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
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.*


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, Jørn Utzon, and Lacaton & Vassal in Daylight / Architecture 15.
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.
**The Design of Our Built Environment**

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. 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: “Designed interventions can make better choices easier or constrain behaviours by making certain actions more difficult.”

The purpose of this article is to outline the definitions 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 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.” 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.

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. 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.” 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:

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 – 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 measurable in terms of the symptoms and causes. For example, air quality (e.g. VOCs, PM or CO2) 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.

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 been a development from narrow and precise physiological comfort theory, based on the seminal work of Fanger, to a more holistic understanding that has led to the adoption of adaptive comfort theory. 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 characteristics 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.

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. 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.
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 and the Commission for Architecture and the Built Environment. This is supported by an increasing wealth of medical research related to physical health and mental health. 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). 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, provides the critical mass of evidence that led to the definition of the Five Ways to Well-Being mentioned above. 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.

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.

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.

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.

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 and through volunteering and offering help.

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. 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. And finally, natural, green or landscape qualities have been widely and for a long time associated with a range of health benefits. 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 enriched by considering 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.

**REKEEP 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 destinations), land use (e.g. mixed use) and walkability (convenient and safe pavements, traffic calming features). Although there are possible additional benefits to physical activity in an outdoor and preferably natural environment, exercise indoors can be equally effective.

In a randomised controlled test, the provision of art, planting and landscape improvements are examples of the kind of interventions that can be shown to improve individuals’ mental health and well-being. Design strategies to promote indoor physical activity include: the provision of (shared) exercise space, equipment, and facilities (e.g. specialised spaces or digital equipment) does not show any improvements in 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.

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. 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. Although it is difficult to observe altruism 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.

**Notes**

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. 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
metabolic activity. 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, 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 neighbour-hood 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, over-illumination 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 circumstances).
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 conditions, 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 heavy-weight 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 dampsens 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 debates]” 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-ceiled 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 spaces46.
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”47.
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-ceiled, rectilinear environments are more likely to encourage focus, concentration and study.

**Conclusion**

Designing for well-being and health includes a plethora of opportunities and 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 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 of the Bioscieve 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’48. 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 texture of the smooth grip to adjust a wooden shutter. Our well-being is intimately linked with such moments of delight. To an extent, such delight 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.

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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 CHW Design and of Cambridge Architectural Research Limited.
TOUR BOIS-LE-PRÊTRE
IN PARIS, FRANCE
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
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 aesthetic 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...
a building (traditionally defined by a narrow set of parameters such as temperature or CO₂ 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. 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...
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.

“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) Socio-demographics 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 (bbr) 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 turn houses 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 turn houses 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 turn houses 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 turn houses 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 turn houses 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 turn houses 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.
SOCIAL HOUSING IN CHÂTEAUDUN, FRANCE
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.

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
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 VEILUX Group has initiated such a survey with the European Healthy Homes Barometer (hhb), a new research programme on health, housing and liveability. 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 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
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 tally 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 standardized methodological design of the Healthy Homes Barometer does not clarify what comfort really means to people and what they consider important to achieve. 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, 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

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 impact that 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
So far, little has been known of what people consider important for their well-being at home. With the Healthy Homes Barometer, the VEILUX 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.

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<th>Scale of evaluation:</th>
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<td>From 1 not important at all</td>
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<tr>
<td>To 7 very important</td>
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<td>365 To be repeated annually</td>
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**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 at 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**

1. 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 than health; avoiding tobacco; regular exercise or spending time outdoors.

2. 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.

3. 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 people’s list of priorities when refurbishing a home.

4. 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.

5. 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 (scores 7 out of 7), and as many as 95% attribute it above average importance (scores 5–7 out of 7).

6. 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.

7. Health disorders are the same in Europe
   - 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.

8. 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.

9. 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. 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.

10. People need fresh air and daylight to feel at home.
    - There is little coherence between concern and action.

11. 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.

12. Europeans are more concerned about health than avoiding tobacco.
    - 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.

13. Unhealthy indoor air quality is a concern for Europeans.
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14. It is not a priority for the moving.
    - 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.

15. Energy cost often go hand in hand
    - Increasing comfort and reducing energy costs 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 people’s list of priorities when refurbishing a home.

16. 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.

17. 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 winter time, 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.

18. 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.

19. 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.

20. 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.

21. 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 (scores 7 out of 7), and as many as 95% attribute it above average importance (scores 5–7 out of 7).

22. Europeans need fresh air and daylight to feel at home.
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24. People need fresh air and daylight to feel at home.
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THE IMPORTANCE OF WINDOWS

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
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 premise 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 resources1. 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 glazing 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 commercial2. 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 offices3. 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 students4; and sunnier hospital rooms have been linked to faster recovery rates and reduced levels of medication5.

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
Solar overheating in summer can be dra-
atically reduced by integrating con-
ventional, integral, or at the very least, interior shading devices and by natural venti-
lation. The design principles and techniques for capturing solar heat precisely during
daylight hours and seasons when heating is
no longer necessary. The importance of this is highlighted by the fact that 20°C (the typi-
cal degree day base) is only 5°C above 15°C,
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cal degree day base) is only 5°C above 15°C,
Balancing financial capital, natural capital and human capital is a shift in decision-making that is critically needed for the built environment.

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 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 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. The architectural masters of environmental surfing will respect, cascade, and regenerate nature’s abundant resources 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. The architectural masters of environmental surfing will preserve, cascade, and regenerate nature’s abundant resources 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.
1. Four terms have been introduced to add depth to the overall thrust on environmental surfacing. Preserve is used to summarise the benefits of conservation, using as few resources as needed. Surf’s up is used to summarise the benefits of passive conditioning with non-depletable natural resources such as light, wind, thermal swing. Cascade is used to summarise strategies to use depletable natural resources several times by reusing the waste stream (energy, water, materials) for secondary and then tertiary uses with a goal of zero waste; regenerate for secondary and then tertiary uses to summarise the potential of actually increasing a resource such as freshwater through innovative technologies and design solutions.

2. http://www.eia.gov/consumption/commer-
cial/data/archive/dcs/cci/bec/2003/deta-
ted_tables_2003/2003html/e01.html


8. K. Buxbaum, J. R. M. Papp. 1996 Sunny Hospital Rooms Expedite Recovery from Se-


10. J. Choi (2000). Study of the Relationship be-
tween Indoor Daylight Environments and Pa-

tient Average Length of Stay (ALOS) in Health-

care Facilities. Unpublished master’s thesis, Department of Architecture, Texas A&M University. College Station, TX.

11. Balance point temperature is the outdoor con-
dition at which heating will be needed given the quality of the construction. Typically set at 18°C, balance point temperature is the basis of heating degree days. Given internal heat gains from people and equipment, super insulated buildings can lower the balance point temperature by 5-15 °C, and the addition of passive solar can lower it even further, eliminating the need for mechanical heating for most of the winter. For a detailed explanation see: Michael Utzinger and James Wasley. Building Balance Point, published in The Vitral Signs Project 1996 Curriculum Materials. http://www.che.berkeley.edu/essays/briefs/"+mode.htm


14. A. Williams B. Atkinson, K. Garbiss & F. Robin-


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29. Terrapin Bright Green, The Economics of Bi-
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of-biophilia/

30. Terrapin Bright Green, The Economics of Bi-
terrapinbrightgreen.com/report/economics-
of-biophilia/
Daylight for the We-Feeling

The Brede Scholen (approximate English translation: broad-based schools) in the Netherlands not only comprise classrooms and specialist subject teaching rooms but also offer child-care services 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: from 2,000 square metres in基础知识 from the middle of the 1990s – it is to provide children from socially disadvantaged families with a home away from home.

But how can we ‘we-feeling’ that this type of school could be expressed in the buildings? For the new school in Steenbergen, in the southern part of the Netherlands, Elements 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 fortification 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 forest, compact in form and protected by multi-coloured brick masonry in red, black and white. In this way, the large classrooms and the sports hall encourage the children to engage play without becoming unnecessary hot in summer.

Good architecture goes beyond what we already know. It exposes us to our emotions and improve our health and well-being. This capability of architecture becomes visible in the images that German photographer Thelka 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 particular buildings and daylight interact with each other in our everyday lives.

Five Points Towards Better Living

In 1972, Le Corbusier and his cousin, Pierre Jean-Joer, called upon the architects of the world to revolt – against the traditional mode of construction of our houses and cities, which, since the 19th century, had become the broadening 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- enriched 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 theoretical thinking into practice with almost no curtailments. The pre-existing conditions on the campus of the ‘Cité Internationale Universitaire’ were ideal for this: a pre-existing Austria building, which was opened in 1933 and financed by the Swiss Confederation and private investors, the two architects were able to put their theoretical thinking into practice with almost no curtailments. The pre-existing conditions on the campus of the ‘Cité Internationale Universitaire’ were ideal for this: a pre-existing Austria building, which was opened in 1933 and financed by the Swiss Confederation and private investors, the two architects were able to put their theoretical thinking into practice with almost no curtailments.

weighted 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 remaining walls can grow pilotis-plants and suntans uninterested. In the beginning, the Le Corbusier had envisaged enclosing this area with high walls and only leaving it open to the sky. However, the main 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 roof. With the intention of allowing only the light in and not the heat, the architects integrated the daylight in 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 play without becoming unnecessarily hot in summer.
the primary school created. Altogether, the built- was to be extended, the library and the schoolyard complex. In addition, the existing school canteen signed was therefore to build four new group The task with which the architects were as- 

dark and had to be lit artificially at all times,” said also a paucity of daylight: “It was mainly the cor-
ures that were implemented. 

in three- to four-storey town houses. The latter also 

local architecture from becoming too great, the 
order to prevent the contrast with the traditional 
ance of the surrounding residential buildings. In

It was the era of large sanatoriums in which abun-
ture as between 1900 and the Second World War. 

the people from the neighbourhood are very proud 
of prosperity to this westerly and largest of the 

Heemskerckstraat 9, Oudeschild, The Netherlands 
Year of completion: 2014

Location: Avenue Général de Gaulle/Place du Phénix/rue Paul 
Gachery, Châtelaun, France
Architects: APBRAT – Almeht & Florence Gächery
Year of completion: 2013

La Défense, the banking district of 

the unemployment rate here is considerably higher 

in three- to four-storey townhouses. The latter also comprises public services, an employment office, and a health centre. The areas are partly accommodated in stepped extensions towards the rear that establish an almost seamless transition between the town houses and the smaller, terraced houses.

15,000 inhabitants 130 kilometres south-west of Paris, was made up of big residen-
tial blocks from the 1950s. They were strictly ali-
enced white, while the steel and glass display 
and enable modern forms of teaching. Insulat-

open-air schools in Amsterdam, Jan Duiker and his clients had something else in mind. Why should only ill children profit from the benefits 
– if any – protection against wind and weather. They were usually lo-
gardless of wind and weather. They were usually lo-

the island of Texel, Mecanoo created a ‘perception 
time and beachcombers museum in Oudeschild on 

The envelope of slats unfolds its unique effect 
from blocking the view. 

architecture are presented are only half-height and, 

in the Netherlands, 25% of the inhabitants live in multi-storey dwellings. In 1970, 30% of Dutch children lived nearby, vertical slats made of zink wood. These are related to the history of shipping, as the true port of Terneuzen was used as such piers. The holiday resort for the winter has been installed. The In-

ANDERSON'S HOUSE 

ON HERMAN RUIJSELT 

FOLLOWING THE SUN

aa and road links that more effectively connect the pre-

the Sanatorium ‘Zonnestraal’ in Heemstede was therefore specifically conceived for the preven-
tions of illness and the healthy teaching children and was built in the heart of the city. By 1940, the building was again used as a sanatorium for use as a modern health centre. On the 

the ground, as well as an additional classroom that 

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 corridor that Duiker con-

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 corridor that Duiker conceived as an ‘open-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 2005 by Wassel de Jonge Architects, who had previously modernised the Zonnestraal san-

OPEN-AIR SCHOOL IN AMSTERDAM


RÉNÉ GUEST SCHOOL CENTRE IN LA GARENNE-COLOMBES

Avenue du Japon/Yau-ye-Kin-Champs-Phillips, La Garenne- Colombes, France
Architects: Mecanoo, Cécile (refurbishment)
Year of completion: 2014

Location: Avenue Général de Gaulle/Place du Phénix/rue Paul Gachery, Châtelaun, France
Architects: APBRAT – Almeht & Florence Gächery
Year of completion: 2013

RENÉ GUEST SCHOOL CENTRE

La défense, a town with 15,000 inhabitants 130 kilometres 

the East India Company anchored here before set-

was known as La Défense, the banking district of 

the building was again as it was after the first refurbishment in 1955, the classrooms have been restored to their original condition.

the view into 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 indoor climate, especially in summer.

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 corridor that Duiker con-

The envelope of slats unfolds its unique effect 
from blocking the view.

In his design, Duiker fully exploited the advan-
tages of the skeleton mode of construction with re-

In the details, however, all has been done to make the interior comfortable according to today’s stand-

and exposed modern forms of teaching. Insulat-
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 In-

Before 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 small indoor courtyards. Com-
posed of solid brick masonry, they were built in the 1920s but eventually needed to be technically refurbished. Above all, the kindergarten had be-

the unemployment rate here is considerably higher 

the material of the walls and ceiling correspond to the changes to the light every quarter of an hour.

If necessary, the steel windows over a large area of 

the classrooms are completely composed of glass.

At virtually no other time in history have healing properties been so clearly associated with architecture as between 1900 and the Second World War. It was the era of large sanatoriums in which abun-
danced wind and water brought a certain amount of 

It was the era of large sanatoriums in which abun-

and the schoolyard remained a new, an urban site in the primary school created. Altogether, the built- 

The task with which the architects were as-

FOUR BETTERMENT OF HEALTH

Of course, the visual comparison of the classroom 

and enable modern forms of teaching. Insulat-


been restored to their original condition.

the view into 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 indoor climate, especially in summer.

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pp. 44–49

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### 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. 7ff.

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Building – construction cost</td>
<td>85%</td>
</tr>
<tr>
<td>Furnishings and furniture – capital cost</td>
<td>1%</td>
</tr>
<tr>
<td>M&amp;E services – running and maintenance</td>
<td>4%</td>
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<tr>
<td>M&amp;E services – depreciation</td>
<td>0.75%</td>
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<tr>
<td>Furnishings and furniture – maintenance and depreciation</td>
<td>0.9%</td>
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<tr>
<td>Building – maintenance</td>
<td>1%</td>
</tr>
<tr>
<td>Salaries of occupants</td>
<td>85%</td>
</tr>
<tr>
<td>Cleaning, security, etc.</td>
<td>1%</td>
</tr>
</tbody>
</table>
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.*


The homes of 80 million Europeans are damp and unhealthy*


Million homes
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.*
