

# The Buildings of Tomorrow. Today.



Results, learnings and  
outlook from the  
VELUX Model Home  
2020 programme



Having worked with roof windows for more than two decades, Michael K. Rasmussen knows more than most about the importance of daylight and fresh air in buildings. He came to the VELUX Group in 1992 and held several positions in marketing, communications and brand strategy functions before taking up his current position as Chief Marketing Officer in 2006.

As CMO, Michael K. Rasmussen is a strong proponent of innovative solutions for sustainable living in buildings. He is equally concerned with the health and well-being of people and planet, and eager to find solutions that bridge human comfort and sustainable development in forward thinking and affordable solutions.

## Can we fulfil the demands of both people and planet? Yes we can!

We started our journey with sustainable living in buildings in 1999, when we took part in the first experiments to find ways to reduce the energy consumption of buildings. Our ideas ripened and the growing concern for global warming and climate change encouraged further development. By 2008, the VELUX Group had built several full-scale demo-houses designed for northern and southern climates. And in 2009, we were ready to launch the Model Home 2020 programme, comprising six buildings in five European countries – an ambitious scheme to show that it is possible to build sustainably with products, processes and technologies already available.

Throughout the many experiments, we have had one important priority: concerns for the environment must never precede concerns for the health and well-being of human beings. Sustainable living in buildings is never a question of either comfort or energy efficiency; it must always be a quest to find solutions that benefit both people and planet.

**Six buildings constructed – immeasurable know-how gained**  
We are very happy that architects, contractors, politicians and manufacturers, as well as scientists and universities, were eager to join us in pioneering forward-thinking solutions based on the Active House principles. I would like to take this opportunity to thank all our partners for their support, hard work and dedication on this journey. It is my hope that we will continue moving forward together.

One by one, the model homes were completed and the subsequent interest in becoming test families and living in the homes for 1-2 years was overwhelming.

Each of the buildings was subjected to extensive data collection during the test period, and from all the collected findings, several important learnings have emerged. For example, the scientists found evidence that the homes increased the residents' health and well-being and that healthy homes even have potential to alleviate chronic diseases, typically related to allergies. Natural ventilation plays an important role in this, ensuring that air quality and temperature levels are good-day and night, summer and winter.

With their large window areas, equivalent to 30-50% of the living area, the elevated daylight levels of the model homes improved the mood and productivity of the residents. All families praised the daylight levels as one of the main bonuses of their new homes.

### Take action – now

The experiments that we conducted in the Model Home 2020 programme confirmed our belief in the Active House vision, which integrates comfort, energy and environment in the design and use of buildings. I am confident that this new holistic approach to building and renovation has the potential to provide maximum benefit to people and the environment.

And why wait to take action? 90% of the building stock that we will be using in 2050 has already been built, and much of it is in need of modernisation to improve comfort as well as energy efficiency.

Paving the way for sustainable renovation will be the next step for the VELUX Group. In 2015, we are starting a new building renovation project based on the Active House principles, this time in Belgium. The objective of this project is to prove that the vision of comfortable and nearly-zero-energy buildings can be achieved in a way that is cost effective, scalable and reproducible.

I sincerely hope that the Healthy Homes Barometer will spark a transition, not only in the way buildings are built, but also in the way we think and communicate about our homes and the role they play in modern lives, cities and society at large.

Michael K. Rasmussen  
CMO of the VELUX Group

Developing the buildings of tomorrow isn't something we dream about. It's what we do today.

**activehouse**.INFO  
NETWORK AND KNOWLEDGE SHARING

## Active House shows the way forward

The VELUX Group is one of the founding partners of the Active House Alliance, and the Model Home 2020 programme was carried out according to Active House principles.

The Active House Alliance comprises companies and organisations in the building sector. Interest in Active House principles is steadily growing across the world, and several countries have seen the establishment of national Active House Alliances, e.g. Canada, the Netherlands, Germany and Denmark.

### The Active House Vision

Active House is a vision of buildings that create healthier and more comfortable lives for their occupants without impacting negatively on the climate – moving society towards a cleaner, healthier and safer world. The Active House vision defines long-term goals for the future building stock. The purpose of the vision is to unite interested parties around a balanced and holistic approach to building design and performance, and to facilitate cooperation on building projects, product development, research initiatives and performance targets to achieve that vision.

An Active House is evaluated on the basis of the interaction between energy consumption, indoor climate conditions and impact on the environment.

### COMFORT

#### – creates a healthier and more comfortable life

An Active House creates healthier and more comfortable indoor conditions for the occupants, ensuring a generous supply of daylight and fresh air. Materials used have a neutral impact on comfort and indoor climate.

### ENERGY

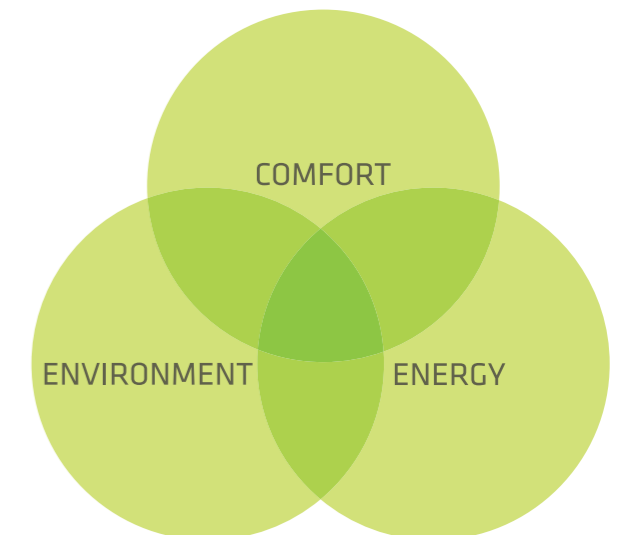
#### – contributes positively to the energy balance of the building

An Active House is energy efficient. All energy needed is supplied by renewable energy sources integrated in the building or from the nearby collective energy system and electricity grid.

### ENVIRONMENT

#### – has a positive impact on the environment

An Active House interacts positively with the environment through an optimised relationship with the local context, focused use of resources, and its overall environmental impact throughout its life cycle.







From 2009-2011, the VELUX Group built six full-scale experimental demo-houses across Europe as part of the Model Home 2020 project. The vision of the project was to showcase sustainable buildings made with know-how, technology and materials available today; and buildings that give top priority to people's health and well-being, at the same time as fulfilling EU requirements for nearly-zero-energy buildings.

A great deal of effort has been put into the design and construction of the model homes to make them as comfortable and sustainable as possible based on Active House principles.

Now, seven years later, the experiment is reaching its conclusion. We have learned a lot shown that we can move forward into tomorrow with what we know today. All we have to do is put it into practice. May this booklet serve as inspiration as we head into the next epoch of sustainable building and renovation.

The VELUX Group

## Planet

Sustainable living in buildings is our commitment to people and planet.

## Buildings

We engage with key stakeholders

## Products

...and deliver products and solutions

## People

...made to optimise human health and well-being and minimise environmental impact.

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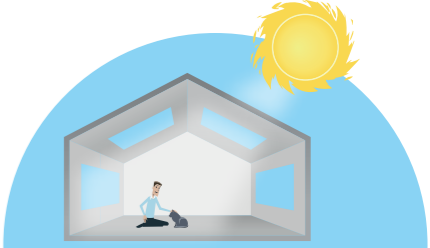
# Planet

## The future shines

Studies show that most people on an average spend up to 90% of their lives indoors. The immense amount of hours in which we confine ourselves inside our homes, offices and public buildings not only increases the need for proper daylight and ventilation, but also raises the question of energy consumption.


In Europe, buildings account for 40% of all energy consumption. Needless to say, this makes buildings a key component in terms of shaping a sustainable future with less CO<sub>2</sub> emissions and reduced global warming.

To help meet the challenges, the VELUX Group is focusing on the immense potential of solar energy. Our goal is to create buildings that can unite the modern demands for daylight and ventilation with much greater use of solar energy for free lighting and heating. The task is gigantic – but we are getting closer all the time.



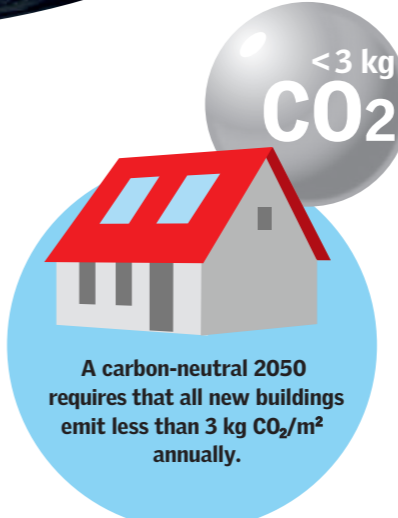
**Daylight could save 15,000,000 tons of CO<sub>2</sub> every year in Europe.**

Daylight cuts the energy used for lighting.



**The sun delivers 1,500 times the amount of energy used by the entire population today.**

Free of charge and with no detrimental side effects.



**< 3 kg CO<sub>2</sub>**

**A carbon-neutral 2050 requires that all new buildings emit less than 3 kg CO<sub>2</sub>/m<sup>2</sup> annually.**



## Getting real

There is a famous saying that sums up the true spirit of a VELUX solution. "One experiment is better than a thousand expert views." These are the words of our founder, Villum Kann Rasmussen, who made it a company virtue to examine every new product by submitting it to full-scale experiments.

The dedication to revealing the exact truth about our creations has been inspirational to the enormous task of developing 21 demo-houses in various settings and different climatic areas. During a 10-year period, these houses has helped us collect a vast amount of valuable knowledge about how our products work in in

full-scale, real-life situations. From Moscow in the East to St. Louis in the West, each project continues to reveal detailed information about vital issues such as health, liveability, energy and convenience; key areas that are pivotal to the realisation of sustainable living.



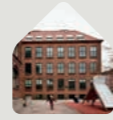
**1** Torzhkovskaya Street, St. Petersburg



**12** Osram Culture Centre, Copenhagen



**2** Soltag, Copenhagen



**13** Guldberg School, Copenhagen



**3** Átika, Bilbao



**14** Solar Prism, Albertslund



**4** VELUXlab, Milan



**15** Russian Active House, Moscow



**5** VELUX House, COP15, Copenhagen and La Rochelle



**16** Solhuset Kindergarten, Hørsholm



**6** Home for Life, Århus



**17** ISOBO aktiv, Stavanger



**7** Green Lighthouse, Copenhagen



**18** Future Active House, Trondheim



**8** Sunlighthouse, Vienna



**19** Smith Residence, St. Louis



**9** LichtAktiv Haus, Hamburg



**20** De Poorters, Montfoort



**10** Maison Air et Lumière, Paris



**21** Great Gulf Active House, Toronto



**11** CarbonLight Homes, Kettering



**22** RenovActive Brussels





# What we have learned so far

Based on hard data from built-in information systems and interviews with the volunteer residents, a valuable corpus of insight into the mechanisms and capabilities of the 21 demo houses' has been gathered, generating common denominators to be examined and utilised in future projects. Most significantly, this is what we've learned so far:



Residential buildings can **meet the energy targets of 2020** with the knowledge, technology and building components of today.



There is **no conflict** between 2020 energy targets and high daylight levels in low-energy buildings.



Low energy buildings with high daylight levels can achieve good thermal performance, using window openings and solar shading to **avoid excessive summer heating**.



Natural ventilation and shading can **increase summer comfort**.



Building automation is becoming increasingly important in future homes as energy-efficient buildings react faster to solar gains. The systems must provide **feedback to residents**.



Sunscreening in combination with **ventilative cooling** and particularly night ventilation is an effective double-strategy to achieve increased summer comfort.



Residents will grow accustomed to automation and learn to **appreciate its benefits**.



Hybrid ventilation performs well, combining automated window operation and mechanical ventilation systems with manual window operation.

Rather than being active at the same time, the two modes of operation should **depend on outdoor temperature**.



It is possible to achieve great daylight conditions **without summer over-heating** in low-energy buildings.



It is possible to have sufficient illumination with daylight (**daylight autonomy**) between sunrise and sunset, regardless of season.




Daylight conditions are a **top-level asset**. Feedback from residents shows an appreciative attitude to good daylight conditions – a positive benefit that came as a surprise to many.

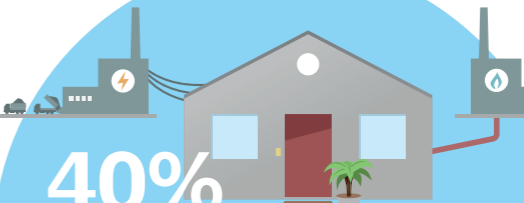


The design principles used in the Active Houses may provide more benefits than those that can be easily quantified, as the residents reported **better sleep, improved well-being and reduced asthmatic symptoms**.



**In 2050**  
9 out of 10 of the existing buildings in Europe will still be in use.



**40%**  
Energy used in buildings accounts for 40% of the total energy consumption in society.



**80,000,000**  
Europeans live in damp and unhealthy buildings.



**10%** **90%**  
We spend up to 90% of our time inside buildings – living, working, learning and playing.



**10 LITER**  
is the amount of moisture generated by the daily activity of a family of four in their home.

# Buildings

## A model for the future

To help us analyse the building stock and how we use it, we employ numbers. How long, how much and how many, we ask, and the numbers keep piling up. Model Home 2020 consists of six buildings that were designed to put all this data into practice. They were intended to translate science into a realistic model for the future.



# Facts about Model Home 2020

- **Six buildings**, five residential, one university, new builds and renovations
- **Five countries:** Austria, Denmark, France, Germany, UK
- **Sponsored** by the VELUX Group, carried out in cooperation with local partners
- **Designed** according to Active House principles
- **Lived in** by test families for 12 months to test and monitor the buildings' functionality
- **Monitoring and evaluation** performed by recognised scientists from European universities



**CarbonLight Homes, United Kingdom 2011**  
Setting the standard for affordable, zero-carbon family housing for the future.

- Creating comfortable, sustainable living environments that improve the quality of life for the people within.

Read more on page 44



**Maison Air et Lumière, France 2011**  
Daylight and natural ventilation create energy efficiency and great indoor comfort – particularly during hot summer months.

- The pitched roof as active 5<sup>th</sup> facade

Read more on page 50

## Home for Life, Denmark 2009

Sustainable parameters maximise quality of life in the Home for Life.

- Very good thermal indoor climate, particularly good summer comfort

Read more on page 20



**Green Lighthouse, Denmark 2009**  
The first CO<sub>2</sub>-neutral public building in Denmark.

- A beacon for sustainable construction, for public-private collaboration and for Denmark

Read more on page 26



## LichtAktiv Haus, Germany 2010

Transforms a classic 1950s semi-detached house into a carbon-neutral, energy-efficient home.

- Innovative modernisations to suit every budget

Read more on page 38



**Sunlighthouse, Austria 2010**  
The first carbon-neutral single-family house in Austria.

- It meets target for daylight, indoor climate, energy efficiency and ecology in an outstanding way.

Read more on page 32



## The Model Home buildings

### The comeback of nature

In historical terms, the current concept of dwelling is extremely novel. During our lifespan we will spend close to 90% of our time indoors – sleeping, cooking, working and playing. We will be sheltered from the elements, safely moored in a controlled environment for our comfort and welfare. Yet our bodies haven't altered one bit since we went shopping with a spear and dozed under the open sky. In essence, we're still adapted to life outside rather than inside.

Not surprisingly studies show a significant increase in performance and health as soon as our houses start to simulate an outdoor environment. As a species, we need daylight and clean air to function optimally.

#### Bringing the outside inside

Model Home 2020 is based on the assumption that sustainable living can be achieved in a home environment that prioritises natural ventilation and large fenestration. Thus one essential target is to recreate the nurturing properties of an outdoor experience without compromising the need for heat and shelter. Discoveries from the six different model homes confirm that access to more daylight and fresh air has a positive impact on the inhabitants' wellbeing and even a direct beneficial effect on people diagnosed with asthma and allergies. One social scientist evaluating the project states directly, "there is evidence that the houses have significantly increased the residents' health and wellbeing and that they even have the potential to alleviate chronic diseases."<sup>1</sup>

All houses achieved a notable daylight factor of at least 5%, exceeding most national standards by a factor of 3-5. Furthermore, residents registered one more hour of daylight between sunrise and sunset, and even led to some family members accepting natural lighting levels as low as 50 lux without turning on artificial illumination. In one instance, the power consumption for lighting was halved to a mere 1.7 kWh/m<sup>2</sup>.<sup>2</sup>

Of course, the relatively large window area, which comprises 30-50% of the living area, is key to achieving these levels of natural daylight. However, it also raises the concern of excessive heating due to solar influx in the warmer seasons. This challenge was successfully addressed by applying natural ventilation and protective sunscreening to each model home. Measurements showed that automated night-time ventilation alone was capable of cooling down the indoor temperatures from 26°C in the evening to around 20°C the next morning.<sup>2</sup>

All in all, the results support the notion that beneficial outdoor properties can be put into effect inside a modern home without compromising the principles on which the future of sustainable building relies. They even describe a home concept that, for the first time in centuries, happens to be supportive of our very own nature.

While we've been here, we haven't had the colds and coughs we usually had before. I think it has to do with the air quality and the daylight.

Glazebrook Family, UK



We turned on the light 1 hour later than our neighbours.

Pastour Family, France



Oldendorf Family, Germany

On really hot days, we have at least two or three sliding doors open so it is very airy in here. You feel as if the room merges with the garden to a certain extent, so that it is more like a veranda. A really nice effect actually.

<sup>1</sup> Quote by M.A. Moritz Fedkenheuer in "Model Home 2020 experiment fosters ground-breaking research into housing well-being" by Jakob Schoof, 2014.

<sup>2</sup> Data from "Evaluation of the Model Home 2020 experiment completed" by Jakob Schoof, 2014.



## The researcher process

We have had **6** design teams of architects and engineers, and **6** research teams of engineers and architects

- 2010 Brussels
- 2011 Hamburg
- 2012 Vienna
- 2013 Hamburg
- 2014 Brussels – final reporting



## Reach

More than **700 m** people read more than **3,200** articles in European newspapers and magazines. More than **26,000** people visited the 6 buildings. Which received **25** awards and recognitions.



## 24 peer-reviewed papers\*

### CISBAT 2011

Indoor environmental quality of the first European Model Home 2020, Home for Life

### INDOOR AIR 2011

Measurements of indoor environmental quality and energy performance of 6 European zero-carbon houses – a case study from the first house

### PLEA 2011

Holistic evaluation of sustainable buildings through a symbiosis of quantitative and qualitative assessment methods

Hybrid ventilation as an energy-efficient solution for low-energy residential buildings

### AIVC 2012

Strategies for controlling thermal comfort in a Danish low-energy building: system configuration and results from 2 years of measurements

### CIBSE 2012

Building Management Systems – Improving building performance without limiting the occupants

### CLIMA 2013

Thermal comfort in two European Active Houses: analysis of the effects of solar shading and ventilative cooling

### PLEA 2013

The psychophysics of housing well-being; methodological approach of the socio-psychological monitoring of the VELUX LichtAktiv Haus

Carbon-neutral living in a modernised settlement house  
Liveability across Europe in 5 Active Houses

### AIVC 2013

Ventilative cooling of residential buildings; three active houses in Austria, Germany and Denmark

### PASSIVE HOUSE NORDIC 2013

LichtAktiv Haus – a model for climate renovation

### AIVC WORKSHOP 2014

Experience with measurements, ventilation and infiltration in the Active House concept. Quality issues and implications for compliance

### AIVC CONFERENCE 2014

Self-evaluated Thermal Comfort Compared To Measured Temperatures During Summer In Three Active Houses Where Ventilative Cooling Is Applied

### INTERNATIONAL JOURNAL OF VENTILATION.

Ventilative Cooling of residential Buildings – Strategies, Results and Lessons learned from three Active Houses in Austria, Germany and Denmark.

### WORLD SUSTAINABLE BUILDING 2014

Climate renovation can pay off – a life cycle cost analysis conducted as part of the LichtAktiv Haus experiment confirms the economic viability of modernising a 1950s settler house

Social performance criteria for buildings according to the CEN TC 350 – case study of the assessment of the VELUX Sunlight-House, Austria

Evaluation of ventilative cooling in a single-family house characterisation and modelling of natural ventilation

Post-Occupancy Evaluation by the test families in five Model Home 2020 across Europe

Control of indoor climate systems in Active Houses – recommendations and experiences from six demonstration houses occupied by families

The Road to Zero Carbon – is it really as long as it is wide?

Subjective and objective measurements of thermal comfort in an Austrian Active House – occupant-reported thermal sensation and measured temperatures during a one-year period

Carbon-neutral living in a modernised settler's house

The psychophysics of well-being – socio-psychological monitoring and benchmark measurement in energy-efficient housing

Tomorrow's buildings today – results, conclusions and learnings from a cross-European demonstration programme

\* For authors and papers please check respective conference proceedings.







Århus, Denmark  
**Home for Life**



Photo by Adam Mork



Photo by Adam Mork

**Design team:** aart  
 Esbensen Rådgivende Ingeniører

**Client:** VELFAC and the VELUX Group

**Monitoring:** Esbensen Engineers,  
 WindowMaster,  
 Engineering College Aarhus,  
 Alexandra Institute

[velux.com/sustainable\\_living](http://velux.com/sustainable_living)

## Design and energy concept focused on the residents' wellbeing

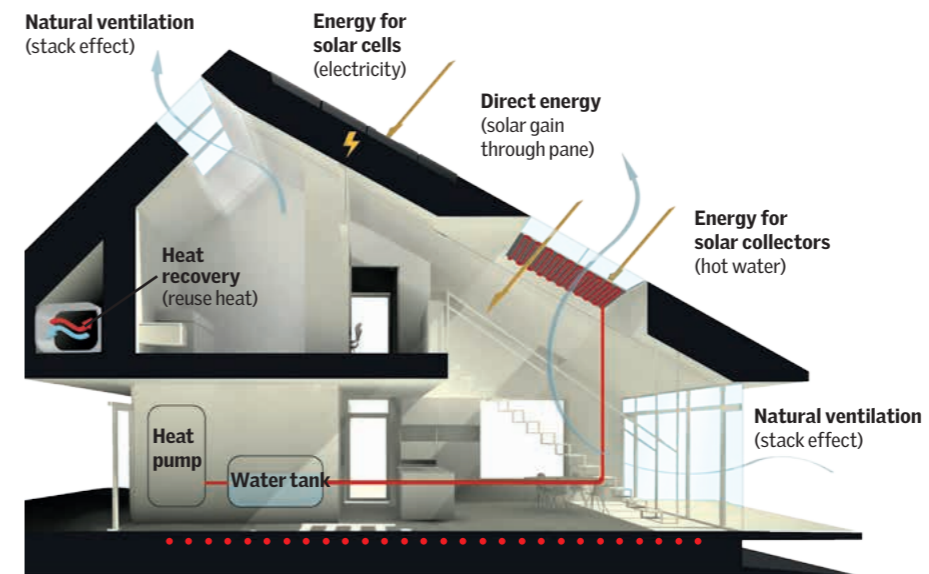
### Indoor climate

Ample daylight, from all facades and roof, and fresh air are great assets. Good indoor climate requires optimised suncreening and natural ventilation.

The qualitative interviews showed that, in many cases, the occupants deactivated the solar shading in favour of daylight, views and contact to the surroundings.

The house meets 2020 requirements and is classified by building regulations as a positive-energy house.

The overall operation of the house is expected to produce a surplus of energy of 1,700 kWh/year. Total energy consumption, including domestic electricity, is expected to be 2,000 kWh/year.







## Key findings of the one-year living experience



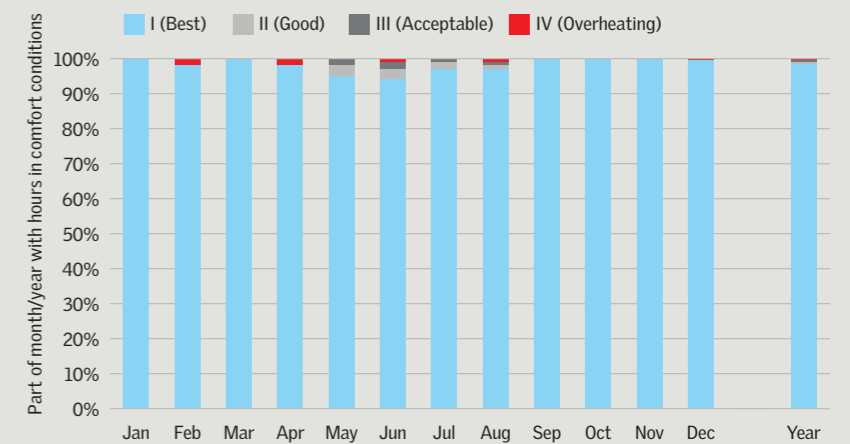
[velux.com/sustainable\\_living](https://velux.com/sustainable_living)

It's been interesting to see that, in some cases, the house's reaction seem to be a direct function of human requirements. For example, the sun shading goes down when you start squinting, and just before the sun breaks through, the skylight blinds come down. If you didn't know better, you might think the house was wired up to your nervous system.



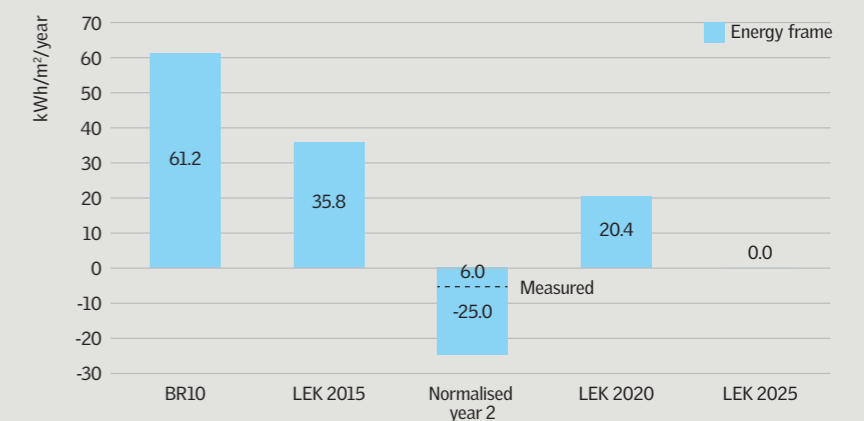
Measured thermal indoor climate, kitchen and multi-purpose area, year 1. The indoor temperature is evaluated according to the European standard EN 15251, which defines four comfort categories from I (best) to IV (unacceptable). The figure shows the distribution of categories for each month and for the entire year. More than 95% of the hours of the year are in category I, which means that the family room is categorised as I as far as indoor temperature according to EN 15251 is concerned.

### Hours overheating



Home for Life's performance in relation to the Danish Building Code's energy requirements. Home for Life achieves an energy performance better than both LEK 2020 (NZEB - Nearly Zero Energy Buildings) and the anticipated LEK 2025 (ZEB - Zero Energy Buildings).

### Home for Life - Energy consumption calculated according to Danish Building Code recommendations







Prof. Dr. Dr. h.c. Bernd Wegener is emeritus professor of social sciences at the Humboldt University of Berlin and Research Professor at the German Institute for Economic Research (DIW). He serves as Senior Advisor to Berlin's Humboldt University and acts as Managing Director of Empirical Social Research and Communication (GeSK) in Berlin. Dr. Wegener and his team have been responsible for the sociological monitoring of the German test family and the cross-project evaluation for all Model Home 2020 test families on that specific topic.



## The psychophysics of living and well-being

Interview with Bernd Wegener

If we want to measure wellbeing (instead of isolated comfort dimensions) we must break away from classical psychophysics

### From your perspective:

#### What are the main results of the Model Home 2020 project?

Architecture determines our wellbeing. But this is also true vice-versa; the wellbeing of users determines how we behave in our houses and how we perceive our living environment. One of the most impressive results of the project was indeed that the test families learned to appreciate the different features of sustainable housing – in particular the excess of daylight and the comfort of good indoor climate – as they continued living there. Also, it seems that experiencing sustainability in one's own immediate surrounding educates people to be more energy preserving and raises their environmental awareness in general. Clearly there is an interaction process going on between the house and its users.

There is an interaction process between the house and its users

#### What impact do these results have on your research discipline?

As a general research field, the study of wellbeing is well established in psychology and the social sciences. The study of housing wellbeing however is still in its infancy. When life satisfaction is being addressed, the wellbeing that individuals experience in their housing environment rarely gets mentioned, and even in post-occupancy studies, which focuses on energy

efficiency and productivity enhancement, the wellbeing of users is usually not one of the surveyed variables. This is about to change now that we are introducing the study of housing wellbeing as a discipline of its own.

#### What about the future effects on the building and living?

Building constructors usually see themselves on the supply side of the housing industry. However, if the idea of sustainable buildings is to spread, the demands put forth by users need to be given acute attention. Switching from the supply side (of house builders) to the demand side (of users), we ask – what is it that people actually want in housing? In view of marketing green housing, there is a need for change, because if sustainable housing is to proliferate, we must take the wellbeing of users into account. They will not buy and move into houses that they don't find worth living in.

#### What in your mind characterises a comfortable home?

To me, this is the heart of the matter; house builders think in terms of comfort and not of wellbeing. Comfort is always tied to particular physical modalities that elicit comfort. We speak of comfort with regard to shade and brightness, for example, temperature, humidity, indoor climate and noise level. Thus there are many different comfort domains based on particular aspects of our living environment. In classical psychophysics, these domains are studied in their relation to felt comfort. Wellbeing in contrast, is a state of mind, a compound measure and overall evaluation of a person's entire housing situation. So if we want to measure wellbeing (instead of isolated comfort dimensions), we must break away from classical psychophysics and turn to a more elaborated version that explains wellbeing by the complete vector of relevant housing parameters.



Prof. Dipl.-Ing. M. Sc. Econ Architekt BDA Manfred Hegger is professor of Energy-Efficient Building Design at the Faculty of Architecture of the TU Darmstadt, Germany. He advises the World Economic Forum, the International Union of Architects and the International Building Exhibition Hamburg 2013, among others. With Doris Hegger-Luhnen and Günther Schleiff, he founded HHS Planer + Architekten AG in Kassel, Germany, in 1980.

Mr. Hegger supervised the design of the German project LichtAktiv Haus.



## Remodelling can lead to sustainable living

Interview with Manfred Hegger

### From your perspective:

#### What are the main results of the Model Home 2020 project?

The LichtAktiv Haus in Hamburg, Germany, encourages owners to upgrade their existing home in terms of energy efficiency and comfort. It shows how to make best use of sunlight: for better daylight conditions, to harvest thermal and electrical energy and for a much friendlier atmosphere.

#### What impact do these results have on your research discipline?

This Model Home proves that also a house of the 1950s can be transformed into a plus-energy, active house with excellent living conditions. A remodelling process of an existing home has the potential to save and to revive existing neighborhoods. This new lease of life also saves the high CO<sub>2</sub>-emissions of new construction by making intelligent use of the existing structure, with its embedded energy.

There is a need for good pilot projects of remodeling homes

Thermal, acoustic and visual comfort associated with beauty make a comfortable home

#### What about the future effects on the building and living?

There is a need for good pilot projects of remodelling homes. They reassure homeowners as well as housing associations that there are viable ways to transform even "ugly ducklings" into attractive living environments. The LichtAktiv Haus also proves that ambitious energy standards can be applied to the existing building stock.

#### From your perspective: What characteristics make for a comfortable home?

Thermal, acoustic and visual comfort associated with beauty make a comfortable home. You can evaluate the physical conditions associated with these comfort conditions, but you cannot measure beauty. Only a good interrelationship between all these features makes a wonderful home fit for the future.





Copenhagen, Denmark  
**Green Lighthouse**



Photo by Adam Mark



Photo by Adam Mark

<b>Design team:</b>	Christensen & Co.	Engineers COWI
<b>Strategic:</b>	Danish Properties Agency Ministry of Climate Energy and Building	University of Copenhagen Municipality of Copenhagen VELUX Group and VELFAC
<b>Monitoring:</b>	Danish Properties Agency, University of Copenhagen, COWI, VELUX Group	

[greenlighthouse.ku.dk](http://greenlighthouse.ku.dk)

## Denmarks first carbon-neutral public building

### COP15 – as a showcase during the Climate Conference in December 2009

Public-private collaboration in which the university, the business community, the ministry and municipality worked to transform a shared vision into concrete reality.

A green campus building fired by the ambition to demonstrate that green building concepts need not conflict with architectural and functional values, nor jeopardise a good indoor climate.

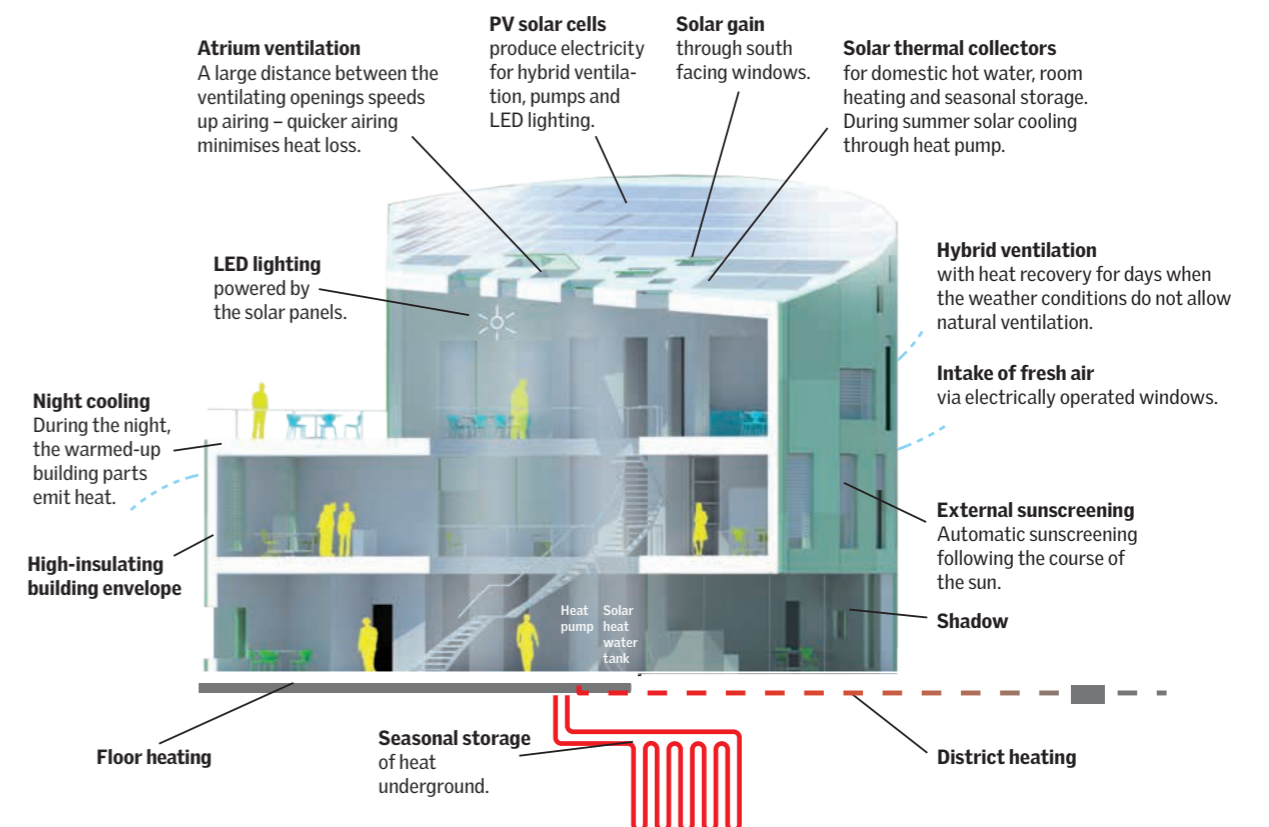




Photo by Adam Mark

## Key findings of the one-year living experience

greenlighthouse.ku.dk



Photo by Adam Mark

Analysis of the responses found that most employees expressed an interest in working in a sustainable building and enjoyed the results. In general, the building is perceived as beautiful and full of daylight.



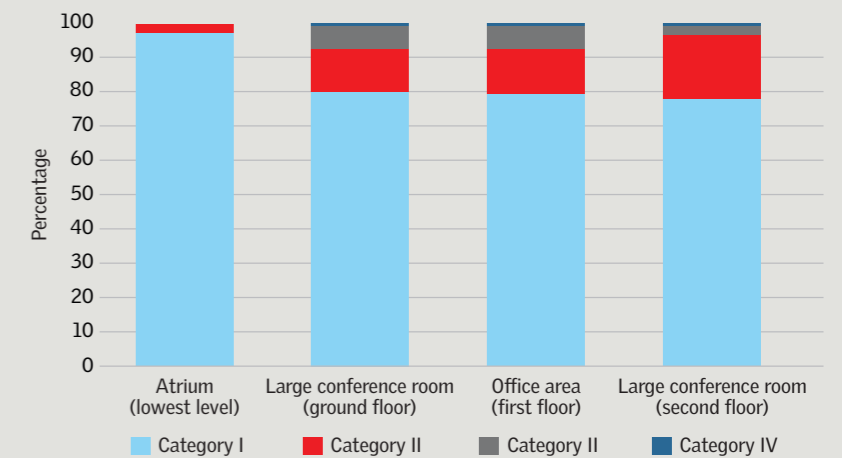
The Active House Radar shows the performance of the building based on calculated and measured data.

■ Calculation performance  
■ Measured performance

Energy calculations based on national building codes.

It is evident that the base of the atrium is Class I, the large conference room on the second floor is Class II, and the large meeting room on the ground floor and the office space on the first floor are Class III. The two following graphs also show that there are significantly lower CO<sub>2</sub> levels in summer than in winter, as that is when natural ventilation system is used most.

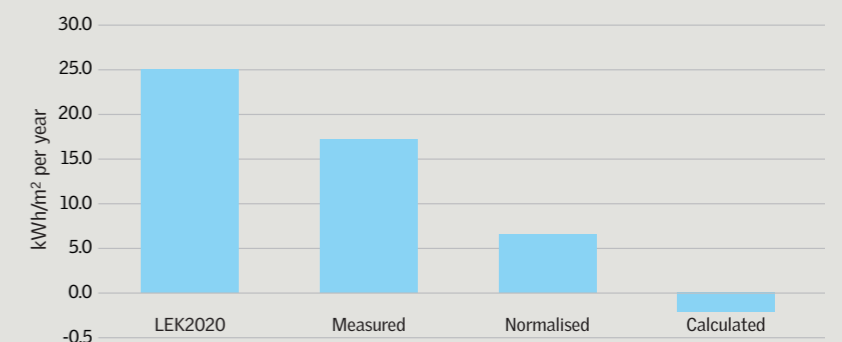
Indoor climate categories, atmospheric indoor climate – year round



When the building was constructed, one of the demands was to respect future demands for buildings in 2020. At that time, these demands were not known and guesswork was required. Since then, Building Category 2020 has arrived, defining the requirements that will apply to buildings in 2020. Among other things, there are new primary energy factors that change the results slightly.

Building Category 2020 requires buildings to meet a maximum consumption of 25 kWh/m<sup>2</sup> per year. The measured values correspond to about 17.2 kWh/m<sup>2</sup> per year, which, when normalised as described above, means an energy demand of about 6.4 kWh/m<sup>2</sup> per year. The calculated energy consumption is roughly -2.2 kWh/m<sup>2</sup> per year, which would make it a plus energy building.

Primary energy consumption including RE, BR2020 energy factors







Bruno Peupartier, PhD, is senior scientist and teacher at MINES ParisTech, and responsible for the Chair "Ecodesign of buildings and infrastructure". He is involved in research on the environmental performance of buildings, particularly the application of life cycle assessment, the study of renewable energies and new technologies.

Dr. Peupartier and his team carried out a research project on the evaluation of ventilative cooling in summer, based on the French Model Home 2020 experiment, Maison Air et Lumière.



## Summer comfort is obtainable the sustainable way

Interview with Bruno Peupartier

### From your perspective: What are the main results of the Model Home 2020 project?

The Maison Air et Lumière research project allowed us to evaluate – on a full-scale single-family house with high fenestration ratio (33% vs. floor area) – the benefits of ventilative cooling by opening windows at night in the summertime. Based on simulations and on-site measurement performed during the summer of 2012, the efficiency of ventilative cooling was evaluated to an average 5°C reduction of the indoor temperature.

Environmental performance is not reached at the expense of good indoor conditions

### What impact do these results have on your research discipline?

These findings will contribute to improving calculation tools for evaluating the efficiency of natural ventilation. Our aim is to implement them into building design software such as the dynamic simulation tool "Pléiades+Comfie", which we have been developing since the 1980s. This will improve the building designer's ability to comprehend the impact of natural ventilation systems in terms of energy savings and thermal comfort.

Project findings will contribute to improving calculation tools for evaluating the efficiency of natural ventilation

### What about the future effects on the building and living?

This demonstrates that it is possible to combine building performances in terms of energy and environment with good indoor conditions such as visual, thermal and olfactory comfort. To illustrate this, we noticed, during the measured period, that the indoor air volume could be renewed within 5 minutes; a strong performance for summer cooling, but also for fast air exchange in winter.

The environmental performance is not reached at the expense of good indoor conditions and that is really reassuring.



### Peter Holzer Bio:

DI Dr. Peter Holzer is an engineer, technician, dedicated researcher, teacher and consultant for sustainable building design. For many years, he actively developed the Department of Building and Environment at Danube University Krems, Austria. He received his PhD at the Faculty of Architecture at the Technical University of Vienna. Today he directs both an engineering office for building physics and engineering, the IPJ GmbH, and a research entity, the Institute of Building Research & Innovation, both situated in Vienna, Austria.

Dr. Holzer was very involved with the energy design, commissioning, and energy and comfort monitoring of the Austrian Model Home "Sunlighthouse".



## Buildings in thermal balance. More than comfort

Interview with Peter Holzer

### From your perspective: What are the main results of the Model Home 2020 project? What is the key finding for you?

Basically I have three key findings.

First: the model home project impressively verified that it's possible achieving and maintaining equally high levels in buildings' comfort, energy efficiency and environmental responsibility; offering a comprehensive comfort much broader than pure thermal comfort, but including visual comfort, health related aspects of thermal and daylight environment, indoor/outdoor connection and others.

Second: the generous daylight supply in the model homes overwhelmed lots of visitors and inhabitants. Even the test families were convinced by experience. Before moving to the model homes they didn't feel having a lack of daylight. After moving out they didn't want to miss this new quality any more.

Third: the model homes raised the discussion on the desirable level of home automation. On the one hand, they all connect to the outdoor environment and invite the user to interact personally. On the other hand they are climatically reactive and need automatic control. We learned a lot about good balance between personal and automatic control.

We require a balance of resource conservation, cost-effectiveness and health

Thermal comfort is widely addressed as steady state thermal environment. I challenge that. Our evolutionary thermoregulatory system has been trained through millions of years within the periodic swing of day and night and of seasons. It is more than just a guess that periodic change in thermal environment is the setting we are trained to.

### What do these results mean for your research discipline? Or your daily work?

Many of the model home 2020 research topics stayed key issues of our Institute's research activities:

- Daylight Architecture
- Design tools for combined thermal and daylight design
- Ventilative Cooling
- Health aspects of both indoor daylight supply and in indoor thermal comfort

### What roles does a healthy indoor climate have in future buildings?

It has to have an essential one. More than 90% of our lifetimes we spend in built environments. Thus, they have to be health supportive and not only bright and warm. A healthy indoor environment has to be secured with the same ambition as resource conservation and cost-effectivity. It was a great achievement of the Model Home 2020 project that the users' needs have been focused, beside physical and technical goals.

### How would you define the next steps regarding ventilation?

Mechanical ventilation systems are reshaped towards simplicity and cost effectivity. Natural and hybrid ventilation are experiencing a renaissance, not at least in the field of night ventilation and ventilative cooling. The Model Home 2020 buildings pushed and strengthened this development.



Pressbaum, Austria  
**Sunlighthouse**



Photo by Adam Mark



Photo by Adam Mark

**Design team:** HEIN-TROY Architekten

**Partners:** drexel und weiss, VELFAC, WindowMaster, Admonter, AEG Electrolux, RHEINZINK, BAUDER, EGGER, RIGIPS Saint-Bobian, ROCKWOOL, ertex solar, FIANDRE, SIGA, SLAGSTAR Ökobeton, GIRA, PICHLER CHEMIE, somfy, Waldviertler Flachshaus

**Academic partners:** Danube University, Dept. for Building and Environment, IBO – Austrian institute of Building Health and Ecology

sunlighthouse.at

## The first carbon-neutral single-family house in Austria

### Comfort:

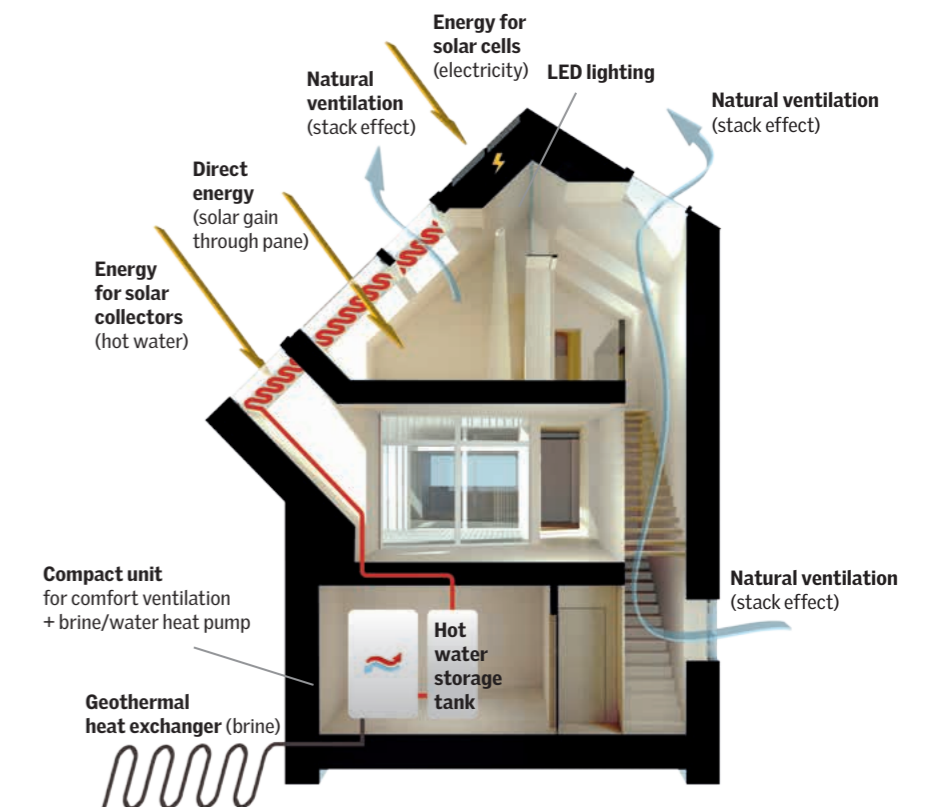
- Well daylight (very balanced) daylight factor average ground floor 3.3% and 7.4% on the first floor
- High amount of direct sunlight in winter (more than 6 hrs. on 21 December)
- High indoor air quality (CO<sub>2</sub>-concentration of 437 ppm and 797 ppm)
- Perfect link between indoor and outdoor
- No overheating in summer (shading devices and Natural Ventilative Cooling)

### Energy

- Well insulated and tight building envelope
- Plus-energy standard
- Use of renewable energy exclusively
- Strategic use of passive solar gains – but no overheating in summer
- No use of energy for cooling
- Hybrid ventilation: mechanical ventilation with heat recovery in winter; sensor-controlled window ventilation in summer and transition time
- Thermal solar collectors to produce domestic hot water (coverage some 70%)
- Highly efficient appliances

### Environment

- Perfectly designed for the challenging plot (sloped, shaded by neighbouring buildings and forest)
- Use of local building materials (timber from Austria; flax for insulation)
- Use of recycling material (cellulose for insulation)
- Construction and material able to be recycled
- Natural material – untreated – also to ensure good indoor air quality
- No use of PVC and HFKW







## Key findings of the one-year living experience

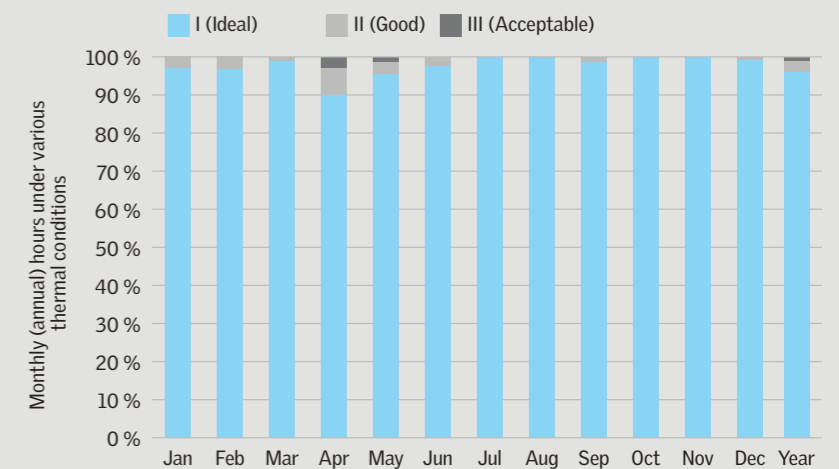


sunlighthouse.at

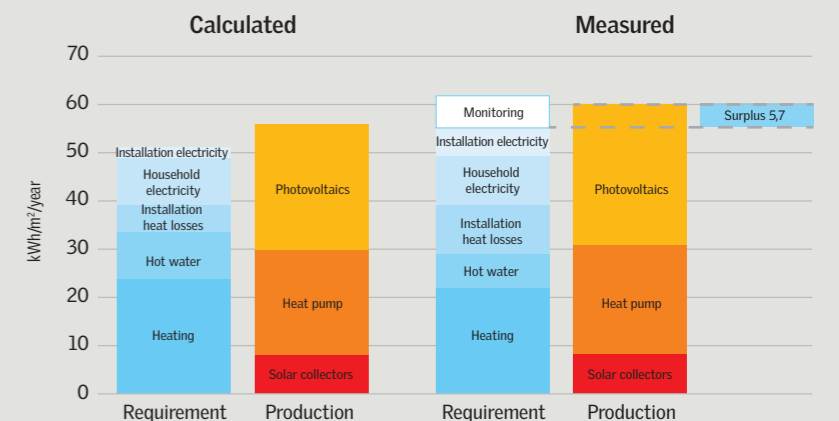
Temperature in the house was well balanced. The house stays cool even in midsummer's heat and very comfortable in winter. Family was concerned about overheating – but positively surprised.



The feeling of the residents in respect of room temperature was regarded as "neutral" during 88% of the time. Calculations according to EN 15251 confirm that. Most of the time, the values are rated in the best category I.



Sunlighthouse is an on-site plus energy house And an on-site zero-carbon-emission house (calculate and evaluated).





Christian Cardonnel is CEO of CARDONNEL Ingénierie (design office, heating and fluids, environment, projects monitoring), specialised in sustainable, comfortable and energy-efficient residential buildings. Since June 2014, he has been President of the Renewable Energies and Construction Committee of the SER (a French renewable energies professional body).

Christian Cardonnel and his team supported the Maison Air et Lumière project in its entirety, from design to construction, as well as the scientific monitoring and analysis of energy performance and thermal comfort measurements.

**CARDONNEL**  
**Ingénierie**  
le confort durable du bâtiment

## Natural lighting has many virtues

Interview with Christian Cardonnel

### From your perspective:

#### What are the main results of the Model Home 2020 project?

The Model Home 2020 experiment has shown that a well-insulated house with large windows can achieve a very good energy performance and provide a comfortable living environment throughout the year, both in winter and summer. With these experiments, we reintroduced natural light into housing as a way of seeing performance in a wider sense, not just in terms of energy. The other essential point to make is the quality of air we managed to achieve in the housing with the installation of a hybrid ventilation system combining mechanical ventilation in winter and natural ventilation by window opening in summer.

The experiment is an invitation to consider natural light as a renewable energy in its own right

#### What was the impact of natural light on the energy performance of Model Home 2020 buildings?

Generous access to natural light reduced lighting-related energy consumption to a bare minimum, even at the level of a detached house.

Proof of this can be seen in very low electricity consumption for lighting in Maison Air et Lumière of 1.7 kWh/m<sup>2</sup>.year, in other words, less than half the usual consumption of a house compliant with French building regulations. This performance is linked to Maison Air et Lumière fenestration area of 33% (percentage of floor area).

With these experiments, we reintroduced natural light into housing as a way of seeing performance in a wider sense, not just in terms of energy

#### What do these results mean for your research discipline?

The Model Home 2020 experiment is an invitation to consider natural light as a renewable energy in its own right. Maison Air et Lumière allowed us to experiment with the principle of natural light as a source of self-sufficiency in a real-life situation, and its benefits in terms of improved visual comfort directly perceived by its inhabitants.

The calculations showed us that the house design generated between 50 to 70 minutes of additional natural light in winter compared to a conventional house.

And the family spontaneously pointed this out, telling us how nice it was to switch the lights on an hour later than their neighbours. The other major learning is the very good level of comfort in summer and mid-seasons, thanks to automated control of shading systems and natural ventilation of the house.

#### What about the effect on the building and living of the future?

We can already meet the requirements of 2020 with today's techniques and products. For the future, we need to make further progress by developing the responsible dimension of sustainable buildings. We need to combine energy sobriety with optimum exploitation of the free energy available from nature such as sun, light and air which, besides their environmental virtues, directly contribute to the inhabitants' needs, i.e. their health and quality of life. Good bioclimatic design using dedicated products such as roof windows and appropriate control systems will be the future of buildings with sustainable comfort.



Dipl.-Ing. Thomas Wilken has been a research associate at the Institute for Building and Solar Technology at TU Braunschweig, Germany, since 2001. In 2003 he took over the leadership group for teaching architectural education in the field of building physics, building technology, renewable energies and energy concepts. Since 2010 he is deputy institute and laboratory manager.

Mr. Wilken has been responsible for the technical monitoring of the German project, LichtAktiv Haus, as well as the cross-project evaluation of that topic for all Model Home 2020 buildings.



## Solutions need to be viable on a grand scale

Interview with Thomas Wilken

### From your perspective:

#### What are the main results of the Model Home 2020 project?

We've managed to go from merely considering energy issues to having a more holistic level approach. Working only on the energy aspect is too one-sided – the user needs to be at the centre. Because first and foremost one needs to feel comfortable in a building and it needs to be fun and engaging for users to deal with topics regarding energy efficiency.

We need concepts that are transferable and suitable for mass-market adoption

#### What impact do these results have on your research discipline?

Concepts need to be much easier and simplified. We must also distance ourselves from 100% solutions. Rather aim at 85% and achieve a large number of buildings instead very few lighthouse projects, which nobody has the ability or desire to reconstruct. We need concepts that are transferable and suitable for mass-market adoption.

Working only on the energy aspect is too one-sided – the user needs to be at the centre

#### What role does a healthy indoor climate play in future buildings?

The topic "health" is gaining relevance, whether it relates to nutrition or living. But at the same, this also increases uncertainty. It is important to overcome this and succeed in creating good living environments. Thus the aspects of comfort need to be joined, which are daylight, fresh air and comfortable indoor temperatures. These factors ensure a good indoor climate and therefore need to be taken into account when modernizing or planning a building. In this context the prevention of pollutants is equally relevant. It is important to consciously look into, what kind of materials and components that are being implemented, and what effect they could have on a room or the user – this requires good planning.

#### What impact does daylight have and why should it be incorporated into future regulations?

On this matter, two things are happening at the moment. The current trend in architecture to use more glass and create light-flooded rooms is being opposed by a new norm for summer heat protection. This partially very narrowly defined norm is a retrograde step as it leads to a reduction of transparent surfaces in order to save cooling energy. Yet if the surface parameters or glass and shading device are well decided and if cooling energy is produced by renewable sources, nothing speaks against using surface cooling to achieve a comfortable indoor climate. However, use of natural ventilation should be the initial choice.





Hamburg, Germany  
**LichtAktiv Haus**



Photo by Adam Mark



Photo by Adam Mark

**Design team:**

Katharina Fey (concept)  
Prof. Manfred Hegger and Tim Bialucha,  
TU Darmstadt ee (design)  
Ostermann Architekten  
(project realisation)

Prof. Klaus Daniels, HL Technik,  
(energy design)  
Prof. Peter Andres, PLDA.  
(light planning)

**Partners:**

Sonnenkraft  
VELFAC  
WindowMaster

**Academic partners:**

Technical University Braunschweig  
Technical University Darmstadt

Humboldt University Berlin

lichtaktivhaus.de

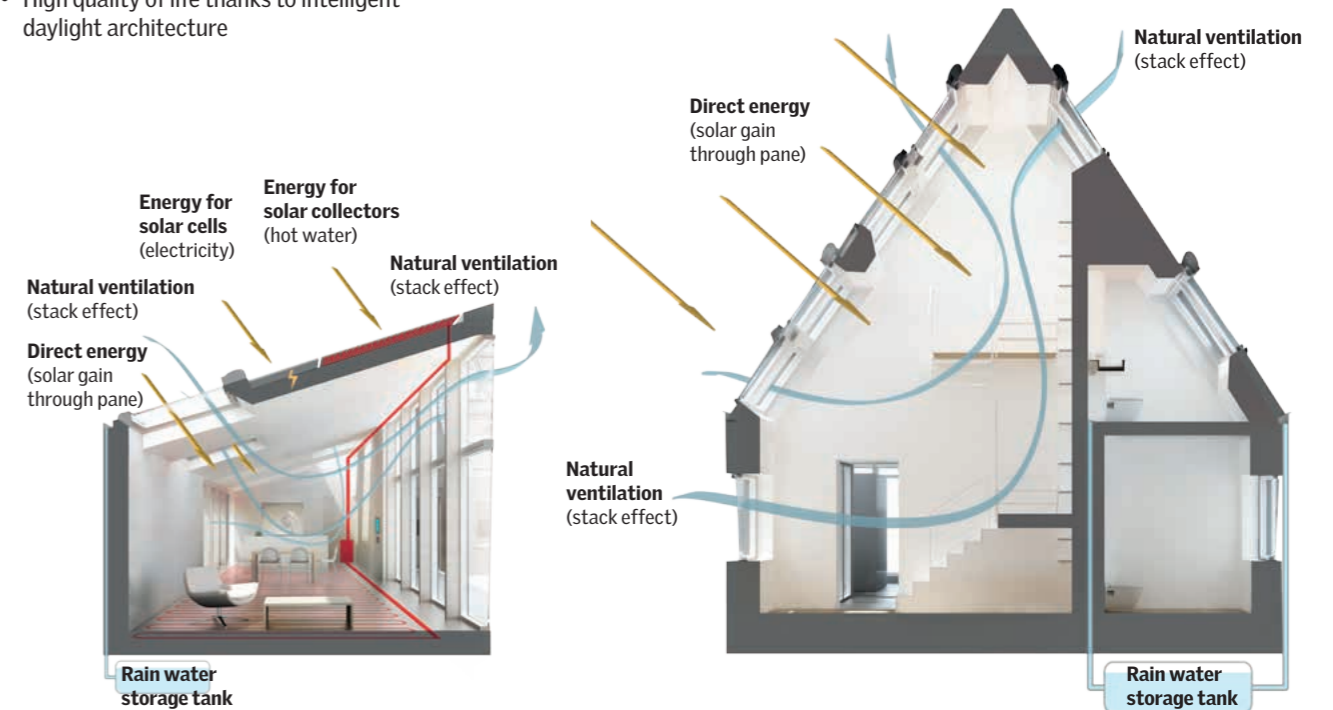
## Energy-efficient architecture and high liveability combined in modernised houses

**Daylight and fresh air**

- The window area of the house has been increased from 18 m<sup>2</sup> to 96 m<sup>2</sup>
- Need-based natural ventilation through automatically-controlled roof windows ensures a comfortable indoor climate with lots of fresh air
- Shutters and blinds prevent overheating in the summer
- Plenty of daylight reduces the need for artificial lighting and has positive impact on health and well-being
- High quality of life thanks to intelligent daylight architecture

**Energy concept**

- Energy-efficient building envelope
- Maximum use of passive solar gains
- 22.5 m<sup>2</sup> of solar collectors supply the home with heating and hot water
- 75 m<sup>2</sup> of polycrystalline photovoltaic cells act as a source of environment-friendly electricity
- Carbon-neutral living in a modernised settler house







## Key findings of the two-year living experience



lichtaktivhaus.de

The increase in light has been the most noticeable plus over the dark winter months. In our old flat, my first reaction was always to reach for the light switch. In the beginning, I didn't even know where they were in the LichtAktiv Haus – even when it's overcast outside, it's always bright enough inside.



The radar charts created on the basis of the Active House Specifications with the calculated and measured values provide an overview of the performance of the LichtAktiv Haus with regard to environment, energy and indoor climate. It shows what influence the power consumption of the system equipment has on performance.

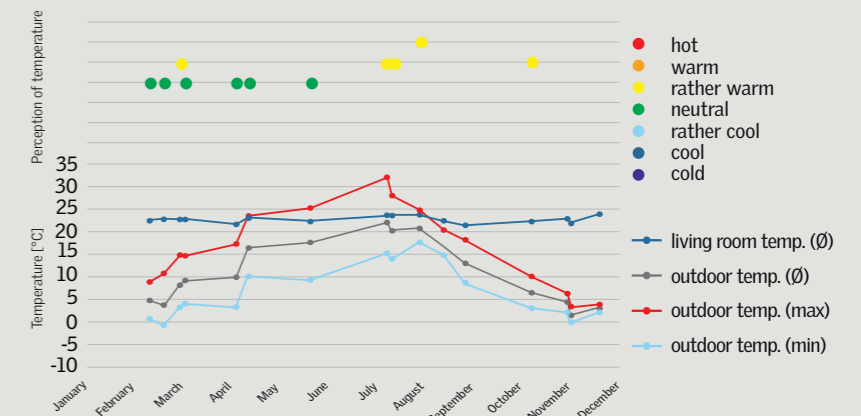
The Active House Radar shows the performance of the building based on calculated and measured data.

- Calculation performance
- Measured performance
- Estimate

Energy calculations base on national building codes.

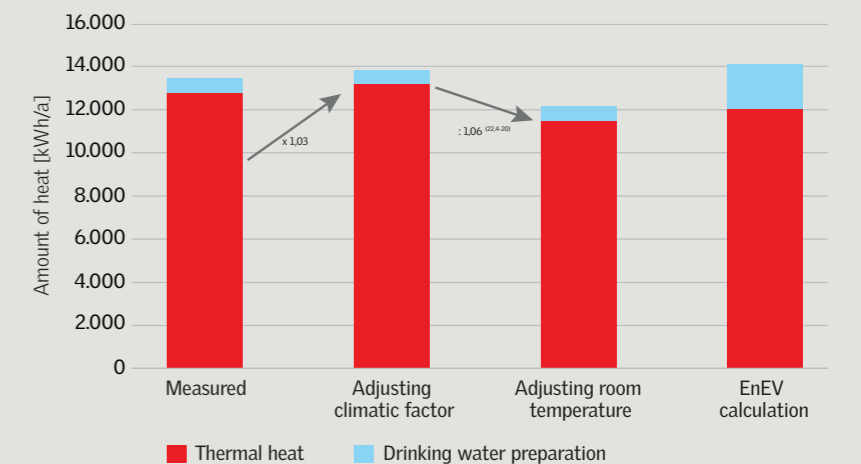
The monitoring concept allows the researchers of the Humboldt University of Berlin and Braunschweig University of Technology to establish a connection with quantitative measurements in questions of personal temperature perception and therefore draw conclusions on the experiences of living and well-being in the LichtAktiv Haus.

### Perception of temperature in LichtAktiv Haus 2012



The data show that the heating requirements in the LichtAktiv Haus are lower than anticipated. This is also proof that lower energy consumption can also be achieved with need-based natural ventilation without heat recovery.

### Calculated normalisation of heating requirements LichtAktiv Haus 2013







Arch. DI Dr. Renate Hammer, MAS studied architecture and philosophy and completed post-graduate studies in Urban Engineering and solar architecture. In 2013, she founded the Institute of Building Research & Innovation as a private research institute with Dr. Peter Holzer. She is a lecturer at the FH Campus Vienna, Austria, and speaker of the platform of building culture. She is a member of the Advisory Council for Building Culture in the Federal Chancellery, and the Oxford Round Table.

Dr. Hammer has been involved with the energy and comfort monitoring of the Austrian Model Home "Sunlighthouse".



## We need to integrate outdoor and indoor

Interview with Renate Hammer

Users want to know and experience in their house what time of the day or season it is as well as what the weather is like

### From your perspective:

**What are the main results of the Model Home 2020 project?**

For me it is raising and forming awareness. This was achieved with the help of real projects and the processes that were associated with them – from the architectural competition to the monitoring and test families. Real projects are always more effective and reinforce theoretical results. Another central finding for me is the fact that the various elements of sustainable building are not standing next to each other at the moment. Even though that is required in standards such as ISO 21931-1.

The topic of building optimisation needs to be looked at more comprehensively

**What impact do these results have on your research discipline?**

We need to push a balance of interests. This means that the topic of building optimization needs to be looked at more comprehensively. We must establish a balance, which is a real scientific challenge in terms of providing basic principles in this regard. It is also a challenge in terms of practical planning and legislative implementation not to mention sensitisation.

**What about the future effects on the building and living?**

The results of the Sunlighthouse monitoring confirmed my assumption that we, meaning human beings, who are actually more outdoor characters, cannot readily adapt to the current indoor lifestyle. Therefore, future building concepts need to integrate more into the outdoor area and vice versa. Users want to know and experience in their house what time of the day or season it is as well as what the weather is.

**How did the test families perceive the daylight concepts of the Model Home buildings, and what aspects do you think require improvement?**

With the Sunlighthouse, it was really interesting to observe the test family moving in and initially not being overwhelmed by the high daylight level. Only after they moved out and into their new home, a house they designed themselves, they experienced their new level of daylight as defective and therefore the level at the Sunlighthouse as very good. In terms of improvement I think that we require things to become more common and technically simpler. Basically, buildings must still function even when pulling the plug.



Prof. Werner Osterhaus is an architect, lighting designer/researcher and Professor of Lighting Design Research in the Department of Engineering at Aarhus University in Denmark. He has been involved in daylighting research and design since he first started working with the Lawrence Berkeley National Laboratory's Windows and Daylighting research group in 1987. Since 1994, he has been a full-time academic in schools of architecture in the USA, New Zealand and Germany and, since 2009, in schools of engineering in Denmark. He focuses on lighting design, sustainable architecture and building environmental science.



## Natural daylight – versatile benefits

Interview with Werner Osterhaus

Human comfort is more than just providing acceptable values for measurable quantities

### From your perspective:

**What are the main results of the Model Home 2020 project?**

A key finding was that it was possible to document how valuable daylight is – and that it is possible to provide very comfortable living conditions with expansive, but well-designed fenestration systems. That has counteracted the common myth that large windows will always lead to poor energy performance. Another highlight is the knowledge gained about the importance of user behaviour with respect to the energy balance of the building. Designers need to be more in touch with users in order to understand their preferences and expectations.

The project demonstrated that it is possible to combine expansive fenestrationsystems and good energy performance

**What impact do these results have on your research discipline?**

We've learned a valuable lesson in "action research" with real buildings and real people. Connecting measured data and human experience – the psychophysics of building design – seems to be the key to building sustainably. Too often, computer simulations are the only tool to measure the success, of a building's design and sustainability rating. An appropriate form of post-occupancy evaluation – with subsequent modifications in design and operation of a building – should be a part of every building contract and would provide huge learning opportunities.

**What about the future effects on the building and living?**

As our understanding of the interplay between human needs and building design grows, designers will likely learn how to create cutting-edge architecture that is more responsive to human needs under a wide variety of social, cultural and climatic conditions. Adaptability will gain importance, for example when users become older or buildings change ownership. But architecture must also appeal to the aesthetic senses, as human comfort is more than just providing acceptable values for measurable quantities. Comfort and wellbeing are experienced in body and mind.

**How did the test families perceive the daylight concepts of the Model Home buildings?**

Daylight was perceived as a significant benefit. The various scenarios offered in the Model Homes provided a different perspective on daylighting design. This changed their expectations and preferences, and will likely lead to criteria being reconsidered for future homes.

**What aspects do you think require improvement?**

Large expanses of glass are not always advantageous, and effective shading and privacy control need to be provided. Implementing climate-based, daylighting performance metrics in national and international standards and building codes will – in my view – also help to further improve daylighting design solutions in the future.



Rothwell, Kettering, United Kingdom  
**CarbonLight Homes**



Photo by Adam Mark



Photo by Adam Mark

Design team:	HTA Design LLP	Clancy Consulting	CHAPS
Partners:	Kettering Borough Council North Northants Development Company	HTA Design LLP (monitoring) Willmott Dixon VELFAC	WindowMaster Sonnenkraft Drexel und Weiss
Monitoring:	HTA Architects		

[thedaylightproject.co.uk](http://thedaylightproject.co.uk)

The design and energy concept used today's technology to create comfortable, sustainable living environments that improve the quality of life for the people within.

**Daylight and fresh air first**

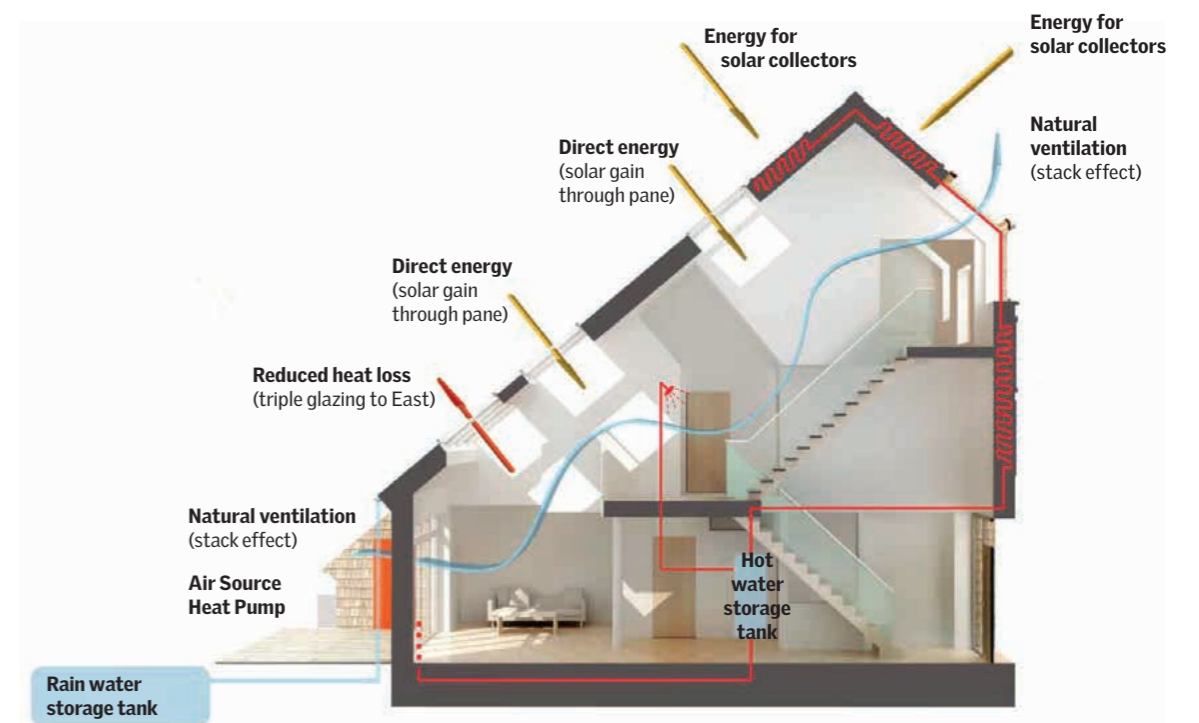
- Glazing to floor area ratio of 25% with an impressive view of the sky
- Designed average daylight factor of 5% – measured average daylight factor of 7.5%
- Hybrid natural/mechanical ventilation system to achieve optimum indoor climate

**Challenging the standard**

- The CLH are the first UK homes to be built to the latest government definition of zero-carbon homes at code level 4
- Unique model for achieving carbon neutral status by upgrading existing housing stock to offset CO<sub>2</sub> emissions
- Automated windows, sunscreening and heating systems controlled by Building Management System
- Visionary architecture which captures the natural elements that minimises energy consumption
- East to West orientation with solar thermal collectors but no PV panels

**Energy concept**

- Highly energy efficient and airtight building envelope
- Central thermal store to provide space heating and domestic hot water
- Solar thermal collectors and air source heat pump to heat thermal store
- Mechanical ventilation system to provide heat recovery in heating period







## Key findings of the one-year living experience



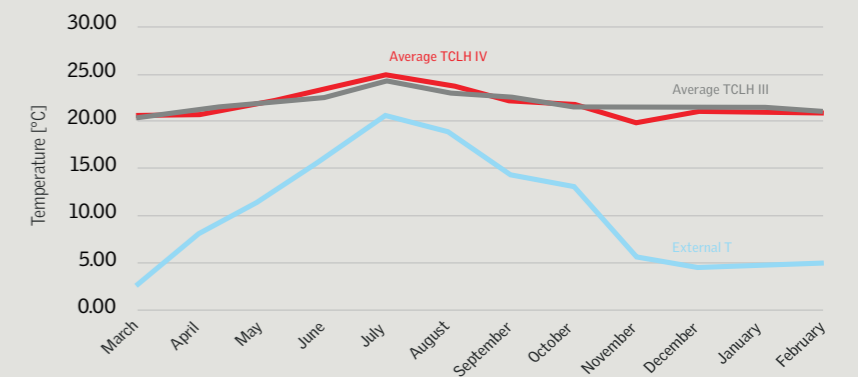
[thedaylightproject.co.uk](http://thedaylightproject.co.uk)

You see new houses and it's all brick with tiny little windows and you think, 'it must be so dark in there'. Living here has changed our perception. What [other] people consider light is not what we consider light.



Conclusions on the temperature comparison between houses  
The 3-bedroom house had a more consistent temperature, while the 4-bedroom house was hotter during the summer and slightly colder during winter.

### Internal Temperatures throughout the monitoring period – CLH IV and CLH III comparative graph

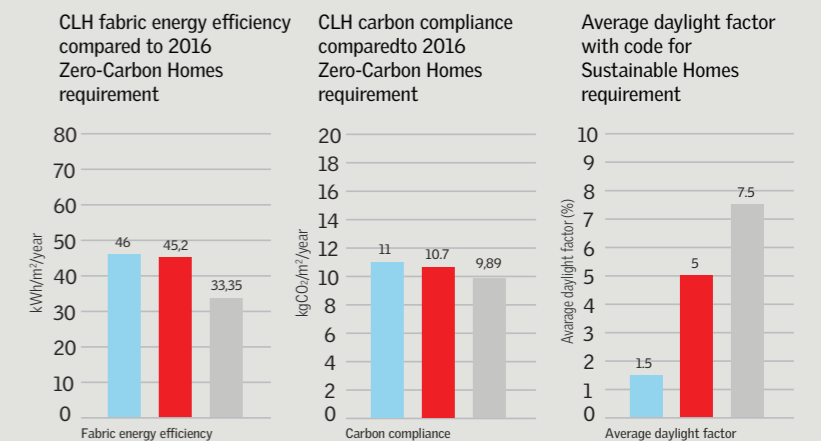


The performance of the CarbonLight Homes exceeded expectations and the adjacent graph shows how the 4 bed house fared with regard to fabric efficiency and average daylight factor.

As a result, the regulated, energy use for heating and lighting was reduced which helped to offset the unregulated energy use by the occupants of televisions, DVD players and computers etc.

The key thing to consider with the energy use on this project, is that no photovoltaics were used and the success in the results is down to a good hybrid combination of solar thermal collectors, air source heat pump and MVHR for space heating and domestic hot water.

### CarbonLight Homes – performance graphs





Dip. Arch Cantab RIBA Benjamin Derbyshire is Managing Partner at HTA Design LLP, a design-based consultancy to the home-building industry, which specialises in place making, providing project management, master planning, urban design, architecture, landscape design, planning, technical design, graphics, web and app design and other disciplines. HTA Design LLP was responsible for the design and monitoring of the CarbonLight Homes – the British Model Home project.



## Practical experiments provide crucial documentation

Interview with Benjamin Derbyshire

### What are the main results of the project?

It is evident that an internal climate with an average of more than 5% daylight factor has the ability to create an environment that lifts the spirits and sustains the emotional wellbeing of the occupants. The CarbonLight Homes gave us the chance to prove that it can be done and easily replicated, as the technical and compliance issues have been resolved.

The CarbonLight Homes prove that an average of 5% daylight factor creates an environment, which lifts the spirits of occupants

### What do these results mean for design and architecture?

In subsequent work, we tested the average daylight factor in 15 contemporary designs, all of which have been submitted to the Housing Forum: [www.homeperformancelabelling.co.uk](http://www.homeperformancelabelling.co.uk) The results ranged from 1.8 to 4.8%, and the huge disparity reveals that the industry has much to learn about the benefits of well-lit, domestic environments. We continue to make the case for Home Performance Labelling to advertise daylight levels in new homes.

Practical experiments serve as a brilliant advertisement for our professional contribution to environments that are better designed and sustainable

### What impact can design have on sustainable parameters? And how does design and architecture contribute towards a healthy home?

Our political leaders often speak of the need for environments that are better designed and more sustainable. Despite this, in the UK at least, the influence of architects – the professionals specifically trained to use design to improve healthy and sustainable outcomes – is actually diminishing. Practical experiments like the CarbonLight Homes serve as brilliant advertisement for our professional contribution to this incredibly important issue.

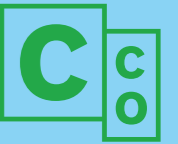
### What is "sustainable by design" in your opinion?

Sustainable by design is nothing if not evidence based. We need to predict the performance of the homes that we are designing, communicate this performance in terms that are meaningful (not technical and obscure) to the consumers of our designs, and finally test and validate the actual performance in post-occupancy evaluation, so as to create a feedback loop of continuous improvement.



Michael Christensen graduated from the Aarhus School of Architecture in 1989. He established Christensen & Co. (CCO) in 2006 after playing a central role at the acclaimed Danish architectural firm Henning Larsen Architects for ten years, the last five years as partner and director. From the very beginning, Christensen & Co. has consolidated itself as an innovative company with a visionary approach to sustainable architecture by winning a number of high-profile projects.

Christensen & Co. designed the Green Lighthouse in Copenhagen, Denmark.



## Sustainability as an integrated part of responsible architecture

Interview with Michael Christensen

### What are the main results of your project? What is the key finding for you?

Green Lighthouse was an experiment that gave us the possibility to activate a number of different sustainable elements within the same building. The particular focus on daylight as an architectural driver gave us profound knowledge and subsequently it is an element we have used in all our projects. The compact circular shape is not always the best method for achieving high level of daylight within the building; however, as a method for the concept of Green Lighthouse, it was the most valuable architectural method, in view of placement, surroundings and the programme.

### What do these results mean for design and architecture? What effect do they have?

Green Lighthouse provided us with a lot of invaluable knowledge, especially as it was continuously evaluated in order to gather evidence for future sustainable projects. We believe that the design and development of Green Lighthouse has played a major part in how sustainable buildings in Denmark developed. With Green Lighthouse, we walked the walk - not just talked the talk.

We believe that the design and development of Green Lighthouse has played a major part in how sustainable buildings in Denmark developed

Sustainability is an integrated part of responsible architecture in our time

### How can design impact sustainable parameters? And what can design and architecture contribute towards a healthy home?

For design to have a real impact on sustainable parameters, it will have to work as a whole. Quality of design and technical solutions need to come together from very early on. Sustainable buildings entail a lot more than technical add-ons; we create buildings that give more than they take – this applies to both its social and design context.

### What is "sustainable by design" in your opinion?

Sustainability is an integrated part of responsible architecture in our time. We have developed a design method that integrates sustainability from start to finish. This entails materials as well as social parameters.





Verrières-le-Buisson, France  
**Maison Air et Lumière**



Photo by Adam Mark



Photo by Adam Mark

<b>Design team:</b>	Nomade Architectes Cardonnel Ingenierie	E.T.H.A.
<b>Partners:</b>	Saint-Gobain and trademarks Placo, Isover, Saint-Gobain Solar and Saint-Gobain Glass Solutions. Sonnenkraft WindowMaster	Aldes Eternit Somfy Umicore
<b>Academic partners:</b>	Monique Eleb, sociologist, member of A.C.S. laboratory of Ecole Nationale d'Architecture Paris-Malaquais.	Centre "Energie et Procédés" – Ecole des Mines de Paris.

maisonairlumiere.fr

## Design and energy concept focused on the residents' wellbeing

**Lots of daylight and fresh air**

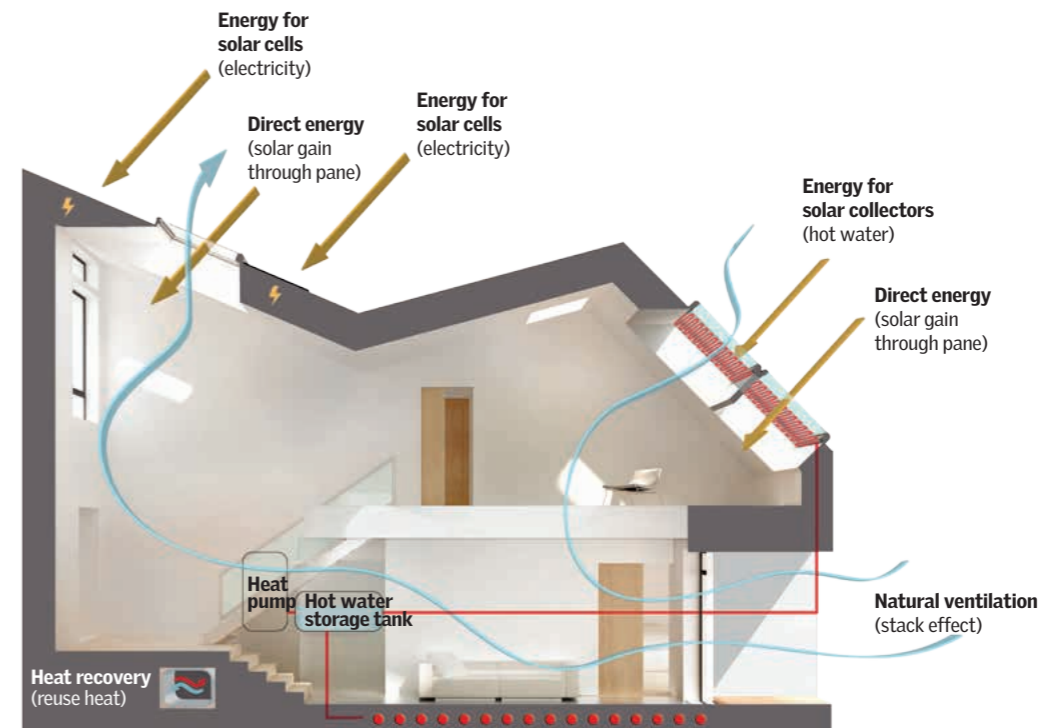
- Window-to-floor ratio of 1:3
- Ventilative cooling for a good indoor climate

**The pitched roof as active 5<sup>th</sup> facade**

- Energy production
- Automated control of roof windows opening and sunscreening
- The architectural signature of the house

**Energy concept**

- Energy-efficient building envelope
- Maximum use of passive solar gains and renewable energy sources





maisonairetlumiere.fr

Ryan [our son] still hasn't had an asthma attack

## Key findings of the one-year living experience

Every day, we can see our consumption on the screen. It is not a constraint – it gives a feeling of responsibility. It is easy to wear a pullover or use less water when taking a shower.



**Objectives achieved regarding energy, comfort and environment**  
Most of the parameters scored level 2. Real-life experiment confirms high-energy performing building envelope with excellent daylight conditions. Also remarkable is the reasonable water consumption, much lower than predicted.

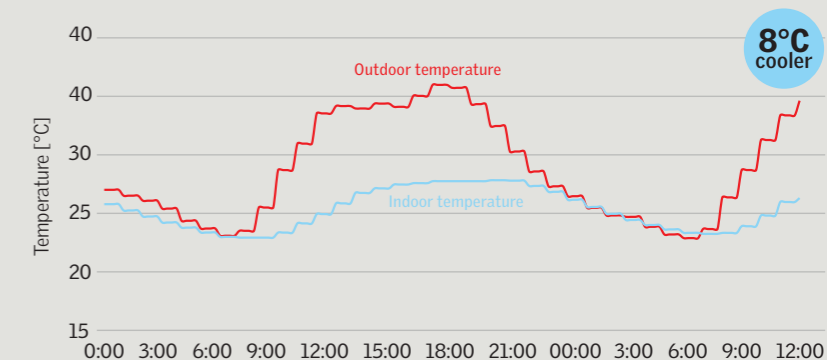
The Active House Radar shows the performance of the building based on calculated and measured data.

- Calculation performance
- Measured performance
- Estimate

Energy calculations base on national building codes.

**Lots of daylight with a good summer comfort experience**  
On warmest July day, 2013: 8°C cooler indoor vs outdoor with no air-conditioning. Only natural ventilation and sun screening.

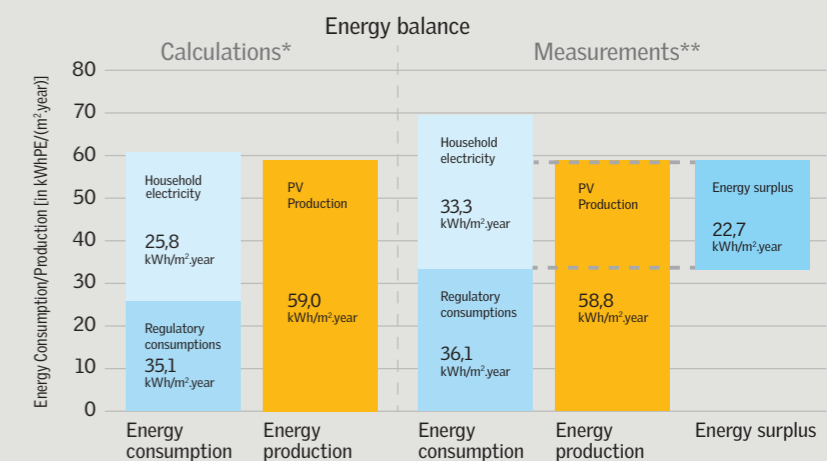
Living-room temperature 22 July, 2013



**High efficient monitored energy performance**  
40% better performance vs reference regulatory building. Energy production surplus of 22.7 kWhPE/(m<sup>2</sup> year) (surplus to regulatory consumptions).

- Regulatory calculations (heating, hot water, lighting, ventilation)
- Household consumptions (White goods + brown goods)

\* Design figures according to national building regulation RT2012 – Cardonnel Ingénierie calculations for household consumptions.  
\*\* On-site measurements with data processing.







A new VELUX roof window leaves a positive CO<sub>2</sub> footprint after 10 years



You can save money on your energy bill by replacing an old roof window with a new VELUX roof window



# Products

## Maintaining balance

A VELUX solution provides daylight control and fresh air, free solar heating and natural cooling. It's a complex solution, because the benefits are plentiful and the outcome extensive. Knowledge from Model Home 2020 shows that different areas of the home offer different challenges and thus require different products to maintain a sustainable balance.





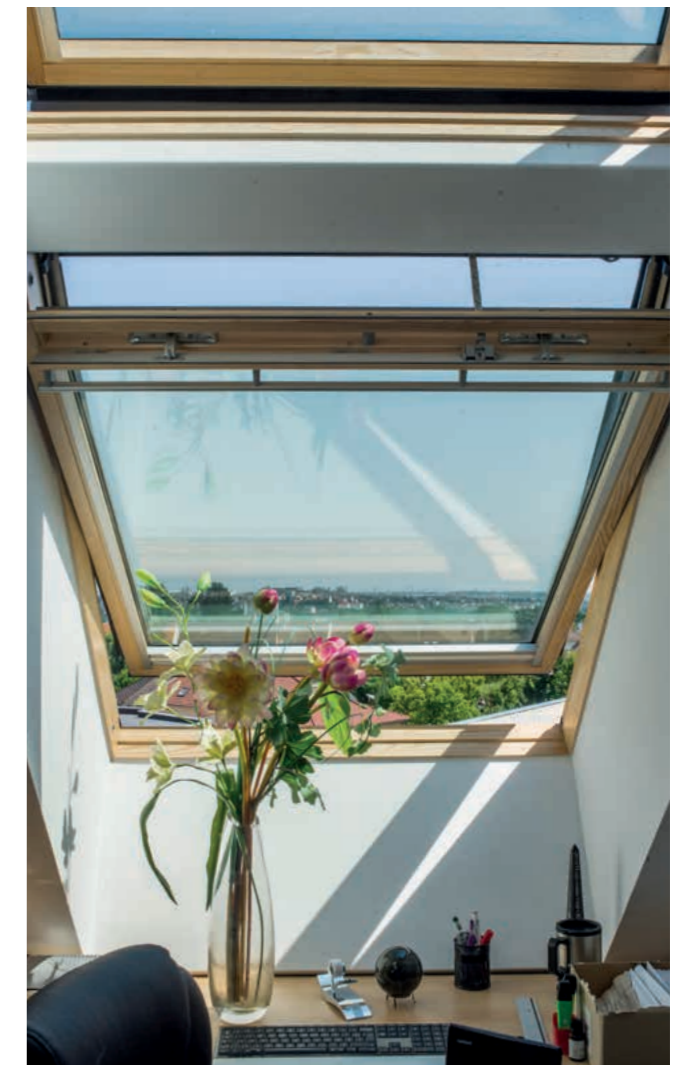
Maison Air et Lumière, France.

## Learning by doing

Essentially, Model Home 2020 is a full-scale learning process. By selecting various locations with different climate conditions and culturally distinct demands for dwelling, every demo house is ripe with valuable knowledge on climate-neutral building.

As shown above, this knowledge has continuously been retrieved in collaboration with leading architects, engineers, scientists and similar building professionals. However, since designing a home in principle is about the feelings and expectations of the people who are going to use it, we have asked the inhabitants of the demo houses – the families who have volunteered to eat, sleep, play and relax in their very own model home – to share their experiences.

By combining layman answers with the findings of the professionals, we have collected a vast volume of insights into the way daylight, ventilation and solar heating can become instrumental in designing homes with better comfort, better indoor climate and lower energy consumption.



Maison Air et Lumière, France.



CarbonLight Homes, United Kingdom.

## 6 key insights

1. A roof window solution will not cause the room to overheat
2. Plenty of daylight will eliminate the use of artificial lighting between sunrise and sunset
3. Cooling by natural ventilation prevents overheating and ensure moderate temperatures at night
4. Exterior sunscreening actively prevents overheating during the day
5. Automated products help home owners utilise the full potential of the solution, even when they are not home
6. Natural ventilation ensures good indoor air quality





LichtAktiv Haus, Germany.

## Sleeping

Most people want their bedroom to be a sanctuary – a place of relaxation and ultimate comfort. That, however, takes a bit of work from the building itself.

Every person needs approximately 30 m<sup>3</sup> of fresh air per hour, which makes ventilation a key word, especially if the bedroom has a limited amount of space. Functionality to ensure a distinct daytime and nighttime environment is also important, since our circadian rhythm is determined by our exposure to daylight. Last, but not least, the room should be able to maintain a moderate temperature, as the body naturally wants to lower its temperature during sleep.



Maison Air et Lumière, France.



Sunlighthouse, Austria.

## How

### Key success factors

#### Healthy sleeping

#### Distinct day and night-time

We all need fresh air and darkness to recharge during sleep – and waking up with natural daylight gives us a morning energy boost that increases our level of alertness.

Enough windows to give you good daylight conditions in the morning is just as important as the black out blinds that give you darkness when you sleep.

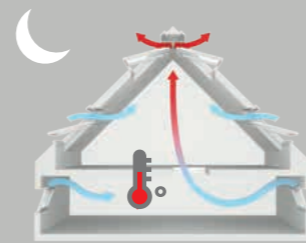
#### Moderate temperature

Avoiding high temperatures will improve your sleep.

Use shading to prevent overheating during the day – and carry out a long airing before bedtime on those warm summer evenings.

#### Good indoor air quality

We spend almost a third of our lives in bedrooms, and the air can easily become stale and stuffy. Breathing fresh air through the night increases our alertness the next day.



With VELUX INTEGRA®, you can easily air out before bedtime and in the morning, and make sure the flap is open only at night. You can even program automatic airings at night.



With two roof windows side-by-side in a bedroom, it only takes 15 minutes to renew the air. If the windows are installed above or across from each other, the airing is even faster. \*\*

In Maison Air et Lumière, France, it only takes five minutes to renew the air. \*

\* Measured by Ecole des Mines in the open air volume (staircase, kitchen, living room) of Maison Air et Lumière.  
\*\* Source: calculations in VELUX EIC Visualizer.  
A room of 4 m by 4 m (16 m<sup>2</sup>) with a single-sided 45° roof. 2 SK06 Integra Windows installed side-by-side, facing south, located in Paris.

## Design solutions

Solar protective glazing, external solar shading and natural ventilation are all efficient ways to prevent overheating. Choose the best combination for your project and climate.

With ventilative cooling in Maison Air et Lumière, it was possible to maintain an indoor temperature 5°C lower than if ventilative cooling had not been used.



Maison Air et Lumière, France.

## Product recommendations



**Good:**  
VELUX roof windows positioned above or opposite each other + blackout blind + awning blind.



**Better:**  
VELUX roof windows + roller shutter.



**Best:**  
Automated VELUX INTEGRA® + roller shutter with a focus on – pre-installed programs: good night, good morning, solar protection in summer (automated roller shutter control).





LichtAktiv Haus, Germany.



Sunlighthouse, Austria.

## Playing

Children and young adults are all about diversity and spontaneity. Finding the right formula means being able to support all kinds of activities such as play, study, entertainment and sleep.

Daylight is known to increase children's learning abilities as well as sleep quality. Findings from Model Home 2020 show that one extra hour of daylight can be obtained with a large roof window solution. While children's extra need for sleep makes complete light control an obvious priority, physical activity and the use of electronic media equipment also trigger extra demand for ventilation.



Maison Air et Lumière, France.



## How

### Key success factors

#### Playing and learning

#### Good indoor air quality

Children's learning abilities are increased by up to 15% in good indoor air quality.

#### Good visual comfort

Good daylight conditions make the room more inviting for the child and also improve learning abilities.

#### Moderate temperatures

Temperature variations can be pleasant, but extremes are not desirable. Furthermore, avoiding overheating improves children's learning abilities.

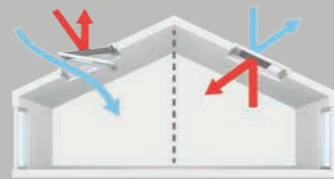
**Playing:**  
Active children playing in their room? No problem – an airing afterwards quickly freshens the air again to keep the little ones fresh.

**Learning:**  
Fresh air can easily be ensured with the VELUX ventilation flap. If the house has mechanical ventilation, an airing before starting homework helps get the math problem right.

Windows with different orientations improve the light distribution in the room. Their positioning of windows will influence the amount of "useful daylight".

Openable windows with more than one orientation make for efficient airings and ensure that you can quickly cool down your room.

Adding solar shading prevents your room from heating up during the day.



#### Quick and efficient air change.\*

Minutes it takes to renew the air	Typical summer day	Typical winter day
Single-sided	40	25
Cross-ventilation	25	11
Stack effect	13	10
Combined stack and cross-ventilation	12	9

\* Ventilation rates achieved for the full body of a house with airing, calculated with VELUX Energy and Indoor Climate Visualizer for a typical house in Berlin. Four windows are used for airing, and the ventilation rates achieved with single-sided airings, cross-ventilation and stack ventilation.



Most children and teenagers are not in the habit of airing their rooms, which often contain many toys and electronic equipment that emit chemicals to the air. VELUX INTEGRA® windows can ensure automatic airings without interrupting play.

## Design solutions

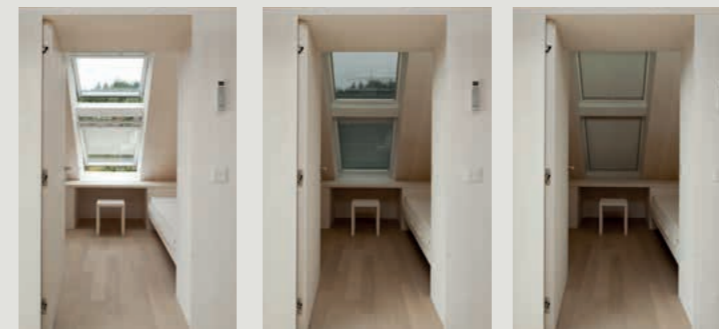


The window configuration of the children's room in Sunlighthouse was designed to provide good daylight conditions. Two roof windows above each other (SK10 and SK06) in combination with daylight through the glass wall to the corridor makes the desk a great place for homework and playing. Even on a very dull day, there will be 1,250 lux\* on the desk – a great place to unfold your creativity.

\* Above 500 Lux, visual comfort is ensured for working tasks and no additional lighting is needed. 5,000 lux is assumed outdoor.

Solar protective glazing, external solar shading and natural ventilation are all efficient ways to prevent overheating. Choose the best combination for your project and climate.

When ventilative cooling was used in combination with solar shading in Maison Air et Lumière on a very warm afternoon in July 2013, the indoor temperature was maintained 8°C lower than the outdoor temperature.



Adding shading to your windows gives great flexibility in how you want to control temperature and light in the room.

## Product recommendations



**Good:**  
VELUX roof window – appropriate size to room geometry + VELUX exterior shading solution (awning blind or roller shutter).



**Better**  
VELUX roof window + exterior shading + VELUX lining that enhances the light.



**Best:**  
combination of 2 VELUX roof windows (side by side or top combination according to room geometry) + VELUX exterior shading + VELUX lining.

\* Deep rooms: combination of 2 windows on top of each other is best

\* Wide rooms: 2 windows side by side is best



# Bathing

The role of the bathroom is for us to be as clean and functional as possible. It is also to be that special place that ensures the day starts and ends on a positive note.

Since our bodies need daylight to adjust their circadian rhythm, access to open sky in the early morning and late evening remains an essential feature of the bathroom. Proper ventilation is also needed to quickly reduce humidity and create a dry and healthy environment with less risk of mould. A VELUX roof window with maintenance-free and water-resistant polyurethane surface provides that extra convenience. Finally, it seems relevant to point out that even a smallish room can look quite spacious with a roof window solution.



Sunlighthouse, Austria.



Sunlighthouse, Austria.

## Recommendations



- The automated VELUX INTEGRA® roof window ensures easy airing and a healthy indoor climate with less risk of mould
- VELUX roof windows positioned above the mirror or shower reduce the need for artificial lighting, create more space and optimize the airing process
- Venetian blinds provide functional sunscreening with easy cleaning and the option of complete privacy



LichtAktiv Haus, Germany.





LichtAktiv Haus, Germany.

## Cooking

The kitchen is like a big melting pot, a place where everyone comes together, where food is prepared, homework is done, issues are debated and even guests hang out. In every way, it represents the creative room of the house.

Because of this multitude of activities, the kitchen requires great versatility in terms lighting and ventilation. Efficient airing is important so that cooking smell and steam can be replaced with fresh air. A bright environment with plenty of daylight is also needed to ensure functional lighting that makes cooking more pleasant, the food more colourful and the interior more generous and attractive for human interaction. Lastly, the tough kitchen environment requires an equally sturdy ally, making the VELUX roof window with maintenance-free polyurethane surface an obvious choice.



## Recommendations

- Two or more VELUX roof windows positioned high and low or opposite each other provide optimal airing properties and reduce energy consumption for the cooker hood
- A large VELUX solution by two or more roof windows provides functional lighting, reduces the need for artificial lighting and makes the kitchen look more spacious and attractive
- Automated VELUX INTEGRA® roof window solutions ensure easy airing and a healthy indoor climate







Sunlighthouse, Austria.

## Living

Certainly the term 'living' must apply to every corner of the house. Still, if we think of 'living' as relaxing with family and friends, watching TV or reading a book, most would point to the informal room at the heart of the home.

Thus the living room needs to stand out as the most accommodating and comfortable area in the house. Being a large room usually, the amount of daylight should be significant and ensure warm sunshine even on a chilly day. Then again, the daylight and temperature must be controlled, using suncreening, ventilation and free solar heating to balance the light transmittance and energy effect in every season.



LichtAktiv Haus, Germany.





LichtAktiv Haus, Germany.



Home for Life, Denmark.

## Connecting

It might look like an unexceptional structure for personal relocation, but the ability of the staircase to spread daylight and fresh air marks it as a very valuable piece of building design. A staircase should be lit with daylight to ensure maximum safety. Artificial lighting creates shadows and can be mischievous, especially for elderly people with poor eyesight. A staircase should also be used to distribute vast amounts of daylight and fresh air to every floor of the house. The inherent funnel design makes it perfect for quick airing with stack effect, and while the fast process reduces the loss of heat, it also supports natural cooling in the summertime.



## Recommendations

- One or more VELUX roof windows positioned right above the staircase will increase safety, save energy for artificial lighting and distribute daylight to every floor in the house
- An automated VELUX INTEGRA® roof window solution ensures easy airing with stack effect (when a façade door or window is opened simultaneously). Airing creates a healthy indoor climate and helps to maintain a comfortable indoor temperature
- For corridors with no daylight access, the VELUX Sun Tunnel is a good solution to enhance perception of space



CarbonLight Homes, United Kingdom.






**People breathe in and out 22,000 times a day.**  
Lack of fresh air hampers learning and working capabilities and causes allergies.



**Good daylight improves health, wellbeing and performance.**  
Dr. Daylight



**2-4 airings a day is all it takes to achieve optimum indoor air quality.**



**15%**  
**Children's learning abilities rise by up to 15% if they are in a good indoor climate.**

# People

## The natural link

Homes are built for people. The argument might seem trivial, but modern building hasn't always met human requirements on an eye-to-eye level. We believe that the quality of people's lives and the quality of the environment are closely linked. It is never a question of either-or. Our goal is to find solutions that will help rebuild the positive relationship between environmental sustainability and comfortable human dwelling.



# The real experts – what do they have to say?

The story told by facts and scientists is one thing. The story told by the families living in the model homes is another. What do they experience? What do they think? And how can this input be applied in future concepts for healthy homes?



The light in the house is impressive [...] and there's no need for electric lights during the daytime.

Kristensen Family, Denmark



Oldendorf Family, Germany

Within the last two years, none of us was ever really sick. Normally everyone has at least once in a year been ill.



Pastour Family, France

We have four double doors and three single doors, which means that we can almost drag the garden into the house.

Dorfstetter Family, Austria

Lots of daylight is becoming a new standard for our future house. In fact, when we pay a visit to friends, we often feel that something is missing ...





# Paving the way for healthier homes

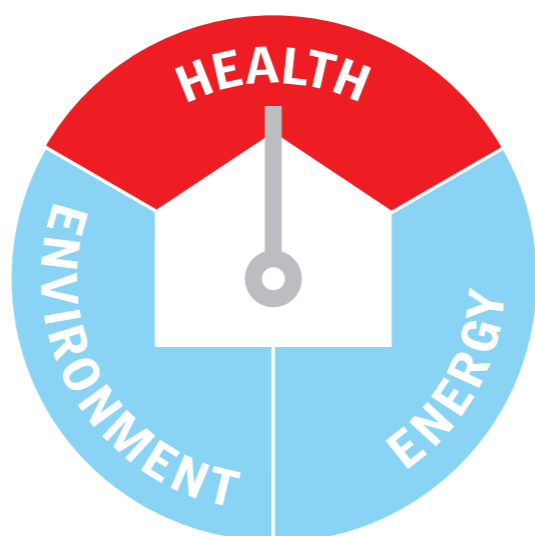
## From what we know to how it is

Today we know a great deal about the environmental impact of our homes. We know how much energy they use, what influence they have on health issues, and how much CO<sub>2</sub> we could save if we replaced electric lighting, heating and cooling with more daylight and natural ventilation.

However, the attitudes and behaviours of the actual home residents haven't attracted the same amount of attention. And that is a shame. In many respects they are the main stakeholders in paving the way for healthier homes.

## The Healthy Homes Barometer

To help fill up the knowledge gap, the VELUX Group conducts a yearly pan-European survey called The Healthy Homes Barometer. The survey examines, how residents relate to their homes, focusing on a number of key aspects such as their attitude towards a healthy indoor environment and the importance of home energy costs. The underlying thesis derives from the Active House vision of buildings that create healthier and more comfortable lives for their occupants without having a negative impact on the climate – moving us towards a cleaner, healthier and safer world.



# Five significant findings

The 2015 edition of the Healthy Homes Barometer is based on a questionnaire given to 12,000 Europeans in 12 different countries. Their answers have resulted in five indicative learning points, revealing how residents perceive their home, their aspirations for a healthy environment and concerns in when it comes to acting on their beliefs.

1

People want their home to be healthy. In their minds there is a clear link between living a healthy life and having a healthy home. They even consider fresh air and daylight to be more beneficial to their health than avoiding tobacco.

2

Although people see the connection between health and home, the link doesn't encompass clinical health issues such as illness, fatigue, asthma and allergies. Instead, fresh air and daylight are seen as a way to obtain general comfort, wellbeing and homeliness.

3

37% of the households with four or more people suffering from asthma or allergies are very concerned about living in a building with bad quality. Yet, in spite of these weaknesses, the same group doesn't air out more frequently than others during winter. This indicates that having a healthy home is, to some extent, an unacknowledged public health factor.

4

Concern doesn't necessarily lead to action. The inclination to air out the home is overshadowed by the preference for heat and comfort, especially in winter. This shows that maintaining a healthy home remains a trade-off related to expenses and emotions rather than clinical factors.

5

People will act, if the pay off is real and immediate. If a given project or purchase guarantees less power consumption or increased home comfort, the owner will be more obliged to invest. Critical challenges are the lack of clear legislation and the owners' inability to take adequate responsibility for the use of sustainable building materials.

# A healthy life starts at home

Europeans have been asked how important nine factors are to their health. When ranked by importance the order is:

- # 1 Sleeping well at night
- # 2 Ventilating and in Home Arena (right)
- # 3 Eating fruit and vegetables
- # 4 Daylight in my home
- # 5 Spending time outdoors
- # 6 Avoiding tobacco
- # 7 Regular exercise
- # 8 Avoiding chemicals
- # 9 Dietary supplements



**The Home Arena**  
Three out of four factors clearly related to home life are rated highly by Europeans.

- #1 Sleeping well at night
- #2 Ventilating my home
- #4 Daylight in my home
- #8 Avoiding chemicals



**Our intake**  
Europeans give secondary attention to how their bodies are fuelled.

- # 3 Eating fruit and vegetables
- # 6 Avoiding tobacco
- # 9 Dietary supplements



**Being active**  
Europeans find it important – but not crucial – to their health to be active.

- # 5 Spending time outdoors
- # 7 Regular exercise

# Principles and guidelines for healthy homes

In 2013 and 2014, the VELUX Group invited an interdisciplinary team of leading experts to participate in a series of five workshops. The group, consisting of scientists from Europe and the United States, was asked to discuss the possibility of designing a home in which the inhabitants can live 'in sync' with the rhythms of nature and enjoy human health and wellbeing. After the workshops, the group presented a range of specific recommendations on how to fulfil their overall vision. These recommendations are called the Circadian House Principles.

A

### Live in balance with nature

A house in balance with nature allows the occupants to live with and follow the daily and seasonal cycles of the outdoor environment.

B

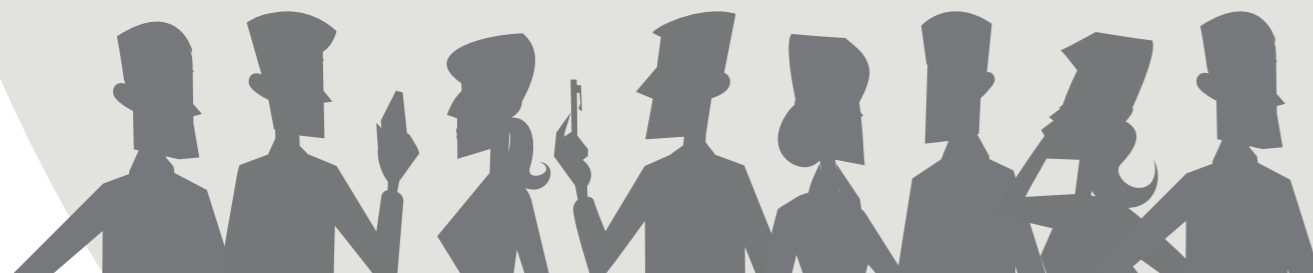
### Adaptability

A house whose space and occupants can adapt to changing conditions (daily as well as seasonal) and needs.

C

### Sensibility

A house that provides protection against harmful substances that humans cannot sense and allows freedom to control parameters that they can sense.



# Design aspects to take into account

1

### Variation

The indoor environment should vary in time and space rather than target uniformity or non-variability.

2

### Stimulation/absence of stimulation

The level of stimulation from environmental factors (light, sound, air and temperature) should be higher during day than at night.

3

### Outdoor/indoor relation

Outdoor and semi-outdoor areas should be designed to be inspiring and easily accessible; occupants should be able to follow (changes in) outdoor conditions in all main living areas of the house.

4

### Warm/cool

The house should provide temporal and spatial variations in the thermal environment that are logical and follow (to a certain extent) variations in the outside temperature.

5

### Silence/sounds

The presence of sound and contact to sounds from outdoors are desirable in the day, whereas quiet spaces are needed at night.

6

### Light/darkness

Exposure to high levels of daylight is needed in the main living areas of the house during daytime; special attention should be given to rooms that are mainly used in the morning, whereas bedrooms should provide complete darkness at night.

7

### Rest/activity

The house design should inspire the occupants to be active – but also provide areas for rest and restitution.

8

### Flexibility related to the seasons

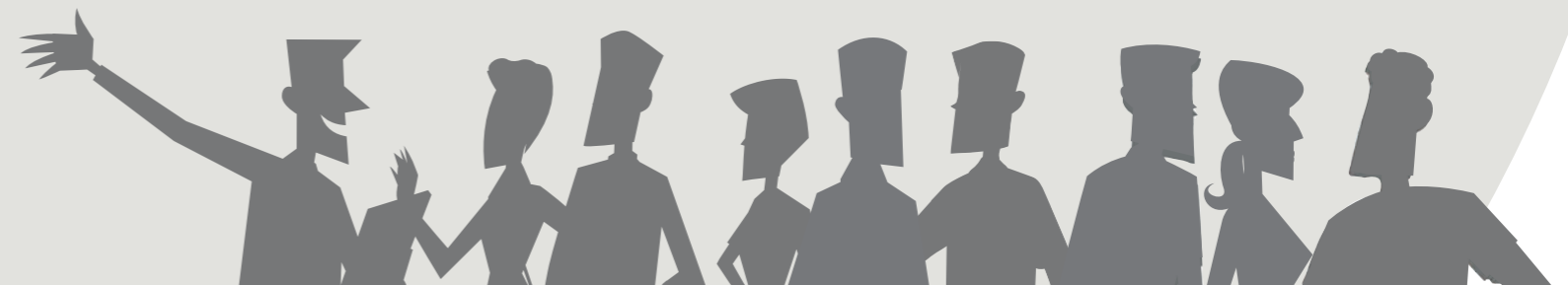
The use of outdoor and semi-outdoor spaces should be stimulated outside the heating season.

Electrical lighting should follow, support and supplement the changes and variations in the daylight spectrum and intensity through the course of the day, as well as its distribution in space.

9

### Control

The occupants should be able to control the systems influencing parameters that can be sensed, e.g. lighting level, air quality and indoor temperature.





The next step on the journey is to upscale sustainable solutions into the existing building stock.

The aim of the RenovActive project in Brussels, Belgium, is to create a new showcase to promote the Active House vision towards the market of social housing and one-family homes.

The VELUX Group has partnered with the social housing company "Le Foyer Anderlechtois" that owns more than 3,600 homes in Belgium. Improved quality of life and increased energy efficiency are the central concerns of both partners in the renovation of an 80 m<sup>2</sup>, dilapidated semi-detached house built in the 1920s that will serve as a showcase for future renovation projects.

The purpose of RenovActive is to develop a sustainable and affordable renovation concept suitable for large-scale renovation and modernisation. A concept that can easily be reproduced both in financial and technical terms accessible for everyone.

Before



After



Before



### Daylight and fresh air

The architectural design of RenovActive was entrusted to ONO Architectuur after a design competition. The solution convincingly combines the technical requirements of the Active House principles with an efficient use of space and a cost-effective approach that can easily be reproduced elsewhere. The main idea is to move the staircase to the centre of the building to create a column of natural ventilation and daylight and to open up the living spaces and the views to the garden and surroundings.

### Affordable solution

One of the main goals of RenovActive is to prove the financial viability of Active House renovation. It makes good sense

VELUX Daylight Visualiser



to focus on renovation, since 90% of the building stock that will still be in use in 2050 has already been built and requires modernisation in the near future. The one-family home in Brussels was chosen for the experiment as it represents a scenario that many home owners face across Europe.

The total cost of the renovation has been estimated according to the budget frame of social housing in Brussels and meets the requirements set up in the Energy Performance of Buildings (EPB) standard. The budget thereby demonstrates the general feasibility of Active House renovation.

### A showcase for inspiration

Upon completion, the VELUX Group will open the doors to the RenovActive in Brussels to visitors for a 12-month period to educate and inspire. Afterwards, a family with 3 children will live in the house for two years. During this period energy, heat and water consumption, as well as the family's interaction with the home, will be monitored by scientists to gain new insights into renovation methods and results.



**RenovActive**  
Brussels, Belgium  
2015

**Model Home 2020**  
Six projects developed  
in the period 2009-11

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[www.velux.com/sustainableliving](http://www.velux.com/sustainableliving)