance if moving to a new house

WHAT MATTERS MOST TO PEOPLE'S HEALTH

1. The home
quality of sleep, daylight and fresh air, avoiding chemicals in the home

2. Our intake
fruit, vegetables and dietary supplements, avoiding tobacco

3. Being active
regular exercise, spending time outdoors

KEY FINDINGS

Europeans desire healthy homes

Sleeping well at night is the most important health factor according to Europeans. More surprisingly, fresh air and daylight were considered even more important to health than avoiding tobacco, regular exercise or spending time outdoors.

Unhealthy homes are a concern to Europeans

Unhealthy indoor air quality is a concern for Europeans. 24 % of Europeans are very concerned, and 59 % have above average concern. They rank this concern at the same level as financial and job insecurity.

People need fresh air and daylight to feel at home…

More than 85% of all Europeans consider indoor air quality and daylight important or very important when moving to a new home. But rather than assigning their health benefits first priority, they connect fresh air and daylight to "feeling at home", feeling fit and comfortable.

…but underestimate health risks at home

Statistics show that 80 million people in Europe live in damp homes. None-the-less, 78% of all Europeans express above average satisfaction with the air quality in their home. And although a high quality indoor climate is a top concern for Europeans, only 28% air out their home more than once a day in winter.

There is little coherence between concern and action

One-third of all respondents said that one person or more in their household suffers from asthma. But although poor indoor air quality significantly increases the risk of asthma, these households do not, on average, air out their home more often than others.

Europeans care about healthy sleep

69% of the European population sleeps in complete darkness every night. This is good news as an estimated 16% to 30% of the working population suffers from insomnia, the risk of which is increased by having too much light at night in the bedroom.

Europeans are willing to act – if it pays off

Increasing comfort and reducing energy cost often go hand in hand in home renovations. However, reducing the environmental impact of building materials – which does not result in cost savings for building owners – ranks lowest on peoples' list of priorities when refurbishing a home.

There is a lack of ventilation in winter

In summer, 68 % of all Europeans air out at least one room in their home more than once a day. However, these numbers drop significantly in the wintertime, when only 28 % air out more than once a day. Almost one fourth of all Europeans neglect the daily change of indoor air in the wintertime.

Energy and health awareness go hand in hand

Europeans who consider energy costs very important when moving to a new home also air out their home significantly more often than others.

Women and elderly people are more aware of health aspects

Women and elderly people seem to be more aware of the benefits of daylight and fresh air. They consistently assigned greater importance to these aspects than men and younger citizens.

Comfort is the number one priority

Out of all the evaluated criteria, Europeans value comfort the most when choosing a new home. 53% attribute it the highest importance (score 7 out of 7), and as many as 95% attribute it above average importance (scores 5–7 out of 7).

Energy costs are a concern - and cause for action

More than half of the European homes have been refurbished to reduce energy costs within the last five years. When moving to a new home, Europeans consider energy costs more important than size, attractiveness and the view to the outside.

Healthy buildings are seen as a private responsibility

When people were asked who is responsible for healthy buildings, owners, property developers and housebuilders, as well as architects were named most frequently. Legislators, banks and mortgage institutions, as well as the tenants themselves, were assigned the least responsibility.

THE FACTS

86%
of all Europeans attribute plenty of daylight above average importance

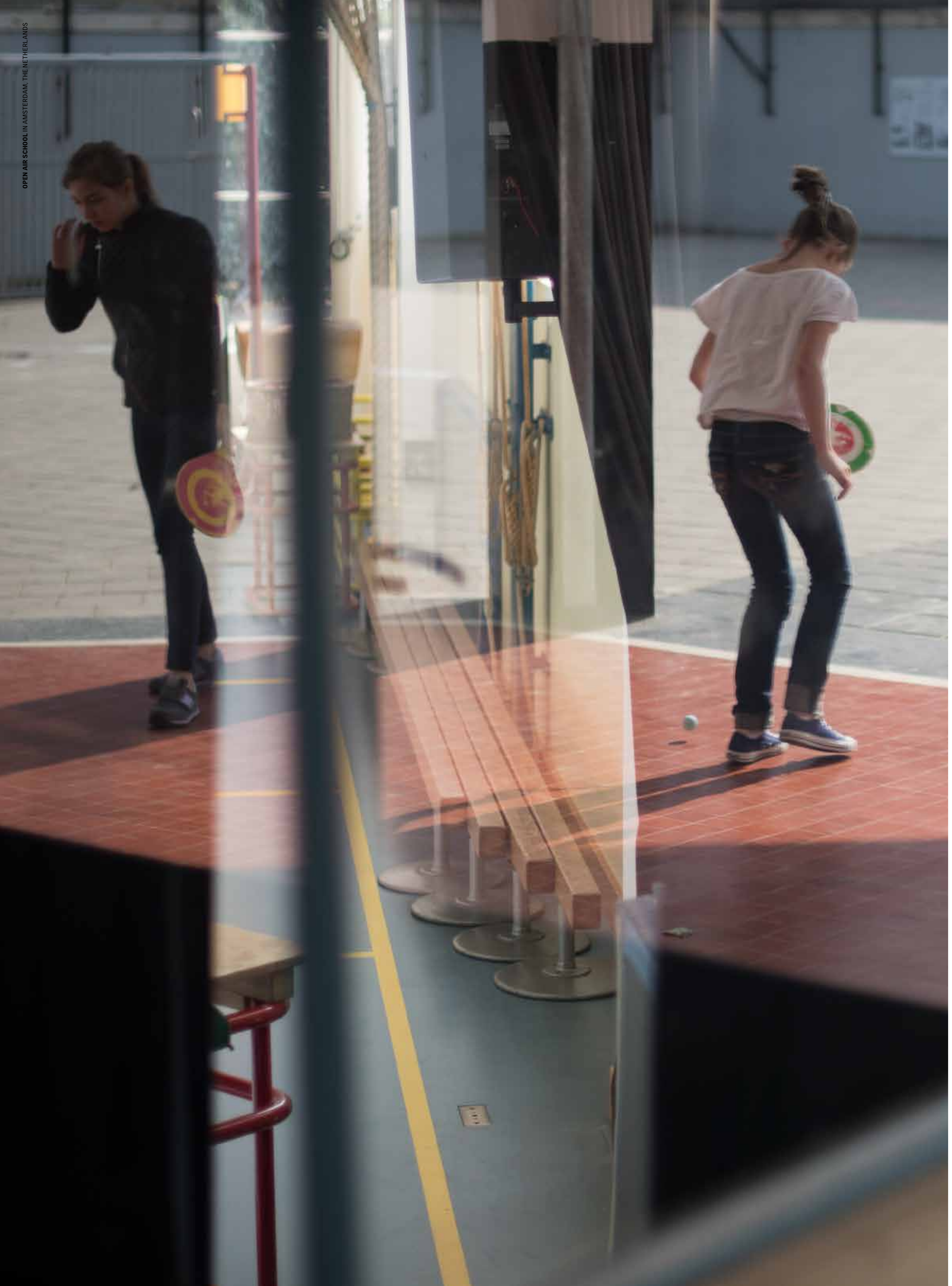
59%
of all Europeans express above average concern for unhealthy indoor air quality

THE IMPORTA NCE OF WIND OWS

FOR ENVIRONMENTAL SURFING

For the past 50 years, buildings have been designed much like spaceships, sealed and served by continuously running machinery to ensure occupant comfort and well-being. This article puts forward a different vision instead: one of buildings that literally 'surf' through the days and seasons of the year, employing windows to harness the renewable forces of nature and to ensure sustainability, resiliency, health and sheer delight.

By Vivian Loftness



OPEN AIR SCHOOL IN AMSTERDAM, THE NETHERLANDS

To even dream of carbon neutrality, we need nature's renewables: daylight, natural ventilation, natural cooling, and passive solar heating. We need active systems that are idle for as long as possible and buildings that 'surf' through hours, days, months, and seasons by capturing nature's sun, wind, and comfortable temperatures. The beauty of buildings that environmentally surf goes beyond the conservation of energy and water, the reduction of carbon, and the promise of resilience in the face of climate change. Buildings that environmentally surf support health, productivity, and a higher quality of life.

Most of the energy used in buildings is for heating, lighting, cooling and ventilation. In contrast, sustainable buildings run for as many hours, days and months as possible on *natural conditioning*: daylighting, natural ventilation, night cooling and passive solar heating. Embracing nature region by region, these buildings sustain limited resources by preserving, then surfing, cascading, and regenerating nature's resources[1]. Moreover, these buildings go well beyond conservation and resiliency to connect building occupants with a richness that is critical to human health and well-being.

Beginning with a detailed and layered commitment to windows

Windows play an invaluable role in environmental sustainability, defining our access to: nature and views, daylight, natural ventilation and night cooling, heat loss/heat gain control, solar control, load balancing (windows as circulatory system), passive and active solar energies, as well as the circadian, seasonal, cultural and climatic richness of each building's context. While designers and occupants alike have an innate knowledge of this richness, the building community must renew its commitment to outstanding window design and specification, fully resolving all of the design choices with climate specific intensity. In Northern Europe, for example, windows should be designed for daylighting without glare, the minimisation of heat loss/heat gain and thermal bridging, winter solar gain without summer overheating, natural and stack ventilation without rain or pests, the maximisation of load balancing – with windows to help dissipate heat, and outstanding views and connections to nature and community. The design solutions go well beyond the plane of the glass to include layers outside, within, and inside the glazing. In commercial buildings, the breadth of facade design decisions might be defined in 12 fields – the transom, viewing field, window parapet, and spandrel panels (top to bottom), and the interior, integral and exterior layers (inside to out) – with changing priorities relative to each performance outcome.

The creative resolution of these design decisions is central to environmental sustainability and our quality of life.

Surfing sunlight for heat

Heating is the largest site energy load in US and European buildings, both residential and commercial[2]. Highly insulated building enclosures, high efficiency mechanical systems, and heat recovery strategies do yield significant benefits for buildings today, reducing heating loads by 30–50 per cent in offices[3]. The *giant leap* in energy savings, however, is achieved by buildings also designed with passive solar heating as the dominant heat source – surfing for 60–90 per cent of the time without mechanical intervention.

Passive solar heating can provide toasty winter spaces without an energy penalty, approaching complete independence and carbon neutrality when combined with deep conservation. Surfing for solar heat also provides full spectrum light which supports health, eliminates pathogens, and reduces the risk of mould. Research findings reveal that early morning sunlight is critical to our sleep cycles and to healthier, more attentive students[4]; and sunnier hospital rooms have been linked to faster recovery rates and reduced levels of medication[5].

Even though heating is the largest energy demand in US and European buildings, designers often block sunlight through

OPEN AIR SCHOOL IN AMSTERDAM, THE NETHERLANDS

OPEN AIR SCHOOL IN AMSTERDAM, THE NETHERLANDS

Windows play an invaluable role in environmental sustainability, defining our access to nature and views, daylight, natural ventilation and night cooling as well as the circadian, seasonal, cultural and climatic richness of each building's context.

Sunlight = Health
In a 1996 observational field study of 174 patients at a hospital in Edmonton, Alberta, Canada, Beauchemin & Hays identified a 2.6-day reduction in length of stay among seasonal affective disorder patients located in sunny rooms, as compared to those in sunless rooms. Patients were randomly assigned to rooms, and the difference in length of stay was consistent across seasons.[6]

Benedetti et al found similar benefits with respect to hospitalisation for bipolar disorder in a field study of 187 inpatients at San Raffaele Hospital in Milan, Italy in 2001. The researchers identified a 30% reduction in length of stay in summer and a 26% reduction in length of stay in autumn among patients in eastern rooms (exposed to direct sunlight in the morning) as compared to patients in western rooms (exposed to direct sunlight in the evening.[7]

Walch et al identified a 22% reduction in analgesic medication use among patients in "bright" rooms who were exposed to more natural sunlight after surgery (average 73,537 lux-hrs), as compared to patients located in "dim" rooms after surgery (average 50,410 lux-hrs of sunlight) in a 2005 prospective study of 89 elective cervical and lumbar spinal surgery patients at Montefiore Hospital in Pittsburgh, PA.[8]

In a 2005 building case study of Inha University Hospital in Korea, Choi identified a 41% reduction (3.2 days) in average length of stay among gynaecology patients in the spring in brightly daylit rooms (317 lux average), as compared to those in dull rooms, and an average 26% reduction (1.9 days) in average length of stay among surgery ward patients in the autumn in bright rooms, as compared to those in dull rooms. Across all seasons, the average daylight illuminance in bright rooms was 317 lux, compared to 190 lux in dull rooms.[9]

poor window orientation and sizing, low transmission glass and unmanageable layers. A building dynamically designed to capture solar heat precisely during the hours and seasons when heating is needed, while eliminating glare and solar overheating, brings energy innovation together with health and thermal delight. For homes, the outdoor temperature at which heating is needed can be shifted from 18°C (the typical degree day base) to a new "balance point" temperature below 10°C before any heating is needed[10]. Solar overheating in summer can be dramatically reduced by integrating external, integral or, at the very least, interior shading devices and by natural venting when outdoor temperatures are cool. This is solar surfing at its best.

SURFING FOR FREE COOLING AND FRESH AIR

Building insulation, shading, and energy-efficient HVAC systems are obvious first steps for 30–50% per cent energy savings in air conditioning loads. The *giant leap* however, is achieved by buildings designed with natural cooling as the dominant cooling source – surfing for nature's cooler air and diurnal temperature swings for up to 90 per cent of the time in the case of office buildings.

This leap in energy savings requires rediscovering the cross- and stack ventilation techniques of previous generations, as well as the use of thermal mass or phase change materials and earth sheltering to delay the heat of the day until cooler times at night, then to hold the cool of the night to absorb the heat of the next day. These traditional design approaches for cooling with nature – daytime and night ventilation, evaporative cooling, time lag construction, and ground source cooling such as earth tubes – can be advanced significantly through twenty-first century material and assembly innovations. Windows play a critical role in natural ventilation with placement, sizing, operability and mechanical system interface critical to extending the period of 'environmental surfing' for free cooling. For buildings or climates that cannot meet all cooling demands naturally, mixed-mode conditioning complements natural cooling with mechanical cooling and ventilation strategies, pursuing concurrent, zoned or seasonal changeover integration[11] representing one of the most cutting edge areas of development for zero-energy buildings.

Surfing for breathing air may be even more important than surfing for natural cooling, because resiliency and human health are often unmet challenges in sealed buildings.

When we seal our buildings, mechanical ventilation becomes mandatory year round, reaching 20 per cent of the total load in US commercial buildings. Innovations in mechanical systems – economiser cycles, occupant-responsive controls, variable-speed fans, task air, desiccant air handlers and heat recovery – can substantially reduce ventilation energy use. The *giant leap*, however, can only be achieved when buildings are designed with natural ventilation as the dominant strategy for as many hours, days and seasons as possible, so that renewable energies can truly meet the remaining mechanical cooling and ventilation loads.

Human beings have thrived without forced air systems for centuries. Natural ventilation is not only a viable method to deliver outdoor air, in substantially higher quantities than forced air systems, it can also deliver cooling whenever the outdoor temperatures are *within* or *below* comfort levels. In the autumn, winter, and spring, a classroom filled with students can and should be conditioned with 'free ventilation and free cooling' through operable windows. Designing windows and building volumes for effective natural ventilation – without drafts, rain penetration, noise, humidity and pollution – is the basis of design excellence.

Naturally ventilated homes, classrooms, offices, hospitals, gymnasiums and other spaces also contribute to greater health and performance outcomes. Air change rates in naturally ventilated spaces can be higher, improving air quality without energy penalty; the cooling effect of air flow allows for a broader range of acceptable temperatures (known as the adaptive comfort zone); and the variability enhances motivation and creativity. Open windows also ensure a connection to the multisensory qualities of nature and community.

The quantifiable benefits of surfing for natural cooling and ventilation are substantial – measurably improving indoor air quality for productivity and health, as well as saving energy and ensuring resiliency in the face of power blackouts. Research findings reveal that natural cooling and ventilation reduces absenteeism and medical attention as well as increasing productivity.

SURFING FOR LIGHT

Energy-efficient lamps, ballasts and light fixtures are obvious first steps for achieving a 30 per cent saving in lighting energy, and daylight and occupancy-responsive controls can shave the next 20 per cent of lighting energy use[14]. The *giant leap*, however, is achieved by buildings designed with daylighting as the dominant light source – surfing for daylight to eliminate any electricity demand for lighting during the daytime. Daylight as the dominant light source requires design excellence and management expertise, integrating space planning with windows and skylights, advanced glazing technologies, light redirection devices and shading layers that enrich and regionalise our architecture.

Daylit classrooms, offices, hospitals, gyms, airports, grocery stores and other spaces also contribute to greater health and performance outcomes. Light levels in daylit spaces can be higher with no energy penalty; full-spectrum light offers rich colour rendition and improves three-dimensional perception; and daylight variations throughout the day trigger melatonin production, circadian rhythms and healthy sleep patterns[15]. As an added benefit, views afforded through windows and other transparent surfaces meet fundamental needs for a connection to nature[16].

SURFING THE REGENERATIVE FORCES OF NATURE

Design for environmental surfing maximises the number of hours, days, months and seasons in which 'passive renewables' – such as daylight, natural ventilation, passive solar heating and time-lag cooling – allow mechanical and electrical systems to be turned off. This is the only way we can achieve the 90 per cent reductions in building loads that take full advantage of active renewable sources.

Design for environmental surfing, however, challenges architects and engineers to collaborate on regional design solutions, merging traditional and innovative materials and systems to create or re-create buildings that are indigenous to each climate. The joy of summer days and nights in unsealed, naturally-conditioned spaces in the Raffles Hotel in Singapore, the Mohonk Mountain House in New York State, Sagrada Familia in Barcelona – each unique to its climate and truly low energy consumption – are irreplaceable experiences. Regionally appropriate designs are critical for zero-energy buildings and for the cultural richness that make travelling and living a unique celebration of place.

Moreover, design for environmental surfing will ensure that our architecture is filled with 'biophilic' richness for health, productivity and all of the natural energies that offer an abundance of light, heat, coll and air. 'Biophilia,' a term coined by E.O. Wilson[21] with deep elaboration by Stephen Kellert[22], is the innate human need for a connection to nature and living systems. Windows play a critical role in environmental surfing as well as being central to our connection with nature and community, and emerging research is helping to quantify these benefits[23].

TRIPLE BOTTOM LINE APPROACHES TO VALUING WINDOWS FOR ENVIRONMENTAL SURFING

Cars and laptops are purchased with far more comprehensive life-cycle considerations than buildings, and yet the life span of cars and laptops are often five years or less. Since buildings are built

Night ventilation cooling = Productivity
In a 2003 meta-analysis study, Seppänen et al identify a productivity increase equivalent to 0.39 hours of work per day (4.9% for an eight-hour workday) due to night-time ventilation cooling of thermal mass, a very energy-efficient method of reducing daytime indoor temperatures by using night-time air to cool a building's structure and furnishings.[12]

Natural ventilation = Health + Productivity
In a 2004 multiple-building study of professional middle-aged women in France, Preziosi et al identify a 57.1% reduction in absenteeism, a 16.7% reduction in medical services use (doctor visits), and a 34.8% reduction in hospital stays among subjects with natural ventilation in their workplace, as compared to those with air conditioning.[13]

Daylight = Productivity
In a 1997 controlled experiment, Boyce et al identify a 1.6-12.8% improvement in night-shift workers' performance on short-term memory and logical reasoning tasks under large skylight-simulating fixtures with hidden fluorescent lamps, capable of providing fixed or variable illuminance from 200 lux to 2,800 lux. Performance was enhanced by fixed high illuminance of 2,800 lux and by steadily decreasing illuminance that simulated daylight from midday to dusk, as compared to fixed low illuminance of 250 lux or steadily increasing illuminance that simulated daylight from dawn to midday.[17]

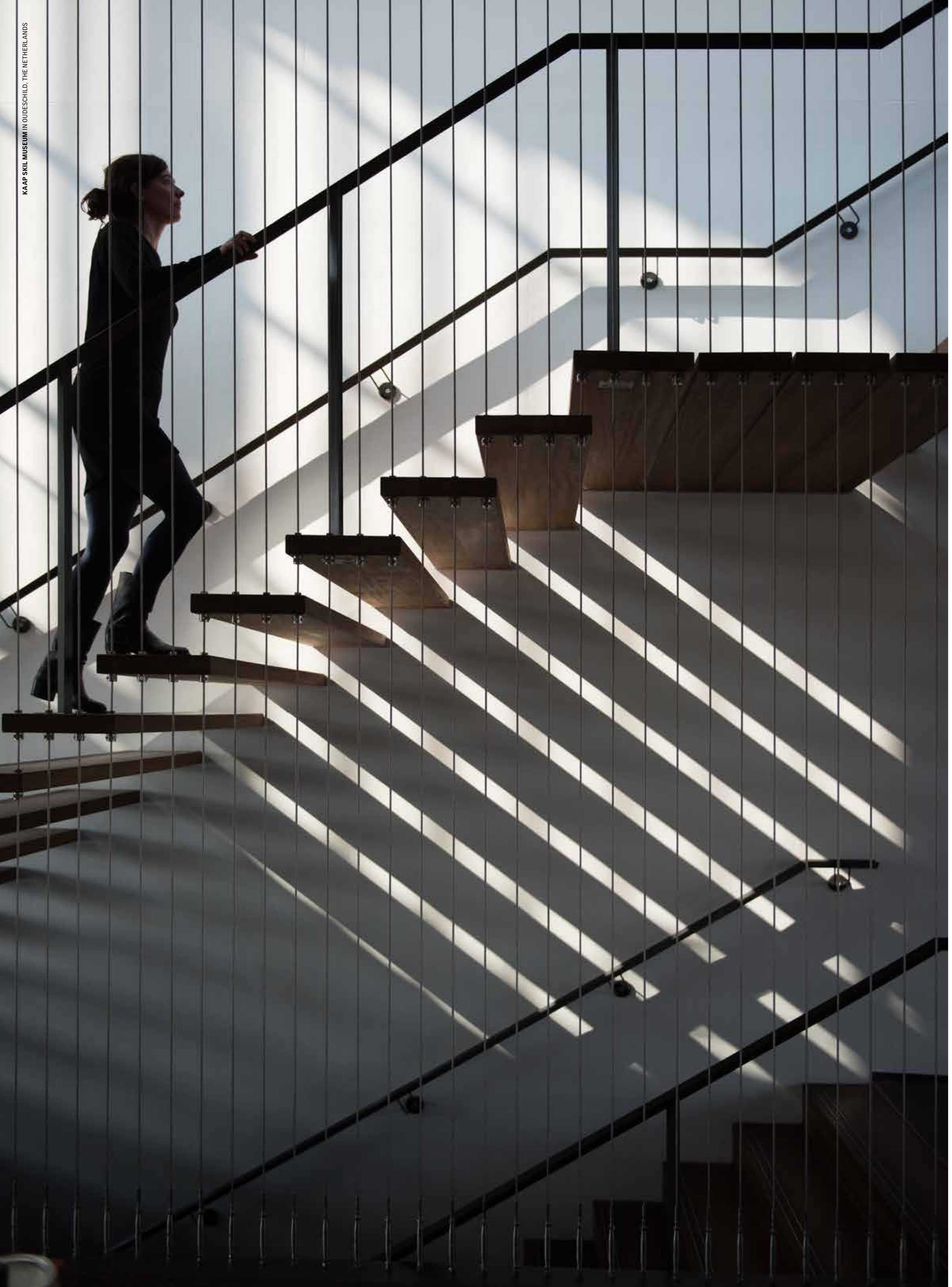
Daylight = Sleep cycles (and performance)
In a 2010 study of sleep cycles of 8th grade students in the Smith Middle School in Chapel Hill, USA, Figuero and Rea identify that student exposure to short-wavelength morning light significantly regulates their circadian clock and improves sleep times by as much as 30 min.

Wolfson and Carskadon (1998) identified that poor-performing students obtained about 25 minutes less sleep per night and went to bed on average 40 minutes later on school nights than those who were good performers.[18]

Window View of Nature = Health
In a 1984 observational field study at a Pennsylvania hospital, Ulrich identifies an 8.5% reduction in post-operative hospital stay (8.7 days versus 7.96 days) for gall bladder surgery patients who had a view of a natural scene from their hospital room, as compared to those with a view of a brick wall. Patients with a view of a natural scene also received fewer negative evaluations from nurses and took fewer strong analgesics.[19]

Window View of Nature = Productivity
In a 2003 building case study of the Sacramento Municipal Utility District (SMUD) Call Center, Heschong et al identify a 6% to 7% faster Average Handling Time (AHT) for employees with seated access to views through larger windows with vegetation content from their cubicles, as compared to employees with no view of the outdoors.[20]

OPEN AIR SCHOOL IN AMSTERDAM, THE NETHERLANDS



KAAP SKIL MUSEUM IN OUDESCHILD, THE NETHERLANDS

Balancing financial capital, natural capital and human capital is a shift in decisionmaking that is critically needed for the built environment.

The biophilic advantages of windows

- Views
- Access to nature
- Sounds of nature
- Smells of nature
- Sensory feel of nature
- Daylight
- Sunlight and Solar Heat
- Shade with light
- Fresh Air and Natural Ventilation
- Thermal delight
- Resiliency
- Transparency
- Community
- Celebration of time and place

Triple bottom line of environmental surfing with windows

Planet
Power Plant CO_2, SO_X/NO_X/PM
Urban heat island mitigation
Glass sustainability
HP window reusability
Motivation
Community engagement
Community safety

People
Respiratory health
Visual system health
Alertness/Sleep cycles
Employee productivity
Student performance

Profit
Lighting energy savings
Heating energy savings
Cooling energy savings
Real estate value

for 30, 50 or even hundreds of years, it is imperative that the client and design community begin to understand the "triple bottom line" benefits of buildings designed to ensure cost-effective environmental sustainability and resiliency as well as human health and productivity.

Balancing profit, planet, place or financial capital, natural capital and human capital, is a shift in decision-making that is critically needed for the built environment. With triple bottom line calculations, building decisions will move beyond first-least-cost and 'value-engineering' budget cuts to reflect the true cost of ownership for individuals and society. It is actually not difficult to monetise triple bottom line benefits once they are understood. The environmental cost benefits of energy use, waste and toxicity can be quantified and put in an NPV calculation, even if assumptions must be made. The human cost benefits of health, productivity, performance at task, market impacts can also be monetised and calculated, creating an iterative triple-bottom-line for decision makers to understand the true value of their investments. If we want to shift away from first-least-cost decision making, the design community and the building industry must capture the economic, environmental and human benefits of investing in quality built environments.

This article has listed a host of human capital benefits to environmental surfing through the integration of high-performance windows that can be justified in a triple bottom line calculation. For example, daylight without glare, with controlled heat loss and heat gain, with passive solar heating in winter, with no solar overheating in summer, can only be achieved through high-performance specifications of visual transmittance, R-value, solar heat gain coefficient, thermal bridge control and layers that support daylight redistribution, shading, night insulation and more. High-performance specifications *should* cost more. While energy savings through environmental surfing (a profit calculation) will probably not pay for the high performance window assembly in less than five years, the health and productivity benefits (a people calculation) most certainly will. A triple bottom line calculation for new, selectively reflective high-performance blinds that are inverted for daylight redirection, for example, reveals a 19-year payback based on energy and maintenance, 15-year payback if environmental costs associated with energy are no longer externalities, and a one-year payback when human health and performance gains are considered[24].

Life cycle, triple bottom line calculations can ensure investments in high-performance windows that support environmentally surfing for – views, daylight, sunlight, fresh air, breezes, natural comfort, passive survivability, access to outdoor spaces and activities, seasons, climate and the full sensory richness of nature and community outdoors.

MASTERS OF ENVIRONMENTAL SURFING

The architectural masters of environmental surfing will preserve, cascade, and regenerate nature's abundant resources for sheer delight; create technologies that mimic nature and regenerate without waste; and ensure shared access to revitalised natural settings, healthy lifestyles, mobility, community. The architecture that environmentally surfs reflects the uniqueness of each climate, culture and community; dynamically responds to the time of day and the seasons; and celebrates nature's creative energies.

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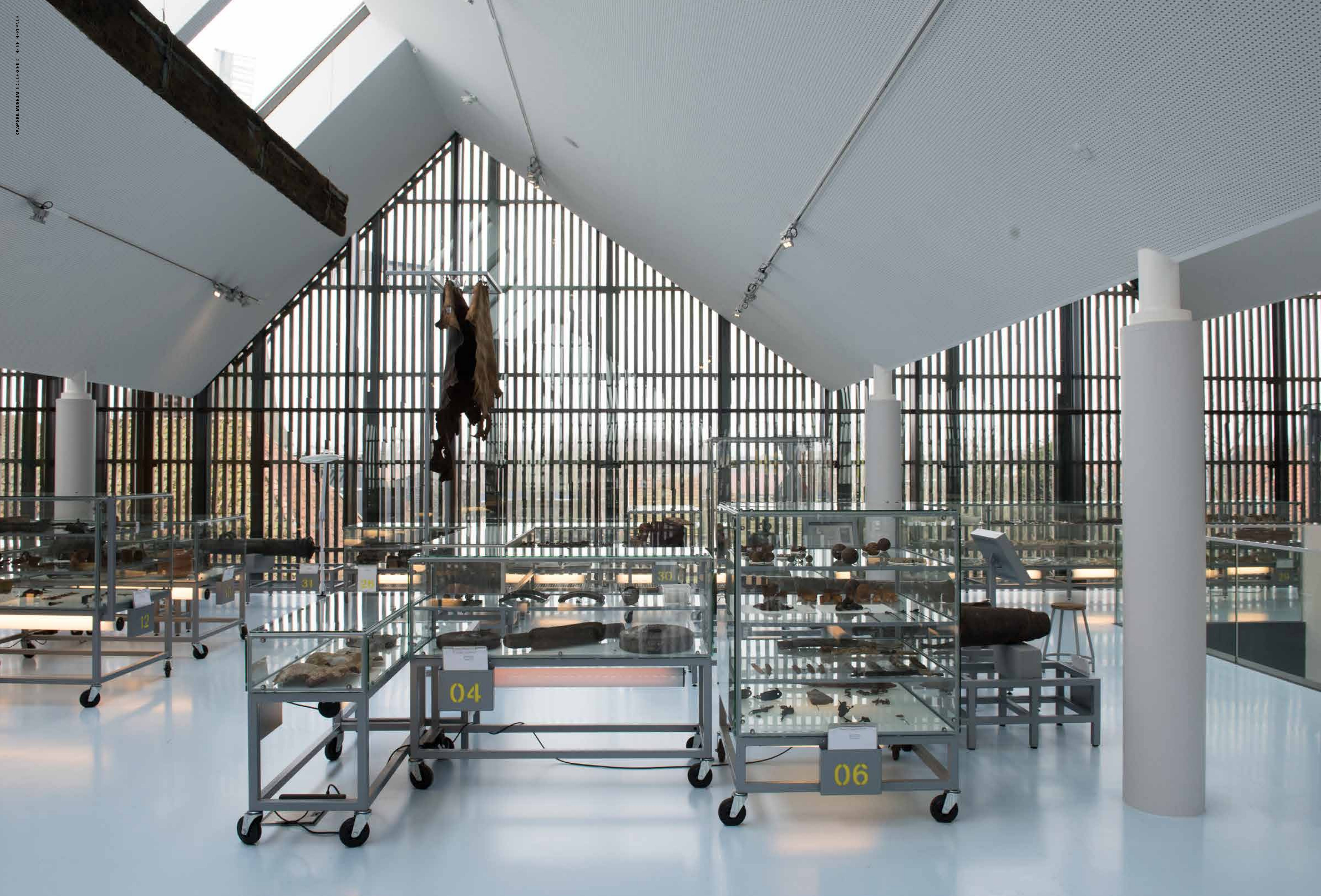

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Notes

1. Four terms have been introduced to add depth to the overall thesis on environmental surfing: *preserve* is used to summarise the benefits of conservation, using as few resources as needed; *surf* is used to summarise the benefits of passive conditioning with non-depletable natural resources such as light, sun, wind, diurnal swing; *cascade* is used to summarise strategies to use depletable natural resources several times by recapturing the waste stream (energy, water, materials) for secondary and then tertiary uses with a goal of zero waste; *regenerate* is used to summarise the potential of actually increasing a resource such as fresh water through innovative technologies and design solutions.
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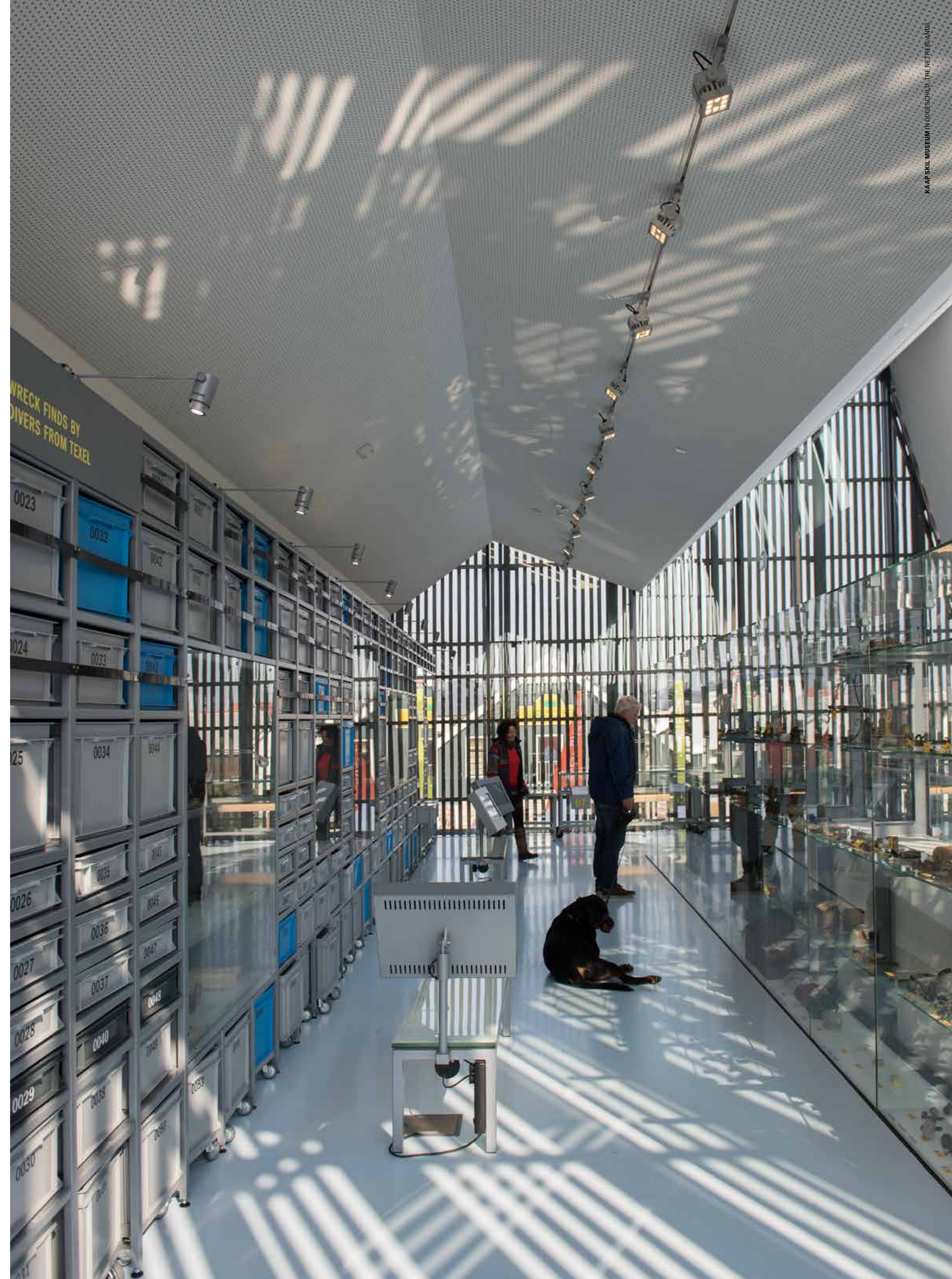

KAAP SKIL MUSEUM IN OUDESCHILD, THE NETHERLANDS

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THE PHOTOGRAPHY IN THIS ISSUE

Good architecture goes beyond what we already know. It exposes us to new, previously unknown situations that stimulate our senses, trigger our emotions and improve our health and well-being. This capability of architecture becomes visible in the images that German photographer Thekla Ehling has taken of a number of exemplary buildings – both modern 'classics' and new builds – as well as their users for this issue of Daylight/Architecture. The photographs illustrate the numerous ways in which people, buildings and daylight interact with each other in our everyday lives.

DAYLIGHT FOR THE WE-FEELING

BUITEN DE VESTE SCHOOL IN STEENBERGEN

pp. 8–19

The Brede Scholen (approximate English translation: broad-based schools) in the Netherlands not only comprise classrooms and special-subject teaching rooms but also offer a child-care service even for very small children, close contact between child-care staff, teachers and parents, as well as – in the ideal case at least – short distances to social and medical centres. The aim of these schools – more than 2,000 of which have been built since the middle of the 1990s – is to provide children from socially disadvantaged families with a home away from home.

But how can the 'we-feeling' that this type of school is meant to convey be expressed in the buildings? For the new school in Steenbergen, in the southern part of the Netherlands, Elemans van den Hork Architecten initially took their inspiration from the exposed location of the site right at the edge of the town – just outside the old fortifications that, for centuries, had surrounded the town, which now has 25,000 inhabitants. They designed the new 3,500 square metre building as a small fortress, compact in form and protected by multi-coloured brick masonry in red, black and white. In contrast, the interior rooms were to be all the more open and brighter. When designing them, the architects utilised an integral planning process whereby, from the very beginning, the central criterion for all design-related decisions was the interior climate – including all of its components, i.e. daylight, heat, air and noise. In order to avoid direct sunlight and overheating in summer, most of the classrooms and the group rooms of the kindergarten and primary school face towards the north. On the west and east facades, movable sun blinds keep out the rays of the low-lying sun. The classrooms themselves are over three metres high in order to facilitate natural ventilation through the windows, all of which can be opened manually.

The communicative heart of the complex – and therefore the catalyst for the strived-for we-feeling – consists of the gymnastics hall and the adjacent playroom with stage. Located on the south facade, where there are not many windows, they obtain their daylight through modular skylights in the roof. With the intention of allowing only the light in and not the heat, the architects integrated the skylights in a saw-tooth roof with north-facing glazing through which direct sunlight cannot enter, even at the height of summer. In this way, the large playroom and the sports hall encourage the children to engage in play without becoming unnecessarily hot in summer.

Location:
Waterlinie 9, Steenbergen, The Netherlands
Architects:
Elemans van den Hork Architecten, Oss
Year of completion:
2014

APARTMENT BLOCKS RECONCEIVED

TOUR BOIS-LE-PRÊTRE IN PARIS

pp. 20–29

In the opinion of the architects Anne Lacaton and Jean-Philippe Vassal, the primary virtues of the 'grands ensembles', those high-rise housing estates from the post-war period that are so numerous in the suburbs of Paris, are their height, the unique view and the surrounding green spaces. The state-owned French agency for urban renewal had originally decided to tear down 130,000 apartments in these buildings and rebuild them between 2003 and 2013. In a study, however, Lacaton & Vassal, together with Frederic Druot, showed that the budget allocated for this purpose could be used not only to implement energy-saving measures for far more apartments but also to fundamentally upgrade these apartments.

In 2011, the Tour Bois-le-Prêtre, a 17-storey building for low-income residents next to the north-west section of the Boulevard Périphérique around Paris, proved the feasibility of the measures they had recommended. The renovation concept of the architects can be described as "more with less". Today, by their calculations, the energy requirement of the building has decreased by around 50%. At the same time, the 100 apartments have been enlarged by 35 square metres on average – and this without the tenants having to move out and without any increase in rent.

Thanks to two new lifts, there is now barrier-free access to all the apartments. Moreover, the bathrooms have been renovated and some of the ground plans of the apartments have been made more open. The biggest change, however, has been on the facades of the high-rise building. In order to let more daylight in, the architects removed the previous window parapets and inserted ceiling-high sliding glass doors. Beforehand, prefabricated steel modules were mounted on the outside. They enclose the two-metre-deep, unheated winter gardens as well as one-metre-deep balconies. Between winter garden and balcony, the occupants can control the ingress of daylight and heat, as well as the view to and from the outside, by means of translucent polycarbonate sliding panels and special heat-repelling curtains made of aluminium foil, sheep's wool and a woven fabric. In winter, the gardens act as passive solar collectors and – at least when it is sunny – as extended living space outdoors. In aesthetic terms, the Tour Bois-le-Prêtre has made decisive gains. Instead of the previous dirty-yellow and pink-coloured panels on the outside, it now presents itself to its surroundings in a translucent shell composed of a total of four transparent layers (including the glass balcony balustrades), which are constantly in motion thanks to their interaction with the occupants.

Location:
Boulevard Bois-le-Prêtre, Paris, France
Architects:
Raymond Lopez (design),
Druot, Lacaton & Vassal (refurbishment)
Year of completion:
1961
Year of refurbishment:
2011

FIVE POINTS TOWARDS BETTER LIVING

SWISS PAVILION IN PARIS

pp. 32–41

In 1927, Le Corbusier and his cousin, Pierre Jeanneret, called upon the architects of the world to revolt – against the traditional mode of construction of our houses and cities, which, in the 19th century, had become the breeding ground for illnesses such as tuberculosis. They proposed a completely new architecture that would literally make people healthier. Their 'Five Points Towards a New Architecture' became the basic vocabulary of classical modernism: large concrete supports (pilotis) intended to raise a building above the wet ground; sun-drenched roof gardens; long horizontal windows for an unobscured panoramic view; as well as free design of ground plans and facades thanks to a skeleton construction based on steel and concrete.

For the students' residence in the south of Paris, which was opened in 1933 and financed by the Swiss Confederation and private investors, the two architects were able to put their manifesto into practice with almost no curtailments. The pre-existing conditions on the campus of the 'Cité Internationale Universitaire' were ideal for this: a 37-hectare, park-like terrain in which the guest houses of the different nations were embedded as solitary buildings. The urban-planning restrictions were minimal but the ground at the site (a filled-up former quarry) was not strong enough to bear heavy loads. Le Corbusier and Pierre Jeanneret therefore construed their building as a light-weight steel construction for the most part. Only the six large supports on the ground floor and the cross-beams on top of them are made of concrete.

The ground plans have been designed to provide all 47 of the student rooms with a maximum amount of sunlight. They all face south and access to them is enabled by a long corridor in the north that runs the entire length of the building. Whereas the north facade is panelled with artificial stone and has only small windows, the south front is conceived as a glass curtain wall and is wide open to the outside. Originally, Le Corbusier had arranged for ceiling-high windows to be installed but then, in the 1950s, added closed breast walls and outside blinds, given that the temperature inside was sometimes over 40 degrees in summer.

Nonetheless, the top floor, with its four roof gardens, continues to be a refuge for sun-worshippers. Here, students can grow potted plants and sunbathe undisturbed. In the beginning, Le Corbusier had envisaged encircling this area with high walls and only leaving it open to the sky. However, he then inserted openings in the top floor that enabled people to see other roof terraces and the surrounding park.

The communal life of the students primarily takes place in the 'Salon Courbe', a single-storey annex located to the north of the building in the garden. This room is famous not least because of the wall-filling 'Peinture de silence', a painting with which Le Corbusier replaced the previous photographic wall decoration in 1948.

Location:
7, boulevard Jourdan, Paris, France
Architects:
Le Corbusier, Pierre Jeanneret
Year of completion:
1933

THE PERSON AS THE SCALE OF THINGS

SUBSIDISED HOMES IN CHÂTEAUDUN

pp.43–49

Until recently, the Quartier Beauvoir in Châteaudun, a town with 15,000 inhabitants 130 kilometres south-west of Paris, was made up of big residential blocks from the 1950s. They were strictly aligned to the four points of the compass but without any relationship to the surrounding green areas and the roads that connect them. Almost two thirds of the people in the quarter live in subsidised homes; the unemployment rate here is considerably higher than in Châteaudun.

The occupants have remained but the structure and appearance of the quarter have changed radically in the last 10 years. Many of the concrete-slab structures have been replaced with smaller buildings that incorporate an altogether different concept of architecture. There are new public squares and road links that more effectively connect the previously rather isolated district to the town centre.

A new type of subsidised housing with a human face and on a human scale has also been created by Ahmet and Florence Gülgönen in the Beauvoir district. The scheme consists of 21 two- to three-storey terraced houses as well as 109 apartments in three- to four-storey town houses. The latter also comprise public services, an employment office, and a health centre. These are partly accommodated in stepped extensions towards the rear that establish an almost seamless transition between the town houses and the smaller, terraced houses.

All the apartments receive daylight from two sides and the much lower height of the buildings – compared to the previous residential blocks – also makes for better lighting.

On the outside as well, the new buildings completely erase any reminders of their predecessors. Instead of large, unstructured volumes, what now meets the eye is a multi-component landscape of roofs covered with slate. Numerous roof windows, mainly at the height of the eaves and combined with vertical window openings, bring a great deal of light, particularly into the upper floors. For the somewhat taller apartment buildings, the architects also chose the same covering for the roofs and a similar arrangement of the windows. Only the facade cladding is different here; it consists of large-format brick elements, whereas the terraced houses were given a coat of cream-coloured plaster.

The architects paid as much attention to the open-air spaces in the district as to the interior of the buildings. They report: "We have realised from our visits after the completion of the buildings that the people from the neighbourhood are very proud of their new environment. They are satisfied not only to have nice private spaces, houses, and apartments, but also happy to share the collective spaces at different scales from a thoughtfully conceived entrance hall to an urban park."

Location:
Avenue General du Gaulle/Place du Phénix/rue Paul Gauchery, Châteaudun, France
Architects:
APRAH – Ahmet & Florence Gülgönen
Year of completion:
2013

FOLLOWING THE SUN

RENÉ GUEST SCHOOL CENTRE IN LA GARENNE-COLOMBES

pp. 50–59

Located in a residential area of the La Garenne-Colombes municipality, the René Guest school centre is just over one kilometre away from what is known as La Défense, the banking district of Paris. But the contrast with the high-rise towers on the banks of the Seine could hardly be any greater; the one- to two-storey buildings of the kindergarten and the primary school are grouped around two tree-lined inner courtyards. Composed of solid brick masonry, they were built in the 1950s but eventually needed to be technically refurbished. Above all, the kindergarten had become too small for the number of children that had to be looked after and, in many areas, there was also a paucity of daylight: "It was mainly the corridors with their high windows that used to be dark and had to be lit artificially at all times," said architect Ariane Ville from the architects' office ave architecture, looking back on her involvement in the project.

The task with which the architects were assigned was therefore to build four new group rooms as well as a prestige entrance area, together with a new forecourt at the corner of the building complex. In addition, the existing school canteen was to be extended, the library and the schoolyard renewed and a new, barrier-free access ramp to the primary school created. Altogether, the built-over area of the school complex grew by around one quarter as a result of the construction measures that were implemented.

Starting from the covered entrance, two long rows of modular skylights accompany the children into the spacious lobby between the canteen, the library and the activity room. A second, almost 40-metre-long row of skylights bathes the central corridor between the group rooms in bright daylight, enabling a view of the sky and clouds above. As 30% of the modules can be opened, the skylights support ventilation of the corridors, thus providing a refreshing, natural cooling effect and a more pleasant interior climate, especially in summer.

Location:
3 rue Louis Jean/6 rue Champs Philippe, La Garenne-Colombes, France
Architects:
ave architecture, Clichy (refurbishment)
Year of refurbishment:
2014

FOR THE BETTERMENT OF HEALTH

OPEN-AIR SCHOOL IN AMSTERDAM

pp. 64–75

At virtually no other time in history have healing powers been so assiduously attributed to architecture as between 1900 and the Second World War. It was the era of large sanatoriums in which abundant sunlight and fresh air were supposed to contribute to the healing of, above all, tuberculosis. A key example of European sanatorium architecture was created by architects Jan Duiker and Bernard Bijvoet in 1928 in the form of the 'Zonnestraal' sanatorium in Hilversum.

At the same time as the sanatoriums, but in considerably lower numbers, so-called 'open-air schools' were built in many places in Europe. In them, children who were ill were taught in the fresh air, regardless of wind and weather. They were usually located in rural regions and only provided rudimentary – if any – protection against wind and weather.

For the first open-air school in Amsterdam, Jan Duiker and his clients had something else in mind. Why should only ill children profit from the benefits of this new type of school, and why only in rural regions? The 'Openluchtschool voor het gezonde kind' was therefore specifically conceived for the prevention of illness among healthy children and was built in the inner courtyard of a block of buildings in the south part of Amsterdam, where large scale urban expansion had been underway since the 1920s.

In his design, Duiker fully exploited the advantages of the skeleton mode of construction with reinforced concrete in order to open up the interior spaces as far as possible to daylight and fresh air. From the low breast wall upwards, the facades of the classrooms are completely composed of glass. If necessary, the steel windows over a large area of the building's outer surface can be opened to let in fresh air.

The school's four-storey square-shaped main building stands diagonally in the inner courtyard. Each floor is divided into four quadrants. The west and east ones each contain a classroom while the south one has a covered terrace that Duiker conceived as an 'open-air classroom' A staircase in the middle of the building connects the floors. The teachers' room is in the north quadrant, which is only one storey high. On the ground floor, there is also the gymnastics hall, which is slightly sunk into the ground, as well as an additional classroom that is now used as a learning and multimedia room.

In the course of several decades, the open-air school was renovated repeatedly, the last time being in 2010 by Wessel de Jonge Architecten, who had previously modernised the Zonnestraal sanatorium for use as a modern health centre. On the outside, the school building is once again as it was after the first refurbishment in 1955; the classrooms have even been restored to their original condition. In the details, however, a lot has been done to make the interior comfortable according to today's standards and enable modern forms of teaching. Insulating glass is used for the windows, the heating has been renewed and a ventilation system with heat recovery for the winter has been installed. The Internet age has also entered the classrooms in the form of data terminals and digital 'blackboards'. And to create a place for concentrated learning for the children, part of the south terraces – barely visible from the school yard – has been converted into little 'study rooms' with ceiling-high glass walls.

Location: Cliostraat 40, Amsterdam, NL
Architects: Jan Duiker, Bernard Bijvoet (design), Auke Komter, Wessel de Jonge Architecten (refurbishment)
Year of completion: 1930
Refurbishment: 1955, 2010

GENIUS LUMINIS

KAAP SKIL MUSEUM IN OUDESCHILD

pp. 76–85

Water and wind are the two elements that have always characterised the North Sea coast of the Netherlands and still do today. In order to grasp this, it is sufficient on many days to look into the sky where the west wind drives the clouds above the coastal landscape and causes changes to the light every quarter of an hour.

With their new entrance building for the maritime and beachcombers museum in Oudeschild on the island of Texel, Mecanoo created a 'perception machine' for the unique light of this region. At the same time, the museum pays homage to a time when wind and water brought a certain amount of prosperity to this westerly and largest of the West Frisian Islands. In the 'Golden Age' of Dutch shipping in the 17th century, the sailing vessels of the East India Company anchored here before setting off on their trading trips to South and Southeast Asia.

All this is illustrated by film and multimedia projections in a model of a sea landscape in the basement of the new building. 72 square metres in size, this model is probably the largest in the world. Above it, there is a two-storey lightweight construction composed of steel and glass whose scale and striking gable-shaped roof echo the appearance of the surrounding residential buildings. In order to prevent the contrast with the traditional local architecture from becoming too great, the architects provided the new building with a cladding of narrow, vertical slats made of azobe wood. These are related to the history of shipping, as the tree trunks from which they were sawn were once used as sheet pilings for the North-Holland Canal, which connects Amsterdam to the North Sea.

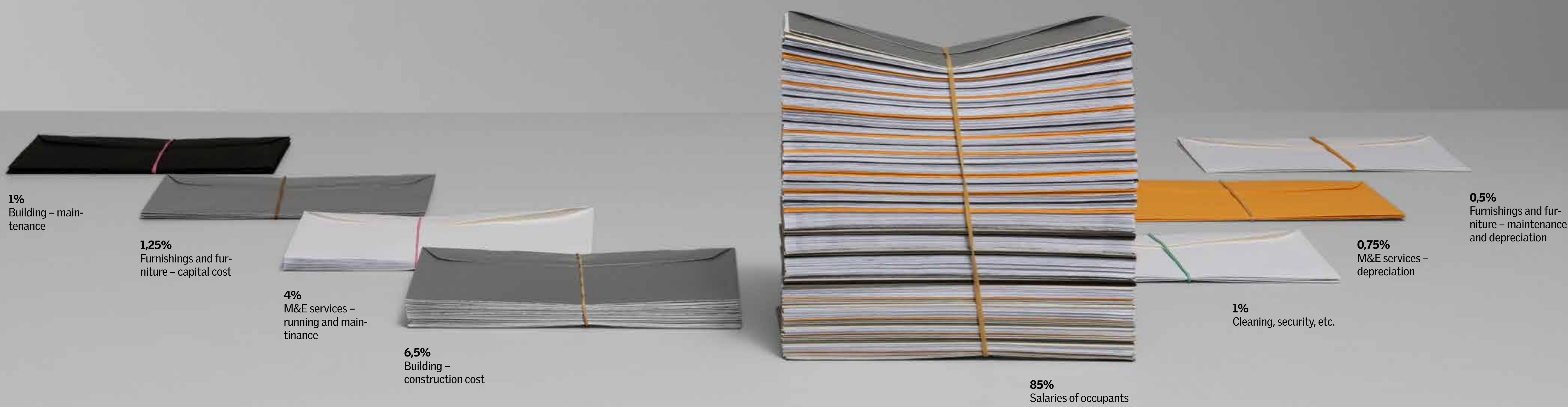
The envelope of slats unfolds its unique effect above all in the large hall on the first floor. During sunny weather, the room is immersed in a shimmering play of fine lines of light and shadow, whose degree of contrast changes continually, depending on how cloudy it is outside. In the roof gables above, there are three skylight strips facing east, allowing a view of the sky. The architects intentionally designed this space in such a way that the light of Texel is shown to full advantage: walls, ceilings, floors and the round steel supports are all uniformly white, while the steel and glass display cabinets in which finds from underwater archaeology are presented are only half-height and, thanks to castors, can be moved to prevent them from blocking the view.

Location:
Heemskerckstraat 9, Oudeschild, The Netherlands
Architects:
Mecanoo Architecten, Delft
Year of completion:
2012

People are what matters, not buildings or energy – also financially

In a typical office building, the salaries and benefits of employees account for over 80% of the overall business costs associated with operating the building. Energy amounts to an insignificant cost – often as low as 1%.*

* Low-carbon buildings are all about people. Interview with Judit Kimpian in DETAIL Green (English edition), November 2012, p. 70ff.



Construction costs are only the beginning

The costs associated with owning a building are much higher than the cost of construction. The figure shows the costs of owning and operating an office building over 30 years. In this example, operating costs exceed construction costs by a factor of five – but these costs are vastly outweighed by the value of the work created in the building.

As a better indoor environment can raise productivity considerably, investment in this area can produce generous returns.*

* Adapted from Davis Langdon Management Consulting (2007): Towards a European Methodoology for Life Cycle Costing (LCC) – Guidance Document

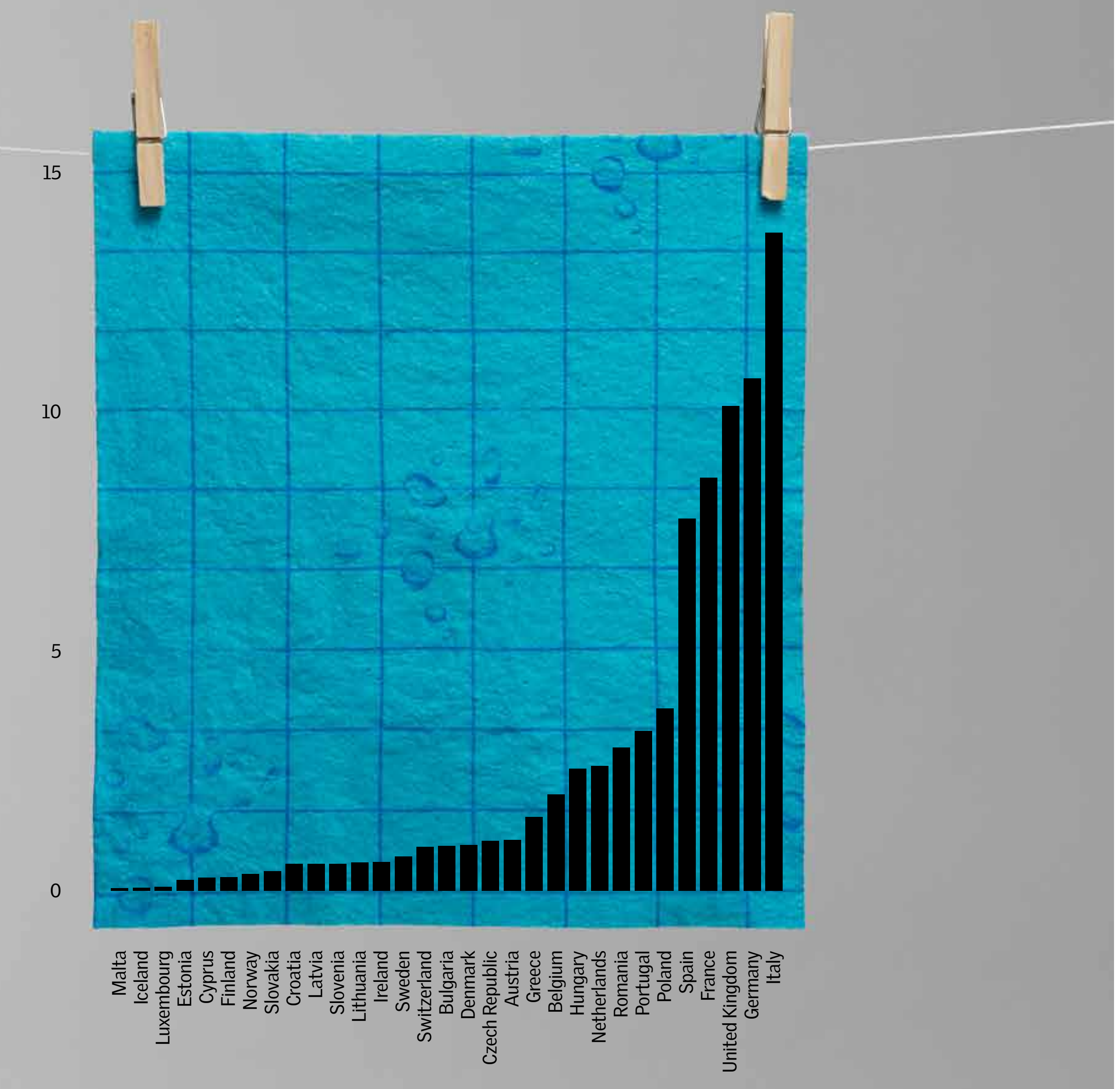
Cost of construction

Operations cost including energy consumption

Value of the work being carried out in the building including wages

The homes of 80 million Europeans are damp and unhealthy*

* Eurostat: EU Statistics on Income and Living Conditions, 2009–2013



One in seven Europeans lives in a damp home

16% of the European population lives in homes that suffer from dampness, which is likely to lead to mould growth. Living in a home with mould growth doubles the risk of developing asthma.*

* Eurostat: EU Statistics on Income and Living Conditions, 2009–2013

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